Hinkley Point C Appropriate Assessment for related Environment Agency permissions

Final Version: July 2012

Background and Purpose

NNB Generation Company Limited (NNB Genco) propose to construct and operate a new nuclear power station at Hinkley Point in Somerset, to be known as Hinkley Point C (HPC). It will be located on the coast, immediately due west of the existing Hinkley Point A nuclear licensed site. The construction and operation of HPC will require various permissions from the Environment Agency (EA).

The Environment Agency is required, under the Conservation of Habitats and Species Regulations 2010 ("Habitats Regulations"), to undertake an appropriate assessment (reffered to as a Habitats Regulations Assessment or HRA in the rest of this assessment) for any permissions it grants that have the potential to impact upon European designated sites. These include, Special Areas of Conservation (SACs) which are designated under the EC Habitats Directive for important high quality habitat sites, and Special Protection Areas (SPAs), designated under the EC Birds Directive, classified for rare and vulnerable birds (as listed on Annex I of the Directive), and for regularly occurring migratory species[1]. Ramsar sites are wetlands of international importance designated under the Ramsar Convention and Government policy gives Ramsar sites broad equivalence to those designated under the Birds and Habitats Directives[1]. Therefore Ramsar sites will be included within the assessment. Collectively they are known as Natura 2000 sites.

The purpose of this assessment is to ascertain, in view of the conservation objectives of the European Sites, whether it can be concluded that the Environment Agency permissions will not adversely affect the integrity of the European sites in question, either alone or in combination with other relevant permissions plans or projects.

The information within this assessment is based on the best available information at the time. Any information presented to the Environment Agency outside of the assessment timeframe may not be considered

Executive Summary

We carried out an Appropriate Assessment (AA) for the relevant Environment Agency permissions needed to build and operate the proposed Hinkley Point C (HPC) development. These include water discharge and combustion activities, radioactive substances and flood defence consents.

The AA assesses the potential impact of our permissions on achieving the conservation objectives for both the Severn Estuary and the Exmoor Quantock Oakwoods Natura 2000 sites, as determined by both Natural England and the Countryside Council for Wales (2009)[1], (date unknown)[2].

The main part of the assessment was concerned with the water discharge activities and their potential effects on the Severn Estuary Special Area of Conservation (SAC), Special Protection Area (SPA) and Ramsar sites, as the proposed HPC site is directly next to and partly within these designated sites.

A number of the conclusions from the assessment involve implementing measures and conditions that are beyond our control. In these cases, the conclusions will only be valid if the appropriate competent authority puts these measures and conditions in place, or if the potentially damaging effects identified in the assessment are addressed in another way.

We carried out desk-based research of scientific papers including information from technical reports written by the Centre for Environment, Fisheries & Aquaculture Science (Cefas) on behalf of Électricité de France (EDF) and Nuclear New Build Generation Company (NNB Genco).

Because of the complex nature of the Severn Estuary sites and the need to make assumptions about precise biological responses to environmental change, we also used expert judgement to reach our conclusions about effects and impacts.

The data, assumptions and approach we used in reaching our conclusions have been internally and externally peer-reviewed and endorsed by national experts with particular knowledge of the Severn Estuary.

The main areas of potential concern we focused on included toxic contamination, thermal impacts, entrainment and impingement of fish and planktonic organisms, and disturbance to birds. These were all assessed in respect of the HPC project itself and the combined impact of the HPC project with other on-going activities and planned projects in the area.

The conclusions below reflect our findings for the Severn Estuary Natura 2000 sites and also cover any potential impacts on associated sites: River Usk/Afon Wysg SAC; River Wye/Afon Gwy SAC; River Tywi/Afon Tywi SAC. We concluded that there was no adverse effect on the integrity of the Exmoor Quantock Oakwoods SAC.

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[1] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[2] Exmoor and Quantock Oakwoods Special Area for Conservation. Natural England' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended.

Toxic contamination

Total residual oxidant (TRO) and hydrazine in the operational discharges were above the relevant standard within the cooling water. We did not consider the resultant mixing zone for TRO to be significant, as it was restricted to small areas around the outfall diffusers. However, the maximum load for hydrazine and the potential mixing zone for this maximum load were potentially significant. For this reason, we could not rule out the potential for an adverse effect on the integrity of the Severn Estuary SAC due to the discharge of hydrazine. Therefore, the environmental permit for the operational discharges will require that hydrazine is removed from the relevant waste streams before discharge.

We concluded that the levels of all other toxic contaminants in the operational discharges from HPC would not have an adverse effect on site integrity of the SAC.

Thermal impacts

The main effect of the thermal plume from HPC on the features of the Severn Estuary SAC is the potential impact of increased water temperatures on the subtidal and intertidal benthic species, and, in particular, the bivalve *Macoma balthica*. This bivalve provides the greatest source of food in the subtidal and intertidal areas. It is also considered to be the species most at risk from increases in the temperature of seawater.

However, evidence on *Macoma balthica* and other benthic invertebrates within the mudflat area of Stert flats that are affected by the existing thermal plume from Hinkley Point B (HPB) show they are no different from those found outside the thermal plume.

This evidence supports the view that the thermal plume from HPC would have no significant effect on intertidal benthic invertebrate species. The subtidal benthic invertebrate species tends to be very limited, and is only affected by water temperatures higher than those on the intertidal area immediately near the outfall diffusers. These factors, together with the lack of any significant effect from the increased water temperatures on the intertidal mudflat area, indicate that any effect on the subtidal benthic invertebrate community will also not be significant.

We have, therefore, concluded that temperature changes due to the operational discharges from HPC would not have an adverse effect on site integrity.

Entrainment and impingement of fish and planktonic organisms

The preventative measures proposed for HPC included a low velocity intake design, acoustic fish deterrent (AFD) system and a fish recovery and return (FRR) system. We took these measures into account when calculating impingement losses from HPC. These were predicted to be similar to or less than those of the existing HPB station.

Based on the information provided in EDF’s report to support the HRA, supporting technical documents and our assessments, we conclude that the predicted rates of fish impingement and entrainment at HPC should not adversely affect either the protected species, estuarine assemblage or integrity of the site.

However, given the many different factors influencing impingement and entrainment within the Severn Estuary/Bristol Channel and the reliance on the proposed preventative measures, there is still scope for potential improvements to systems to improve the predicted rates and, in turn, protect more fish.

We, therefore, consider it extremely important that the final designs of both the FRR and AFD are tested well in advance of the operation of HPC, preferably at the commissioning stage, to give enough time to reach maximum performance before operation begins.

We have advised the competent authorities (Infrastructure Planning Committee (IPC) and Marine Management Organisation (MMO)) that a comprehensive ecological monitoring and contingency plan should be developed before any water is abstracted. This would identify the measures needed to detect early and prevent any changes that may lead to environmental or ecological harm.

Disturbance to birds

The main disturbance issues are predicted to be caused by the construction of Combwich Wharf as part of the flood defence consent activity. We concluded that the Parrett Estuary next to Combwich Wharf, which is part of the Severn Estuary SAC/SPA/Ramsar, remains an important site for birds.

The data indicated that there are large numbers of birds within 250m of the wharf construction area, including three SPA qualifying species (gadwall, redshank and curlew) and three SPA listed species (wigeon, mallard and lapwing). There are also significant numbers of SPA birds in Combwich Brickpits County Wildlife Site next to Combwich Wharf, which were not included within the counts. This meant that the bird counts did not represent total counts for the whole river area. On the basis of the information provided, we were unable to conclude that there would be no adverse effect on the integrity of the site without taking preventative measures.

As it was not appropriate to implement these measures via the flood defence consenting process, we have strongly advised the competent authorities (local planning authority (LPA) and Marine Management Organisation (MMO) to make sure that further preventative measures are incorporated into the project to protect migratory birds and bird assemblage. These measures include:

- *confining piling work between April and September to avoid the winter months when birds are feeding on exposed mudflats;*
- *stopping construction in the event of severe winter weather leading to voluntary wildfowling restraint by the British Association for Shooting and Conservation (BASC) (after seven days of freezing conditions); developing a scheme for piling works before construction.*

In combination effects

The main concerns from both the combined effects of all the activities within the HPC project and also those combined with all other current activities and planned future projects in the area (in-combination assessment) were the combined HPC construction activities and the effects of the overlap period between HPC and HPB. As with the assessment of the impacts of the activities within our permissions in isolation (‘alone’ assessment), the main areas of potential concern we focused on were toxic contamination, thermal impacts, entrainment and impingement of fish and planktonic organisms. The main impacts to birds were considered to be from impact of water temperature increases on their food source within the intertidal and subtidal mudflats.

A major factor in assessing the in combination effects for the thermal discharges was the close proximity of the HPB discharge to the proposed cooling water discharge from HPC. As discussed in the alone assessment, the species most likely to be affected by the potential rise in water temperature from the combined thermal plumes from HPB and HPC is the Baltic tellin, *Macoma balthica*. However, using desk-based studies, together with comparative studies from the Gironde Estuary in France and historical data from Hinkley Point A, we have concluded that the combined thermal plume from HPB and HPC that will exist until 2023 will not compromise the conservation objectives and, therefore, will not have an adverse effect on site integrity.

We also considered the thermal effects of fish in combination in relation to direct effects and effects of thermal occlusion. Neither were considered to significantly impact on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

The in combination effects of the chemical discharges focused on the discharge of TRO from HPB and HPC, together with the discharge of hydrazine just from HPC, as HPB does not have a permit to discharge hydrazine.. As with the assessment of HPC on its own, it was not possible from the information available to conclude that the discharge of hydrazine does not have an adverse effect on the integrity of the site.

We assessed the cumulative effects of impingement and entrainment together with the in combination effects of HPB and HPC. The species that required detailed investigation included the brown shrimp, *Crangon crangon*, whiting, *Merlangius merlangus*, sprat, *Sprattus sprattus* and cod, *Gadus morhua*. Extensive desk-based studies, compared with the International Council for the Exploration of the Sea (ICES) sector allocations for this area of the Severn Estuary have shown the impacts of HPC and HPB will not have a significant effect on the species during the timeframe considered. Although, it should be noted that if the operation of HPB has to be extended further beyond 2023, then another Habitats Regulations Assessment will be needed.

There were minor in combination effects for both the Bristol Port and Environment Agency Steart Peninsula Projects and the combined construction activities.

Conclusion

This assessment has considered all relevant factors and undergone an internal peer review, as well as consultation with Natural England and Countryside Commission for Wales. As the competent authority for permits associated with this proposed site, we have concluded that:

- The maximum load for hydrazine and the potential mixing zone could potentially have a significant impact on the features of the site. Removing hydrazine from the relevant waste streams before discharge will eliminate this risk. We have required within the Environmental Permit for the operational water discharges from the site that hydrazine is removed from the effluent prior to release into the environment.

- Temperature increases from the discharge of cooling water create a plume of water with an increase in temperature, particularly when HPB and HPC are run at the same time. The Baltic clam, *Macoma balthica* in particular, and other benthic invertebrates found in the mudflat areas of Stert flats are the most vulnerable species. Evidence based on modelling, research into similar sites and the response of the species in the existing plume from HPB alone indicates that there would be no significant effect on these intertidal invertebrate species.

- With the site operating alone with the preventative measures of a fish recovery and return system, and an acoustic deterrent system in the design of the intake for the proposed HPC site in place, we believe that there will be no adverse effect on fish. However, given the complex nature of the estuary and the reliance on these proposed measures, the final designs should be tested at the commissioning stage of the set up, well in advance of the full operation of HPC to allow maximum performance.

- We were unable to conclude there would be no adverse effect on the birds listed in the European site designation due to disturbance (noise and visual) at the construction stage of the Combwich Wharf. To ensure migratory birds are protected, we have strongly advised the competent authorities to implement measures related to the timing of piling work and to stop work if there is severe winter weather.

Provided that the safeguards identified above are put in place we are satisfied that there will not be an adverse impact on the site integrity of the Severn Estuary SPA and SAC.

The technical sections of the appropriate assessment that follow include detailed evidence and our reasons for the conclusions above.

Contents

1. Introduction

The proposed Hinkley Point C (HPC) station will consist of two United Kingdom European Pressurised Reactors (UK EPR), based on the European Pressurised Reactor (EPR™) design. The Environment Agency is required, under the Conservation of Habitats and Species Regulations 2010, to undertake a Habitats Regulations Assessment (HRA) for any permissions it grants relating to the construction, commissioning and operation of HPC that has the potential to affect upon European designated sites.

The UK EPR is a single, pressurised water reactor capable of generating in total 1735 megawatts (MW) of electricity and providing 1630 MW of this to the national grid. In the reactor core, the uranium oxide fuel is cooled by water in a pressurised circuit, the primary circuit. The primary circuit includes four steam generators where heat is transferred from the primary circuit to an isolated secondary circuit, producing steam. This steam then drives a turbine-generator to produce electricity, is condensed by a condenser system and the condensate returned to the steam generators. At HPC it is proposed that the condenser will be directly cooled by sea water. The proposed direct cooling system will continuously abstract large volumes (in the order of 67 m^3/s per reactor) of water from the Bristol Channel and return this water to source once utilised within the plant.

The construction of HPC will result in discharges to water comprising of surface run-off, de-watered groundwater, sewage effluent, concrete washwater and wastewater arising during the drilling of the cooling water intake and outfall tunnels. The construction phase will also result in the alteration and development of flood defences at both the main site and associated development sites, and will therefore be subject to Flood Defence Consents. A further aspect of the HPC development will be an aggregates offloading jetty and associated storage area. The construction and operation of this facility will result in discharges of surface water run-off.

The commissioning of HPC will result in discharges to water resulting from commissioning tests on the various plant systems. Discharges to air will result from the testing of standby combustion plant, i.e. diesel generators.

The operation of HPC will result in discharges to the environment of an aqueous and gaseous nature, from both radiological and non-radiological processes. Non-radiological discharges to water are primarily associated with the cooling water system and water treatment processes. Non radiological discharges to air are associated with the operation of the standby combustion plant. Radiological discharges to water are associated from the treatment of primary coolant and decontamination, washing and cleaning of plant, equipment and clothing. Radiological discharges to air are associated from degassing of the primary coolant and the ventilation of buildings.

The de-commissioning effects will be taken into consideration in the in-combination section of the document. The cessation of energy production at HPC is anticipated to be approximately 2080 so it would be very difficult to carry out any detailed assessments on potential permissions required from the EA at this stage. However, before decommissioning can take place, there is a requirement for the operator to obtain consent from the Health and Safety Executive (HSE) under the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 (EIADR 99). This requires the submission of an Environmental Statement following an Environmental Impact Assessment (EIA) and it will be during this period that it will be clearer what EA permissions will be required for the decommissioning process.

The majority of the above discharges will be subject to regulatory control under the Environmental Permitting (England and Wales) Regulations 2010 (SI 2010, No. 675) – further detail is contained within the relevant sections of this report.

1.1 Environment Agency Permissions

The following EA permissions are required for the **construction** of HPC nuclear power station.

Type of permission	Activity	Reference No.	NGR
Flood Defence Consent (FDC)	Construction of sea wall	TBC	ST199461
Flood Defence Consent (FDC)	Construction of Combwich Wharf and modifications to existing flood defences.	TBC	ST216454
Flood Defence Consent (FDC)	Main site operations – Abandonment and diversion of HPC site drainage system.	TBC	Various ST201458
Environmental Permitting Regulation (EPR) – Water Discharge Activity	The discharge of surface water run-off, de-watered groundwater, sewage effluent, concrete washwater and tunnelling wastewater.	EPR/ JP3122GM	ST202461 (HPC drainage ditch shoreline outfall) ST 203461 (spine drain outfall)

The following EA permissions are required for the **commissioning** of HPC nuclear power station.

Type of permission	Activity	Reference No.	NGR
Environmental Permit (EPR) – Water Discharge Activity	The discharge of effluents arising from various commissioning tests.		ST 203461 (spine drain outfall) ST192475 (main cooling water tunnel outfall)

The following EA permissions are required for the **operation** of HPC nuclear power station.

Type of permission	Activity	Reference No.	NGR
Environmental Permitting Regulations (EPR) – Water Discharge Activity	The discharge of cooling water and process effluents.*	EPR/ HP3228XT	ST192475 (main cooling water tunnel outfall)
Environmental Permitting Regulations (EPR) – Combustion Activity	Burning of fuel in the standby diesel generators.	EPR/ZP3238FH	ST201458
Environmental Permitting Regulations (EPR) - Radioactive Substances Activity	The disposal of radioactive waste to air and water and by transfer	EPR/ZP3690SY	ST201458

* Fish Recovery & Return discharge could potentially require an environmental permit

The Environment Agency has decided that an abstraction licence for direct cooling is not required for HPC as we consider that the abstraction is from the open sea. Abstraction licences are only required if the location or method of abstraction leads to the water being abstracted from inland waters as defined in section 221 Water Resources Act 1991.

Historically, under the Water Resources Act 1963 [WRA63] the seaward boundaries for water abstraction licensing were generally taken as the low water mark (of ordinary spring tides) on the coast of the area, or at such point(s) where Local Orders made provision for more useful seaward boundaries to be defined. The subsequent Water Acts of 1973 and 1989 respectively, repealed these provisions.

Today, the main legislation for abstraction licensing is the Water Resources Act 1991 (as amended by the Environment Act 1995) and the Water Act 2003. Currently there is no specifically defined seaward boundary of jurisdiction for water resources and generally, the requirement for an abstraction licence is based on whether the water being abstracted is located within what is termed a “Source of Supply” which is defined as inland waters and underground strata. By definition, inland waters includes any channel, creek, bay, estuary or arm of the sea and doesnot include the open sea.

However, while the Environment Agency does not require the cooling water abstraction to be licensed, the abstraction is linked to the discharge in that it is part of the same overall process stream. We will assess the impacts arising through the abstraction of cooling water in the context of whether the system of direct cooling represents BAT (Best Available Techniques).

1.2 Location of proposed development

Figure 1.2.1 Area of HPC proposal is outlined in red below.

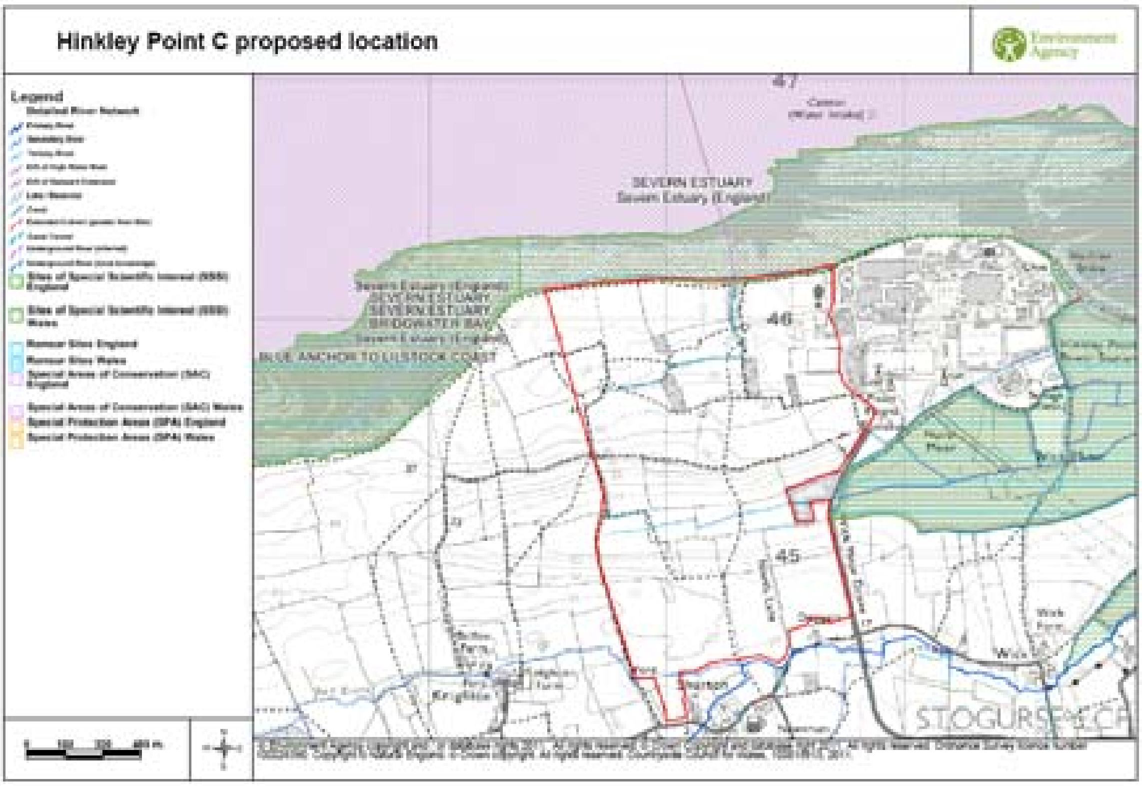


Figure 1.2.2 Natura 2000 sites within 15 km of the proposed development area

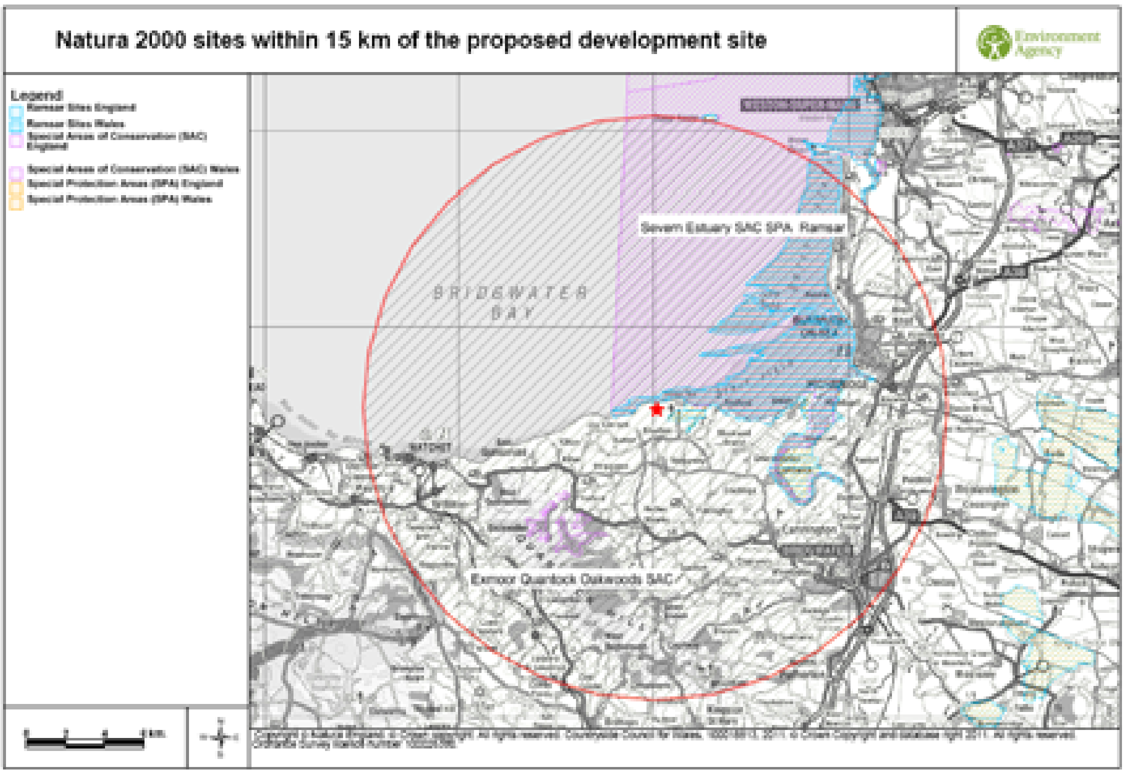
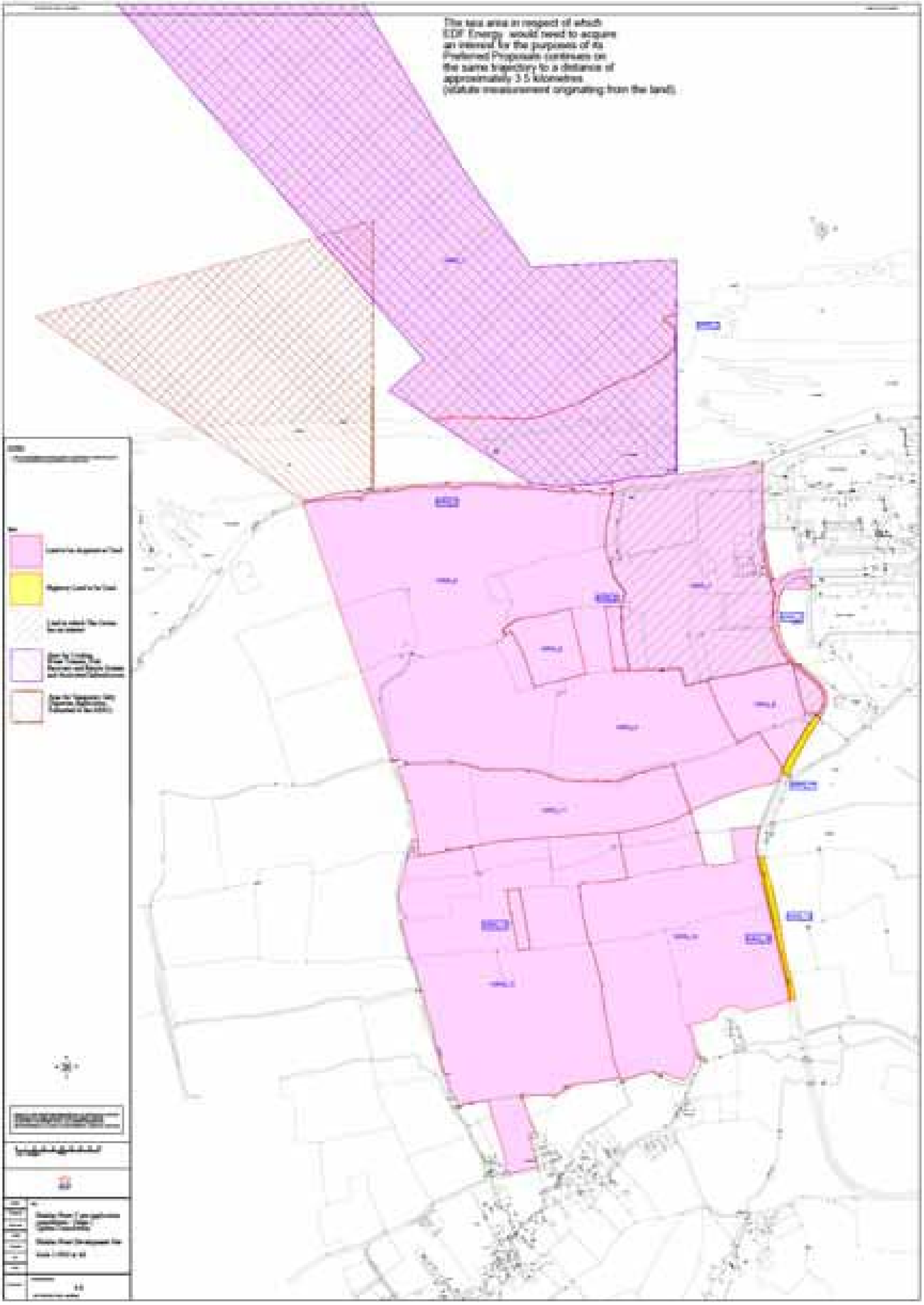


Figure 1.2.3. Area of HPC proposal including area for cooling water tunnels, fish recovery and return system, temporary jetty and the main construction area. (map taken from EDF, 2011)[3]



3 http://hinkleypoint.edfenergyconsultation.info/ Stage 2 consultation. Proposed red line plans. 25 February 2011.

1.3 Overview of Natura 2000 (European) sites

Natura 2000 (European) sites included within the HRA depend on the type of permission and criteria for the proposed activity. The table below outlines the criteria used for each type of permission, in accordance with the relevant Environment Agency (EA) Habitats Directive technical guidance notes.

Activity	EA Guidance	Criteria	Relevant Natura 2000 sites
Discharge	Applying the Habitats Regulations to water quality permissions to discharge OI 141_07[4]	All discharges within hydrological continuity, surface water and groundwater of a Natura 2000 site	• Severn Estuary/Môr Hafren SPA, SAC and Ramsar. • River Usk SAC* • River Wye SAC* • Afon Tywi SAC*
Abstraction	Assessment of new water resource permissions OI 226_10 [5]	All Abstractions within hydrological continuity, surface water and groundwater of a Natura 2000 site	• Severn Estuary/Môr Hafren SPA, SAC and Ramsar. • River Usk SAC* • River Wye SAC* • Afon Tywi SAC*
Combustion	Assessment of new PIR permissions under the Habitats Regulations[6]	Any Power station within 15km of a Natura 2000 site	• Severn Estuary/Môr Hafren SPA, SAC and Ramsar. • River Usk SAC* • River Wye SAC* • Exmoor Quantock Oakwoods SAC
Radioactive Substances	RSR permitting – Prospective radiological assessments for human health and wildlife (habitats) OI 338_04	All emission pathways at distances that reflect the specific dosing rates.	• Severn Estuary/ Môr Hafren SPA, SAC and Ramsar. • River Usk SAC* • River Wye SAC* • Exmoor Quantock Oakwoods SAC
Flood defence	Assessment of Flood and Coastal Risk Management Plans and Projects under the Habitats Regulations[7]	Any works likely to affect Natura 2000 sites.	• Severn Estuary/ Môr Hafren SPA, SAC and Ramsar.

[4] Applying the habitats regulations to water quality permissions to discharge: review and new applications, Habitats Directive. Operational Instruction (OI) 141_07. 2008.

[5] Assessment of new water resource permissions under the Habitats Regulations. Operational Instruction (OI) 226_10. 2010.

[6] Stage 1 and 2 Assessment of new PIR permissions under the Habitats Regulations. Operational Instruction (OI) 251_06. 2008. **Note** PIR permissions are now referred to as Environmental Permits for combustion activities under the Environmental Permitting Regulations (EPR).

[7] Using the Habitats Directive Handbook for Coastal Risk Management Permissions, Plans and Projects. Operational Instruction (OI) 53_02.

Natura 2000 sites to be included within the HRA include:

- Severn Estuary/ Môr Hafren SPA, SAC and Ramsar
- Exmoor Quantock Oakwoods SAC
- River Usk / Afon Wysg SAC*
- River Wye / Afon Gwy SAC*
- River Tywi / Afon Tywi SAC*

The qualifying interest features of the Severn Estuary/ Môr Hafren Ramsar site overlap with those of the Severn Estuary/ Môr Hafren SAC and SPA. To facilitate the development of integrated objectives across the designations the Ramsar criteria have been interpreted and defined so that they are consistent with those already identified under the SAC and SPA criteria[8].

*Although the River Usk SAC, River Wye SAC and Afon Tywi SAC lie outside of the 15km inclusion zone, they are both intrinsically linked to the Severn Estuary/ Môr Hafren SAC in relation to migratory fish. However, it has been agreed[9] by both Natural England (NE) and the Countryside Council for Wales (CCW) that potential effects to the Rivers Usk, Wye and Tywi SACs will not be directly considered as part of the assessment, but will be considered if effects arise in relation to the Severn Estuary/Môr Hafren migratory fish feature, specifically in relation to Atlantic Salmon, shad and sea lamprey.

[8] Severn Estuary/ Môr Hafren European site. Natural England and Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. June 2009. Qualifying interest features of the Severn Estuary/ Môr Hafren Ramsar Site.
[9] Agreement via e-mail from Jessica Poole (CCW) dated 28/04/2011.

1.4 Assessment process

Regulation 61 of the Habitats Regulations defines the procedure for the assessment of the implications of plans or projects on European sites. In accordance to Environment Agency guidance[10] there are four defined stages that are collectively known as the Habitats Regulations Assessment (HRA). These stages describe how the process has been conducted, however the process collectively is the appropriate assessment in legal terms.

Stage1: **Screening**: A course screening exercise to identify European sites within relevant screening distances.

Stage 2: **Assessment of Likely Significant Effect (LSE)** Determining whether the permission, plan or project 'either alone or in combination with other plans or projects' is likely to have a significant effect on a European site(s). See Figure 1.4.1 Those that are considered likely to have a significant effect require an appropriate assessment at Stage 3.

Stage 3: **Appropriate Assessment**: Determining whether, in view of the European site's conservation objectives (see below), whether it can be ascertained that the permissions 'either alone or in combination with other plans or projects' would not have an adverse effect on the integrity of the site. See Figure 1.4.2

Stage 4: **Determining the application**: Where it cannot be concluded that the permission will not have an adverse effect on the integrity of a site, the permission should be refused unless restrictions or conditions can be imposed to ensure there is no adverse effect on integrity of the site (s)

If it is not possible to identify mitigation or restrictions it will be necessary to establish whether the permissions can be granted on the basis of 'imperative reasons of overriding public interest' (IROPI). Before deciding on whether IROPI applies alternative solutions to the proposed plan or project must be examined. However, this is not considered a standard part of the process and will only be carried out in exceptional circumstances.

To assess the likely significant effect, a risk assessment consisting of three elements should be completed. The elements are based on answering the following questions:

I) Is there a potential hazard by which the proposal could affect the interest features of the site either directly or indirectly? Are the interest features sensitive to this hazard?

II) Is there a pathway such that the potential hazard could affect the interest features of the site alone and/or in combination. What is the exposure of the feature to this hazard?

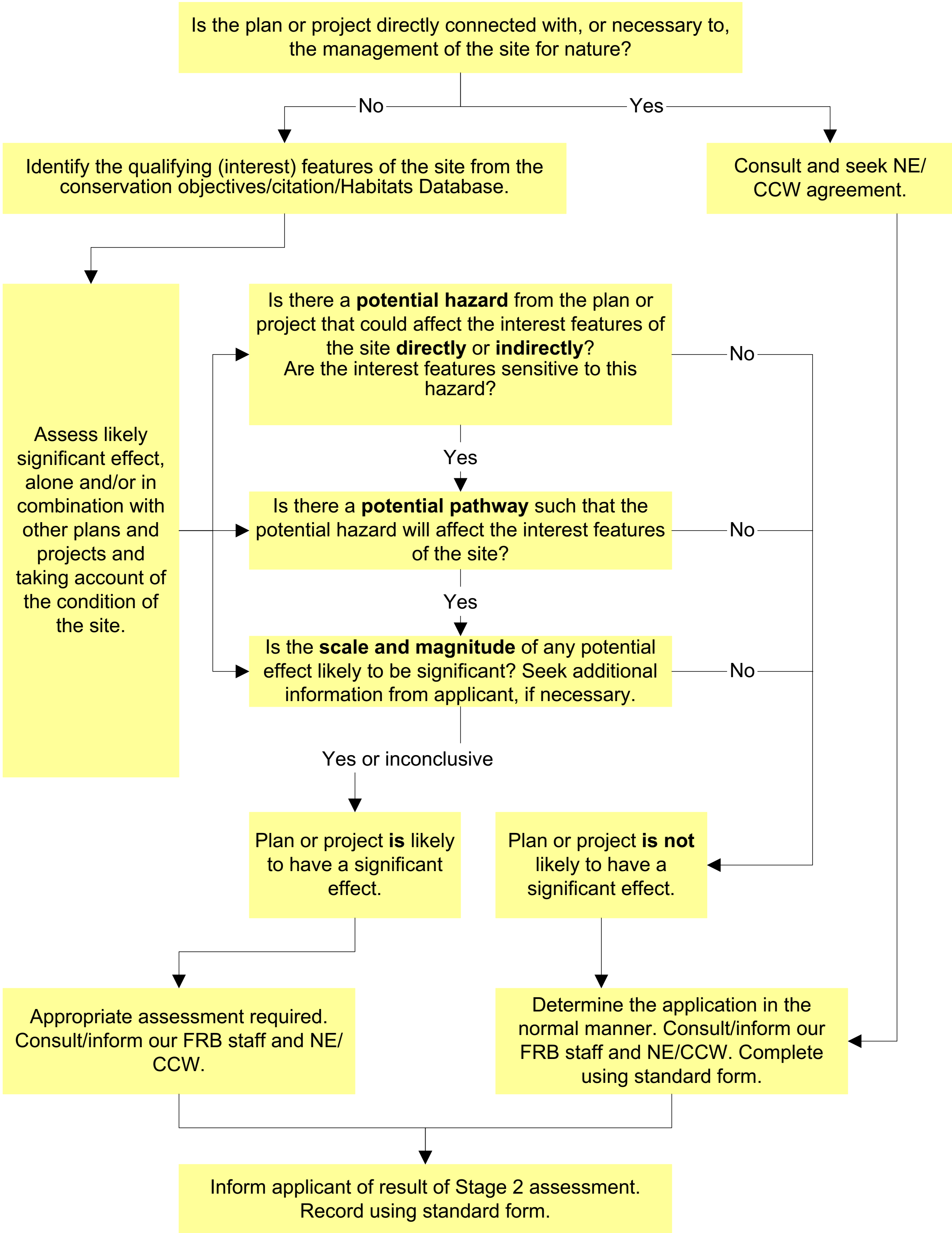
III) For each hazard is the potential scale or magnitude of any effect likely to be significant?

[10] Habitats Directive: Taking a new permission, plan or project through the regulations. Operational Instruction (OI) 183_01

These elements reflect on the guidance agreed between the Environment Agency and NE/CCW[11] that outlines the generic sensitivity of habitats and species groups to permitted activities. Unless local circumstances require otherwise, licences should not be considered further for likely significant effect for those habitats/species **not** sensitive to the permitted activity, providing that any cumulative, indirect and/or synergistic effects can and have been adequately considered.

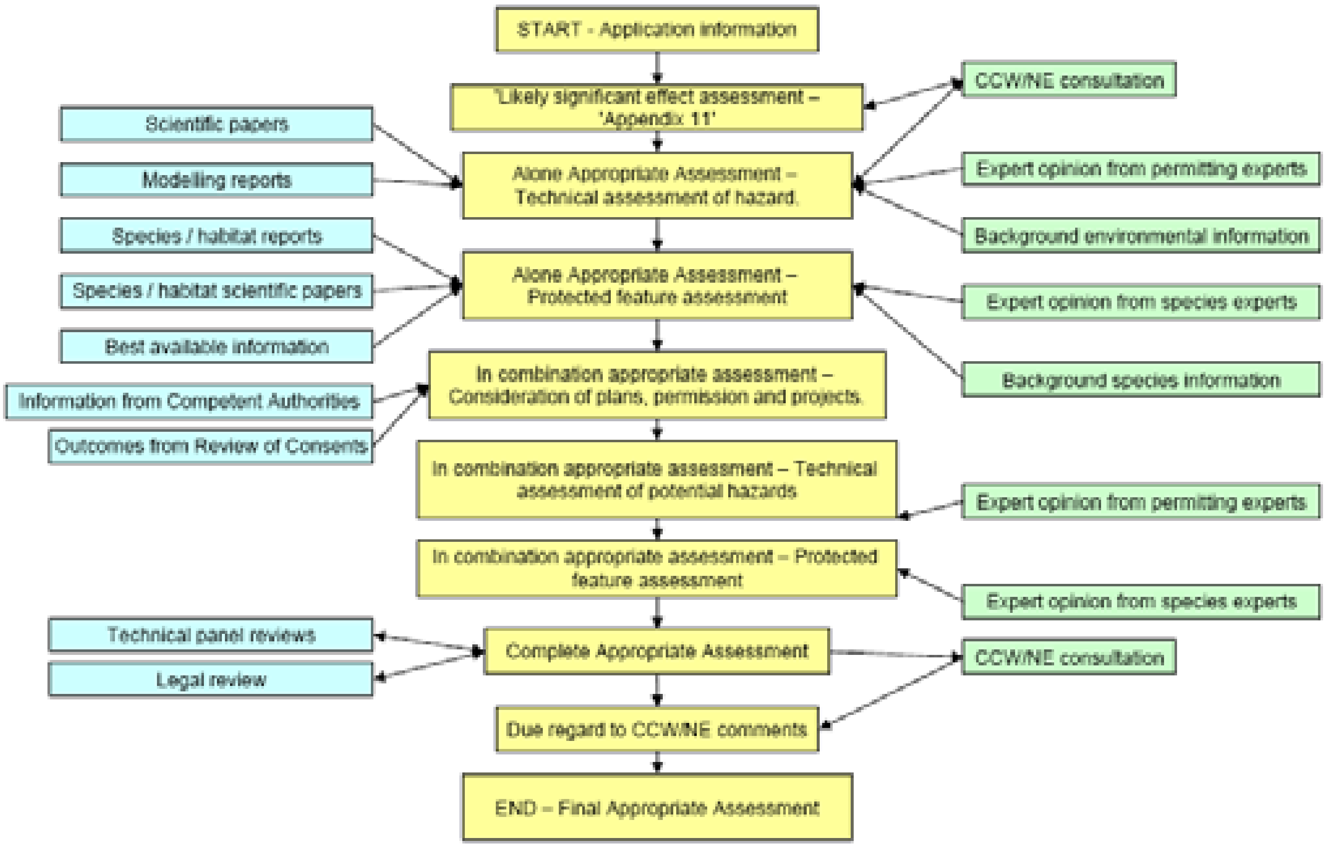
[11] 'Guidance for the review of Environment Agency permissions: determining relevant permissions and significant effect' EAS/3100/3/1 version 1.0, English Nature, Environment Agency, Countryside Council For Wales, 31 March 1999.

Figure 1.4.1. A summary of the procedure for assessing whether a permission, plan or project is likely to have a significant effect on a European site[12]



[12] EA Habitats Directive Guidance: taking a new permission, plan or project through the regulations. Operational Instruction 183_01. 2010.

Figure 1.4.2. A summary of the procedure for completing an 'appropriate assessment'



1.5 Natura 2000 site features list

Severn Estuary / Môr Hafren SAC Interest Features [13]	
Group*	**Feature**
1.12 Estuarine & Inter-tidal habitats	• Estuaries (inc. rocky shore as a sub-feature) • Intertidal Mudflats & Sandflats (not covered by seawater at low tide) • Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
1.13 Submerged marine habitats	• Sandbanks (which are slightly covered by sea water all the time) • Reefs (*Sabellaria alveolata*)
2.5 Migratory fish *(also a notable species sub-feature of the SAC estuaries feature)*	• Twaite shad (*Alosa fallax)* • Sea lamprey (*Petromyzon marinus)* • River lamprey (*Lampetra fluviatilis)*

Severn Estuary / Môr Hafren SPA Interest Features	
Group*	**Feature**
3.6 Birds of lowland habitats **3.8 Birds of coastal habitats** **3.9 Birds of estuarine habitats** *(also notable species sub-feature of the SAC estuaries feature)*	4.1 Internationally important populations of regularly occurring Annex 1 species (under Article 4.1 of the EU Birds Directive) Bewick's Swan
	4.2 Internationally important populations of regularly occurring migratory species European white-fronted goose, Dunlin, Redshank, Shelduck, Gadwall, Ringed Plover*, Curlew*, Pintail*. (*recommended additions under the SPA review)
	Internationally important assemblage of waterfowl (>20,000) (under Article 4.2 of EU Birds Directive). European white-fronted goose, Dunlin, Redshank, Shelduck, Gadwall, Ringed Plover* Curlew* Pintail*, Wigeon, Lapwing*, Teal, Mallard*, Shoveler*, Pochard, Tufted Duck, Grey Plover, Whimbrel, spotted redshank*, (*recommended additions under the SPA review)

*Habitat and species groups taken from 'Habitats and species protected under the Habitats Regulations' Quick Guide 42_06

[13] Severn Estuary/ Môr Hafren European site. Natural England and Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended.

Severn Estuary / Môr Hafren Ramsar Interest Features (*Revised Criteria, 2005*)	
Group*	**Feature**
1.12 Estuaries	***Criterion 1:*** Qualifies due to its immense tidal range (second largest in world), this affects both the physical environment and biological communities.
	***Criterion 3*:** Qualifies due to its unusual estuarine communities, reduced diversity and high productivity (1995 Ramsar criterion 2b).
2.5 Migratory fish	***Criterion 4*:** Qualifies as it is important for the run of migratory fish between sea and river via estuary (1995 Ramsar criterion 2c). Species include: Salmon *Salmo salar,* sea trout *Salmo trutta,* twaite shad *Alosa fallax,* allis shad *Alosa alosa,* sea lamprey *Petromyzon marinus,* river lamprey *Lampetra fluviatilis,* eel *Anguilla Anguilla.*
	Criterion 8: Qualifies as the fish assemblage of the whole estuarine and river system is one of the most diverse in Britain, with over 100 species recorded (1995 Rmasar criterion 2c). Note: the wider estuarine fish assemblage is a 'notable species assemblage' sub-feature of the SAC estuaries feature.
3.6 Birds of lowland habitats **3.8 Birds of coastal habitats** **3.9 Birds of estuarine habitats**	***Criterion 6****:* Internationally important populations of wintering waterfowl (1995 Ramsar Criterion 3c). Qualifies as it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird. Bewick's swan, European white-fronted goose, Dunlin, Redshank, Shelduck, Gadwall, Lesser black-backed gull (breeding)*, Ringed plover*, Teal*, and Pintail*. * recommended additions under the Ramsar review (possible future inclusions)
	Criterion 5: Internationally important assemblage of waterfowl (1995 Ramsar Criterion 2c, 3a and 3c) regularly supporting in winter over 20,000 waterfowl. 1998/99-2002/3 5 year peak mean was 70,919 waterfowl. Bewick's swan, European white-fronted goose, Dunlin, Redshank, Shelduck, Gadwall, Ringed plover, Whimbrel,Teal, Pintail, Wigeon, Pochard, Tufted duck, Grey plover, Curlew, Spotted redshank, Lesser black-backed gull (breeding)*, Ringed plover*, Teal*, and Pintail*. * recommended additions under the Ramsar review (possible future inclusions)

*Habitat and species groups taken from 'Habitats and species protected under the Habitats Regulations' Quick Guide 42_06

Exmoor Quantock Oakwoods SAC Interest Features	
Group*	**Feature**
1.1 Fens and wet habitats	• Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*) – Alder woodland on floodplains
1.6 Woodlands	• Old sessile oak woods with *Ilex* and *Blechnum* in the British Isles (Western acidic oak woodland)
2.8 Mammals of wooded habitats	• Barbastelle bat *Barbastella barbastellus* • Bechsteins bat *Myotis bechsteinii*
2.9 Mammals of riverine habitats	• Otter *Lutra lutra*

1.5.1 Conservation Objectives

In order for us to assess whether a hazard from a permitted activity is likely to have a significant effect on an interest feature, we need to know the temporal extent of the impact in relation to the site. We have referred to the advice given under the Regulation 35(3)(a) (formally Regulation 33(2)(a)) written by Natural England and the Countryside Council for Wales, which includes the conservation objectives for the relevant sites:

- Severn Estuary/ Môr Hafren European Marine site, comprising of the SAC, SPA and Ramsar. Natural England and Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. June 2009. Full advice can be found at the following Natural England internet path: http://www.naturalengland.org.uk/ourwork/marine/protectandmanage/mpa/severnestuaryreg33.aspx

- Exmoor and Quantock Oakwoods Special Area for Conservation. Natural England' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. advice can be found at the following Natural England internet path: http://www.naturalengland.org.uk/Images/UK0030148-Exmoor-and-Quantock-Oakwoods-SAC_tcm6-31989.pdf

- River Wye / Afon Gwy Special Area for Conservation. Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Conservation objectives can be found at the following CCW internet path: http://www.ccw.gov.uk/landscape--wildlife/protecting-our-landscape/special-sites-project/river-to-usk-sac-list/river-wye-sac.aspx

- River Usk / Afon Wysg Special Area for Conservation. Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Conservation objectives can be found at the following CCW internet path: http://www.ccw.gov.uk/landscape--wildlife/protecting-our-landscape/special-sites-project/river-to-usk-sac-list/river-usk-sac.aspx

- River Tywi / Afon Tywi Special Area for Conservation. Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Conservation objectives can be found at the following CCW internet path: http://www.ccw.gov.uk/landscape--wildlife/protecting-our-landscape/special-sites-project/aber-to--brecon-sac-list/afon-tywi--river-tywi-sac.aspx

The following conservation objectives have been taken from these different Regulation 33 documents. As the overarching aim is to achieve Favourable Condition Status (FCS) for each of these sites, the conservation objectives are used as our guide to assessing potential effects from the plans permissions and projects, such that they do not prevent the achievement of FCS.

Conservation objectives for the Severn Estuary/ Môr Hafren SAC and Ramsar

Feature to maintain in favourable condition	Targets
	The conservation objectives for the features listed below are to maintain them in favourable condition, as defined below: The feature will be considered to be in favourable condition when, subject to natural processes, each of the following conditions are met:
Estuaries	i. The total extent of the estuary is maintained; ii. the characteristic physical form (tidal prism/cross sectional area) and flow (tidal regime)of the estuary is maintained; iii. the characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained; iv. the extent, variety and spatial distribution of estuarine habitat communities within the site is maintained; v. the extent, variety, spatial distribution4 and community composition of notable communities is maintained; vi. the abundance of the notable estuarine species assemblages is maintained or increased; vii. the physico-chemical characteristics of the water column support the ecological objectives described above; viii. Toxic contaminants in water column and sediment are below levels which would pose a risk to the ecological objectives described above; ix. Airborne nutrient and contaminant loads are below levels which would pose a risk to the ecological objectives described above.
Subtidal sandbanks which are covered by seawater all of the time	i. The total extent of the subtidal sandbanks within the site is maintained; ii. the extent and distribution of the individual subtidal sandbank communities within the site is maintained; iii. the community composition of the sub tidal sandbank feature within the site is maintained; iv. the variety and distribution of sediment types across the subtidal sandbank feature is maintained; v. the gross morphology (depth, distribution and profile) of the subtidal sandbank feature within the site is maintained.
Inter-tidal mudflats and sandflats not covered by seawater at low tide	i. The total extent of the mudflats and sandflats feature is maintained; ii. the variety and extent of individual mudflats and sandflats communities within the site is maintained; iii. the distribution of individual mudflats and sandflats communities within the site is maintained; iv. the community composition of the mudflats and sandflats feature within the site is maintained; v. the topography of the inter-tidal flats and the morphology (dynamic processes sediment movement and channel migration across the flats) are maintained.

Feature to maintain in favourable condition	Targets
Atlantic salt meadows	i. The total extent of Atlantic salt meadow and associated transitional vegetation communities within the site is maintained; ii. The extent and distribution of the individual Atlantic salt meadow and associated transitional vegetation communities within the site is maintained; iii. the zonation of Atlantic salt meadow vegetation communities and their associated transitions to other estuary habitats is maintained; iv. the relative abundance of the typical species of the Atlantic salt meadow and associated transitional vegetation communities is maintained; v. the abundance of the notable species of the Atlantic salt meadow and associated transitional vegetation communities is maintained; vi. the structural variation of the salt marsh sward (resulting from grazing) is maintained within limits sufficient to satisfy the requirements of conditions iv and v above and the requirements of the Ramsar and SPA features; vii. the characteristic stepped morphology of the salt marshes and associated creeks, pills, drainage ditches and pans, and the estuarine processes that enable their development, is maintained. viii Any areas of *Spartina anglica* salt marsh are capable of developing naturally into other saltmarsh communities.
Reefs	i. The total extent and distribution of *Sabellaria* reef is maintained; ii. the community composition of the *Sabellaria* reef is maintained; iii. the full range of different age structures of *Sabellaria* reef are present; iv. the physical and ecological processes necessary to support *Sabellaria* reef are maintained.
River lamprey *Lampetra fluviatilis*	i. The migratory passage of both adult and juvenile river lamprey through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; ii the size of the river lamprey population in the Severn Estuary and the rivers which drain 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 river lamprey's food resource within the estuary is maintained. vi. Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.

Feature to maintain in favourable condition	Targets
Sea lamprey *Petromyzon marinus*	i. The migratory passage of both adult and juvenile sea lamprey through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; ii. the size of the sea lamprey population in the Severn Estuary and the rivers which drain into it, is at least maintained as is at a level that is sustainable in the long term; iii. the abundance of prey species forming the sea lamprey's food resource within the estuary is maintained. vi. Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.
Twaite shad *Alosa fallax*	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.
Assemblage of migratory fish species (Ramsar & SAC estuaries sub-feature)*	i. The migratory passage of both adults and juveniles 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 populations of the assemblage species 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 principle food resources for the assemblage species 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.
Allis shad *Alosa alosa* (Ramsar & SAC estuaries sub-feature)*	i. The migratory passage of both adult and juvenile allis 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 allis 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 allis 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.

Feature to maintain in favourable condition	Targets
European eel *Anguilla Anguilla* (Ramsar & SAC estuaries sub-feature)*	i. The migratory passage of both adult and juvenile eel through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; ii. the size of the eel population in the Severn Estuary and the rivers which drain into it, is at least maintained as is at a level that is sustainable in the long term; iii. the abundance of prey species forming the eel's food resource within the estuary is maintained. vi. Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.
Sea trout *Salmo trutta* (Ramsar & SAC estuaries sub-feature)*	i. The migratory passage of both adult and juvenile sea trout through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; ii. the size of the sea trout population in the Severn Estuary and the rivers which drain into it, is at least maintained as is at a level that is sustainable in the long term; iii. the abundance of prey species forming the sea lamprey's food resource within the estuary is maintained. vi. Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.
Atlantic salmon *Salmo salar* (Ramsar & SAC estuaries sub-feature)*	i. The migratory passage of both adult and juvenile Atlantic salmon through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by physical barriers, changes in flows, or poor water quality; ii. the size of the Atlantic salmon population in the Severn Estuary and the rivers which drain into it, is at least maintained as is at a level that is sustainable in the long term; iii. the abundance of prey species forming the Atlantic salmon's food resource within the estuary is maintained. vi. Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.

* Note: Although officially conservation objectives do not exist for the Ramsar fish features we have given them objectives based on a reflection of the SAC conservation objectives for the migratory fish.

Conservation objectives for the Severn Estuary / Môr Hafren SPA* and Ramsar

Feature to maintain in favourable condition	Targets
	The conservation objectives for the features listed below are to maintain them in favourable condition, as defined below: The feature will be considered to be in favourable condition when, subject to natural processes, each of the following conditions are met:
Internationally important population of regularly occurring Annex 1 species: Bewick's swan *Cygnus columbianus bewickii*	i. The 5 year peak mean population size for the Bewick's swan population is no less than 289 individuals (ie the 5 year peak mean between 1988/9 - 1992/3); ii. the extent of saltmarsh at the Dumbles is maintained; iii. the extent of inter-tidal mudflats and sandflats at Frampton Sands, Waveridge Sands and the Noose is maintained; iv. the extent of vegetation with an effective field size of >6 ha and with unrestricted bird sightlines > 500m at feeding, roosting and refuge sites are maintained; v. greater than 25% cover of suitable soft leaved herbs and grasses in winter season throughout the transitional saltmarsh at the Dumbles is maintained; vi. aggregations of Bewick's swan at feeding, roosting and refuge sites are not subject to significant disturbance.
Internationally important population of regularly occurring migratory species: wintering European white-fronted goose *Anser albifrons albifrons*	i. The 5 year peak mean population size for the wintering European white fronted goose population is no less than 3,002 individuals (ie the 5 year peak mean between 1988/9- 1992/3); ii. the extent of saltmarsh at the Dumbles is maintained; iii. the extent of inter-tidal mudflats and sandflats at Frampton Sands, Waveridge Sands and the Noose is maintained; iv. greater than 25% cover of suitable soft-leaved herbs and grasses is maintained during the winter on saltmarsh areas; v. unrestricted bird sightlines of >200m at feeding and roosting sites are maintained; vi. aggregations of European white-fronted goose at feeding or roosting sites are not subject to significant disturbance.
Internationally important population of regularly occurring migratory species: wintering dunlin *Calidris alpina alpina*	i. The 5 year peak mean population size for the wintering dunlin population is no less than 41,683 individuals (ie the 5 year peak mean between 1988/9 - 1992/3); ii. the extent of saltmarsh is maintained; iii. the extent of inter-tidal mudflats and sandflats is maintained; iv. the extent of hard substrate habitats is maintained; v. the extent of vegetation with a sward height of <10cm is maintained throughout the saltmarsh; vi. the abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained; vii. the abundance and macro-distribution of suitable invertebrates in hard substrate habitats is maintained;

Feature to maintain in favourable condition	Targets
	viii. unrestricted bird sightlines of >200m at feeding and roosting sites are maintained; ix. aggregations of dunlin at feeding or roosting sites are not subject to significant disturbance.
Internationally important population of regularly occurring migratory species: wintering redshank *Tringa totanus*	i. The 5 year peak mean population size for the wintering redshank population is no less than 2,013 individuals (ie the 5 year peak mean between 1988/9 - 1992/3); ii. the extent of saltmarsh and associated strandlines is maintained; iii. the extent of inter-tidal mudflats and sandflats is maintained; iv. the extent of hard substrate habitats is maintained; v. the extent of vegetation with a sward height of <10cm throughout the saltmarsh is maintained; vi. the abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained; vii. the abundance and macro-distribution of suitable invertebrates in hard substrate habitats is maintained; viii. unrestricted bird sightlines of >200m at feeding and roosting sites are maintained; ix. aggregations of redshank at feeding or roosting sites are not subject to significant disturbance.
Internationally important population of regularly occurring migratory species: wintering shelduck *Tadorna tadorna*	i. The 5 year peak mean population size for the wintering shelduck population is no less than 2,892 individuals (ie the 5 year peak mean between 1988/9 - 1992/3); ii. the extent of saltmarsh is maintained; iii. the extent of intertidal mudflats and sandflats is maintained; iv. the extent of hard substrate habitats is maintained; v. the abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained; vi. unrestricted bird sightlines of >200m at feeding and roosting sites are maintained; vii. aggregations of shelduck at feeding or roosting sites are not subject to significant disturbance.
Internationally important population of regularly occurring migratory species: gadwall *Anas strepera*	i. The 5 year peak mean population size for the wintering gadwall population is no less than 330 (i.e. the 5 year peak mean between 1988/9 – 1992/3); ii. the extent of inter-tidal mudflats and sandflats is maintained; iii. unrestricted bird sightlines of >200m at feeding and roosting sites are maintained; iv. aggregations of gadwall at feeding or roosting sites are not subject to significant disturbance.

Feature to maintain in favourable condition	Targets
Internationally important population of regularly occurring migratory species: **From the SPA review** Ringed plover, curlew, pintail	i. Wintering populations are maintained (5 year peak mean) ii. the extent of saltmarsh is maintained; iii. the extent of inter-tidal mudflats and sandflats is maintained; iv. the extent of hard substrate habitats is maintained; v. the abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained; vi. unrestricted bird sightlines of >200m at feeding and roosting sites are maintained; vii. aggregations of birds at feeding or roosting sites are not subject to significant disturbance.
Internationally important assemblage of waterfowl	i. the 5 year peak mean population size for the waterfowl assemblage is no less than 68,026 individuals (ie the 5 year peak mean between 1988/9 - 1992/3); ii. the extent of saltmarsh and their associated strandlines is maintained; iii. the extent of inter-tidal mudflats and sandflats is maintained; iv. the extent of hard substrate habitats is maintained; v. extent of vegetation of <10cm throughout the saltmarsh is maintained; vi. the abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained; vii. the abundance and macro-distribution of suitable invertebrates in hard substrate habitats is maintained; viii. greater than 25% cover of suitable soft leaved herbs and grasses during the winter on saltmarsh areas is maintained; ix. unrestricted bird sightlines of >500m at feeding and roosting sites are maintained; x. waterfowl aggregations at feeding or roosting sites are not subject to significant disturbance.

*** SPA population**

Natural England & Countryside Council for Wales' advice on the conservation objectives for the Severn Estuary SPA and Ramsar birds (2009)[14] uses 5 year peak mean population sizes for dates between 1988/9 and 1992/3. Since the report was published, more up-to-date WeBS counts have been available that include both the SPA and Ramsar review population estimates. Where up-to-date WeBS count data has been available, they have been used within the report and will be referenced.

[14] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

Conservation objectives for the Exmoor and Quantock Oakwoods SAC

Feature to maintain in favourable condition	Targets
	The conservation objectives for the features listed below are to maintain them in favourable condition, as defined below: The feature will be considered to be in favourable condition when, subject to natural processes, each of the following conditions are met:
Old Sessile Oak Woods	i. No loss of ancient semi-natural stands. At least current area of recent semi-natural stands maintained, although their location may alter. At least the area of ancient woodland retained. ii. At least the current level of structural diversity maintained. Understorey (2-5m) present over at least 10% of total stand area. Ground flora present over at least 50% of area. Canopy cover present over 30-90 % of stand area. All age classes present but not necessarily in an heterogeneous mix. Minimum 3 fallen lying trees >20 cm diameter. per ha and 4 trees per ha allowed to die standing. iii. Signs of seedlings growing through to saplings to young trees at sufficient density to maintain canopy density over a 10 yr period (or equivalent re-growth from coppice stumps). No planting in sites where it has not occurred in the last 15 years. iv. At least the current level of site-native species maintained. At least 90% of cover in any one layer of site-native or acceptable naturalised species. V. Oak present and providing at least 30% cover in the canopy of mature stands over feature as a whole Death, destruction or replacement of native woodland species through effects of introduced fauna or other external unnatural factors not more than 10% by number or area in a five year period. vi. 80% of ground flora cover referable to relevant NVC community (W10, W11, W16, W17). Distinctive elements maintained at current levels and in current locations (where appropriate). Patches and transitions maintained in extent and where appropriate location. vii. Epiphytic lichen communities are sensitive to enrichment and acidification from atmospheric deposition; no proscribed air quality standards can be set at this stage but objectives will need to reflect this sensitivity. Species indicative of nutrient enrichment are restricted to appropriate locations. These species are not increasing in abundance.

Feature to maintain in favourable condition	Targets
Alluvial Forests	i. No loss of ancient semi-natural stands. At least current area of recent semi-natural stands maintained, although their location may alter (see baseline map). At least the area of ancient woodland retained. ii. At least the current level of structural diversity maintained (see baseline map). Understorey (2-5m) present over at least 20% of total stand area. Ground flora present over at least 50% of area excluding temporary pool areas. Canopy cover present over 30-90 % of stand area. Age class structure appropriate to the site, its history and management. A minimum of 3 fallen lying trees or major branches per ha and 4 trees per ha allowed to die standing. At least the current level of natural hydrological features should be maintained (channels, pools, periodic flooding). iii. Signs of seedlings growing through to saplings to young trees at sufficient density to maintain canopy density over a 10 yr period (or equivalent re-growth from coppice stumps). No planting in stands where it has not occurred in the last 15 years. iv. At least the current level of site-native species maintained (see baseline map). At least 90% of cover in any one layer of site-native or acceptable naturalised species. v. Death, destruction or replacement of native woodland species through effects of introduced fauna or other external unnatural factors not more than 10% by number or area in a five year period. vi. 80% of ground flora cover referable to relevant NVC wet woodland community (W 7). Distinctive elements maintained at current levels and in current locations (where appropriate). Patches and transitions maintained in extent and where appropriate location.
Otter *Lutra lutra*	i. Water quality should be good, with no pollution incidents. ii. No reduction in water flow attributable to increased abstraction. No reduction of fragmentation of area. iii. Fish stocks appropriate to the nutrient status of the river. No significant decline in fish biomass or species diversity. iv. No significant change to river or bankside usage; no significant development. No permanent decrease in bankside cover. v. Signs of otters found at least once per year.
Barbastelle bat *Barbastella barbastellus* and Bechsteins bat *Myotis bechsteinii*	i. Conservation of Barbastelle within the SAC will not be achieved without conservation of habitats in the surrounding landscape, as summer foraging ranged up to 9km from roost locations. Over 90% of foraging appears to occur outside the SAC along linear wooded/scrub strips including along watercourses, overgrown hedgerows, uncut grassland, heather moorland edge (within Exmoor Heath SAC), gardens and areas of low level street lighting.

1.6 In combination assessment

Regulation 61 of the Conservation of Habitats and Species Regulations 2010 requires the competent authority to consider within the appropriate assessment, any permission, plans or projects (including EA permissions and plans/projects) which are likely to have a significant effect on a European site, either alone or in combination with other permissions, plans or projects. Here permissions indicate a likely significant effect these will be assessed in combination with each other and with other relevant plans and projects, which will be discussed further in section 6.

The assessment of in combination occurs twice within our HRA process, once at Stage 2 and then again at Stage 3. At each step we exclude de-minimus effects and exclude effects where no pathway exists by which protected features could be affected. At each step we will clarify which emissions or possible effects will no longer be included in the in combination assessments.

1.7 Consultation on the HRA

Under Regulation 61(3) of the Habitats Regulations, the competent authority must for the purposes of the appropriate assessment consult the appropriate nature conservation body and have regard to any representations made by that body within such reasonable time as the authority specify. In this case both Natural England (NE) and the Countryside Council for Wales (CCW) will be consulted due to the European sites in question being within both England and Wales.

Please note: throughout this document when we make reference to the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar, unless specified we will shorten the name to just Severn Estuary for ease of reading and writing.

2. Environmental Permits for Water Discharge Activities

2.1 Introduction

For the purposes of our assessment this section will consider the potential impacts from the following activities:

2.1.1 Construction Phase Discharges

- Surface water run-off;
- De-watered groundwater;
- Sewage effluent;
- Concrete washwater; and
- Wastewater arising from the drilling of the cooling water intake and outfall tunnels.

The construction phase of Hinkley Point C will require the management of large volumes of surface water run-off, dewatered groundwater, sewage arising from the on-site welfare facilities, concrete washwater and wastewater arising from the drilling of the cooling water intake and outfall tunnels.

Surface water run-off and dewatered groundwater will be collected and treated in a number of water management zones (WMZ) prior to being discharged to (a) the Hinkley Point C drainage ditch, (b) the Severn Estuary via a new foreshore outfall and (c) to the Holford Stream.

With regard to surface water run-off arising from construction of the sea wall this assessment has been based on a worst case scenario where no positive drainage measures are used, with run-off draining directly onto the foreshore. This said an e-mail for EDF on 26 March 2012 stated that" The only discharge that is envisaged from the seawall is sediment run-off during the preparation of the cliff and construction of the wall. During this time we could capture any sediment containing run-off in a sump and pump to one of existing, permitted water management zone where it would be included in the surface water run-off permit requirements for that Water Management Zone. Therefore, the true impact is likely to be less than that assessed.

Sewage (grey and black wastewater) will be managed in several ways. During initial site preparation, sewage will be collected and tankered away for off-site treatment and disposal. During the main construction phase, initial plan was for sewage from the on-site workers accommodation building to be treated and discharged to the Holford Stream. This appropriate assessment has been carried out on that basis. However, an e-mail subsequently received from the Applicant indicates that all plant sewage **may** be treated via temporary package plants with the resultant effluent being discharged via an outfall on to the foreshore. Therefore, the assessment has been based on a worst case scenario where the sewage effluent is discharged temporarily to the Holfod Steam. It was always planned for the remainder of the on-site sewage to be treated via temporary package plants and discharged via the new outfall to the foreshore.

Concrete washwater will be treated using a Siltbuster unit and discharged via a WMZ, initially to the Hinkley Point C drainage ditch, and then once the deep drains are in place, to the Severn Estuary via the new outfall.

Wastewater arising during drilling of the cooling water intake and outfall tunnels could arise in a number of ways:

(a) water and additives used at the drill head of the tunnel boring machine (TBM);
(b) infiltration / seepage of seawater into the tunnels during normal drilling operations; and
(c) inundation of the tunnels with seawater in an emergency, for example, hitting a major fault line.

Drilling will require the use of a water and bentonite slurry at the drill head. Drilling waste could include the release of drilling compounds such as bentonite and other chemicals (e.g. organic polymer and residual salt compounds from the use of hydrochloric acid). Bentonite will be recovered for reuse where possible.

It is understood that the fish recovery and return outfall tunnel will be drilled using micro-tunnelling techniques. Discharges of similar quality wastewater may occur.

Construction phase discharges and the potential contaminants are described below:

Surface water run-off

- Suspended solids, primarily from soils washed into the drainage system
- Oils and hydrocarbons, from heavy plant and other machinery and general site traffic
- pH alteration of the water, due to (a) the generation of ARD (acid rock drainage) from the stockpiling of earth and rock and (b) concrete leachate
- Phosphorus and nitrate, present in the soil due to the sites former agricultural use.

Dewatered groundwater

- Suspended solids, naturally present in the groundwater and from material blown into or present in the treatment lagoons
- Non-radiological substances present in the groundwater, for example, heavy metals.

Sewage effluent

- Suspended solids, ammonia, nitrate and phosphate

Concrete washwater

- High suspended solids
- High pH (typically 11-12) due to calcium hydroxide (derived from the cement)
- Other trace materials, some originating from cement, others from additives or from the mixing equipment.

Since all the discharges above are of fresh water and effluent, their impact on the marine coastal habitats and species fronting the Hinkley Point C site will need to be assessed.

Tunnelling waters

- Typical constituents could include suspended solids, oils / hydrocarbons, bentonite and other chemical additives. The salinity of the tunnelling waters is at this stage unknown.

2.1 2 Commissioning Phase Discharges

- The discharge of effluents arising from various commissioning tests

The commissioning phase of Hinkley Point C will generate discharges associated with testing various systems. Commissioning activities resulting in discharges are described briefly below:

Production of demineralised water - the effluent from the production process will primarily contain sulphates and sodium, introduced as sulphuric acid and sodium hydroxide respectively, to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit. It will also include trace metals such as cadmium and mercury, present in bulk raw materials; detergents; suspended solids; iron; chlorides; and sequestering agents used to prevent the build-up of mineral deposits within the system.

Pre-operational testing using demineralised water with or without the addition of conditioning agents to control pH therefore minimising corrosion. Specific activities include hydraulic testing, gravity and dynamic flushing and treatment with a water lance. Discharges will contain suspended solids, iron oxide (rust) and small quantities of conditioning agents e.g. ammonia, ethanolamine, morpholine and hydrazine.

Testing the primary circuits associated with the reactor, using demineralised water with or without the addition of morpholine and other chemical reagents. Specific activities include:

(a) vessel flushing and cold testing; and hydraulic testing of the nuclear steam system. These tests will use demineralised water only, so the effluent is purely demineralised water.

(b) hot testing using demineralised water with morpholine and chemical reagents. The effluent will contain morpholine, hydrazine, lithium hydroxide and boron.

Testing the secondary circuits associated with the steam system using demineralised water with the addition of morpholine**.** Specifically this relates to the hydraulic testing of the shell side of the steam generator assembly. The effluent will contain suspended solids and morpholine.

Testing the cooling water system, where specific activities include conditioning the auxiliary circuits using demineralised water conditioned with phosphate. The effluent will contain phosphate and suspended solids.

Although not stated it has been assumed that all of the commissioning tests will result in the discharge of suspended material either present as a result of the construction process or washed off the various surfaces during cleansing and testing.

At the time of writing our understanding is that discharges arising during the commissioning phase will be to the Bristol Channel, as follows:

(a) cold commissioning effluent will be discharged via the new foreshore outfall to the Severn Estuary. This is because at this stage the cooling water pumps will not have been commissioned and therefore the main cooling water outfall will not be available for discharge.

This so called “cold flush testing” phase will result in discharges containing suspended solids, iron oxide, and small quantities of conditioning agents, e.g. ammonia, ethanolamine, morpholine, and hydrazine. Other residues from the installation process cannot be ruled out but we have no further information on this.

(b) hot commissioning effluent will be discharged via the main cooling water tunnel to the Severn Estuary. This so called “hot functional testing” will be undertaken prior to fuelling of the reactor. The main cooling water pumps will have been commissioned and therefore the outfall tunnel will be available for discharge.

2.1.3 Operational Phase Discharges

- The abstraction of seawater for direct (or once-through) cooling; and
- the discharge of cooling water, the discharge from the fish recovery and return (FRR) system, and process effluent from various plant systems.

Cooling water will be discharged through two diffuser heads at the end of a single 1.8km long tunnel (see figure 5), at a depth of approximately 10m below ODN (Ordnance Datum Newlyn). These two structures, which will be aligned in series offshore, will each discharge a proportion of the outgoing cooling water, directing this horizontally and offshore, at right angles to the prevailing tidal currents. These discharges will occur at approximately mid depth in the water column towards the time of low tide but in the lower third of the water column towards the time of high tide.

Each UK EPR will generate liquid effluents of two types, namely:

- radioactive liquid effluent associated with the reactor coolant. The radioactivity of this effluent is dealt with in section 4 but the effluent will also contain chemicals and metals, e.g. corrosion products, circuit conditioners, that need to be considered here; and
- non-radioactive liquid effluent coming from conventional parts of the plant such as the demineralisation plant, turbine hall drains and the site sewage treatment facilities. The cooling water itself (which may be dosed with biocide to inhibit biofouling) is also included here as an effluent stream.

It is proposed to discharge the various process effluents into the main cooling water flow, prior to discharge to the Bristol Channel. The outlet is located approximately 1.8km offshore. This provides a significant initial dilution of chemicals before they reach the environment.

The UK EPR at Hinkley Point C will incorporate a fish recovery and return (FRR) system to (a) minimise the risk of injury of fish that are drawn into the cooling water system and (b) return them to the source water at a point where they are not likely to be returned to the intake. Our current understanding of the proposed design , based on the information submitted from the applicant, is that fish will be returned via a separate outfall to below mean low water.

As before, we have split up the overall operational discharge into its contributory process streams. These are described below with the contaminants arising in each:

Primary circuit

- Boron, from boric acid added to the primary coolant as a neutron absorber;
- Lithium hydroxide, added to the coolant to offset the acidity of the boric acid, to keep the pH slightly alkaline and to prevent equipment corrosion;
- Metals will arise from corrosion and erosion in the circuits where coolant and other process waters contact equipment, Metals used in the UK EPR equipment include aluminium (Al), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn);
- Trisodium phosphate, added to the cooling and the heating circuits to inhibit corrosion in circuits in contact with air;
- COD (Chemical Oxygen Demand), from the organic compounds, particularly detergents used in the laundry and also from oxidisable mineral salts in the water to be used;
- Suspended solids, largely arising from collected effluent that may be polluted by dust;
- Trace metals present in bulk raw materials, typically cadmium, mercury, arsenic and silver which could arise in trace amounts from corrosion of control rods.

Secondary circuit

- Hydrazine, used as an oxygen scavenger in the feedwater;
- Ammonia, morpholine and ethanolamine, to adjust pH of secondary circuit water to minimise corrosion;
- Acetates, formats, glycolates and oxalates, as a result of thermal decomposition of morpholine and ethanolamine;
- Nitrogen;
- Nitrate and nitrite;
- Phosphate;
- Metals will arise from corrosion and erosion in the circuits where coolant and other process waters contacts equipment. Metals used in the UK EPR equipment include aluminium (Al), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn);
- Trisodium phosphate, added to the cooling and the heating circuits to inhibit corrosion in circuits in contact with air;
- COD (Chemical Oxygen Demand), from the organic compounds from oxidisable mineral salts in the water to be used;
- Suspended solids, largely arising from collected effluent that may be polluted either by dust or raw water used auxiliary installations in the secondary circuit;

Cooling water circuit

- Temperature (increased), from the removal of waste heat from the condenser
- TRO (total residual oxidant), as a result of adding biocide in the from of sodium hypochlorite to the incoming cooling water
- CBPs (chlorination by-products), from the reaction of residual oxidants with seawater

Demineralisation plant

- Iron, predominantly introduced as ferric chloride into the demineralisation plant;
- Suspended solids, present in the slurry and filter backwashings from the demineralisation plant;
- Sulphates, introduced as sulphuric acid to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit.
- Sodium, introduced as sodium hydroxide to (a) clean the resins and membranes within the demineralisation plant; and (b) treat effluent within the neutralisation pit.
- Chlorides, introduced as ferric chloride or sodium hypochlorite in the demineralisation plant;
- Trace metal contamination of raw materials such as sodium hydroxide and sulphuric acid used in the demineralisation process. Contamination usually includes cadmium and mercury.

- Detergents
- Sequestering agents

Sewage treatment plant

Typically, sewage effluent contains:

- Suspended solids
- Ammonia
- Nitrate
- Phosphate

and one of the resulting detrimental effects is increased BOD (Biochemical Oxygen Demand)

Drainage from turbine hall, transformer area, oil and grease store, and storage areas that may be contaminated with hydrocarbons

- Oils
- Hydrocarbons
- Suspended solids

2.1.4 Abstraction

While the Environment Agency does not require the cooling water abstraction to be licensed, the abstraction is linked to the discharge in that it is part of the same overall process stream. We will assess the impacts arising through the abstraction of cooling water in the context of whether the system of direct cooling represents BAT (Best Available Techniques) as set out in the EU's 2001 BREF on industrial cooling systems[15].

Our recent report on cooling water options for new nuclear build[16] indicates that direct cooling can be BAT for estuarine and coastal sites, provided that (a) best practice in planning, design, mitigation and compensation is followed and (b) any residual impacts are not deemed to be unacceptable. This therefore is our basis for assessing potential impacts from the cooling water system in its entirety.

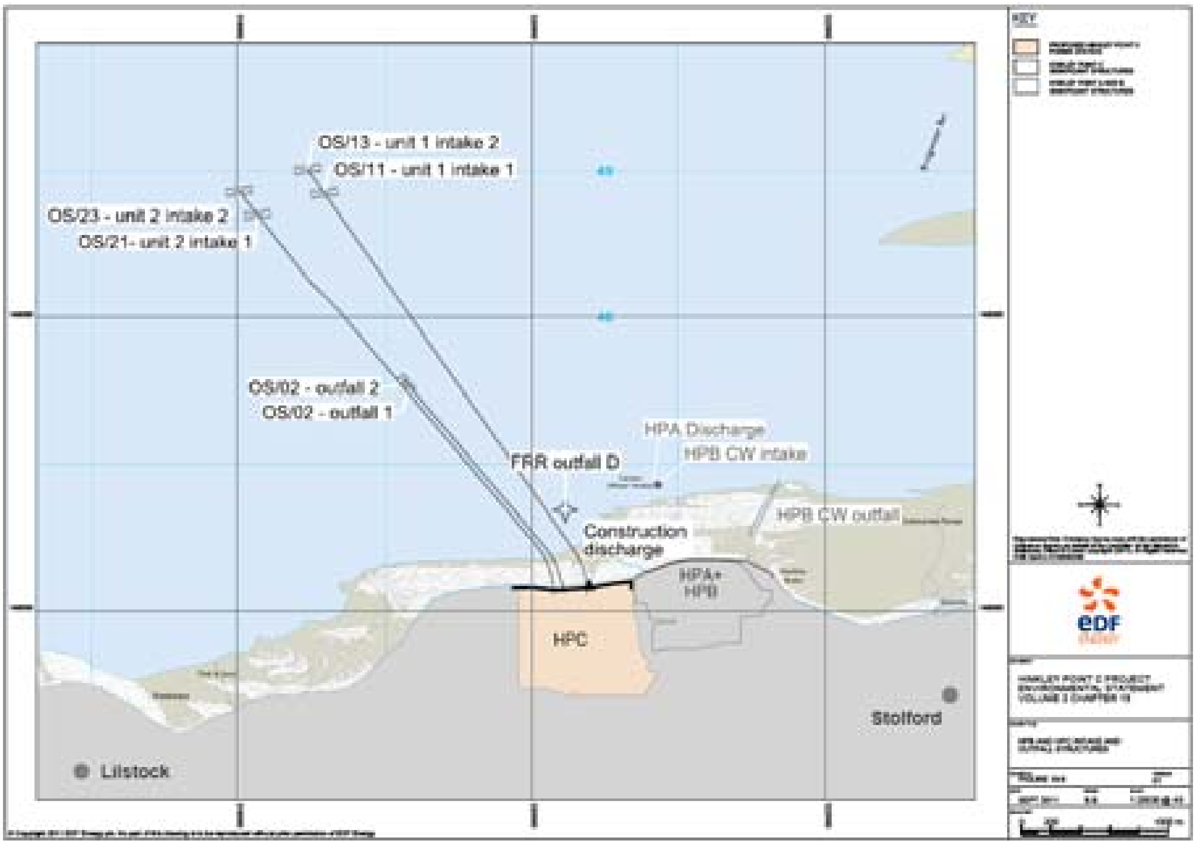
Regardless of whether or not an abstraction licence is required for direct cooling, operators and developers are required to develop mitigation measures and monitoring programmes to ensure that conservation objectives of Natura 2000 sites are not jeopardized.

Each UK EPR reactor unit will have a dedicated cooling water intake tunnel approximately 3.4 and 3.5km in length (see figure 2.1.4.1 below.) There will be two intake heads on each tunnel, located 100m apart, and sitting just above the sea bed. The two intakes on each tunnel will provide for a flow of 67m3/s per reactor unit, resulting in a maximum cooling water flow of $134m^3/s$ for the whole power station.

[15] BREF/IPPC, 2000. EC Joint Research Centre reference document on the application of Best Available Techniques to industrial cooling systems, Seville. Available from http://eippcb.irc.es

[16] Cooling water options for the new generation of nuclear power stations in the UK. Environment Agency June 2010. SC070015/SR3.

Figure 2.1.4.1. HPC cooling water intake and outfall locations (Map courtesy of EDF)[17].



The abstraction of seawater from the Bristol Channel means that organisms present in the water will be drawn into the water intakes, which will be located offshore. These organisms can include anything from planktonic bacteria and algae to macro-invertebrates and fish. The following definitions are commonly used to describe the mechanism by which organisms may be drawn into the cooling water system:

- Entrapment - inadvertent entry into the cooling water system of aquatic organisms caused by the ingress of water;

- Impingement - retention of entrapped organisms on cooling water intake screens employed to prevent debris entering the cooling water heat exchangers; and

- Entrainment - passage of entrapped organisms that penetrate cooling water screens, via the pumps, heat exchangers and other components of the cooling water circuit and back to the receiving water.

A number of methods are available to reduce the risk of fish entering the cooling water system. Passive deflection focuses primarily on controlling the approach velocities around the intake head, to keep velocities low enough to avoid fish being drawn in. Active deflection includes techniques such as air bubble curtains, acoustic deterrents and strobe lights.

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[17] EDF. (2011). Hinkley Point C Environmental Statement: Chapter 19 Marine Ecology.. Doc. Ref: 4.3. October 2011. Figure 19.6.

In the case for HPC, the intake ports will be designed to lie parallel to the tidal flow, and thus will not face into that tidal flow at any time but will abstract water at right angles from the tidal stream as it passes along the full length of both sides of that structure, creating a ‘passive’ intake of water. From a design perspective, this intake design together with the arrangement of internal baffle walls and hydraulic guides, has been demonstrated by numerical modelling simulations to achieve a mean intake velocity of 0.3m/s.

A behavioural cue which will provoke an avoidance reaction amongst certain groups of fish would be provided by use of acoustic fish deterrent systems (AFDs).

2.2 Generic sensitivities

The only Natura 2000 sites to be directly included within the water abstraction and discharge assessments are the Severn Estuary/Môr Hafren SAC, SPA and Ramsar sites respectively, as per the criteria set out in section 1.3 of this document.

2.2.1 Discharges matrix

Our assessment of discharges to surface water is based on the water quality generic sensitivities for the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar sites, as shown in Table 2.2.1.1 below.

Table 2.2.1.1. - Generic sensitivity matrix for the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar sites in relation to water quality.

Hazard	Habitat Group		Species Group	Bird Species Group		
	Estuarine and intertidal habitats (1.12)	Submerged marine habitats (1.13)	Migratory fish (2.5) & fish assemblage	Birds of lowland freshwaters and their margins (3.6)	Birds of coastal habitats (3.8)	Birds of estuarine habitats (3.9)
Toxic contamination	✔	✔	✔	✔	✔	✔
Non-toxic contamination (nutrient enrich. & organic loading	✔	✔	✔	✔	✔	✔
pH			✔	✔		
Salinity	✔	✔	✔	✔	✔	✔
Changes in thermal regime	✔	✔	✔	✔	✔	✔
Turbidity	✔	✔	✔	✔	✔	✔
Siltation	✔	✔	✔	✔	✔	✔
Physical damage	✔	✔	✔	✔	✔	✔
Competition non-native species	✔	✔	✔			

✔ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

2.2.2 Abstraction matrix

Our assessment of the cooling water abstraction is based on the water resources generic sensitivities for the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar sites, as shown in Table 2.2.2.1 below.

Table 2.2.2.1. Generic sensitivity matrix for the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar sites in relation to water resources

Hazard	Habitat Group		Species Group	Bird Species Group		
	Estuarine and intertidal habitats (1.12)	Submerged marine habitats (1.13)	Migratory fish (2.5) & fish assemblage	Birds of lowland freshwaters and their margins (3.6)	Birds of coastal habitats (3.8)	Birds of estuarine habitats (3.9)
Change in water level or table (groundwater only)	✔		✔	✔	✔	✔
Change in flow or velocity regime	✔	✔	✔	✔	✔	✔
Change in surface flooding				✔	✔	✔
Changes in water chemistry	✔	✔	✔	✔	✔	✔
Change in freshwater flow to estuary	✔		✔	✔	✔	✔
Change in salinity regime	✔	✔	✔		✔	✔
Reduced dilution capacity	✔	✔	✔	✔	✔	✔
Habitat loss	✔		✔	✔	✔	✔
Physical damage (Entrapment)	✔	✔	✔			

✔ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

Note: These matrices are not comprehensive and are based on the judgment of staff in the Environment Agency, NE and CCW. There may be other hazards and sensitivities, which will vary according to circumstances.

Potential hazards from activity (contaminants & hazards matrix)

2.3.1 Construction phase contaminants matrix

The table below shows the mechanism by which the contaminants present in the construction phase discharges could impact upon designated habitats.

Table 2.3.1.1. Contaminants and hazards matrix for Hinkley Point C construction phase

CONTAMINANTS	**HAZARD**									
	Toxic contamination (synthetic)	**Toxic contamination (non-synthetic)**	**Nutrient enrichment**	**pH**	**Salinity**	**Changes in thermal regime**	**Turbidity**	**Siltation**	**Physical damage**	**Organic enrichment**
SURFACE WATER RUN-OFF										
Suspended solids							✓	✓		
Oils	✓	✓								
Hydrocarbons	✓	✓								
Freshwater					✓				✓	
pH				✓						
Phosphorus			✓							
Nitrate			✓							
DEWATERED GROUNDWATER										
Suspended solids							✓	✓		
Freshwater					✓				✓	
Heavy metals		✓								
ON-SITE SEWAGE EFFLUENT										
BOD										✓
Suspended solids							✓	✓		
Ammonia		✓								
Nitrate			✓							
Phosphate			✓							
Freshwater					✓				✓	
CONCRETE WASHWATER										
Suspended solids							✓	✓		
pH				✓						
Other trace elements / chemical additives	✓	✓					✓	✓		✓
Freshwater					✓				✓	

Table 2.3.1.1. Contaminants and hazards matrix for Hinkley Point C construction phase (continued)

CONTAMINANTS	**HAZARD**									
	Toxic contamination (synthetic)	**Toxic contamination (non-synthetic)**	**Nutrient enrichment**	**pH**	**Salinity**	**Changes in thermal regime**	**Turbidity**	**Siltation**	**Physical damage**	**Organic enrichment**
TUNNELLING WASTEWATER										
Suspended solids							✓	✓		
Oils	✓	✓								
Hydrocarbons	✓	✓								
Bentonite							✓	✓		
Other chemical additives	✓	✓					✓	✓		✓
Freshwater					✓				✓	

2.3.2 Commissioning phase contaminants matrix

The table below shows the mechanism by which the contaminants present in the commissioning phase discharges could impact upon designated habitats.

Table 2.3.2.1. Contaminants and hazards matrix for Hinkley Point C commissioning phase

CONTAMINANTS	**HAZARD**									
	Toxic contamination (synthetic)	**Toxic contamination (non-synthetic)**	**Nutrient enrichment**	**pH**	**Salinity**	**Changes in thermal regime**	**Turbidity**	**Siltation**	**Physical damage**	**Organic enrichment**
DEMINERALISED WATER PRODUCTION										
Iron		✓								
Suspended solids							✓	✓		
Sulphates		✓								
Sodium		✓								
Chlorides		✓								
Trace metals (Cd, Hg)		✓								
Detergents	✓									✓
Sequestering agents	✓									

Table 2.3.2.1. Contaminants and hazards matrix for Hinkley Point C commissioning phase (continued)

CONTAMINANTS	HAZARD									
	Toxic contamination (synthetic)	Toxic contamination (non-synthetic)	Nutrient enrichment	pH	Salinity	Changes in thermal regime	Turbidity	Siltation	Physical damage	Organic enrichment
PRE-OPERATIONAL TESTING										
Morpholine	✓									
Ethanolamine	✓									
Hydrazine	✓									
Suspended solids	✓	✓					✓	✓		
Iron		✓								
Other metals (Al, Cu, Cr, Mn, Pb, Ni, Zn) – dissolved & particulate		✓								
TESTING THE PRIMARY CIRCUIT										
Morpholine	✓									
Suspended solids	✓	✓					✓	✓		
Hydrazine	✓									
Lithium hydroxide	✓									
Boron (boric acid)		✓								
Temperature						✓				
TESTING THE SECONDARY CIRCUIT										
Morpholine	✓									
Suspended solids	✓	✓					✓	✓		
Temperature						✓				
TESTING THE COOLING WATER CIRCUIT										
Suspended solids							✓	✓		
Phosphate			✓							
Chlorides			✓							
Temperature						✓				

2.3.3 Operational phase contaminants matrix

The table below shows the mechanism by which the contaminants present in the operational phase discharges could impact upon designated habitats.

Table 2.3.3.1. Contaminants and hazards matrix for Hinkley Point C operational phase

CONTAMINANT	**HAZARD**									
	Toxic contamination (synthetic)	**Toxic contamination (non-synthetic)**	**Nutrient enrichment**	**pH**	**Salinity**	**Changes in thermal regime**	**Turbidity**	**Siltation**	**Physical damage**	**Organic enrichment**
PRIMARY CIRCUIT										
Boron (boric acid)		✓		✓						
Lithium hydroxide		✓		✓						
Metals (Al, Cu, Cr, Fe, Mn, Pb, Ni, Zn)		✓								
Trisodium phosphate			✓							
COD										✓
Detergents	✓									✓
Suspended solids							✓	✓		
Trace metals (Cd, Hg, As, Ag)		✓								
SECONDARY CIRCUIT										
Hydrazine	✓									
Ammonia	✓									
Morpholine	✓									
Ethanolamine	✓									
Acetates, formats, gylcolates, oxalates	✓									
Nitrate			✓							
Phosphate			✓							
Metals (Al, Cu, Cr, Fe, Mn, Pb, Ni, Zn)		✓								
Trisodium phosphate			✓							
COD										✓
Suspended solids							✓	✓		
COOLING WATER CIRCUIT										
Temperature						✓				
TRO	✓									
CBP's	✓									

Table 2.3.3.1. Contaminants and hazards matrix for Hinkley Point C operational phase (continuous)

CONTAMINANT	**HAZARD**									
	Toxic contamination (synthetic)	**Toxic contamination (non-synthetic)**	**Nutrient enrichment**	**pH**	**Salinity**	**Changes in thermal regime**	**Turbidity**	**Siltation**	**Physical damage**	**Organic enrichment**
DEMINERALISATION PLANT										
Iron		✓								
Suspended solids							✓	✓		
Sulphates		✓								
Sodium		✓								
Chlorides		✓								
Trace metals (Cd, Hg)		✓								
Detergents	✓									
Sequestering agents	✓									
SEWAGE TREATMENT PLANT										
BOD										✓
Suspended solids							✓	✓		
Ammonia		✓								
Nitrate			✓							
Phosphate			✓							
DRAINAGE FROM TURBINE HALL & OTHER PLANT										
Oils	✓	✓								
Hydrocarbons	✓	✓								
Suspended solids							✓	✓		
FISH RECOVERY & RETURN SYSTEM										
TRO	✓									
CBP's	✓									

2.4 Interest features sensitive to the hazard

Whilst the generic sensitivity matrices give us an idea of which features could be sensitive to the hazards, the species and habitats groups are very generalized and the hazards are based on a generic list.

In order to give us an understanding of specific sensitivities of the Severn Estuary designated features, the habitat and species groups have been expanded and hazards have been defined with relevance in the form of a potential exposure assessment. The results of this assessment have been tabulated and can be found in Appendix 1.

2.4.1 Construction phase discharge matrix

For the potential exposure Assessment for the Severn Estuary/Môr Hafren SAC/SPA/Ramsar for discharges during the **construction phase** the following species and habitats are to be assessed:

- *Estuaries*
- *Atlantic salt meadows/saltmarsh*
- *Intertidal mud and sand flats*
- *Subtidal sandbanks*
- *Reefs*
- *Migratory fish*
- *Fish assemblage*
- *Birds including: 4.2 Internationally important populations of regularly occurring migratory species*
- *Internationally important assemblage of waterfowl (>20,000) (under Article 4.2 of EU Birds Directive).*

Against the following hazards:

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Salinity*
- *Turbidity*
- *Siltation*
- *Physical Damage*
- *pH*

2.4.2 Commissioning phase discharge matrix

In order to give us an understanding of specific sensitivities of the Severn Estuary designated features, the habitat and species groups have been expanded and hazards have been defined with relevance in the form of a potential exposure assessment. The results of this assessment have been tabulated and can be found in Appendix 2.

For the potential exposure assessment for the Severn Estuary/Môr Hafren SAC/SPA/Ramsar for discharges during the **commissioning phase** the following species and habitats are to be assessed :

- *Estuaries*
- *Atlantic salt meadows /saltmarsh*
- *Intertidal mud and sand flats*
- *Subtidal sandbanks*
- *Reefs*
- *Migratory fish*
- *Fish assemblage*
- *Birds, including 4.2 Internationally important populations of regularly occurring migratory species and;*
- *Internationally important assemblage of waterfowl (>20,000) (under Article 4.2 of EU Birds Directive).*

Against the following hazards related to the **production of demineralised water**:

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Turbidity*
- *Siltation*

Against the following hazards related to **pre-operational testing:**

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Turbidity*
- *Siltation*

Against the following hazards related to the **primary circuit**, **secondary circuit** and **cooling water circuit**:

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Changes in thermal regime*
- *Turbidity*
- *Siltation*
- *pH*

2.4.3 Operational phase discharge matrix

In order to give us an understanding of specific sensitivities of the Severn Estuary designated features, the habitat and species groups have been expanded and hazards have been defined with relevance in the form of a potential exposure assessment. The results of this assessment have been tabulated and can be found in Appendix 3.

For the potential exposure assessment for the Severn Estuary/Môr Hafren SAC/SPA/Ramsar for discharges during the **operational phase** the following species and habitats are to be assessed:

- *Estuaries*
- *Atlantic salt meadows /saltmarsh*
- *Intertidal mud and sand flats*
- *Subtidal sandbanks*
- *Reefs*
- *Migratory fish*
- *Fish assemblage*
- *Birds, including 4.2 Internationally important populations of regularly occurring migratory species and;*
- *Internationally important assemblage of waterfowl (>20,000) (under Article 4.2 of EU Birds Directive).*

Against the following hazards related to the **primary circuit**:

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Turbidity*
- *Siltation*
- *pH*

Secondary circuit and Sewage Treatment Works:

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Turbidity*
- *Siltation*

Production of demineralised water:

- *Toxic Contamination (synthetic & non-synthetic compounds)*
- *Turbidity*
- *Siltation*

Non-nuclear plant drainage and site drainage:

- *Non-toxic contamination (nutrient enrich. & organic loading)*
- *Turbidity*
- *Siltation*

Discharge of Cooling water :

- *Toxic Contamination (synthetic compounds)*
- *Changes in thermal regime*
- *Physical damage*
- *Competition from non-native species*

2.4.4 Abstraction matrix

Although the generic sensitivity matrix for water abstraction in table 1 selects a number of hazards that may impact on the various Severn Estuary features, we will only be assessing the impacts arising through the abstraction of cooling water in the context of whether the system of direct cooling represents BAT. This means we will be focussing on the potential impacts to fish and their eggs and larvae, as this is directly linked to what will be processed through the cooling water system and discharged out again through the Fish Recovery and Return system (FRR). See section 2.5.2 below.

Table 2.4.4.1. Sensitivity matrix for the Severn Estuary/ Môr Hafren SAC and Ramsar features in relation to the abstraction activity.

Hazard	Migratory fish (2.5)									
Species	Shad		Lamprey		Salmonids		Eels		Fish assemblage	
Life stage	Adult	Eggs/ Larval	Adult	Eggs/ Larval	Adult	Eggs/ Larval	Adult	Eggs/ Larval	Adult	Eggs/ Larval
Physical damage (Entrapment)	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Impingement	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Entrainment	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Table 2.4.4.1 continued…

Hazard	Submerged marine habitats (1.13)		Estuarine and intertidal habitats (1.12)	
Species	*Sabellaria* (Reefs)		Plankton (Estuaries)	
Life stage	Adult	Eggs/ Larval	Phyto-plankton	Zoo-plankton
Physical damage (Entrapment)		✔	✔	✔
Impingement		✔	✔	✔
Entrainment		✔	✔	✔

For the potential exposure assessment for the Severn Estuary/Môr Hafren SAC and Ramsar for abstraction during the **operational phase** the following species are to be assessed:

- *Migratory fish*
- *Fish assemblage*
- *Reefs (specifically sabellaria larvae)*
- *Estuaries (specifically phytoplankton and zooplankton)*

For the purpose of this assessment we will assume that all of the fish that become physically damaged or lost (entrapped) will become impinged or entrained, therefore we will consider the following hazards associated with abstraction.

- *Impingement*
- *Entrainment*

2.5 Assessment Methodology

Abstraction

The following Environment Agency guidance will be used to help assess whether the cooling water option is in accordance with Best Available Technique (BAT) and also to assess the potential impacts from the cooling water abstraction:

- **The appropriate assessment of fish entrainment from water resources permissions under the Habitats Regulations**[18]. This guidance describes how to assess and make decisions on water resources permissions that could cause the entrainment of fish species designated under the EU Habitats Directive, and whilst the cooling water abstraction will not be licensed, most parts of guidance will still be relevant.

- **Science Report: Screening for intake and outfalls: A best practice guide.**[19]. This guidance provides a description of the legal responsibilities of operators of water intakes and outfalls and, from a review of current, worldwide examples, to present a synopsis of methods that are known to work best for different species and life stages of fish in different situations. A review of the wide range of technologies that are in common use for fish screening is provided, including physical and behavioural screening technologies.

- **Cooling water options for the new generation of nuclear power stations in the UK.**[20] This report explores cooling water options for new reactors and evaluates their potential environmental impacts in terms of effects on biota, and thermal, chemical and radionuclide pollution and issues arising from water abstraction. These include fish and invertebrate intake and impingement on filter screens and the effects of passage of planktonic and small life-stages through the cooling system. The report also discusses different mitigation measures (such as intake location, intake screen designs to minimise impacts of entrapment, entrainment and impingement).

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[18] The appropriate assessment of fish entrainment from water resources permissions under the Habitats Regulations. Environment Agency internal guidance - Operational Instruction (OI) 1046_08.

[19] Turnpenny, A W H, and O'Keeffe. 2005. Screening for intake and outfalls: a best practice guide/ Environment Agency. Science Group; Jacobs Babtie Aquatic - Bristol : Environment Agency. 2005'.

[20] Cooling water options for the new generation of nuclear power stations in the UK. Environment Agency June 2010. SC070015/SR3.

[7] Chemical discharges from nuclear power stations: historical releases and implications for Best Available Techniques. Environment Agency September 2011. SC090012/R1.

Discharges

The following Environment Agency guidance will be used as background reference material to help assess the discharge of cooling water and process effluent:

- **Cooling water options for the new generation of nuclear power stations in the UK.**[6]

- **Chemical discharges from nuclear power stations: historical releases and implications for Best Available Techniques.**[7] This report presents the findings of a survey of non-radioactive chemical discharges from nuclear power stations in the UK, USA, France, and Germany. Plants were selected to represent the two candidate designs for the new nuclear build programme for England and Wales, and also to include plants located on the coast. The candidate designs are the UK EPR™ supplied by AREVA (joint submission with EDF) and the AP1000™ supplied by Westinghouse. Both are based on pressurised water reactor (PWR) technology.

All discharges from the proposed Hinkley Pont C (HPC) station are deemed to be relevant discharges with respect to the Habitats Directive.

No discharges have been screened out as insignificant, prior to assessing whether they have a likely significant effect (LSE).

The assessment of LSE will use the Tables presented above, which provide the potential exposure assessment for each of the discharges or process streams in relation to the interest features of the SAC, SPA and Ramsar. The significance of the potential contaminants will be assessed against relevant environmental standards or targets using relevant guidance for assessing the impact of discharges to tidal waters, and additional guidance which was developed for discharges affecting Natura 2000 sites.

Relevant guidance includes the following:

- Environmental Agency's H1 (Horizontal) Guidance on Environmental Risk Assessment
- Water Quality Technical Advisory Group (WQTAG) papers for Habitats Directive sites, including:

Document ref.	Title
WQTAG081a	Standards for Aluminium in Discharges to Saline Waters
WQTAG083f	European Marine Sites: toxic substances and associated mixing zones
WQTAG086	Ammonia Standards in Estuaries
WQTAG088	Dissolved Oxygen Limits for Estuaries: Determining likely significant effect
WQTAG089a	Guidance on appropriate assessments – assessing risks and impacts of eutrophication in SAC and SPA estuaries
WQTAG160	Guidance on Assessing the impact of thermal discharges on European Marine Sites

- Environment Agency guidance on calculating permit conditions for chemical pollutants in discharges to surface waters

- Environment Agency's draft guidance papers (2010) for Nuclear New Build, entitled:

Nuclear New Build – Guidance on Temperature Standards and Environmental Permit Requirements
Nuclear New Build – Guidance on Permitting Non-nuclear Discharges
Nuclear New Build – Guidance on Hydrodynamic Modelling Requirements
Nuclear New Build – Guidance on Permitting Construction Phase Discharges

Relevant environmental standards or targets include:

- Environmental Quality Standards (EQSs), where these exist;
- Probable No Effects Concentrations (PNECs), in the absence of EQSs and where these can be derived;
- Good Ecological Status standards defined for Water Framework Directive;
- Habitats Directive Water Quality TAG guidance where this is different to other standards; and
- operational targets in the absence of any other relevant statutory or regulatory target.

All the relevant standards and targets are summarised in Table B1 of Annex C

Discharges arising from the construction phase will be assessed against relevant targets, where these discharges require an environmental permit.

Similarly, discharges arising from the commissioning phase for each of the reactors will be assessed in terms of likely significant effect, both 'alone' and 'in combination' with other discharges occurring during the commissioning phase.

Most of the effluent streams from the plant during the operational phase are discharged to the cooling water system. It is proposed that these discharges will be assessed 'alone' and 'in combination', on the basis that there is a base flow of cooling water circulating through the cooling water system. These discharges would not be able to exit the cooling water outfall if there was no flow within the cooling water system. This base flow will be taken to provide 'initial dilution' for these discharges. The cooling water discharge is itself a separate discharge, and will be assessed as such, both 'alone' and 'in combination' with the other discharges. The Fish Recovery and Return discharge, which will flow through its own outfall, will also be assessed 'alone' and 'in combination' with the other discharges.

All assessments

For all assessments, the following will also be used as references;

- Scientific papers will be used where available to support a desk-based study.

- EDF's technical support papers, specifically those produced under the BEEMS programme (British Energy/EDF Estuarine and Marine Studies).

- EDF's report to inform the HRA (Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011) will also be used as a reference.

- Hinkley Point C Environmental Statement: Specifically;
  - Chapter 11 Noise and Vibration
  - Chapter 12 Air Quality
  - Chapter 16 Surface Water
  - Chapter 17 Coastal Hydrodynamics
  - Chapter 18 Marine Water and Sediment Quality
  - Chapter 19 Marine Ecology
  - Chapter 20 Terrestrial Ecology and Ornithology

- Severn Estuary Review of Consents for the Severn Estuary SAC/SPA - Final Version March 2010. Environment Agency

- Severn Estuary Site Characterisation Report

Any documents used will be appropriately referenced throughout the document.

2.6 Assessment

2.6.1 Estuaries

2.6.1.1 Baseline

a) Location of the Proposed Infrastructure

The site of the proposed power station consisting of 2 reactors is on the North Somerset coast at the seaward edge of Bridgwater Bay in the Inner Bristol Channel (Fig. 2.6.1S1). The proposed locations of the intakes and outfalls for the cooling water discharge are shown in Figure 2.6.1S2. There will be 2 separate intake tunnels, one for each reactor. On each intake tunnel there will be 2 intake heads about 200 m apart. The intakes on each tunnel are about 3.4 to 3.5 km offshore and the seaward ends of the tunnels are separated by about 500m. The intakes lie on the western boundary of the Severn Estuary SAC (Fig. 2.6.1S3). The 2 outfall diffusers are on a single outfall tunnel, and are about 75m apart along the tunnel axis. The end of the outfall will be about 1.8km offshore in a water depth of about 5m below Mean Low Water Spring tide level (Fig 2.6.1S2). The diffusers lie within the Severn Estuary SAC, although the boundary is about 1.2 km to the west (Fig. 2.6.1S3). The approximate locations of the intakes and outfall diffusers along a cross-section of the Inner Bristol Channel at the Severn Estuary SAC boundary are shown in Figure 2.6.3.1S4.

Figure 2.6.1S1 – Map of Bridgwater Bay

Figure 2.6.1S2 – Location of intake and outfall tunnels

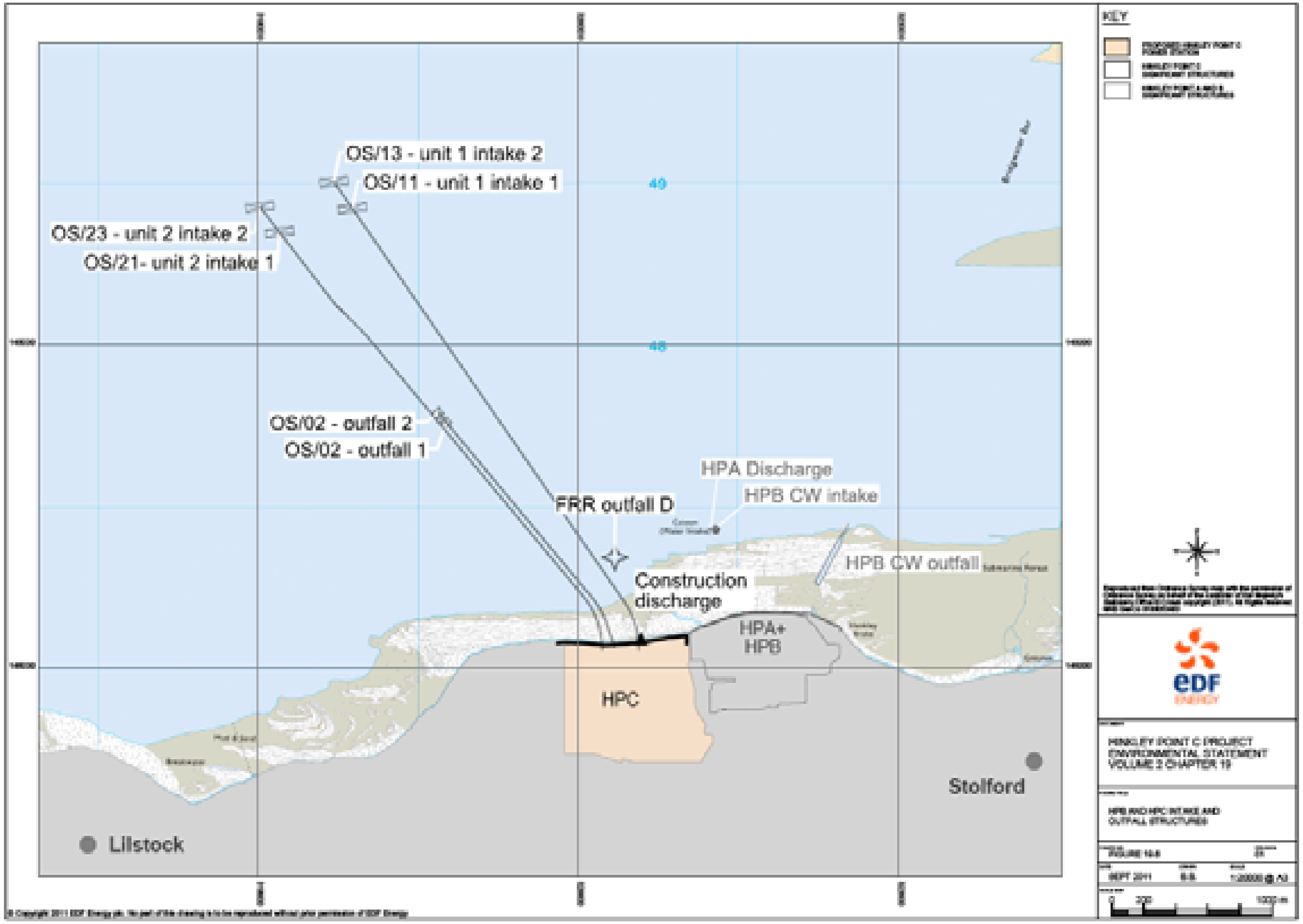


Figure 2.6.1S3 – Intake and Outfall heads in relation to SAC boundary

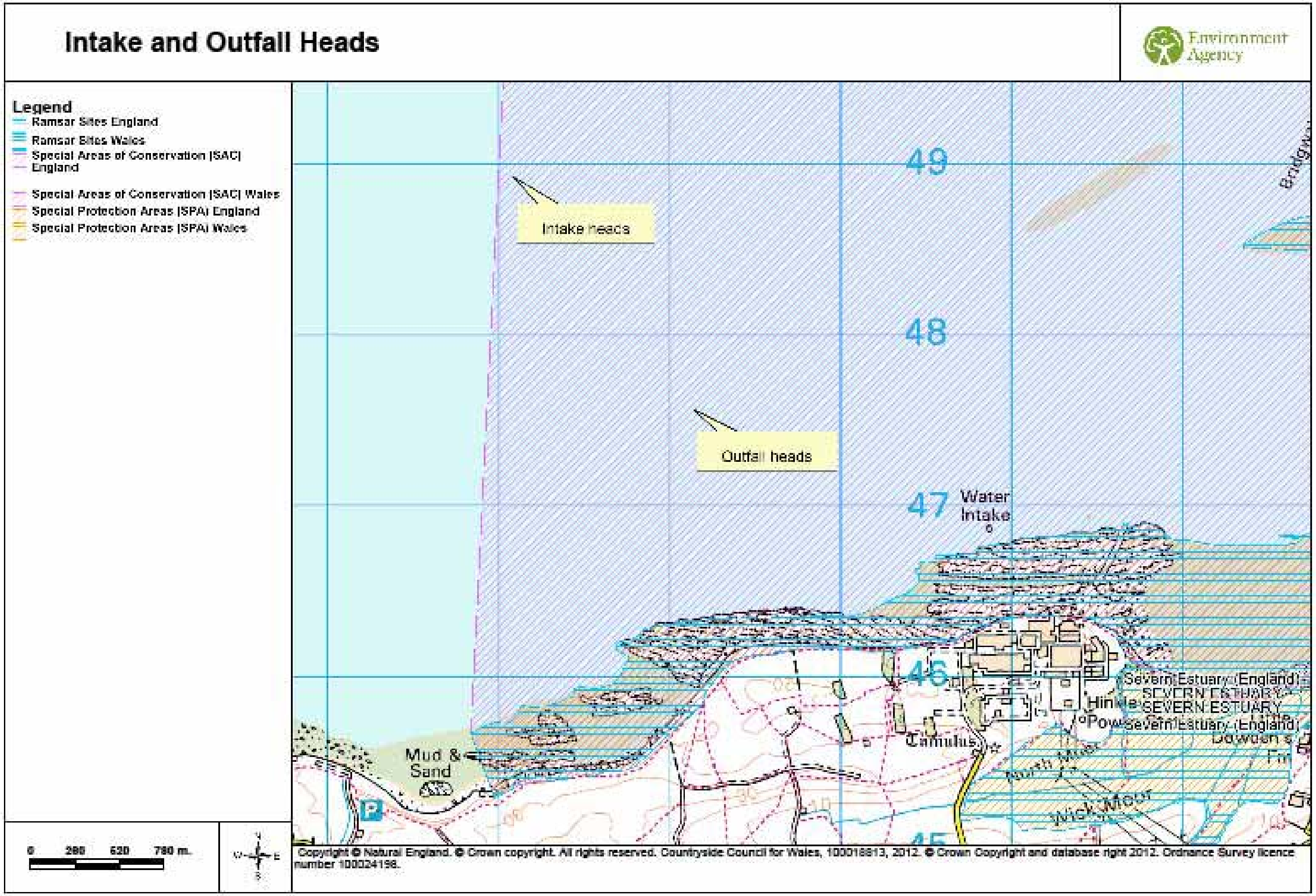
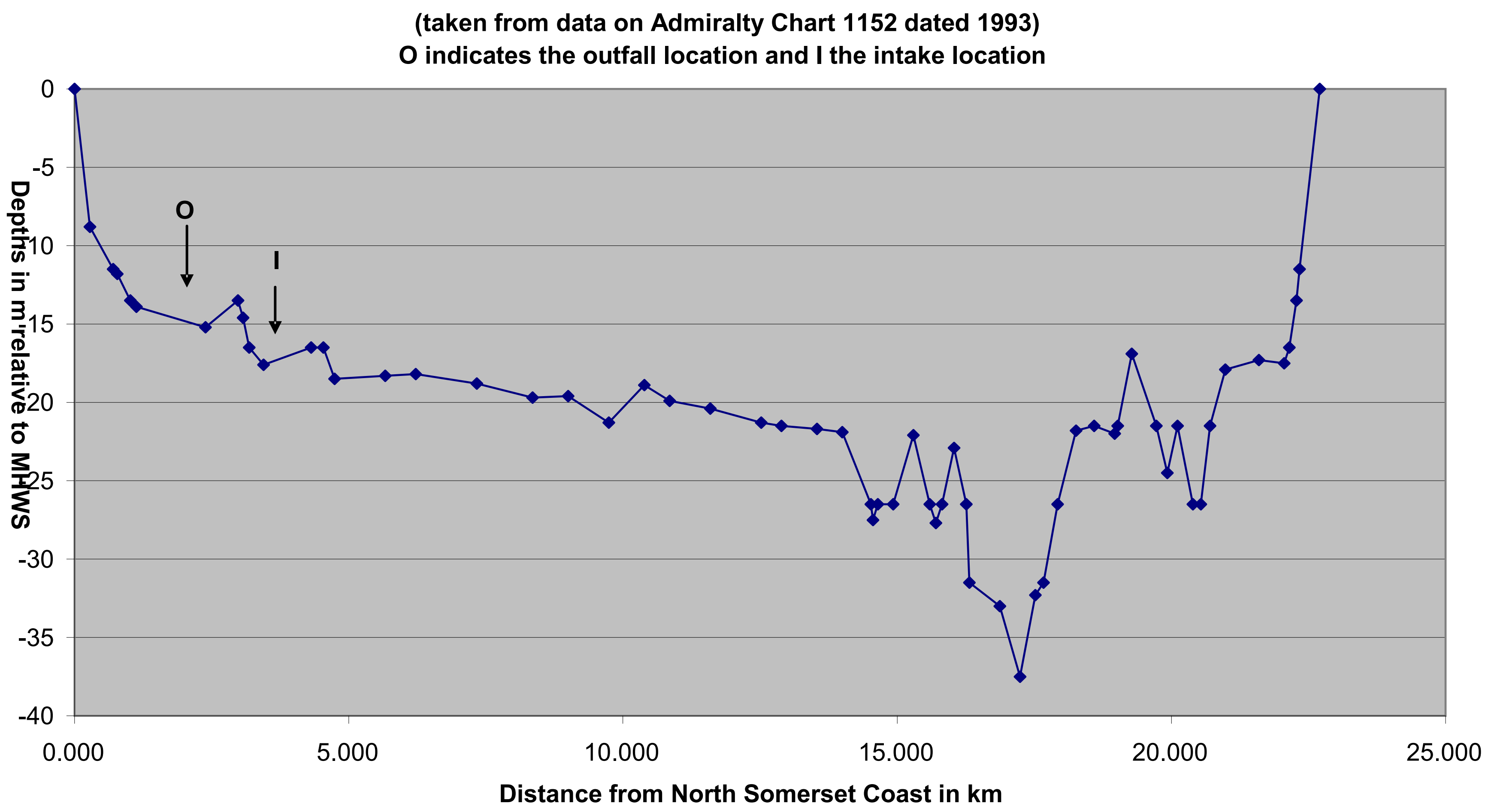


Figure 2.6.1S4 – Inner Bristol Channel Cross-section at seaward boundary of Severn Estuary SAC



b) Hydrodynamics

Tides

The tidal range in this part of the Inner Bristol Channel is very large; the mean spring tidal range at Hinkley Point being 10.7m and the mean neap tidal range 4.8m (data from Admiralty Tide Tables 2011, and UK National Tidal Data Facility in Chapter 17 of the ES for the Main Site)[21]. Seaward of Hinkley along the North Somerset coast, the tidal ranges decrease in amplitude, while up-estuary they increase in amplitude, reaching a maximum near Avonmouth, as shown in Table 2.6.1S5 below.

Table 2.6.1S5 – Tidal ranges on the North Somerset coast.

Site	Mean Spring Tidal Range m	Mean Neap Tidal Range m
Minehead	9.6	4.3
Watchet	10.2	4.4
Hinkley Point	10.7	4.8
Burnham-on-Sea	11.0	5.5
Weston-Super-Mare	11.2	5.8
St Thomas's Head	11.7	5.7
Avonmouth	12.2	6.0

Tidal Currents

The peak flood tidal currents offshore from Hinkley are about 1.4m/s on spring tides and about 0.75m/s on neap tides. The ebb tidal currents are slightly greater, being about 1.5m/s on spring tides and about 0.8m/s on neap tides. The tidal flows are essentially to the east on the flood tide, and to the west on the ebb tide (BEEMS Tech Report 052, 2010)[22]. The tidal current turns from flood to ebb, and from ebb to flood, are very rapid, so that the period of slack tide is very short, in the order of a few minutes. The time of the flood to ebb turn is close to high water, while that from ebb to flood is close to low water.

Based on the tidal current speeds, the tidal excursions (or distances travelled by a water molecule or passive tracer starting at high water or low water) are about 20km to 21km on spring tides and about 10km to 11km on neap tides. To the west of Hinkley, the ebb tide excursion would therefore reach about Watchet on neap tides and about Minehead on spring tides. To the east of Hinkley, the tidal flows enter Bridgwater Bay, so that the excursions are influenced by the mouth of the Parrett Estuary as well as the extensive intertidal zone of Bridgwater Bay. The excursions may then be either on to the intertidal zone of Stert Flats, or into the Parrett Estuary.

Excursions measured by drogues during the oceanographic survey by Titan (BEEMS Tech Report 052, 2010)[2] confirm these excursion lengths, being up to 26km for the ebb tide on spring tides, while on the flood tide the drogues travelled into the Parrett Estuary.

These excursion lengths define an effective envelope of impact of any thermal plume, as they represent the distance which a plume will be transported over a tidal cycle.

Residual Currents

The residual current regime is important, as it defines the level of exchange which occurs between the area impacted by the plume and the other waters of the Bristol Channel and Severn Estuary, both across-channel and along-channel. If the exchange is poor, then there can be a build up of heat in the vicinity of the discharge point.

[21] Environmental Statement for the Development Site – Volume 2 of the Environmental Statement submitted by EDF to the Infrastructure Planning Committee as part of their application for a Development Consent Order (October 2011)
[22] BEEMS Technical Report TR052. Oceanographic survey; Hinkley Point. EDF BEEMS (Titan), 2010.

The residual current regime of the Bristol Channel and Severn Estuary has been described by Uncles (2010)[23]. There are 3 main components of the residual currents. Gravitational circulation occurs in the Central and Inner Bristol Channel, with currents of a few cm/s, directed up-channel at the bed, and down-channel at mid-depth and the surface. Non-linear residual currents occur over the whole water column related to the Neap-Spring tidal cycle and are of several cm/s. Finally, there are wind-driven residual currents which appear to be down-wind in the upper part of the water column and up-wind (i.e. in opposition to the wind) in the lower part of the water column. These wind-driven currents have speeds of a few cm/s for winds of a few m/s. The effects of wind-driven circulations can generate both along-estuary exchange as well as across-estuary exchange.

To relate the significance of residual currents to the excursion lengths defined above, a constant residual current of 10cm/s in a particular direction equates to a distance of 8.64km over a day. For an excursion length of about 21km, a residual current of this speed, along the main axis of flow, would mean that plumes would no longer interact after about 2.5 days, or 5 tidal cycles. A similar time scale would occur for cross-channel movement for a channel width of about 21km, which is that for the Inner Bristol Channel.

The information on residual currents from the measured current data by Titan (BEEMS Tech Report 052, 2010)[2] does not provide any long term data on the nature and scale of the residual current regime in the waters off Hinkley, as the deployments were only for 42 days. However, the data does show that the net flow can be significantly influenced by wind events. For the 3 sub-tidal sites, it is stated that 2 sites show an apparent net flow (for depth-averaged currents) to the NW or W, while one shows an apparent net flow (for depth-averaged currents) to the SE. However, it is not entirely clear how these conclusions were made from the plots provided. Also, a better definition of the residual flows, from both the upper and lower parts of the water column, could have been obtained by filtering the current data to remove the tidal signal.

Given the available information on the residual current regime in the Inner Bristol Channel off Hinkley, it is not expected that exchange will be poor, or there will be any long-term build up of temperature in the waters off Hinkley.

Based on the available information on the residual current regime in the Inner Bristol Channel off Hinkley, with residual current speeds shown to be in the order of 5 to 10 cm/s, water exchange in the area is not poor. No long-term build up of temperature in the waters off Hinkley is therefore predicted to occur, although tidal and meteorological conditions prevailing at any given time will influence the local temperature distribution, and may result in some short-term increases in water temperature above the average.

Mixing Characteristics (inc water column structure)

The water column in the Inner Bristol Channel is generally well-mixed, showing no significant thermal or salinity stratification (Amec 2010[24], Uncles 2010[3]). Vertical mixing is generally rapid in the Inner Bristol Channel and Severn Estuary (e.g. Riddle and Lewis 2000)[25], while horizontal or lateral mixing is less rapid. However, the discharge of a large buoyant thermal plume will tend to result in the development of stratified conditions in water column, particularly over high water (see

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[23] Uncles, R.J., 2010 – Physical properties and processes in the Bristol Channeland Severn Estuary. Marine Pollution Bulletin 61, 5-20.

[24] AMEC 2010. Summary of Marine Surface Water Quality Non-Radiochemical Analysis Results (Campaigns 1-4 including WFD). Report reference 15011/TN/00081. August 2010.

[25] Riddle, A.M., and R.E. Lewis. 2000. Dispersion Experiments in U.K. Coastal Waters. Estuarine, Coastal and Shelf Science. 51: 243-254.

Fischer *et al* 1979)[26]. Vertical mixing will therefore tend to be damped in the plume, while horizontal mixing will be increased due to the lateral density differences.

c) Water Quality

Ambient Baseline Water Quality including contaminants
The ambient baseline conditions for water quality in the Bristol Channel offshore from Hinkley have been defined in surveys undertaken by Amec for EDF (Amec 2010)[4] and by the EA for the Habitats Directive Review of Consents (EA 2006)[27], and also through monitoring undertaken by the EA for the Water Framework Directive. The main source of data used here is the Amec report, although where necessary, data from the EA sources has been used.

Data has been collected on a range of determinands and contaminants including; salinity; temperature; dissolved oxygen; ammonia; suspended sediments; nutrients; and toxic contaminants, both non-synthetics and synthetics.

The means and maxima of the contaminants from the Amec report (Amec 2010)[4] in relation to the contaminants in the waste streams which are proposed to be discharged from Hinkley Point C are given in Tables A1 to A5 of Annex 3.

The means, minima, and maxima of the salinity, temperature, and dissolved oxygen from the Amec report (Amec 2010)[4] are given in the Table 2.6.1S6 below.

Table 2.6.1S6 – Salinity, temperature and dissolved oxygen for Severn Estuary.

Data from Amec 2010				
	Minimum	Mean	Maximum	Range from Profile Data
Salinity	23.3	30.4	33.3	23.6 to 30.1
Temperature (^{o}C)				5.2 to 18.9
pH	7.04		8.05	
Dissolved Oxygen (mg/l)				6.2 to 8.9

This data is compared with data collected by the Environment Agency for Water Framework Directive purposes from six sites off Hinkley Point in the Bridgwater Bay and Bristol Channel Inner South Waterbodies. Five of the sites are in the Bridgwater Bay Waterbody, while the sixth site was off Watchet, just to the west of Hinkley. This data has mostly been collected each month over the period 2007 to 2010, although some data was collected at a few sites in 2004 and 2005 (see Table 2.6.1S7.

[26] Fischer H.B., List E. J., Koh R.C.Y., Imberger J., and Brooks N. H. 1979 Mixing in Inland and Coastal Waters. Academic Press Inc., London. 483 pp.

[27] Environment Agency review of consents for Severn Estuary marine habitat 2006

Table 2.6.1S7 - Means and ranges of EA Water Framework Directive data.

EA Data from 6 sites offshore of Hinkley			
	Minimum	Mean	Maximum
Salinity	17.2	26.3	32.9
Temperature in deg C	4.5	12.1	19.5
pH	7.74		8.18
Dissolved Oxygen in mg/l	7.0	8.9	10.9
Dissolved Oxygen in % saturation	86.8	96.0	118.0

Both these data sets generally show similar ranges, although there are some differences in the minima and the maxima. The reasons for these differences are not known, but probably reflect the different nature of the two datasets.

Ambient Background Water Temperatures

The ambient baseline conditions for water temperature in the Inner Bristol Channel require more detailed data than a few data points from the Amec surveys or the EA dataset. The ambient background water temperatures in the Inner Bristol Channel are therefore discussed in more detail below.

Introduction

The natural seawater temperature regime in an estuary or near shore coastal site can be complex, and may vary considerably, both spatially and temporally (Langford et al 1998)[28]. In addition to this variability in the seawater temperature regime, the temperature variations in the intertidal zone also need to be considered, particularly in a hyper-tidal environment such as Bridgwater Bay where there are extensive intertidal mudflats and sand-flats which are the main areas of biological productivity.

The ambient seawater temperature regime has been described in BEEMS Report TR 186 (2011)[29]. The following section uses this and other available information on the seawater temperature regime in estuarine systems.

Mean Seawater Temperature Regime

The main sources of near shore water temperature data are those which are available on the Cefas website (www.cefas.defra.gov.uk). These have been assessed in various reports, the most recent of which is Joyce 2006[30]. There are several sites along the Bristol Channel; Hinkley Point, Minehead, and Ilfracombe on the south shore, and Swansea and Barry on the north shore. Minehead, Ilfracombe, Swansea, and Barry are Cefas sites, while Hinkley Point is a BNFL and CEGB site. Methods of data collection and analysis are described in Joyce 2006[10] and the Cefas

[28] Langford T.E., Hawkins S.J., Bray S., Hill C., Wells N., and Yang Z. 1998 Pembroke Power Station: Impact of cooling water discharge on Marine Biology of Milford Haven. CCW Contract Science Report 302 . Countryside Council for Wales. 73 pp.

[29] BEEMS Technical Report 186 (TR186) Predited effects of New Nuclear Build on Water Quality at Hinkley Point. EDF BEEMS (Cefas), 2010.

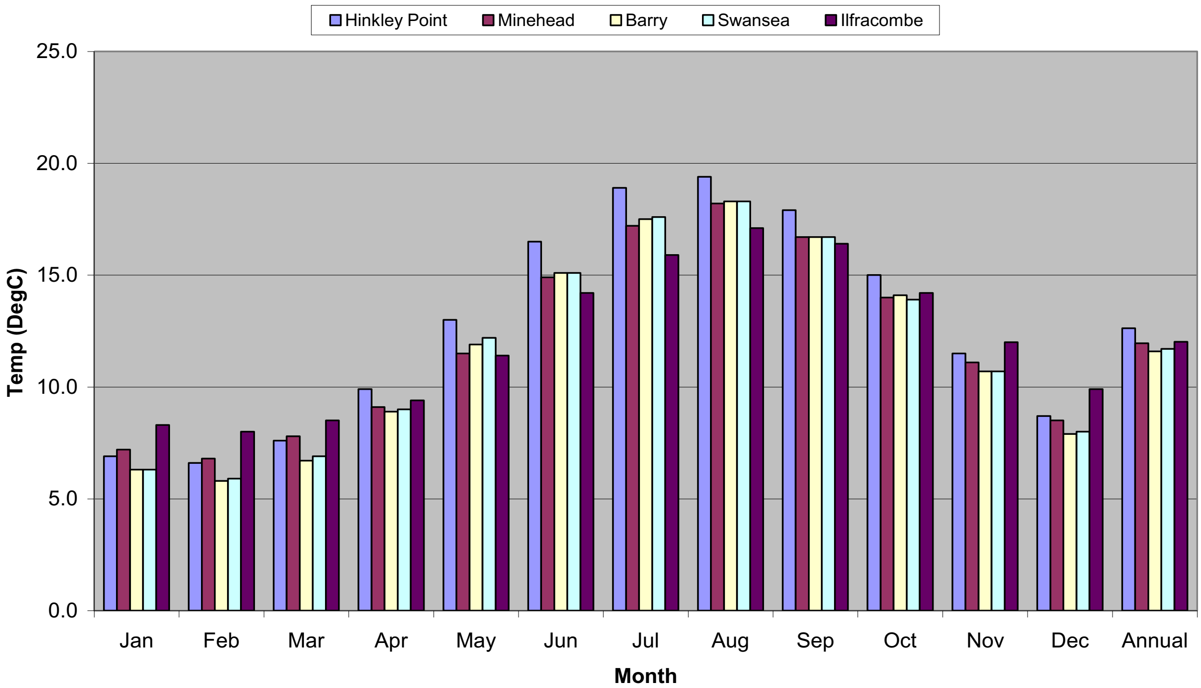
[30] Joyce A.E. 2006 The coastal temperature network and ferry route programme: long-term temperature and salinity observations. Sci. Ser. Data Rep., Cefas Lowestoft. 43. 129 pp.

website. The data periods covered at each of the sites are: Ilfracombe 1992-2008, Minehead 1972-1978 and 1988-1998, Swansea 1976-2000, Barry 1978-1999, and Hinkley Point 1976-2009, although not all years are complete. The data is presented as monthly mean seawater temperatures. The monthly mean seawater temperatures for each site are shown below in Table 2.6.1S8 and in Figure 2.6.1S9.

Table 2.6.1S8 Mean Seawater Temperatures at Sites in the Bristol Channel

Month	Hinkley Point	Minehead	Barry	Swansea	Ilfracombe
Jan	6.9	7.2	6.3	6.3	8.3
Feb	6.6	6.8	5.8	5.9	8
Mar	7.6	7.8	6.7	6.9	8.5
Apr	9.9	9.1	8.9	9	9.4
May	13.0	11.5	11.9	12.2	11.4
Jun	16.5	14.9	15.1	15.1	14.2
Jul	18.9	17.2	17.5	17.6	15.9
Aug	19.4	18.2	18.3	18.3	17.1
Sep	17.9	16.7	16.7	16.7	16.4
Oct	15.0	14.0	14.1	13.9	14.2
Nov	11.5	11.1	10.7	10.7	12
Dec	8.7	8.5	7.9	8	9.9
Annual	12.6	12.0	11.6	11.7	12.0

Figure 2.6.1S9 – mean seawater temperatures in the Bristol Channel



This data shows several features. Firstly all sites have a similar annual variation, with a maximum mean seawater temperature in August and a minimum in February. This reflects the seasonal variation in solar radiation which is the dominant input to the heat input to the seawater (Uncles and Stephens 2001)[31]. Secondly the seawater temperatures at Hinkley Point are consistently higher than the other sites from May to September, but not from November to March. Lastly, Ilfracombe shows the smallest variation in mean seawater temperatures over the year, and has the lowest summer mean temperatures and the highest winter mean temperatures.

On the basis of this data, it would appear that the mean seawater temperature regime at Hinkley Point is not dissimilar to the rest of the Bristol Channel. The main differences with respect to other sites on the southern shore of the Bristol Channel (Minehead and Ilfracombe) are higher summer water temperatures and lower winter water temperatures. These differences in water temperature along the North Devon and Somerset coast are also evident in the data collected by IMER in 1973 to 1975 (Williams and Collins 1985)[32]. These observed differences may be a consequence of the location of Hinkley Point being close to the extensive intertidal area of Stert Flats and Berrow Flats, as these will transfer heat to the water column in the summer months, while in the winter they will absorb heat from the water column (Harrison and Phizacklea 1985)[33]. However, Uncles and Stephens 2001[11] suggest that the role of mudflats in the heat balance of estuaries is minor, so that the higher mean seawater temperatures at Hinkley Point may be more related to the shallower mean water depths rather than the intertidal area. To what extent the mean temperature variation at Hinkley Point includes any effect from the past and existing power stations of Hinkley Point A (operational period 1965 to 2000) and Hinkley Point B (operational period 1976 to the present) is not know, as there are no water temperature data for the period before 1976.

[31] Uncles R.J. and Stephens J.A. 2001 The annual cycle of temperature in a temperate estuary and associated heat fluxes to the coastal zone. Journal of Sea Research 46, 143-159.

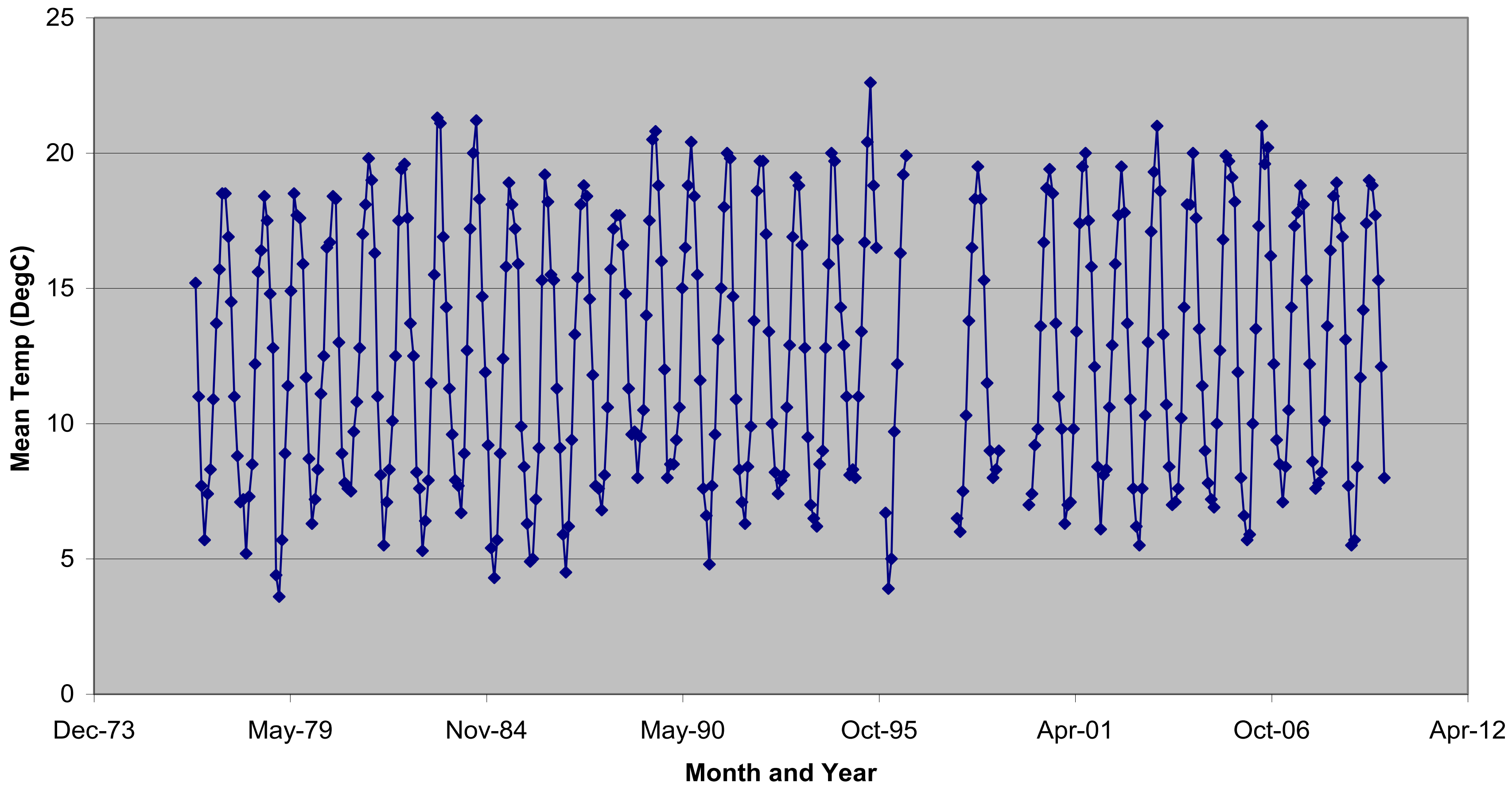
[32] Williams R. and Collins N.R. 1985 Zooplankton Atlas of the Bristol Channel and Severn Estuary Institute for Marine Environmental Research October 1985. 181 pp.

[33] Harrison S.J. and Phizacklea A.P. 1985 Seasonal changes in heat flux and heat storage in the intertidal mudflats of the Forrth Estuary, Scotland. Journal of Climatology 5, 473-485.

Interannual Variation in Mean Sea Temperature

The interannual variation in mean seawater temperature at Hinkley Point is shown in Figure 2.6.1S10

Figure 2.6.1S10 – Monthly mean seawater temperatures at Hinkley Point



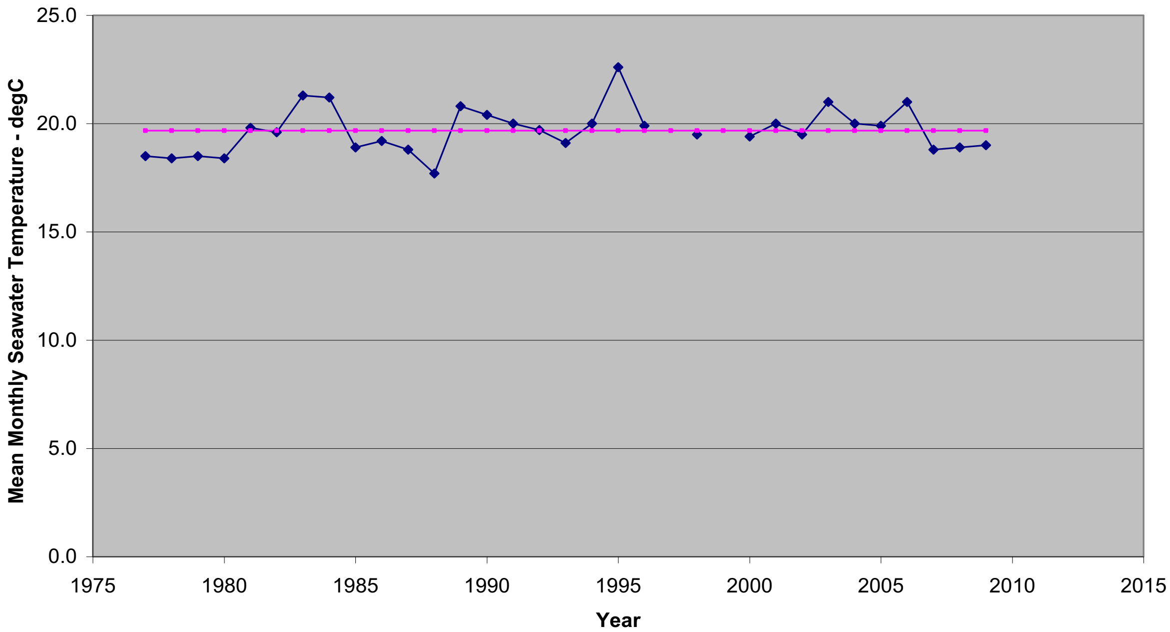
This data shows that there is considerable variation in the mean seawater temperature regime between years, with the seasonal (winter to summer or summer to winter) range varying by a factor of about 2; the minimum range being 9.7ºC and the maximum range being 18.7ºC.

The maximum mean monthly seawater temperature occurred in August 1995 when the mean temperature was 22.6 ºC. The minimum mean seawater temperature occurred in February 1979 when the mean temperature was 3.6 ºC.

Based on the mean seawater temperature for full years only, the 98%ile of mean seawater temperature at Hinkley is 20.4ºC. This figure has been used in the assessments of the thermal plumes as the baseline 98%ile, such that the mean temperature differential to achieve a 98%ile standard equates to the standard minus 20.4 ºC. In other words to define the extent of the mixing zone for a temperature of 21.5ºC as a 98%ile, a temperature differential of 1.1ºC has been used. Similarly, for a temperature of 23.0ºC as a 98%ile, a temperature differential of 2.6ºC has been used.

The average of the maximum mean monthly temperature is 19.7 ºC , and the year to year variation in the maximum mean monthly temperatures is shown in Figure 2.6.1S11 below.

Figure 2.6.1S11 – Year to Year maximum mean monthly seawater temperature relative to the mean maximum at Hinkley Point



The average of the maximum mean monthly temperatures (19.7ºC) is slightly greater than the annual maximum mean monthly temperature of 19.4ºC which occurs in August, because in some years the maximum mean temperature occurred in either July or September, and not August.

Tidal and Diurnal Temperature Amplitudes

The mean monthly seawater temperatures described in the sections above provide a reasonable definition of the seasonal and inter-annual temperature regime. However, the seawater temperatures will also show variations at higher frequencies, including those over the period of a day and also over a tidal cycle (see Uncles and

Stephens 2001)[11] In the Tamar Estuary, the greatest amplitude of the diurnal signal was 0.4ºC and occurred in the upper estuary where depths were most shallow. However, the greatest amplitude of the tidal signal was 0.3ºC in the lower estuary where longitudinal temperature gradients were generally the largest. As a comparison, the maximum amplitude of seawater temperature variations measured at several points in a tidal creek in Georgia in the USA was about 1ºC. Tidal advection was the dominant process in the outer part of the creek, while solar heating was the dominant process in the shallower inner part of the creek.
Overall, therefore, variations in seawater temperatures at a point in an estuarine system are likely to have a maximum variation of about 1ºC about the daily average.

Finally, the temperature variations which can occur in the intertidal sediments need to be recognised, as organisms living within the intertidal zone will be subjected to a range of temperatures during the time that the intertidal sediments are exposed. There have been various studies on the temperature variations in intertidal sediments. These studies have shown that, in the spring and summer close to the surface (2 -5cm), temperatures in the intertidal sediments can reach 10 to 12ºC, above the temperature existing prior to exposure of the sediments (see eg. Harrison 1985[34], Harrison and Phizacklea 1987[35], Cho *et al* 2005[36]). The heating effect is dampened with depth, and little increase is seen at about 20cm to 30cm below the surface. The rise and fall in temperature of the intertidal sediments as they are exposed can be relatively fast and be in the order of minutes rather than hours, although the rate of heat exchange is very dependent on the prevailing climatic conditions. During winter, in contrast, the intertidal sediments can be cooled during exposure relative to the ambient temperatures when they are immersed (Harrison and Phizacklea 1987)[14]. A further important factor affecting the temperature regime of intertidal sediments is the nature of the prevailing spring-neap tidal signal. At locations where low water for spring tides occurs about midday, as occurs in Bridgwater Bay, the intertidal sediments will be exposed to maximum solar heating, so that more of the intertidal zone will be affected by large temperature variations, compared with those locations where low water for neap tides occurs about midday.

d) Spatial Extent of Interest Features

The extent of the main interest features of the Severn Estuary SAC and SPA are given in Table 2.6.1S12 below. These areas are those which have been used to assess the relative significance of the impact of various mixing zones on the interested features and therefore the integrity of the SAC and SPA. There are some minor differences between the data from the JNCC website and those in the Reg 33 Advice, in particular with the areas for saltmarsh. The figures in the Reg 33 Advice have been taken to be the best estimate as they relate to all saltmarsh, rather than particular sub-divisions.

[34]. Harrison S.J. 1985 Heat Exchanges in Muddy Intertidal Sediments: Chichester harbour, West Sussex, England. Estuarine, Coastal and Shelf Science 20, 477-490.

[35] Harrison S.J. and Phizacklea A.P. 1985 Seasonal changes in heat flux and heat storage in the intertidal mudflats of the Forrth Estuary, Scotland. Journal of Climatology 5, 473-485

[36] Yank-Ki Cho, Tae-Wan Kim, Kwang-Woo You, Lae-Hwan Park, Hyung-Tae Moon, Sang-Ho Lee, and Yong-Hoon Youn. 2005 Temporal and spatial variabilities in the sediment temperature on the Baeksu tidal flat, Korea. Estuarine, Coastal and Shelf Science 65, 302-308.

Table 2.6.1S12 – Areas for the Severn Estuary SAC, SPA and Specific Features

	Areas in ha from SAC Data Spreadsheet on JNCC website	**Areas in ha from Reg 35 Advice**		**Comment**
Severn SAC	73715.4	73715.4		
Estuaries Feature	73678.54	73678		
Sub-tidal Sandbanks	11779.72	1300	Permanent sandbanks	
		10440	Associated ephemeral sandbanks	
Total Sub-tidal Area		50500		Estimate based on Estuaries Feature less Intertidal Area of Intertidal Mudflats and Sandflats, Saltmarsh, and Rocky Shore
Reefs	1474.3	No data		
Intertidal Mudflats and Sandflats	20271.74	20271		
Atlantic Salt Meadows	656	1400	Saltmarsh	Includes pioneer to upper marsh
Spartina swards	191.66			
Salicornia and other annuals colonising mud and sand	0			
		1500	Hard substrate (Rocky shore)	Rock, boulders, mussel/cobble scars, rocky pools, shingle
	Areas in ha from SPA Data Spreadsheet on NE website			
Severn Estuary SPA	24662.98			
Tidal rivers. Estuaries. Mud flats. Sand flats. Lagoons	21950.05			
Salt marshes. Salt pastures. Salt steppes	1479.774			

The distribution of the main features of the SAC, notably the sub-tidal sandbanks feature, the intertidal mudflats and sandflats feature, and the hard substrate (rocky shore) are shown in Figures 2.6.1S13, 2.6.1S14 and 2.6.1S15. These provide an indication of the extent and location of the main features, although the maps are not definitive.

Figure 2.6.1S13 – Map showing the extent of the sub-tidal sandbanks feature of the Severn Estuary SAC

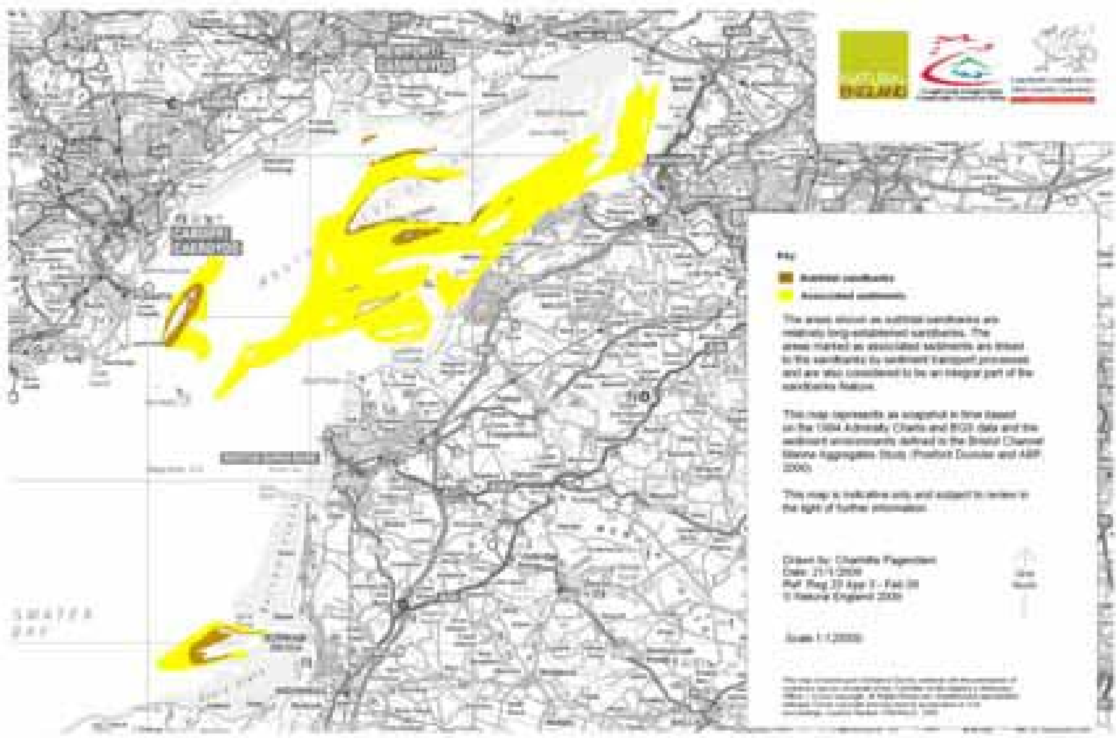


Figure 2.6.1S14 – Map showing the extent of the intertidal mudflats and sandflats feature of the Severn Estuary SAC

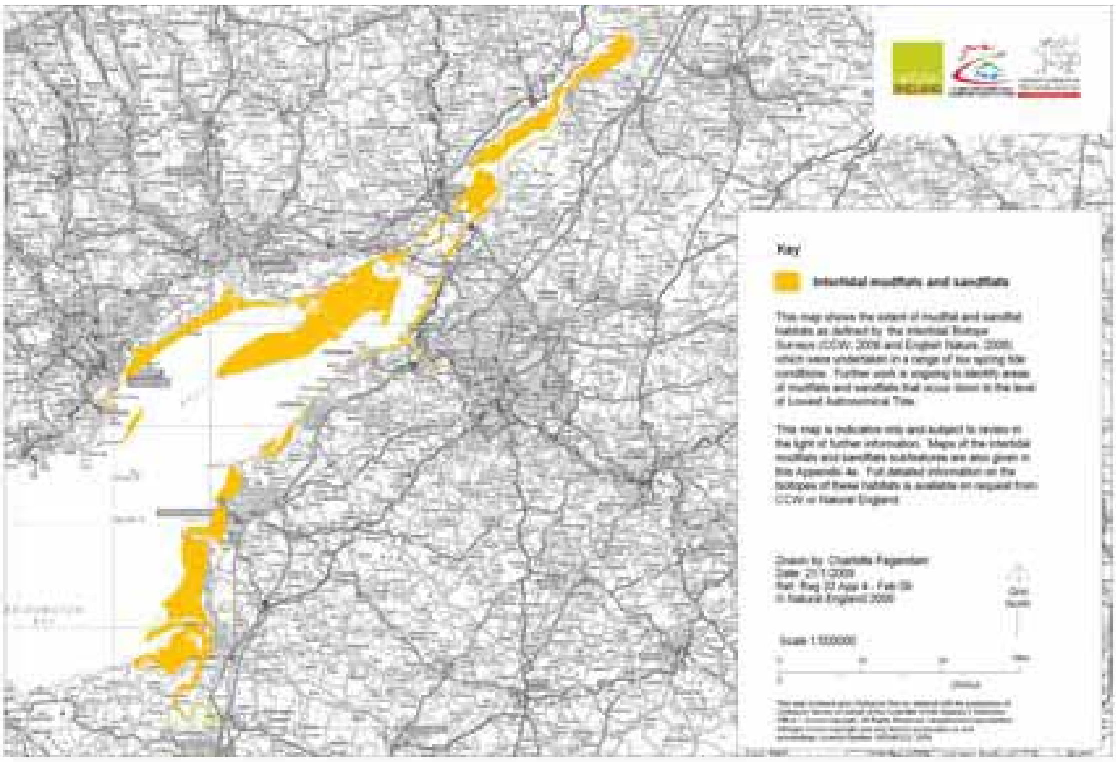
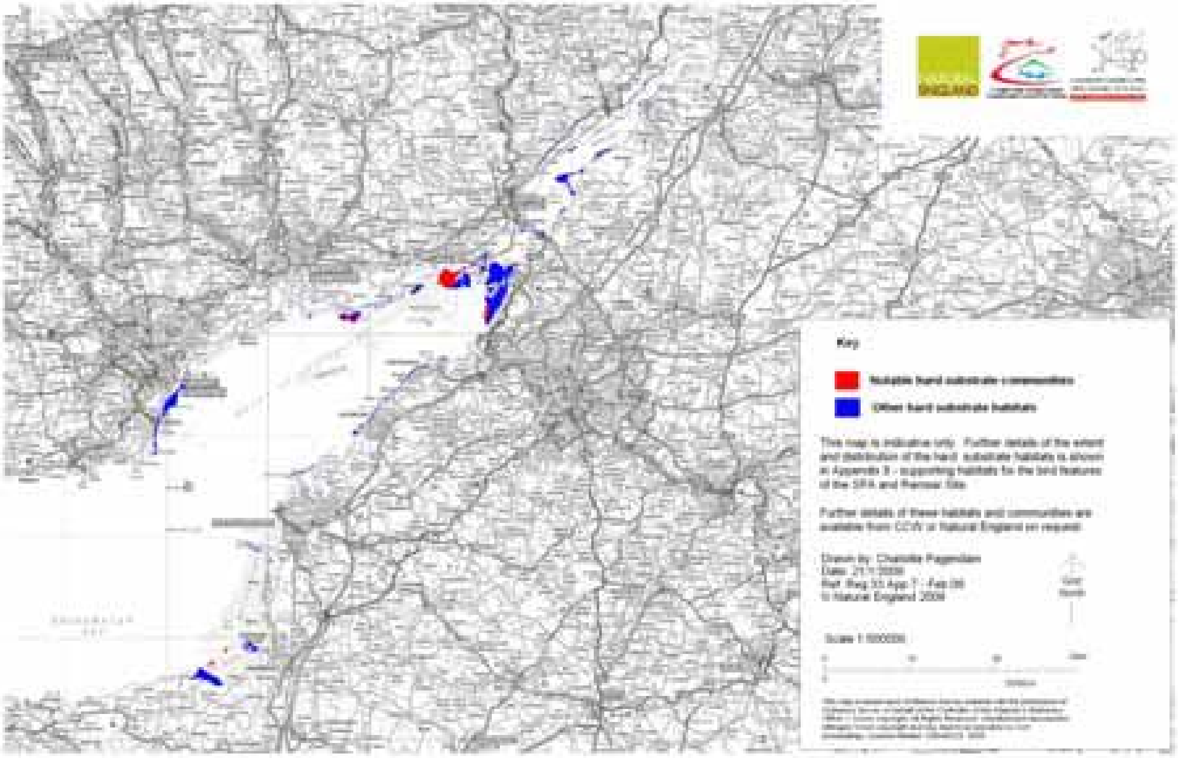


Figure 2.6.1S15 – Map showing the extent of the hard substrate habitats and their notable communities sub-feature of the Estuaries feature of the Severn Estuary SAC and Ramsar site



2.6.1.2 ‘Likely Significant Effect’ (LSE) Assessment of Operational Discharges

The Appendix 11, dated 23 January 2012, for the Operational Discharges which were covered in the Permit Application EPR/HP3228XT/A001 concluded that we could not be satisfied that there would not be a likely significant effect from the proposed discharge either alone or in combination with permissions, plans or projects of other competent authorities and that an appropriate assessment (Appendix 12) was, therefore, necessary.

However, no detailed assessment was made in the Appendix 11 on which aspects of the potential hazards did constitute a likely significant effect on site integrity. This section therefore looks at the nature of the various discharges within the permit application, and what aspects exceed a likely significant effects test. The likely significant effects tests applied here are:

- Does the level of a contaminant in the discharge exceed EQS or target, before being discharged into the cooling water?

- Is the level of a contaminant more than 10 per cent of the EQS or target or ambient background value following dilution in the cooling water discharge?

If the answer to the last test is yes, then the relative proportion of the EQS or target or ambient background has been considered further, to assess the relative deterioration and whether the contaminant concentration remains greater than the EQS or target, following dilution within the cooling water.

In addition, the contribution of the total load of various contaminants in the proposed discharges from HPC have been compared with the total loads to the SAC to assess their relative significance to the Severn Estuary SAC, and any potential effects in combination with other discharges and freshwater inputs.

a) Nature of Discharges

Waste Streams

There are 7 waste streams which contribute to the discharge of contaminants during the operation of the power station. These are summarised in Table 2.2.1 of the permit application, which is reproduced here:

Table 2.2.1 Proposed Discharges from the HPC Power Station

Waste Stream	Effluent Type	Brief Overview
A	Trade – returned abstracted water	Return of abstracted cooling water, which will be characterised by thermal content and will potentially be dosed with sodium hypochlorite to prevent biofouling of the cooling water infrastructure. This will be the most significant discharge in terms of flow.
B	Trade – known volume	Trade effluent from operations within the nuclear island, excluding effluent from the Steam Generator Blowdown System.
C	Trade – known volume	Trade effluent from the Steam Generator Blowdown System.
D	Trade – known volume	Trade effluent from the Turbine Hall and uncontrolled area floor drains, excluding blowdown from the Steam Generator Blowdown System.
E	Trade – known volume	Trade effluent associated with water potentially contaminated with hydrocarbons from the areas where oils are used (e.g. workshops, diesel generators and transformers) which will pass through an oil/water interceptor before joining the main discharge.
F	Trade – known volume	Trade effluent from the production of demineralised water, which will be treated to neutralise extremes of pH before joining the main discharge.
G	Domestic sewage	Sanitary effluent from administration and mess facilities, which will be treated in an appropriate effluent treatment plant before joining the main discharge.

The sources contributing to each waste stream are described in some detail in Sections 2.3 and 2.4 of the permit application. Briefly these include:

- Waste stream A - seawater abstracted for direct cooling of the condensers and various other plant systems. Passed once through the cooling water system and discharged via the outfall tunnel with the addition of waste heat and possibly TRO (total residual oxidant) as a consequence of bio-fouling control.

- Waste streams B, C & D - chemicals associated with various dosing processes used to condition the primary circuit, the secondary circuit and the nuclear and conventional auxiliary circuits. Dosing is primarily required to control pH levels and eliminate oxygen, thus reducing the potential for corrosion within the circuits and the production of corrosion products. Dosing chemicals used in the UK EPR reactor include lithium hydroxide, ammonia, morpholine, ethanolamine and hydrazine. Additionally, boric acid is used as a neutron absorber within the primary circuit to control reactivity.

  To maintain the correct chemistry within the secondary circuit there is a continual bleed known as blowdown from the steam generators and a corresponding top up with fresh demineralised water.

  Leakage and/or drainage (not blowdown) from the secondary circuit and other systems within the turbine hall and the floor drains therein are also included within waste streams B, C and D.

- Waste stream E - water contaminated with oils, greases and hydrocarbons from areas that contain back-up diesel generators, transformers, electrical substations, oil and fuel offloading facilities; stores and workshops.

- Waste stream F - waste water from the demineralisation process used to produce demineralised water, using a combination of membrane technology and ion exchange processes. The effluent generated will contain various contaminants including iron, chloride, suspended solids, sulphates, sodium, phosphates, acetic and phosphoric acid.

- Waste stream G - domestic sewage arising from staff welfare facilities across the site and treated in an on-site sewage works prior to discharge. The effluent is characterised by BOD (biochemical oxygen demand), suspended solids and ammonia.

Treatment systems of various types will be applied to all of the waste streams to reduce the contaminant concentrations, and for waste stream B to recycle boron and water from the primary circuit. The proposed treatment systems and techniques are described in Sections 2.3, 3.4, 3.5. 3.6, and 3.8 of the permit application, and include filtration, demineralisation using ion exchange, degassing, evaporation and oil / water separation. The type of treatment is specific to both the origin and nature of the waste stream and the required treatment objectives.

The waste streams B to G, following any treatment, are all directed into the abstracted cooling water return, waste stream A, which is discharged through the outfall tunnel. Waste streams B and C are combined prior to discharge to the cooling water system, while waste streams D, E, F, and G are discharged separately.

In addition to the operational discharges from the 7 waste streams defined above, the permit application also covers hot functional testing of each of the reactors, which is part of the reactor commissioning process.

Commissioning of the UK EPR reactor will take place in two stages, namely (i) cold flush testing and (ii) hot functional testing. Cold flush testing, which primarily involves cleansing and flushing of the various systems with demineralised water to remove surface deposits and residual debris from installation, is not covered in the permit application. The discharges resulting from cold flush testing will be subject to a separate, later permit application.

Hot functional testing is the process whereby the reactor is tested under pressure and temperature prior to operation under normal conditions. Hot functional testing occurs prior to fuelling of the reactor and only once the cooling water infrastructure is in place and operational. Therefore any effluent will be diluted within the cooling water system prior to discharge via the outfall tunnel. The information available on the nature of the discharges during hot functional testing is limited and described in Section 2.7.2 of the permit application. Here it is stated that the hot functional testing discharges will be bounded by the discharges made during the normal operation of the new power station. By this statement, it is assumed that any limits which are defined in the operational permit for specific contaminants will also apply to the discharges arising during hot functional testing.

Discharge Volumes and Composition

The summary data in this section for each waste stream is based on the information in the permit application, and any additional supporting information which has been provided in response to our Schedule 5 notices.

Waste stream A

The amount of cooling water flow varies depending on the tidal state at the intake heads, and the number of reactors in use. Under normal operations, the power station will abstract between $116m^3/s$ and $134m^3/s$. The higher flows are abstracted at high water spring tides, and the lower flows at low water spring tides. There is therefore a tidally varying flow rate passing through the cooling water system which will influence the subsequent temperature increase across the condensers and thus the maximum temperature of the returned cooling water.

The contaminants contained within the returned abstracted cooling water are excess heat gained from the condensers in the secondary steam generating circuit, and total residual oxidant (TRO) should it prove necessary to control bio-fouling in the cooling water system. While NNB Genco do not envisage that there will be a need to control bio-fouling based on the historic experiences at Hinkley Point B power station, they must retain the right to chlorinate should operational requirements dictate, and so dosing proposals have been included in the permit application. If required, risk-based dosing will be achieved through the injection of sodium hypochlorite into the abstracted cooling water upstream of the condensers. TRO is used as the relevant parameter for assessing the level of chlorine in seawater, because of the chemical interactions which occur when chlorine or hypochlorite is added to seawater. In essence, chlorine or hypochlorite reacts with bromide in seawater to form hypobromous acid. The free oxidants generated through the chlorination of seawater are thus predominantly hypobromous acid and the hypobromite ion (Jenner *et al* 1997[37], Taylor 2006[38]).

The predicted temperature rise in the cooling water across the condensers, and the potential levels of TRO in the cooling water downstream of the condensers are shown in Table A1 in Annex C, together with the relevant cooling water flows. As stated earlier, the predicted temperature rise varies with the tidally varying cooling water flow rate, the variation being 0.9ºC above or below the average temperature rise of 11.6ºC under normal operating conditions.

There are also planned periods when a reactor is closed down (outages), e.g. for refuelling or plant maintenance, as well as unplanned periods of shutdown which may occur due to plant breakdown. NNB GenCo have stated that during normal operations there would always be a minimum of two cooling water pumps operating. This would result in an average flow rate through the cooling water system of about $64m^3/s$ and a minimum flow of $60.4m^3/s$. This latter flow rate of $60.4m^3/s$ has been taken to be the minimum flow which will be maintained in the cooling water system and which will therefore be available for dilution of the other 7 waste streams prior to their discharge into the Bristol Channel through the outfall tunnel.

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[37] Jenner H.A., Taylor C.J.L., van Donk M., and Khalanski M. 1997 Chlorination By-Products in Chlorinated Cooling Water of some European Coastal Power Stations. Marine Environmental Research 4, 279-293.

[38] Taylor C.J.L. 2006 The effects of biological fouling control at coastal and estuarine power stations. Marine Pollution Bulletin 53, 30-48.

Unplanned outages are considered to be an emergency or abnormal situation and as such are not subject to permit control as per the normal operational discharges. Any environmental permit would require that NNB Genco manage the power station in accordance with a written Environmental Management System that identifies and minimises the risks of pollution, including those arising from maintenance, accidents, and incidents. The operator would further be required to consider through the development of an Emissions Management Plan, how emissions not covered by emission limits in the permit will be prevented, or where that is not practicable, minimised. Any liquid wastes arising during unplanned outages would fall under these requirements.

Waste Streams B and C combined, and D, E, F, and G

The discharge volumes and the contaminants loads associated with each of these waste streams are summarised in Tables A2 to A7 in Annex C. Waste streams B and C will be treated and discharged as a combined discharge, while the other four waste streams will be managed and discharged individually. However, it is possible that the effluent from waste stream B&C combined could be discharged at the same time as waste stream D, although this is considered to be unlikely for operational reasons. To cover this possibility, the potential concentrations arising from the discharge of waste streams B&C and D together have been calculated and are also presented in Table A4 in Annex C. This situation where waste streams B&C and D are discharged together represents the worst case situation as the loadings are combined. Therefore the assessment against relevant EQSs and targets discussed in the next section has only been undertaken for this situation. The relevant values for the various contaminants relating to the individual waste streams B&C combined and D (with the exception mercury and cadmium) can be found in the Tables in Annex C. At this stage, the relative contribution of mercury and cadmium to the two waste streams B&C combined and D has not been defined, so that it has only been possible to consider the loadings as if the waste streams were discharged together.

In addition, the effective total loading of nutrients, in terms of nitrogen and phosphorus, has also been calculated for those waste streams which contain N- and P-bearing compounds.

Based on the load and flow figures in the Tables A1 to A7 of Annex C, contaminant concentrations, both as short-term values and long-term average values, have been calculated for each waste stream prior to dilution within the cooling water flow. The short-term values are based on a maximum loading during a 24 hour period and the maximum flow, while the long-term average values are based on the loading over the year and an assumed average flow of half the maximum flow, except for waste stream F for which the maximum flow has been used.

The expected concentration of the contaminants from each waste stream following dilution in the cooling water return has also been calculated (see Tables C1 to C7 in Annex C). For the long-term average situation, it has been assumed that the treated waste stream effluent will be discharged into a cooling water flow of 116m^3/s. Meanwhile for the short-term situation, it has been assumed that the treated waste stream effluent will be discharged into a cooling water flow of 60.4m^3/s. These represent the minimum (or worst case) cooling water flows available for the dilution of the waste streams B&C combined, D, E, F, and G, in both the long and short term respectively.

For waste streams B&C combined and D, concentrations following dilution with cooling water have been calculated assuming that the waste stream discharge was either continuous over 24 hours, or only over12 hours. A discharge over 12 hours has subsequently been used in the assessment against relevant targets, as the treated effluent for waste streams B&C combined and D will be held in storage tanks, each waste stream having two storage tanks of 750 m^3. A discharge from each tank is expected to occur over about 6 hours, which means two tanks will discharge over 12 hours. For the other waste streams, E, F, and G, the discharge has been assumed to be continuous over 24 hours.

The concentrations obtained using the above loadings and dilutions in the cooling water flows are considered to represent the maximum concentrations which will occur in the cooling water in both the long term average situation, and the short term maximum situation.

b) Comparison of Contaminant Levels in the Waste Streams with Standards

Environmental Quality Standards and Other Targets

In order to assess the potential impact of the discharges from the different waste streams, the concentrations of the contaminants in the waste streams need to be compared with relevant environmental standards and targets. There are various standards and targets which are used, ranging from statutory Environmental Quality Standards (EQSs) (eg. as defined in the EQS Directive 2008) to operational targets for Special Areas of Conservation agreed between the Environment Agency, Natural England, and the Countryside Council for Wales.

The EQSs and targets relating to the contaminants in each waste stream are summarised in Table B1 in Annex C.

Comparison of Concentrations of Contaminants in the Different Waste Streams with Relevant Targets and Ambient Background Levels

The concentrations of the contaminants in each waste stream both before and after mixing with the cooling water are compared with the relevant EQSs and targets in Tables C1 to C7 in Annex C. These Tables show that the concentrations of the contaminants generally exceed the EQSs or targets prior to mixing, but are mostly less than the EQSs or targets after mixing with the cooling water.

To assist in the comparison between the available EQSs and target values and the concentrations of the contaminants , the relative contribution of the contaminants within each waste stream has been calculated as a percentage of the relevant EQS or target, both before and after discharge into the cooling water flow. The concentrations calculated for the long-term scenario have been compared with annual average EQSs or targets. The concentrations for the short-term scenario have been compared with Maximum Allowable Concentrations (MAC), where these are available; otherwise they were just compared with annual average EQSs or targets. The percentage contributions are provided in Tables D1 to D6 in Annex C. Also included in these Tables, is the relative contribution of the contaminants in each waste stream as a percentage of the ambient background levels of the contaminants which were measured during the 4 marine sampling surveys undertaken between January and September 2009 (AMEC 2010)[4].

This assessment is intended to indicate which contaminants exceed the relevant EQS or target prior to discharge into the cooling water, and which contaminants remain a concern following dilution within the cooling water flow. This assessment is not quite the same as the H1 Screening Assessment which was undertaken by

AMEC for EDF (AMEC 2012)[39], as it includes specific comparison with the ambient background levels, as well as with the EQSs or targets following dilution in a defined volume of cooling water flow. No additional secondary dilution following discharge has been included.

The contaminants which are not considered to be a concern in the waste streams prior to discharge into the cooling water flow are shown in Table 2.6.1S16 below. These contaminants are not more than 10% of the EQS/target as an average or maximum, or are less than the ambient background level in the particular waste streams as an average or maximum where there is no EQS/target. The contribution of these contaminants from waste streams prior to dilution in the cooling water flow are therefore considered to be insignificant both alone and in combination.

Table 2.6.1S16 - Contaminants in the Waste Streams prior to discharge into the cooling water flow which are < 10% of Target or the ambient Background level

Waste Stream A	Waste Stream B&C combined	Waste Stream D	Waste Stream B,C,D (if combined)	Waste Stream E	Waste Stream F	Waste Stream G
	Suspended Solids	Suspended Solids	Suspended Solids		Sulphates	Suspended Solids
	COD				Sodium	
	Aluminium				Suspended Solids	
					Chloride	

Based on this initial assessment of the concentration of contaminants prior to discharge, the contaminants in the effluent from different waste streams shown in the table above can be screened out as having no likely significant effect on the SAC.

The contaminants which remain a concern after dilution in either a cooling water flow of 116m^3/s or 60.4m^3/s are given below in Table 2.6.1S17. A criterion of 10% of the target concentration or ambient background levels has been used, but here a value of >10% is considered to be potentially significant, and warranting further consideration. This criterion of >10% for the target values is simply a screen to define the relative significance of the contaminant in the discharge. The main factor defining whether the contaminant has a likely significant effect is if the concentration exceeds the EQS or target. The >10% criterion in relation to ambient background levels defines whether the discharge could potentially cause a localised deterioration in water quality, and therefore needs to be considered further. However, this criterion needs to be balanced against the existing water quality, and the contaminant levels in the discharge relative to the EQS or target.

[3] AMEC 2012 H1 Assessment of Chemical Discharges from Hinkley Point C on the Marine Environment (incorporating revised dilution factors – March 2012).
[4] AMEC 2010. Summary of Marine Surface Water Quality Non-Radiochemical Analysis Results (Campaigns 1-4 including WFD). Report reference 15011/TN/00081. August 2010.

Table 2.6.1S17 - Contaminants in the Waste Streams after dilution in the cooling water which are >10% of Target or Background

Waste Stream A		Waste Stream B&C combined		Waste Stream D		Waste Stream B&C&D (if combined)		Waste Stream F	
Target Value	Background	Target Value	Background	Target Value	Background	Target Value	Background	Target Value	Background
Excess Temperature	Excess Temperature	Hydrazine		Hydrazine		Hydrazine			Iron
TRO	TRO	Morpholine	Morpholine	Morpholine	Morpholine	Morpholine	Morpholine		
		Ethanolamine	Ethanolamine	Ethanolamine	Ethanolamine	Ethanolamine	Ethanolamine		
			Phosphate		Phosphate		Phosphate		
			Detergents				Detergents		
					Chromium		Chromium		

None of the contaminants in Waste Streams E and G are greater than 10% of either the target values or the ambient background levels after dilution in the cooling water.

Waste Stream A

Excess Temperature and Total Residual Oxidant
Both the excess temperature and TRO exceed the relevant targets in the receiving water. This waste stream and its contaminants therefore have a likely significant effect on the integrity of the SAC and need to have an appropriate assessment.

Waste Stream B&C combined and D

Hydrazine
Hydrazine exceeds both the average and maximum target values by a significant amount, indicating that further dilution and decay of the discharge would be required. It should be noted here, however, that treatment has been proposed by the developer in the permit application, but what form this treatment will take is not yet finalised. The potential impact of hydrazine could therefore be mitigated through treatment.

The contribution of the discharge of hydrazine relative to the ambient background levels does not appear to be significant, being less than 10%. However, the level of detection of 100µg/l used in the survey work was very large compared with the target level, so that it is not possible to determine whether the proposed discharge would be a deterioration.

Since the proposed discharge exceeds the average and maximum target values, it is considered that it could have a likely significant effect on the integrity of the site, and therefore needs to have an appropriate assessment.

Morpholine
The average concentration of morpholine in the waste stream represents a contribution of 5.38% compared with the average target value and 9.15% compared with the average ambient background concentration. However, the maximum concentration is greater than the maximum target value, being 126.27%, and is also greater than the maximum ambient background, being 353.55%.

There are no known inputs of morpholine to the SAC which could act in combination with the proposed discharge from Hinkley Point C . However, as the maximum concentration could exceed the maximum target value, there could be a likely significant effect on the integrity of the site due to the discharge of morpholine, so that it needs to have an appropriate assessment.

Ethanolamine
The average concentration of ethanolamine in the waste stream represents a contribution of 3.14% compared with the average target value and 5.02% compared with the average ambient background concentration. However, the maximum concentration is greater than 10% of the maximum target value, being 59.28%, and is also greater than 10% of the maximum ambient background, being 94.85%. This indicates that there may be some intermittent marginal deterioration at the point of discharge compared with ambient background levels, and that the discharge could reach over 50% of the maximum target value.

However, there are no known inputs of ethanolamine to the SAC which could act in combination with the proposed discharge from Hinkley Point C.

Based on the loadings information provided, and assuming that the maximum daily load is being discharged into the minimum cooling water flow, the potential frequency of occurrence of this maximum concentration is about 35 days per year. This would represent a worst case situation, and on average there will be no significant deterioration.

It is therefore concluded that the discharge of ethanolamine does not have a likely significant effect on the integrity of the site.

Detergents
The average concentration of detergents in the waste stream represents a contribution of 1.75% compared with the average ambient concentration. However, for maximum concentration of detergents is more than 10% of the maximum ambient background, being 103.5%. This indicates that there may be some intermittent marginal deterioration at the point of discharge compared with ambient background levels. There are no targets for detergents with which to compare the concentrations in the waste stream.

Based on the loadings information provided, and assuming that the maximum daily load is being discharged into the minimum cooling water flow, the potential frequency of occurrence of this maximum concentration is only about 10 days per year. This would represent a worst case situation, and on average there will be no significant deterioration.

There are no known inputs of detergents to the SAC which could act in combination with the proposed discharge from Hinkley Point C.

It is therefore concluded that the discharge of detergents does not have a likely significant effect on the integrity of the site.

Phosphate
The average concentration of phosphate in the waste stream represents a contribution of <1% compared with the average ambient concentration. However, the maximum concentration of phosphate is more than 10% of the ambient background, being 31.5%. This indicates that there may be some intermittent marginal deterioration at the point of discharge. Based on the loadings information provided, and assuming that the maximum daily load is being discharged into the minimum cooling water flow, the potential frequency of occurrence of this maximum concentration is only about 2 days per year. This would represent a worst case situation, and on average there will be no significant deterioration.

It is therefore concluded that the discharge of phosphate does not have a likely significant effect on the integrity of the site.

Chromium
The average and maximum concentration of chromium are more than 10% of the ambient background, being 22.9% and 54.3% respectively. However, the concentrations in the discharge are very low, being only 0.03% and 4.34% of the EQS of 15µg/l. This indicates that while there may be an intermittent marginal deterioration in water quality in relation to ambient levels at the point of discharge, it is not significant in relation to the EQS.

It is therefore concluded that the discharge of chromium does not have a likely significant effect on the integrity of the site. This conclusion is supported by a comparison of the loading of chromium from Hinkley Point C with the overall loadings to the Severn Estuary SAC, which is provided in Section c) below. The potential input from Hinkley Point C represents 0.05% of the total loading to the Severn Estuary SAC, so that in combination with other inputs, the input from HPC is not significant.

Mercury
The annual and maximum concentrations of mercury are less than 1% compared with both the EQSs and the ambient background levels. However, mercury is being considered here, because of the ambient background levels in the receieving waters of the Bristol Channel. The MAC of the EQS is exceeded in the receiving waters, based on the marine water quality monitoring data collected in 2009 (Amec 2010)[4]. 4 exceedances of the MAC were reported; 3 from the sampling in January and 1 from the sampling in May. In contrast, no exceedances were recorded from the sampling in June and September. Occasional high values for dissolved mercury, which would have exceeded the current MAC, were also noted at various locations from the marine water quality sampling in 2004 to 2005, which was carried out throughout the SAC for the Review of Consents[7]. The occasional high values occurred at different locations at various times of the year, and did not appear to be related to specific discharges. This type of occurrence would suggest that mercury is being intermittently adsorbed and desorbed from the fine sediments in the Severn Estuary and Inner Bristol Channel, probably as a consequence of intermittent deposition and erosion, although the exact mechanisms are not fully understood. Copper shows a similar behaviour in the Severn Estuary (Jonas and Millward 2010)[a]. (Jonas P.J.C. and Millward G.E. 2010. Metals and nutrients in the Severn Estuary and Bristol Channel: Contemporary inputs and distributions. Marine Pollution Bulletin 61, 52-67)

It would therefore appear that the exceedances of mercury reflect the effect of biogeochemical processes in the Severn Estuary and Inner Bristol Channel on the historical legacy of mercury, which was discharged from a variety of sources, but which is now intimately associated with the fine sediments.

The concentrations of mercury in the proposed discharge from Hinkley Point C compared with the EQSs are very small, being 0.05% of the Annual Average, and 0.28% of the MAC. This would suggest that the effective contribution of mercury from Hinkley Point C will be insignificant, and it is concluded that the discharge of mercury has no likely significant effect on the integrity of the SAC.

It should also be borne in mind that the cadmium and mercury are predominantly impurities in the chemicals used in ion-exchange treatment processes related to the waste streams B&C combined and D . It would be prudent for the developer to source chemicals in ion-exchange treatment processes with the lowest level of metal impurities, particularly mercury and cadmium. This requirement has been identified as a pre-operational condition (PO12) in the Draft Permit.

Waste Stream F

Iron
The average and maximum concentration of iron are more than 10% of the ambient background, being 93.15% and 59.88% respectively. However, the concentrations in the discharge are very low, being 1.3% and 4.8% of the EQS of 1000µg/l. This indicates that while there may be a very slight deterioration in water quality in relation to ambient levels at the point of discharge, it is not significant in relation to the EQS.

The potential input from Hinkley Point C represents <1% of the total loading to the Severn Estuary SAC, so that in combination with other inputs, and given the ubiquitous distribution of iron and its abundance in the sediments of the Severn Estuary, the input from HPC is not significant.

It is therefore concluded that the discharge of iron does not have a likely significant effect on the integrity of the site.

c) Loadings of Various Contaminants from Hinkley Point C

The total predicted loadings of various contaminants in the Waste Streams from Hinkley Point C have also been compared with the total measured loadings to the Severn Estuary SAC, in order to assess the potential increase in loadings due to Hinkley Point C. The background water quality within the SAC generally reflects the overall inputs, due to the nature of mixing in the SAC, and the effects of individual discharges tend to be very localised (see eg. Langston *et al* 2007). It is therefore considered reasonable to compare the inputs from Hinkley Point C with the total loadings to the SAC.

The total loadings for a variety of contaminants to the Severn Estuary SAC were calculated for the Review of Consents which was reported in May 2009, and finalised in November 2009 (EA 2009)[40]. The relevant contaminants for this comparison are: BOD (and COD), Inorganic Nitrogen as N, Ammonia as N, Inorganic Phosphate as P, Cadmium, Chromium, Copper, Mercury, Lead, and Zinc. The measured loadings for the Review of Consents were calculated using the average measured contaminant concentration in a discharge or a river and the average flow, except for some discharges where only the maximum flow was known. Since the Review of Consents, there have been closures of some industrial sites, notably Terra Nitrogen, Sevalco, and Rhodia Organique, all on Severnside, and Royal Ordnance near Bridgwater. The loadings from these sites have been removed from the total loadings to the SAC.

The resulting total annual measured loads for the various contaminants to the SAC as a daily load are given in Table 2.6.1S18 below, together with the total annual loadings from Hinkley Point C. The proportions as percentages that the proposed new inputs from Hinkley Point C would represent are also provided in the Table.

[4] EA 2009. Severn Estuary SAC & SPA Review of Consents Stage 3 Appropriate Assessment. November 2009

Table 2.6.1S18 – Annual loads from all waste streams compared with the total measured loads to the Severn Estuary SAC.

Contaminant	Total Measured Load from the Review of Consents (kg/d)	Annual Load from All Waste Streams (kg/d)	Annual Load as %age of Total Measured Load from the Review of Consents
BOD	55812.449	3.500	0.006
Inorganic Nitrogen as N	155753.046	34.385	0.022
Ammonia	10355.022	31.255	0.302
Inorganic Phosphate as P	9423.372	11.613	0.123
Cadmium	2.407	0.001	0.042
Chromium	46.969	0.023	0.049
Copper	102.833	0.001	0.001
Mercury	0.762	0.000	0.036
Lead	77.341	0.001	0.001
Zinc	447.500	0.016	0.004
BOD and COD	55812.449	17.337	0.031

It is apparent that the annual load from Hinkley Point C as a percentage of the Total Measured Load of each contaminant to the SAC is less than 0.1% with the exception of Inorganic Phosphate which is 0.12%, and Ammonia which is 0.302%. These potential inputs from Hinkley Point C are not considered to be significant, when considered in combination with the other inputs.

d) Conclusions

The only waste streams and contaminants which are considered to have a likely significant effect are the excess temperature and TRO in Waste Stream A, and hydrazine and morpholine in Waste Stream B,C,& D. No other contaminants in any of the other waste streams are considered to have a likely significant effect on the integrity of the Severn Estuary SAC.

2.6.1.3 'Appropriate Assessment' of Operational Discharges in relation to the Estuaries Feature

Modelling of the Discharges

Most of the modelling undertaken to assess the impact of the thermal and chemical plumes from HPC has used a site specific model based on the modelling structure, known as the General Estuarine Transport Model (GETM). This was set up by outside consultants for Cefas who audited the model (BEEMS TR102 2011)[41]. The model was set up to run for a year, using meteorological forcing data obtained from the European Centre for Medium-range Weather Forecasting. In addition, a Delft 3D model was set up by APBMer for use over shorter time periods, mainly a spring to neap tidal cycle of a fortnight. Both models were assessed in the BEEMS report TR040 v2 (2008)[42]. The modelling output for most of the assessment is reported in BEEMS TR177 (2011) [43]and TR 186 (2011)[44].

a) Toxic contamination (synthetic and non-synthetic compounds)

Conservation objectives

- *The total extent of the estuary is maintained;*
- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *Toxic contaminants in water column and sediment are below levels, which would pose a risk to the ecological objectives;*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained.*

Natural England & Countryside Council for Wales, 2009

The only toxic contaminants which were not screened out in the LSE assessment above are TRO in Waste Stream A (the returned abstracted cooling water), and hydrazine in Waste Stream B,C, & D after discharge into the returned cooling water.

There are 2 aspects concerning the potential impacts of toxic contaminants within the cooling water discharge: one relates to the impact of the contaminants within the cooling water plume on the receiving water and the sea bed as the plume dilutes and disperses, and the contaminants decay; the other relates to the impact of the contaminants on entrained organisms within the cooling water system prior to discharge.

The impact of the first aspect is considered here, while the assessment of entrainment impact is considered in Section 6.10.7. The combined effects of the two aspects are also considered in Section 6.10.7.

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[41] BEEMS Technical Report 102: A Consideration of "Extreme Events" at Hinkley Point, Somerset, With Particular Reference to Coastal Flooding and Coastal Change. 2010.

[42] BEEMS Technical Report TR040. HP Thermal Plume Modelling: Stage 2 Review - Initial evaluation of the Stage 2 models. EDF BEEMS (Cefas).

[43] BEEMS Technical Report 177: Hinkley Point Thermal Plume Modelling: GETM Stage 3a results with the final cooling water configuration. EDF BEEMS (Cefas). 2010.

[44] BEEMS Technical Report 186 (TR186), Predicted Effects of New Nuclear Build on Water Quality at Hinkley Point. EDF BEEMS (Cefas). 2010.

As the levels of these contaminants exceed their respective targets in the discharge of cooling water, there is a need to define the extent of the contaminant plumes, and the areas at the sea surface and sea bed where the relevant targets are exceeded; i.e. the size of the mixing zones. These provide an initial assessment of whether the likely scale of an impact is significant, and whether there may be an adverse effect on the integrity of the site.

The mixing zone for morpholine only relates to the potential maximum concentration in the discharge, as the average concentration does not exceed the average target value. The exceedance of the maximum is small, with the maximum concentration being estimated as 35.35µg/l compared with the acute Probable No Effects Concentration (PNEC) of 28µg/l. A dilution of about 1.26 is therefore required to achieve the acute PNEC. From the dilution assessment given in BEEMS SPP068/S (2012), this dilution would be achieved within 100m of the discharge point. The extent of any mixing zone is therefore predicted to be less than 1 ha. This area is not considered to be significant with respect to the area of the Severn Estuary SAC in relation to either the Estuaries feature, or the subtidal sandbanks feature. It is considered that the mixing zone would not impact any other features of the SAC.

Mixing zones have been defined for both TRO and hydrazine using modelling output from GETM (BEEMS TR186)[23]. An average cooling water flow of 125m^3/s was used for the modelling of the plumes for both TRO and hydrazine.

The size of the mixing zones and their relationship with the various habitats are shown in Figures 2.6.1S19A and B. The extent of these mixing zones in hectares is given in Table 2.6.1S20 below, while the percentages that these areas represent of the Estuaries interest feature are given in Table 2.6.1S21. The TRO mixing zone has been calculated using an initial concentration in the cooling water of 0.2 mg/l with the target being 10µg/l as a 95%ile. It should be noted for the potential mixing zone for TRO that the use of chlorination for the cooling water discharge at HPC may not be required, as chlorination has never been used at HPB. The requirement for the use of any chlorination at HPC will be carefully monitored and there will have to be a demonstrable need for its use, before it will be used.

The hydrazine mixing zone was modelled using either an initial concentration of 0.01µg/l or one of 0.0071µg/l; it is not clear from the text and tables in BEEMS TR186. From Table C2 within that report, an initial concentration of 0.01µg/l should have been used. It is assumed that value was used for the modelling. If it was not then the area of the mixing zone would be slightly larger than that given in the Table 2.6.1S20 and Figure 2.6.1S19A. The target values for this average scenario would be an average of 0.0004µg/l hydrazine (the chronic PNEC), although the acute PNEC of 0.004µg/l hydrazine has also been used as a target, as a 95%ile. However what has not been modelled is the maximum concentration against the acute PNEC. In Table C2 with TR186, the maximum concentration in the cooling water is predicted to be 1.53µg/l, based on a cooling water flow of 60.4m^3/s. The loading from this scenario is about 40 times greater than that for the average scenario. The size of the potential mixing zone related to this initial concentration is therefore certainly larger than in Table 2.6.1S20, to the order of about 40 times.

Table 2.6.1S20 – Extent of mixing zones for TRO and hydrazine in hectares

	Total Extent of Mixing Zone ha	Mixing Zone in the SAC ha
TRO Surface	159	139
TRO Bed	63	60
Hydrazine Surface	191	161
Hydrazine Bed	77	77

Table 2.6.1S21 – Extent of TRO and hydrazine mixing zones as a percentage of Estuaries feature

	Total Extent of Mixing Zone as a %age of the Estuaries feature	Mixing Zone in the SAC as a %age of the Estuaries feature
TRO Surface	0.216	0.189
TRO Bed	0.086	0.081
Hydrazine Surface	0.259	0.219
Hydrazine Bed	0.105	0.105

These areas and percentages on the face of it are not significant, being less than 0.3% of the Estuaries feature, and the mixing zones do not affect the more sensitive intertidal habitats of Bridgwater Bay. However, the potential area of the mixing zone for the maximum concentration of hydrazine in relation to the acute PNEC is potentially significant, and could be more than 10% of the Estuaries feature. While this is only an estimate of the potential size of the mixing zone for hydrazine, the uncertainty introduced needs to be addressed, as it is not possible with the available information to conclude that the discharge of hydrazine does not have an adverse effect on the integrity of the site. The simplest option to manage this uncertainty is to mitigate the discharge of hydrazine through treatment of Waste Stream B,C, & D and reduce the concentration of hydrazine at source. It is recognised that EDF are assessing options for treating hydrazine. However, this assessment indicates that some form of treatment to reduce the discharge of hydrazine must be in place prior to any discharges taking place. We will eliminate this potential impact by including a requirement within the operational Water Discharge Activity permit to require removal of hydrazine prior to discharge.

Because of the reactions of chlorine or hypochlorite with bromide ions in seawater, many of the chemical by-products produced due to the chlorination of seawater and subsequent reactions with organic matter and ammonia are organo-bromine compounds. Four major groups of halogenated chemical species have been identified which could be formed by the chlorination of seawater; trihalomethanes, haloacetic acids, haloacetonitriles, and halophenols (BEEMS SAR009 2011)[45]. In studies of the chlorination by-products (CBPs) in chlorinated cooling water discharges at 10 power stations across Europe, the most commonly found CPBs are bromoform, dibromoacetonitrile (DBAN), dibromochloromethane, bromodichloromethane, and 2,4,6-trichlorophenol (Jenner *et al* 1997)[16]. In terms of

[45] BEEMS Scientific Advisory Report Series SAR 009. Chlorination by-products in power station cooling waters. EDF BEEMS (Expert Panel), 2011

concentrations, based on a mean chlorine dosage of 0.5mg/l to 1.5mg/l, bromoform had the highest concentration with a mean of 16.32µg/l, DBAN the second highest with a mean of 1.48µg/l, while the other 3 compounds were all <1µg/l.

Based on the expected level of bromoform in the cooling water discharge of about 30µg/l, and a proposed PNEC of 5µg/l, it was concluded in BEEMS TR186 (2011) that the mixing zone for a bromoform plume would be similar in size to that for TRO, and would therefore be coincident. As the area affected by the TRO is relatively small, and does not affect the more sensitive intertidal area of Stert Flats, the mixing zone for CPBs are also not considered to be significant.

However, to ensure chlorine dosing is controlled should it be required, we will ensure that a dosing regime is written up and agreed with the Environment Agency as part of a requirement under the Environmental Permit.

Conclusion

Based on the potential area of impact for TRO and associated CBPs, it is concluded that toxic contamination from the operational discharges from HPC alone will not compromise the conservation objectives for the Estuaries feature, and will not have an adverse effect on site integrity.

However, we have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Required mitigation

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

b) Non toxic contamination (Nutrient enrichment and organic loading)

- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009

Based on the assessment in Section 2.6.1, neither the increase in nutrient inputs nor the increase in organic load arising from the operational discharges from HPC are considered to have a likely significant effect on the integrity of the Severn Estuary SAC.

Conclusion

Based on the increase in nutrients and organic loading from the operational discharges from HPC, it is concluded that non toxic contamination from the operational discharges from HPC alone will not compromise the conservation objectives for the Estuaries feature, and will not have an adverse effect on site integrity.

Figure 2.6.1S19A – extent of TRO mixing zone and relationship to Habitat features

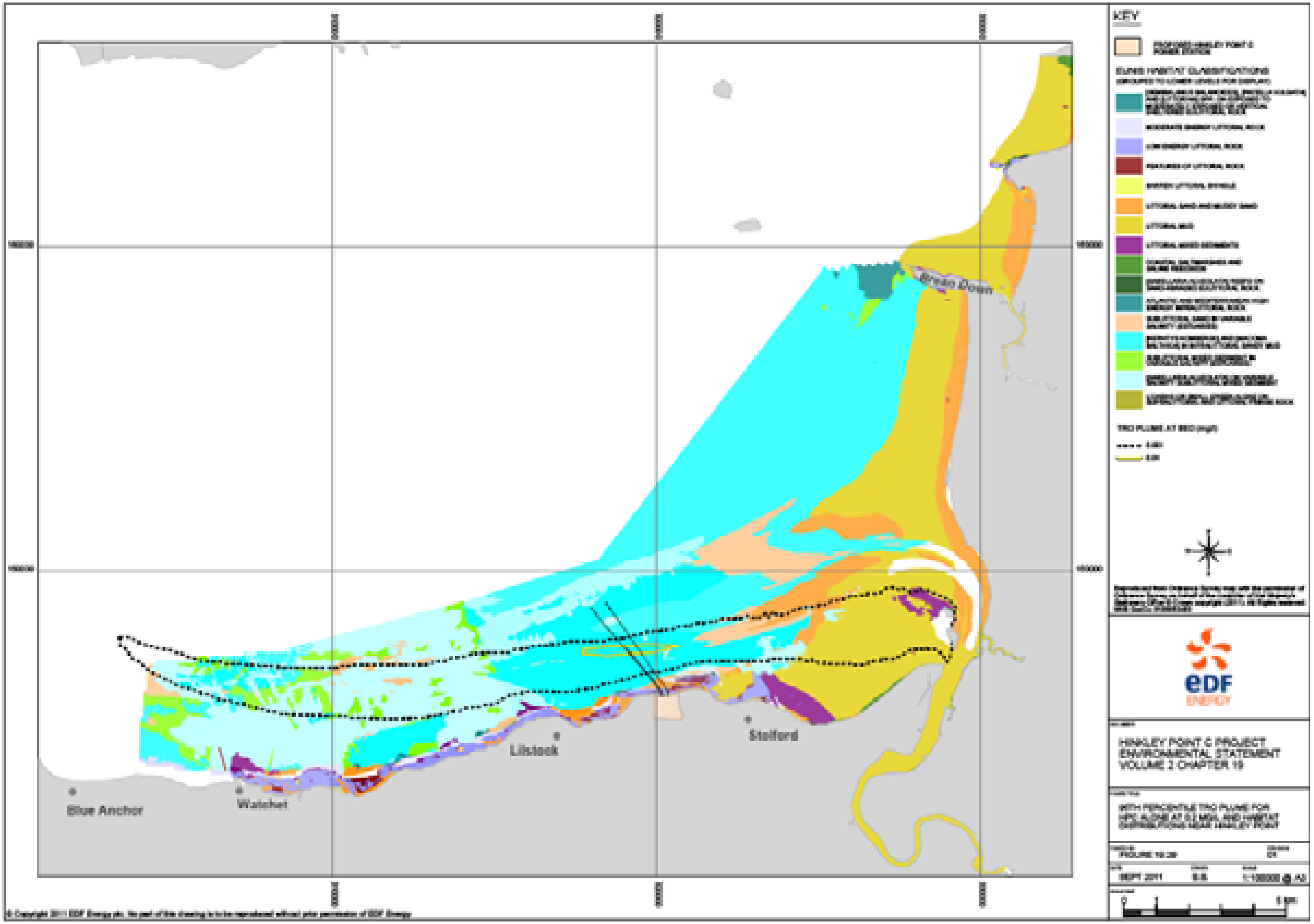
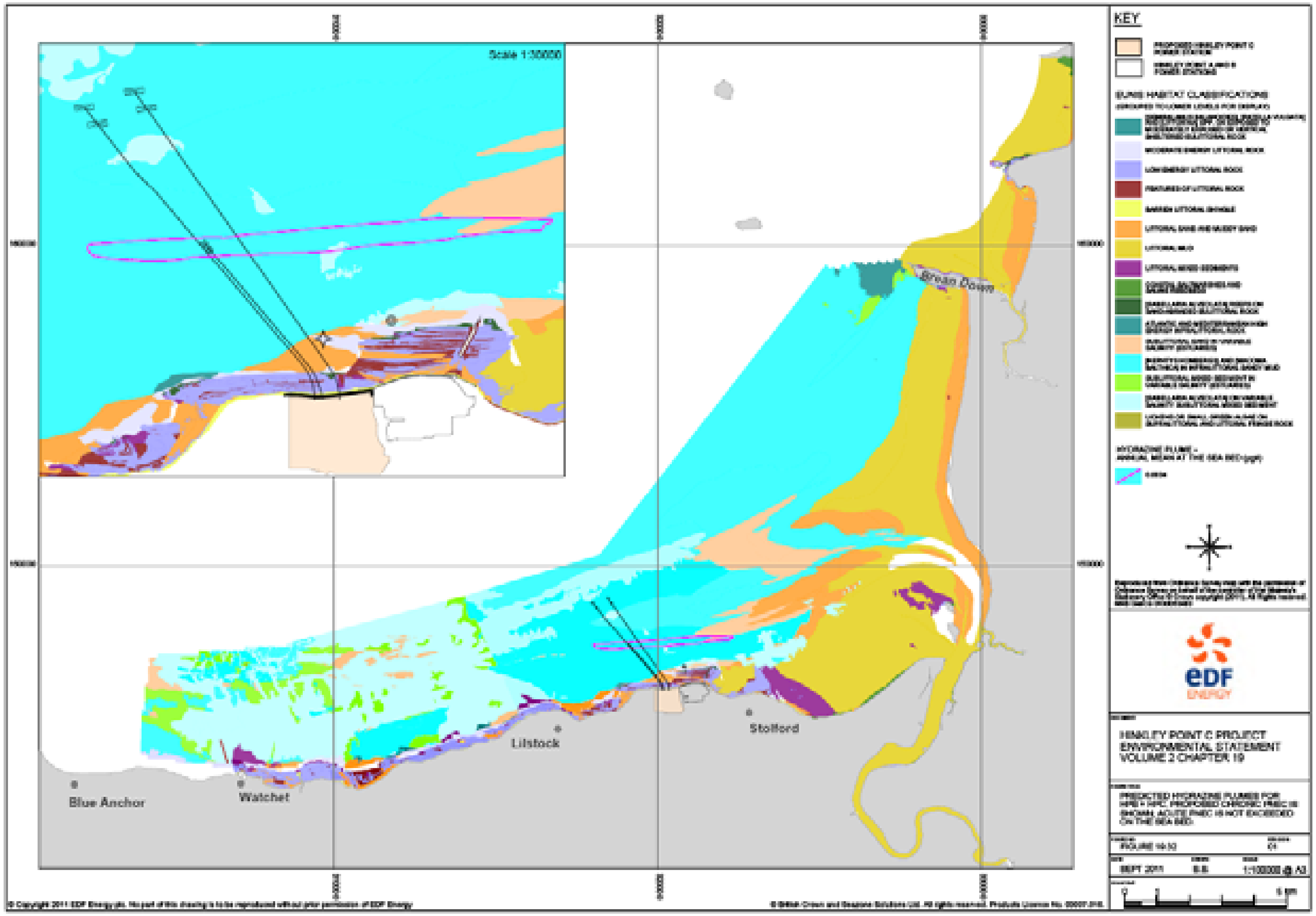


Figure 2.6.1S19B – extent of hydrazine mixing zone and relationship to Habitat features



c) Changes to thermal regime

- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009

It was not possible to screen out a Likely Significant effect as a result of the changes to the thermal regime arising from the cooling water discharge from HPC. This was due to the expected temperature differential exceeding the target of 2ºC, and the expected maximum temperature in the cooling water discharge exceeding the target maximum temperature of 21.5ºC. There are 2 aspects relating to the impact of excess temperature: those relating to the thermal plume on the water column and the sea bed in the receiving waters following discharge through the outfall; and those relating to the thermal shock to entrained organisms within the cooling water system prior to discharge. The first aspect is considered here, while the assessment of entrainment impact is considered in Section 6.10.7. The combined effects of the two aspects are also considered in Section 6.10.7.

Once the cooling water is discharged through the outfall, the temperature will start to decrease due to mixing with ambient water and heat loss at the surface to the atmosphere. Very high temperatures will therefore only occur within the cooling water in the outfall tunnels downstream of the condensers. The organisms which will experience the greatest temperatures will therefore be those entrained in the abstracted cooling water.

From earlier work on the impact of thermal plumes, it has been considered that free-swimming organisms tend to avoid areas where water temperatures are elevated, while any planktonic organisms in the water column will only receive a generally small increase in temperature, as the thermal plume mixes with ambient sea water. Following any initial temperature increase, subsequent mixing will decrease this initial temperature rise, so that the impact will not be sustained.

The main area of impact of the thermal plume is considered to be the sea bed, and hence the benthic ecology, as this can be subjected to a persistent temperature increase, depending on the behaviour and mixing of the thermal plume. The potential impacts of the thermal plume on the communities in the sub-tidal and intertidal habitats are discussed under the specific interest features, sub-tidal sandbanks and intertidal mudflats and sandflats. In relation to the Estuaries feature, the initial test is the size of the mixing zones in relation to the target values in WQTAG Paper 160.

To assess the scale of impact of the elevated temperatures in the cooling water discharge, modelling of the cooling water plume has been undertaken using both the GETM model and a Delft 3D model. This modelling work has allowed the definition of the mixing zones in relation to the temperature differential target (ΔT) of 2ºC and the maximum temperature of 21.5ºC as a 98%ile. There is an additional consideration concerning the mixing zone for a ΔT of 2ºC, which relates to the passage of migratory fish in estuaries and the potential for thermal barriers in estuaries and rivers (Turnpenny and Liney 2006)[46]. In this test, the

[46] Turnpenny, A.W.H. and Liney, K.E. 2006. Review and development of temperature standards for marine and freshwater environments. Report for SNIFFER, 70pp.

cross-sectional areas of the estuary must not be affected by a temperature increase of >2ºC across >25% of a cross-section for >5% of the time. This test has been applied to 4 sections across the Inner Bristol Channel and the Parrett Estuary (see Figure 2.6.3.1S22).

The size of the thermal plume at various temperature differentials and their relationship with the various habitats are shown in Figure 2.6.1S22. The extents of the mixing zones for a ∆T of 2ºC and a maximum temperature of 21.5ºC as a 98%ile are given for the surface and the sea bed for the SAC and the SPA in 2.6.1S23 below. The extents for the SPA give the effective area of intertidal zone affected by the mixing zones. Also included is the total area of the mixing zones, ie. including that area lying outside the SAC. This data is derived from the model output from GETM, as this model is considered to be more precautionary than the Delft 3D model; ie. the extents of the mixing zones are greater using GETM than those using Delft 3D. It should also be noted that the mixing zone for the maximum temperature of 21.5ºC as a 98%ile has been determined using a temperature differential of 1.1ºC, based on the fact that the 98%ile of mean monthly temperatures from the Hinkley long-term time series is 20.4ºC.

Table 2.6.1S23 – extent of thermal mixing zone on surface and sea bed

	Extent of MZ for ∆T of 2ºC - ha			**Extent of MZ for Max Temp of 21.5ºC as a 98%ile - ha**		
	Total	SAC	SPA	Total	SAC	SPA
Surface	580	573	237	3388	2408	1377
Sea Bed	531	528	307	3277	2452	1510

The relative proportions of these areas for the Total Mixing Zone and the Mixing Zone within the SAC have been compared with area of the Estuaries feature, while the mixing zones affecting the SPA have been compared with the area of the SPA. The resulting percentages are given in 2.6.1S24 below.

Table 2.6.1S24 – extent of thermal mixing zone as a percentage of the Estuaries feature.

	Extent of MZ for ∆T of 2ºC - %age of Estuaries feature or SPA			**Extent of MZ for Max Temp of 21.5ºC as a 98%ile - %age of Estuaries feature or SPA**		
	Total	SAC	SPA	Total	SAC	SPA
Surface	0.79	0.78	0.96	4.60	3.27	5.58
Sea Bed	0.72	0.72	1.24	4.45	3.33	6.12

These percentages show that the mixing zone for a ∆T of 2ºC is less than 1% of the Estuaries, but at or just greater than 1% for the SPA, which equates approximately to the intertidal area. However, the percentages for the maximum temperature of 21.5ºC as a 98%ile are greater than 1% for both the Estuaries feature and the SPA. These percentages for the maximum temperature of 21.5ºC as a 98%ile are relatively large compared with those for a ∆T of 2ºC , but the question for both of them is 'are they acceptable or not?' This is discussed in detail in the sections relating to the specific interest features: ie. the sub-tidal sandflats (Section 2.6.3) and intertidal mudflats and sandflats (Sections 2.6.2), as these features are potentially more sensitive to changes in the thermal regime.

The potential for the formation of thermal barriers is also not discussed here, but is considered in the section on the Migratory Fish interest feature (Section 2.6.5), as the potential for thermal occlusion relates specifically to the passage of migratory fish.

DO and Ammonia
Increasing temperature affects both the solubility of oxygen in seawater, as well as the speciation of ammonia. For dissolved oxygen (DO), increasing the seawater temperature reduces the amount of oxygen held in solution. For ammonia, increasing the seawater temperature increases the proportion of ammonia which is unionised; unionised ammonia is the more toxic form.

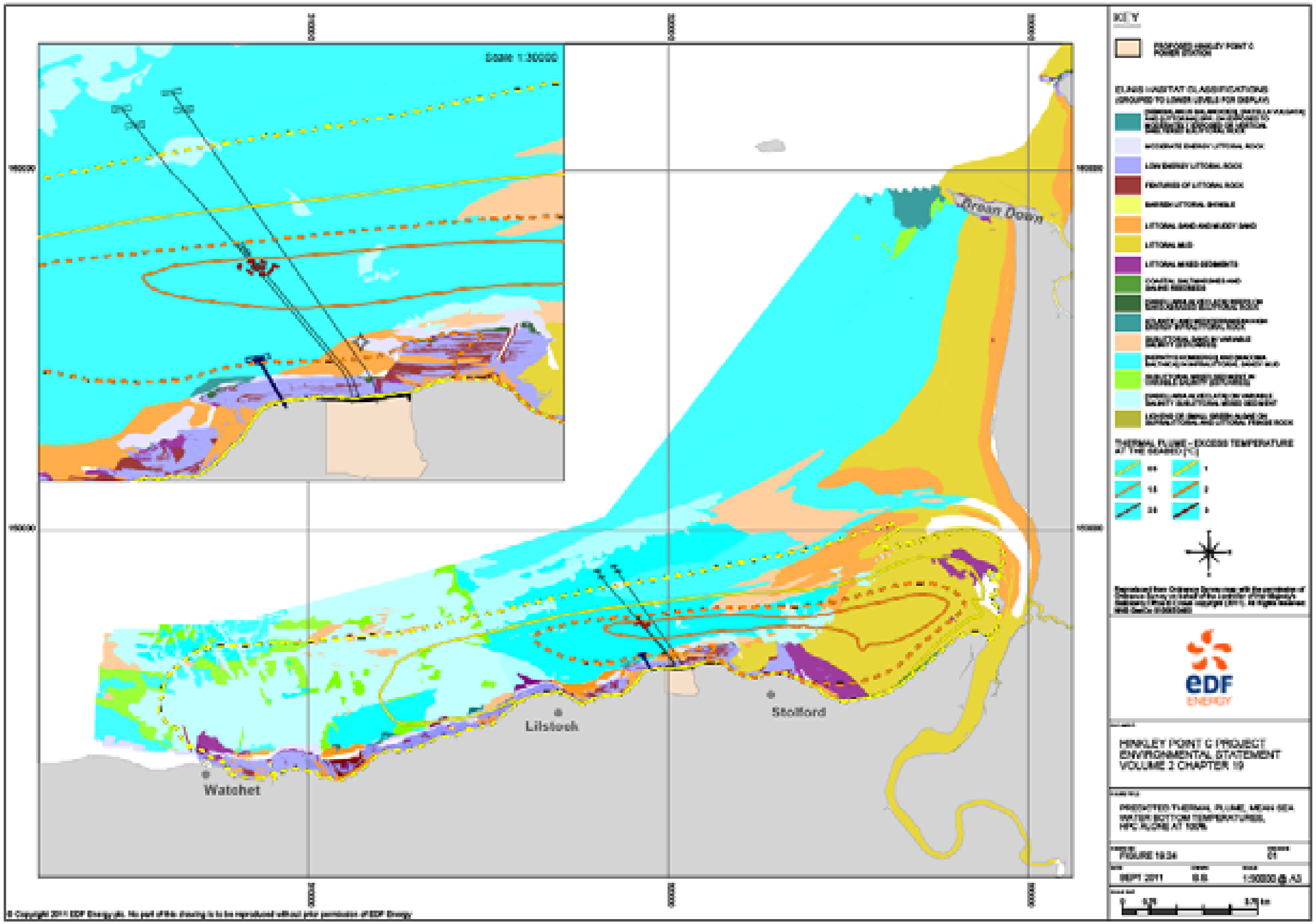
In order to assess the effect of increasing temperature on the waters off Hinkley, DO data collected by the EA from 6 sites in the vicinity if Bridgwater Bay have been considered. The data has been collected each month over the period 2007 to 2010, although some data was collected at a few sites in 2004 and 2005. The minimum DO concentration from the data was 7.01mg/l and the 5%ile DO concentration was 7.46mg/l. By increasing all the measured seawater temperatures by 3 ºC , and recalculating the DO using the UNESCO formula[47] and the measured temperature and DO saturation level, the minimum DO concentration decreased to 6.59mg/l and the 5%ile DO concentration to 7.01mg/l. From the WQTAG Paper 88e on DO standards for Natura 2000 sites (WQTAG 2004), the 5%ile DO level is between about 5.1 and 5.5 mg/l for the salinities occurring off Hinkley. This suggests that the increase in temperature arising from the thermal plume from HPC will not affect the DO levels of the waters off Hinkley to a significant extent.

The same EA have been used to assess the effect of temperature on the speciation of ammonia in the waters off Hinkley. Using the measured temperature, salinity, and pH data, a mean and maximum value for the percentage of UIA has been calculated using the formula developed by Clegg and Whitfield (1995)[48]. The mean percentage was 2.3% and the maximum percentage was 4.4%. In order to result in a value of UIA of 21µg/l, the resulting total ammonia levels would have to be 922µg/l and 477µg/l. When the measured seawater temperatures are increased by 3ºC, the resulting mean percentage of UIA becomes 2.8% and the maximum percentage 5.4%. In order to result in a value of UIA of 21µg/l, the resulting total ammonia levels would have to be 737µg/l and 386µg/l. The maximum measured value for total ammonia (filtered) from the EA data was 45.7µg/l. This suggests that the effect of any temperature rise on the level of UIA in the waters off Hinkley due to the thermal discharge from HPC is very small, and does not result in any significant increase.

Conclusion
Although the size of the mixing zone for the thermal discharge from HPC alone is quite large, there is a lack of any significant effect from the present HPB discharge on the benthic communities in the sub-tidal area and intertidal mudflats and sandflats as a result of a similar scale of impact in terms of the temperature differential. Also there is only a minor effect from the temperature increase in the thermal plume on the DO and UIA levels in the waters off Hinkley. It is therefore concluded that the changes to the thermal regime due to the cooling water discharge from HPC alone does not compromise the conservation objectives of the Estuaries feature, and does not have an adverse effect on site integrity.

[47] UNESCO formula
[48] Clegg and Whitfield, 1995

Figure 2.6.1S22 – thermal mixing zones under different scenarios



d) Habitat Loss and Physical Damage

It was recognised in the Appendix 11 that there was a potential for physical damage due to the entrainment of planktonic organisms through the cooling water system. As the potential effect relates to entrainment, this is covered in this section 6.10.7.

e) Competition from non-native species

- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009

Thermal discharges have been associated with the establishment of introduced warm-water species for many years (Naylor, 1965[49]; Langford, 1983[50]; Bamber, 1993[51]). Potential effects of the successful invasion and establishment of exotic (non-native) species include replacement of indigenous species as a result of competition enhanced reproductive success, competition for space and food, alteration of habitat and introduction of diseases and parasites (Smith, 1995[52]; Langford, 1990[53]). Thus, animals may compete for habitats with preferential temperatures, to maximise growth and other fitness-enhancing traits that tend to be optimised when body temperature approaches the physiological thermal optimum for the species (Gilchrist, 1995)[54].

It is possible that the thermal discharge could encourage non-native species to be drawn into the area around Hinkley Point and Bridgwater Bay and compete for resources and therefore affect the composition of planktonic organisms within the estuary. Temperatures in certain habitats will be optimum for any given organism and therefore the subject of potential competition (Attrill & Power, 2004)[55]. The smaller organisms also have the potential to change the composition of fish (and bird) prey availability.

However, as discussed in the changes to thermal regime assessment (e) above, although the size of the mixing zone for the thermal discharge from HPC alone is quite large, there is a lack of any significant effect from the present HPB discharge on the benthic communities in the sub-tidal area and intertidal mudflats and sandflats as a result of a similar scale of impact in terms of the temperature differential.

To support this, Collins and Williams (1982)[56] looked at the species composition of zooplankton in the Severn Estuary and Bristol Channel and noted that the species

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[49] Naylor, E., (1965). Biological effects of heated effluent in docks at Swansea, S. Wales, Proc. Zool. Lond., 144(2), 253-68.
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[55] Attrill, M.J., Power, M. (2004) Partitioning of temperature resources amongst an estuarine fish assemblage. Estuarine, Coastal and Shelf Science 61 (2004) 725–738.
[56] Williams, R., and Collins, N.R. (1982). Zooplankton Communities in the Bristol Channel and Severn Estuary. Marine Ecology Vol.9: 1-11.

within the inner estuary (around Hinkley Point) and outer estuary zones were relatively consistent in terms of types of species, with the calanoid copepods (*Eurytemora Spp. Acartia bifilosa* Spp., *Centropages hamatus* and *Calanus helgolandicus) being the dominant species.* Although the number of individuals varied between zones and this was linked to changes in salinity through the Bristol Channel.

So whilst it is possible that the thermal plume may cause some localised changes in species composition around the outfall, any changes are not likely to be significant enough to cause an adverse effect on the estuaries feature.

Conclsion
It is therefore concluded that the changes to the thermal regime due to the cooling water discharge from HPC alone will not have a significant effect on the estuaries feature from the competition of non-native species, and will not have an adverse effect on site integrity.

Overall Conclusion
Based on the above assessment, it is concluded that none of the hazards which could affect the Estuaries feature compromise the conservation objectives of the Estuaries feature and would not have an adverse effect on site integrity, except for hydrazine in relation to toxic contamination.

For the discharge of hydrazine, we have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Hazard assessed	Adverse effect on estuaries feature?
Toxic contamination	Yes – Requirement to remove hydrazine via permit condition (see below)
Non-toxic contamination	No
Changes to thermal regime	No
Habitat loss & physical damage	No
Competition from non-native species	No
Overall conclusion	**With the permit condition in place we can conclude no adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Required mitigation *Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges*	Environment Agency	Operational Permit Ref: HP3228XT

2.6.1.4. Impact of abstraction on the Estuaries feature

The operation of Hinkley Point C (HPC) will require up to 134m³ of water per second for direct cooling, which will be abstracted from the Severn Estuary via a series of seabed intake structures and associated intake tunnels. Each UK EPR reactor unit will have a single dedicated intake tunnel with two dedicated seabed intakes. The tunnels extend approximately 3.4km and 3.5km from the foreshore high water mark and at a depth of approximately 20m below the seabed. At their seaward extent, the two intake tunnels will be 480m apart. The two sea bed intake heads associated with each intake tunnel will be separated by approximately 200m (see Figure 2.1.4.1 in section 2.1.4).

The abstraction of seawater from the Bristol Channel means that organisms present in the water will be drawn into the water intakes. These organisms can include anything from planktonic bacteria and algae to macro-invertebrates and fish. Larger organisms (>25mm length) will be impinged on the cooling water intake screens and removed from the fine-mesh (5mm) drum screen employed to prevent debris entering the cooling water heat exchangers. Smaller organisms, such as fish eggs and juveniles, are likely to penetrate the cooling water screens and will be taken through the cooling water system and returned via the thermal discharge to the estuary. This process is known as entrainment. Cefas conclude that, without mitigation, impingement at Hinkley Point C would increase about fourfold over that of Hinkley Point B (HPB) simply as a result of the increased abstraction of cooling water (Haskoning, 2011)[57]. The entrainment of organisms including fish eggs and larvae could also exacerbate the situation which would undoubtedly cause an impact to the estuarine and marine populations of the Severn Estuary.

Aside from the Habitats Directive, other key regulatory drivers for incorporating intake mitigations in the case of the Severn Estuary include the Salmon and Freshwater Fisheries Act 1975 [SFFA] (as amended by the Environment Act 1995), which requires intake fish screening on migratory salmonid rivers, the Water Framework Directive, which aims to achieve by 2015 Good Ecological Status/Potential in all UK waterbodies, and the European Eel Regulation 2010.

Entrainment assessments: Entrained phytoplankton and zooplankton are assessed under the estuaries feature, *Sabellaria* larvae are assessed under the reefs feature and juvenile fish and fish larvae/eggs are assessed under the migratory fish and fish assemblage section.

Impingement assessments: Impinged fish and crustaceans are assessed under the migratory fish and fish assemblage section

[57] Haskoning. (2011). Hinkley Point C Project: Report to inform the Habitats Regulations Assessment (HRA). Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. (Section 6.2.776 pg.336).

2.6.1.4.1 Abstraction impacts on planktonic organisms

Conservation objectives (see section 1.5.1)

- *The total extent of the estuary is maintained;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009[58]

a) Physical damage (entrainment of planktonic organisms)

Planktonic organisms make up an important component of the estuarine community. The HPC requirement for 134m^3 of water per second for direct cooling, will inevitably abstract a variety of these organisms from the water column, and those that are small enough to filter through the proposed 5mm drum screen will be entrained through the cooling water system via pumps, heat exchangers and other components, and will finally be returned via the thermal discharge to the estuary. This entrainment will subject these organisms to a number of factors that may affect the overall population numbers within the Severn Estuary, which could have implications for those species which rely on them higher up in the tropic food chain, such as fish and birds.

The following BEEMS technical papers have been used to support this assessment:

- BEEMS Science Advisory Report 005 (SAR005)[59]: Highlights the methodology for the measurement of entrainment used within the report to inform the HRA.
- BEEMS Technical Report 81 (TR081)[60]: Reviews the available literature from laboratory and power plant entrainment studies. The report identifies the major factors that can cause mortality (mechanical damage, pressure effects, thermal stress and the addition of biocides such as chlorine) and considers the evidence provided by the various studies that have been conducted to date.
- BEEMS Scientific Support Paper 063 (SPP063)[61]: Supports the assessments with further information on entrainment of organisms; and
- BEEMS Technical Report 065 edition 2 (TR065 ed2)[62]: looks at predictions of impingement and entrainment by new nuclear power station at Hinkley Point.

Other technical papers not listed above have also been used and they will be referenced throughout the assessment.

The main factors likely to affect the entrained organisms are:

- Mechanical stress – movement through 3.3 km of inlet tunnels through the cooling water system and back out through the 2 km long offshore discharge.
- Pressure change – changes in hydrostatic and hydrodynamic pressure caused by differences in level and by pumping.

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[58] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[59] BEEMS Science Advisory Report 005 (SAR005)[59] Methodology for the measurement of entrainment. Report for EDF. March 2011.

[60] BEEMS Technical Report 081 (TR081). Laboratory and Power Plant Based Entrainment Studies: A Literature Review. (2008) Cefas report prepared for EDF

[61] BEEMS Scientific Position Paper 063 (SPP063). Entrainment impact on organisms at Hinkley Point – supplementary note. October 2011. Cefas report prepared for EDF

[62] BEEMS Technical Report 065 eddition.2 (TR065 ed2). Predictions of impingement and entrainment by new nuclear power station at Hinkley Point. Cefas. September 2010

- Temperature shock – ambient temperature raised by up to about 12.5˚C (mean of 11.6˚C). The temperature differential will vary with the flow rate which is tidally dependent (see Section 2.6.1c), while the temperature shock can also vary with respect to the ambient (or acclimation) temperature.
- Chlorination – if biofouling becomes an issue HPC may need to chlorinate either at 0.2mg/l continuously or on a 50% duty cycle. Whilst under current conditions at Hinkley point chlorination is unlikely to be needed, it will still be assessed. It should be noted that the maximum concentration used to dose the discharge is quoted to be 0.5mg/l, although this concentration will reduce rapidly down to the required concentration of 0.2mg/l. As far as an entrained organism is concerned, therefore, it could be impacted by an initial concentration of 0.5mg/l near the condensers, which then decreases to a relatively constant value of 0.2mg/l during the rest of the organism's journey down the outfall.

The effects of these combined factors can be synergistic, for example increased temperature may increase the sensitivity of some organisms to chlorination. In general, with the exception of the egg stage, younger stages of organisms are more sensitive than older stages to entrainment effects so entrainment survival can be highly determined by the size and life stage of the organism/species. Entrainment effects and survival rates will also vary with the season. Animals entrained in winter are far less likely to suffer effects from temperature rise than in mid summer (SPP063) so maximum temperature exposure is important.

Table 2.6.1S23 below has been taken from a revised edition of SPP063 (Ed.2), which shows the predicted temperatures at the output of the HPC condensers in 2020 and 2085 based upon the specified mean ΔT of 11.6ºC in the HP C cooling water system. It is stated within SPP063 (Ed.2) that any organisms entrained through HPC will be exposed to this temperature for an 18 minute transit time from the condenser to the outfall, after which the temperature exposure will drop as heat is lost from the plume and/or the organism leaves the buoyant surface plume. For many, but not all organisms, exposure to temperatures greater than 30 to 33 ºC leads to increased mortality., which will be discussed later on. The HPC discharge temperature is predicted to exceed 30 ºC as a 95%ile from July to September in 2020 and from June to October in 2085 based upon UKCP09 projections.

Table 2.6.1S23 - Predicted HP C monthly discharge temperatures as a 95%ile.

Month	2020 HPC Discharge Temp ºC at ∆T=11.6ºC	2085 HPC Discharge Temp ºC at ∆T=11.6ºC
Jan	21.6	23.1
Feb	21.3	22.9
Mar	21.1	22.7
April	23.2	24.8
May	26.1	27.6
June	29.9	31.4
July	32.8	34.3
Aug	33.2	35.1
Sept	31.6	33.6
Oct	29.4	31.4
Nov	25.9	27.8
Dec	24.2	25.8

Organisms within the estuary that are likely to be entrained fall into three categories:

Phytoplankton – free floating microalgae (plants) that form an essential component of the marine food chain. These single-celled plants provide nourishment to many marine species and they also play an important role in regulating the amount of carbon in the atmosphere. There are two main types of the larger phytoplankton species; Diatoms and Dinoflagellates.

Zooplankton – free floating tiny animals that also form an essential component of the marine ecosystem. Zooplankton feed on phytoplankton and other planktonic organisms. The main species include copepods, mysids, decapods, amphipods, and include the larvae of crustaceans, gastropods, worms and fish. Also larvae of *Sabellaria spp*.

Juvenile fish – small enough to pass through the 5mm mesh on the drum screens.

Plankton are comprised of two main groups, permanent members of the plankton that are planktonic their entire life cycle, called holoplankton (such as diatoms, dinoflagellates, amphipods, krill, copepods, salps, etc.), and organisms that are planktonic for only part of their life cycle (such as most larval forms of sea urchins, sea stars, crustaceans, marine worms, some marine snails, most fish, etc.), which are called meroplankton. For the sake of this assessment we will divide the plankton into phytoplankton and zooplankton and we will only focus on the main groups present in the Severn Estuary.

Compared to impingement, fewer studies of entrainment rates at UK power stations have been reported. Entrainment is less visually obvious than impingement and sampling techniques are more difficult (Turnpenny *et al*, 2010)[63]. BEEMS Technical

[63] Turnpenny, A.W.H., Coughlan, J, Ng, B., Crews, P. Bamber, R.N., Rowles, P. (2010). Cooling water options for the new generation of nuclear power stations in the U.K. Environment Agency Science Report SC070015.

Report 081 (TR081)[64] provides an extensive summary of the large number of experimental determinations of entrainment mortalities that have been undertaken in the past. The three main approaches used within BEEMS Scientific Support Paper (SPP063) to assess entrainment effects are; intercepting a sample of CW flow with fine-meshed plankton nets to measure mortality directly after passage through the plant; laboratory ecotoxicology experiments and the use of the Entrainment Mimic Unit (EMU) that simulates conditions inside an operating system.

BEEMS Technical Report TR065[65] estimated the predicted zone that was at risk from cooling water abstraction as roughly equivalent to the plume volume at the 1˚C contour, of which 1.1% would be abstracted by HPC per day. This figure has been used within SPP063.

Descriptive and quantitative information regarding the geographical distribution, seasonal abundance and production of both phytoplankton and zooplankton within the Bristol Channel and Severn Estuary is limited (Joint & Pomroy, 1981[66]; Joint, 1984[67]). The various scientific literature show that seasonal distribution and abundance of planktonic organisms are strongly influenced by the extreme physical and chemical conditions such as high turbidity and wide salinity variations, which typify the Bristol Channel and Severn Estuary extensive tidal range (APEM, 2008)[68].

Williams and Collins (1986)[69] studied the seasonal composition of meroplankton and holoplankton in the Bristol channel, and they observed a decreasing graduation in the plankton stock of the channel from the seaward section to the inner, less saline, reaches. Referring to the subdivisions shown in Figure 2.6.1S24 annual production estimates for the Outer Channel and Inner Channel based on 14C-fixation experiments (excluding a large *Phaeocystis pouchetti* bloom) ranged from 164.9g C m^{-2} $y^{-}1$ in the Outer Channel (North and South) to 6.8g C m^{-2} $y^{-}1$ in the Inner Channel (Joint & Pomroy, 1981[70], Joint, 1984[71]). More than half (62%) of the annual production occurred in the Outer Channel in May and June, while the Inner Channel the major proportion (44%) of the production occurred during June and July (Williams & Collins, 1986). Primary production in the inner channel was only 4% of that in the outer channel due to rapid light attenuation and the rate of vertical mixing in the turbid waters of the inner channel. The studies suggest that zooplankton play a minor role in the Inner channel, and that benthic filter-feeding communities are presumed better adapted to exploit the heavy particulate load within the estuary, if suitable substrates are available for colonisation.

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[64] BEEMS Technical Report 081 (TR081). Laboratory and Power Plant Based Entrainment Studies: A Literature Review. (2008) Cefas report prepared for EDF.

[65] BEEMS Technical Report 065 eddition.2 (TR065 ed2). Predictions of impingement and entrainment by new nuclear power station at Hinkley Point. Cefas. September 2010.

[66] Joint, I.R. & Pomroy, A.J. (1981). Primary production in a turbid estuary. Estuarine and Coastal Shelf Science, 13, 303-316.

[67] Joint, I.R. (1984). The microbial ecology of the Bristol Channel. Marine Pollution Bulletin 15, 62-66.

[68] APEM (2008) Severn Tidal Power – Scoping Topic Paper – Migratory and estuarine fish (2010). (P&B, B&V consultants) Report prepared for DECC.

[69] Williams, R., Collins, N.R. (1986). Seasonal composition of meroplankton and holoplankton in the Bristol Channel. Marine Biology 92; 93-101.

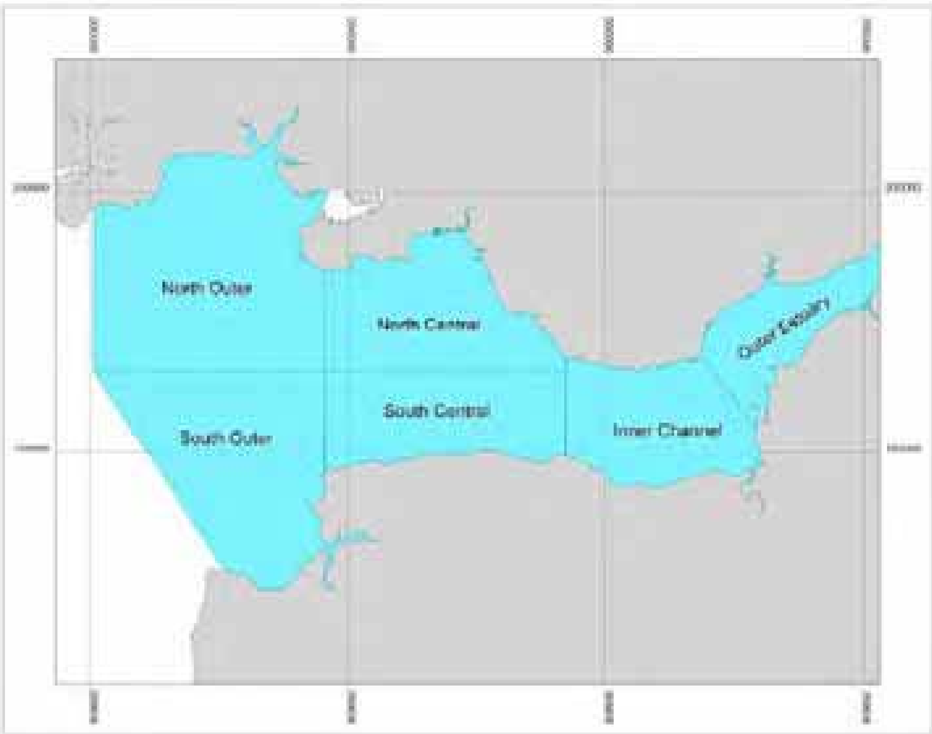
[70] Joint, I. Pomroy, A. (1981). Primary production in a turbid estuary. Estuary Coastal Shelf Science 13:303–316.

[71] Joint, I.R. (1984). The microbial ecology of the Bristol Channel. Marine Pollution Bulletin 15, 62-66.

Entrainment of phytoplankton

Phytoplankton are distributed throughout the Severn Estuary based on salinity gradients and water turbidity. Phytoplankton species composition is poorly understood (APEM, 2008). It is known that their occurrence is greatly influenced by the physical processes of the Bristol Channel and Severn Estuary. For example, the large tidal range and excursion maintain high concentrations of inorganic particles in suspension. This creates high turbidity, which severely limits light penetration and hence phytoplankton growth (Joint, 1984). Despite these limitations photosynthesis is still possible because rapid vertical mixing in the water column is sufficiently long to allow growth (Joint & Pomroy, 1981)[72].

Figure 2.6.1S24. Bristol Channel sub regions as defined by IMER (see Joint 1984[11]) figure taken from BEEMS SPP063)



From the surveys carried out between November 2008 and October 2009 for EDF (TR068v2)[73], a total of 21 species of phytoplankton were recorded off Hinkley Point. The most frequently recorded species was the diatom *Odontella regia* which was present at nearly all of the sites on each occasion. The densities of phytoplankton varied among sampling periods with the highest phytoplankton densities recorded in July 2009, at a mean density of 278 individuals per m^3 (TR068v2). Diatoms are considered important primary producers within the estuary and are typically suspended in the water before being deposited on mudflats after periods of rough weather (Hay *et al*, 1993)[74]. The presence of benthic cysts has indicated a poor abundance of dinoflagellates in the sediment of the Severn Estuary (Reid, 1972)[75].

[72] Joint, I. Pomroy, A. (1981). Primary production in a turbid estuary. Estuary Coastal Shelf Science 13:303–316.
[73] BEEMS Technical Report 68 v2 (TR068v2). An initial review of the effects of new nuclear build on the marine ecology of Hinkley Point and Bridgwater Bay. Cefas Report prepared for EDF.
[74] Hay, S.I., Maitland,T.C. & Paterson, D.M., 1993. The speed of diatom migration through natural and artificial substrata. Diatom Research, 8, 371-384.
[75] Reid, P.C., (1972). Dinoflagellate cyst distribution around the British Isles. Journal of Marine Biology Association UK, 52, 939–944.

EA sampling of the coastal waters of the Bridgwater Bay waterbody has shown that a range of diatoms are the predominant components of the phytoplankton, with the most common taxa appearing to be *Bacillaria*, *Coscinodiscus*, *Fragilaria*, *Naviculaceae, Paralia*, and *Skeletonema*. However, occasionally other diatom species have been recorded in large numbers, e.g. *Chaetoceras* . Cryptomonads (notably *Rhodomonas*) have also been recorded as a common component of the phytoplankton, and often in very large numbers. Dinoflagellates occur only occasionally.

Marcy et al (1978)[76] reviewed entrainment literature from several power stations across the United States, which included studies of phytoplankton. However, the literature appeared to conflict on the results, which may have been because the power stations were a mix of coastal, estuarine and lakeside with varying abstraction rates and so forth. At two power stations phytoplankton productivity was stimulated between 18 and 30%, while at six stations mortality ranged from 11 to 100% and averaged at about 55%. Entrainment studies of marine phytoplankton passing through two southern California coastal plants indicate that plant (phytoplankton) passage disrupted the community severely by reducing diversity, promoting differential survival of some species and reinforcing the dominance of the two major species (Briand, 1975)[77]. Mortalities, a portion of which were physically related, approached 42% during passage. As a result of his findings, (Briand, 1975) advocates using deep sea water rather than shore zones for cooling water.

BEEMS Technical Report 081[78] reports on a series of experiments at Fawley power station by Davies, (1983)[79], which demonstrated that, in the absence of chlorination, primary production was enhanced by increased water temperature up to a discharge temperature of 23ºC but thereafter was progressively inhibited. No significant net loss in phytoplankton productivity was found at discharge temperatures of up to 27ºC. As a result of these experiments it was concluded that the entrainment effects of mechanical damage and thermal shock on phytoplankton were negligible.

SPP063 states that laboratory experiments on the effects of thermal shock upon the diatoms *Phaeodactylum tricornutum* and *Gyrosigma spencerii* have shown that neither species are significantly affected when cultured at 12ºC or 16ºC by thermal shocks of up to 17ºC. Both species were killed at ambient temperatures of 24ºC and a Δt of 15ºC (39ºC). Growth was inhibited at a Δt of 10ºC and Δt of 12ºC respectively. The LT50 (lethal temperature to 50% of the species) was 36.5ºC and 37ºC respectively.

Furthermore, the flagellate *Dunaliella tertiolecta* was more resistant and survived an exposure time of 40 minutes at a final temperature (Tf) of 41ºC; cell growth stopped for five days and then recovered to densities similar to the control within 12 days.

The maximum predicted discharge temperature from Hinkley Point C in August is 31ºC, or 34.2ºC in a heat wave (i.e. below the expected LT50 values). We would therefore agree that no loss of productivity would occur at a discharge temperature of

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[76] Marcy, B.C.,Jr., Beck, A.D., Ulanowicz, R.E. (1978) Effects and impacts of entrained organisms. Chapter 4 – Power plant entrainment: A biological assessment. Adacemic Press pp 135-188.

[77] Briand, F. J-P. (1975). Effects of power plant cooling systems on marine phytoplankton. Marine Biology 33:135-146.

[78] BEEMS Technical Report 081 (TR081). Laboratory and Power Plant Based Entrainment Studies: A Literature Review. (2008) Cefas report prepared for EDF.

[79] Davies, M.H., (1983). The response of entrained phytoplankton to chlorination at a coastal power station (Fawley, Hampshire). Central Electricity Generation Board. Report TPRD/L/2470/N83.

31ºC. We would also agree that at 34ºC there is a possibility of a small reduction in growth, but this may not be noticeable in the enhanced productivity of the warmer receiving waters.

In the absence of chlorination the thermal effects of entrainment on primary production would appear to be negligible, however because the possibility of chlorination exists it must be considered. Technical paper SPP063 states that if chlorination resulting in an in-circuit level of 0.2mg/l TRO were employed by Hinkley Point C, the available evidence suggests that an approximate 60% reduction in productivity would be expected in entrained phytoplankton. Making worst case assumptions that the effected cells were killed and that HPC extracts 1% of the available source (plume) volume per day within the zone of abstraction, then it has been calculated that 0.7% of the phytoplankton cells in that plume volume would be killed per day. Assuming phytoplankton are uniformly distributed over the entire inner channel, operation of Hinkley Point C could lead to the loss of 0.05% of the inner channel phytoplankton abundance per day.

The overwhelming majority of phytoplankton production and consumption by copepod zooplankton takes place outside of the inner channel and outside of the influence of Hinkley Point C. Although some phytoplankton are present in the highly turbid sections of the Bristol Channel, primary production rates are far greater in the less turbid areas. Inter-tidal sediments in the Severn Estuary are known to support microphytobenthic populations, which are frequently dominated by diatoms (Haskoning. 2011)[80]. Although the position of the intake is not within the deepest section of the estuary as recommended by Briand (1975), it is of sufficient depth and distance from the inter-tidal zone to ensure that the inter-tidal species where most of the biodiversity thrive in the Bridgwater Bay area, are not adversely affected.

BEEMS Technical Report (TR065) estimated that the predicted recirculation of the HPC discharge water into the intakes will be considerably small (1.1%). Moreover that the reduced phytoplankton abundance in the discharge water would rapidly be restocked from phytoplankton cells from elsewhere in the Channel that are outside of the abstraction zone.

Conclusion

Taking the above information into account we can conclude that the abstraction at HPC alone will not have an adverse effect on the phytoplankton population of the Severn Estuary and Bristol channel as a result of entrainment.

Entrainment of zooplankton

Comprehensive descriptions of the zooplankton for the Severn Estuary area collected by the Institute for Marine Environmental Research (IMER) over a nine year period between 1971 and 1981 has provided the basis for a basic description of zooplankton distribution. They are considered normal for estuaries in northern latitudes, both in abundance and composition (Williams, 1984)[81]. However, the diversity of zooplankton was found to be relatively low compared to neighbouring shelf seas and even lower in the Severn Estuary (APEM, 2010)[82]. Zooplankton has been strongly influenced by salinity ranges throughout the estuary with species

[80] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.
[81] Williams, R., (1984). Zooplankton of the Bristol Channel and Severn Estuary. Marine Pollution Bulletin, 15, 66-70.
[82] APEM (2010) Severn Tidal Power Feasibility Study Strategic Environmental Assessment (SEA) – Migratory and estuarine fish (2010). (P&B, B&V consultants) Report prepared for DECC.

assemblages showing a distribution that changes with seasonally low riverine inputs (Collins & Williams, 1981)[83].

Annual patterns of abundance from Hinkley Point B Power Station entrainment studies show that mysids and caridean decapods make up a significant proportion of the biomass within the Bristol Channel and Severn Estuary and are therefore key members of the marine food web in this estuarine system (Bamber & Henderson, 1994)[84].

Mysid entrainment

Mysids are a group of shrimp-like crustaceans. Their common name opossum shrimps stems from the presence of a brood pouch, or *marsupium*, in females. Mysids are common in the Bristol Channel and Severn Estuary and make a considerable contribution to the biomass of the region (Williams, 1984)[85], and they are an important part of the diet of *Crangon crangon* and fishes in the 3cm to 15 cm length category. The majority of mysids are known to be omnivorous in feeding habit and consume a wide variety of food items, often indiscriminately (Tattersall and Tattersall, 1951)[86].

The main mysids found in the Inner Bristol Channel and the Hinkley Point forebay have been observed to be (by % number): *Schistomysis spiritus*, 66%; *Mesopodopsis slabberi*, 20%; Gastrosaccus spinifer, 11%; *Neomysis integer*, 4%. Mysids (particularly *Schistomysis spiritus*) constitute a large part of the total zooplankton biomass in summer (approximately 80%) (Haskoning, 2011)[87]. The peak abundance of *S.spiritus* occurred in the Inner Channel in September (mean of 14 individuals m^{-3}, ca. 250 individuals $^{-2}$ for the sub-region) (Williams and Collins, 1984) [88]. Mean natural mortality has been estimated for another common, temperate latitude mysid, *Metamysidopsis elongate*, as 0.04 d^{-1} adults, 0.06 d^{-1} (6%) juveniles and 0.013 d^{-1} (1%) for brood pouch young (Clutter and Theilacker, 1971)[89]

BEEMS Scientific Position Paper 063 (SPP063) reports very limited data availability on entrainment mortality for mysids and thus, as a precautionary measure, a 100% mortality rate has been assumed. The assessment presented in SPP063 calculates that the additional mortality in the Bristol Channel from entrainment losses associated with Hinkley Point C would be 0.08% d^{-1} (predominantly to juveniles), assuming a ratio of plume volume to volume of the Inner Channel as 7.2% and assuming mysids are uniformly distributed throughout the Inner Channel.

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[83] Collins, N.R. & Williams, R., (1981). Zooplankton communities in the Bristol Channel and Severn Estuary. The distribution of four copepods in relation to salinity. Marine Biology, 64, 273-283.

[84] Bamber, R.N and Henserson, P.A. (1994). Seasonality of caridean decapod and mysid distribution and movements within the Severn Estuary and Bristol Channel. Biological Journal of the Linnean Society volume 51, Issue 1-2, pages 83–91.

[85] Williams, R. (1984). Zooplankton in the Bristol Channel and Severn Estuary. Marine Pollution Bulletin, 15; 66-70.

[86] Tattersall, W.M., Tattersall, O.S. (1951). The British Mysidacea. The Ray Society, London. 460.

[87] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

[88] Williams, R, Collins, N.R. (1984). Distribution and variability in abundance of *Schistomysis spiritus* (Crustacea: Mysidacea) in the Bristol Channel in relation to environmental variable, with comments on other mysids. Marine Biology 80; 197-206.

[89] Clutter, R., Theilacker, G.H. (1971) Ecology efficiency of a pelagic mysid shrimp: estimates for growth, energy budgets and mortality studies. Fishery bulletin 69(1) 93-114.

Conclusion

The natural mortality of mysids is 4% per day (adults) to 6% per day (juveniles); hence we would agree that there would not be a negligible increase in mysid mortality due to entrainment and therefore we can conclude that the abstraction at HPC alone will not have an adverse effect on the mysid population of the Severn Estuary and Bristol channel as a result of entrainment.

Copepod entrainment

The zooplankton within the estuary is also made up of a large number of calanoid copepods ("oar-footed" organisms), which are a small group of crustaceans found drifting through the water column of the estuary. The dominant members of the plankton at Hinkley Point are members of the genus Acartia (*Acartia spp.).* Other species include, *Calanus helgolandicus, Centropages hamatus, and Eurytemora affinis.* These copepods have been recorded in maximum densities in July following increases in abundance in March, April and May (Collins & Williams, 1981). Copepods not only represent the major crustacean group of permanent plankton, they are also a significant component of the diet of planktivourous species, for example the commercially important clupid fish (Bamber & Seaby, 2004)[90]. *Acartia tonsa* has shown to have several useful characteristics to play the role of test-species in ecotoxicology in the procedure of "risk assessment" concerning different chemicals (Pane *et al.*, 2011)[91] and is therefore an estuarine species used as a standard test organism in ecotoxicological studies. Since the *Acartia Spp*. has value in terms of indicating the likely scale of impact on the local holoplanktonic assemblage as a whole, it can be used to assess the likely impact on the genus alone.

Bamber and Seaby (2004) also used the Entrainment Mimic Unit (EMU) to test the various entrainment factors on the copepod *Acartia tonsa* at Fawley Marine Laboratory. The results showed that the copepod was not sensitive to mechanical stress, nor an increase in temperature. However the pressure cycle, involving changes of up to 2 At. (ca. $2x10_6$ Pa) caused significant mortality of copepod adults in the order of 11%. Furthermore, levels of residual chlorine (TRO) also caused significant mortality with a mean of 13.5% between 0.14 and 0.24 ppm i.e. within the range of normal biocide-dosing at a coastal power station. Thus in combination , the stresses of entrainment under standard power station operating levels would result in the order of 20% mortality of *Acartia tonsa*.

The assessment work presented in BEEMS Scientific Position Paper 063 (SPP063) takes the above calculations of predicted mortality into account and concludes that entrainment mortality in the summer at Hinkley Point would represent 0.016% of the inner channel population per day. The population of *Acartia spp*. is distributed over the entire central and inner channels in the summer (Williams & Collins, 1986)[92] and, therefore, the percentage of the Bristol Channel population that would be killed by Hinkley Point C has been calculated to be less than 0.004% of the estimated population.

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[90] Bamber, R.N., and Seaby, R.M.H. (2004) The effects of power station entrainment passage on three species of marine planktonic crustacean, *Acarti tonsa* (Copepoda), *Crangon crangon* (Decapoda) and *Homarus gammarus* (Decapoda). Marine Environmental Research. 57, 281-294.

[91] Pane, L., Agrone, C., Giacco, E., Somà, A., and Mariottini , G.L.(2011) Utilization of Marine Crustaceans as Study Models: A New Approach in Marine Ecotoxicology for European (REACH) Regulation. *DIP.TE.RIS, University of Genova, Genova,*

[92] Williams, R., and Collins, N.R. (1986). Seasonal composition of meroplankton and holoplankton in the Bristol Channel. Marine Biology. 92, 93-101.

Aside from the calculations above, in the study by Williams and Collins (1986), copepods in the Inner Channel only made up just over 9% of the biomass compared to the Outer Channel, with the total zooplankton in the Inner Channel being only 14% of the total zooplankton in the Outer Channel. The studies suggest that zooplankton play a minor role in the Inner channel, and that benthic filter-feeding communities are presumed better adapted to the estuary.

This is supported by Burkill and Kendall (1982)[93] who studied the production of *Eurytemora. affinis* in the Bristol Channel. They noted that the population density and production of *E. affinis* was low (range of 0.2 to 4.8 m^{-3}) in a region with a salinity higher than at the centre of abundance. However, the species was capable of growing with a Production/Biomass quotient of 33 yr^{-1}, which is higher than many recorded values for copepods. Temperature, food availability (nutrition) and predation were the key environmental factors influencing production, with salinity and flushing being of less importance.

Conclusion
Given the natural productivity of the species and the evidence that a higher proportion of copepods are found in the outer channel rather than the inner channel where the HPC abstraction will be situated then we can conclude that the abstraction at HPC alone will not have an adverse effect on the copepod population of the Severn Estuary and Bristol channel as a result of entrainment.

Decapod entrainment
Decapods ("ten-footed" organisms) are an order of crustaceans and include many familiar groups, such as, prawns and shrimp. Caridean decapods are the swimming shrimp variety found as zooplankton in the Severn Estuary. Boyden *et al* (1977)[94] reported 44 species of decapod from the Severn Estuary and Bristol Channel, however, the species richness at any single locality is considerably lower. For example, between 1981 and 2009 only 15 species of decapod have been recorded from Hinkley Point B intake (Henderson and Bird, 2010)[95]. By far the most abundant macro-crustaceans are the common shrimp, *Crangon crangon* and the pelagic prawn, *Paciphaea sivado*. Other species found in large numbers include, the Atlantic prawn, *Palaemon serratus*, the pink shrimp, *Pandalus montagui* and the swimming crab, *Liocarcinus holsatus.*

The Common or brown shrimp, *C. crangon* play a key trophic role within the estuary, feeding upon polychaetes and other small animals, particularly meiofauna (Pihl & Rosenberg, 1982)[96]. They are also an important component of the diet for most fish within Bridgwater Bay and they are unique in being the only crustacean that is abundant throughout the year (Henderson *et al*, 1992)[97]. Due to the ubiquity and importance of *C. crangon* within the estuary it has been studied in detail over the years and therefore has the most available data as a decapod species. It will therefore be used to assess the impacts of entrainment on decapods as a whole,

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93 Burkill, P.H. and Kendall, T.F. (1982). Production of the copepod *Eurytemora affinis* in the Bristol Channel. Marine Ecology Progress Series Vol.7: 21-31.
94 Boyden , C.R., Crothers, J.H., Little, C., Mettam, C. (1977). The intertidal invertebrate fauna of the Severn Estuary. Field Studies. 4, 477-554.
95 Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.
96 Pihl, L. & Rosenberg, R., 1982. Production, abundance and biomass of mobile epibenthic marine fauna in shallow waters, western Sweden. Journal of Experimental Marine Biology and Ecology, 57, 273-301.
97 Henderson, P.A., James, D., Holmes, R.H.A. (1992). Trophic structure in the Bristol Channel: seasonality and stability in Bridgwater Bay. J. Mar. Biol. Ass. U.K. 72:675-690.

although it is acknowledged that several other decapod species exist within the estuary that are also of high importance.

Although *C. crangon* is always present at Hinkley Point, it varies seasonally in abundance (Bamber & Henderson, 1994). Its local population biology has been described by Henderson & Holmes (1987). Numbers peak in the autumn owing to the arrival of young, spawned in the spring; further peaks in abundance occur during the winter as shrimps from the upper estuary move seawards to avoid low winter salinities. The females move inshore into lower salinity waters to brood their young and move offshore to release them. The authors further report that *C. crangon* larvae have not been found within the monthly plankton sampling at HPB and instead are found in the highest densities in the outer Channel. With the 5mm screening mesh proposed at HPC it has been calculated that approximately 90% of the animals will be impinged and 10% entrained (SPP063). The lifecycle stages that are vulnerable to entrainment are therefore likely to be juveniles with the odd larvae of *C. crangon*.

Bamber and Seaby (2004)[98] used the Entrainment Mimic Unit (EMU) to test the various entrainment factors on the decapod *C. crangon* larvae at Fawley Marine Laboratory. The results showed that *C. crangon* was not sensitive to mechanical stresses, nor pressure and temperature changes. *C. crangon* larvae only suffered significant mortalities in response to TRO at unrealistically high levels of 0.4 ppm or above. However, as the temperature increased, so did the sensitivity to TRO, such that at an increase of temperature ≥ 8˚C significant mortalities occurred at 0.1 ppm TRO (~20-25% mortality). Although there are no larvae of *C. crangon* present around Hinkley Point, it is highly likely that the larvae are the most sensitive of the life stage to entrainment pressures, particularly in relation to TRO. No results from juvenile or adult *C. crangon* are available.

BEEMS Science Advisory Report 008 (SAR008)[99] summarises the thermal upper lethal temperature (ULT) for invertebrates as falling within a range of 30°C to 33°C and for decapods as a mean of 32.9°C. As a result, in the months of July or August, there may be some thermally induced mortality associated with Hinkley Point C.

Using previous estimates of population size, Henderson *et al* (2006) estimated the recent increase in *C. crangon* standing crop. In June 1981 and November 1983 the population size on the Stert flats in Bridgwater Bay was estimated as $3x10^6$ and $5x10^7$ individuals respectively, suggesting a standing crop that varied between 10^6 and 10^8, with an average of around 10^7 individuals (Henderson & Holmes, 1987)[100]. This represented a biomass of about 10^4 kg wet weight, as the average *C. crangon* weighs approximately 1g. The abundance in Bridgwater Bay in October 2002 was about 26 times that observed in the early 1980s, suggesting an increase in standing crop to about $3x10^8$ individuals, weighing $2.6x10^5$ kg (2,600 tonnes).

Henderson et al (2006)[101] estimated the mean biomass ratio of *C. crangon* in the area of Bridgwater Bay over the period of 1981 – 2004 to be 1781 kg/km^2, (i.e. the

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[98] Bamber, R.N., and Seaby, R.M.H. (2004) The effects of power station entrainment passage on three species of marine planktonic crustacean, *Acarti tonsa* (Copepoda), *Crangon crangon* (Decapoda) and *Homarus gammarus* (Decapoda). Marine Environmental Research. 57, 281-294.

[99]BEEMS – Scientific Advisory Report (SAR008) Thermal standards for cooling water from new build nuclear power stations. March 2011.

[100] Henderson, P.A. & Holmes, R.H.A. (1987). On the population biology of the common shrimp *Crangon crangon* (L.) (Crustacea: Caridea) in the Severn Estuary and Bristol Channel. Journal of the Marine Biological Association of the United Kingdom, 67, 825-847.

[101] Henderson, P.A., Seaby, R.M, and Somes, J.R. (2006). A 25-year study of climatic and density dependant population regulation of the common shrimp *Crangon crangon* (Crustacea: Caridea) in the Bristol Channel. J. Mar. Biol. Ass. U.K. 70, 287-298

production from Stert/Berrow flats is 85 tonnes) and the 200 km2 of the Bristol Channel inter-tidal flats is 356 tonnes. BEEMS Scientific Support Paper 063 (SPP063)[102] has estimated the combined losses from entrainment together with impingement at Hinkley Point C of *C. crangon* within the Bristol Channel, which equates to 1.1% annual production with no chlorination, and with chlorination 1.2%.

For the past 25 years the adult population of *Crangon crangon* within Bridgwater Bay has been notably stable, however, average *C. crangon* abundance has increased because recruitment has increased with average seawater temperature. This has resulted in a clear example of density-dependent control as the mortality rate of recruits over their first winter increases with recruitment (Henderson *et al*, 2006). It envisaged that increased *C. crangon* abundance is associated with increased predator and competitor abundance, and it is thought that a fixed physical constraint, such as the amount of available habitat, is setting an upper limit on the adult population. The evidence from the Hinkley Point B impingement surveys is that the production/ biomass ratio has increased over the past 25 years. Any reductions in the population size due to entrainment will be rapidly filled by new recruits.

Conclusion

Given the natural productivity of the species and on the basis of the findings described above, we can conclude that the abstraction at HPC alone will not have an adverse effect on the decapod population of the Severn Estuary and Bristol channel as a result of entrainment together with impingement.

Other zooplankton species

BEEMS Technical Report 029 (TR029) reports on the inter-tidal and sub-tidal ecology of Bridgwater Bay. The three most significant invertebrates in terms of biomass, *Macoma balthica, Hediste diversicolor and Hydrobia ulvae* were widly distributed across Berrow and Stert Flats and together constitute 86% of the biomass of benthic organisms found on the Stert Flats.

Based on information in Fish and Fish (1996), the following information in Table 2.6.1S25 is given on the spawning time and larval stage of most of the significant components of the intertidal benthic community around Bridgwater Bay. The information suggests that although most of the species appear to avoid breeding around the summer months when the larval stages are most likely to be exposed to the upper lethal temperatures if entrained, both *Nephtys* and *Hydrobia* species larval stages could be present. Also *Macoma* larvae have the potential to be exposed to entrainment, although perhaps not during the summer months.

Zooplankton sampling carried out by APEM (2010)[103] showed that the diversity around the Inner Channel was found to be relatively low compared to neighbouring shelf seas and even lower in the Severn Estuary. Annual patterns of abundance from Hinkley Point B Power Station entrainment studies show that mysids and caridean decapods make up a significant proportion of the zooplankton biomass within the Bristol Channel and Severn Estuary and are therefore key members of the marine food web in this estuarine system (Bamber & Henderson, 1994)[104]. BEEMS Technical

[102] BEEMS Scientific Position Paper 063 (SPP063). Entrainment impact on organisms at Hinkley Point – supplementary note. October 2011. Cefas report prepared for EDF

[103] APEM (2010) Severn Tidal Power Feasibility Study Strategic Environmental Assessment (SEA) – Migratory and estuarine fish (2010). (P&B, B&V consultants) Report prepared for DECC.

[104] Bamber, R.N and Henserson, P.A. (1994). Seasonality of caridean decapod and mysid distribution and movements within the Severn Estuary and Bristol Channel. Biological Journal of the Linnean Society volume 51, Issue 1-2, pages 83–91.

report 067 (TR067) reported on the sub-tidal sampling during 2008-2010 where the average species richness and abundance was less than 2 species and 3 individuals per $0.1m^2$ respectively, while mean biomass was less than $0.005g.m^{-2}$.

Table 2.6.1S25 - *Spawning time and larval stage of most of the significant components of the intertidal benthic community of the Severn Estuary and Bristol Channel*

Species	**Common name**	**Breeding Period**	**Larval stage**
Hediste diversicolor	Ragworm	Breeding occurs in spring.	Ragworms do not have a planktonic larval stage. The larvae develop within existing burrow systems.
Nephtys spp	Catworm	*N. hombergii* breeds during April and May on the NE coast of the UK.	The pelagic life cycle of *N. hombergii* lasts seven to eight weeks at the end of which larvae metamorphose into benthic juveniles (Cazaux, 1970)[105].
Arenicola marina	Lugworm	Breeding generally occurs in October to November.	The larvae initially develop in burrows, and then in mucous tubes attached to a coarse substrate.
Hydrobia ulvae	Laver spire shell	Breeding occurs from spring to autumn. Peaks of spawning may be in spring and autumn, or could be a single peak.	Eggs are attached to stones and shells of adults. Veliger larvae emerge from the eggs after 20-30 days, and have a pelagic life of about 3 weeks.
Macoma balthica	Baltic clam / tellin	On the west coast of Wales, the main breeding period is February to March, with a second spawning in autumn.	Eggs are pelagic, but for an unknown period before metamorphosing into larvae. Free-swimming veliger larvae are pelagic for 7 or 8 weeks.

There are currently no entrainment estimates for the larval stages of *Nephtys hombergii* and *Hydrobia ulvae,* but both species have a limited planktonic stage of 1-2, which are reliant on the spring and neap tides for dispersal so they will not always be within the vicinity of the HPC abstraction.

N. hombergii have a generation time of 1-2 years and on average an individual generates >10,000 eggs per year[106], so it is likely that populations will be replenished from other areas should HPC cause a minor impact on the local population.

Various studies have suggested that the gastropod *H. ulvae* lives from just over 1 year up to 2.5 years. There is considerable conflicting evidence over the developmental mechanism of the larvae of this species[107]. Fish & Fish (1977)[108] have found the planktonic stage to last up to four weeks and development to be entirely

[105] Cazeau, C., 1970. *Recherches sur l'écologie et le developpement larvaire des Polychétes d'Arcachon.*

[106] MarLIN BIOTIC (Biological Traits Information Catalogue. *Nephtys hombergii* On-line information - http://www.marlin.ac.uk/biotic/browse.php?sp=4414

[107] MarLIN BIOTIC (Biological Traits Information Catalogue. *Hydrobia ulvae* On-line information - http://www.marlin.ac.uk/biotic/browse.php?sp=4186

[108] Fish, J.D. & Fish, S., 1974. The breeding cycle and growth of *Hydrobia ulvae* in the Dovey estuary. *Journal of the Marine Biological Association of the United Kingdom*, 54, 685-697

planktotrophic. Others, such as Pilkington (1971)[109] have found the planktonic stage to be completely absent with a non-feeding benthic larva that metamorphoses after just two days. The maximum number of eggs recorded from one mass is 50 and the eggs are laid preferentially on the shells of live individuals of this species but also on empty shells and grains of sand. TR029 reported that *H. ulvae* was uniformly distributed across Bridgwater Bay, therefore it is also likely that populations will be replenished from other areas should HPC cause a minor impact on the local population

M. balthica have a generation time of 1-2 years and on average an individual generates >10,000 – 30,000+ eggs per year[110]. They are found in sub-tidal and inter-tidal areas of Bridgwater Bay which means that a proportion of the local annual production of their eggs and larvae are likely to be entrained into HPC power station and potentially suffer increased mortality. Edition 2 of the BEEMS SPP063 reported on the potential impacts to *M. balthica* by comparing the predicted instantaneous mortality from HPC along with the natural mortality of the plantonic stage. The predicted instantaneous mortality of eggs and larvae from HPC has been taken from BEEMS Scientific Position Paper 070/S (SPP070/S)[111] using particle tracking and was calculated to be equivalent to 0.0027 and 0.0019 $day^{-1}$for planktonic stage lengths of 18 and 25 days respectively; assuming a worst case scenario of no organisms surviving through the cooling water system. The natural mortality of the planktonic phase has been taken from Philippart et al (2003)[112] who estimated it to be >0.1 d^{-1}. Changes in mortality due to HPC power station entrainment have been calculated (within SPP063 Ed.2) to be between 0.004% and 0.5%, which we would agree is insignificant, especially given the likelihood that areas outside of Bridgwater Bay contribute significantly to recruitment in the Bay (SPP070/S).

On the basis on the information above, we do not believe that entrainment impacts form HPC alone will be significant on any of the species discussed above, especially since Hinkley Point B power station has shown to have no impact on the local populations, and it is very likely that should any minor impacts occur within the local populations, they will soon be replenished by new recruits around Bridgwater Bay and beyond.

Conclusion
We can therefore conclude that the abstraction at HPC alone will not have an adverse effect on the benthic populations of the Severn Estuary and Bristol channel as a result of entrainment.

Overall conclusion

Hazard assessed	Adverse effect on estuaries feature?
Entrainment of planktonic organisms	No
Overall conclusion	**No adverse effect upon site integrity**

[109] Pilington, M.C., (1971). The veliger stage of *Hydrobia ulvae* (Pennant). *Proceedings of the Malacological Society of London*, 39, 281-287.
[110] MarLIN BIOTIC (Biological Traits Information Catalogue. *Macoma balthica* On-line information - http://www.marlin.ac.uk/biotic/browse.php?sp=4272
[111] BEEMS Scientific Position Paper 070/S. Numerical simulation of the risk of entrainment of Macoma eggs and larvae by the proposed Hinkley Point C power station. Cefas report for EDF. 2012.
[112] Philippar, C.J.M., Van Aken , H.M., Beukema, J.J., Bos, O.G. Gerhard C. Cade´e, G.C., and Dekker, R. (2003). Climate-related changes in recruitment of the bivalve Macoma balthica. Limnol. Oceanogr., 48(6), 2003, 2171–2185.

2.6.1.4.2. Abstraction impacts on Sabellaria larvae (reefs feature)

a) Physical damage (entrainment of *Sabellaria* larvae*)*

Conservation objectives (see section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009[113]

Like most marine benthic invertebrates, reef-building organisms exhibit a bentho-pelagic life cycle including a planktonic larval stage of development and two sedentary benthic juvenile and adult stages (Ayata *et al*, 2009)[114]. For those organisms, successful settlement requires that larvae reach a suitable habitat within a competence period at the end of larval development. It depends on numerous factors involved in larval dispersal and results either from the local retention of larvae or from the connectivity among spatially isolated populations (Caley *et al,* 1996)[115]. Since they drive planktonic larvae, oceanographic processes (e.g., tidal residual currents, wind-induced currents, upwellings, river plumes or gyres) and their variability on time and space scales relevant to the life history of the organism greatly control larval dispersal (Ayata *et al*, 2009).

The most detailed work done on *S. alveolata* reproduction within Britain is that of Wilson who studied the worms in Cornwall. Wilson (1971)[116] reported on a short summer spawning period around July. Dubois et al. (2007) suggested that the seasonal reproduction of *S. alveolata* may be related to spring temperature increase and to spring and autumn phytoplanktonic blooms. The larvae are thought to spend anything between six weeks and six months in the plankton (Wilson 1968a[117], 1971) so that dispersal could potentially be widespread. After many weeks/months of pelagic development, the larvae actively crawl over any solid surfaces with which they happen to make contact, seeking indicative characters distinctive of their normal adult environment (Wilson, 1968b)[118]. Once the larvae settle into a chosen location they begin to form their sand tubes and commence the metamorphosis into a young adult. The planktonic life stage of *S. alveolata* is therefore the only stage vulnerable to entrainment at HPC.

There are no published data on the entrainment mortality of *Sabellaria* larvae. To assess whether *Sabellaria* eggs and larvae would be exposed to entrainment we need to understand where the spawning areas are in relation to tidal stream lines

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[113] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[114] Ayata, S-D., Ellien, C., Dumas, F., Dubois, S., Thiébaut, E. (2009). Modelling larval dispersal and settlement of the reef building polychete *Sabellaria alveolata*: Role of hydroclimatic processes on the sustainability of biogenic reefs. Continental Shelf Research 29; Issue 13; 1605-1623.

[115] Caley, M., Carr, M., Hixon, M.A., Hughes, T.P., Jones, G.P., Menge, B.A. (1996). Recruitment and the local dynamics of open marine populations. Annual Review of Ecology and Systematics 27, 477500.

[116] Wilson, D.P. (1971). *Sabellaria* colonies at Duckpool, North Cornwall, 1975. Journal of the Marine Biological Association U.K. 50; 509-580.

[117] Wilson, D.P. (1968). Some aspects of the development of eggs and larvae of *Sabellaria alveolata*. Journal of Marine Biology U.K. 48; 367-386.

[118] Wilson, D.P. (1968). The settlement behaviour of the larvae of *Sabellaria alveolata* (L.). Journal of the Marine Biological Association of the United Kingdom, 48 (2). pp. 387-435.

within the estuary and Bristol Channel. In order to understand the prevalence of this BEEMS Scientific Support Paper 066 (SPP066) looks at a numerical simulation of eggs being released from potential *Sabellaria* habitat and being transported by passive tracers by the currents. Potential Sabellaria spawning areas in Bridgwater Bay were derived from known Sabellaria habitat locations from data collected during surveying between 2008 and 2010 (TR039).

The modelling by particle tracking in the HPC GETM model predicts a 0.33% chance of larval abstraction per day for four intakes. Assuming 100% entrainment mortality, the predicted worst case loss of *S. alveolata* larvae has been calculated as 0.33% per day. For comparison the daily natural mortality for larvae from field data has been estimated as 0.09 (9%) per day (Dubois et al, 2007)[119]. Field observations performed in 2002 by Dubois *et al*., (2007) have shown that large scale spatial distribution of *S. alveolata* larvae was patchy and was mainly controlled by residual currents. Highest densities (up to 28,000 larvae m2) were generally located in near-shore waters close to the adult reefs (Ayata et al, 2009), but there still remains the possibility that larval dispersion happens in the wider channel, so the abstraction risk has the potential to be lower.

Conclusion
We would therefore agree that the resultant increase in natural mortality from 9% to less than 9.33% is considered to be of negligible significance and therefore we can conclude that the abstraction at HPC alone will not have an adverse effect on the Sabellaria alveolata population of the Severn Estuary and Bristol channel as a result of entrainment.

Overall conclusion

Hazard assessed	**Adverse effect on estuaries and reef feature?**
Entrainment of *Sabellaria* larvae	No
Overall conclusion	**No adverse effect upon site integrity**

[119] Dubois, S., Comtet, T., Retière, C., Thiébaut, E., 2007. Distribution and retention of *Sabellaria alveolata* larvae (Polychaeta: Sabellariidae) in the Bay of Mont-Saint-Michel, France. Marine Ecology Progress Series 346, 243254.

2.6.1.4.3 Abstraction impacts on Migratory fish and fish assemblage

Henderson and Bird (2010)[120] report that the filter screens at Hinkley Point B have a solid square mesh of 10 mm and catch few fish less than 40 mm in length. HPC proposes to have a 6 mm filter screen, so only juvenile fish small enough to pass through the mesh on the drum screens will become entrained. Larger sinuous fish, such as glass eels/ elvers, and lamprey transformers may pass through the 6 mm screen. The entrainment of ichthyoplankton (fish eggs) is also a potential issue that will be assessed.

a) Physical damage (entrainment of juvenile fish and ichthyoplankton)

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by physical barriers*
- *The size of the populations of the migratory fish and assemblage species 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*
- *The abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary is maintained*

Natural England & Countryside Council for Wales, 2009[121]

Screen mesh size is the main factor determining the sizes of organisms retained on the CW drum or band screens and those that become entrained. For fish, the size that will be retained by the screen is a function of mesh size and fineness ratio (body length divided by maximum body diameter), the latter being high for elongate, thin fish such as eel or pipefish and low for rotund ones such as lumpfish (Turnpenny *et al*, 2010)[122]. HPC will be fitted with a purpose-built fish return systems, so they will use mesh sizes of 6 mm or less under present guidance (Turnpenny *et al*, 2010).

The maximum ambient sea temperature at Hinkley Point in the last 35 years has been 22.6°C in the August 1995 heat-wave. More typical August maximum temperatures are 19.4°C. Hinkley Point C will raise cooling water temperatures by 11.6°C. The likely maximum temperatures in the cooling water system will therefore be 31.2°C with up to 34.2°C in a heat wave (corresponding to the expected typical summer maximum temperature at the end of the station life after climate change). The water temperature within the cooling water system, is detailed in BEEMS TR187[123].

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[120] Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.

[121] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[122] Turnpenny, A.W.H., Coughlan, J, Ng, B., Crews, P. Bamber, R.N., Rowles, P. (2010). Cooling water options for the new generation of nuclear power stations in the U.K. Environment Agency Science Report SC070015.

[123] BEEMS Technical Report 187 (TR187) HP thermal plume modelling: selection of meteorological and geomorphological scenarios. February 2011. Cefas. Report for EDF.

BEEMS Science Advisory Report 005 (SAR005)[124] highlights the methodology for the measurement of entrainment used within the report to inform the HRA (HRA ref). The previous entrainment studies at Hinkley Point B and plankton studies within the vicinity of the site suggest that the juveniles, eggs and larvae of the following key species are potentially at risk of being entrained through the cooling water system: sea bass, cod, eel, flounder, haddock, herring, lemon sole, plaice, pout, sole, sprat, gobies and whiting.

Fish assemblage - entrainment

BEEMS Technical Report 083 (TR083)[125] reports on the ichthyoplankton surveys off the Hinkley Point area that were undertaken quarterly in 2008 and again in May 2009. Eggs and larvae of just 14 species were detected in very low numbers (Table 2.6.1S26 However, those surveys were designed to increase understanding of the sub-tidal ecology of the area and not just the ichthyoplankton community, so the timing of the surveys in 2008 were not optimal for the main fish spawning season.

In order to obtain a better estimate of ichthyoplankton communities at the site, intensive monthly surveys were undertaken between February and June 2010 (BEEMS 83a)[126]. The plankton sampling conducted in 2010 was specifically designed to cover the main spawning periods of most fish species known in the Bristol Channel area, i.e. late winter, spring and early summer. Despite this greatly increased sampling effort, the eggs and larvae of only 18 species were detected, although much better temporal and spatial density estimates were obtained. Together with the 2008/09 data 20 different species of eggs and larvae were collected, along with one glass eel (juvenile). The 2010 surveys confirmed the findings of the 2008 and 2009 surveys that the Hinkley Point area has a very limited ichthyoplankton community and therefore the risk of entrainment loss is both low and is limited to a narrow range of species (Haskoning, 2011)[127].

However, it should be noted that the Severn Estuary and Inner Bristol Channel provide a good habitat for fish nursery grounds within the inter-tidal area, and therefore it is possible that small and juvenile fish species are present around Hinkley Point that have not been picked up by the plankton surveys. Especially since the plankton surveys 2008-2010 encountered difficulties in trawling within the estuary due to the many obstacles on the sea floor. Environment Agency (EA) data from the lower River Severn (EA, 2011)[128] reveal the presence of many small bodied and juvenile fish of all the main functional feeding groups. Species included smelt, flounder, sprat, herring, lesser sandeel, bleak, common carp, silver bream and perch. However the area studied represents fish populations of the outer River Severn rather than the Inner Severn Estuary where salinity is likely to be remarkably different. The EA data is therefore not a good representative of fish species likely to be found at Hinkley Point. In the absence of other comparable data the plankton surveys from 2008 – 2010 represent best available evidence.

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[124] BEEMS Science Advisory Report 005 (SAR005) Methodology for the measurement of entrainment. Report for EDF. March 2011.
[125] BEEMS Technical Report No. 083. (WP2): Hinkley Point Nearshore Communities: Results of the 2m Beam Trawl & Plankton Surveys 2008-2010, Edition 3. Cefas.
[126] BEEMS Technical Report 083a (TR083a). Hinkley Point Site Nearshore Communities; Plankton Surveys 2010. Edition 1. Cefas. Report for EDF.
[127] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. Section 6.2.822 pg. 345.
[128] Environment Agency (EA). (2011). Water Framework Directive Transitional and Coastal Waters (WFD-TraC waters) surveys on the lower River Severn to Sand Point. June and October 2011.

TR081 looks at the available literature on entrainment studies and one of the most reliable forms is data from the Entrainment Mimic Unit (EMU). The EMU unit is capable of simulating most of the conditions likely to be encountered by entrained organisms such as pressure changes, sudden increases in temperature (ΔT) and biocide exposure as used in antifouling regimes (Seaby & Fleming, 1993)[129]. Full details of the EMU and how it functions is provided in Seaby & Fleming (1993, Appendix A).

Juvenile fish entrained at Hinkley Point C would be subject to mortality from:

- mechanical damage from the impellors in the cooling water pumps;
- thermal shock (maximum discharge temperature would be in the range 18ºC to 22ºC); and
- exposure to chlorination for an 18 minute period inside the plant at 0.2mg/l-1 at the inlet to the condenser (if HPC uses chlorination).

The recommendations from TR081 by the BEEMS Expert Panel advise that an EMU experiment should be carried out for the species present around the HPC proposed site with the conditions programmed in that the organisms are likely to be exposed to during the operation of HPC (as stated above). Although the applicants have taken on this recommendation, it would seem that such experiments are not yet complete as the data takes many years to validate to obtain reliable results. In the absence of specific data, the best available comparison for survival rates can been taken from various EMU experiments, including results from the Sizewell B Power Station. These EMU experiments are based on typical operating conditions for a UK power station (ΔT 10 °C, Cl at 0.2 ppm) and are detailed in TR081 with the results summarised in Table 2.6.1S27

Table 2.6.1S26 *Presence ( ) of Fish Eggs and Larvae Detected in Ichthyoplankton Surveys off Hinkley Point in 2008/09 (TR083) and 2010 (TR083a).*

Species	Eggs		Larvae		Juvenile	
	2008/9	2010	2008/9	2010	2008/9	2010
European anchovy (*Engraulis encrasicolus*)	✔	✔				
Dover sole (*Solea solea*)	✔	✔	✔	✔		
Rocklings (*Gaidropsarus* spp/*Onos* spp.)	✔	✔		✔		
Solenette (*Buglossidium luteum*)	✔	✔	✔	✔		
European sea bass (*Dicentrarchus 'morone' labrax*)	✔	✔	✔	✔		
Gurnard spp.	✔					
Dragonets (Callionymidae)		✔	✔			✔
Herrings (Clupeidae)			✔	✔		
Sprat (*Sprattus sprattus*)			✔	✔		
Sandeels (Ammodytidae)			✔	✔		
Gobies (Gobiidae)			✔	✔		✔
Mackerel (*Scomber spp.*)	✔					
Pilchard (*Sardina pilchardus*)	✔	✔		✔		
Scaldfish *(Arnoglossus spp.)*	✔					
Five-bearded rockling (*Ciliata mustela*)				✔		

[129] Seaby, R.M.H. & Fleming, J.M., 1993. The Entrainment Mimic Unit (EMU) Operation Manual. *Fawley Aquatic Research Laboratories Ltd*., Internal Report No., FOM 061/93.

Table 2.6.1S26 *Presence ( ) of Fish Eggs and Larvae Detected in Ichthyoplankton Surveys off Hinkley Point in 2008/09 (TR083) and 2010 (TR083a).(continued)*

Species	Eggs		Larvae		Juvenile	
	2008/9	2010	2008/9	2010	2008/9	2010
Butterfish (*Pholis gunnellus*)				✔		
European flounder (*Platichthys flesus*)				✔		
European plaice (*Pleuronectes platessa*)				✔		
Soles (Soleidae)		✔		✔		
Sea scorpion (*Taurulus bubalis*)				✔		
European eel (*Anguilla Anguilla*)						✔
Unidentifiable fish		✔		✔		

Table 2.6.1S27 Survival Rates and Susceptibility of Entrained Fish and Crustacean from EMU Cooling Water Passage Simulation Experiments (TR081) based on normal power station operating conditions (ΔT 10 °C, Cl at 0.2 ppm) as determined by EMU experiments (Bamber & Seaby, 1993[130], 1994a[131], b[132], c[133], 1995a[134]; Turnpenny, 2000[135]).

Species	Life Stage	Entrainment Survival rate at 0.2 ppm TRO and Approximately 10°C ΔT	Primary cause of mortality			
			Pressure	Temperature	Chlorine	Mechanical
Sole (*Solea solea*)	eggs	90%		✔	✔	
	Post larvae	63% *		✔	✔	
Turbot (Psetta maxima)	eggs	93%	✔	✔		
	post larvae	27%	✔	✔		✔
Sea bass (*Dicentrarchus* labrax)	eggs	80%		✔		
	larvae	70%		✔	✔	
Eel (*Anguilla anguilla*)**	larvae	52%			✔	✔ *
Shrimp (*Crangon crangon*)	larvae	73%				
Lobster (*Homarus gammarus*)	larvae	85%				✔

* This figure appears in TR081 and TR065 but not in TR148

** Damage via the cooling water pump

130 Bamber, R.N. and Seaby, R.M.H., 1993. The effects of entrainment passage on planktonic stages of sole and turbot. *Fawley Aquatic Research Laboratories Ltd*., Report No., FCR 054/93.

131 Bamber, R.N. and Seaby, R.M.H., 1994a. The effects of entrainment passage on planktonic stages of sole, *Solea solea*. *Fawley Aquatic Research Laboratories Ltd*., Report No., FRR 097/94.

132 Bamber, R.N. and Seaby, R.M.H., 1994b. The effects of entrainment passage on planktonic larvae of the common shrimp. *Fawley Aquatic Research Laboratories Ltd*., Report No., FCR 095/94.

133 Bamber, R.N. and Seaby, R.M.H., 1994c. The effects of entrainment passage on larvae of the lobster. *Fawley Aquatic Research Laboratories Ltd*., Report No., FRR 103/94.

134 Bamber, R.N. and Seaby, R.M.H., 1995a. The effects of entrainment passage on planktonic stages of the bass, *Dicentrarchus labrax*. *Fawley Aquatic Research Laboratories Ltd*., Report No., FRR 160/95.

135 Turnpenny, A.W.H., 2000. Shoreham Power Station: Survival of elvers (*Anguilla anguilla*) during simulated cooling system passage. *Fawley Aquatic Research Laboratories Ltd*., Report No., FCR 332/00.

The results from Table 2.6.1S27 show that entrainment survival for fish eggs is fairly high, whilst entrainment survival for fish larvae are lower. The results also illustrate that both temperature and chlorine were the main factors causing mortality under normal operating conditions, the latter being an unsurprising result given its use as a biocide. Factors such as abrasion and pressure differentials are largely considered negligible, even for the more fragile organisms such as the larvae of some fish species e.g. bass. However, 70% of turbot larvae entrained in the EMU incurred mechanical damage (Ref: TR081). These findings back up the conclusion of Bamber & Seaby (2003) that generalisations from the responses of one species to another are not valid and therefore specific species assessments are required with specific conditions associated to HPC as recommended. On this basis we would be hesitant to apply this or other EMU survival rates detailed in Table XXE1 to HPC, because the temperature and pressure profiles used in the EMU were all based on those for Sizewell B. However, the only comparable species from the EMU experiments that can be found in the Severn Estuary are dover sole and European sea bass. Eel larvae are not known to be present around the Bristol Channel or Severn Estuary area.

EDF's report to inform the HRA (Haskoning, 2011)[136] states that Ichthyoplankton varies spatially throughout the Bristol Channel, being highest for eggs in the spawning areas (particularly around Trevose Head, some 100 miles along the coast to the west of Hinkley Point, off the north Cornwall coast and around Land's End, for most commercial species), and may also be high near-shore where larvae and post-larvae begin to recruit to nursery areas (e.g. for sea bass). It has been noted that the water entrained at Hinkley Point will not be representative of other areas of the Bristol Channel, although the inner reaches of the Severn Estuary are well mixed. The Trevose Head spawning grounds have therefore been used as a reference area, although only for European sea bass, dover sole, and sprat because these are the only ones of commercial interest identified during the BEEMS plankton surveys that can be compared with those species present (HRA - 6.2.823 pg. 345).

The estimated entrainment of eggs and larvae over the period February to June 2010 given in Table 2.6.1S28 has been taken from Haskoning (2011)[137] and it has been made assuming:

- no exchange between the pool and adjacent sea areas;
- uniform distribution and abundance of ichthyoplankton throughout the water column; and
- the mean ichthyoplankton abundances from the 2010 surveys close to Hinkley Point power station occur within the identified 'pool'.

[136] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. 6.2.820 pg. 344.
[137] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. (Section 6.2.824 pg. 345.

Table 2.6.1S28. *Predicted Entrainment of Fish Eggs and Larvae between February and June 2010 at Hinkley Point C (based on data from Ref. TR083a, table from TR148) in relation to the Abundance in the Trevose Spawning Area*

Species/ species group	Eggs	Larvae	A total:	B: Trevose	A/B (%)
Sandeels		9,075,949	9,075,949		
Solenette	368,278	2,496,257	2,864,536		
Five-bearded rockling		333,687	333,687		
Herring		414,615	414,615		
European sea bass	47,282,931	41,981,786	89,264,717 22,051,122**	29,906,261,000***	0.43% 0.11%**
Rockling	18,546,479	799,420	19,345,899		
Gobies		10,351,234	10,351,234		
Butter fish		389,819	389,819		
European flounder		2,711,333	2,711,333		
European plaice		3,322,735	3,322,735		
Pilchard	2,891,002	386,310	3,277,311		
Dover sole	9,461,839	1,929,208	11,391,047 1,659,991**	274,633,000,000	0.004% 0.001%**
Soles*	450,281	369,308	819,589		
Sprat		7,114,303	7,114,303	478,943,000,000	0.001%
Sea scorpion		474,262	474,262		
Unidentifiable fish	5,004,020	21,322,227	26,336,246		
European anchovy	12,141,963		12,141,963		
Dragonets	383,685		383,685		

Notes:
Soles* indicates eggs and larvae that, due to damage, could not be confirmed as Dover sole, but were identified as belonging to the family Soleidae.
Total** for Dover sole and sea bass, the results can be adjusted so as to account for estimated survival based on EMU experiments.
*** This figure is stated as 29,206,261,000 in the HRA

The uniform distribution and abundance of ichthyoplankton throughout the water column has been determined on the basis that fish eggs and larvae would be entrained in direct volumetric proportion to their densities within the Bristol Channel within the vicinity of Hinkley Point (ICES rectangles[138] 29E4, 30E4, 31E4, 30E5, 31E5 and 31E6) . This assumption is likely to be over-pessimistic. A study by Dempsey (2006)[139] found that the densities of fish larvae in Southampton Water were greater than those entrained from the entire water column, indicating that larvae were able to avoid entrainment and that actual entrained numbers were significantly lower than would be expected from off-shore plankton surveys.

The entrainment estimates have been compared and put into context with the abundance of ichthyoplankton at the Trevose Head ground by examining the mean abundance of the same species in the Trevose spawning area, ICES rectangles 29–31E4, 30–31E5 and 31E6, (TR065 ed2)[140] assuming that:

[138] The International Council for the Exploration of the Sea (ICES). ICES Rectangles are used to standardise the division of sea areas for statistical analysis. Each ICES statistical rectangle is ’30 min latitude and 1° longitude in size, and are thus approximately 30 nautical miles.
[139] Dempsey, C.H. (1998). Icthyoplankton entrainment. Journal of Fish Biology Volume 33, Issue Supplement sA, pg. 93–102.
[140] BEEMS Technical Report 065 edition 2 (TR065 ed2): Predictions of impingement and entrainment by new nuclear power station at Hinkley Point. (2010) Cefas. Report prepared for EDF.

- the mean abundances of eggs and larvae from the 1990 surveys were within the ICES rectangles 29–31E4, 30–31E5 and 31E6;
- the mean abundances of eggs and larvae from the 1990 surveys are still a reasonable approximation of the current situation;
- the assumptions about the distribution and abundance of ichthyoplankton within the Trevose spawning area will be the same as that within the 'pool' (i.e. uniform distribution) and abundance throughout the water column.

Within the period February to June 2010 (main period when eggs are likely to be present in the estuary), the predicted numbers of eggs and larvae of sea bass entrained by Hinkley Point C are predicted to be <0.45% of the mean abundance within the Trevose spawning ground. For sole and sprat the numbers of entrained eggs and larvae over the same period are predicted to be <0.005% of the mean abundance within the Trevose spawning ground, all of which are insignificant losses.

For the other species, where risk of entrainment of eggs and larvae exists, it is difficult to quantify the exact impact entrainment will have on the species population without a comparable spawning stock figures, such as those from the Trevose. However, It appears that the community of fish eggs and larvae at Hinkley Point is small in both species and numbers. It should also be noted that the results assume that fish eggs and larvae would be entrained in direct volumetric proportion to their densities within th Bristol Channel within the vicinity of Hinkley Point, which is unlikely to be the case. The figures also assume 100% mortality of all entrained organisms, but previous EMU studies have indicated that this is also not likely to be the case, in which case the impacts of entrainment mortality on local populations would be reduced further.

Conclusion

On the basis of the information above we can conclude that the abstraction at HPC alone will not have an adverse effect on the fish assemblage population of the Severn Estuary and Bristol channel as a result of entrainment.

Juvenile migratory fish & ichthyoplankton entrainment

Six of the migratory species designated under the Severn Estuary SAC and the Ramsar are anadromous species and include Atlantic salmon (*Salmo salar*), twaite shad (*alosa fallax*), allis shad (*alosa alosa*), river lamprey (*Lampetra fluviatilis*), sea lamprey (*Petromyzon marinus*), and sea trout (*Salmo trutta*). Being anadromous, all of the species spawn in freshwater, therefore the very early egg and larval stages will not be exposed to entrainment impacts at Hinkley Point. The catadromous eel designated under the Ramsar however, is vulnerable to entrainment impacts.

Lamprey entrainment

Both species of lamprey use the Rivers Severn, Wye and Usk to spawn. The larvae stages of both river and sea lamprey remain in freshwater for several years before becoming transformers and moving with the floods into the marine environment. River lamprey metamorphosis happens after approximately four years and the eventual weight and length after this period in a river is 1.5 g and approximately 100–120 mm in length, compared to 70 g and 200–240 mm after 2.5 years feeding in estuaries (Maitland, 2003)[141]. Sea lamprey larvae remain in the silty deposits of a river for 5-6 years depending on the water temperature and food supply (Hardisty & Potter 1971)[142]. They grow slowly, filter feeding on algae, diatoms and other organic detritus until they reach 150-200 mm, when they undergo a radical metamorphosis (Bird, 2008)[143] into transformers. The juvenile lamprey then begin a downstream migration to the sea in the autumn when rivers are in flood (Potter 1980)[144]. Very little is known about this stage in the life-cycle although it is believed that entry into salt water is an important stimulus for the onset of parasitic feeding (Bird, 2008). Taking the sizes of transformers into consideration, it is possible that river and sea lamprey transformers may be present around Hinkley Point and may thus pass through the 5 mm mesh and become entrained, however firstly there are no known records of transformers of either species being entrained at HPB, and they are highly likely to be of a larger size by the time they reach the HPC area within the Severn Estuary and Bristol Channel, so will become impinged (see following impingement assessment).

Conclusion

We can therefore conclude that the abstraction at HPC alone will not have an adverse effect on the sea and river lamprey populations of the Severn Estuary and Bristol channel as a result of entrainment.

Shad entrainment

There are no confirmed spawning sites for allis shad in the UK (Maitland & Lyle 1990)[145]. Twaite shad use the Rivers Severn, Wye and Usk to spawn. After hatching, the young remain in the slow-flowing reaches of the lower parts of rivers, then move into the estuary and eventually into coastal waters and the open sea, occasionally occurring in water up to 300 m deep. The fry are about 10 mm on hatching but rapidly grow to between 80 and 140 mm after one year. By this time many of them

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[141] Maitland, P.S. (2003). Ecology of the River, Brook and Sea Lamprey. Conserving Natura 2000 Rivers Ecology Series No. 5. Life in UK Rivers.

[142] Hardisty, M. W. & Potter, I. C. (1971) The behaviour, ecology and growth of larval lampreys. *The Biology of Lampreys Volume 1*, pp. 85-127. Academic Press, London.

[143] Bird, D.J. (2008). The Biology and Conservation of the Fish Assemblage of the Severn Estuary (cSAC). CCW Regional Report No. CCW/SEW/08/1.

[144] Potter, I.C. (1980) Ecology of larval and metamorphosing lampreys. *Canadian Journal of Fisheries and Aquatic Sciences*, **37**, 1641-1657.

[145] Maitland, P.S. & Lyle, A.A. (1990). Practical conservation of British fishes: current action on six declining species. *Journal of Fish Biology*, 37, 255-256.

have descended to the sea and the remainder follow during their second year (Maitland *et al*, 2003)[146]. Larvae show a preference for the mid-channel and areas of greatest depth in rivers, where the current is maximal, and a preference for temperatures in the range 17–21ºC for larvae 7.7–15.2 mm in length, and from 17–21.5ºC for larvae 18.4–23.8 mm in length (Gerkens & Thiel 2001)[147]. The larvae migrate back downstream to the estuary and young 0+ fish first appear in samples at Oldbury in mid-July and reach a maximum abundance in September when the water temperature has declined to below 19ºC (Bird, 2008). The young migrate seawards out of the estuary in the autumn and by late August, they appear at Hinkley Point in the Bristol Channel (Claridge & Gardner 1978).

Juvenile twaite shad are about the tenth most abundant species at Oldbury (Potter *et al*. 2001)[148]. Based on corrected weekly samples from the water-intake screens at Oldbury power station, the mean annual abundance of 0+ and 1+ individuals was 737 between 1972 and 1977 and rose to 949 between 1996 and 1998 (Potter et al. 2001). Oldbury Power Station has an intake screen of 10mm. Since the juvenile shad are picked up on the screens at Oldbury Power Station from impingement it is highly likely that the juvenile shad will be impinged at Hinkley C too rather than entrained, mainly due to their shape.

Salmon are known to migrate up the River Parrett and on to the River Tone to spawn, whilst sea trout have a preference for the West Somerset Rivers. Both salmon and trout young (from Alevins to Parr) remain in freshwater from one to four years and in their second to fourth year they become better equipped for the marine environment and turn into smolts ready to migrate to the sea. So although it is possible for the juvenile smolts of salmon and trout to be within the vicinity of Hinkley Point and the intake structures, they will be of sufficient size to avoid their passage through the 5mm drum screen mesh and would thus be subject to impingement mortality instead (see following impingement assessment).

Conclusion
We can therefore conclude that the abstraction at HPC alone will not have an adverse effect on the shad populations of the Severn Estuary and Bristol channel as a result of entrainment.

Salmonids entrainment
Salmon are known to migrate up the River Parrett and on to the River Tone to spawn, whilst sea trout have a preference for the West Somerset Rivers. Both salmon and trout young (from Alevins to Parr) remain in freshwater from one to four years and in their second to fourth year they become better equipped for the marine environment and turn into smolts ready to migrate to the sea. So although it is possible for the juvenile smolts of salmon and trout to be within the vicinity of Hinkley Point and the intake structures, they will be of sufficient size to avoid their passage through the 5mm drum screen mesh and would thus be subject to impingement mortality instead (see previous following assessment).

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[146] Maitland, P.S., Hatton-Ellis, T.W. (2003). Ecology of the Allis and Twaite Shad. Conserving Natura 2000 Rivers Ecology Series No. 3. Life in UK Rivers.
[147] Gerkens M and Thiel (2001). A comparison of different habitats as nursery areas for twaite shad (*Alosa fallax* Lacépède) in the tidal freshwater region of the Elbe River Germany. *Bulletin Français de la Pêche et de la Pisciculture* 362/363, 773–784.
[148] Potter, I.C., Bird, D.J., Claridge, P.N., Clarke, K.R., Hyndes, G.A. & Newton, L.C. (2001) Fish fauna of the Severn Estuary. Are there long-term changes in abundance and species composition and are the recruitment patterns of the main marine species correlated? *Journal of Experimental Marine Biology and Ecology*, 258, 15-37.

Conclusion

We can therefore conclude that the abstraction at HPC alone will not have an adverse effect on the salmonid populations of the Severn Estuary and Bristol channel as a result of entrainment.

Eel entrainment

The European eel (*Anguilla anguilla*) is believed to breed in the Sargasso Sea, with the planktonic leptocephali migrating across the Atlantic via oceanic currents. When 12-18 months old, the flattened *lepocephalus* larvae metamorphoses into a transparent *glass eel* while still in the ocean and a further transformation occurs when glass eels become pigmented as they enter estuaries, at which point they are known as elvers (Bird, 2008). Glass eels enter the Bristol Channel/Severn Estuary in large runs, moving upriver in the spring, mainly using selective tidal stream transport (White & Knights, 1997a)[149]. However, the migration routes that the glass eels take through the Bristol Channel and estuary are not known. Studies by Castelnaud *et al* (2001)[150] from the Gironde Estuary indicates that the glass eel distribution is very homogenous within the estuary and that there is no significant difference in the density with depth nor laterally across the estuary.

A revised edition of SPP063 (SPP063 Ed.2)[151] states that a model has been developed within the BEEMS programme that uses particle tracking to provide some insights into their behaviour. However, before it is initialised it requires information on glass eel distribution across the Channel (spatial, vertical and temporal). BEEMS Technical Report TR-S 211[152] in preparation at writing) describes a survey undertaken in February 2012 to determine the distribution of glass eels within the Estuary. The results from the survey have not yet been analysed statistically but initial suggestions are that:

- Eels migrated up- estuary on the flood tide by day and night
- Eels were not in the water column on the ebb tide
- Eels migrated preferentially on or near to the surface on the flood tide but were also found in lower densities across the full measured depth range (0, 4 and 7m depending on the available water depth)
- They were distributed across the full width of the Bristol Channel at Hinkley Point
- That higher densities appeared to occur in shallower waters close to shore, particularly along the southern shore in the vicinity of the HP B inlet. In such circumstances densities at HPB were greater than at the proposed HPC offshore intakes.

Henderson *et al*, (2011)[153] noted that the pattern of eel capture at Hinkley Point B with maximum rates occurring at low water spring tides suggests that yellow eels occupy inter-tidal habitat when available. This view is supported by the historically frequent capture of the eel by the fixed net fishermen at Steart Flats on the receding

[149] White, E. M. & Knights, B. (1997*a*). Dynamics of upstream migration of the European eel, *Anguilla anguilla* (L.), in the Rivers Severn and Avon, England, with special reference to the effects of man-made barriers. *Fisheries Management and Ecology* 4**,** 311–324.

[150] Castelnaud, G., Girardin, M., Rochard, E. (2001). Surveillance halieutique de l'estuaire de la Gironde - Suivi des captures 1999. Cestas : Cemagref. 186 p. Rapport pour EDF CNPE du Blayais / Etude Cemagref, groupement de Bordeaux, no. 71.

[151] BEEMS Scientific Support Paper 063 Edition 2/S (SPP063 Ed.2). March 2012. Cefas report for EDF.

[152] BEEMS Technical Report TR-S 210. glass eel distribution in the inner channel/lower Severn Estuary. Cefas report for EDF. 2012.

[153] Henderson, P.A., Plenty, S.J., Newton, L, C., Bird, D.J. (2011). Evidence for a population collapse of European eel (*Anguilla anguilla*) in the Bristol Channel. Journal of Marine Biology.

tide. Having the intake at 3.4-3.5km off shore could therefore significantly reduce eel and potentially glass eel entrainment.

It is thought that the majority of any glass eels abstracted at HPC will be entrained as they will be small enough to pass through the 5mm inlet mesh (Turnpenny & O'Keefe, 2005)[154]. Roqueplo (2000)[155] reported that 97% of glass eels were able to pass through a 3mm mesh within 1 minute, with the remained being impinged.

BEEMS TR081 reports on EMU experiments that were conducted on elvers of the European eel to determine their likely survival rates following entrainment through Shoreham Power Station (West Sussex) (Turnpenny, 2000)[156]. The test subjects were on average 66mm total length, which means that they were more likely to be classed as glass eels. The elver study demonstrated that temperature, pressure and mechanical stresses did not affect survival whereas chlorine concentrations of 2 and 5ppm resulted in mortalities of 39% and 53% of entrained elvers respectively. However, when the actual chlorination regime of the power station was considered (2 x 20 minute pulses per day), it was calculated that the chlorination would only result in the mortality of an additional 1.1% and 1.5% of all elvers entrained in a particular day. SPP063 report on 'Further evidence of entrainment mortality of glass eels and the range of mortality' estimates a range from 1.8% from pump damage predictions and laboratory experiments to 0.9% to 15% from in situ experiments at French power stations.

BEEMS Technical Report TR065[157] estimated the predicted zone that was at risk from cooling water abstraction as roughly equivalent to the plume volume at the 1˚C contour, of which 1.1% would be abstracted by HPC per day. It has been estimated that the mortality of entrained glass eels at worst case scenario is 15% (i.e. the daily mortality is 0.165% of eels within the plume). Based on the assumption that eels use the whole of the inner channel to migrate, the daily mortality due to entrainment would be 0.012%. If it were assumed that glass eels migrate very close to the coast, then the calculated daily mortality would be much smaller as the animals would no longer be in the abstraction zone of influence of Hinkley Point C. The natural mortality of glass eels (i.e. excluding fishing mortality) has been estimated to be in the range of 0.0233 – 0.049 per day (Beaulaton et al, 2007)[158]. Taking a mean value for natural mortality of 0.01 per day (or 0.995%), entrainment through HPC has been calculated to increase the mortality of glass eels at worst case scenario by 1.007% per day.

Conclusion

We would thus agree that such increases are not significant, and as these calculations are very conservative and are based on worst case scenario. We can therefore conclude that the abstraction at HPC alone will not have an adverse effect on the eel population of the Severn Estuary and Bristol channel as a result of entrainment.

[154] Turnpenny, A.W.H., and O'Keefe, N. (2005). Screening for intakes and outfalls: A best practice guide. Environment Agency, Science Report No. SC030231.

[155] Roqueplo, C., Lambert, D., Gonthier, P., Mayer, N. (2000). Estimation de la mortalité des civelles de la Gironde après leur passage dans le circuit de refroidissement de la Centrale nucléaire du Blayais. P.56 Etude CEMAGREF, Groupement de Bordeaux. Etude No. 58.

[156] Turnpenny, A.W.H., 2000. Shoreham Power Station: Survival of elvers (*Anguilla anguilla*) during simulated cooling system passage. *Fawley Aquatic Research Laboratories Ltd*., Report No., FCR 332/00.

[157] BEEMS Technical Report 065 eddition.2 (TR065 ed2). Predictions of impingement and entrainment by new nuclear power station at Hinkley Point.

[158] Beaulaton, L. Briand, C. (2007). Effect of management measures on glass eel escapement. ICES. Journal of Marine Science 64 (7): 1402-1413.

b) Physical damage (impingement)

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by physical barriers*
- *The size of the populations of the migratory fish and assemblage species 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*
- *The abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary is maintained*

Natural England & Countryside Council for Wales, 2009[159]

The operation of Hinkley Point C (HPC) will require 125m³ of water per second for direct cooling, which will be abstracted from the Severn Estuary via a series of seabed intake structures and associated intake tunnels. Each UK EPR reactor unit will have a single dedicated intake tunnel with two dedicated seabed intakes. The tunnels extend approximately 3.4km and 3.5km from the foreshore high water mark and at a depth of approximately 20m below the seabed. At their seaward extent, the two intake tunnels will be some 480m apart. The two sea bed intake heads associated with each intake tunnel will be separated by approximately 200m.

The abstraction of seawater from the Bristol Channel means that organisms present in the water will be drawn into the water intakes. Larger organisms (>25mm length) will be impinged on the cooling water intake screens and removed from the fine-mesh (~5mm) drum screen employed to prevent debris entering the cooling water heat exchangers. Cefas conclude that, without mitigation, impingement at Hinkley Point C would increase about fourfold over that of Hinkley Point B (HPB) simply as a result of the increased abstraction of cooling water (Haskoning, 2011)[160].

Comparison of data from the fish trawling sites surveyed during 2008 to 2009 suggests that, when taking the full catch across surveys as a whole, there was little difference in terms of the fish catch between offshore and near-shore zones (TR02)[161] Therefore impingement records from HPB have provided a satisfactory basis for predicting abstraction effects for HPC. However, it is noted that larger fish populations are expected to be present within inter-tidal areas.

A number of methods are available to reduce the risk of fish entering the cooling water system. Passive deflection focuses primarily on controlling the approach velocities around the intake head, to keep velocities low enough to avoid fish being drawn in. Active deflection includes techniques such as air bubble curtains, acoustic deterrents and strobe lights.

In the case for HPC, the intake ports will be designed to lie parallel to the tidal flow, and thus will not face into that tidal flow at any time but will abstract water at right angles from the tidal stream as it passes along the full length of both sides of that

[159] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[160] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. Section 6.2.776 pg.336.

[161] Technical Report 02 (TR02): Provisional assessment for impingement and entrainment for cooling water intakes for the proposed Hinkley power station. APEM 2010. Report to EDF.

structure, creating a 'passive' intake of water. This intake design is known as a 'low-velocity side-entry (LVSE) and from a design perspective, this design together with the arrangement of internal baffle walls and hydraulic guides, has been demonstrated by numerical modelling simulations to achieve a mean intake velocity of 0.3m/s under the majority of tidal conditions. The design is also compliant with Environment Agency guidance with respect to fish protection.

It is thought that in waters of high visibility, the sight of the intake structure along with the low velocity intake would significantly reduce the number of fish being impinged on the intake structure as fish would have a visual cue to avoid it. However, since visibility is poor within the estuary, this would not be the case and therefore another type of deflection is required for the low velocity intake to be effective.

Active deflection in the Severn Estuary is limited due to the harsh estuarine conditions. The high suspended sediment content and high turbidity within the estuary, means that neither strobe lighting or bubble curtains are recommended, therefore a acoustic fish deterrent (AFD) system will be provided at each intake head that will provoke an avoidance reaction amongst certain groups of fish.

Acoustic Fish Deterrent (AFD) system

Haskoning (2011)[162] state that an AFD system will be associated with each intake head, which will act as a behavioural deterrent that will provoke an avoidance reaction amongst certain groups of fish. The AFD will compromise two modular sound projector arrays (SPA), that will amplify and project the varying frequencies of sound. The number and positioning of sound projectors will be determined by acoustic modelling using PrISM™ software, as per Environment Agency guidance (Turnpenny *et al*, 2005) [163]. This will also ensure that the soundfield will be confined to the immediate area of the intake head, avoiding the risk of any acoustic disturbance in the wider estuarine environment.

All fish appear to be sensitive to sound in the frequency range 50 to 3000 Hz (Henderson, 2008)[164]. The effectiveness of the AFD system will depend on the hearing sensitivity of individual species, which is dependent upon their physiology in terms of both the presence/absence of a swimbladder and the connection between the swimbladder and inner ear. Species fall into three broad categories; *non-specialists* which have no swim bladder, *generalists* which have a swimbladder but no special connection between it and the inner ear and *specialists* which not only have a swimbladder but also a connection between it and the inner ear which can extend their upper hearing ability by several kilohertz[165].

Performance data for AFD systems are summarised by Turnpenny *et al* (2005) and include data for estuarine and coastal power stations. A literature review on the performance of AFD systems is further provided within Technical Report 199 (TR199)[166]. It is noted however, that there are few published studies on the effectiveness of AFD systems. A case most representative of the latest technology combined with use of acoustic modelling techniques is reported in a study by Maes *et*

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[162] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. Section 3.3.37.
[163] Turnpenny, A.W.H and O'Keeffe, N., (2005). Screening for intakes and outfalls: a best practice guide. Environment Agency. Science Report SC030231
[164] Henderson, P.A.(2008). A Literature review of the possible effects of impact and vibratory piling on fish in the Severn Estuary. Pisces Conservation Ltd.
[165] Severn Tidal Power SEA Scoping Topic Paper – Fish. December 2003. Black and Veatch & Parsons Brinckerhoff.
[166] Technical Report 199 (TR199) - Literature Review: Performance of Acoustic Fish Deterrence Systems, with particular reference to marine power stations. (CEFAS 2008) Report for EDF.

al (2004)[167] on Doel nuclear power station on the Scheldt Estuary in Belgium. The report concluded that deflection efficiencies were correspondingly high, (around 80-95%) for hearing specialists, which include pelagic fish such as herring (shad) and sprat, but also members of the carp family and catfishes. For hearing generalists, such as many demersal species, including most members of the cod family, bass and other 'roundfish', AFD deflection efficiencies were between 50-70% for these species. Eel which have a swimbladder but no connection to the inner ear, as with salmon, are classed as hearing *generalists*, but they are thought to have fairly poor hearing capabilities. The non-specialists include lamprey, flatfishes and other benthic species with reduced or no swimbladder function. Efficiencies were considerably lower for these species (Turnpenny et al, 2010)[168].

Table 2.6.1S29 - Deflection efficiencies reported for the acoustic fish deflection system at Doel nuclear station (Maes et al. 2004)

Fish species	**Deflection efficiency ('on' versus 'off')**	**Statistical significance**
Herring (*Clupea harengus*)	95%	P<0.001
Sprat (*Sprattus sprattus*)	88%	P<0.001
Smelt (*Osmerus eperlanus*)	64%	P=0.004
Bass (*Dicentrarchus labrax*)	76%	P<0.001
Flounder (*Platichthys flesus*)	46%	P=.0.028
Gobies (*Pomatoschistus* spp.)	50%	P>0.05 (NS)

The deflection efficiencies reported for the acoustic fish deflection system at Doel nuclear station are shown in Table 2.6.1S29 above. It should be noted however, that the Doel power station is on a an estuary with different tidal velocities, and withdraws a considerably smaller amount of water (25.1 m²/sec) in comparison to HPC proposal. Furthermore, the Maes *et al* (2004) paper states that some fish may detect the AFD sounds, but if the current velocity towards the intake exceeds the maximum swimming speed, they cannot necessarily escape and become impinged. This is particularly true at cooling water intakes in estuaries where strong tidal currents prevent fishes perceiving a current towards the intake. The power station in question however, does not benefit from having a low-velocity intake, so improvements would be expected where lower velocities allow more fish to escape.

Although the presence of hearing-related modifications does not appear to guarantee successful deflection alone, particularly if the intake velocity exceeds the swimming capabilities of the fish, a low-velocity intake and AFD together would appear to provide suitable mitigation for hearing specialist fish, particularly shad, and some hearing generalists. Provided that the design of the intake ports and AFD are in line with the Environment agency guidance and recommendations (see Ref 68).

Some concern was raised by the Conservation Agencies and the Environment Agency that the AFD system would not be operating during slack water as the AFD

[167] Maes, J., Turnpenny, A.W.H., Lambert, D., Nedwell, J.R., Parmentier, A., Ollevier, F., 2004. Field evaluation of a sound system to reduce estuarine fish intake rates at a power plant cooling water inlet (Doel, Belgium). *Journal of Fish Biology.* 64, 938-946.

[168] Turnpenny, A.W.H., Coughlan, J, Ng, B., Crews, P. Bamber, R.N., Rowles, P. (2010). Cooling water options for the new generation of nuclear power stations in the U.K. Environment Agency Science Report SC070015.

design intent would presume that the majority of fish at risk of entrapment by these intakes will effectively be supplied to them by the tide. The applicants thus thought that the need for fish protection would be greater during periods of tidal flow than during the short periods of slack water. However, in response to concerns the applicants have since confirmed in a consultation response logged in Appendix 4A of Haskoning (2011), that the AFD will be operating throughout the tidal cycle.

It is acknowledged that there is very little published peer-reviewed literature on the AFD technology and that TR199 notes some past projects that have suffered unsatisfactory deterrent performance which required 'experimental adaptation' to achieve predicted performance.

Fish Recovery and Return (FRR) system

As epibenthic species such as eel, lamprey and flatfish are unlikely to be deterred by the AFD system, the main mitigation to prevent high mortalities will be via the fitting on an onshore Fish Recovery and Return (FRR) system within the HPC proposed development.

The general principle applied to the system design will accord with guidance published by the Environment Agency (Turnpenny & O'Keeffe, 2005[169] and Turnpenny *et al,* 2010[170]). A brief description is provided below, but for a detailed description of the design see BEEMS Technical Report 106[171] and sections 3.2.39 to 3.2.55 (inc. figures 3.6-3.8) of the Report to inform the HRA[172].

It has been noted that Turnpenny *et al* (2010) recommended a new issue in the design of fish buckets to handle large, sinuous species such as adult eels and lampreys. Survival rates of large eels in fish return studies have generally been low (see Clough *et al.* 2003). The main reason is that eels writhe and fall out of the buckets, probably many times before being removed by the screens. As a result they become exhausted and often have multiple wounds and sores by the time they are removed. The same may be true of lampreys, although observations are fewer (Turnpenny *et al,* 2010). Fish buckets typically have an opening width of 60 mm which may be too small to handle these species safely so the new design at HPC will be of suitable design for the retention of eel, lamprey and other fish and crustacean species. It should be noted however, that a finalised design is not yet available at the time of writing.

Water abstracted via the intake tunnels will be directed to two onshore cooling water pump houses, which will each contain a large rotating drum screen that will prevent smaller debris, that has passed the coarse screens on the intake head, from entering the cooling water system. These drum screens have been designed to facilitate an FRR system and in particular will include the following features in line with Environment Agency guidance:

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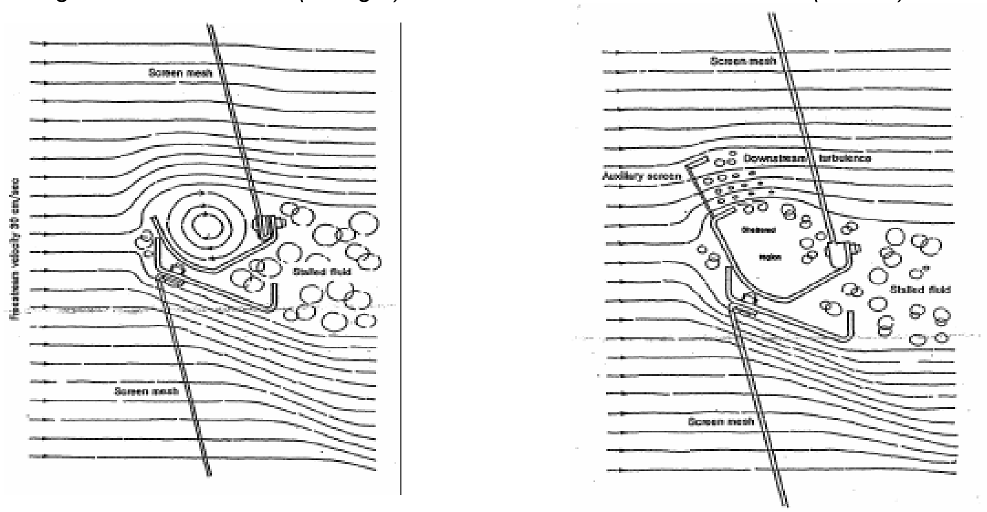
[169] Turnpenny, A. W. H., O'Keeffe, N. (2005). Screening for intake and outfalls: a best practice guide. Environment Agency . Science Report. SC030231.
[170] Turnpenny, A.W.H., Coughlan, J, Ng, B., Crews, P. Bamber, R.N., Rowles, P. (2010). Cooling water options for the new generation of nuclear power stations in the U.K. Environment Agency Science Report SC070015.
[171] BEEMS Technical Report 106 (TR106). Cooling Water Intake Mitigation Measures in New Nuclear Build. Cefas report for EDF.
[172] Haskoning. (2011) Hinkley Point C: Report to inform the Habitats Regulations Assessment (HRA) Final version. Report prepared for EDF.

- Smooth-finish 5 mm drum screen mesh;
- Fish bucket design suitable for retention of eel, lamprey and other fish and crustacean species;
- Continuous screen rotation at an elevation rate at least 1.5 m per minute;
- Low- (<1 bar) followed by high-pressure (usually >3 bar) backwash sprays;
- Hopper geometry to minimise the risk of fish recycling within the screen-well; and
- Smooth-finish troughs with horizontal and vertical bend radius ≥3m.

The inner circumference of each drum screen will have elevator ledges or 'buckets', which lift debris and marine organisms including fish clear of the seawater surface.

As stated above, the buckets will be designed for the retention of eel, lamprey and other fish and crustacean species. Figure 2.6.1S30 a) shows a fish bucket design in some older systems in the US, which modelling studies have shown to create a rotational flow that causes fish to be lost from the bucket before it exits the water column (Fletcher *et al.*, 1988). The effect of this would be to repeatedly re-impinge the fish, increasing injury risk. The alternative design shown in figure 1 b) includes a 90-degree return on the top lip of the bucket that eliminates the problem by stalling the retained water. The designers for HPC propose a further improvement using an auxiliary screen mesh attached along the top lip of the bucket to enhance fish retention. Continuous wash-water sprays will then flush the collected material and organisms to collection troughs from which they will then be flushed to a gully. The fish and debris will then go through a series of pumps before being returned to the estuary.

Figure 2.6.1S30 . Streamlines around a travelling screen fish bucket (a - left) traditional, showing rotational flow and (b - right) modified to stall flow within bucket (TR106).



The chosen route for fish return to the sub-tidal estuary will be via a dedicated bored tunnel driven from landward, under the seawall and inter-tidal shore, to a specific point on the tidally scoured rock exposure below Low Astronomical Tide (LAT) but above the sub-tidal muddy plain.

BEEMS Technical Report 197[173] has modelled the optimum position for an FRR system at HPC. The selection of FRR outfall has taken into consideration factors such as the risk of re-impingement of discharged fish by the HPB intake; the avoidance of the HPB thermal plume; and potential predation by sea birds, fish or

[173] BEEMS Technical Report 197 (TR197): Modelling of the optimal position of an FRR system for Hinkley Point C. EDF BEEMS (Cefas). June 2011.

marine mammals. The fish return tunnel will discharge continuously at a point approximately 550 m offshore, some 150 m beyond and 1 m below the LAT mark

The report estimates <1% risk of fish re-entering a cooling water intake on a single ebb-flood tide. A relatively short simulation was used as it was considered that animals which survived any longer will have responded and will start to exhibit their own behaviour; animals not exhibiting near normal behaviour within this time are likely to have been predated.

The report further considers the effect on migratory fish that are drawn in from an intake point 3km offshore and discharged further inshore, showing that fish discharged from the release point quickly re-disperse offshore.

Table 2.6.1S31 - Assumed recovery rates for the FRR system

Group	Survival rate
Pelagic (e.g. herring, sprat, shad)	0%
Demersal (e.g. cod, whiting, gurnards)	50%
Epibenthic (e.g. flatfish, eels, gobies, rocklings, crustaceans)	80%

BEEMS Technical Report TR148[174] states that currently, most FRR survival studies have been relatively short-term (typically 24-96 hours), and few have considered the mid- to long-term effects on the susceptibility to disease or predation. Well-designed FRR systems can achieve 80-100% survival rates for more robust epibenthic species like plaice and flounder, and moderate rates (~50-60%) for demersal species such as the robust gadoids (e.g. cod). However, survival rates for delicate pelagic species like herring, sprat and shad are usually low (<10%). The report further states that gadoids and other physoclistous (closed swimbladder) species are prone to pressure-related swimbladder damage in systems where cooling water intakes are 10 m or more below the water surface. The proposed cooling water intake for Hinkley Point C is at -12.4 m ODN (Ordinance Datum Newlyn).

Table 2.6.1S32 is a conservative estimate of the likely survival and recovery rates of the 3 groups of fish, which has been taken from Turnpenny & O'Keeffe, (2005)[175]. The FRR at Hinkley Point C is being designed to achieve high rates of survival for eels and lamprey in particular, but it will also benefit other epibenthic and demersal species with a higher survival rate than older designs.

Turnpenny & O'Keeffe (2005) also point out that the use of low-velocity cooling water intakes (above) will significantly affect the size and age composition of the fish that are impinged on the intake screens, with smaller and younger fish dominating, and any differences in survivorship between small and large individuals of the same species may impact the overall effectiveness of FRR systems.

EA guidance advises against the use of biocides upstream of the fish return water supply to prevent toxicity to fish. It is our understanding that the FRR system will not be chlorinated and that any chlorination will be downstream of the forebays and FRR. If biocides are needed within the FRR then it will require a permit for which an

[174] BEEMS Technical Report 148 (TR148 Ed.2): A synthesis of impingement and entrainment predictions for NNB at Hinkley Point. Report for EDF (Cefas). March 2011.
[175] Turnpenny, A.W.H and O'Keeffe, N., (2005). Screening for intakes and outfalls: a best practice guide. Environment Agency. Science Report SC030231

assessment will be required to ensure that the fish being returned will not be subjected to acute or sub-lethal toxic risk.

Table 2.6.1S32 - assumed proportional effects of intake system mitigations

Species	AFD efficiency	Survival through FRR
Sprat	0.88	0.00
Whiting	0.55	0.50-0.80
Sole	0.16	0.80
Cod	0.55	0.50-0.80
Herring	0.95	0.00
Plaice	0.16	0.80
Blue whiting	0.55	0.50-0.80
Eel (Ramsar)	0.16	0.80
Twaite shad (SAC, Ramsar)	0.88	0.00
Allis shad (Ramsar)	0.88	0.00
Sea lamprey (SAC, Ramsar)	0.06	0.80
River lamprey (SAC, Ramsar)	0.06	0.80
Salmon (SAC, Ramsar)	n/a	n/a
Sea trout (SAC, Ramsar)	n/a	n/a
Crangon	0.00	0.8

Further supporting evidence for the stated efficiencies of both the AFD system and FRR systems are provided in BEEMS TR199, and BEEMS TR197 respectively and they are summarised within sections 19.8.46 – 19.8.48 in EDF's report to support the HRA[176].

Estimated impinged fish numbers

To estimate the impinged numbers at HPC, three quasi-independent sources of data have been used to gain a broad view of potential impacts and these include;

1) Most recent 5 years (2005-09) of data from long-term (29yr) drum screen sampling programme undertaken at HPB in more recent years by Pisces Conservation Limited.
2) Recently completed 1 year BEEMS Comprehensive Impingement Monitoring Programme (CIMP).
3) Recently up-dated computer based "expert system" PISCES 2009 (Final version 5.2.0.103), developed by Pisces Conservation Limited.

Although three, quasi-independent, sources of impingement were used to predict the levels of impingement at a NNB at HPC for TR065, the predicted impingement losses for HPC are described within Technical Report 148[177] and are scaled from recent HPB screen surveys. Predictions in this report are primarily based on the BEEMS Comprehensive Impingement Monitoring Programme (CIMP) carried out over 12 months from February 2009 to February 2010* (TR129)[178].

[176] Haskoning. (2011) Hinkley Point C: Report to inform the Habitats Regulations Assessment (HRA) Final version. Report prepared for EDF.
[177] BEEMS Technical Report 148 (TR148 Ed.2): A synthesis of impingement and entrainment predictions for NNB at Hinkley Point. Report for EDF (Cefas). March 2011.
[178] BEEMS Technical Report 129 (TR129): HP Comprehensive impingement monitoring programme 2009-2010. Pisces Conservation Ltd. Report prepared for EDF. February 2011.
* Note: Although 12 months of data have been used here, the full CIMP was carried out over a 16 month period from February 2009 to May 2010, which is recorded within BEEMS Technical Report 147 (TR147): CIMP (Impingement Monitoring Programme) final report inc. Year 2 Q1 data. 2010.

TR129 uses the 12 months of impingement data collected by the CIMP at HPB to update the BEEMS Technical Report 065, where estimated total annual impingement by a proposed HPC will be put into context of the local fishery and adjacent fish populations. The key points of this report are:

- Forty one successful 24-hour impingement samples were collected during the one year programme, rather than the required forty samples, due to one extra date being added as a consequence of the failure of several bulk samples;
- Seven overnight 18-hour bulk samples were not carried out due to either crane malfunction or miscommunication between station staff. The data from the six hourly samples acquired on those dates has been extrapolated to give a complete 24-hour sample;
- 64 fish species, 63 of which were usually marine or estuarine in habitat use, were impinged at HPB over the year-long period in widely differing numbers.
- Sprat, whiting, Dover sole, cod and thin-lipped grey mullet were caught in the greatest numbers;
- Nearly 80,000 sprat and over 45,000 whiting were impinged over the 41 sampling days;
- 13 of the fish species caught were Biodiversity Action Plan (BAP) species, including 3 of the species impinged in the largest numbers (whiting, Dover sole and cod);
- A majority of the species impinged between February and December were represented by young age-classes, with relatively few sexually mature individuals;
- Maximum numbers and weights of fish are impinged per unit time during the winter. The maximum 24-hr rate observed was 22,620 individuals, 255 kg wet weight, in December 2009;
- 15 species of macro-crustacean were recorded over the 41 sampling dates, at an average rate of 23 kg and 16,830 individuals per day. Brown shrimp (*Crangon crangon*) were the most abundant with over 370,000 recorded, followed by ghost shrimp (*Pasiphaea sivado*), pink shrimp (*Pandalus montagui*), Atlantic prawn (*Palaemon serratus*) and edible crab (*Cancer pagurus*);
- Using the observed 24-hr totals to interpolate for missing days, the estimated total annual impingement of fish at Hinkley Point B was approximately 2.7 x 106 individuals with a total wet weight of 2.8 x 104 kg, and for crustaceans, approximately 7.4 x 106 individuals belonging to 15 species with a total wet weight of 1.0 x 104 kg.

TR148 presents CIMP data for up to 64 species of fish and up to 14 species of crustacean (see Appendix A of TR148). For many of these species the predicted impingement is based upon very small numbers of individuals caught on the screens of existing power stations during limited (40 x 24 h) sampling intervals at an abstraction rate of 30 m3 s-1 (cumecs). The predicted impingement has been calculated by scaling the numbers up to a full year at the proposed cooling water abstraction rate of 125 m3 s-1. For example, only two Allis shad (*Alosa alosa*) were caught, but after scaling up, this leads to a predicted impingement of 68 individuals per year. Such impingement predictions for species caught infrequently are subject to considerable uncertainty, so must be treated with caution. Within TR148 the CIMP data have been rescaled to proved estimates of annual impingement assuming full cooling water pumping capacity for:

1. The current HPB station pumping 33.7 $m^3 s^{-1}$ (cumecs).
2. HPC station pumping 125 $m^3 s^{-1}$ (cumecs) assuming current intake location and configuration (Appendix A).

Table 2.6.1S33 - The numbers of the top 15 species impinged at HPB from the 41 samples between February 2009 and February 2010, in descending order (TR129).

Species name	**Total number**
Sprat	79,209
Whiting	45,990
Sole, Dover	9,772
Cod	6,627
Mullet, Thin-lipped grey	5,276
Flounder	4,078
Rockling, 5-bearded	3,131
Herring	2,460
Goby, Sand	1,632
Pipefish, Snake	1,201
Bass	741
Sea snail, Common	706
Poor cod	266
Pout	179
Conger	120

It should be noted that a great deal of fish caught at HPB are juvenile, and this is likely to be similar at HPC as larger fish are expected to be better equipped to escape. The assessment therefore depends on a calculation of Equivalent Adult Value (EAV), a method described in detail by Turnpenny (1988)[179]. Based upon known fisheries-related and conservation-related estimates of population and age structure this technique essentially assigns a probability of survival to adulthood (and hence the fished population) of each juvenile fish killed by impingement at the power station[180], which will scale the level of impact.

With the AFD and FRR mitigation measures in place, the predicted outcome is summarised within Table 2.6.1S34 below, with estimates of key conservation and commercial fish losses due to HPC compared to HPB.

It should be noted however, that Cefas consultants on behalf of EDF have not been able to derive EAVs for twaite shad, lamprey, eel and sprat because of the absence of necessary life history data. The life history data is not the sort of information that is available to us either, therefore the impingement estimates derived from the CIMP data have not been re-scaled for these species.

179 Turnpenny, A.W.H, (1988). Fish impingement at estuarine power stations and its significance to commercial fishing. Journal of Fish Biology. 33A, 103 – 110.
180 Greenwood, M.F.D., (2007), Fish mortality by impingement on the cooling-water intake screens of Britain's largest direct-cooled power station, Marine Pollution Bulletin: 56 (2008) 723–739

Table 2.6.1S34 Predicted Total Annual Impingement (numbers of fish, Equivalent Adult Value (EAV)) at Hinkley Point C (HPC) and Hinkley Point B (HPB) for selected species assuming an abstraction rate of 125 cumecs via current and intake design and with mitigation (AFD/low-velocity intake structures and with a fish recovery and return system) taken from TR148.

Species	**Hinkley Point C, intake design (no mitigation)**	**Hinkley point B**	**Hinkley Point C with AFD/low velocity (% increase from current Hinkley Point B)**		**Hinkley Point C with AFD/low velocity intake and FRR (% increase from Hinkley Point B)**	
Sprat	3,380,850	936,386	405,702	(-57%)	405,702	(-57%)
Whiting	288,078	79,253	129,635	(64%)	64,818	(-18%)
Sole	32,429	8,559	27,241	(218%)	5,448	(-36%)
Cod	32,063	8,733	14,428	(65%)	7,214	(-17%)
Herring	44,792	12,570	2,240	(-82%)	2,240	(-82%)
Plaice	493	129	414	(221%)	83	(-26%)
Blue whiting	160	46	72	(55%)	36	(-22%)
Eel (Ramsar)	1,304	351	1,304	(272%)	261	(-26%)
Twaite shad (SAC, Ramsar)	2,276	646	273	(-58%)	273	(-58%)
Allis shad (Ramsar)	68	22	8	(-63%)	8	(-63%)
Sea lamprey (SAC, Ramsar)	207	42	207	(398%)	41	(0%)
River lamprey (SAC, Ramsar)	82	18	82	(355%)	16	(-9%)
Salmon (SAC, Ramsar)	0	0	0	(0%)	0	(0%)
Sea trout (SAC, Ramsar)	0	0	0	(0%)	0	(0%)
Brown shrimp	19,135,756	4,911,592	19,135,756	(0%)	3,827,151	(-22%)

Impacts from impingement on migratory fish species

To assess the impacts of impingement on the fish populations of the Severn Estuary, it is vital to get an understanding of the current population estimates of the key species. However, because of the nature of the Severn Estuary, with its large expanses of inaccessible mudflats and macro-tidal conditions, the use of conventional fish sampling techniques is extremely difficult. This means that attempts at population estimates have been problematical and are often derived from best guesses. Apart from migratory species, considerably less information is available for the large number of other fish that occur in the estuary (Bird 2008). A good deal of our knowledge of the fish in the Severn Estuary and Bristol Channel comes from data obtained from fish entrained on the cooling-water intake screens at various nuclear power stations sited along the shore, such as Hinkley Point B. However, population estimates are difficult to extrapolate from such data. The Severn Tidal Power Feasibility Study Strategic Environmental Assessment carried out by APEM in 2010 (Ref) has pulled together a good deal of existing data to derive population estimates for certain key species, which has proven to be vital in the following assessments.

Both Spawning Stock Biomass (SSB) data and local fishery data have been used as comparison data where available, however, where both are available the SSB is considered to be more reliable estimate to compare impacts on fish stocks as the local fishing effort within the Severn Estuary and Bristol Channel is small scale and variable. This has been supported by both Natural England and Countryside Council for Wales[181].

Shad (*Alosa fallax, Alosa alosa*) impingement

The last four rivers known to support a spawning population of twaite shad in the UK are the rivers Tywi, Usk, Wye and Severn (including its tributary the River Teme) (Aprahamian et a. 1998a)[182]. Adult twaite shad enter the Severn Estuary to migrate upstream between April and June with peak numbers observed in May (Claridge & Gardner 1978[183]). Although a rare species within the UK twaite shad can be observed in some number on the Rivers Usk, Wye and Severn with, at times, shoals of hundreds of fish[184]. The presence of three of these remaining spawning populations being within the Severn Estuary places twaite shad at particular risk as there is potential for the entire UK population to be impacted by abstractions at Hinkley point.

The favourable conservation status for twaite shad in the Severn Estuary has not yet been described under Regulation 35(3)(a) (formally Regulation 33(2)(a)) by the Conservation Agencies, but it is thought that twaite shad are in unfavourable conservation status. The number of migratory fish species has declined in abundance and distribution in recent years (Bird 2008)[185], however, the increased numbers of weirs and other migratory barriers have long been implicated as a contributing factor in the decline of anadromous species including lampreys and shads.[186] Weirs and other migratory barriers are believed to prevent shad from reaching suitable spawning sites and this has almost certainly contributed to their decline in the Severn and Usk.[187 188]

To estimate the twaite shad population within the Severn Estuary, Technical Report 148 (TR148) uses the Severn Tidal Power Feasibility Study Strategic Environmental Assessment that estimates shad population size and age distribution using a simplified age-structured matrix model (APEM, 2010)[189]. The model applies a matrix incorporating life history parameters (adult survival rates; sex ratio; fecundity at weight/age; spawning propensity and density dependence) to predict the number of adult female shad within the River Severn River Basin District (RBD). The model estimate indicates an average population size of approximately 92,000 female shad. Given a sex ratio of 1:1, the total mean population of twaite shad aged between 3 and 9 years in the Severn RBD is therefore estimated to be 184,000, although variation in year-class strength may result in estimates ranging between 112,000 and

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[181] Environment Agency Hinkley HRA Meeting with Natural England and Countryside Council for Wales. Horizon House, Bristol. 29th March 2012.

[182] Aprahamian, M.W.S., Lester, M. & Aprahamian, C.D. (1998) Shad conservation in England and Wales. Environment Agency, R&D Technical Report W110. Bristol, UK.

[183] Claridge, P.N. & Gardner, D.C. (1978) Movements of twaite shad *Alosa fallax* (Lacépède) in the Severn Estuary. Journal of Fish Biology. 12(3):203-211.

[184] APEM (2010) Severn tidal Power Feasibility Study Strategic Environmental Assessment (SEA) – Migratory and estuarine fish (2010). (P&B, B&V consultants) Report prepared for DECC.

[185] Bird, D.J. (2008) The Biology and Conservation of the fish assemblage of the Severn Estuary (cSAC). Report for Countryside Council for Wales (CCW).

[186] Bird, D.J, (2008). The biology and conservation of the fish assemblage of the Severn Estuary cSAC, Report for the Countryside Council for Wales.

[187] Maitland, P.S. & Lyle, A.A. (1990) Practical conservation of British fishes: current action on six declining species. *Journal of Fish Biology*, 37, 255-256.

[188] Aprahamian, M.W. & Aprahamian, C.D. (1990) Status of the Genus *Alosa* in the British Isles: past and present. *Journal of Fish Biology*, 37A, 257-258.

[189] APEM (2010) Severn Tidal Power Feasibility Study Strategic Environmental Assessment (SEA) – Migratory and estuarine fish (2010). (P&B, B&V consultants) Report prepared for DECC.

596,000. With the Severn RBD figure in mind the predicted 273 shad equates to 0.15% of the population, which is the figure used by EDF in their report to inform the HRA. The Joint Nature Conservation Committee (JNCC) Species Accounts for the twaite shad, roughly estimate the UK population to be approximately 100,000 fish (best guess)[190], which is highly likely to be a conservative number and therefore represents worst case scenario. If the predicted number of individual twaite shad caught on HPC intake is calculated to be 273 then that accounts for 0.27% of the UK population. As this is highly precautionary and <1%, HPC alone is not likely to adversely affect the twaite shad populations of the Severn Estuary. To support this view, Environment Agency shad specialist Miran Aprahamian considered the predicted number of shad being caught on the intake screen (273 individuals) to be trivial and unlikely to impact on population numbers over the years (Miran Aprahamian personal Observation)[191]. Further to this, because it is not currently possible to derive EAVs for twaite shad then the predicted total annual impingement of 273 shad is even less likely to impact on the overall shad population.

In most respects, the life cycle of the allis shad is very similar to that of its more common relative the twaite shad, except that the allis shad tends to be larger and migrate further upstream during their spawning migration (Bird, 2008). The River Severn has historically had breeding populations of allis shad, however, there are currently no known spawning populations of these species in the UK, which is why it was recently removed as having SAC status within the Severn Estuary. Even without mitigation in place impingement impacts from HPC alone will not have an adverse effect on the allis shad.

Conclusion
We can conclude that the abstraction at HPC alone will not have an adverse effect on either the twaite shad or allis shad populations designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Lamprey (*Petromyzon marinus, lampetra fluviatilis*) - impingement
Two anadromous species of lampreys use the Severn Estuary as a migratory corridor, the sea lamprey (*Petromyzon marinus*) and the river lamprey or lampern (*Lampetra fluviatilis*). The River Severn has always been an important river for both species and despite the extensive construction of weirs in the 19th century; it probably still supports the greatest number of sea and river lampreys of any northern European river (Bird 2008).

Like shad, the favourable condition status for lamprey in the Severn Estuary has not yet been described under Regulation 35(3)(a) (formally Regulation 33(2)(a)) by the Conservation Agencies, but again it is thought that both lamprey populations are in unfavourable condition. The most recent condition assessment for the Wye and the Usk in 2007 classified the River Usk as unfavourable for river lamprey and the River Wye as unfavourable for sea lamprey.

To estimate the lamprey population within the Severn Estuary, Technical Report 148 again uses the Severn Tidal Power Feasibility Study Strategic Environmental Assessment, that recently attempted to estimate lamprey population size and age distributions (APEM 2010) using measurements of life history traits collated from the

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190 Second Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2001 to December 2006 Conservation status assessment for : S1103: *Alosa fallax* - twaite shad. http://www.jncc.gov.uk/article17
191 Advice sought from Miran Aprahamian 17 October 2011, via telephone conversation.

literature to construct a generic life table for sea lamprey and river lamprey. Lampreys were assumed to represent one discrete population, given the species' capacity to disperse as evidenced by their lack of homing and wide juvenile movement within several rivers throughout the UK. The life cycle of lamprey was represented by a stage structured model and constructed with vital rate data and information on: average age at metamorphosis (ammocoete and parasitic juvenile); average ammocoete density per m^2 of optimal and suboptimal habitat; metamorphosis success (ammocoete to parasitic juvenile); ammocoete survival; and sex ratio.

Markov Chain Monte Carlo (MCMC) simulations were used to estimate the mean population size from the model output and provide a likely average population size of adult lamprey in the Rivers Usk and Wye. These estimates have been based on best guesses of available habitat of 1% per metre length of river for both optimal and suboptimal habitat. The population estimates are for sea lamprey 15,269 and for river lamprey 116,109 (APEM, 2010). Although the River Severn is known to support large populations of both river and sea lamprey, no other data on lamprey populations in and around the Severn Estuary exists. Therefore, population estimates of both the Wye and Usk appear to make a useful conservative approximation that can be used as a worst-case scenario for the Severn Estuary. Taking the above figures into account the numbers of lamprey likely to be affected by the abstraction process equate to 0.014% of the river lamprey population and 0.27% of the sea lamprey population. As both figures calculate that <1% of each population will be potentially affected as a worst case scenario, impacts are not considered to be significant.

Conclusion

On this bases of the above impingement calculations, we can conclude that the abstraction at HPC alone will not have an adverse effect on either the river or sea lamprey populations designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Eel (*Anguilla anguilla*) - impingement

The Severn Estuary and its rivers constitute the largest eel fishery in the UK; constituting 95% of all glass eels (juveniles migrating towards freshwater) caught in England and Wales. The River Parrett, supports the second most productive elver fishery in England (Langston et al. 2003)[192]. However a recent completion of a 30-year study of the estuarine population of yellow eel (*Anguilla anguilla)*, abundance in Bridgwater Bay, showed that the population number has collapsed since 1980 at an average decline of 15% per year (Henderson, 2011)[193]. The abundance of eel in 2009 is estimated at only 1% of that in 1980 and the reasons for the decline are unknown.

The European eel is listed as critically endangered on the IUCN red list for threatened species. In March 2009, the European eel was also added to the Convention on International Trade of Endangered Species (CITES) Appendix II list to control trade.

Advice from the International Council for the Exploration of the Sea (ICES) indicates that the stock of the European eel, is outside safe biological limits across European

[192] Langston, W. J., Chesman, B. S., Burt, G. R., Hawkins, S. J., Readman, J., & Worsfold, P. (2003) Characterisation of the South West European Marine Sites: The Severn Estuary pSAC, SPA. pp. 206. Marine Biological Association Occasional publication No.13.

[193] Henderson, P.A., Plenty, S.J., Newton, L, C., Bird, D.J. (2011). Evidence for a population collapse of European eel (*Anguilla anguilla*) in the Bristol Channel. Journal of Marine Biology.

waters[194]. To enable the recovery of stock, the European Union adopted Council Regulation No 1100/2007/EC which requires Member States to develop national management plans, with the objective of "permit[ting] with high probability the escapement to the sea of at least 40% of the silver eel biomass relative to the best estimate of escapement that would have existed if no anthropogenic influences had impacted the stock". Within each plan, Member States will identify a number of measures necessary to contribute towards the recovery of eel stocks[195].

These plans aim to achieve an escapement of silver eel to the spawning population that equals or exceeds a target set at 40% of the potential biomass that would be produced under conditions with no anthropogenic disturbance due to fishing, water quality or barriers to migration.

The Environment Agency (EA) has worked with Cefas, Defra and Welsh Government to produce 11 Eel Management Plans to cover England and Wales. Data on eel abundance within the Severn Estuary has been taken from the Severn River Basin District (RBD) Eel Management Plan[196]. The Severn RBD covers an area of 21,590 km² and encompasses the main River Severn, its tributaries, and several rivers joining the estuary, including the Bristol Avon to the south, and the Wye, Usk and Welsh Valleys rivers (Rhymney, Ebbw, Taff and Ely) to the north.

The data suggest that eels are currently well distributed throughout the lower and middle parts of the catchments, and the EA has concluded that the eel population in the Severn downstream from Worcester has shown little change since the early 1980s, over the period when average recruitment to Europe has declined substantially (by 95% or more). The density and the biomass of eel in the middle reaches of the Severn and Warwickshire Avon catchments were low during the 1980s, but have not been surveyed in recent years. Similar survey data for the Bristol Avon catchment and Somerset rivers within the Severn RBD indicate a general decline in densities and biomasses between 1991 and 1993, and 1994 and 2006, by 37% and 48%, respectively[197].

TR148 considers that the most useful indicator of impact is a comparison between impingement data for eels (although these are not differentiated by life stage) at Hinkley Point power station and estimates of the reported catch of each life stage 2005–2008 in the Severn RBD. A total of 774 kg of glass eels was declared as caught in the Severn RBD in 2005, 684 kg in 2006 and 1254 kg in 2007. The declared annual catches of yellow eels in the years 2005–2007 were 4088, 2785 and 892 kg respectively, and 419, 968 and 133 kg of silver eels.

In the absence of data on historical production of eel in England and Wales, a standard production rate of 16.9 kg per hectare has been applied by the Environment Agency in estimating historic production and hence setting the 40% escapement biomass target (6.76 kg per hectare) required under the European Eel Regulation 110/2007. Using the Defra/Environment Agency Probability Model[198], silver eel output from the Severn RDB is estimated to be about 8.4 kg per hectare, which has been

[194] Report of the 2006 session of the Joint EIFAC/ICES Working Group on Eels Rome, 23-27 January 2006. ICES CM 2006/ACFM:16.367pp
[195] Eel Management Plants for the United Kingdom: Introduction. Department for Environment, Food and Rural Affairs (defra). March 2010.
[196] Eel management plans for the United Kingdom: Severn River Basin District. March 2010. Defra.
[197] Haskoning. (2011). Hinkley Point C: Report to inform the Habitats Regulations Assessment (HRA). Section 6.2.288-289 , pg322. Report prepared for EDF.
[198] http://www.defra.gov.uk/foodfarm/fisheries/freshwater/eelmp.htm

calculated to equal about 133.4 t of silver eel per year, although there is a high degree of uncertainty surrounding this (see TR148).

Currently, eel fishing is banned in the Severn Estuary. However, given that the assumed wetted area is 15881 ha (i.e. 133 400 kg / 8.4 kg ha-1), the 40% escapement biomass target equates to 15 881 x 6.76 = 107.36 t. This leaves a fishery potential of 26 t (i.e. 133.4 – 107.36) if fishing is allowed to resume.

Based on the scaled-up CIMP dataset, the total annual estimated impingement of eel at a new power station at Hinkley Point, assuming a constant abstraction rate of 125 cumecs, would be 1304 fish (table xx15) equivalent to 0.08 t of adult eels. Owing to a lack of biological and population data and complex life history, it is not possible to derive an EAV for eel, so impingement rates have not been re-scaled. However, with the current cooling water intake design, TR148 estimates the equivalent adult numbers of eel likely to be impinged annually at Hinkley C (i.e. 0.08 t) as equating to <0.3% of a potential eel fishery (26 t) and <0.06% of the local Spawning stock Biomass (SSB) (133.4 t). Studies have indicated that a FRR system could reduce impingement mortality by up to 100% (Travade & Bordet, 1982)[199], but a more conservative estimate of 80% has been assumed (Turnpenny & O'Keeffe , 2005)[200]. This would reduce the numbers of eel impinged to approximately 0.016t, which is approximately 0.06% of a potential eel fishery and 0.01% of the local SSB.

It should be noted that the River Parrett and West Somerset rivers that make up a large proportion of eel and elver fisheries, fall under the South West River Basin District, which has not been taken into consideration in the above assessments. This would thus assume that the numbers of eel have been greatly under estimated within the Severn.

Eels are present in the Severn Estuary throughout the year, although there are large seasonal variations in abundance. Downstream runs of European silver eels typically start in the autumn and may last until early spring. Silver eels migrating from the River Parrett and out towards the Sargasso Sea to breed are more likely to escape impingement due to their size and stamina. Henderson et al, (2011)[201] noted that the pattern of yellow/silver eel capture at Hinkley Point B with maximum rates occurring at low water spring tides suggests that eels occupy inter-tidal habitat when available. This view is supported by the historically frequent capture of the eel by the fixed net fishermen at Steart Flats on the receding tide. In addition, Henderson el al, (2011) notes it is also possible eels are moving down the estuary and out of the River Parrett at low water and concentrating in the vicinity of the HPB intake. The HPB intake is approximately 540 metres offshore, so this could suggest that having the HPC intake approximately 3.4-3.5km offshore would reduce the number of eels impinged.

However, the concern lies with small glass eels migrating from the Atlantic sea through the estuary and down towards the River Parrett from mid February to July. They enter the Bristol Channel/Severn Estuary in large runs, moving upriver in the

[199] Travade, F., Bordet, F. (1982). Etudes expérimentales relatives aux entrainments d'organismes dans les prises d'eau de la Centrale du Blayais. Resultats de 1981 perspectives. Electricité de France. HE/31 – 82.07. 17pp.
[200] Turnpenny, A.W.H and O'Keeffe, N., (2005). Screening for intakes and outfalls: a best practice guide. Environment Agency. Science Report SC030231
[201] Henderson, P.A., Plenty, S.J., Newton, L, C., Bird, D.J. (2011). Evidence for a population collapse of European eel (*Anguilla anguilla*) in the Bristol Channel. Journal of Marine Biology.

spring, mainly using selective tidal stream transport (White & Knights, 1997a)[202]. However, the migration routes that the glass eels take through the Bristol Channel and estuary are not known. Although it should be noted that if glass eels are present in the vicinity of the HPC abstraction, the 5mm mesh on the drum screens will entrain most of the glass eels and thus this has been assessed within the entrainment assessment (section 2.6.4.3 a). Most of those impinged will be returned by the FRR and have been considered.

Conclusion
Considering the above assessment, we believe that provided the relevant mitigation, in the form of an AFD system and FRR system, is in place we can conclude that the abstraction at HPC alone will not have an adverse effect on the eel populations designated under the Severn Estuary Ramsar as a result of impingement.

Salmonids (*Salmo salar, salmo trutta*) impingement
The rivers draining into the Severn Estuary support important populations of salmon and sea trout. Salmon are known to migrate up the River Parrett to the River Tone and tributaries to spawn, whilst trout have a preference for the West Somerset rivers. Salmon stocks in the major rivers feeding into the Bristol Channel are depleted compared with the situation in the first half of the 20th Century, mainly due to climatic factors, pollution and industrial development. Although some rivers in South Wales that were once devoid of salmon are now reporting increasing runs.

There are fisheries for salmon and sea trout within the Severn Estuary. Commercial net and trap fisheries are present upstream of HPC along with rod and line fisheries in many of the rivers along both the English and Welsh coasts. Although the value of salmon and sea trout landed and sold from these fisheries is relatively low (compared with crabs, sole, sea bass etc.) these fisheries are very important in socio-economic terms, often with high heritage value (TR065)[203]. The mean annual catch (2004-08) of salmon from the Severn Estuary net fishery was 837 (long-term average of ~3000), with rods taking an average of 336, 682 and 987 from the Severn, Wye and Usk respectively.

The PISCES 2009 prediction of the total annual estimated impingement at a new power station at Hinkley Point, assuming a constant abstraction rate of 125 cumecs, would be about 276 salmon (TR065). No predictions on sea trout impingement have been made. However, very few sea trout, salmon or smolts have been recorded in impingement data at HPB over the past decade and no salmon or sea trout were recorded in the long-term impingement monitoring programme at Hinkley Point between 2005 and 2009 or in the Comprehensive Impingement Monitoring Programme (CIMP), which indicates that there is likely to be a negligible effect at the population level.

Conclusion
We would therefore agree that the impingement impacts from the HPC abstraction will not cause an adverse effect on the salmonid populations designated under the Severn Estuary Ramsar.

[202] White, E. M. & Knights, B. (1997*a*). Dynamics of upstream migration of the European eel, *Anguilla anguilla* (L.), in the Rivers Severn and Avon, England, with special reference to the effects of man-made barriers. *Fisheries Management and Ecology* 4, 311–324.
[203] BEEMS Technical Report 065 Edition 2 (TR065). Predictions of impingement and entrainment by a new nuclear power station at Hinkley Point. Cefas. Report prepared for EDF.

Fish assemblage impingement

An analysis of the abundance trends by species group from 1981 to 2008 from the long-term impingement monitoring programme dataset for HPB collected and collated by Pisces Conservation Ltd shows that HPB has not had any obvious positive or negative effect on the fish community structure at Hinkley Point. It has been noted that Where the data do indicate some population changes (e.g. for European Eel) these would appear to have been the consequence of a change in species abundance across the northeast Atlantic broadly rather than losses to impingement or entrainment at HPB itself (TR148).

Table 2.6.1S35 - Predicted total annual impingement (numbers of fish) at Hinkley point C for selected species assuming an abstraction rate of 125 cumecs via current and low-velocity intake structures with Acoustic Fish Deterrent system and with a fish recovery and return system compared with local fishery and estimated local population size. ("NA" indicates no assessment made, data from Appendix B4 of TR148).

Species	Hinkley Point C intake (without EAV or mitigation)	EAV (number, current intake)	EAV (number, low-velocity, AFD & FRR)	Local fishery (t)	Local SSB (t) or number	AFD & FRR: %of local fishery	AFD & FRR: % local SSB / population
Sprat (largest numbers)	3,380,850	3,380,850	405,702	0.19	N/A	1665.5	-
Whiting (UK BAP)	2,102,759	288,078	64,818	33.5	1613	34.4	0.72
Sole (UK BAP)	602,776	32,429	5,448	263	3240	0.5	0.04
Cod (UK BAP)	371,097	32,063	7,214	65.2	975	48.5	3.24
Herring (UK BAP)	90,526	44,792	2,240	119.4	N/A	0.2	-
Plaice (UK BAP)	5,383	493	83	84	952	0.0	0.00
Blue whiting (UK BAP)	1,166	160	36	37,900	5,360,000	0.0	0.00
Eel (Ramsar)	1,304	1,304	261	-	133.4	-	0.01
Twaite shad (SAC, Ramsar)	2,276	2,276	273	-	184,000* 100,000**	-	0.15 0.27
Allis shad (Ramsar)	68	68	8	-	-	-	-
Sea lamprey (SAC, Ramsar)	207	207	41	-	15,269	-	0.27
River lamprey (SAC, Ramsar)	82	82	16	-	116,109	-	0.01
Salmon (SAC, Ramsar)	0	0	0	-	-	0.0	0.00
Sea trout (SAC, Ramsar)	0	0	0	-	-	0.0	0.00
*Crangon crangon****	19,135,756	19,135,756	3,827151	-	-	-	-

* River Severn River Basin District (RBD) population estimate of 184,000
** Joint Nature Conservation Committee (JNCC) population estimate of 100,000
***main crustacean impinged

The 13 most abundant species detected during 1985 to 1989 and in 2004 to 2008 were whiting, sprat, common sea-snail, sand goby, flounder, pout, Dover sole, poor cod, dab, bass, five-bearded rockling, herring and cod and accounted for 95.8 % of all the fish impinged in both periods. Of the top 13 species detected from 1985 to 1989, all but two (cod and dab) were also in the top 13 in the years 2004-2008.

For some (13) species of commercial and/or conservation importance, sufficient data are available to make an assessment of the impact of predicted impingement on the local fish populations in the Severn Estuary area. For those species, the assessments have been further refined to identify the potential reductions in impact that could possibly be achieved by implementing 1) low-velocity intake and acoustic fish deterrent mitigation (using TR117[204] as source data) and 2) fish return and recovery mitigation. Full details of the methods and source data are given in TR065, 2nd Edition. Results are given in Table 2.6.1S35 . For a few species, where suitable and appropriate biological data are available, these predictions have been put into the context of local commercial landings and local fish populations (spawning-stock biomass, SSB)[205].

The International Council for the Exploration of the Sea (ICES) uses rectangles to standardise the division of sea areas for statistical analysis. Each ICES statistical rectangle is '30 min latitude and 1° longitude in size, and are thus approximately 30 nautical miles square. HPC, Bridgwater Bay and a large percentage of the inner Bristol Channel fall under ICES rectangle 31E6 (Division VIIf). The rest of the Bristol Channel make up ICES Rectangles 29E4, 30E4, 31E4 (Division VIIg), 30E5, 31E5 and these can be used to look at landings data reported for UK vessels fishing in the Bristol Channel for each species where available.

Herring (*Culpeidae*) impingement

Fishes of the culpeidae group are amongst the most important economically in the oceans. Not only are they heavily exploited commercially, but they are an important food item for larger fish. Juvenile clupeids are some of the most important components of temperate estuaries both in terms of numbers and biomass (Bird, 2008). Sprat (*Sprattus sprattus*) and Herring (*Clupea harengus)* along with the twaite shad are the most abundant culpeidae found in the Severn Estuary.

Sprat (*Sprattus sprattus*) impingement

Sprat once contributed significantly to the fishery of the Bristol Channel and Severn Estuary (Robertson 1938) and although this fishery has now declined, they remain an important component of the teleost fauna (Bird, 2008). They are present throughout the year and are consistently in the top 15 most abundant species present in the estuary (Bird, 2008).

BEEMS Technical Report 148 (TR148) states that the most useful comparison for sprat is between impingement data at Hinkley Point power station and landings data

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[204] BEEMS Technical Report 117 (TR117): Assessment of effects of cooling water intake velocity on fish entrapment risk at Hinkley Point. (2010). Cefas report prepared for EDF.
[205] Marine Ecology ES Volume 2, Chapter 19: Hinkley Point C Development Site: FINAL Report. (Section 19.6.246 Pg119). October 2011.

reported for UK vessels fishing in the Bristol Channel; ICES statistical rectangles 32 E5–E7, 31 E5–E7 and 30 E5 (sprat = 190 kg). Sprat is the dominant (>97%) clupeiform fish impinged at HPB and the population trend for this group since 1981 has remained stable. Based on the scaled-up CIMP dataset, the total annual estimated impingement of sprat at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, without mitigation would be about 3.38 million fish (Table 2.6.1S34)

Owing to a lack of biological and population data, it is not possible to derive an EAV for sprat, but as adult sprat are comparatively small, the assessment within TR148 has assumed an equivalent adult value of unity, which is likely to be a conservative assumption. It has been calculated that with the current cooling water intake design, the equivalent adult numbers of sprat likely to be impinged annually at HPC is approximately 26.4 t. As the catch of sprat in the local fishery is small (0.19 t currently), this impingement is almost 140 times that of the local fishery. As no stock assessment is made for sprat, it has not been possible to assess the impact of impingement on local populations. With the AFD/low-velocity cooling water intake design, the equivalent adult numbers of sprat impinged annually at HPC could be reduced to approximately 3.16 t, which is about 17 times the local fishery. Sprat are a delicate-bodied pelagic species, and studies conducted at Sizewell B power station indicate that a FRR system is unlikely to reduce impingement mortality (Seaby, 1994[206]; O'Keeffe and Turnpenny, 2005).

Whilst the predicted numbers of impinged sprat appear to be high, the graph in figure xA1 for sprat (*Sprattus sprattus*) shows appreciable inter-annual fluctuations in abundance, but with a generally stable population despite any pressures from the current HPB. It is therefore apparent that the current HPB is not significantly impacting on the sprat population within the Bristol Channel, and the impingement data from Table 2.6.1S35 shows that with mitigation, HPC would impinge 57% less sprat than HPB.

Conclusion
On this basis we can conclude that the abstraction at HPC alone will not have an adverse effect on the sprat population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Herring (*Clupea harengus*) impingement
Young herring remain in shallow water during the first two years of life where they grow to about 160-180 mm. It is during this period that they may enter estuaries where they frequently form mixed shoals with similar-sized young sprat and shad. The adults however, are primarily pelagic and found in offshore waters from the surface down to depths of 200 m (Bird, 2008).

BEEMS Technical Report 148 (TR148) has considered that the most useful comparison is between impingement data at HPB power station and herring landings data reported for UK, vessels fishing in ICES statistical rectangles 32 E5–E7, 31 E5–E7 and 30 E4–E5 (119.4 t, mean for 2004–2008). Based on the scaled-up CIMP dataset, the total annual estimated impingement of herring at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, would be about 90,526 fish. Using the relationship between total numbers, EAV numbers and EAV weights provided by PISCES 2009 to re-scale the impingement estimates derived from the

[206] Seaby, R.H.S (1994) Survivorship trial of the fish return system at Sizewell 'B' Power Station. Fawley Aquatic Research Laboratories, Report to Nuclear Electric plc, No. FCR102/94.

CIMP data, and with the current cooling water intake design, TR148 has estimated the equivalent adult numbers of herring likely to be impinged annually at HPC as 44 792 fish (5.64 t). This equates to approximately 5% of the local herring fishery (119.4 t). As no stock assessment is carried out for herring in the area, it has not been possible to assess the impact of impingement on local populations. With the AFD/low-velocity cooling water intake design, the equivalent adult numbers of herring impinged annually at HPC could be reduced to approximately 0.28 t, which is about 0.24% of the local fishery. Herring are a delicate-bodied pelagic species, and studies conducted at Sizewell B power station indicate that a FRR system is unlikely to reduce impingement mortality (Seaby, 1994; O'Keeffe and Turnpenny, 2005[207]).

Estuaries are an extremely important nursery ground for juvenile herring and other culpeids as they provide a relatively safe haven for the young recruits. Their fast growth, early maturity and short lives are characteristics of *r*-selected species which tend to be less vulnerable to over-exploitation since they can recover quickly if fishing pressures are reduced (Bird, 2008). In comparison to the current HPB power station abstraction, the impingement data from Table 2.6.1S34 shows that with mitigation, HPC would impinge 82% less herring than HPB.

Conclusion
This together with the impingement losses calculated to be approximately 0.24% of the local fishery mean that we can conclude that the abstraction at HPC alone will not have an adverse effect on the herring population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Dover sole (*Solea solea*) ***impingement***
Members of sole family are typically warm-water species that are at the northern limit of their range in British waters. Only the dover sole occurs in any numbers in the Severn Estuary. Dover sole are the most common members of the Soleidae and are a highly adaptable species. They occur offshore in water as deep as 185 m but are also common in estuaries where they can be found in water only a few metres deep (Bird, 2008). Sole stocks have shown substantial variations in abundance over the past 50 years, largely as a result of fishing and variability in breeding success (Millner and Whiting, 1996).

The stock is currently considered by ICES to be fished sustainably and to have full reproductive capacity (ICES, 2008)[208]. The mean (2003–2007) total annual international catch in VIIf,g (not including discarding) was 1114 t; UK landings were 263 t; and the SSB estimate was 3240 t. BEEMS Technical Report 148 (TR148) has considered that the most valid comparison for sole is between impingement data at HPB power station and landings data reported for UK vessels fishing in the Bristol Channel and Celtic Sea (Divisions VIIf and VIIg), and with the SSB estimate for this stock.

Based on the scaled-up CIMP dataset, the total annual estimated impingement of sole at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, would be 602,776 fish (Table 2.6.1S35). Using the relationship between total numbers, EAV numbers and EAV weights provided by PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling

[207] Turnpenny, A. W. H., O'Keeffe, N. (2005). Screening for intake and outfalls: a best practice guide. Environment Agency . Science Report. SC030231.
[208] ICES. (2008). Report on the working group on the assessment of southern shelf demersal stocks, 30 April – 6 May 2008. ICES CM 2008/ACOM:12.

water intake design, TR148 estimates the equivalent adult numbers of sole likely to be impinged annually at HPC is 32,429 fish (7.43 t). This equates to approximately 3% of the local sole fishery (263 t) and 0.23% of the VIIf,g SSB (3,240 t). With the AFD/low-velocity cooling-water intake design, the equivalent adult numbers of sole impinged annually at HPC could be reduced to approximately 6.24 t, which is about 2.4% of the local fishery and 0.2% of the SSB. Sole are a demersal species and studies conducted at Sizewell B power station indicate that a FRR system could reduce impingement mortality by about 96% (Seaby, 1994), but a more conservative estimate of 80% has been assumed (O'Keeffe and Turnpenny, 2005). This would reduce the numbers of sole impinged to approximately 1.24 t, which is approximately 0.5% local fishery and 0.04% of the local SSB.

Sole are a highly valued food fish and are mainly caught by trawling at night when they are most active. In recent years the number of juvenile sole entrained at HPB has increased almost exponentially and this has been shown to be highly correlated with increased seawater temperatures during the early part of the season (Bird, 2008). It has been suggested that this marked increase is a consequence of changes in the North Atlantic Oscillation (Henderson & Seaby 2005b). In comparison to the current HPB power station abstraction, the impingement data from Table 2.6.4.3.34 shows that with mitigation, HPC would impinge 36% less sole than HPB.

This together with the impingement losses calculated to be approximately 0.5% local fishery and 0.04% of the local SSB mean that we can conclude that the abstraction at HPC alone will not have an adverse effect on the dover sole population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Cod fish (*Gadidae*) impingement

The members of the cod fish family (Gadidae) are of the greatest economic importance since the group includes many species that are heavily commercially exploited (Wheeler 1969)[209]. The six most abundant species are all marine estuarine-opportunistic and comprise the northern rockling, five-bearded rockling, whiting, bib, poor cod, and pollack. Because of their high commercial value and available data only cod and whiting are discussed in detail below, along with blue whiting.

Cod (*Gadus morhua*) impingement

ICES (2008) considers cod in Divisions VIIe–k to be over-fished, but currently harvested sustainably. The stock has had a truncated age structure over several decades, and its dynamics have been strongly recruitment-driven.

BEEMS Technical Report 148 (TR148) has considered that the most useful comparison is between impingement data at HPB power station and landings data reported for UK vessels fishing in ICES statistical rectangles 32 E4–E7, 31 E4–E7, 30 E4–E5 and 29 E4 (= 65.17 t, mean 2004–2008). To give some idea of the impact at a stock level, the EAV can be compared with the SSB estimate for Divisions VIIe–k, weighted by the ratio of the above landings to total UK landings from VIIe–k as used by ICES (343 t). Therefore, the estimated "local" SSB = 5133 x (65.17/343) = 975 t.

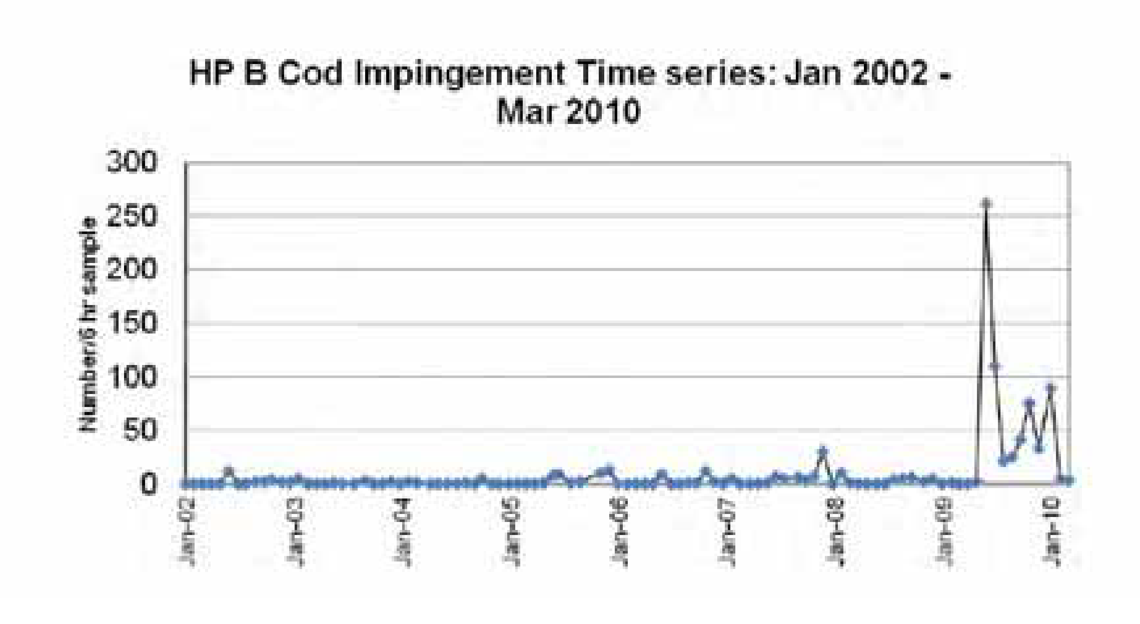
Based on the scaled-up CIMP dataset, the total annual estimated impingement of cod at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, would be about 371,097 fish (table xx15). Using the relationship between total numbers, EAV numbers and EAV weights provided by PISCES 2009 to re-scale

[209] Wheeler, A. (1969) *The fishes of the British Isles and North-West Europe*. Macmillan, London.

the impingement estimates derived from the CIMP data, and with the current cooling water intake design, TR148 has calculated the equivalent adult numbers of cod likely to be impinged annually at HPC as 32,063 fish (140.4 t). This equates to approximately 215% of the local cod fishery (65.2 t) and 14% of the local SSB (975 t). With the AFD/low-velocity cooling water intake design, the equivalent adult numbers of cod impinged annually at HPC could be reduced to approximately 63.1 t, which is about 97% of the local fishery and 6.48% of the local SSB. Cod are a demersal species and studies conducted at Sizewell B power station indicate that a FRR system could reduce impingement mortality by about 94% (Seaby, 1994)[210] but we have assumed the more conservative estimate of 50% (Turnpenny & O'Keeffe, 2005)[211]. This would further reduce the numbers of cod impinged to approximately 31.6 t, which is 48,5% of the local fishery and <3.24% of the local SSB.

The results above suggested a rather high proportion of cod impinged in relation to the local fishery and SSB, so they were looked into further and re-assessed with results detailed in BEEMS Scientific Position Paper 065 (SPP065). The raw data was re-examined and it was found that 2009 was an exceptional year for cod recruitment, with an extremely large recruitment spike spawned in spring of that year. According to the impingement data time series, cod is the only species at HPB that shows a dramatic rise in recruitment numbers in 2009 (see Figure 2.6.1S36). It has therefore been concluded that the predictions for cod in TR148 as stated above are inappropriate as the data collected at the time of this clear recruitment spike would be biased towards an exceptional event and would be unlikely to be representative of the likely situation. New predictions have therefore been made using data that are synchronous with those used for the deviation of the spawning stock estimate.

Figure 2.6.1S36 Cod impingement time series data from HPB with spike in 2009 (taken from SPP065).



Taking the worst case figure of basing cod impingement upon the mean data collected from 2004 to 2008, the predicted cod impingement would become 7.3% of that estimated using the 2009 data. Therefore the predicted equivalent adult numbers

[210] Seaby, R.H.S (1994) Survivorship trial of the fish return system at Sizewell 'B' Power Station. Fawley Aquatic Research Laboratories, Report to Nuclear Electric plc, No. FCR102/94.

[211] Turnpenny, A. W. H., O'Keeffe, N. (2005). Screening for intake and outfalls: a best practice guide. Environment Agency . Science Report. SC030231

of cod likely to be impinged annually at HPC would equate to 2.3 t, which is about 3.53% of the local fishery and 0.24% of the SSB.

Conclusion
On these calculations we can conclude that the abstraction at HPC alone will not have an adverse effect on the cod population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Whiting *(Merlangius merlangus)* impingement
Whiting are shallow water gadoids that are particularly abundant in the North Sea where they are found at depths of 30 to 100 m (Bird, 2008)[212]. Young 0+ whiting are commonly found in estuaries, which they use as a nursery and evidence suggests that whiting migrate to deeper waters as soon as they are large enough to do so (Potter et al. 1988)[213].

BEEMS Technical Report 148 (TR148) has considered that the most useful comparison for whiting is between impingement data at HPB power station and landings data reported for UK vessels fishing in ICES statistical rectangles 32 E5–E7, 31 E5–E7 and 30 E5 (= 33.48 t, mean 2004–08). At a population level, an indicative (but not robust) comparison is with the SSB estimate for Divisions VIIe–k, weighted by the ratio of the above landings to total UK landings for VIIe-k as used by ICES (on the assumption that these respectively reflect the abundance at the local and "assessment stock" levels). TR148 has calculated that the average UK landings from this stock from 2004 to 2008 were 529 t, and the average annual SSB is estimated at 25,492 t (corresponding to international landings of 9,240 t as estimated by ICES). Therefore, the estimated "local" SSB = 25492 x (33.48/529) = 1613 t.

Based on the scaled-up CIMP dataset, the total annual estimated impingement of whiting at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, would be about 2.1 million fish (Table 2.6.1S35). Using the relationship between total numbers, EAV numbers and EAV weights provided by PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, it has been estimated that the equivalent adult numbers of whiting likely to be impinged annually at HPC is 288,078 fish (51.28 t). This equates to approximately 153% of the local whiting fishery (33.5 t) and 3% of the "local" SSB (1724 t). With the AFD/low-velocity cooling water intake design, TR148 has estimated the equivalent adult numbers of whiting impinged annually at HPC could be reduced to approximately 23.0 t, which is about 69% of the local fishery and 1.4% of the local SSB. Whiting are a demersal species and studies conducted at Sizewell B power station indicate that a FRR system could reduce impingement mortality by about 50% (Seaby, 1994)[214]. This would reduce the numbers of whiting impinged to approximately 11.5 t, which is approximately 34.5% local fishery and 0.72% of the local SSB.

The gadoids, and whiting in particular, make an extremely important contribution to the fish fauna of the Severn Estuary. They depend on the estuary as a nursery in the

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[212] Bird, D.J. (2008). The Biology and Conservation of the fish assemblage of the Severn Estuary (cSAC). Report for Countryside Council for Wales (CCW).

[213] Potter, I.C., Gardner, D.C. & Claridge, P.N. (1988) Age composition, growth, movements, meristics and parasites of the whiting, *Merangius merangus*, in the Severn Estuary and Bristol Channel. *Journal of the Marine Biological Association of the United Kingdom*, 68, 295-313.

[214] Seaby, R.H.S (1994) Survivorship trial of the fish return system at Sizewell 'B' Power Station. Fawley Aquatic Research Laboratories, Report to Nuclear Electric plc, No. FCR102/94.

early years of life and this fact is critical to the management of whiting which are an important commercial fish in Europe and one of the principal items of inshore boat fisheries (Bird, 2008). Whilst the predicted numbers of impinged whiting appear to be high, the graph in figure xA1 for whiting (*Merlangius merlangus*) shows a remarkable consistency in abundance from year to year with a very stable population despite any pressures from the current HPB. It is therefore apparent that the current HPB is not significantly impacting on the whiting population within the Bristol Channel, and the impingement data from Table 2.6.1S34 shows that with mitigation, HPC would impinge 18% less whiting than HPB.

Conclusion

On this basis we can conclude that the abstraction at HPC alone will not have an adverse effect on the whiting population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Blue whiting (*Micromesistius poutassou*) *impingement*

Using the ICES (2010) assessment values BEEMS Technical Report 148 (TR148) has considered that the most useful comparison is between impingement data at HPB power station and landings data reported for all vessels fishing the combined stock in Subareas VIII and IX, and Divisions VIId-k (the " southern areas") (= 37 900 t, mean 2004–2008). At a population level, the mean SSB estimate for the whole stock in the years 2004-2008 was 5,360,000 t, which is near the long-term mean for the stock. Based on the scaled-up CIMP dataset, the total annual estimated impingement of blue whiting at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, would be about 1166 fish (Appendices B2 and B3). Using the relationship between total numbers, EAV numbers and EAV weights for whiting (which we have assumed will be similar for blue whiting) provided by PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, TR148 has estimated the equivalent adult numbers of blue whiting likely to be impinged annually at HPC as 160 fish (0.02 t). With the AFD/low velocity cooling water intake design, it has been estimated that the equivalent adult numbers of blue whiting impinged annually at HPC could be reduced to 72 fish (0.01 t). This equates to <0.1% of the blue whiting fishery (37,900 t) and <0.1% of the corresponding SSB (5,360,000 t). Assuming that the effectiveness of a FRR for blue whiting is similar to that for whiting (above), a FRR system could reduce impingement mortality by up to 50%. This would further reduce the numbers of blue whiting impinged to approximately 0.005 t, which is < 0.01% of the local fishery and <0.01% of the local SSB.

On the basis of the calculations above, and on the basis that HPC is likely to impinge 22% less than HPB, then we can conclude that the abstraction at HPC alone will not have an adverse effect on the blue whiting population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Plaice (*Pleuronectes platessa*) *impingement*

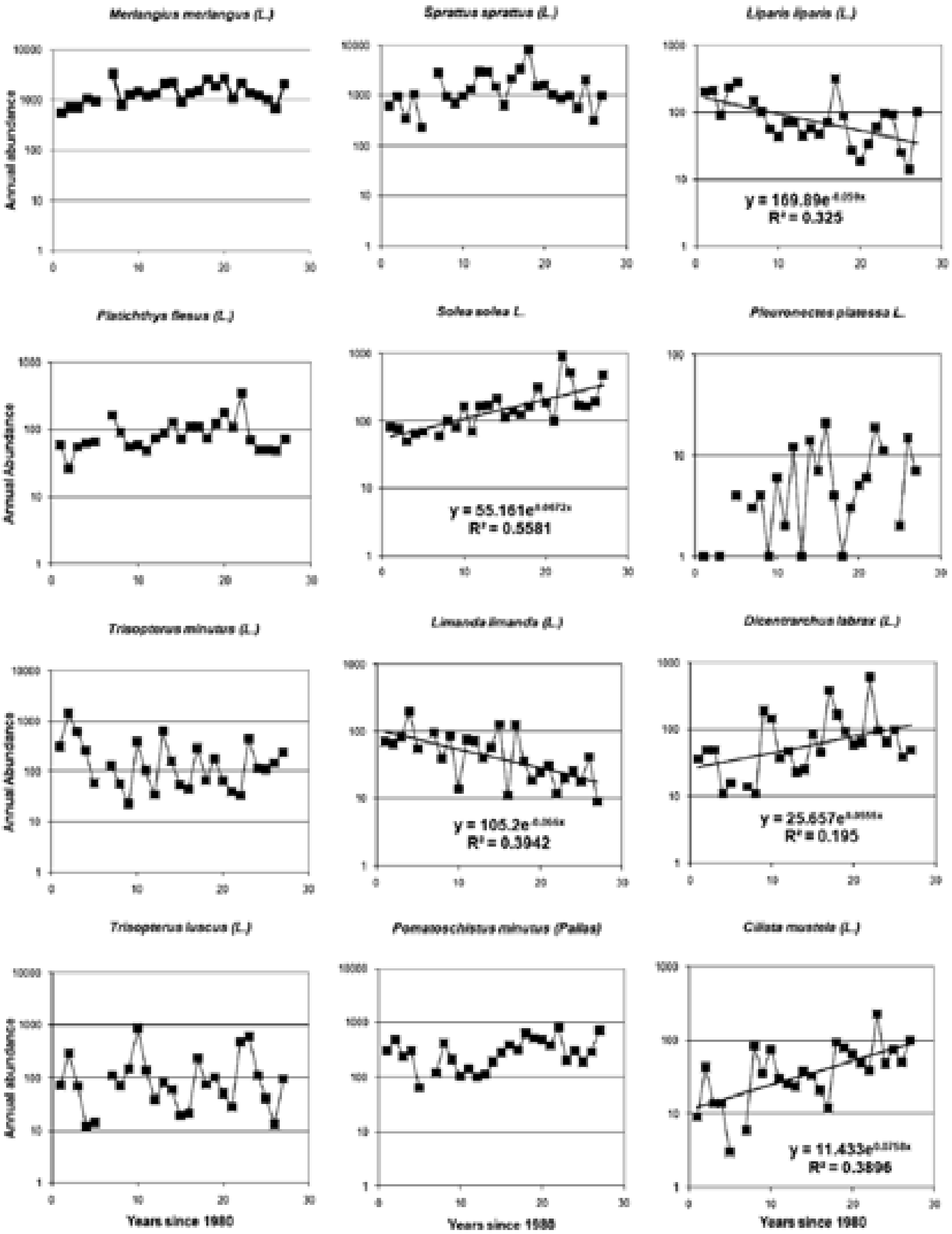
ICES (2008) advised that the plaice stock in the Celtic Sea (Divisions VIIf,g) had reduced reproductive capacity and was over fished. There have been some very weak year classes since the late 1990s. The mean (2003–2007) total annual international catch in VIIf,g (not including discarding) was 461 t; UK landings were 84 t; and the SSB estimate was 952 t.

BEEMS Technical Report 148 (TR148) has considered that the most useful comparison for plaice is between impingement data at HPB power station and landings data reported for UK vessels fishing in the Bristol Channel and Celtic Sea (Divisions VIIf and VIIg), and with the SSB estimate for this stock. Based on the scaled-up CIMP dataset, the total annual estimated impingement of plaice at a new power station at HPC, assuming a constant abstraction rate of 125 cumecs, would be about 5,383 fish (Table 2.6.1S35). Using the relationship between total numbers, EAV numbers and EAV weights provided by PISCES 2009 to re-scale the impingement estimates derived from the CIMP data, and with the current cooling water intake design, TR148 estimates the equivalent adult numbers of plaice likely to be impinged annually at HPC as 493 fish (0.23 t). This equates to approximately 0.3% of the local plaice fishery (84 t) and 0.02% of the Celtic Sea SSB (952 t). With the AFD/ low-velocity cooling water intake design, the equivalent adult numbers of place impinged annually at HPC could be reduced to approximately 0.19 t, which is about 0.23% of the local fishery and 0.02% of the local SSB. Plaice are a demersal species and studies conducted at Sizewell B power station indicate that a FRR system could reduce impingement mortality by up to 100% (Seaby, 1994), but we have assumed the more conservative estimate of 80% (Turnpenny & O'Keeffe, 2005). This would further reduce the numbers of plaice impinged to approximately 0.038 t, which is 0.005% of the local fishery and <0.004% of the local SSB.

Conclusion

On the basis of the calculations above, and on the basis that HPC is likely to impinge 26% less than HPB, then we can conclude that the abstraction at HPC alone will not have an adverse effect on the plaice population designated under the Severn Estuary SAC and Ramsar as a result of impingement.

Figure 2.6.1S37. The variation in the Log total number of common fish species caught per year within Bridgwater Bay in the lower Severn Estuary. Data were collected between 1981 and 2008 during regular monthly sampling at Hinkley Point. The total number of individuals recorded each year is plotted on a log scale. For species showing significant trends in annual abundance, an exponential curve has been fitted by regression, the equation and coefficient of determination is given in each plot (figures taken from Henderson & Bird, 2010)[215] *.*



[215] Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.

Impingement of other fish assemblage species

The fish species assessed above only make up part of the fish assemblage within the Severn Estuary. To get a more complete picture of the impacts via impingement, the top 18 fish impinged during the BEEMS comprehensive impingement monitoring programme, 2009-2010 have been assessed against their annual abundance derived from data collected between 1981 and 2008 during regular monthly sampling at HPB (Pisces Conservation Ltd.) expressed within Figure 2.6.1.S37 (Henderson & Bird, 2010) above. Where data from Figure 2.6.1S37 is missing, annual abundance has been derived from figure 1 in BEEMS TR148.

Table 2.6.1S38 - Summary of annual abundance from 1981 – 2008 of the top 18 fish impinged at HPB from BEEMS comprehensive impingement monitoring programme, 2009-2010. Annual abundance derived from impingement data from HPB and expressed within figure xA1 (Henderson & Bird, 2010) above. Where data from figure xA1 is missing, annual abundance has been derived from figure 1 in BEEMS TR148. Species that have been greyed out are those already assessed above.

Species common name	**Scientific name**	**Family**	**Annual abundance 1981 – 2008 within the Severn Estuary / Bristol Channel**
Sprat	Sprattus sprattus	Clupeidae	Appreciable inter-annual fluctuations in abundance. Stable population with a gradual decline from year 2000.
Whiting	*Merlangius merlangus*	*Gadidae*	Remarkable consistency in abundance from year to year. Stable population with a gradual increase in abundance.
Dover sole	*Solea solea*	Soleidae	Inter-annual fluctuations in abundance. Stable population with a significant increase in abundance.
Cod	Gadus morhua	*Gadidae*	No data from Figure xA1. However, figure 1 from TR148 suggests considerable inter-annual variations with a gradual increase in abundance.
Flounder	*Platichthys flesus*	Pleuronectidae	Appreciable inter-annual fluctuations in abundance. Stable population.
Thin-lipped grey Mullet	*Liza ramada*	*Mugilidae*	No data from Figure xA1. However, figure 1 from TR148 suggests considerable inter-annual variations with a gradual increase in abundance.
Five-bearded rockling	*Ciliata mustela*	*Gadidae*	Inter-annual fluctuations in abundance. Stable population with a significant increase in abundance.
Herring	*Clupea harengus*	Clupeidae	No data from Figure xA1. However, figure 1 from TR148 suggests considerable inter-annual variations with a gradual increase in abundance.

Table 2.6.1S38 (continued) - Summary of annual abundance from 1981 – 2008 of the top 18 fish impinged at HPB from BEEMS comprehensive impingement monitoring programme, 2009-2010. Annual abundance derived from impingement data from HPB and expressed within figure xA1 (Henderson & Bird, 2010) above. Where data from figure xA1 is missing, annual abundance has been derived from figure 1 in BEEMS TR148. Species that have been greyed out are those already assessed above.

Species common name	**Scientific name**	**Family**	**Annual abundance 1981 – 2008 within the Severn Estuary / Bristol Channel**
Sand goby	*Pomatoschistus spp.*	Gobiidae	Appreciable inter-annual fluctuations in abundance. Stable population with a gradual increase in abundance since early 1990s.
Snake pipefish	*Entelurus aequoreus*	Syngnathidae	No data from Figure xA1. However, figure 1 from TR148 suggests inter-annual variations in abundance. Low population with a significant increase in abundance from 2003 onwards.
Bass	*Dicentrarchus labrax*	Percichthyidae	Considerable inter-annual variations in abundance. Stable population with a significant increase in abundance.
Sea snail*	*Liparis liparis*	*Liparidae*	Appreciable inter-annual fluctuations in abundance. Significant decline in adundance.
Poor cod	*Trisopterus minutus*	*Gadidae*	No data from Figure xA1. However, figure 1 from TR148 suggests considerable inter-annual variations in abundance. Stable population.
Pout	*Trisopterus luscus*	*Gadidae*	Considerable inter-annual variations in abundance. Stable population.
Lesser spotted dogfish	*Scyliorhinus caniculus*	Scyliorhinidae	No data from Figure xA1. However, figure 1 from TR148 suggests inter-annual fluctuations in abundance. Stable population with a gradual increase in abundance.
Conger	*Conger conger*	*Congridae*	No data from Figure xA1. However, figure 1 from TR148 suggests inter-annual fluctuations in abundance. Stable population with a gradual increase in abundance.
Plaice	*Pleuronectes platessa*	Pleuronectidae	Considerable inter-annual variations with a gradual increase in abundance.
Dab	*Limanda limanda*	Pleuronectidae	Appreciable inter-annual fluctuations in abundance. Significant decline in abundance.

* The sea snail is a small clinging fish, and not a gastropod as the name may suggest.

According to Table 2.6.1S38 and Figure 2.6.1S37 most of the species, with the exception of sea snail and dab, appear to have had a stable population over the past 25 years in Bridgwater Bay, despite the presence of the HPB abstraction. However, there is considerable inter-annual variations in abundance over the years, which can be associated to temperature and salinity changes and in some cases the North Atlantic Oscillation Index (NOAI) (Henderson *et al*, 2011)[216]. For example, the annual recruitment of bass, *D. labrax*, is highly variable and a strong year class will suppress the next generation by cannibalism, in addition increases in abundance have been correlated with exceptionally warm years (Henderson and Corps, 1997)[217]. Recent increases in water temperature have also been used to explain the increase in sole, (*S. solea)* (Henderson and Seaby, 2005)[218]. On the other hand, the abundance of sea snail (*L. liparis)*, and dab (*L. limanda)* have been shown to decline with increasing water temperature as they are close to the southern edge of their range. However, they have not been lost, probably because they are able to avoid harm during periods of excessively warm water by moving deeper (Henderson & Seaby, 1999)[219]. There are also recent rapid changes in abundance that cannot be related to any single factor and may be caused by events outside of the estuary (Henderson & Bird, 2010)[220]. The figures also show a recent explosive increase in the snake pipefish (*Entelurus aequoreus)*, which has also been noted in other North Atlantic regions (van Damme and Couperus, 2008)[221].

Although not part of the top 18 species impinged, eel, shad, lamprey and salmon show a long-term gradual decline in abundance from 1981 – 2008 and it is thought that the declines are related to other factors including the introduction of parasites and obstructions to migration in the rivers (Henderson & Bird, 2010), rather than impacts from power station cooling water intakes.

Despite the potential impact of water-intake screens on fish mortality, between the 1970s and 1990s, the abundance of many species of fish has increased at Hinkley Point (Henderson & Bird, 2010). Where the data do indicate some population changes these would appear to have been the consequence of a change in species abundance across the northeast Atlantic broadly rather than losses to impingement or entrainment at Hinkley B (TR148).

Conclusion

We would therefore agree that HPC abstraction alone will not have an adverse effect on the fish assemblage designated under the Severn Estuary SAC and Ramsar as a result of impingement.

[216] Henderson, P.A, Seaby, R.M.H., Somes, J.R. (2011). Community level response to climate change: The long-term study of the fish and crustacean community of the Bristol Channel. Journal of Experimental Marine Biology & Ecology. 400; 78-89.

[217] Henderson, P.A., Corps, M. (1997). The role of temperature and cannibalism in inter-annual recruitment variation of bass in British waters. Journal of Fish Biology 50, 280–295.

[218] Henderson, P.A., Seaby, R.M. (2005). The role of climate in determining the temporal variation in abundance, recruitment and growth of sole Solea solea in the Bristol Channel. Journal of the Marine Biological Association of the United Kingdom 85, 197–204.

[219] Henderson, P.A., Seaby, R.M., 1999. Population stability of the sea snail at the southern edge of its range. Journal of Fish Biology 54, 1161–1176.

[220] Henderson, P.A, and Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61; 100-114

[221] van Damme, C.J.G., (Bram) Couperus, A.S., 2008. Mass occurrence of snake pipefish in the Northeast Atlantic: result of a change in climate? Journal of Sea Research 60, 117–125.

Crustaceans impingement

Impingement and entrainment studies carried out at HPB over the last 35 years have provided extensive information on the local mobile epifauna. The common or brown shrimp *Crangon crangon* has remained the most abundant animal caught, and the population has remained relatively stable, aside from the remarkable explosion in abundance in 2002 with the capture of more than 30,000 individuals in a single monthly sample (Henderson & Seaby, 2006)[222]. The number of recruits has greatly changed between years, and has found to be positively correlated with both average water temperature from January to August and river flow rate, and negatively correlated with the Winter North Atlantic Oscillation Index (Henderson *et al*, 2006)[223].

C. crangon, play a key trophic role within the estuary, feeding upon polychaetes and other small animals, particularly meiofauna (Pihl & Rosenberg, 1982)[224]. They are also an important component of the diet for most fish within Bridgwater Bay and they are unique in being the only crustacean that is abundant throughout the year (Henderson *el al*, 1992)[225]. Due to the ubiquity and importance of *C. crangon* within the estuary it has been studied in detail over the years and therefore has the most available data as a crustacean species.

Other common species caught at HPB intake screens include the pelagic prawn (*Pasiphaea sivado*), large edible or common prawn (*Palaemon serratus*), the pink shrimp *(Pandalus montagui)* and the swimming crab, (*Liocarcinus holsatus)*, which have all shown a clear gradual trend of increasing abundance locally as well as similar patterns of seasonality in relation to salinity.

Table 2.6.1S39 -. Comparison of impingement of the top six crustaceans at HPB and HPC from BEEMS comprehensive impingement monitoring programme, 2009-2010. HPC figures are based on scaled-up data from HPB (33.7 cumecs) with estimated mean numbers assuming an abstraction rate of 125 cumecs (mean data from Appendix A of TR148).

Species common name	Scientific name	HPB (mean No.)	HPC (mean No.)	HPC + FRR	Change from Hinkley Point B
Brown shrimp	*Crangon crangon*	4,911,592	19,135,756	3,827,151	- 22%
Pelagic prawn / Ghost shrimp	*Pasiphaea sivado*	3,213,195	11,448,037	2,289,607	- 29%
Pink shrimp	*Pandalus montagui*	896,492	3,253,744	650,749	- 27%
Atlantic prawn	*Palaemon serratus*	348,361	1,286,515	257,303	- 26%
Swimming crab	*Liocarcinus holsatus*	13,004	47,988	9,598	- 26%
Edible crab	*Cancer pagurus*	11,994	45,962	9,192	- 23%

[222] Henderson, P.A, Seaby, R.M. (2007). Fish and crustacean captures at Hinkley Point B nuclear power station: Report for the year April 2006 to March 2007. Pisces Conservation Ltd.

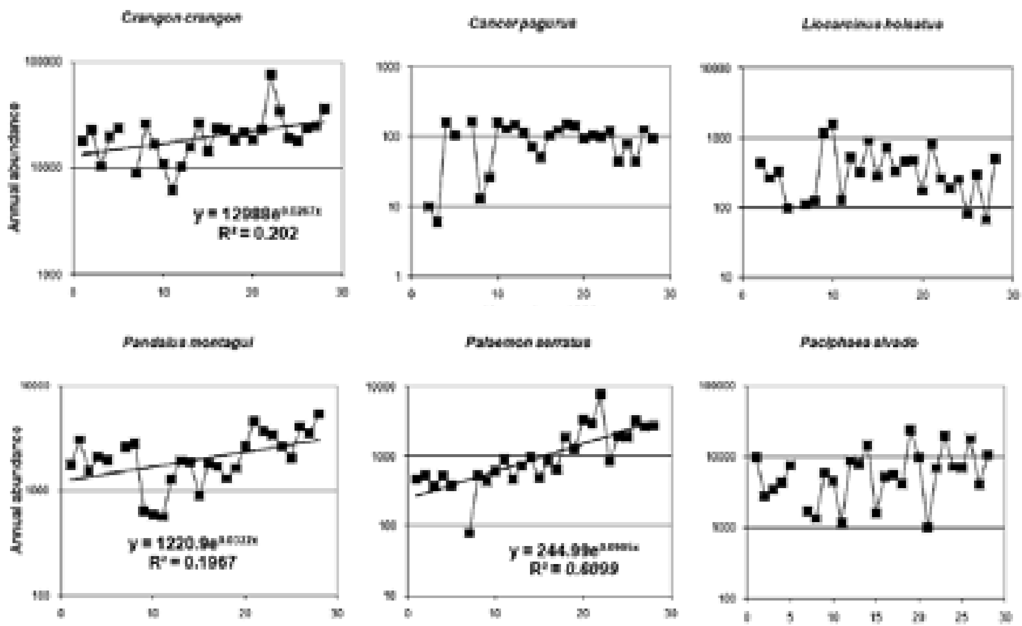
[223] Henderson, P.A, Seaby, R.M., Somes, J.R. (2006) A 25-year study of climatic and density-dependent population regulation of common shrimp Crangon crangon (Crustacea: Caridea) in the Bristol Channel. J. Mar. Biol. Ass. U.K. 86, 287^298

[224] Pihl, L. & Rosenberg, R., 1982. Production, abundance and biomass of mobile epibenthic marine fauna in shallow waters, western Sweden. Journal of Experimental Marine Biology and Ecology, 57, 273-301.

[225] Henderson, P.A., James, D., Holmes, R.H.A. (1992). Trophic structure in the Bristol Channel: seasonality and stability in Bridgwater Bay. J. Mar. Biol. Ass. U.K. 72:675-690.

The results for the Comprehensive Impingement Monitoring Programme (February 2009 to May 2010) at HPB almost mirror such abundances, with 14 species of macro-crustacean recorded over the 51 sampling dates, at an average rate of 19kg and 14,000 individuals per day. Brown shrimp (*C. crangon*) were the most abundant with nearly 400,000 recorded, followed by pelagic prawn (P. sivado), pink shrimp (*P. montagui*), and Atlantic prawn (*P. serratus*). With the 5mm screening mesh proposed at HPC it has been calculated that approximately 90% of *C. crangon* will be impinged and 10% entrained (SPP063). The lifecycle stages that are vulnerable to impingement are therefore likely to be the larger adults. The scaled-up data based on HPB predicts that an estimated 19,135,756 *C. crangon* will be impinged annually at HPC. Assumed recovery rates for crustaceans via the Fish Recovery and Return system is 80% so the predicted annual impingement from HPC alone is 3,827,151 for *C. crangon* (see Table 2.6.1S39), which represents a 22% reduction from the mean numbers currently impinged at HPB.

Figure 2.6.1S40. *The variation of the total numbers caught per year of common crustacean species. Data were collected between 1981 and 2008 during regular monthly sampling at HPB. The total number is plotted on a log scale for species caught every year. For species showing significant trends in annual abundance, an exponential curve has been fitted by regression, the equation and coefficient of determination is given in each plot. All abundances are log values.* ***Y axis = Years since 1980.*** *(figures taken from Henderson & Bird, 2010)*[226] .



The predicted impingement losses of the brown shrimp *C. crangon (*the main crustacean impinged) are expected to be similar to those of HPB. As discussed under the entrainment of decapods assessment, the past 25 years the adult population of *Crangon crangon* within Bridgwater Bay has been notably stable (see Figure 2.6.1S40, however, average *C. crangon* abundance has increased because recruitment has increased with average seawater temperature. This has resulted in a clear example of density-dependent control as the mortality rate of recruits over their

[226] Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.

first winter increases with recruitment (Henderson *et al*, 2006)[227]. It envisaged that increased *C. crangon* abundance is associated with increased predator and competitor abundance, and it is thought that a fixed physical constraint, such as the amount of available habitat, is setting an upper limit on the adult population. The evidence from the Hinkley Point B impingement surveys is that the production/ biomass ratio has increased over the past 25 years. Any reductions in the population size due to impingement will be rapidly filled by new recruits.

The other five main crustacean species in question are also expected to have predicted impingement losses similar to those of HPB, although potentially between 23-27% less impact with mitigation. According to Figure 2.6.1S40 the other five species also appear to have a stable population over the past 25 years in Bridgwater Bay, with the pink shrimp (*P. montagui*), and Atlantic prawn (*P. serratus*) (along with *C. crangon*) having a significant increase in abundance since the early 1990s. Although there is considerable inter-annual variation between years, this has been associated to temperature and salinity changes and in some cases the North Atlantic Oscillation (NOA).

Conclusion
Given the natural productivity of each species and on the basis of the findings described above, we would agree that the number of Crustaceans impinged on the HPC intake alone will not have an adverse effect on the overall populations within Bridgwater Bay or wider estuary and Bristol Channel.

Combined impacts

Entrainment and impingement
The combined impacts of impingement and entrainment have the potential to cause an additive effect on the fish populations of the Bristol Channel and Severn Estuary. Very rough estimates have been made by comparing the predicted species numbers from the impingement data to the predicted species numbers from the entrainment data for HPC (see table combo1). However, these calculations should be used with extreme caution as the eggs & larvae do not necessarily compare to juvenile or adult fish numbers as we do not know what proportion of the eggs and larvae will survive to become fish. On the other hand, we also do not know what proportion of the juveniles impinged will become adults without estimating Estimated Adult Values (EAVs), therefore neither dataset has any type of mitigation or EAV calculated into it. Furthermore, the data is from two separate data sets; the HPC entrainment predictions have been calculated from the 2008/09 & 2010 surveys, and the HPC impingement predictions have been calculated using scaled-up data from HPB (33.7 cumecs) with estimated mean numbers assuming an abstraction rate of 125 cumecs (data from Appendix A of TR148). The margin for error is thus very high and will only be used to scope out insignificant numbers, rather than actually predict the percentage increase via combined effects.

It should be noted that no eggs or juvenile species of migratory fish designated under the Severn Estuary SAC and Ramsar are thought to be impacted by entrainment (section 2.6.1.3.3) and therefore are not included within this assessment.

Table 2.6.1S41 suggests that five species appear to have the potential for more than 1% increase in impact from impingement over entrainment, and they include Dover

[227] Henderson, P.A, Seaby, R.M., Somes, J.R. (2006) A 25-year study of climatic and density-dependent population regulation of common shrimp Crangon crangon (Crustacea: Caridea) in the Bristol Channel. J. Mar. Biol. Ass. U.K. 86, 287^298

sole, herring, sprat, five-bearded rocking and European flounder, which have been looked at in more detail in Table 2.6.1S41. Those below a 1% increase are deemed to have an insignificant combined impact.

Table combo2 looks at the numbers of entrained and impinged fish, but this time we have excluded the calculations on potential % increase in impact from impingement (table combo1), because it is the fish numbers rather than percentage increase that is relevant in this instance. Thus the predicted numbers of entrained fish together with entrained early life stages has been calculated.

Table 2.6.1S41 . Potential percentage increase in impact of combined impingement and entrainment

Species	**HPC annual fish entrainment predictions**	**HPC annual fish impingement predictions**	**Potential % increase in impact from impingement**
	Eggs & larvae	**Fish**	
European anchovy (*Engraulis encrasicolus*)	12,141,963	66	<0.01
Dover sole (*Solea solea*)	11,391,047	602,776	5.30
Soles (Solidae)	819,589	No other known Solidae species present in top 64 species impinged	0.00
Rocklings (*Gaidropsarus* spp/*Onos* spp.)	19,345,899	1,725 (Northern) +130 (3-bearded) + 78 (shore) = 1933	<0.01
Solenette (*Buglossidium luteum*)	2,864,536	Not present in top 64 species impinged	0.00
European sea bass (*Dicentrarchus labrax*)	89,264,717	33,562	0.04
Gurnard spp.	No figures available	587 (grey) + 715 (tub) = 1302	0.00
Dragonets (Callionymidae)	383,685	690	0.18
Herrings (Clupeidae)	414,615	90,526	21.8
Sprat (*Sprattus sprattus*)	7,114,303	3,380,850	47.5
Sandeels (Ammodytidae)	9,075,949	1, 024 (Greater) + 56 (common) = 1,080	0.01
Gobies (Gobiidae)	10,351,234	74,724 (sand)+ 1,170 (painted) + 47 (black) = 75,941	0.73
Mackerel (*Scomber spp.*)	No figures available	Not present in top 64 species impinged	Unknown
Pilchard (*Sardina pilchardus*)	3,277,311	97	<0.01
Scaldfish *(Arnoglossus spp.)*	No figures available	Not present in top 64 species impinged	Unknown
Five-bearded rockling (*Ciliata mustela*)	333,687	144,019	43.2
Butterfish (*Pholis gunnellus*)	389,819	Not present in top 64 species impinged	0.00
European flounder (*Platichthys flesus*)	2,711,333	219,753	8.10
European plaice (*Pleuronectes platessa*)	3,322,735	5,383	0.16
Sea scorpion (*Taurulus bubalis*)	474,262	Not present in top 64 species impinged	0.00
Unidentifiable fish	26,336,246	???	Unknown

Table 2.6.1S42 - Potential impact on fish numbers from the combined hazards of entrainment and impingement.

Species	HPC estimated annual entrainment	HPC estimated annual impingement with mitigation	Total Numbers with mitigation	% of the Trevose spawning numbers
Dover sole (*Solea solea*)	11,391,047 1,659,991*	102,471 5,448*	11,493,518 1,665,439*	0.004 0.001*
Herrings (Clupeidae)	414,615	2,240	416,855	
Sprat (*Sprattus sprattus*)	7,114,303	405,702	7,520,005	0.001
Five-bearded rockling (*Ciliata mustela*)	333,687	28,804**	362,491	
European flounder (*Platichthys flesus*)	2,711,333	118,667***	2,830,000	

* Dover sole with EAV numbers
**Five-bearded rocking assumed proportional reduction = 0.80 for FRR, unknown for AFD
***Flounder assumed proportional reduction = unknown for FRR, 0.46 for AFD

Combined impacts on Dover dole and sprat fish numbers from impingement and entrainment (Table 2.6.1S42) appear to be not much different from those assessed against the Trevose spawning ground, which are deemed to be insignificant. Herring, five-bearded rockling and the European flounder numbers do appear to be high when no such comparable data exists, however, data from 1981-2008 (summarised in table 2.6.1S42) show that for herring, the population in Bridgwater Bay shows inter-annual variations, but with a gradual increase in abundance. Five bearded rockling shows a stable population with a significant increase in abundance and for the flounder, although there is appreciable inter-annual fluctuations in abundance, the population has remained stable. Furthermore, with the added mitigation of a acoustic fish deterrent system and fish returns system, along with a specialist intake design (passive, low-velocity), the result will be that

We therefore believe that the effects of entrainment together with impingement from HPC intake alone will not have an adverse effect on the overall fish and crustacean populations within Bridgwater Bay or wider estuary and Bristol Channel.

Entrainment, impingement and toxic/non-toxic contamination

On top of impingement and entrainment pressures it is acknowledged that further stresses from the cooling water discharge, such as an increase in toxins within Bridgwater Bay, also have the potential to cause combined additive impacts, which can be difficult to quantify. However, with the exception of hydrazine such effects have been confidently assessed as not having an adverse effect on the designated fish of the Severn Estuary SAC and Ramsar (see section 2.6.1 (a)), therefore it is unlikely that such additive pressures will change the situation one way or another, especially since we see no evidence of the current HPB causing any adverse impact on the fish populations.

The proposed discharge of hydrazine has the potential to cause an additive effect upon the organisms entrained through the cooling water system that will pass out through the same discharge. This means that the survival rate for planktonic organisms and juvenile fish is likely to substantially decrease to the point where we are unable to conclude no adverse effect on the integrity of the estuaries feature, in relation to planktonic organisms, and the fish assemblage designated under the Severn Estuary SAC and Ramsar.

Conclusion

We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Required mitigation

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

Crustaceans

The shrimp Crangon crangon has been used as a key species to assess the impacts of entrainment, and the entrainment assessment within the estuaries section 2.6.4.1(a) covers the potential effects of entrainment together with impingement.

Overall conclusion of entrainment and impingement

Hazard assessed	Adverse effect on migratory fish and fish assemblage?
Entrainment of juvenile fish and ickthyoplankton	No
Fish impingement	No
Combined entrainment and impingement	No
Combined thermal / chemical	Yes – Requirement to remove hydrazine via permit condition (see below)
Overall conclusion	**With the permit condition in place we can conclude no adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Required mitigation *Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges*	Environment Agency	Operational Permit Ref: HP3228XT

Overall conclusion continued

The picture that emerges for the fish and macro-crustacean assemblage in the Severn Estuary and Bristol Channel is one of complex, multi-factoral interactions. The system is characterised by remarkably consistent and robust seasonal cycles in the fish and macro-crustacean composition, but highly variable inter-annual patterns of abundance that are affected and influenced by a range of environmental variables (Henderson & Bird, 2010), including temperature and salinity.

The impingement and entrainment of fish on the intake-screens of power stations in the Severn Estuary and Bristol Channel has allowed seasonal variations in the abundance of fish in the estuary, as well as inter-annual and longer term trends to be monitored in considerable detail (Henderson & Bird, 2010). Despite the potential impact of water-intake screens on fish mortality, between the 1970s and 1990s, the abundance of many species of fish has increased at Hinkley Point (Henderson & Bird, 2010). Since about 2002, the rate of increase has accelerated by a factor of two to four (Henderson, 2007)[228]. The reason for the changes in fish abundance are likely to be multi-factorial, but there is evidence for the role of climate change and water temperature increase and the North Atlantic Oscillation in particular (Henderson, 2007).

Where the data do indicate some population changes (e.g. European eel) these would appear to have been the consequence of a change in species abundance across the northeast Atlantic broadly rather than losses to impingement or entrainment at HPB (TR148).

The mitigation proposed for HPC, including the intake design, low velocity intake, acoustic fish deterrent system and fish recovery and return system, will provide suitable protection so that impingement losses have been calculated to be similar or less than those of the existing HPB station.

Based on the information provided in EDF's Report to support the HRA and supporting technical documents, and on the conclusions from our assessments we conclude that the predicted rates of fish impingement and entrainment at HPC alone appear to be at a level that will not adversely affect either the protected species or estuarine assemblage, in view of their conservation objectives and there will be no adverse effect on the integrity of the site.

However, given the wide variables influencing impingement and entrainment within the Severn Estuary/Bristol Channel and the high dependency on the proposed mitigation measures, there is still scope for potential improvements to such systems, that may enhance the predicted rates and therefore enhance fish protection. We therefore consider it extremely important that the final designs of both the FRR and AFD are tested well in advance to the operation of HPC, preferably at the commissioning stage, to give enough time to reach maximum performance before operation begins.

We would therefore advise the competent authorities, in this case the Infrastructure Planning Committee (IPC) and Marine Management Organisation (MMO), to ensure that prior to abstraction of any water (including that abstracted for any trials) a comprehensive ecological monitoring and contingency plan should be developed which identifies the measures necessary for early identification and mitigation of changes which may lead to environmental or ecological harm. This would ensure that mitigation activities work to the optimal levels necessary to maximise protection of the environment and ecology.

[228] Henderson, P.A. (2007). Discrete and continuous change in the fish community of the Bristol Channel in response to climate change. Journal of the Marine Biological Association of the United Kingdom 87, 589–598.

The Environment Agency has suggested the following conditions for the competent authorities to implement:

Advice / Requirements	Competent Authority	Method
Advice given *No water abstraction should take place until a marine monitoring and contingency plan has, after consultation with the Environment Agency been submitted to and approved by the Local Planning Authority and implemented as agreed.* *No water abstraction should take place until a marine monitoring and contingency plan has, after consultation with the Environment Agency been submitted to and approved by the Marine Management Organisation and implemented as agreed.*	Local Planning Authority (LPA) and Marine Management Organisation (MMO)	Development Consent Order or Marine Licence
No water abstraction shall occur for operational or safety purposes until the abstraction mitigation systems including the Fish Return System and Acoustic Fish deterrent system have been fully commissioned	LPA and MMO	Development Consent Order or Marine Licence
The Acoustic Fish Deterrent system is to remain in operation whenever water is being abstracted.	LPA and MMO	Development Consent Order or Marine Licence
Prior to the commencement of commissioning (Hot Functional Testing) the Operator shall submit to the Environment Agency for approval a Commissioning Plan for AFD and FRR Systems. The Plan shall include, but not be restricted to the following: – *a description of how the Operator intends to optimise the AFD and FRR systems to minimise impacts upon fish;* – *details of the monitoring proposed to facilitate optimisation and meet the above objective;* – *confirmation of the timetable associated with the AFD and FRR system commissioning;* – *proposals for demonstrating the effectiveness of the optimisation process to the Environment Agency prior to the start of Active Commissioning of Unit 1 (fuel loading).*	LPA and MMO	Development Consent Order or Marine Licence

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2.6.2 Inter-tidal mud and sandflats not covered by seawater at low tide

2.6.2.1 Baseline

Sources of Data and Scale of the Intertidal Mudflats and Sandflats Feature
The historical and recent data for the intertidal mudflats and sandflats, comprising Stert Flats and Berrow Flats, have been summarised or presented in various reports: BEEMS TR 016 (2011)[229], BEEMS TR 029 (2011)[230], BEEMS TR 068 (2011)[231], BEEMS TR 154a (2011)[232], BEEMS TR 155a (2011)[233], BEEMS TR 156a (2011)[234], BEEMS TR 157 (2011)[235], BEEMS TR 183 (2011)[236], and BEEMS TR 184 (2011)[237].

The intertidal mudflats and sandflats of Stert Flats and Berrow Flats comprise an area of some 5,300 ha which equates to about 26 % of the total intertidal mudflat and sandflats feature of the Severn Estuary SAC which is about 20,300 ha (CCW & NE 2009). This percentage indicates the relative significance of the intertidal flats of Bridgwater Bay to the feature in the SAC. The spatial extent of the intertidal mudflats and sandbanks feature in the SAC is shown in Figure 2.6.3.2S1 below.

229 BEEMS Technical Report TR016. Hinkley Point intertidal review of biological and physical habitat information. EDF BEEMS (ABP Mer Ltd.), 2008.

230 BEEMS. Technical Report TR029. Ecological Characterisation of the Intertidal Region of Hinkley Point, Severn Estuary: Results from the 2008 Field Survey and Assessment of Risk. EDF BEEMS (Cefas), 2009.

231 BEEMS Technical Report TR068 (Edition 2). The effects of the new nuclear build on the marine ecology of Hinkley Point and Bridgwater Bay. EDF BEEMS (Cefas), 2011.

232 BEEMS Technical Report TR154. Hinkley spring intertidal survey and analysis report. EDF BEEMS (IECS). 2010.

233 BEEMS Technical Report TR155. Hinkley summer intertidal survey and analysis report. EDF BEEMS (IECS), November 2010.

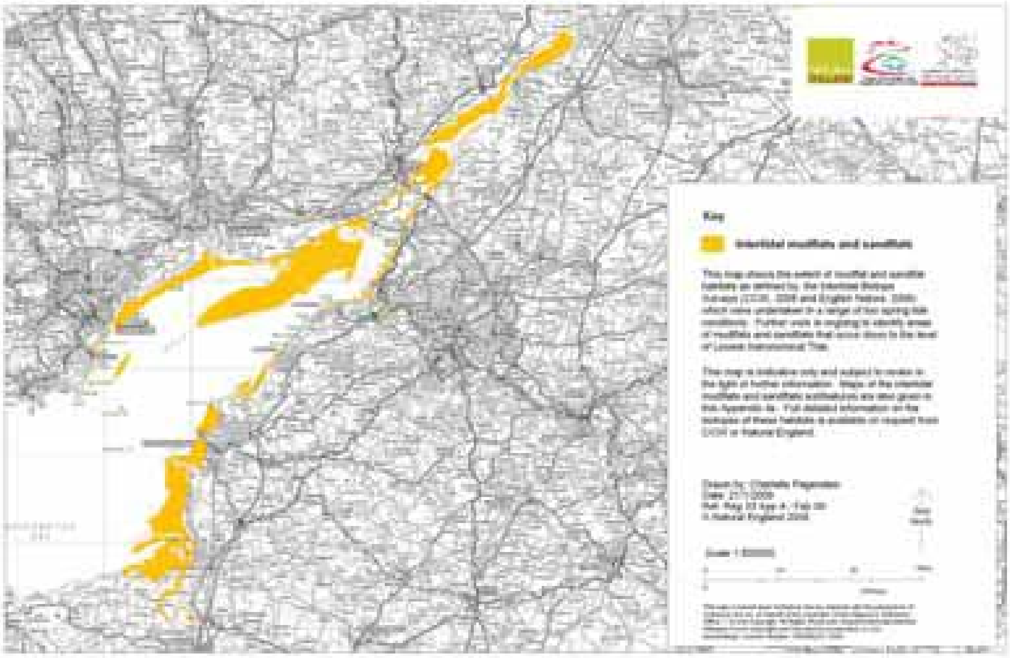
234 BEEMS Technical Report 156. Hinkley autumn intertidal survey and analysis report. EDF BEEMS (IECS) 2011.

235 BEEMS Technical Report TR157. Hinkley winter intertidal survey and analysis report. EDF BEEMS (IECS), 2011.

236 BEEMS Technical Report TR183. I nter-annual variability in the intertidal mudflat communities of Bridgwater Bay. EDF BEEMS (Cefas), 2011

237 BEEMS Technical Report 184: Hinkley Point Site. Hinkley Point Marine Ecological Synthesis Report. EDF BEEMS (Cefas) 184. 2011.

Figure 2.6.2S1 – Map showing the extent of the intertidal mudflats and sandflats feature of the Severn Estuary SAC



Habitat Types and Community Structure

A survey of the foreshore area from Brean Down to Watchet was undertaken in July 2008. There were 40 soft sediment sampling stations covering the intertidal mudflats and sandflats feature. The main components of the benthic infauna of the intertidal mudflats and sandflats from this 2008 survey were *Macoma balthica, Hydrobia ulvae, Nephtys hombergii, Pygospio elegans, nematodes, Corophium volutator, and Hediste diversicolor*. However, in terms of biomass*, Macoma balthica* was the most significant component (63%), with *Hediste diversicolor* and *Hydrobia ulvae* being the next two (15% and 8% respectively). It is therefore suggested that these three species are the more significant in the community structure and are also the most important in terms of bird prey species.

These three species were also important on Stert Flats in terms of numbers of individuals, in the study reported by Boyden and Little (1973)[238], although *Corophium volutator* and *Nephtys hombergii* appeared to be more common than *Hediste (Nereis) diversicolor*.

The similarities and differences between the 2008 survey data and earlier surveys undertaken by Boyden and Little (1973) and EMU (2006)[239] are discussed in BEEMS TR 029 (2011)[2]. Temporal variations in the benthic invertebrate community on Stert Flats has also been assessed in BEEMS TR183 (2011)[8]. Overall, the intertidal faunas from all the years were similar, but there were variations in the densities of species and their spatial distribution. It was concluded that it was not possible to ascertain whether the assemblages sampled in 2008 were consistent with those

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[238] Boyden C. R. and Little C.1973 Faunal distributions in soft sediments of the Severn Estuary. Estuarine and Coastal marine Science 1, 203-223.

[239] EMU Ltd 2006 Severn Estuary Intertidal Biotope Mapping Baseline Phase 1 Study. A Report commissioned by Natural England.

mapped in 2003/4, as the raw data for the 2003/4 survey was not available. However, part of the observed differences was attributed to changes in sediment type.

The most extensive macrofaunal assemblage from the 2008 survey was that covering the mid- and upper shores of Stert Flats and Berrow Flats comprising assemblage of *Macoma balthica*, *Hydrobia ulvae*, and *Nephtys hombergii*. The biotope in the past has been considered to be dominated by *Hediste* and *Macoma,* but *Hediste* was scarce in 2008.

Further seasonal surveys of the foreshore have occurred in April 2010, July 2010, October 2010, and January 2011 in order to inform the understanding of the benthic ecology of Bridgwater Bay. It would not appear that there has been a complete assessment of all the survey data collected in 2010 and 2011, but the data has been used in 2 different assessments: one on the inter-annual variability in intertidal flat communities in Bridgwater Bay, Hinkley Point, in which the July 2010 survey data was used to compare with the 2008 data (Report TR 183)[8], and the other on the *Macoma balthica* population structure at Hinkley Point and elsewhere in the Severn Estuary (BEEMS SPP 062)[240]. The results of the latter report are considered later in relation to the potential impact of the thermal plume on the benthic community of the intertidal flats

The conclusions of Report TR 183 are that the community structure had varied between the two years, partly due to changes in the main taxa, but also because of changes in 'rare' taxa across the site. This result is not considered surprising for three reasons:

- only 17 sample stations were compared in the assessment. The reason for this was to remove those sample stations which were modelled to be within the 1ºC envelope of the thermal plume from Hinkley B.

- comparisons between the earlier data suggested that while the overall community structure is relatively stable, being dominated by a few defined species, the relative balance of these at any one location on the intertidal area is variable over time. Whether this variability is due to variations in substrate properties, or food sources, or recruitment variations related to predation variation, or simply sampling chance is not known. Changes in the elevation of the intertidal mudflats in Bridgwater Bay have been described in Kirby and Kirby (2008)[241], who showed that mudflat development occurred over a range of timescales (monthly/seasonal to inter-annual). However, they concluded that the long-term changes in the mudflats were due to erosion. The interactions of biological community structure and sediment processes on intertidal flats has been shown to be complex both spatially and temporally (Herman et al 2001)[242]. What is clear is that further biological and sediment

[240] BEEMS Scientific Position Paper SPP062. Macoma balthica population structure at Hinkley Point and elsewhere in the Severn Estuary. EDF BEEMS (Cefas), 2011.

[241] Kirby J. R. and Kirby R. 2008 Medium timescale stability of tidal mudflats in Bridgwater Bay, Bristol Channel, UK: influence of tides, waves and climate. Continental Shelf Research 28, 2615-2629.

[242] Herman P.M.J., Middelburg J.J., and Heip C.H.R. 2001 Benthic community structure and sediment processess on an intertidal flat: results from the ECOFLAT project. Continental Shelf research 21, 2055-2071.

sampling of the intertidal flats is needed to understand the spatial and temporal variation in the benthic community structure of Stert Flats.

- the inherently energetic nature of the tidal currents and sediment transport of the Severn Estuary and Inner Bristol Channel, coupled with storm-driven events, means that natural variation can be potentially large, resulting in apparently large perturbations in the 'average' conditions.

Whatever the natural spatial and temporal variability of the benthic community on Stert Flats and Berrow Flats is, all the major invertebrate infaunal species are important bird prey species (see Langston et al 2003[243] and Langston et al 2007[244]). Their response to changes in the thermal regime and the chemical contaminants in the cooling water discharge could therefore have an impact not only on the intertidal mudflats and sandflats feature itself, but also on the birds feature of the SPA.

[243] Langston W.J., Chesman B.S., Burt G.R., Hawkins S.J., Readman J., and Worsfold P. 2003, Characterisation of the South West European Marine Sites: The Severn Estuary pSAC, SPA, Marine Biological Association of the UK Occasional Publication No.13, 206pp

[244] Langston W.J., Chesman B.S., Burt G.R., Campbell M., Manning A. & Jonas P.J.C. 2007 The Severn Estuary: Sediments, contaminants and biota. Marine Biological Association of the United Kingdom Occasional Publication (19). 176 pp.

2.6.2.2 Assessment of Operational Discharges in relation to the intertidal Mudflats and Sandflats Feature

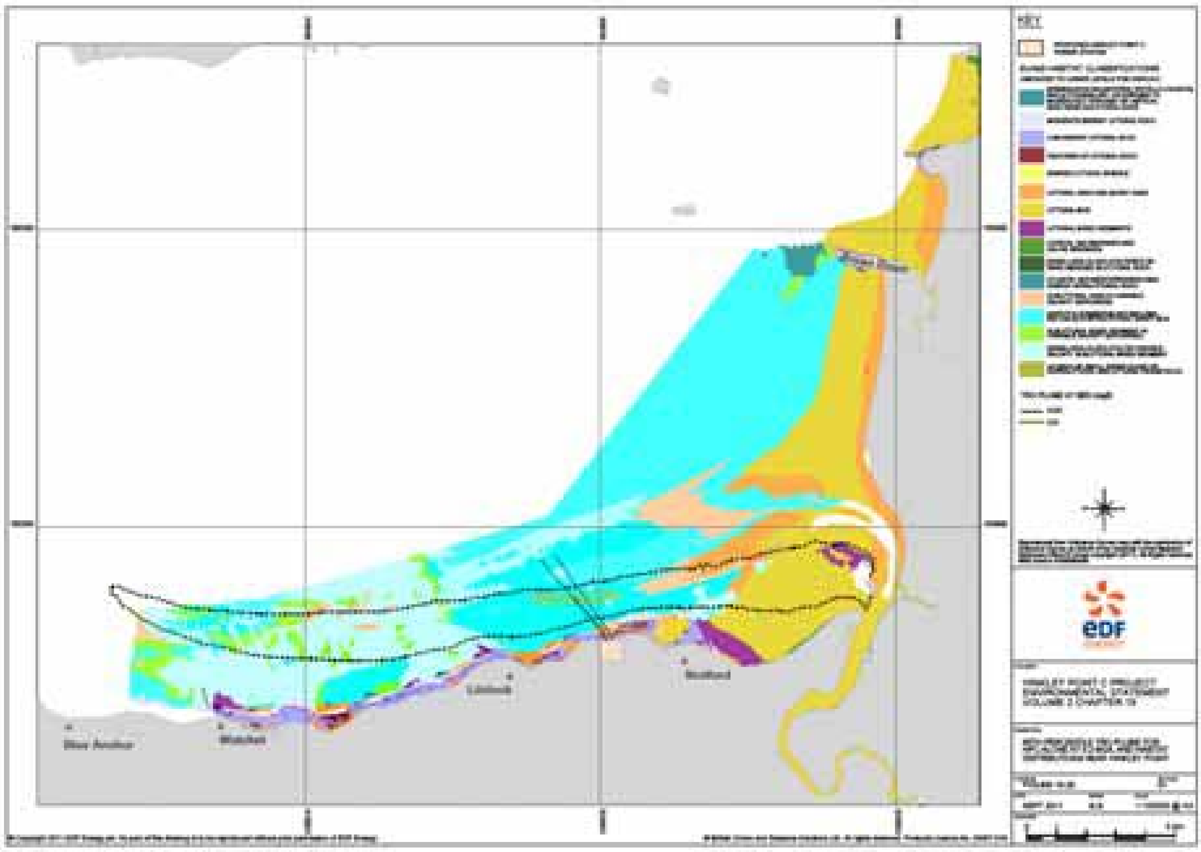
a) Toxic contamination

Conservation objectives

- *the total extent of the mudflats and sandflats feature is maintained;*
- *the variety and extent of individual mudflats and sandflats communities[3] within the site is maintained;*
- *the distribution of individual mudflats and sandflats communities[3] within the site is maintained;*
- *the community composition of the mudflats and sandflats feature within the site is maintained;*

The only toxic contaminants which were not screened out by the assessment of 'Likely Significant Effect' presented in the section on the Estuaries feature were TRO and Hydrazine. The mixing zone associated with TRO is shown if Figure 2.6.2S2

Figure 2.6.2S2 – mixing zone for TRO discharges.



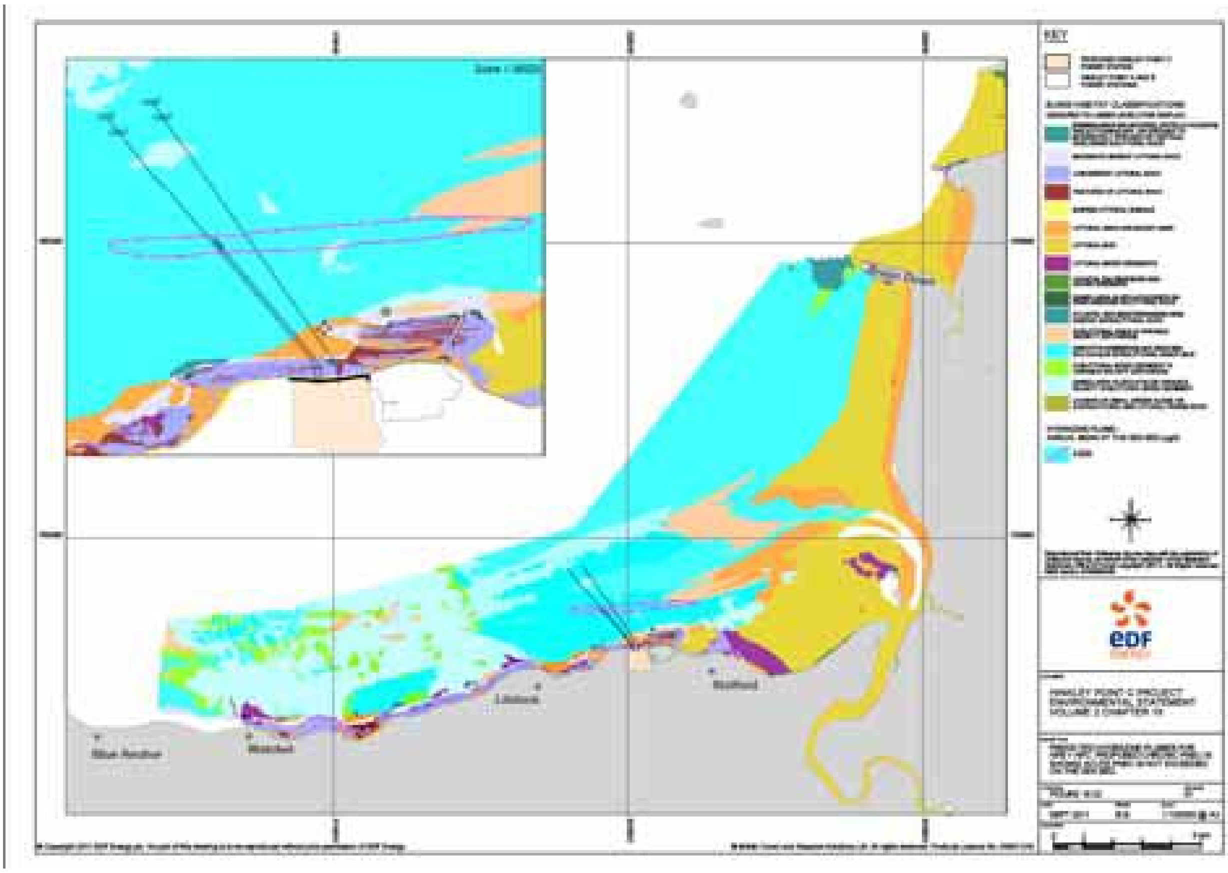
It is apparent from this Figure that the mixing zone does not extend onto the intertidal mudflats and sandflats, although levels below the EQS would impact on Stert Flats. This suggests that there may be some very low level stressing of the intertidal flat community, although the concentrations are below any levels considered to be significant from a literature review of the chlorination responses of key intertidal species (BEEMS TR 162 (2011))[245]. Furthermore, laboratory experiments on the sensitivity of three intertidal species (*Corophium, Hydrobia,* and *Macoma*) to chlorinated seawater showed that that *Corophium* was the most sensitive species (BEEMS TR 163 (2011))[246]. Lethal concentrations were in the range 0.193 to 0.360mg/l TRO, although some influence was observed at concentrations of 0.032 to 0.039mg/l. These concentrations are well above expected concentrations over the intertidal flats, and impacts from TRO are therefore not considered to be significant.

As discussed in Section 2.6.3.1.3b of the assessment for the Estuaries feature alone, the mixing zone for bromoform, the main by-product of chlorination, has been estimated to be coincident with the mixing zone for TRO. The mixing zone for bromoform will therefore not extend into the intertidal mudflats and sandflats feature.

It should be noted for the potential mixing zone for TRO and bromoform, that the use of chlorination for the cooling water discharge at HPC may not be required, as chlorination has never been used at HPB. The requirement for the use of any chlorination at HPC will be carefully monitored and there will have to be a demonstrable need for its use, before it will be allowed to be used.

The mixing zone for hydrazine is shown in Figure 2.6.2S3 below.

Figure 2.6.2S3 – mixing zone for hydrazine discharges



[245] BEEMS Technical Report TR162, 2010. Hinkley Point chlorination responses of key intertidal species - literature review. EDF BEEMS (Cefas), 2010.

[246] BEEMS Technical Report TR 163. Acute and behavioural effects of chlorinated seawater on inter-tidal mudflat species. EDF BEEMS (Cefas), 2011.

The mixing zone here only relates to the chronic PNEC for the average long-term discharge condition and not the acute PNEC for the maximum short-term discharge condition. (see text in Estuaries feature). It is apparent from this Figure that the mixing zone is very similar to that for TRO, and does not impact on the intertidal area of Stert Flats. However, it is considered that the intertidal flats would be impacted by the hydrazine mixing zone for the maximum long-term discharge scenario, although how extensive that impact would be is not known. Given the uncertainty with the hydrazine plume modelling, it was concluded in the section on the Estuaries feature, that treatment to remove hydrazine was needed prior to discharge.

Assuming that hydrazine is removed prior to discharge, it is considered that there will be no significant impact on the intertidal mudflats and sandflats from hydrazine.

The concentration of metals in the cooling water discharge from HPC are not significant , as discussed in Section 2.6.1.2b. The loadings of metals from the HPC discharges are also not significant in relation to the loadings to the Severn Estuary SAC, so are not considered to contribute to any significant change in the levels of sediment-bound contaminants in the Severn Estuary.

Conclusion
Based on the limited extent of the mixing zones for both TRO and bromoform, and the lack of an impact on the intertidal mudflats and sandflats feature, it is concluded that the conservation objectives for the intertidal mudflats and sandflats feature are not compromised by toxic contamination from the operational discharges from HPC alone, and that there is no adverse effect on site integrity. However, this conclusion is dependent on the need for hydrazine to be removed from the operational discharges prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

b) Non toxic contamination (Nutrient enrichment and organic loading)

- *The variety and extent of individual mudflats and sandflats communities within the site is maintained;*

It was concluded in the section on the Estuaries feature that neither the increase in nutrient inputs nor the increase in organic load arising from the operational discharges from HPC were considered to have a likely significant effect on the integrity of the SAC. This conclusion was reached, because the discharges make a very small contribution, about 0.1% or less, to the overall annual loadings to the SAC.

Even at a local scale, the average increase in nutrients is considerably less than the ambient background values, being about 0.1% for N, about 3.8% for P, and less than 0.1% for oxygen demand. These increases are not considered to be significant.

Conclusion
It is therefore concluded that the conservation objectives for the intertidal mudflats and sandflats feature will not be compromised by non-toxic contamination from the operational discharges from HPC alone, and that there will be no adverse effect on site integrity.

c) Changes to thermal regime,

- *The community composition of the mudflats and sandflats feature within the site is maintained;*

Potential Impacts
Increased temperatures can impact on the intertidal mudflats and sandflats in a variety of ways. These can be summarised into:

- Direct impacts on the microphytobenthos,
- Direct impacts on the benthic invertebrates, and
- Indirect impacts on the interactions between the various organisms comprising the intertidal community, including predator-prey relationships.

Direct impacts cover all those impacts which can influence the life cycle and behaviour of an organism (starting from reproduction); eg. survival; age of maturation; spawning time; gamete, egg, and larval development; substrate attachment, including sprat fall; and feeding response (see Kennedy and Mihursky 1971[247], Philippart et al 2003[248], Beukema et al 2009[249]).

Indirect impacts include the availability of food sources for different life stages of the benthic community, the timing of predator species foraging on juvenile stages of the benthic community, and the arrival of or preferential support for exotic species which could compete with other resident species for particular food sources (see Freitas et al 2007[250], Freitas et al 2008[251], Beukema et al 2009[21], Freitas et al 2009[252]).

Certain aspects are relatively well defined for some organisms, eg. upper temperature limits or upper lethal temperatures, some of which are given in Table 2.6.2S4 below.

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247 Kennedy V.S. and Mihursky J.A.1971 Upper Temperature Tolerances of Some Estuarine Bivalves. Chesapeake Science 12, 193-204.

248 Philippart C.J.M., van Aken H.M., Beukema J.J., Bos O.G., Cadée G.C., and Dekker R. 2003 Climate-related changes in recruitment of the bivalve *Macoma balthica*. Limnology and Oceanography 48, 2171-2185.

249 Beukema J.J., Dekker, R., and Jansen J.M. 2009 Some like it cold: populations of the tellinid bivalve *Macoma balthica* (L.) suffer in various ways from a warming climate. Marine Ecology Progress series 384, 135-145.

250 Freitas V., Campos J., Fonds M., and Van der Veer H.K. 2007 Potential impact of temperature change on epibenthic predator–bivalve prey interactions in temperate estuaries. Journal of Thermal Biology 32, 328-340.

251 Freitas V., Bailey K.M., and van der Veer H.K. 2008 Population regulation of epibenthic species in coastal ecosystems, with implications for latitudinal patterns. Journal of Sea Research 60, 105-116.

252 Beukema J.J., Dekker, R., and Jansen J.M. 2009 Some like it cold: populations of the tellinid bivalve *Macoma balthica* (L.) suffer in various ways from a warming climate. Marine Ecology Progress series 384, 135-145.

Table 2.6.2S4 – upper temperature limit for key intertidal species.

	Upper Temperature Limit	Source
Mya arenaria – young	30.9 – 34.4	Kennedy and Mihursky 1971
Mya arenaria – adult	30.1 – 32.5	Kennedy and Mihursky 1971
Macoma balthica – small	31.2 – 34.1	Kennedy and Mihursky 1971
Macoma balthica - large	30.8 – 32.9	Kennedy and Mihursky 1971
Crangon crangon	30	Freitas et al 2007
Phaeodactylum tricornutum	36.5	EDF 1978 in BEEMS TR081
Gyrosigma spencerii	37	EDF 1978 in BEEMS TR081
Acartia spp	37 - 39	Quoted in BEEMS SPP 063
Eurytemora velox	26	EDF 1978 in BEEMS TR081
Maja squinado larvae	31.5	EDF 1978 in BEEMS TR081
Homarus gammarus larvae	34	Gruffydd et al 1975 in BEEMS SAR 008
Decapoda	Mean 32.9	Yeung 1983 in in BEEMS SAR 008
Amphipoda	Mean 34.4	Yeung 1983 in in BEEMS SAR 008
Fucus serratus	28	Luning 1984 in Langford et al 1998

These upper lethal temperatures will not occur on the intertidal mudflats and sandflats as a result of the impact of the thermal plume, so that losses of species due to mortality will not arise. What is apparently less well established is the different temperature requirements of the life stages of all the major components of the intertidal mudflats and sandflats, and how these could be impacted by the thermal plume. This is discussed in more detail in the sections below.

Microphytobenthos

The potential impact of increased water temperature on the microphytobenthos on the intertidal flats is likely to be very limited, as the phytoplankton are on the surface of the sediments essentially when the tide is out, ie. the period when they are able to photosynthesise. They are also exposed during this period to relatively high ambient temperatures, which are almost certainly higher than those in the thermal plume. In addition, the turbidity of the waters of the Inner Bristol Channel reduces the ability of the microphytobenthos to photosynthesise when the tide is in, to a very short time at best, so that their exposure to the increased water temperatures in the thermal plume is very limited.

It has been argued in the BEEMS Report TR184 (2011)[54] that the impact of the thermal plume on the intertidal flats will lead to enhanced metabolic rates in the microphytobenthos when the intertidal flats are submerged, which is not compensated by increased photosynthesis due to the turbidity of the water column. However, while respiration rates in benthic phytoplankton could be increased by the warmer waters associated with the thermal plume, any effect will be very marginal, as the intertidal flats will already be warm from sub-aerial exposure, and are more likely to be giving up heat to the water column than absorbing it.

Benthic Infauna

It was concluded in the BEEMS TR 134 (2011)[253] that the only intertidal invertebrate prey species in Bridgwater Bay to be sensitive to increasing water temperature is *Macoma balthica.* The species has a range from the Arctic to the Gironde in SW France, so that it is a northern cold-water species. Increased temperatures are thought to result potentially in reduced growth, reduced recruitment, and increased mortality. The only other intertidal species which may show a response to a change in thermal regime is *Crangon crangon*, but this is predicted to increase in numbers with increasing temperature.

Based on the assessment of risks related to the benthic community on Stert Flats it was proposed in TR 183[53] that, within the existing sedimentary constraints, increasing temperatures would promote colonisation of warm-water species, or inhibit the abundance of thermally sensitive species. In effect, this argument relates either to the promotion of warmer water species and/or the reduction in colder water species.

This argument essentially leads to the assumption that the response of *Macoma balthica* was the critical factor in the assessment of the impact of the thermal plume from Hinkley C. The underlying reason for this was the recognition of the significance of *Macoma balthica* both in the benthic community and as a bird prey species.

Initial work on *M. balthica* focussed on their feeding habits, as they were reported to cease growing when sea water temperatures exceeded 15ºC, which suggests that they do not feed when water temperatures exceed 15ºC. This temperature results in the period available for feeding and growth to be restricted to between October to May based on ambient mean sea temperatures at Hinkley. On the intertidal flats, this simplistic view is not sufficient. Modelling has therefore been undertaken to assess the potential shortening of the feeding period available for those *M. balthica* impacted by the thermal plume. These results have been reported in the report BEEMS TR 184[54]. It was predicted that the mean reduction in growth period would be 3 days on Stert Flats and 1 day on Berrow Flats. However, this change on growth period was considered to be within the background variation, although potentially discernible.

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The implication of the changes in the feeding behaviour of *M. balthica* is potentially an important aspect. However, the majority of *M. balthica* in the Severn Estuary and Stert Flats are juveniles. Bachelet (1980)[254] states that in the Gironde Estuary, the maximum growth in length for *M. balthica* occurs between April and July/August, and that growth is fastest in the first growing season. From available data on seawater temperatures in the Gironde Estuary, temperatures exceed 15ºC for most of this period (see Section 6.5.4 - in combination assessment for the Estuaries feature). This suggests that food supply may be the most important factor, particularly for juveniles. Primary production by the microphytobenthos in the intertidal zone will be at or near its maximum during the summer, in response to the length of daylight and the intensity of solar radiation. Other work on the population dynamics of *M. balthica*

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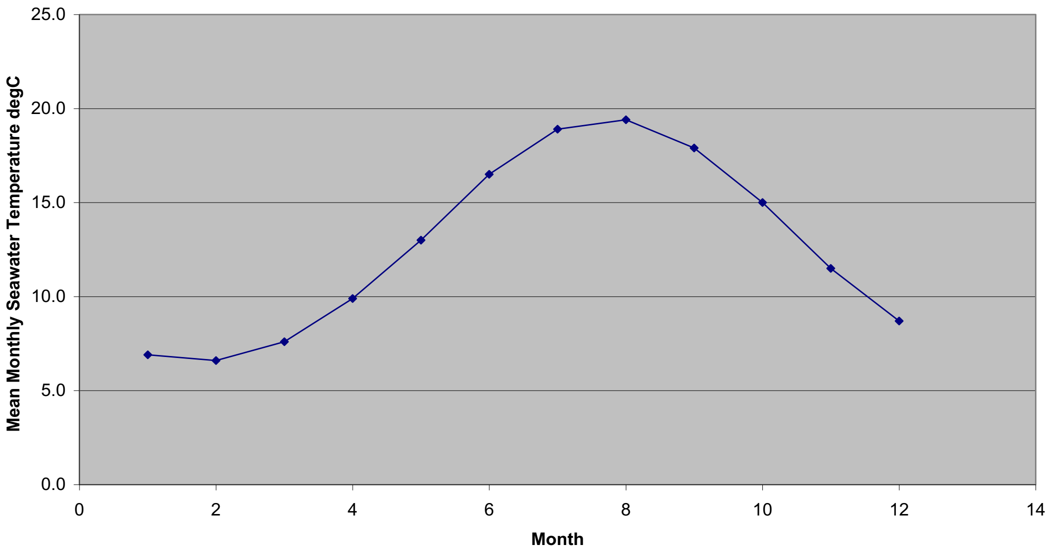
[253] BEEMS Technical Report 134 (TR134), 2011

[254] Bachelet G., 1980 Growth and recruitment of the Tellinid bivalve *Macoma balthica* at the Southern limit of its geographic distribution, the Gironde estuary (SW France), Marine Biology 59, 105-117

in the Westeschelde (Bouma *et al* 2001)[a] and the western Dutch Wadden Sea (Cardoso *et al* 2007)[b] shows that in the intertidal zone, *M. balthica* (and particularly the juveniles) are growing throughout the summer, and tend to show less growth in the winter. These studies also suggest that food supply, and not water temperature, is the most critical factor concerning the growth of *M. balthica*.

There are other behavioural responses of *M. balthica* which are known to be temperature related. For example, the onset of spawning for *M balthica* is known to be temperature related, and temperatures of 10ºC, or between 7 and 14ºC, have been quoted to be critical (Kennedy and Mihursky 1971)[255]. More recently, a mean sea water temperature of 8.3ºC has been defined for *M. balthica* in the Wadden Zee (Philippart et al 2003)[64] as the critical water temperature for the onset of spawning. It is not known if this temperature is the relevant temperature for the spawning of *M. balthica* in the Severn Estuary and Inner Bristol Channel. However, using a potential critical water temperature of 10ºC, the onset of spawning would happen in March to April (see Fig 2.6.2S5).

Figure 2.6.2S5 – Hinkley Point mean monthly sea temperatures



A 2ºC rise in mean water temperature would result in the onset of spawning being a month earlier, February to March. The question then arises, would the mature *M. balthica* have enough food reserves to support reproduction, as they would have been stressed by a shorter feeding period? This question must be balanced against the spawning time of *M.balthica* on the west coast of Wales which is reported to be February to March (Fish and Fish 1996)[256].

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[255] Kennedy V.S. and Mihursky J.A.1971 Upper Temperature Tolerances of Some Estuarine Bivalves. Chesapeake Science 12, 193-204.

[a] Bouma H., de Vries P.P., Duiker J.M.C., Herman P.M.J., Wolff W.J. 2001 Migration of the bivalve *Macoma balthica* on a highly dynamic tidal flat in the Westerschelde estuary, The Netherlands. Marine Ecology Progress 224, 157-170
[b] Cardoso J.F.M.F., Witte J.IJ., van der Veer H.K. 2007 Habitat related growth and reproductive investment in estuarine waters, illustrated for the tellinid bivalve *Macoma balthica* (L.) in the western Dutch Wadden Sea . Marine Biolog 152, 1271-1282.

[256] Fish J.D. and Fish S., 1996 A student's guide to the seashore. Second edition. Cambridge University Press, Cambridge. 564 pp.

It is stated in Drent (2002)[257] that a large part of the population dynamics in *M. balthica* is determined by the early life stages, ie. the planktonic larval stage and the following post-settlement period (Van der Meer et al 2001)[258]. As a different question therefore, it can be asked whether the larval stages of *M. balthica* would survive the temperature increase due to the thermal plume? Based on the work of Drent (2002)[73], who compared the temperature responses of larvae from Norway and France, it would appear that the larvae of both populations were tolerant to rearing temperatures considerably higher than they would ever experience in nature. In addition, Drent (2002) noted that French larvae developed and grew faster than Norwegian larvae, in agreement to adaptation to local temperatures.

These questions are not possible to answer with the existing information on *M.balthica* on Stert Flats, and there are various additional factors which will also influence the recruitment of both juveniles and adults on the intertidal flats. For example, there is limited information on the temperature control and timing of predator-prey relationships on Stert Flats, particularly the predation of juvenile *M. balthica* by young *Crangon crangon*, which is an important factor in the recruitment of *M. balthica* to the intertidal sediments of Stert Flats (see eg. Philippart et al 2003[64], Freitas et al 2007[66], 2008[67], 2009[68]). In addition, if certain intertidal areas are disturbed due to temperature or other effects, the potential for the re-settlement of these disturbed areas can occur through a variety of mechanisms, involving larval dispersal through to adult immigration (Gunther 1992)[259]. Little is known about the capacity of Bridgwater Bay to re-settle disturbed areas. However, given the ubiquity of the important intertidal features and the large distances which larvae will be transported by the tidal and the residual currents in the lower Severn Estuary and Inner Bristol Channel, the potential for re-settlement from other sites, particularly by larval dispersal, is very high. Evidence for this is provided by the apparently continuous replacement of juvenile *M. balthica* on Stert Flats every year (see discussion in Section 6.5.4 - in combination assessment for the Estuaries feature).

A lot of the recent and present work on the impact of increasing water temperatures on marine and estuarine benthic species quoted here (see eg. Philippart et al 2003[64], Freitas et al 2007[66], 2008[67], 2009[68]) is related to improving our understanding of the consequences of climate change on intertidal benthic ecology. The conclusion of these recent and present studies is that the result of thermal impact is not easy to predict, because of all the ecological interactions.. This difficulty is perhaps best evidenced by a study of the impact of a power station cooling water discharge on the marine benthic communities of a bay on the Californian coast (Schiel et al 2004[260], and Steinbeck et al 2005[261]). At this site, the hypothesis was that those species which were close to the maximum of their temperature range (i.e. colder water

[257] Drent J. 2002. Temperature responses in larvae of *Macoma balthica* from a northerly and southerly population of the European distribution range. Journal of Experimentral Marine Biology and Ecology 275, 117-129.

[258] Van der Meer J., Beukema J.J., and Dekker R. 2001 Long-term variability in secondary production of an intertidal bivalve population is primarily a matter of recruitment variability. Journal of Animal Ecology 70, 159-169.

[259] Gunther C.-P. 1992 Dispersal of intertidal invertebrates: a strategy to react to disturbances of different scales? Netherlands Journal of Sea Research 30 45-56.

[260] Schiel D.R., Steinbeck J.R. and Foster M.S. 2004. Ten years of induced ocean warming causes comprehensive changes in marine benthic communities. Ecology 85, 1833-1839.

[261] Steinbeck J.R., Schiel D.R. and Foster M.S. 2005. Detecting long term change in complex communities: a case from the rocky intertidal zone. Ecological applications 15, 1813-1832

species) would tend to decline, while those which could accommodate the temperature increase would be at an advantage and therefore thrive. The study found, however, that this hypothesis was flawed, and that the community structure was influenced by the complex interaction of the feeding response of grazing organisms, as much as the temperature tolerances of the organisms. In fact, many of the organisms which were impacted by the temperature change were apparently cosmopolitan species and supposedly warm-water tolerant species. Whether these results reflect a lack of knowledge on thermal tolerances, or as is suggested, a lack of knowledge of the ecological interactions is moot. Clearly, care is needed in predicting ecological outcomes on limited knowledge.

What evidence is available therefore to assess the potential impact of the thermal plume from Hinkley C on the intertidal benthic community of Stert Flats? The main source of evidence is simply the present intertidal benthic community of Stert Flats which is directly influenced by the existing thermal plume from Hinkley Point B power station. While there are differences in the volume and temperature differentials between the cooling water discharges from Hinkley Point B and the proposed Hinkley Point C power station, the potential areas of impact on the intertidal flats are similar, due to the different discharge locations. It should be noted here that there is a recognised impact from the existing Hinkley Point B discharge on an intertidal community. This impact is on the macro-algal intertidal community immediately to the east of the outfall culvert for Hinkley Point B, and is described in BEEMS SAR 008[262]. This impact is noted here because it indicates the potential for the existing plume from Hinkley Point B to impact on the intertidal benthic ecology of Stert Flats. As it is believed that *M. balthica* is the critical species on Stert Flats, most of the recent work related to Hinkley C has concentrated on assessing the *M. balthica* population on Stert Flats, both inside and outside the thermal plume from Hinkley Point B, together with comparing the *M. balthica* population on Stert Flats with other populations in the Severn Estuary, and elsewhere in Europe (BEEMS TR 160 (2011)[263], and BEEMS SPP 062 (2011)[264]).

The main conclusions of these reports are:

- the populations of *M. balthica* on Stert Flats are significantly different from the populations of *M. balthica* at other locations on the west coast of the UK, and along the European coast from the Westerschelde in Holland to the Gironde in France.
- the main feature of the *M. balthica* on Stert Flats compared with the other populations is that it is dominated by the 0-1 year age class, with none of the adult individuals found at all other sites.
- no large-scale temperature sensitivity was demonstrated in the comparison of the French, Dutch, and English sites, although the evidence indicated that temperature was a potential stressor for the species.
- the populations of *M. balthica* on Stert Flats are not significantly different from other populations in the Severn Estuary, as they are within the measured

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[262] BEEMS Science Advisory Report Series. SAR 008: Thermal Standards for cooling water from new build nuclear power stations. BEEMS Expert Panel. 2010.

[263] BEEMS Technical Report TR160,. Variability in population structure and condition of Macoma balthica along its geographical range. EDF BEEMS (Cefas), 2011

[264] BEEMS Scientific Position Paper SPP062. Macoma balthica population structure at Hinkley Point and elsewhere in the Severn Estuary. EDF BEEMS (Cefas), 2011.

range of variability of other *M. balthica* populations sampled in the Severn Estuary

- there is no significant difference in the populations of *M. balthica* on Stert Flats which are within the Hinkley Point B plume to those on Berrow Flats which are not affected by the Hinkley Point B plume, although a small number of large (>10 mm) individuals were found on Berrow Flats.
- the seasonal variations in the populations of *M. balthica* on Stert Flats did not show any association with the zone of impact of the thermal plume from Hinkley B.

Based on the available data therefore, it would suggest that there is no significant difference between the *M. balthica* on Stert Flats within the predicted thermal plume and those without. The question then arises as to whether the expected impact of the thermal plume from Hinkley C is similar to that from Hinkley B at 100%. The areas of impact are slightly different, reflecting the difference in discharge location, as shown on Figures 2.6.2S6 and 2.6.2S7 below. However, the effective areas defined by the mixing zones for a ΔT of 2ºC are similar: the area of the SPA at the sea bed affected by the 2ºC mixing zone being 322 ha for HPB at 100% and 307 ha for HPC. This would suggest that the conclusions reached above concerning the impact of the thermal plume from Hinkley Point B could also be applied to the impact from the thermal plume from Hinkley Point C. On this basis, it is expected that there would be no significant difference between the *M. balthica* within the area of the thermal plume and those outside the thermal plume.

Conclusion
Based on the evidence of the effect of the present thermal plume on the intertidal benthic community of Stert Flats, it is therefore concluded that the conservation objectives for the intertidal mudflats and sandflats feature will not be compromised by changes in thermal regime from the operational discharges from HPC alone, and that there will be no adverse effect on site integrity.

d) Habitat Loss and Physical Damage

It was recognised in the Appendix 11 that there was ‘potential exposure due to the entrainment of planktonic organisms through the cooling water system’. As the potential effect relates to entrainment, this is covered in Section 2.6.4 of the document.

Overall Conclusion

Based on the above assessment, it is concluded that none of the hazards which could affect the Intertidal mudflats abd sandflats feature will compromise the conservation objectives of the Intertidal mudflats and sandflats feature, and will therefore not have an adverse effect on site integrity.

Hazard assessed	**Adverse effect on inter-tidal mudflats and sandflats feature?**
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Habitat loss & physical damage	No
Overall conclusion	**No adverse effect upon site integrity**

Figure 2.6.2S6 – temperature differentials within thermal mixing zone.

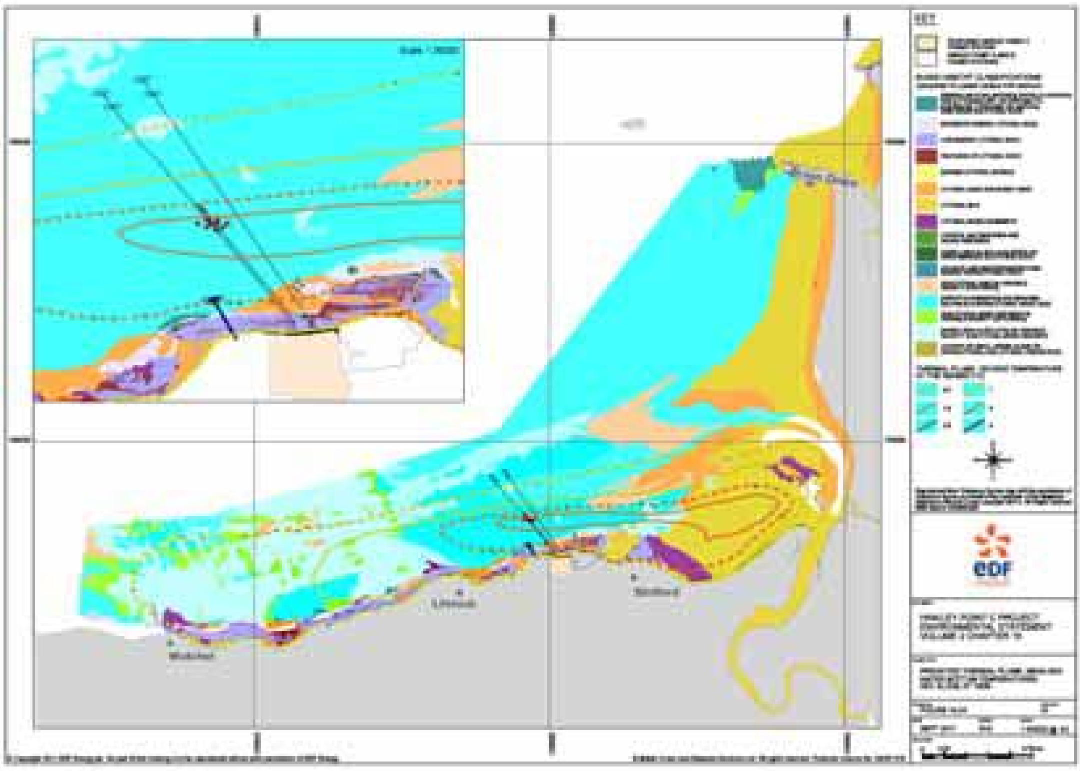
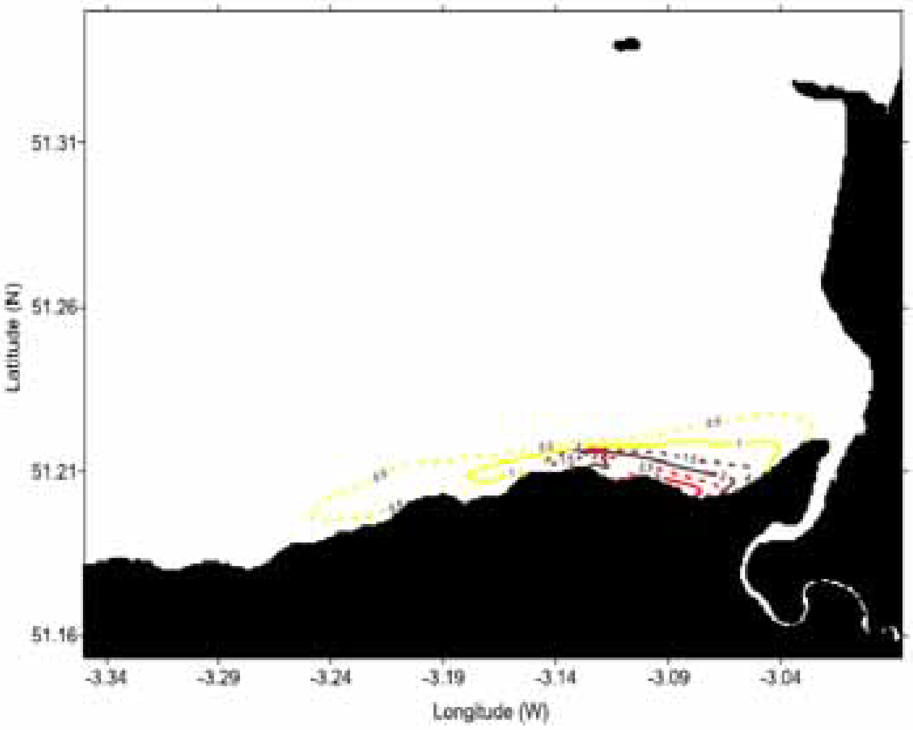


Figure 2.6.2S7 – Annual mean excess bottom temperatures (^{o}C) Hinkley Point B operating at 100%



2.6.3 Subtidal sandbanks

2.6.3.1 Baseline / Introduction

Sources of Data and Scale of the Subtidal Sandbanks
The historical and recent data for the sediments and marine communities of the sub-tidal area off Hinkley have been summarised or presented in various reports: BEEMS TR 039 Ed 4 (2011)[265], BEEMS TR 067 Ed 2 (2011)[266], BEEMS TR 068 (2011)[267], BEEMS TR 083 Ed 3 (2011)[268], BEEMS TR 136 (2011)[269], BEEMS TR 136a (2011)[270], BEEMS TR 138 (2011)[271], and BEEMS TR 184 (2011)[272]. Recent studies on the benthic fauna of the sub-tidal area fronting Hinkley have occurred over the period 2008 to 2010, including five quarterly surveys in 2008 and 2009.

The sub-tidal sandbanks feature comprise a total area of some 11,750 ha of which about 10,450 ha are ephemeral sandbanks (CCW & NE 2009). Most of the sub-tidal sandbanks occur in the middle and outer parts of the Estuary (see Figure 2.6.3S1 from CCW & NE 2009 below). There is a small area of the sub-tidal sandbanks feature in Bridgwater Bay at the mouth of the Parrett Estuary, which could be affected by the thermal plume from HPC. This area is estimated to be just less than 10% of the sub-tidal sandbanks feature.

Figure 2.6.3S1

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[265] BEEMS Technical Report TR039 (Edition 4) Seabed habitat mapping: interpretation of swath bathymetry, side-scan sonar and ground-truthing results. EDF BEEMS (Cefas), 2011

[266] BEEMS Technical Report TR067 (Edition 2). Hinkley Point nearshore communities: Results of the day grab surveys 2008 - 2010. EDF BEEMS (Cefas), 2010.

[267] BEEMS Technical Report TR068 (Edition 2). The effects of the new nuclear build on the marine ecology of Hinkley Point and Bridgwater Bay. EDF BEEMS (Cefas), 2011.

[268] BEEMS Technical Report TR083 (Edition 3). Hinkley Point nearshore communities: Results of the 2m beam trawl and plankton surveys 2008 - 2010. EDF BEEMS (Cefas), 2010.

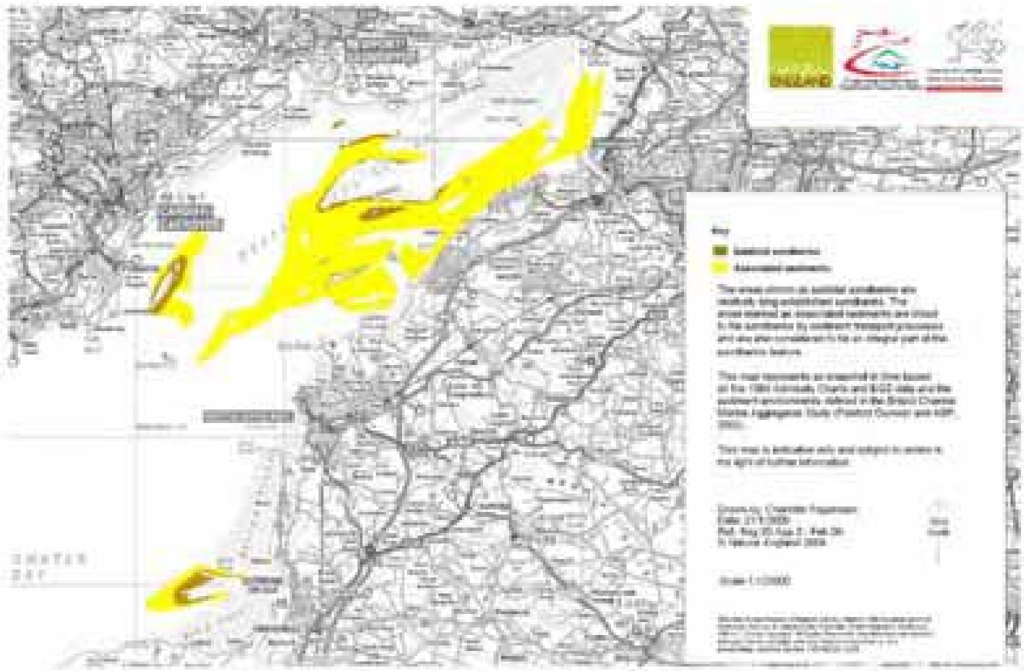
[269] BEEMS Technical Report TR136. Benthic biological resource characterisation. EDF BEEMS (Marine Ecological Surveys Ltd.), 2011.

[270] BEEMS Technical Report TR136A. Comparison of macrobenthic fauna and sediment characteristics from Hamon and Day grab samples. EDF BEEMS (Cefas), 2011.

[271] BEEMS Technical Report TR138. BEEMS nearshore habitat survey: Hinkley Point - Bridgwater Bay final report. EDF BEEMS (Titan Environmental Surveys Ltd.), 2011.

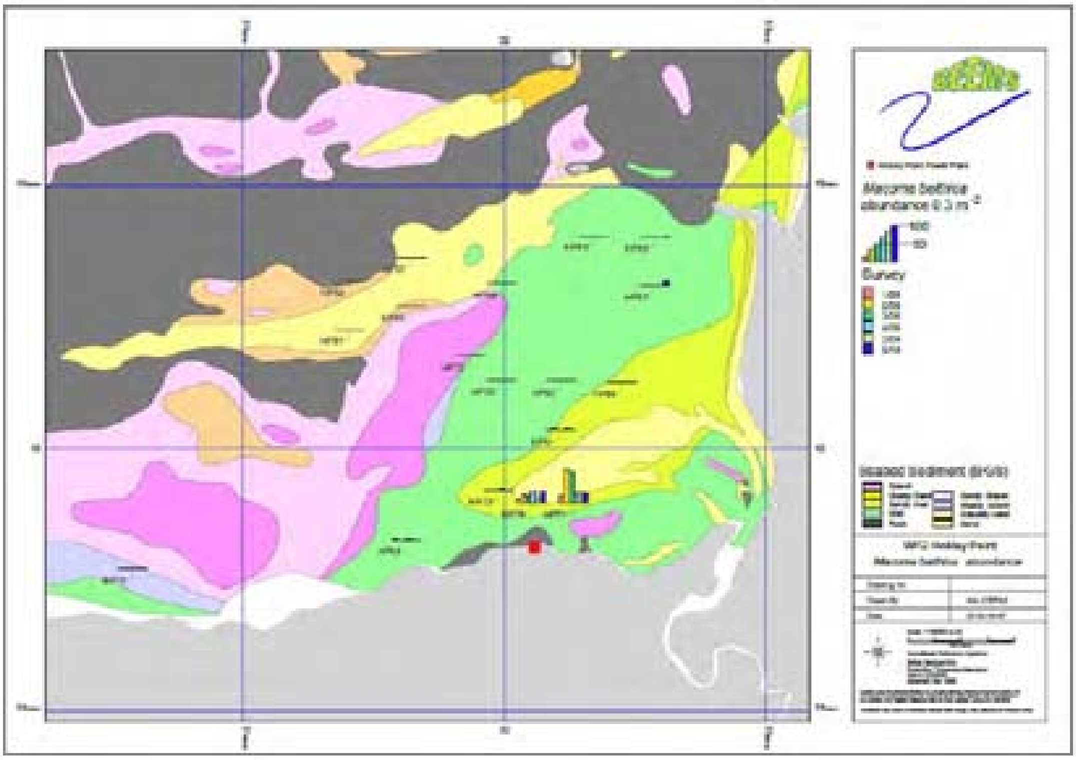
[272] BEEMS Technical Report 184: Hinkley Point Site. Hinkley Point Marine Ecological Synthesis Report. EDF BEEMS (Cefas) 184. 2011.

Appendix 3 Map showing the extent of the "subtidal sandbanks" feature of the Severn Estuary SAC



Habitat Types and Community Structure
The sediments of the sub-tidal region off Hinkley are variable from bare rock to gravels, coarse sands, fine sand and muds, together with various mixed sediment types. Figure 2.6.3S2 below shows the abundance of *M. balthica* from sub-tidal sampling sites in relation to sediment type.

Figure 2.6.3S2 – Distribution of M. Balthica within sub-tidal area in relation to sediment type



From the recent surveys over the 3 years 2008-2010, some 300 grab samples were taken. In all, 60 benthic invertebrate taxa were identified during the surveys. However, overall species richness and individual abundance were found to be very low, with the average number of taxa per survey being 20, and the average number of taxa per sample being <2. Over a quarter of samples (27%) contained no fauna at all. Where fauna were present, on average only 3 individuals were found per $0.1m^2$ sample.

The total numbers of taxa recorded across a single survey were higher in February, June and August of 2008 (23 to 26 taxa) than in the 2008-2009 winter (11 to 15 taxa), while densities of individuals were typically lowest in both winter periods.

The key infaunal species by number from all the surveys were the bivalve molluscs *Nucula nucleus* (mean abundance 32 individuals per m^2) and *Macoma balthica* (mean abundance 22 individuals per m^2), the cumacean *Diastylis rathkei* (mean abundance 5.8 individuals per m^2), the polychaetes *Nephtys hombergii* (mean abundance 5.9 individuals per m^2) and *Scoloplos armiger* (mean abundance 4.4 individuals per m^2), and the oligochaete *Tubificoides amplivasatus .* However, by biomass, *Macoma balthica* (58%) and *Nucula nucleus* (28%) were the dominant species. There was a clear spatial trend in diversity and abundance, with the sites near shore showing consistently higher numbers of species, greater species abundance, and greater biomass compared with the sites further offshore. However, the data were too sparse to demonstrate any relationship between the "community" and the substrate type.

Similar results for the key species and general impoverished nature of the benthic macrofauna were also found from the benthic sampling in Bridgwater Bay undertaken by the Environment Agency from May 2004 to March 2009.

These results from the infaunal samples of the sub-tidal area off Hinkley show that the benthic macroafauna is impoverished both in number of species and abundance. This is consistent with other surveys of the Severn Estuary and Bristol Channel (eg. Mettam et al 1984[273], Warwick et al 2001[274], and Warwick and Somerfield 2010[275]). The reasons for this are the tidal scouring and the high turbidity. The main factor controlling the distribution of benthic communities is the shear stresses at the sea bed (Warwick and Uncles 1980[276]).

2.6.3.2 Assessment of Operational Discharges in relation to the Sub-tidal Sandbanks

Conservation objectives

- the total extent of the sub-tidal sandbanks within the site is maintained;
- the extent and distribution of the individual sub-tidal sandbank communities within the site is maintained;
- the community composition of the sub-tidal sandbank feature within the site is maintained;
- the variety and distribution of sediment types across the sub-tidal sandbank feature is maintained;
- the gross morphology (depth, distribution and profile) of the sub-tidal sandbank feature within the site is maintained.

a) Toxic contamination

The only toxic contaminants which were not screened out by the assessment of 'Likely Significant Effect' presented in the section on the Estuaries feature were TRO and Hydrazine. The mixing zone associated with TRO, should chlorination be required, is shown in Figure 2.6.3S3

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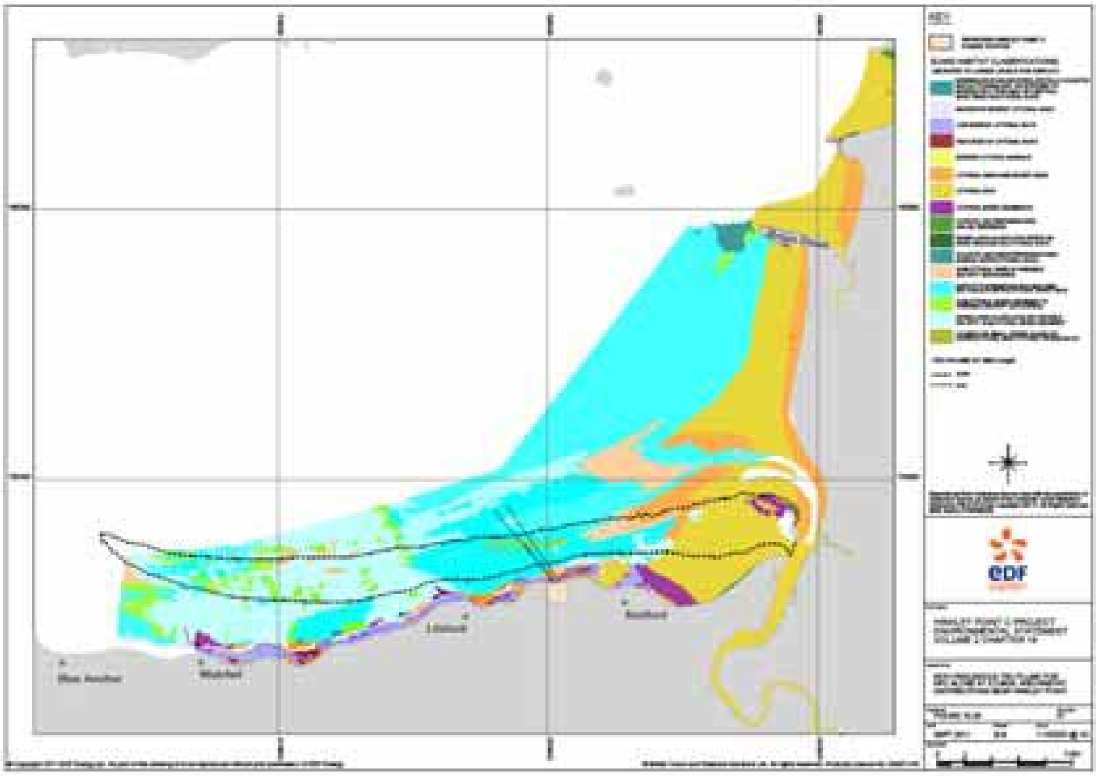
[273] Mettam C, Conneely M.E., White S.J. 1994. Benthic macrofauna and sediments in the Severn Estuary. Biological Journal of the Linnean Society 51, 71-81.

[274] Warwick R.M., Henderson P.A., Fleming J., Somes J.R. 2001. The impoverished fauna of the deep water channel and marginal areas between Flatholm Island and King Road, Severn Estuary. Report to the Bristol Port Company. 21 pp.

[275] Warwick R. M. and Somerfield P.J. 2010. The structure and functioning of the benthic macrofauna of the Bristol Channel and Severn Estuary, with predicted effects on a tidal barrage. Marine Pollution Bulletin 61, 92-99.

[276] Warwick R.M. and Uncles R.J., 1980. The distribution of benthic macrofauna associations in the Bristol Channel in relation to tidal stress. Marine Ecology Press series 3, 97 – 103.

Figure 2.6.3S3 – mixing zone for TRO based on constant chlorination



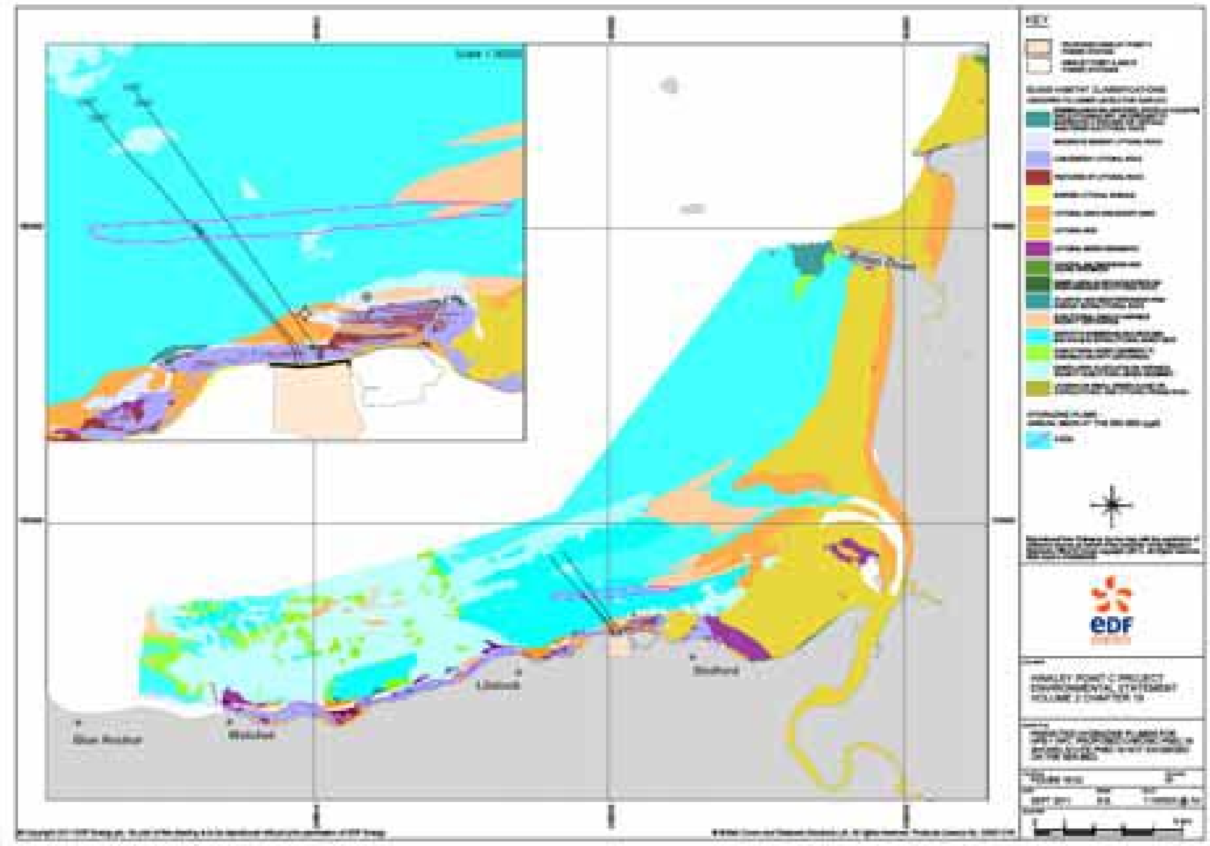
It is clear from Figure 2.6.3.3S3 that the mixing zone impacts on the sub-tidal area, although it does not appear to impact on the sub-tidal sandbanks feature. This suggests that there will be some stressing of the benthic communities of the sub-tidal area at levels above the EQS, but not the benthic communities related to the sub-tidal sandbanks feature. Some of the species in the sub-tidal benthic communities are also components of the intertidal mudflat and sandflat communities. While the levels of TRO which may affect the sub-tidal communities are greater than those affecting the intertidal flats, the levels will be below lethal concentrations which have been quoted to be between 0.193mg/l and 0.360mg/l (BEEMS TR 163 (2011)[277]), as the maximum concentration of TRO in the thermal plume at the point of discharge will be 0.200mg/l. It is therefore accepted that there could be some effect from TRO on the sub-tidal communities, where the EQS is exceeded. However, the area of EQS exceedance for TRO at the sea bed is estimated to be 63ha which is only about 0.12% of the total sub-tidal area of the Severn Estuary SAC which extends to about 50,500 ha. As discussed in Section 2.6.3.1.3b of the assessment for the Estuaries feature alone, the mixing zone for bromoform, the main by-product of chlorination, has been estimated to be coincident with the mixing zone for TRO.

This area for the mixing zones of TRO and bromoform is not considered to be significant, so that it is concluded that the TRO and bromoform does not have an adverse effect on the sub-tidal habitat of the Severn Estuary SAC. As the TRO and bromoform mixing zone does not affect the sub-tidal sandbanks feature, it can be concluded that there is no adverse impact on this feature of the Severn Estuary SAC.

[277] BEEMS Technical Report TR 163. Acute and behavioural effects of chlorinated seawater on inter-tidal mudflat species. EDF BEEMS (Cefas), 2011.

The mixing zone for hydrazine is shown in Figure 2.6.3S4 below.

Figure 2.6.3S4 – mixing zone for hydrazine based on constant dosing.



The mixing zone here only relates to the chronic PNEC for the average long-term discharge condition and not the acute PNEC for the maximum short-term discharge condition. (see text in Estuaries feature). It is apparent from this Figure that the mixing zone is very similar to that for TRO, and impacts on the sub-tidal area of the Severn Estuary SAC. However, unlike the mixing zone for TRO, the mixing zone for hydrazine appears to affect the western edge of the sub-tidal sandbanks feature at the mouth of the Parrett Estuary. The sub-tidal area and the sub-tidal sandbanks would also be impacted by the hydrazine mixing zone for the maximum long-term discharge scenario, although how extensive that impact would be is not known. Given the uncertainty associated with the hydrazine plume modelling, it was concluded in the section on the Estuaries feature, that treatment of hydrazine was needed prior to discharge. Any permit issued for operational water discharges from HPC will therefore include a requirement for the destruction of hydrazine prior to discharge into the Severn Estuary.

Therefore, the operational water discharge permit will ensure that no hydrazine is discharged into the Severn Estuary and therefore we can conclude that there will be no adverse effect on the sub-tidal sandbanks as a result of hydrazine.

It was concluded in Section 2.6.1.2 that the concentrations of metals in the cooling water discharge from HPC are not significant. It was also concluded that the loadings of metals from the HPC discharges are not significant in relation to the loadings to the Severn Estuary SAC, so that they will not contribute to any significant change in the levels of sediment-bound contaminants in the Severn Estuary.

Conclusion
Based on the limited extent of the mixing zones for both TRO and bromoform, and the lack of an impact on the sub-tidal sandbanks feature, it is concluded that the conservation objectives for the sub-tidal sandbanks feature are not compromised by toxic contamination from the operational discharges from HPC alone, and that there is no adverse effect on site integrity. However, this conclusion is dependent on the need for hydrazine to be removed from the operational discharges prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

b) Non toxic contamination (Nutrient enrichment and organic loading)

It was concluded in Section 2.6.1.2 of this document that neither the increase in nutrient inputs nor the increase in organic load arising from the operational discharges from HPC were considered to have a likely significant effect on the integrity of the SAC. This conclusion was reached, because the discharges make a very small contribution, about 0.1% or less, to the overall annual loadings to the SAC.

Even at a local scale, the average increase in nutrients is considerably less than the ambient background values, being about 0.1% for N, about 3.8% for P, and less than 0.1% for oxygen demand. These increases are not considered to be significant.

Conclusion
It is therefore concluded that the conservation objectives for the sub-tidal sandbanks feature will not be compromised by non-toxic contamination from the operational discharges from HPC alone, and that there will be no adverse effect on site integrity.

c) Changes to thermal regime

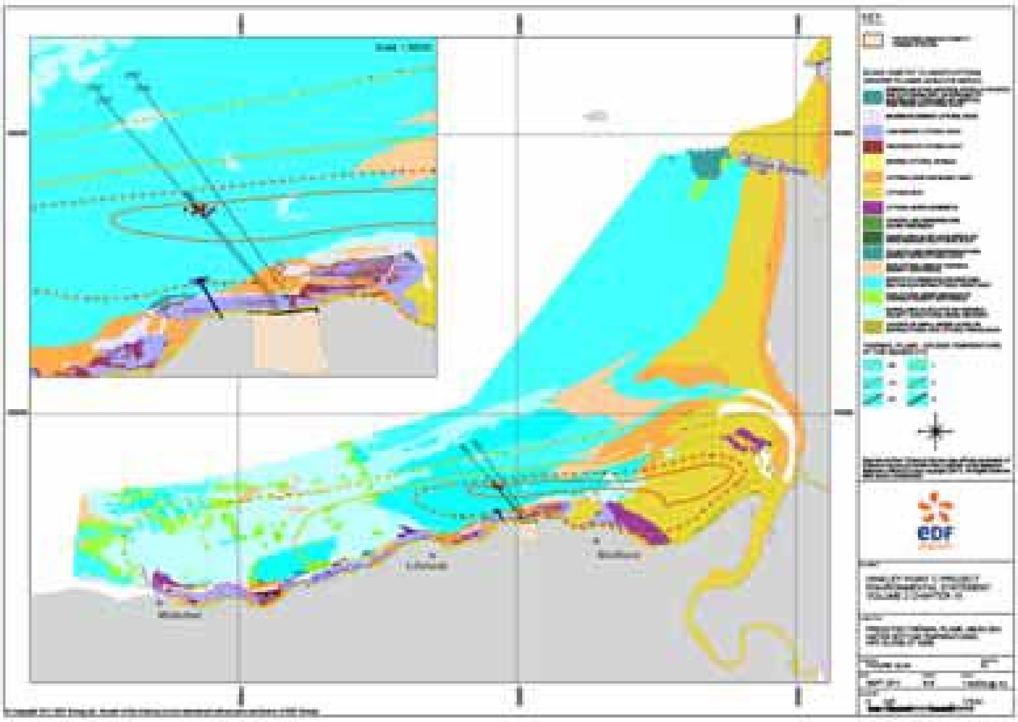
The discharge of abstracted cooling water occurs some 1.8km offshore a water depth of about 5m below Mean Low Water Spring tide level within the SAC boundary. This means that any significant temperature impact will occur in the sub-tidal benthic community within the immediate vicinity of the discharge point. This is based on the available evidence for the impact of the cooling water discharge from the operational Hinkley Point B power station. This discharges down a culvert cut into the rock across the intertidal foreshore. The flow at maximum 100% operation is given as 33.7m^3/s with a temperature differential of 15.8ºC in BEEMS TR 177 (2011)[278]. In the report BEEMS SAR 008 (2011)[279], it is reported that fucoids have been eliminated some 100m to 200m up-estuary (ie. to the east), whereas elsewhere a clear fucoid zonation down the intertidal zone is evident. This lack of fucoids can be seen in a photograph from this report, as shown in Figure 2.6.3S5 below.

[278] BEEMS Technical Report TR177 : Hinkley Point thermal plume modelling GETM Stage 3a results with the final cooling water configuration. EDF BEEMS (Cefas). 2012
[279] BEEMS Science Advisory Report Series. SAR 008: Thermal Standards for cooling water from new build nuclear power stations. BEEMS Expert Panel. 2010.

Figure 2.6.3S5 – Zonation of fucoids in sub-tidal area

The new discharge from Hinkley Point C will be offshore in an area where the sediments are predominantly sandy mud, and the community is defined as *Nephtys hombergii* and *Macoma balthica,* as shown in Figure 2.6.3S6

Figure 2.6.3S6 – location of Hinkley Point C discharge and sub-tidal community structure.



The range of temperature differentials will be between 10.7ºC and 12.5ºC for a discharge flow of between 134m^3/s and 116m^3/s. It is considered that there may be scouring of the sea bed in the vicinity of the discharge, given the size of the discharge and the nature of the sea bed. However, as shown in Figure 2.6.3S2 which shows the abundances of *M. balthica* in the sub-tidal sediments, the discharge is into an area where the abundances are low. This would suggest that any impacts where temperatures will be elevated more than about 5ºC above ambient will be restricted to at most a few hectares around the discharge point, although this area is also likely to coincide with the potential area of scour.

Apart from this very localised area of impact in the vicinity of the discharge point, the extent of the thermal plume in relation to the temperature targets needs to be defined, in order to assess the relative scale of the potential impact.

The extents of the mixing zones for a ∆T of 2ºC and a maximum temperature of 21.5ºC as a 98%ile are given for the surface and the sea bed for the sub-tidal area of the SAC in Table 2.6.3.3S7 below. Also included is the total area of the mixing zones in relation to the sub-tidal area, i.e. including that area lying outside the SAC. These data are derived from the model output from GETM, as this model is considered to be more precautionary than the Delft 3D model; i.e. the extents of the mixing zones are greater using GETM than those using Delft 3D. It should also be noted that the mixing zone for the maximum temperature of 21.5ºC as a 98%ile has been determined using a temperature differential of 1.1ºC, based on the fact that the 98%ile of mean monthly temperatures from the Hinkley long-term time series is 20.4ºC.

Table 2.6.3S7 – Extent of mixing zone on sub-tidal area.

	Extent of MZ for ∆T of 2ºC - ha		**Extent of MZ for Max Temp of 21.5ºC as a 98%ile – ha**	
	Total	SAC	Total	SAC
Surface	343	336	2011	1031
Sea Bed	224	221	1767	942

The relative proportions of these areas for the Total Mixing Zone and the Mixing Zone within the SAC have been compared with the total area of the sub-tidal feature of the SAC in Table 2.6.3.3S8 below.

Table 2.6.3.3S8 – Mixing zone as a percentage of total sub-tidal area of the SAC.

	Extent of MZ for ∆T of 2ºC - %age of subtidal area of SAC		**Extent of MZ for Max Temp of 21.5ºC as a 98%ile - %age of subtidal area of SAC**	
	Total	SAC	Total	SAC
Surface	0.67	0.66	3.94	2.02
Sea Bed	0.44	0.43	3.46	1.85

It is apparent that the mixing zone related to a ∆T of 2ºC is not large, being less than 1% of the total sub-tidal area of the SAC. However, the relative areas of mixing zone defined by the maximum temperature of 21.5ºC as a 98%ile is larger, being as much as 3.5% of the total sub-tidal area of the SAC. These areas and percentages relate to the sub-tidal area of the SAC, and are not specifically related to the sub-tidal sandbanks feature. However, from Figure 2.6.3.3S6, it is apparent that the mixing zone related to the ∆T of 2ºC will not affect the sub-tidal sandbanks feature, although that for the Max Temp of 21.5ºC as a 98%ile will affect the south west corner of the sub-tidal sandbanks feature at the mouth of the Parrett Estuary.

The area of the sub-tidal sandbanks feature affected by the thermal plume is therefore very small, so that it is considered that any impact on the sub-tidal sandbanks feature is not significant. However, there are sub-tidal habitats affected by the mixing zones for the thermal plume, notably muds/sandy muds with *N. hombergii* and *M. balthica*, and mixed sediments, some with *Sabellaria*. It is recognised that the sub-tidal communities are already subjected to extreme physical stressing, and are impoverished relative to other estuarine and coastal sites in the UK (Warwick et al 2001[10], and Warwick and Somerfield 2010[11]). The additional stressing due to a change in thermal regime may exacerbate this situation, and result in even greater impoverishment. Alternatively, it may have little effect, as the majority of the recruitment to the sub-tidal area may be almost entirely the result of larval and juvenile immigration from other sites in the Severn Estuary and the Bristol Channel. In addition, it has been recognised that most of the *M. balthica* in the Severn Estuary are juveniles (Boyden and Little 1973[280], and Ferns 1977[281]), so that it is likely that the recruitment of *M. balthica* to the subtidal zone will continue as a consequence of the replenishment of *M. balthica* from other sites in the Severn Estuary (see Section 6.5 - in combination assessment for the Estuaries feature). The available evidence is not able to answer all these questions, and there is also no present analogue to compare with.

The available evidence suggests that the sub-tidal macrofauna is impoverished, and does not contribute greatly to the productivity of the Seven Estuary SAC, and that the intertidal mudflats and sandbanks contribute by far the greater contribution to the productivity of the SAC (see eg. Langston *et al* 2003[282] and 2007[283]), and are also used by birds, fish, and the hyperbenthos (notably *Crangon crangon* and mysids) for feeding.

On this basis, it can be argued that any potential marginal loss of productivity from the sub-tidal area affected by the thermal plume from Hinkley Point C will not significantly affect the overall productivity of the Severn Estuary SAC nor the food webs that exist.

Conclusion

Based on the available evidence of the effect of the present thermal plume on the intertidal benthic community of Stert Flats, and the apparent continuous recruitment of juvenile M. balthica to both the sub-tidal and intertidal zone of Bridgwater Bay, it is concluded that the conservation objectives for the sub-tidal feature will not be compromised by changes in thermal regime from the operational discharges from HPC alone, and that there will be no adverse effect on site integrity.

d) Habitat Loss and Physical Damage

It was recognised in the Appendix 11 that there was potential for habitat loss and physical damage due to the volume and rate of water discharge. This relates to the potential for scouring of the seabed in the vicinity of the outfall structures by the cooling water as it is discharged. There is also an area of seabed which could be scoured by the intake structures. The combined area of scour by the outfall and

[280] Boyden C. R. and Little C.1973 Faunal distributions in soft sediments of the Severn Estuary. Estuarine and Coastal marine Science 1, 203-223.

[281] Ferns P.N. 1977 Wading Birds of the Severn Estuary. Report to the Nature Conservancy Council. University College, Cardiff. 114 pp.

[281]Langston, W.J., Chesman, B.S., Burt, G.R., Hawkins, S.J., Readman, J., and Worsfold, P. 2003 Characterisation of the South West European Marine Sites: The Severn Estuary pSAC, SPA. Marine Biological Association of the UK Occasional Publication No.13. 206 pp.

[283] Langston W.J., Chesman B.S., Burt G.R., Campbell M., Manning A., and Jonas P.J.C. 2007The Severn Estuary sediments, contaminants and biota. Marine Biological Association of the United Kingdom Occasional Publication (19), 176 pp.

intake structures has been estimated to be about 0.18 ha. The sub-tidal habitat most affected by the intakes and outfall structures is mud, and the biotope *Nephtys hombergii* and *Macoma balthica* infralittoral sandy mud. This habitat comprises about 7,600 ha of the subtidal area surveyed in Bridgwater Bay (Section 6.2.160 p.194 of EDF's report to inform the HRA). The area of sub-tidal habitat loss therefore equates to about 0.002% of this biotope in Bridgwater Bay, which is insignificant. In relation to the total extent of this biotope occurring in the sub-tidal area of the Severn Estuary SAC, the area of impact will be much less. The area of the sub-tidal sandbanks feature in Bridgwater Bay will not be affected by any potential scour from the outfall and intake structures as it is about 2 km from the structures.

Conclusion
Based on the very small extent of any scouring related to the outfall and intake structures, it is concluded that the conservation objectives for the sub-tidal sandflats feature will not be compromised and that there will be no adverse effect on site integrity.

Overall Conclusion

Based on the above assessment, with the exception of hydrazine, it is concluded that none of the hazards which could affect the sub-tidal sandbanks feature will compromise the conservation objectives of the sub-tidal sandbanks feature, and will therefore not have an adverse effect on site integrity.

We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the sub-tidal feature and the integrity of the Severn Estuary SAC without mitigation.

Required mitigation

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

Hazard assessed	**Adverse effect on sub-tidal sandbanks feature?**
Toxic contamination	Yes – Requirement to remove hydrazine via permit condition (see below).
Non-toxic contamination	No
Changes to thermal regime	No
Habitat loss & physical damage	No
Overall conclusion	**With the permit condition in place we can conclude no adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Required mitigation *Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges*	Environment Agency	Operational Permit Ref: HP3228XT

2.6.4 Reefs

The Severn Estuary has areas of biogenic reefs, formed by the reef building polychete worm *Saballaria alveolata,* also known as the 'honeycomb worm'. A Sabellaria reef has been defined arbitrarily as a dense aggregation of worms (over 1,000 per m^2), generally forming a thick (2cm or more) crust of tubes, covering an area generally exceeding $25m^2$, although patchily (Hendrick & Foster-Smith, 2006)[284]. *Sabellaria* reefs are solid (albeit fragile) structures, that are generally raised above the surrounding seabed and they make up part of the Severn Estuary's benthic communities. As such, they provide a biogenic habitat that allows many other associated species to become established. *S. alveolata* reefs in the UK are predominantly an inter-tidal habitat but the Severn Estuary is one of the few places where *S. alveolata* reefs occur extensively in the sub-tidal, as well as the inter-tidal[285]. *Sabellaria spinulosa* also exists within the Severn Estuary, but it is more associated with building less stable crusts within the sub-tidal area rather than large 'biogenic' reef systems, that are designated under the SAC.

S. alveolata are dependent on hard substrata along with a good supply of sand for reef building and thus live in areas which are subject to large scale changes in sand supply and suspended coarse sediment (Holt *et al*, 1998)[286]. They are found to the west of Hinkley Point and along the low shore directly in front of Hinkley Point A station, as well as on some low shore areas of Stert Flats.

Based on the off-shore survey data collected as part of the EIA study surveys, areas of suspected reef growth were investigated during side-scan sonar and swath bathymetry surveys in March and April 2010 (BEEMS TR138)[287], with ground truthing later in 2010 (BEEMS TR104[288] and TR141[289]). TR141 investigated *Sabellaria* within the vicinity of HPC by collecting Hamon Grab samples in areas that were previously identified by Cefas as revealing a *Sabellaria*-like signature (TR104). Where no sample could be recovered using a Hamon Grab, an anchor dredge was deployed in an attempt to collect a sample from the seabed.

Figure 2.6.4S1 shows the areas where both species of *Sabellaria* has been found from the investigations reported in TR141. Where *Sabellaria* fragments were recovered from the seabed, a 'reefiness' assessment was undertaken in line with best practice methodology based on the work of Hendrick & Foster-Smith (2006). From the 19 stations where *Sabellaria* reef fragments were found, 5 qualified as "Medium" developed reefs, ten as "Low" developed reefs and 4 as "No reef" (see figure 2.6.4S2). *S. spinulosa* was mainly found at inshore stations and was not recovered as reef fragments. *S. alveolata* was more widespread and encountered as reef.

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[284] Hendrick, V.J and Foster-Smith, R.L. (2006). *Sabellaria spinulosa* reef: a scoring system for evaluating 'reefiness' in the context of the Habitats Directive. J.Mar.Bio.Ass. U.K. 86; 665-677.

[285] The Severn Estuary/ Môr Hafren European Marine Site. Natural England and the Countryside Council for Wales' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats &c.) Regulations 1994, as amended. June 2009.

[286] Holt, T.J, Rees, E.I, Hawkins, S.J., Seed, R. (1998). Biogenic Reefs: An overview of dynamic sensitivity characteristics for conservation management of Marine SACs. Prepared fro the Scottish Association of Marine Sciences.

[287] BEEMS Technical Report TR138 (TR138). BEEMS nearshore habitat survey: Hinkley Point - Bridgwater Bay final report. EDF BEEMS (Titan Environmental Surveys Ltd.), 2011.

[288] BEEMS Technical Report TR104 (TR104). Hinkley Point Sabellaria assessment: analysis of survey data for 2009. EDF BEEMS (Marine Ecological Surveys Ltd.), 2010.

[289] BEEMS Technical Report TR141 (TR141). Hinkley Point Sabellaria assessment: analysis of survey data 2010. EDF BEEMS (Marine Ecological Surveys Ltd.), 2010.

Figure 2.6.4S1. *Presence of Sabellaria alveolata (green) and Sabellaria spinulosa (orange) across the Hinkley Point area surveys carried out in February and March 2010. Open circles indicate stations where no Sabellaria were observed in samples. Figure taken from TR141.*

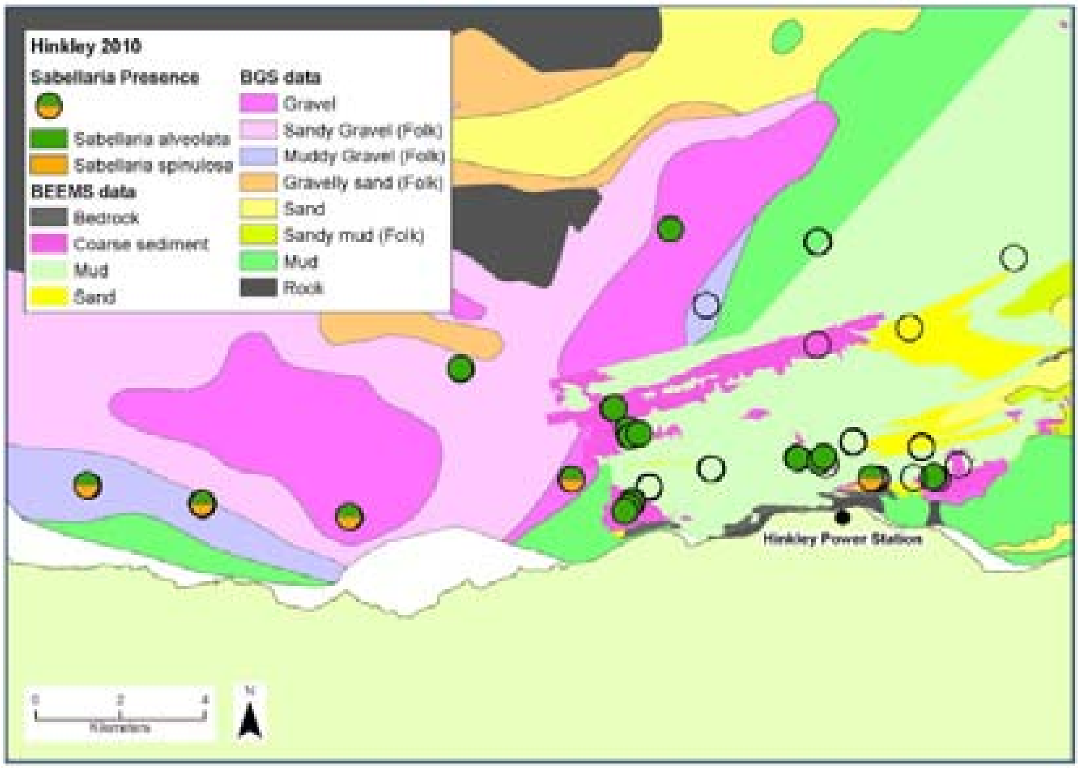
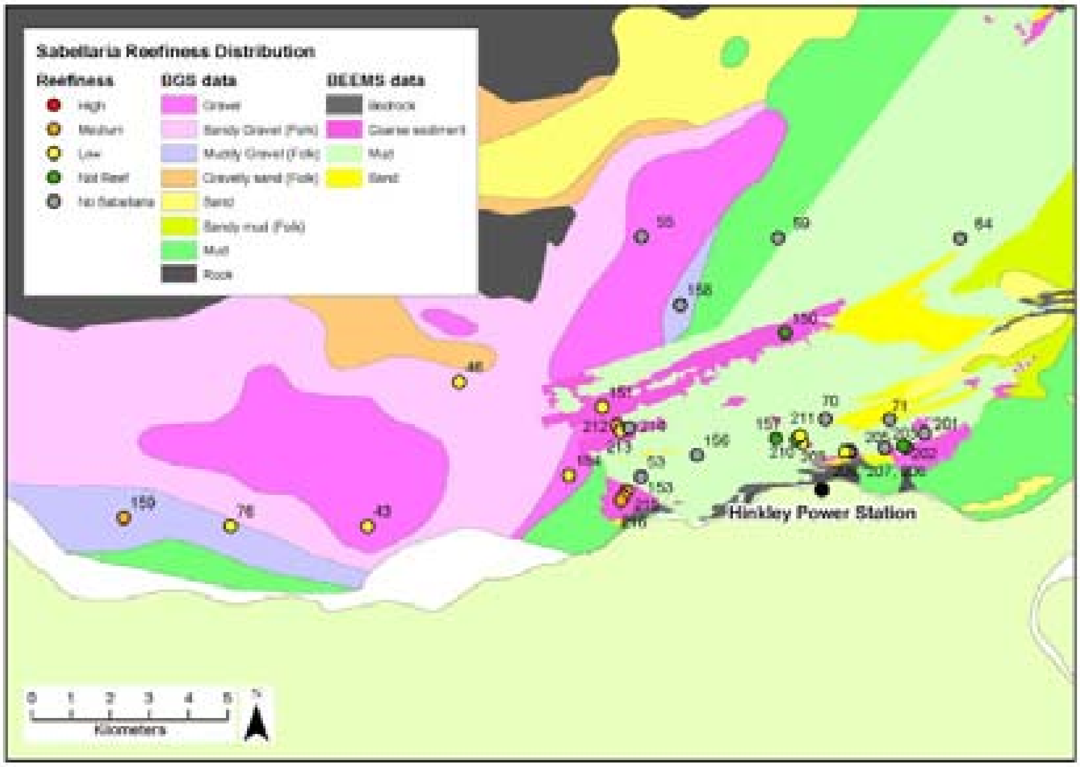


Figure 2.6.4S2. *Distribution of Sabellaria reefiness categories in the vicinity of Hinkley Point based on results from Hamon grab and anchor dredge sampling during February – March 2010 (Figure taken from TR141).*



a) Toxic contamination

Conservation objectives (see Section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009[290]

During the operational phase of HPC small amounts of potentially toxic substances will be discharged via the cooling water outfall from various different waste streams, which may be toxic to the marine ecology. Suspension feeding organisms, such as *Sabellaria,* process large volumes of sea water and remove organic and inorganic particulates from the water column. Therefore, they are vulnerable to both water soluble contaminants and contaminants adsorbed onto particulates.

Within the estuaries feature toxic contamination assessment (2.6.1a), only chlorine (in aqueous form as Total Residual Oxidant (TRO)) and hydrazine from waste streams B, C and D were concluded to have a potential effect within the estuaries feature as the amounts proposed to be discharged exceeded the relevant targets in the receiving waters (EQS). Both *S. alveolata* and *S. spinulosa* appear to be very tolerant of polluted conditions and thus have a good tolerance of poor water quality conditions[291], so they are unlikely to be impacted by contaminants within their EQS values. So although small concentrations of other contaminants will be released into the estuary from the discharge, as set out in the estuaries water quality assessment, only TRO and hydrazine will be assessed.

Chlorine (TRO)

The report to inform the HRA (Haskoning, 2011)[292] states that although the likelihood of bio-fouling is expected to be low at Hinkley Point C there may be occasions when cooling water flows are reduced, such as during major outages, when organisms will be able to colonise the cooling system more readily. This is less significant at the forebay but fouling in the water box next to the condenser is potentially serious as it could result in the blockage of condenser tubes. It is therefore considered important that during operation that Hinkley Point C has the ability to chlorinate the cooling system, should this prove to be necessary.

The current impact assessment modelling stated within BEEMS technical paper 186[293], is based on the maximum concentration of residual oxidants (aqueous chlorine) downstream of the condensers being 0.2 mg/l if both UK EPR units are being dosed and 0.1 mg/l if only one UK EPR unit is being dosed. Results for a modelled discharge from continuous dosing to achieve 0.2mg/l at the condensers for Hinkley Point C operating alone at 100% indicate that 60 hectares at the seabed

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[290] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[291] Sabellaria Species Biodiversity Action Plan, http://www.ukbap.org.uk/UKPlans.aspx?ID=38

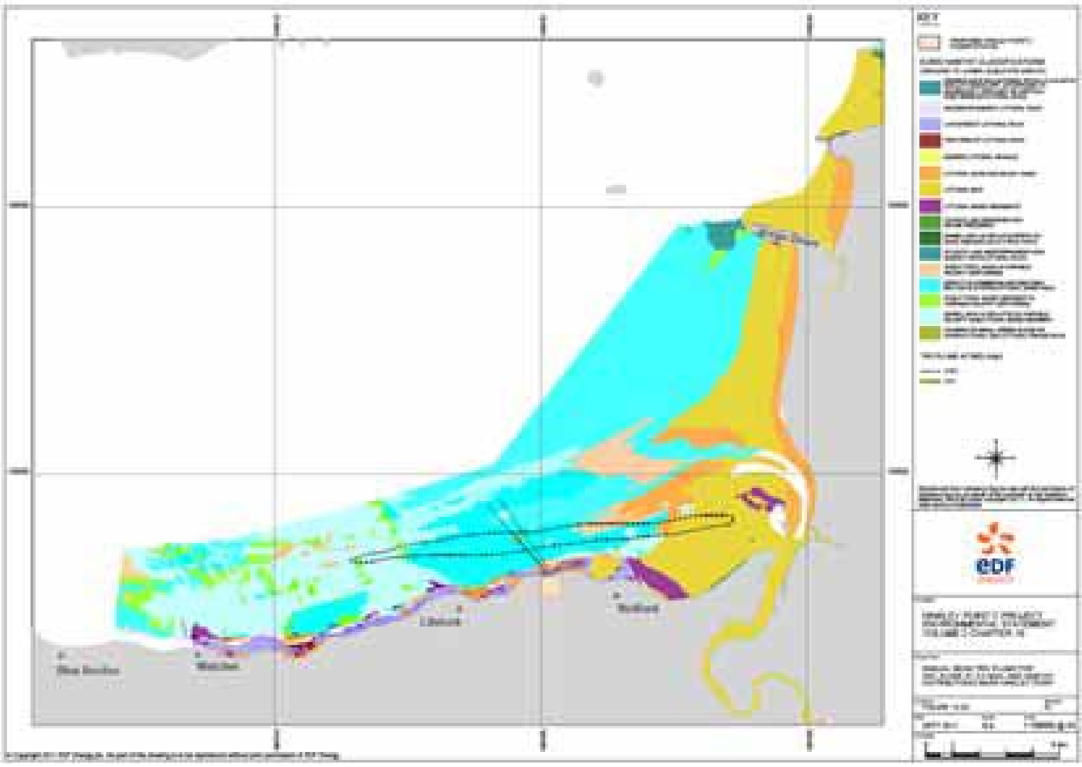
[292] Royal Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

[293] BEEMS Technical Report 186. Predicted effects of NNB on water quality at Hinkley Point. April 2011.

(0.1% of the SAC) and 139 hectares at the surface (0.2% of the SAC) would exceed the Total Residual Oxidant (TRO) EQS of 0.01mg/l.

BEEMS Technical Report 153 (TR153)[294] presents the final results of experiments carried out to measure the survival of the tube growth of *S. spinulosa* when exposed to chlorinated seawater containing residual oxidants (TRO). Experiments were conducted at the Scottish Association for Marine Science (SAMS) in a Vortex Re-suspension tank (VoRTs) aquarium facility purpose-built for experimental studies with sabellid polychetes. Although the species of primary interest is *S. alveolata* at Hinkley Point, the contractor gave preference to working with *S. spinulosa* because they already had extensive experience with the complex nature of experimental work that comes with these tube-dwelling sabellids. In this instance, the use of surrogate species has been deemed appropriate as it is closely related to the species of primary interest, as it employs similar methods of feeding and tube construction to that of *S. alveolata*.

Figure 2.6.4S3. Annual mean TRO plume for HPC alone at 0.2 mg/l and habitat distribution near Hinkley Point. Figure taken from Hinkley Point C Environmental Statement, Volume 2 - Chapter 19 (Figure 19.26)



The tests indicate that *S. spinulosa* has shown no statistically significant acute sensitivity to either the 0.02 or 0.10 mg/l TRO treatments across 28 days of exposure. There was however, significant tube growth rate between the chlorine treatments over the duration of the trial. Animals maintained under 0.1 mg/l TRO grew significantly more than those under control of 0.02 mg/l TRO. The reasons for this are unknown, but it is thought that the TRO may cause a slight irritation to the worms, which means they build larger tubes to try and get away from the mild irritation (Colin Taylor personal observation)[295].

[294] BEEMS Technical Report TR153 (TR153). Tolerance of *Sabellaria spinulosa* to Aqueous Chlorine; Final Report. EDF BEEMS (SAMS. 2010).
[295] Colin Taylor – Marine Biologist for EDF Energy. Comment made during Barnwood workshop June 2011.

The outfall location, where the TRO is likely to be of the highest concentration (at 0.01 mg/l), is not known to support *Sabellaria* reefs, particularly since the substrata beneath the outfall is not of suitable reef building material (see figure 2.6.3.5S3). The area of the TRO plume where annual mean concentrations are likely to rise to around 0.001mg/l, is likely to contain *Sabellaria* reefs, but the results form TR153 would suggest that this would have a negligible effect on the *Sabellaria* around the Hinkley Point area. Furthermore, Haskoning (2011) states that should dosing be required, then a 'risk based intermittent dosing regime' will be implemented based on "Cooling water management in European power stations: Biology and Control of Fouling" and best practice used by EDF Energy Nuclear Generation (formally British Energy) for its existing fleet of nuclear power stations as set out in their strategy document (British Energy, 2006)[296]. This involves the maintenance of a site specific risk based protocol to prevent bio-fouling.

The strategy describes the fouling control hierarchy as involving screening, cleaning and dosing in that order of preference, so dosing is always the last available option. Furthermore, the need for chlorination will be identified and closely linked to monitoring protocols for fouling, including monitoring of the condenser efficiency, examination of growth in circuits and monitoring populations of organisms on surrounding shores.

To ensure that the dosing regime is implemented within HPC and impact of TRO is minimised, as discussed in this section, the Environment Agency will ensure that it will be stated as a condition of any permit issued for the operational water discharge from the site.

Chlorinated by-products (CBPs)
Upon addition of chlorine to seawater, other water quality factors such as the pH and the presence of compounds like ammonia or the amount and form of organic matter in the water may lead to the formation of chloramines/bromamines and chlorination by-products (CBPs).

BEEMS TR186 reports on bromoform being the dominant CBP produced in coastal power station cooling water discharges where concentrations are dependent upon the receiving water quality and loss from the marine environment is largely via volatisation to the atmosphere. Only bromoform and dibromoacetonitrile were found in chlorinated cooling water effluents at concentrations significantly higher than detection limits; Chloroform was below the detection limit (0.1 µg/l) at all marine power stations during a study reported in BEEMS Science Advisory Report Series (2010) No 009.

There is no published European quality standard for bromoform or for any of the other commonly encountered CBPs. The only relevant statutory environmental quality standard (EQS) appears to be that for chloroform. Under the Water Framework Directive (2000/60/EC) chloroform is characterized as a priority substance with an EQS of 2.5 µg/l expressed as an annual average.

BEEMS Technical Report 162 (TR162)[297] has reviewed the existing literature related to the potential acute and behavioural effects of CPBs in relation to marine

[296] British Energy (2006). British Energy Operational Memorandum (BEOM) 006. The control of marine fouling. BEG/SPEC/ENG/BEOM/006.
[297] BEEMS Technical Report 162 (TR162) Hinkley Point chlorination responses of key inter-tidal species – a literature review. January 2011. Report produced by Cefas for EDF.

invertebrates. The report states that the ability of marine species to bio-accumulate bromoform has been assessed and that long term (28-d) studies with bivalve and shrimp species found limited bio-accumulation and rapid depuration within days of being returned to clean waters (Gibson et al. 1976)[298]. More recently, Taylor (2006)[299] used the Quantitative Structure-Activity Relationship (QSAR) approach to generate toxicity thresholds for CBPs. The QSAR process assumes that the biological activity of a compound can be predicted if its chemical structure is known (i.e. similarly structured compounds should have similar activity). Taylor (2006) proposed a Maximum Allowable Concentration for bromoform in surface waters of 5 μg/l and between 5 and 20 μg/l for a range of bromophenols.

Given that chlorination has not occurred at the Hinkley Point B site for many years the likely level of CBP production, particularly bromoform production, is unknown. However, Haskoning (2011) states that extensive monitoring around existing nuclear power plants whilst confirming the presence of many CBPs, showed that concentrations measured in the cooling water outfalls are approximately 1,000 times lower than acute toxicity thresholds. Additionally, these CBPs are not bio-magnified in the food chain. BEEMS Technical Report 186 (TR186)[300] presents all information available and concludes that the evidence for CBPs indicates that discharge concentrations are likely to be below calculated thresholds of effect and that concentrations will further decrease within 1km of the discharge. Impacts associated with CBPs are therefore not predicted to occur.

We therefore conclude that the levels of TRO from the discharge permission, including chlorinated by-products, will not have an adverse effect on the Sabellaria species designated under the SAC and Ramsar features.

Hydrazine

To reduce maintenance time and cost, corrosion inhibitors and oxygen scavengers are often added to control the pH of water in boiler and cooling systems for various industrial processes (TR186). Hydrazine is a strong reducing agent that is frequently used in the cooling water circuits of boilers in Nuclear Power stations because of its anti-oxidant properties (Audrieth and Ogg, 1951)[301]. Hydrazine (N_2H_4) is an ammonia-derived compound. It is generally considered that in all the aqueous solutions of hydrazine is present as hydrazine hydrate (Environment Canada, 2010)[302].

The fate of hydrazine in the aquatic environment is dependent on dilution/dispersion and chemical and biological degradation as well as processes such as volatilisation and sedimentation (Kuch, 1996)[303], with hydrazine ultimately degrading to form nitrogen. It is thought that hydrazine can cause growth inhibition, immobilisation, anomalies and mortality within aquatic organisms.

[298] Gibson, C., Thatcher, T., and Apts, C. (1976). Some effects of temperature, chlorine and copper on the survival and growth of the coon stripe shrimp. *Thermal Ecology*. G. Esch and R. McFarlane. Springfield, VA, Technical Information Centre, Energy Research and Development Administration.
[299] Taylor, C. (2006). "The effects of biological fouling control at coastal and estuarine power stations." *Marine Pollution Bulletin* 53: 30-48.
[300] BEEMS Technical Report 186 (TR186): Predicted effects of NNB on water quality at Hinkley Point. Cefas Report for EDF. April 2011.
[301] Audrieth, L. and B. Ogg (1951). *The chemistry of hydrazine*. New York, Wiley.
[302] Environment Canada (2010). Draft screening assessment for the challenge: hydrazine, Environment Canada.
[303] Kuch DJ. (1996). Bioremediation of hydrazine: a literature review. Report No. AL/EQ-TR-1994-0055. Armstrong Laboratory/Environics Directorate, Tyndall Air Force Base, FL 32403-5323.

The modelling from TR186 shows that although hydrazine will be present in toxic quantities, it is not expected to persist and its likely impact upon organisms associated with the seabed is predicted to be very low. Its main threat is therefore to species in the water column such as fish and plankton. There is no formal quality standard for hydrazine and there is uncertainty regarding the quality of toxicity data that has influenced the low predicted no effect concentration (PNEC) value.

The extent of the contaminant plumes for hydrazine has been defined within the estuaries toxic contamination assessment, along with the areas at the sea surface and sea bed where the relevant targets are exceeded; i.e. the size of the mixing zones. The extent of these mixing zones along with the percentages that these areas represent of the Estuaries interest feature are given in table 2.6.4S4.

Table 2.6.4S4 Extent of mixing zones for hydrazine along with the percentages that these areas represent of the Estuaries interest feature.

	Total Extent of Mixing Zone ha	**Mixing Zone in the SAC ha**	**Total Extent of Mixing Zone as a %age of the Estuaries feature**	**Mixing Zone in the SAC as a %age of the Estuaries feature**
Hydrazine Surface	191	161	0.259	0.219
Hydrazine Bed	77	77	0.105	0.105

Figure 2.6.4S5. Predicted hydrazine plume for HPC. Proposed chronic PNEC is shown. Acute PNEC is not exceeded on the sea bed. Figure taken from Hinkley Point C Environmental Statement, Volume 2 - Chapter 19 (Figure 19.32)

The outfall location, where the hydrazine is likely to be of the highest concentration (average concentration in effluent 0.01 µg/l), is not known to support *Sabellaria* reefs, particularly since the substrata beneath the outfall is not of suitable reef building material. The area of the hydrazine plume where annual mean concentrations are likely to rise to around 0.004 µg/l, appears to overlap with a very small section of *Sabellaria alveolata* on variable salinity sublittoral mixed sediment (see figure 2.6.4S5, note the small light blue patch within the pink circle that represents the hydrazine plume), however according to the 'reefiness' assessment (Hendrick & Foster-Smith, 2006)[304] this small path is not considered to be an actual reef, and its size appears to be insignificant in relation to the reef feature as a whole in the Severn Estuary.

We can therefore conclude that the release of hydrazine from the operational cooling water discharge will not have an adverse effect on the Sabellaria alveolata reefs designated under the Severn Estuary SAC and Ramsar.

[304] Hendrick, V.J and Foster-Smith, R.L. (2006). *Sabellaria spinulosa* reef: a scoring system for evaluating 'reefiness' in the context of the Habitats Directive. J.Mar.Bio.Ass. U.K. 86; 665-677.

b) Non toxic contamination (Nutrient enrichment and organic loading)

Conservation objectives (see Section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009

During the operation of HPC, treated sewage effluent will be discharged into the estuary which will have the potential to increase the nutrient content to a localised area of the estuary. Added to this, both the primary and secondary circuits have the potential to release ammonia, which can lead to elevated levels of nitrates in the water column. *Sabellaria* are not known to be sensitive to increased levels of nutrients and are not sensitive to eutrophication (Apis 2012)[305]. Walker & Rees (1980)[306], Walker & Rees (1980)[307] reported in a study of the benthic ecology of Dublin Bay that in the STW discharge area and down tide of the area *Sabellaria spinulosa* was present in greater densities and diversities than elsewhere in the bay.

As concluded in the estuaries non-toxic contamination assessment, Nitrogen and Phosphorus loadings into the estuary will be negligible. The increased nutrient levels may even benefit the species. We can therefore conclude that there will not be an adverse effect on the site integrity of Sabellaria alveolata reefs by non toxic contamination from the HPC operational discharge.

c) Changes to thermal regime

Conservation objectives (see Section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009

The thermal outputs into the estuary from the cooling water discharge has the potential to impact on both the *Sabellaria* reef as a habitat and the larvae of *Sabellaria* as free floating plankton. Wilson (1971)[308] reported on a short summer spawning period around July. The larvae are thought to spend anything between six

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[305] APIS - Air Pollution Information System (2012): Severn Estuary SAC www.apis.ac.uk

[306] Walker, A.J.M, & Rees, E.I.S. 1980. Benthic ecology of Dublin Bay in relation to sludge dumping: Fauna. Irish Fisheries Investigation. B Mar. 22.

[307] Walker, A.J.M, & Rees, E.I.S. 1980. Benthic ecology of Dublin Bay in relation to sludge dumping: Fauna. Irish Fisheries Investigation. B Mar. 22.

[308] Wilson, D.P. (1971). *Sabellaria* colonies at Duckpool, North Cornwall, 1975. Journal of the Marine Biological Association U.K. 50; 509-580.

weeks and six months in the plankton form (Wilson 1968[309], 1971) so that dispersal could potentially be widespread. *S. alveolata* is an iteroparous breeder (reproducing more than once in a lifetime) whose individuals become mature after one year (Ayata *et al*, 2009).The planktonic life stage of *S. alveolata* could therefore be affected by the thermal plume.

Using the thermal plume modelling outputs presented in BEEMS Technical Report 040 (v2), the habitats affected by the thermal plume were assessed (TR039). The main habitat affected by an increase of more than 2°C in temperature is the mud dominated EUNIS Habitat Type A5.331. The nearest areas of known *Sabellaria* reef occur outside of the modelled 3°C uplift contour for the discharge from Hinkley Point C but inside the modelled 2°C area.

Cunningham *et al.* (1984)[310] reported increasing growth rates of *Sabellaria* reefs with temperatures up to 20°C and studies at Hinkley Point B, found that growth of the tubes in the winter was considerably greater in the cooling water outfall, where the water temperature was raised by around 8-10°C, than at a control site, although the size of the individual worms themselves seemed to be unaffected (Bamber & Irving, 1997)[311]. Further to this, the growth of *Sabellaria alveolata* is severely restricted below 5°C (Gruet, 1982, cited in Holt *et al*., 1998) [312] so it is particularly vulnerable to the cold. For example, it has been recorded that there were many severe losses of *S. alveolata* in South and North Wales as well as Lyme Bay due to the severe winter of 1962-63[313]. There is therefore evidence to suggest that *S. alveolata* and their reefs could benefit from the predicted increase in water temperature around the cooling water discharge plume.

Since S. alveolata reef habitat is only expected to be subject to maximum temperature increases of 2°C *and that those increases in temperature are more likely to benefit the reef building worms, we can conclude that the cooling water discharge will not adversely impact on the Sabellaria populations within the vicinity of HPC and Bridgwater Bay.*

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309 Wilson, D.P. (1968). Some aspects of the development of eggs and larvae of *Sabellaria alveolata*. Journal of Marine Biology U.K. 48; 367-386.

310 Cunningham, P.N., Hawkins, S.J., Jones, H.D. & Burrows, M.T., (1984). The geographical distribution of *Sabellaria alveolata* (L.) in England, Wales and Scotland, with investigations into the community structure of and the effects of trampling on *Sabellaria alveolata* colonies. *Nature Conservancy Council, Peterborough, Contract Report* no. HF3/11/22., University of Manchester, Department of Zoology.

311 Bamber, R.N. & Irving, P.W. 1997. The differential growth of *Sabellaria alveolata* (L.) reefs at a power station outfall, Polychaete research, 17, 9-14.

312 Holt, T.J., Rees, E.I., Hawkins, S.J. & Seed, R., (1998). Biogenic reefs (Volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Scottish Association for Marine Science (UK Marine SACs Project)*, 174 pp.

313 Crisp, D.J. 1964. The effects of the severe winter of 1962-63 on marine life in Britain, *Journal of Animal Ecology*, 32-33, 165-211.

d) Increased turbidity and suspended sediment

Conservation objectives (see Section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009

S. alveolata do not rely on visual sense for feeding, reproducing etc. so they are not likely to be impacted by an increase in turbidity. In effect, they require a certain amount of water movement to suspend coarse sand particles in order to build tubes and so they are generally found in quite exposed areas. They can tolerate burial for a period of days or even weeks. However, prolonged burial will cause mortality. *S. alveolata* reefs are therefore potentially vulnerable to accumulations or losses of sand.

The cooling water discharge is likely to cause some localised turbidity and increase in suspended sediment and siltation around the location of the outfall. No S. alveolata are present around the outfall therefore, no adverse effect will occur from the increased turbidity and suspended sediment from the operational discharge at HPC.

e) Entrainment of *Sabellaria* larvae is covered within the estuaries abstraction section under section 2.6.1.4

Overall conclusion

Hazard assessed	Adverse effect on reef feature?
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Changes in turbidity and suspended sediment	No
Entrainment	No
Overall conclusion	**No adverse effect upon site integrity**

2.6.5 Migratory fish and fish assemblage

To be able to understand what the potential impacts on the fish assemblage are likely to be from the HPC proposed permissions, there must first be an understanding of what fish species and assemblages are likely to be present around the HPC area, and also what juvenile and ichthyoplankton species will be present, since these life stages will be the most sensitive to any impacts.

Most of the knowledge of the fish in the Severn Estuary and Bristol Channel comes from data obtained from fish impinged on the cooling-water intake screens at various nuclear power stations sited along the shore, including Hinkley Point B (Bird 2008) [314]. The applicant has used this impingement data collected at HPB[315] along with various other methods including; sampling at sea[316] and inter-tidal fish surveys[317], to understand what species are present. The dominant species recorded include sprat, whiting, herring, sole and flounder. Both the sampling at sea and the impingement data reveal a wide range of fish species including a number of commercially important species.

Fish are highly mobile and move up and down the estuary with the changing tides and seasons. Many species can tolerate high turbidity and a wide range of temperatures, salinity and oxygen concentrations. According to Bird 2008, the species most vulnerable to anthropogenic and environmental factors, such as temperature changes and impingement that could affect the habitat and ecology of the estuary include those species that rely on the estuary for some aspect of their life-cycle (see table 2.6.5S1 below).

The estuary is critical for both Anadromous (A) and catadromous (C) species, for which the estuary provides a connecting corridor between fresh water and marine habitats, critical for the completion of their life cycle. Salmon and trout along with both species of lamprey and shad designated under the SAC and Ramsar feature are anadromous, returning to the freshwater rivers to spawn. The European eel is catadromous, returning to the marine environment to spawn. Also, marine estuarine-opportunistic (MEO) fish e.g. whiting, bass, spend the first few years of life in the sheltered waters of the estuary where suitable food is abundant and there are fewer predators. The Severn Estuary ranks as one of the top ten estuaries in the UK for the number of MEO species it supports (Potts & Swaby 1993)[318]. Finally, there are just a few species that spend their entire life cycle within the estuary (E) that are also vulnerable to anthropogenic and environmental factors.

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[314] Bird, D.J. (2008). Biology and Conservation of the Fish Assemblage of the Severn Estuary cSAC. CCW Regional Report No. CCW/SEW/08/1

[315] BEEMS TR129. HP comprehensive impingement monitoring programme 2009-2010. EDF BEEMS (Pisces Conservation Ltd.) Technical Report No. 129, February 2011.

[316] BEEMS TR083 (Edition 3). Hinkley Point nearshore communities: Results of the 2 m beam trawl and plankton surveys 2008 – 2010. EDF BEEMS (Cefas) Technical Report No. 083, November 2010.

[317] BEEMS TR159, 2010. Intertidal fish survey August 2010, EDF BEEMS (APEM) Technical Report TR 159.

[318] Potts, G. W. & Swaby, S. E. (1993) Review of the status of estuarine fishes. pp. 278. English Nature Research Report No. 34, Marine Biological Association/English Nature.

Table 2.6.5S1 Species of fish that are dependent on the estuary for some part of their life-cycle. Those that use the estuary as a migratory corridor may be anadromous (A) or catadromous (C). Others, termed marine estuarine opportunistic (MEO) are primarily marine but depend on the estuary for some aspect of their life-cycle. A few species normally live and breed only in estuaries (E). Rare (+), regularly caught (++), common (+++). Species highlighted in blue are migratory fish designated under the Severn Estuary SAC and Ramsar site. Taken from Bird 2008 and adapted from Claridge et al. (1986)[319].

Family	Species	Common name	Life cycle category	Occurrence
Petromyzontidae	*Petromyzon marinus*	Sea lamprey	A	+
	Lampetra fluviatilis	River lamprey	A	+++
Clupeidae	*Alosa alosa*	Allis shad	A	+
	Alosa fallax	Twaite shad	A	+++
	Sprattus sprattus	Sprat	MEO	+++
	Clupea harengus	Herring	MEO	+++
Salmonidae	*Salmo salar*	Salmon	A	++
	Salmo trutta	Sea trout	A	+
Anguillidae	*Anguilla anguilla*	European eel	C	+++
Syngnathidae	*Syngathus rostellatus*	Nilsson's pipefish	MEO	+
Gadidae	*Merlangius merlangus*	Whiting	MEO	+++
	Trisopterus luscus	Bib	MEO	+++
	Trisopterus minutus	Poor cod	MEO	+++
	Pollachius pollachius	Pollack	MEO	++
	Ciliata septentrionalis	Northern rockling	MEO	++
	Ciliata mustela	Five-bearded rockling	MEO	++
Percichthyidae	*Dicentrarchus labrax*	Bass	MEO	+++
	Pomatoschistus microps	Common goby	E	+++
	Pomatoschistus minutes & Pomatoschistus lozanoi	Sand goby complex	MEO	+++
	Gobius niger	Black goby	EST	+
Mugilidae	*Liza ramada*	Thin-lipped grey	MEO	+++
Atherinidae	*Atherina boyeri*	Sand smelt	E & M	++
Liparidae	*Liparis liparis*	Sea snail (fish)	MEO	+++
Gasterosteidae	*Gasterosteus aculeatus*	3-spined stickleback	E & F	+++
Pleuronectidae	*Platichthys flesus*	Flounder	MEO	+++
Soleidae	*Solea solea*	Dover sole	MEO	++

[319] Claridge, P.N., Potter, I.C. & Hardisty, M.W. (1986) Seasonal changes in movements, abundance, size composition and diversity of the fish fauna of the Severn Estuary. *Journal of the Marine Biological Association of the United Kingdom*, 66, 229-258.

a) Toxic contamination (changes to water chemistry)

Conservation objectives (see Section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by poor water quality*
- *The size of the populations of the migratory fish and assemblage species 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*
- *The abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary is maintained*
- *Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives*

Natural England & Countryside Council for Wales, 2009[320]

During the operational phase of HPC small amounts of potentially toxic substances will be discharged via the cooling water outfall from various different waste streams, which may be toxic to the marine ecology and have an impact on the migratory fish and fish assemblage either directly, or indirectly via bioaccumulation.

The Severn Estuary has been studied in considerable detail over many decades partly because of the concerns about the level of contamination in the estuary emanating from industrial effluent discharged from Sewage Treatment Works (STWs) along the Welsh and English coasts (Bird 2008)[321]. There is now a good understanding of the hydrodynamics and sedimentation processes in the estuary, that define the region's inter-tidal habitats that range from rocky shores in some parts of the estuary to the establishment of mudflats and sandflats at other locations (Kirby, 1994)[322]. These markedly different substrata largely determine the abundance and distribution of organisms in the estuary[323] and to some extent, the distribution of the fish that feed on them (Bird 2008). The re-mobilisation of metals is possible whenever sediments are disturbed (Hitchcock & Thomas 1992) however this is unlikely to be a problem in the estuary system since sediment redistribution occurs naturally. Specific information relating to contaminants and the Severn Estuary can be reviewed in the Site Characterisation Report[324], which provides a comprehensive report of each contaminant type and its potential impact to the designated features.

All of the migratory fish and fish assemblage are sensitive to some form of toxic contamination. This assessment will be focusing on the potentially significant outcomes of the estuaries toxic contamination assessment, where contaminants from the proposed thermal plume discharge have been assessed against their relevant environmental targets. The Severn Estuary Water Quality Model (updated March

[320] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[321] Bird, D.J. (2008) The Biology and Conservation of the fish assemblage of the Severn Estuary (cSAC). Report for Countryside Council for Wales (CCW).

[322] Kirby, R. (1994) The evolution of the fine sediment regime of the Severn Estuary and Bristol Channel. Canadian Journal of Fisheries and Aquatic Sciences, 40, 83-95.

[323] Uncles, R.J. (1983) Modelling tidal stress, circulation and mixing in the Bristol channel as a prerequisite for ecosystem studies. Canadian Journal of Fisheries and Aquatic Sciences, 40, 8-9.

[324] Langston, W.J. et al (2003). Characterisation of the Severn Estuary pSAC and SPA. Marine Biological Association.

2009)[325], which assessed the impact of regulated discharges on water quality in the Severn Estuary, has been used to help determine the quality of the estuarine water in relation to Environmental Quality Standards (EQS).

Within the estuaries feature toxic contamination assessment (2.6.1a), only chlorine (in aqueous form as Total Residual Oxidant (TRO)) and hydrazine from waste streams B, C and D were concluded to have a likely significant effect within the estuaries feature as the amounts proposed to be discharged exceeded the relevant targets in the receiving waters (EQS).

Chlorine (TRO)
Chlorine is one of the most common biocides used to prevent bio-film development and the establishment of macro-fouling organisms, e.g. mussels, in industrial cooling water systems. The report to inform the Habitats Regulations Assessment (Haskoning, 2011) states that operational experience at Hinkley Point A and Hinkley Point B suggests that the risk of biofouling is likely to be low at Hinkley Point C. This long-term operational experience at the site is thought to be due primarily to the extreme turbidity regime normal to the nearshore waters of Bridgwater Bay as:

- The very high turbidity levels in the waters around the seabed intake will prevent bio-fouling by algae.
- Flow rates within the cooling system will typically be 2m/s, and in combination with these high turbidity levels this will tend to discourage successful settlement.
- The very high suspended solids levels of the water extracted from Bridgwater Bay and their low available organic carbon content are understood to greatly limit the ‘scope for growth’ (i.e. a negative energy balance where energy used to filter food from the suspended sediment is greater than that assimilated from the filtered particles) of species such as the common blue mussel Mytilus.

The report further states that although the likelihood of bio-fouling is expected to be low at Hinkley Point C there may be occasions when cooling water flows are reduced, such as during major outages, when organisms will be able to colonise the cooling system more readily. It is therefore considered important that during operation that Hinkley Point C has the ability to chlorinate the cooling system, should this prove to be necessary. When chlorination is undertaken the dosing will take place prior to the condensers but after the drum-screens, thus avoiding any dosing of the Fish Recovery and Return system.

Under normal conditions at HPC the worst case chlorination would involve dosing to 0.5mg/l of active chlorine, applied sequentially once every 30 minutes per cooling channel to achieve a Total Residual Oxidant (TRO) level of 0.2mg.l-1. This would only be applied when the sea temperature exceeds 10°C. However, under most circumstances at Hinkley Point C it is expected that chlorination will not be required.

Although it is thought that chlorine dosing within HPC is highly unlikely, there is a requirement for it should it be needed, and therefore with a discharge of 0.2mg/l the TRO concentration at the HPC outfall is expected to be of the order of 100 to 200µg/l with an EQS of 10µg/l (see Table 2.6.5S2).

Fish may show a range of behavioural, chronic and acute effects on exposure to chlorine and impacts will depend on the metabolism of the individual species, but

[325] Murdoch et al (2009), Severn Estuary Water Quality Model for the Severn Estuary Review of Consents Stage 3 Assessment. Environment Agency.

generally chlorine affects the gills and causes a change in the routine oxygen consumption, which can lead to death by asphyxiation. Acute sensitivity may show a threshold effect, with mortality increasing rapidly across a narrow TRO range when a threshold concentration is exceeded (Capuzzo *et al.* 1977)[326]. BEEMS Technical Report 184 (TR184)[327] reported on the limited species-specific data that was found for TRO sensitivity for species that occur at Hinkley Point and included:

- Larval plaice *Pleuronectes platessa* has a 96-hr LC50 (median lethal dose) of approximately 0.025mg/l to 0.035mg/l TRO; and
- Larval dover sole *Solea solea* has a 48-hr LC50 of approximately 0.03mg/l to 0.06mg/l TRO, increasing to 0.07mg/l to 0.09mg/l TRO after metamorphosis.

Table 2.6.5S2 - *Hydrazine concentrations from proposed discharge waste streams B,C and D at Hinkley Point C.*

Contaminant	Average Concentration in Effluent µg/l	Max Concentration in Effluent µg/l	EQS or Target µg/l
TRO (from chlorination if used)	200	500	10 T as a 95%ile

Modelling reported in BEEMS Technical Report 186 (TR186)[328] is based on the maximum concentration of residual oxidants downstream of the condensers being 0.2 mg/l if both UK EPR units are being dosed and 0.1 mg/l if only one UK EPR unit is being dosed. Results for a modelled discharge from continuous dosing to achieve 0.2mg/l at the condensers for Hinkley Point C operating alone at 100% indicate that 60 hectares at the seabed (0.1% of the SAC) and 139 hectares at the surface (0.2% of the SAC) would exceed the TRO EQS of 0.01mg/l. The report further concludes that the concentrations within Table 2.6.5S2 are not predicted to occur outside of the area immediately adjacent to the discharge points.

Adult fish are mobile animals and could be assumed to respond to a chemical plume by avoiding it, conferring a high level of resistance to the impact. For migratory fish, a chemical plume could act as a physical barrier to the migratory passage, disrupting the species' life cycles and, potentially, the ability to reproduce. TR186 states that such an effect appears unlikely in Bridgwater Bay given the relatively small area of chemical impact relative to the available habitat. To review such conclusions, the extent of the contaminant plumes for TRO has been defined within the estuaries toxic contamination assessment, along with the areas at the sea surface and sea bed where the relevant targets are exceeded; i.e. the size of the mixing zones. The extent of these mixing zones along with the percentages that these areas represent of the estuaries interest feature are given in Table 2.6.5S3 .

The areas and percentages for TRO from Table 2.6.5S3 are not significant, being less than 0.3% of the Estuaries feature being the habitat for the fish, in an area with no habitat or features unique to the site, and based on operational experience from HPB, the need for bio-fouling is likely to be low. Furthermore, Haskoning (2011) states that should dosing be required, then a 'risk based intermittent dosing regime'

[326] Capuzzo, J., J. Davidson, S. Lawrence and M. Libni (1977). "The differential effects of free and combined chlorine on juvenile marine fish." *Estuarine, Coastal and Marine Science* **5**(6): 733-741.
[327] BEEMS Technical Report 184 (TR184): Hinkley Point Marine Ecology Synthesis Report. EDF 2008.
[328] BEEMS Technical Report 186 (TR186): Predicted effects of NNB on water quality at Hinkley Point. Cefas Report for EDF. April 2011.

will be implemented based on "Cooling water management in European power stations: Biology and Control of Fouling" and best practice used by EDF Energy Nuclear Generation (formally British Energy) for its existing fleet of nuclear power stations as set out in their strategy document (British Energy, 2006)[329]. This involves the maintenance of a site specific risk based protocol to prevent bio-fouling.

The strategy describes the fouling control hierarchy as involving screening, cleaning and dosing in that order of preference, so dosing is always the last available option. Furthermore, the need for chlorination will be identified and closely linked to monitoring protocols for fouling, including monitoring of the condenser efficiency, examination of growth in circuits and monitoring populations of organisms on surrounding shores.

To ensure that the dosing regime is implemented within HPC, the Environment Agency will ensure that it will be a requirement within the permit (see conclusion).

Table 2.6.5S3 *Extent of mixing zones for TRO along with the percentages that these areas represent of the Estuaries interest feature.*

	Total Extent of Mixing Zone ha	**Mixing Zone in the SAC ha**	**Total Extent of Mixing Zone as a %age of the Estuaries feature**	**Mixing Zone in the SAC as a %age of the Estuaries feature**
TRO Surface	159	139	0.216	0.189
TRO Bed	63	60	0.086	0.081

Chlorinated by-products (CBPs)
Upon addition of chlorine to seawater, other water quality factors such as the pH and the presence of compounds like ammonia or the amount and form of organic matter in the water may lead to the formation of chloramines/bromamines and chlorination by-products (CBPs).

BEEMS TR186 reports on bromoform being the dominant CBP produced in coastal power station cooling water discharges where concentrations are dependent upon the receiving water quality and loss from the marine environment is largely via volatisation to the atmosphere. Only bromoform and dibromoacetonitrile were found in chlorinated cooling water effluents at concentrations significantly higher than detection limits; Chloroform was below the detection limit (0.1 µg/l) at all marine power stations during a study reported in BEEMS Science Advisory Report Series (2010) No 009.

There is no published European quality standard for bromoform or for any of the other commonly encountered CBPs. The only relevant statutory environmental quality standard (EQS) appears to be that for chloroform. Under the Water Framework Directive (2000/60/EC) chloroform is characterized as a priority substance with an EQS of 2.5 µg/l expressed as an annual average.

Long-term studies of the sea bass *Dicentrarchus labrax* in a fish farm receiving power station cooling water indicated that levels of mortality were comparable with

[329] British Energy (2006). British Energy Operational Memorandum (BEOM) 006. The control of marine fouling. BEG/SPEC/ENG/BEOM/006.

other fish farms over a three-year study (Taylor, 2006)[330]. Bromoform was present in fish tissues at concentrations up to 1.7 mg/kg in the fatty tissues of exposed fish, but this decreased rapidly when chlorination ceased. There was no indication of elevated detoxification enzymes, or abnormal pathology or tumour development in the tissues of exposed fish (TR186). The evidence therefore suggests that bromoform does not represent a long term threat based in particular on the long term studies on sea bass.

Given that chlorination has not occurred at the Hinkley Point B site for many years the likely level of CBP production, particularly bromoform production, is unknown. However, Haskoning (2011) states that extensive monitoring around existing nuclear power plants whilst confirming the presence of many CBPs, showed that concentrations measured in the cooling water outfalls are approximately 1,000 times lower than acute toxicity thresholds. Additionally, these CBPs are not bio-magnified in the food chain. BEEMS Technical Report 186 (TR186)[331] presents all information available and concludes that the evidence for CBPs indicates that discharge concentrations are likely to be below calculated thresholds of effect and that concentrations will further decrease within 1km of the discharge. Impacts associated with CBPs are therefore not predicted to occur.

Conclusion
We can conclude that the levels of TRO from the discharge permission, including chlorinated by-products, will not have an adverse effect on the migratory fish or fish assemblage designated under the SAC and Ramsar features.

However, to ensure chlorine dosing is controlled should it be required, we will ensure that a dosing regime is written up and agreed with the Environment Agency as part of a requirement under the Environmental Permit.

Hydrazine
To reduce maintenance time and cost, corrosion inhibitors and oxygen scavengers are often added to control the pH of water in boiler and cooling systems for various industrial processes (TR186). Hydrazine is a strong reducing agent that is frequently used in the cooling water circuits of boilers in Nuclear Power stations because of its anti-oxidant properties (Audrieth and Ogg, 1951)[332]. Hydrazine (N2 H4) is an ammonia-derived compound. It is generally considered that in all the aqueous solutions of hydrazine is present as hydrazine hydrate (Environment Canada, 2010)[333].

The fate of hydrazine in the aquatic environment is dependent on dilution/dispersion and chemical and biological degradation as well as processes such as volatilisation and sedimentation (Kuch, 1996)[334], with hydrazine ultimately degrading to form nitrogen. It is thought that hydrazine can cause growth inhibition, immobilisation, anomalies and mortality within fish and other aquatic organisms.

[330] Taylor, C. J. L. 2006. The effects of biological fouling control at coastal and estuarine power stations. *Marine Pollution Bulletin*, 53: 30–48.
[331] BEEMS Technical Report 186 (TR186): Predicted effects of NNB on water quality at Hinkley Point. Cefas Report for EDF. April 2011.
[332] Audrieth, L. and B. Ogg (1951). *The chemistry of hydrazine*. New York, Wiley.
[333] Environment Canada (2010). Draft screening assessment for the challenge: hydrazine, Environment Canada.
[334] Kuch DJ. (1996). Bioremediation of hydrazine: a literature review. Report No. AL/EQ-TR-1994-0055. Armstrong Laboratory/Environics Directorate, Tyndall Air Force Base, FL 32403-5323.

Teratogenicity (ability to cause birth defects) and toxicity screening of hydrazine were reported using the fathead minnow (Henderson *et al*, 1981)[335], and rainbow trout (Henderson *et al*, 1983)[336]. Eggs of fathead minnows (*Pimephales promelas*) at the mid-cleavage stage were exposed to hydrazine for 24 or 48 h. Embryos, exposed for 24 hour, to 0.1mg/l, showed several defects, such as slightly or moderately subnormal heart beat, haemoglobin levels, body movement amount of eye pigment. From 1 mg/litre upwards, the responses were generally stronger; in addition, body pigment was absent and developmental arrest was observed. Embryos exposed to a hydrazine concentration of 1.0mg/l for 48 hours appeared to have little chance of survival. Surviving embryos showed severe deformities and larvae exhibited reduced growth (Henderson et al, 1981).

Henderson *et al*, (1983) also exposed eggs of rainbow trout *(Salmo gairdneri)* for 48 h, to hydrazine in continuous-flow tests at 11.5 - 12 °C, a pH of 7 - 7.5, and a water hardness of 15 mg calcium carbonate/litre. During exposures up to 5 mg/litre a dose-related increase was observed in the incidence of poorly fitting jaws, pronounced mouth gape, and absence of body movement. However, no effects were observed on mortality, heart beat, hatching rate, or hatching period. Reduced growth and abnormal development of larvae were observed at 1 and 5 mg/litre. Poor muscular development and poor bone growth were observed; the authors postulate that this is a result of calcium binding by hydrazine.

When introduced into seawater, hydrazine concentrations are observed to decrease with time. BEEMS Technical Report TR146 describes the methodology of the deriving decay rates.

The modelling from TR186 shows that although hydrazine will be present in toxic quantities, it is not expected to persist and its likely impact upon organisms associated with the seabed is predicted to be very low. Its main threat is therefore to species in the water column such as fish and plankton. There is no formal quality standard for hydrazine and there is uncertainty regarding the quality of toxicity data that has influenced the low predicted no effect concentration (PNEC) value.

Table 2.6.5S4. *Hydrazine concentrations from proposed discharge waste streams B,C and D at Hinkley Point C.*

Contaminant	**Average Concentration in Effluent (µg/l)**	**Average Concentration in Effluent following dilution in CW flow of 116 m3/s (µg/l)**	**Max Concentration in Effluent (µg/l)**	**Max Concentration in Effluent following dilution in CW flow of 64 m3/s (µg/l)**	**EQS or Target µg/l**	
Hydrazine	51.14 (0.051mg)	0.01 (<0.0001mg)	1333.33 (1.3mg)	0.72 (0.00072mg)	0.0004 as chronic PNEC	0.004 as acute PNEC

[335] Henderson, V., Fisher, J.W., & D'allessandris, R. (1981). Toxic and teratogenic effects of hydrazine on fathead minnow (*Pimephales promelas*) embryos. *Bull. environ. Contam. Toxicol.***,** 26**:** 807-812.
[336] Henderson, V., Fisher, J.W., D'allessandris, R., & Livingston, J.M. (1983) Effects of hydrazine on functional morphology of rainbow trout embryos and larvae. *Trans. Am. Fish. Soc.,* 112**:** 100-104.

Studies by Henderson et al (1981 & 1983) suggest that exposure to hydrazine >0.1 mg/l (0.0001µg/l) could cause defects to fish eggs, and exposure at 1.0-5.0mg/l (0.001µg/l to 0.005µg/l) could cause defects and even mortality to fish embryos. Table 2.6.5S4 shows the hydrazine concentrations from the proposed discharge at HPC, and the figures suggest that even the average concentrations in the effluent have the potential to have an adverse effect on fish eggs and embryos.

Modelling from TR186 conclude that the potentially more sensitive areas both for migratory fish passage and for other species are within the Parrett and the SPA and these areas are relatively unexposed to hydrazine and only for negligible areas above the proposed PNEC. To review such conclusions, the extent of the contaminant plumes for hydrazine has been defined within the estuaries toxic contamination assessment, along with the areas at the sea surface and sea bed where the relevant targets are exceeded; i.e. the size of the mixing zones. The extent of these mixing zones along with the percentages that these areas represent of the Estuaries interest feature are given in Table 2.6.5S5.

Table 2.6.5S5 *Extent of mixing zones for hydrazine along with the percentages that these areas represent of the Estuaries interest feature.*

	Total Extent of Mixing Zone ha	Mixing Zone in the SAC ha	Total Extent of Mixing Zone as a %age of the Estuaries feature	Mixing Zone in the SAC as a %age of the Estuaries feature
Hydrazine Surface	191	161	0.259	0.219
Hydrazine Bed	77	77	0.105	0.105

The percentages of hydrazine compared to the total extent of the mixing zone and SAC estuaries feature do not appear to be significant. However, the potential area of the mixing zone for the maximum concentration of hydrazine in relation to the acute PNEC is potentially significant, and could be more than 10% of the Estuaries feature, which may impact on the fish within the zone. While this is only an estimate of the potential size of the mixing zone for hydrazine, the uncertainty introduced needs to be addressed. This assessment therefore indicates that some form of mitigation to treat or reduce the discharge of hydrazine must be in place prior to any discharges taking place.

Conclusion
We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Required mitigation
Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

b) Non-toxic contamination (Nutrient enrichment, organic loading)

Conservation objectives (see Section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by poor water quality*
- *The abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary is maintained*

Natural England & Countryside Council for Wales, 2009[337]

During the operation of HPC, treated sewage effluent will be discharged into the estuary which will have the potential to increase the nutrient content to a localised area of the estuary. Added to this, both the primary and secondary circuits have the potential to release ammonia, which can lead to elevated levels of nitrates in the water column.

It is possible that changes in nutrient levels may affect the food supply of the lamprey and shad. However, due to the high turbidity of the system and the volumes of water involved, it is thought that any effects would be minimal (NE & CCW, 2009). Furthermore, the turbidity is considered to be such that although concentrations of nutrients within the Estuary could potentially give rise to increased phytoplankton growth, the availability of light is the limiting factor.

Levels of non-toxic contamination released via discharges during the operation of HPC are thought to be minimal and highly diluted, therefore they will not cause an adverse effect on the fish features of the Severn Estuary SAC and Ramsar.

c) Changes to thermal regime

Conservation objectives (see Section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded*
- *the abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary, in particular at the salt wedge, is maintained.*

Natural England & Countryside Council for Wales, 2009[338]

The operational discharge will consist of heated water from the removal of waste heat from the condenser, and the temperature of this water is expected to be discharged at 10 to 12.5˚C above ambient (or intake) temperature, which may have direct and indirect impacts on the Severn Estuary fish. Because of the size and

[337] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[338] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

volume of the Severn Estuary, impacts from thermal discharges are likely to be localised to mixing zones.

For European Marine Sites the thermal threshold of 21.5°C as a 98 percentile and temperature uplift 2 ºC from the 2006 WQTAG 160[339] interim guidelines applies to SACs and SPAs. It is also acknowledged that the Water Framework Directive (WFD) UKTAG[340] standards could also be considered appropriate to be applied to SACs and SPAs with a thermal threshold of 23°C as a 98 percentile and temperature uplift 3 ºC, however this has not yet been formally adopted into EA practice. For the alone assessment these criteria were met by HPC with some very small areas affected in Bridgwater Bay.

Using the WQTAG 160 standards (21.5°C as a 98%ile and ∆2 ºC) the modelling results for HPC running at 100% indicate that 2,452ha of seabed and 2,408ha at the surface (both just over 3%) within the designated SAC will be affected (see Table 2.6.5S6A). The SPA area affected would be 1510 ha of seabed and 1377ha at surface (1%) would be affected by temperatures greater than 21.5°C (see Table 2.6.5S6B) which reflects the largely off-shore nature of the thermal plume (the SPA designation extends down to Medium Low Water (MLW). In respect of uplift temperature (i.e. area of plume at surface and seabed exceeding 3°C as an annual average) less than 0.01% of seabed and surface area for both the SAC and SPA were predicted to be impacted.

Table 2.6.5S6A Extent of thermal plume within the estuaries SAC areas using 2006 WQTAG 160 standards (21.5ºC as 98%ile with ∆T 2ºC) compared with WFD UKTAG standards (23 ºC as 98%ile with ∆T 3ºC). HPC running at 100%

Severn Estuary SAC					
Area		**21.5 ºC as 98%ile**	**∆T 2ºC**	**23 ºC as 98%ile**	**∆T 3ºC**
(ha)	**Surface**	2408	573	38	9
	Bed	2452	528	2	0.4
as a %tage	**Surface**	3.27	0.78	0.05	0.01
	Bed	3.33	0.72	0.00	0.00

Table 2.6.5S6B Extent of thermal plume within the estuaries SPA areas using 2006 WQTAG 160 standards (21.5ºC as 98%ile with ∆T 2ºC) compared with WFD UKTAG standards (23 ºC as 98%ile with ∆T 3ºC). HPC running at 100%

Severn Estuary SPA					
Area		**21.5 ºC as 98%ile**	**∆T 2ºC**	**23 ºC as 98%ile**	**∆T 3ºC**
(ha)	**Surface**	1377	237	0	0
	Bed	1510	307	0	0
As a %tage	**Surface**	5.58	0.96	0.00	0.00
	Bed	6.12	1.24	0.00	0.00

339 Water Quality Technical Advisory Group 160 (WQTAG 160): Guidance on assessing the impact of thermal discharges on European Marine sites. Environment Agency 2006.
340 UK Technical Advisory Group (UK TAG) on the Water Framework Directive (2008). UK Environmental Standards and conditions Phase II (SRI-2007). March 2008.

The potential impacts of a thermal discharge can be classed as direct or indirect impacts. The direct potential temperature impacts of thermal plume discharge fall into four categories[341] :

- The mean temperature in relation to normal temperature (the water is warmer);
- The absolute temperature (as it may approach lethal levels);
- Short-term fluctuations in temperature (particularly tidally-driven); and
- Barriers to fish migration.

The Marine Ecology ES[342] states that the water column of the Severn Estuary is generally well-mixed in terms of temperature and the temperature-stratification of a plume is predicted to vary depending on environmental factors such as temperature of the surrounding water and meteorological conditions. Turbulent conditions (e.g. from storms) will increase heat-loss by mixing with the receiving waters, while high winds will increase heat-loss by radiation to the air. Generally, the heated plume will be less dense and thus more buoyant than the receiving water, and so will rise to the surface and restrict direct contact of the discharge water with the seabed.

Potential impacts on fish assemblages attributable to the discharge of thermal effluent have been comprehensively reviewed by the BEEMS Expert Panel[343]. Some of these may include changes to spawning season, reproductive capacity[344], feeding behaviour changes and recruitment impacts[345]. An increase in temperature may also encourage earlier fish migration upstream. However, if temperature is excessive, it may block migration completely. Possible thermal occlusion of migratory pathways thus remains one of the primary considerations when assessing thermal effluent effects on migratory fish.

In order to carry out an assessment, we first need to understand which fish are likely to be affected by the plume and then look at the temperature requirements of the various fish to identify their sensitivities.

Migratory fish

Fish are generally more sensitive to impacts such as temperature during the embryonic and juvenile life stage and during spawning and hatching. All of the designated migratory fish, with the exception of eel, are anadromous meaning that they live their adult lives in estuarine and marine waters and move to freshwater when they spawn. Eels being catadromous means they do the reverse and spawn in the marine environment. This means that temperature effects around Hinkley Point C will be greatly associated to those fish migrating near to the power station and specifically those migrating up and down the River Parrett.

EA local fisheries experts have confirmed that only eel and salmon are known to use the River Parrett for migrating to and from spawning grounds. Salmon migrate up the Parrett and spawn in the River Tone and tributaries whilst eel move upstream into the many tributaries of the Parrett to return to their home grounds. Sea trout however,

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341 Bamber, R. N. (1995). The influence of rising background temperature on the effects of marine thermal effluents. J. Therm. Biol. Vol. 20. No. 1/2. p. 105 – 110.

342 Marine Ecology Environmental Statement (ES) Vol.2 Chap.19. Section 19.3.16 Pg.32) supplied by EDF

343 BEEMS SAR 008. Thermal standards for cooling water from new build nuclear power stations. EDF BEEMS Scientific Advisory Report No. 008, Expert Panel, March 2011

344 Lukšiene, D., Sandström, O., Lounasheimo, L. and Andersson, J., 2000. The effects of thermal effluent exposure on the gametogenesis of female fish. J. Fish. Biol. Vol. 56 pp. 37 ‐ 50.

345 Marine Ecology ES Volume 2 Chapter 19. (Pg. 100). EDF

have been known to favour the West Somerset streams rather than the River Parrett so although they are not migrating up the Parrett it is likely that they will be within the vicinity of Bridgwater Bay. Equally, river and sea lamprey and potentially shad are thought to be present around the Bridgwater Bay area on their way to spawning grounds further up the Severn.

In summary all the migratory fish could be exposed to elevated temperatures and thermal occlusion.

Table 2.6.5S7. Migratory movements of diadromous species found within the Severn Estuary, showing important months and directions of movement (arrows show upstream or downstream movement and hatched lines show peak migration times).

Species		*JAN*	*FEB*	*MAR*	*APR*	*MAY*	*JUN*	*JUL*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
Salmon	↑												
Salmon smolt (juvenile)	↓												
Sea trout	↑												
Sea trout smolt (juvenile)	↓												
Shad	↑												
Shad (juvenile)	↓												
Sea Lamprey	↑												
S. Lamprey (juvenile)	↓												
River Lamprey	↑												
R. Lamprey (juvenile)	↓												
Elvers (juvenile eel)	↑												
Eel	↓												

Lamprey

The Severn Estuary is used as a migratory corridor for both river and sea lamprey, which head towards the various rivers to spawn. The River Severn is considered to be one of the most important rivers for both species of lamprey, where the lamprey spawn in gravelly sections of the river (Bird, 2008)[346]. Both species are also present in the Rivers Usk and Wye where they are designated under the Usk and Wye River SAC designations. As neither river or sea lamprey are known to spawn in the Parrett or rivers around West Somerset then it is unlikely that juveniles (transformers) will be present in or around Bridgwater Bay and eggs and ammocoetes (young elongate larvae) will be limited to the freshwater environments.

River lamprey begin to migrate through the estuary as early as August and spawn in British rivers when the water temperature reaches 10–11ºC, usually in March and April (Morris & Maitland 1987)[347] which is often the following year. Mature adult sea lampreys enter the estuaries of many North Atlantic rivers from April onwards (see Table 2.6.5S7), and the upstream migration from the estuary appears to be triggered by temperature. The sea lamprey usually spawns in late May or June in British rivers,

[346] Bird, D.J. (2008) The Biology and Conservation of the fish assemblage of the Severn Estuary (cSAC), Countryside Council for Wales.

[347] Morris, K.H. & Maitland, P.S. (1987). A trap for catching adult lampreys (*Petromyzonidae*) in running water. *J. Fish Biol.*, 31, 513-516.

when the water temperature reaches at least 15ºC[348]. The thermal niche proposed for sea lamprey by Holmes & Lin (1994) [349] is 17.8–21.8ºC.

Although both lamprey may use Bridgwater Bay as a resting place on their migration up through the estuary, we would not foresee that small scale temperature changes around the bay will interfere with their migration. At worst it may make them move on from Bridgwater Bay up through the estuary where temperatures will fall back to ambient and normal behaviour will resume. We can therefore conclude that lamprey will not be adversely affected by any potential thermal impacts from HPC.

Shad

Like lamprey, the shad use the Severn Estuary as a migratory corridor and head towards the River Severn, which is one of only four rivers in the UK known to support spawning twaite shad[350]. The upstream migration from the estuary appears to be triggered by temperature. Claridge & Gardner (1978)[351] found that twaite shad migration started when the water reached 12ºC, and Aprahamian (1982)[352] confirmed that peak migratory activity occurred at temperatures of 10–14ºC. Aprahamian & Aprahamian (2001)[353] found a strong positive correlation between year-class strength and water temperature in the Severn, where water temperature is strongly correlated with discharge.

Aprahamian *et al*. (1998)[354] found that mean July temperature explained the greatest proportion (67.1%) of the variance in 0+ twaite shad year-class strength from the Severn Estuary, followed by August (50.9%) and June (30.9%). Claridge & Gardner (1978) attributed the highly successful spawning of twaite shad in 1975 and 1976 to exceptionally high temperatures, which may have encouraged spawning activity and enhanced subsequent larval survival and growth. Part of this variation can be associated with variation in temperature; for example, Holmes & Henderson (1990)[355] reported that good recruitment was associated with warm years. There seems every possibility that an increase in seawater temperatures would make British waters more favourable (Henderson 2003*).*

We can therefore conclude that there will be no adverse effect on shad by an increase in temperature around Bridgwater Bay and to some respects it appears it could prove to be favourable for the species.

The allis shad is a very similar species to the twaite shad and so will have no adverse effect.

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348 Ecology of the River, Brook and Sea Lamprey. Ecology Life Series 2000.

349 Holmes JA & Lin P (1994).Thermal niche of larval sea lamprey, *Petromyzon marinus*. *Canadian Journal of Fisheries and Aquatic Sciences* 51, 253–262.

350 Twaite and Allis Shad Species Action Plan, Worcestershire Biodiversity Partnership, 2007.

351 Claridge PN & Gardner DC (1978). Growth and movements of the twaite shad *Alosa fallax* (Lacépède) in the Severn Estuary. *Journal of Fish Biology* 12, 203–211.

352 Aprahamian, M.W. (1982) Aspects of the biology of the twaite shad (*Alosa fallax*) in the rivers Severn and Wye. Ph.D Thesis, Liverpool, 381p.

353 Aprahamian, M.W and Aprahamian, C.D. (2001) The influence of water temperature and flow on year class strength of twaite shad (*Alosa fallax*) from the River Severn, England. Bulletin François de la Peche et de la Peisciculture, 362/363, 953-972.

354 Aprahamian, M.W, and Lester, S.M (1998). *Shad conservation in England and Wales*. Environment Agency Technical Report W110, 1–124.

355 Holmes RHA and Henderson PA (1990). High fish recruitment in the Severn Estuary: the effect of a warm year. Journal of Fish Biology 36, 961–963.

Eel
All estuaries have an important function for eels but the Severn and the Parrett are of particular significance, with the Severn supporting 95% of the UK elver run. A 30 year study of the estuarine population of yellow eel, *Anguilla Anguilla*, abundance in Bridgwater Bay, Somerset, shows that the population number has collapsed since the 1980s, with the decline averaging 15% per year (Henderson, 2011)[356]. The reasons for the decline are unidentified.

A wide range of factors have been reported as influencing successful anguillid eel recruitment, defined as the colonization of estuarine and freshwater habitats by glass eels and elvers, and these include selective tidal stream transport (Edeline *et al.*, 2007)[357], and water temperature (August & Hicks, 2008) [358].

White & Knights (1997a[359] b[360]) discussed temperature and upstream migration in *A. anguilla* elver activity from multiple locations in the Rivers Severn and Avon. The analyses carried out showed that water temperature is the most important single factor affecting the upstream migration of elvers and that water temperatures in excess of 10-11°C appeared to be the major factor determining the initiation of elver migration in May and its cessation in September. They also noted that a threshold temperature of 14–16 ºC is the most statistically robust predictor of elver migration in the upper (mainly fresh water) parts of estuaries and lower non-tidal rivers. Evidence also suggests an upper temperature limit may exist where migration is inhibited. August & Hicks, (2008), concluded that this limit was 22°C.

The sea temperature of Bridgwater Bay and the River Parrett Estuary has been known to range naturally from 2 – 23 ºC[361]. Glass eel and elver migration takes place from mid February to July which means that despite there being a temperature threshold for peak migration, migration could take place from >10ºC up to 20ºC, but rarely below 10-11ºC (White & Knights 1997b). It seems suggestive that different zones within an estuary (and the different anguillid eel stages that colonize these zones) might be viewed as separate units to accurately capture the complicated dynamics of (condition-mediated) lower estuary settlement (Edeline *et al.*, 2006)[362] and (temperature-mediated) up-river migration (White & Knights, 1997*b*).

Under a scenario of increased temperatures around Bridgwater Bay, glass eels and elvers may experience earlier upstream migration windows, which may be at odds with lower condition of the individuals. However, since the heated plume is less dense and thus more buoyant than the receiving water, it likely to rise to the surface and avoid creating a curtain of warm water. The maximum temperature uplift that the

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356 Henderson, P.A., Plenty, S.J., Newton, L, C., and Bird, D.J. (2011). Evidence for a population collapse of European eel (*Anguilla anguilla*) in the Bristol Channel. Pisces Conservation Ltd. Journal of the Marine Biological Association of the UK.
357 Edeline, E., Beaulaton, L., Le Barh, R. & Elie, P. (2007). Dispersal in metamorphosing juvenile eel *Anguilla anguilla*. Marine Ecology Progress series. 344; 213-218.
358 August, S. M. & Hicks, B. J. (2008). Water temperature and upstream migration of glass eels in New Zealand: implications of climate change. *Environmental Biology of Fishes* 81, 195–205.
359 White, E. M. & Knights, B. (1997*a*). Dynamics of upstream migration of the European eel, *Anguilla anguilla* (L.), in the Rivers Severn and Avon, England, with special reference to the effects of man-made barriers. *Fisheries Management and Ecology* **4,** 311–324.
360 White, E. M. & Knights, B. (1997*b*). Environmental factors affecting migration of the European eel in the Rivers Severn and Avon, England. *Journal of Fish Biology* **50,** 1104–1116.
361 Langston, W. J., Chesman, B. S., Burt G. R., Hawkins, S. J., Readman, J. and Worsfold, P., 2003. Characterisation of the south-west marine sites: The Severn Estuary pSAC, SPA. Marine Biological Association of the United Kingdom (13) 205p.
362 Edeline, E., Lambert, P., Rigaud, C., Elie, P. (2007). Effects of body condition and water temperature on *Anguilla Anguilla* glass eel migratory behaviour. Journal of experimental Marine Biology and Ecology. 331; 217-225.

elvers/eels in Bridgwater Bay are likely to be exposed to from the plume is 2.5 ºC (unless they happen to pass through the small discharge outfall hotspot where temperatures will be around 3ºC above ambient), so glass eels and elvers are unlikely to experience such a contrast in temperature across the bay, and as such we do not foresee any direct impacts from the temperature increases. Nevertheless, the extent of the plume is likely to depend on environmental factors such as meteorological and turbulent conditions and whilst such conditions are generally likely to create further mixing in the estuary, thermal dilution may be inadequate if a particular tidal direction/ or tide size caused the plume to steer East and inland towards the mouth of the Parrett. This area is particularly important for glass eels and elvers as this interface where the seawater and fresh water mix is a trigger area for the species.

However, in terms of directly affecting the eels within the Bridgwater Bay area, the thermal plume from the cooling water discharge at the proposed HPC will not cause an adverse effect on the eel population designated under the Ramsar feature. Any impacts to the up-stream or down-stream migration of eels will be covered in the barriers to migratory fish assessment below.

Downstream migration of silver eels

Most of the knowledge on the timing and dynamics of downstream migration comes from the commercial fishing industry. Downstream runs of European silver eels typically start in the autumn and may last until early spring. The effect of temperature is not clear and the range of temperatures during which migration takes place is extremely variable according to different studies[363]. Overall, downstream runs occur when the temperature decreases. The data ranged from -3 ºC to 21 ºC in various studies in France, Norway and Spain.

This data show that the temperature range at which eels migrate is fairly wide and it is not possible (and maybe not relevant) to set a threshold. It is probable that temperature acts more on the physiology of eels (i.e. silvering), than on migratory movements. Furthermore, larger eels are thought to be less sensitive to temperature changes so an increase in temperature around Bridgwater Bay is unlikely to impact on downstream migration of silver eels.

We can therefore conclude that there will be no adverse effect on silver eels by temperature increases from the proposed HPC cooling water discharge.

Salmonids

Salmon and trout are anadromous cold-water fish species, spending a great deal of their lifecycle in the marine environment, returning to freshwater to spawn. Salmon are known to migrate up the River Parrett to the River Tone and tributaries to spawn, whilst trout have a preference for the West Somerset rivers. Both salmonids are therefore likely to be present in and around Bridgwater Bay. Salmon are sensitive to poor oxygen and high temperature conditions (Alabaster *et al*, 1991) and reduced adult returns around the UK are thought to be a consequence of such conditions.

Many of the lethal and non-lethal effects of temperature on salmonids are well understood and in many cases have been quantitatively established with both lethal and sub-lethal effects of temperature depending on magnitude in relation to duration

[363] Maarten C.M. Bruijs and Caroline M.F. Durif. (2009). Silver Eel Migration and Behaviour. EEL BOOK Chapter 4.

of exposure[364]. Most of the lethal effects are related to freshwater environments where optimum temperatures range from 14-20˚C for adults (min 8˚C, max. 23˚C) and lethal effects at 27.8˚C[365].

As both salmon and trout spawn in freshwaters, the eggs and juvenile stages are not likely to be exposed to any changes in temperature from the thermal discharge around Hinkley Point, and adults are expected to move away from the the outfall where temperatures could prove to be uncomfortable for the species. We can therefore conclude that the thermal plume from the cooling water discharge will not have an adverse effect on salmon or sea trout populations designated under the Ramsar feature.

Barriers to migratory fish

Turnpenny *et al* (2007)[366] states that blockage by thermal plumes appears to be an intuitive rather than observed concept. The reasoning is thought to be because salmonids (one of the main migratory species of interest) are cold-water stenotherms and therefore avoid warm water. In fact, fish tracking studies carried out in rivers and estuaries in the UK and elsewhere in the world do not provide any clear evidence of thermal barriers (Langford, 1990)[367] and where evidence suggests possible effects it has been confounded by other issues such as changes in - or absolute levels - of freshwater discharge and the levels of dissolved oxygen (Turnpenny, 2007).

However, young fish undertake migrations in transitional waters by hitching a ride on the tide whilst sitting out the reverse tide on the estuary bed. This phenomenon is known as 'selective tidal stream transport' (STST) and it is seen regularly during the summer months when a 'ribbon' of small fish such as dace (*Leuciscus leuciscus*), flounder (*Platichthys flesus*), elvers (*Anguilla anguilla*) and smelt (*Osmerus eperlanus*) occupies the shallow water margins of the channel (Turnpenny *et al*, 2007). Their movements through the estuary may be for a migratory purpose or simply for dispersal, but for whatever purpose, it has raised questions about whether intrusion of the plume into shallow marginal areas might cause a barrier to juvenile migrations.

To resolve this, Turnpenny has come up with the following key points to consider when assessing thermal plumes: It is necessary to show either (a) that the plume does not impinge on the intertidal foreshore or (b) that the temperature rise is not sufficient to cause a barrier or (c) that there are sufficient remaining migration paths or temporal windows of opportunity to ensure that the fish can pass.

The EDF report to support the HRA assessment (Haskoning, 2011)[368] also uses a standard proposed by Turnpenny and Liney (2006)[369] which requires that estuaries should not be subject to temperature increase of >2°C across >25% of a cross section for >5% of the time. A detailed description of the history of how these

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[364] Sullivan, K., Martin, D.J., Cardwell, D.E., Toll, J.E., Duke, S. (2000). An analysis of the effects of temperature on salmonids of the pacific northwest with implications for selecting temperature criteria. Sustainable Ecosystems Institute.

[365] Alabaster, J.S. and Lloyd, R. (1980) Water Quality Criteria for Freshwater Fish. Butterworths, London.

[366] Turnpenny, A.W.H, and Liney, K.E (2007). Review and development of temperature standards for marine and freshwater environments. Jacobs Report: 21960.

[367] Langford, T.E.L. (1990). Ecological effects of thermal discharges. Elsevier Applied Sciences, London

[368] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Section 6.2.328-9. Report prepared for EDF.

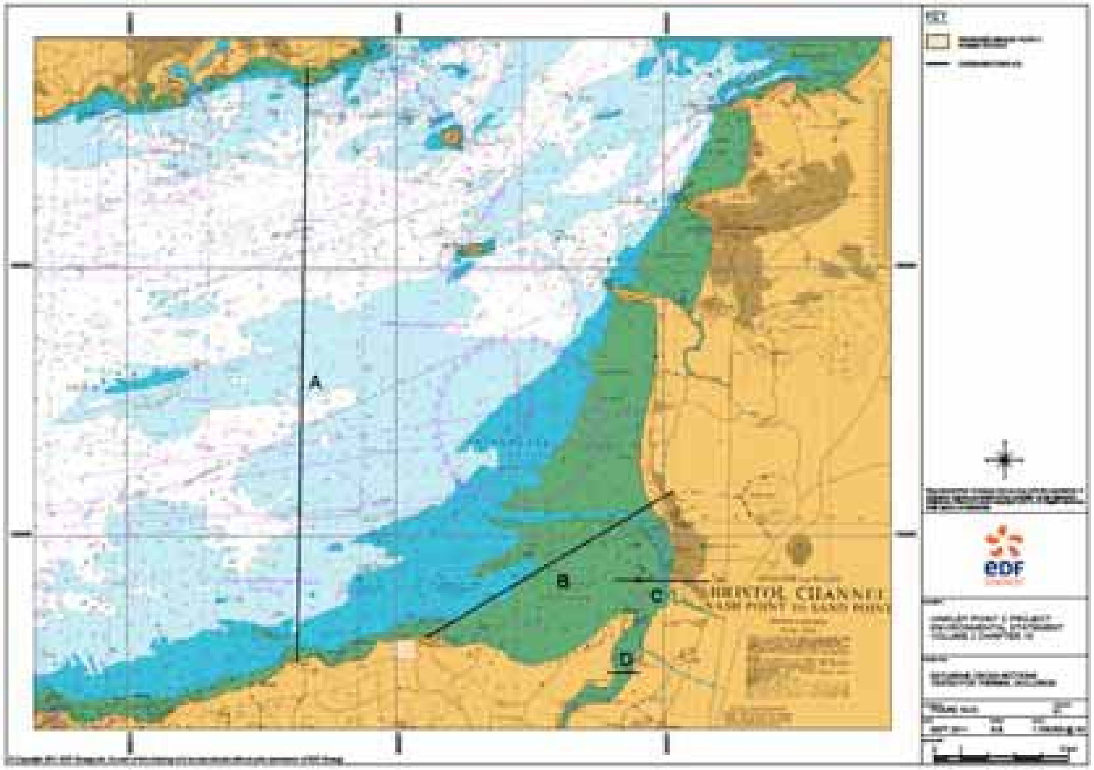
[369] Turnpenny, A.W.H & Liney, K.E. (2006). Review and development of temperature standards for marine and freshwater environments. Jacobs Engineering Consultancy Report No. 21960.

standards have been determined and their subsequent application to Transitional and Coastal (TraC) waters is provided in BEEMS T186[370].

Four sections of the estuary were considered (see Figure 2.6.5S8)

Section A) From Lilstock, Somerset to Sully in the Vale of Glamorgan, Wales, covering any migration through the width of the estuary.
Section B) From Hinkley to Berrow, Burnham, covering migration through Bridgwater Bay.
Section C) Across the mouth of the River Parrett within Bridgwater Bay.
Section D) Across the Parrett Estuary.

Figure 2.6.5S8. *Estuarine cross sections tested for thermal occlusion (Haskoning, 2011)*



At all four locations, it was calculated that the criterion of not more than 2°C difference across 25% of the cross section would be met by discharging 100% cooling water from Hinkley Point C alone. It should be noted however that the estuary is highly dynamic and the extent of the plume is likely to depend on environmental factors such as meteorological and turbulent conditions which may out-weigh such statistics during certain key migratory periods. For example, if a particular tidal direction/ or tide size caused the plume to steer East and inland towards the mouth of the Parrett. This area is particularly important for glass eels and elvers as this interface where the sea water and fresh water mix is a trigger area for the species.

BEEMS Technical Report 121 (TR121)[371] considered a number of meteorological conditions, as identified by Cefas (full details on the justification for these scenarios is provided in BEEMS Technical Report TR187). A total of 3 meteorological scenarios,

[370] BEEMS. Technical Report 186: Predicted Effects of NNB on Water Quality at Hinkley Point. April 2011.
[371] BEEMS Technical Report 121 (TR121) Thermal Plume Dispersion at Hinkley Point in the Severn Estuary: Stage 3 - Additional Modelling Results (January 2011) R\3987 13 R.1758. Produced for EDF.

were considered to investigate how the plume is likely to evolve under both present and possible future climate conditions. The scenarios included a heat wave scenario (M1) and a scenario of westerly winds (M6) and also a scenario of HPC in combination with HPB (M7), which will be considered within Section 6. The scenarios were chosen to consider a worst case with respect to either recirculation or plume impact on sensitive inter-tidal areas and potential for occlusion. All meteorological scenarios were undertaken in 3D, with a time varying discharge rate, temperature and momentum applied at the outfall sites and with the westerly wind driving both the heat exchange and the hydrodynamics.

TR121 states that for scenario M1 surface excess temperatures were elevated in the plume due to the reduced heat exchange associated with the low winds. The reduced heat loss increased plume temperatures and resulted in higher percentage areas of cross sections exceeding a 2ºC rise. Highest percentage areas exceeding a 2ºC rise occurred at low water on neap tides across Section A (0.73%) and at high water on neap tides across Section B (0.97%). In addition, the plume was more buoyant than under mean summertime conditions due to the reduced river flow and warmer background temperature.

The application of winds in scenario M6 increased both the loss of heat to the atmosphere and the mixing of the plume through the water column, reducing the maximum excess temperatures and the stratification across Section B. However, the plume was driven into the shallow inter-tidal area to the east of the outfall, increasing excess temperatures in potentially sensitive areas. The reduced background temperature applied for scenario M6 yielded a lower heat exchange coefficient per degree of excess temperature than considered for summertime conditions, resulting in more of the excess temperature being retained by the water column. This explained the higher excess plume temperatures in Scenario M6, compared to the plume temperatures for mean summertime conditions.

Both meteorological scenarios for Hinkley Point C alone indicated that in general, excess temperatures are less than 2ºC throughout both spring and neap tides across defined sections of the Severn and the Parrett and that there is no risk of thermal occlusion.

However, regardless of these scenarios, we do know that glass eels are currently migrating up through the Parrett in large numbers, due to work carried out by the Environment Agency (EA). The EA work has involved building a series of 'eel passes' at Oath Lock and King Sedgemoor's Drain on the River Parrett to enable the eels to swim upstream. To help monitor the eel's progress, a micro-camera has been installed to count the numbers of eels migrating up and down the Parrett, and so far the passes have helped hundreds of thousands each year.

Furthermore, electric fishing surveys carried out by the Environment Agency on the River Parrett suggest that there has been no decline in eel density and a much less pronounced increase in length with increasing distance from the tidal limit. This may be because the population is now very low, although there is no evidence to support this; or the surveys in the lower reaches of the river are very inefficient, due to habitat factors such as river depth compared to the other rivers (DEFRA, 2010)[372].

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[372] Eel Management Plans for the United Kingdom – South West River Basin District. March 2010. DEFRA.

Smolt downstream migration along the River Parrett and into the estuary occurs from spring to early summer. The intensity and timing of Atlantic salmon smolt migrations have been correlated with a variety of environmental factors, including water temperature, light intensity, river flow and turbidity[373]. On entry to sea there is a rapid reversal of the osmotic and ionic gradients, resulting in an increased water loss and a gain in ions across the gills (osmotic shock) (Aas *et al,* 2011)[374]. A temperature-dependant response has been reported both for acute hyper-osmotic shock and the longer stabilisation period associated with seawater acclimation. (Aas *et al,* 2011). The migration of smolts through estuaries occurs mainly at night, and on the ebb tides, with smolts swimming close to the surface, which is often the fastest moving section of the water column. (Lacriox *et al*, 2007)[375].

Duston *et al* (1991)[376] give optimum smolt migration temperatures at between 7 – 14.3˚C with a minimum of 5˚C and a maximum of 19˚C. These are likely to be effective within freshwater environments, with a higher temperature range for marine environments.

Although smolt could be subject to slightly higher temperatures once they reach the estuary around Bridgwater Bay, particularly if they are swimming close to the surface, the temperature difference (+1-2.5˚C) is likely to be minimal, with sufficient remaining migratory paths of cooler temperatures around the bay to ensure fish can pass. Again, smolts can avoid any areas of lethal temperature exposure.

Furthermore, we have evidence that the salmon population on the River Tone has substantially increased in the last decade, despite the presence of HPB and this has been linked to water quality improvements in this period of time.

On this evidence it is clear that eels and salmon are moving up and down the Parrett to and from the Estuary, so a thermal barrier is not likely to currently exist with Hinkley Point B. With the criterion calculated above that the River Parrett and Parrett Estuary will not have more than 2°C difference across 25% of the cross section by discharging 100% cooling water from Hinkley Point C alone, then we agree that the thermal plume from HPC alone will not have an adverse effect on migratory fish passage.

Fish assemblage

The species most vulnerable to anthropogenic and environmental factors, such as temperature changes that could affect the habitat and ecology of the estuary include those species that rely on the estuary for some aspect of their life-cycle (see Table 2.6.3S7). The potential impacts on fish assemblages attributable to the discharge of thermal effluent have been comprehensively reviewed by the BEEMS Expert Panel[377]. These may include changes to spawning season, reproductive capacity, feeding behaviour changes and recruitment impacts.

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[373] Riley, W.D. (2007) Seasonal downstream movements of juvenile Atlantic salmon, *Salmo salar* L., with evidence of solitary migration of smolts. *Aquaculture*, *Volume 273, Issues 2-3*, *18. Pages 194-199*.

[374]Aas, A., Klemetsen, A. Einum, S. Skurdal, J. (2011). Atlantic Salmon Ecology Aas John Wiley & Sons. Nature

[375] Lacroix G. L., Knox D., McCurdy P.(2004).Effects of implanted dummy acoustic transmitters on juvenile Atlantic salmon. Transactions of the American Fisheries Society 2004;133:211-220.

[376] Duston, J. R.L. Saunders and D.E. Knox. 1991. Effects of increases of freshwater temperatures on loss of smolt characteristics in Atlantic salmon. Can. J. Fish. Aquatic. Science. 48:164-169.

[377] BEEMS SAR 008. Thermal standards for cooling water from new build nuclear power stations. EDF BEEMS Scientific Advisory Report No. 008, Expert Panel, March 2011.

The Marine ecology ES[378] states that responses of fish to changes in temperature have been extensively studied in the past, particularly in relation to commercially important species and protected species and in relation to community changes in response to regional climate change[379] (Genner *et al*, 2004) [380]. Egg and embryonic life stages may be most at risk from increases in temperature and the significance of this risk will depend in a large part upon their relative abundance within the area and the significance of these larval stages in terms of recruitment, as well as the degree to which they are actually exposed. Young juvenile fish may also be at risk.

Ichthyoplankton studies carried out in BEEMS Technical reports 83[381] and 83a[382] suggest that local fish egg and larval abundances are chronically low. However, Bridgwater Bay is considered to be an important nursery area for juvenile fish and a number of fish species utilise the inter-tidal areas. The fringing saltmarsh is of particular significance and it provides a feeding, refuge and nursery area for fish life (Colclough *et al*, 2004)[383], with fish populations moving into the high inter-tidal and saltmarsh areas during flood tides returning to deeper water on the ebb (Lyndon *et al*, 2002)[384]. However, few species are able to complete their life cycles solely in estuarine systems (Potter et al, 2001)[385], with many species moving into the outer Bristol channel to spawn. For some species, temperature is a trigger for these movements between the different zones within the estuary. Data from Hinkley Point, have shown that the abundance of juvenile sole in Bridgwater Bay is positively correlated with the seawater temperature in April and May, the time when young fish are migrating back inshore (Henderson & Holmes 1991)[386], so any changes in temperature could also impact on these movements.

According to Table 2.6.5S1 there are many species in the fish assemblage that could be affected by the thermal plume, but it is agreed that the overall effect is difficult to quantify due to the varying species within the assemblage. In British waters no species would tolerate temperatures as high as 40 °C, although eel can survive to 38 °C and some freshwater cyprinids can tolerate temperatures in the high-thirties (Langford, 1990)[387]. Since bulk temperatures (i.e. outside any thermal plume) in Britain are unlikely to exceed around 25 °C outside the mixing zone of thermal discharges, it is unlikely that fish kills would occur due to temperature alone (Turnpenny, 2007)[388]. Even within thermal plumes, where temperatures can reach +10-14 °C above background (which might reach ≥22 °C in an estuary during a warm

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[378] Marine Ecology ES Volume 2 Chapter 19. (Section 19.6.150 Pg. 100). EDF

[379] BEEMS SAR 008. Thermal standards for cooling water from new build nuclear power stations. EDF BEEMS Scientific Advisory Report No. 008, Expert Panel, March 2011.

[380] Genner, M. J., Sims, D. W., Wearmouth, V. J., Southall, E. J., Southward, A. J., Henderson, P. A. and Hawkins, S. J., (2004). Regional climatic warming drives long-term community changes of British marine fish. Proceedings of the Royal Society of London B 271:pp. 655–661.

[381] BEEMS TR083 (Edition 3). Hinkley Point nearshore communities: Results of the 2 m beam trawl and plankton surveys 2008 – 2010. EDF BEEMS (Cefas) Technical Report No. 083, November 2010.

[382] BEEMS TR083a. Hinkley Point nearshore communities: plankton surveys 2010. EDF BEEMS (Cefas) Technical Report No. 083a, November 2010.

[383] Colclough, S. Fonseca, L. Astley, T. Thomas, K & Watts, W. (2005). Fish utilisation of managed realignments. Fisheries Management and Ecology, 12, 351-360.

[384] Lyndon, A.R., Bryson, J.G., Holding, N. & Moore, C.G. (2002) Feeding relationships of fish using inter-tidal habitats in the Forth Estuary, eastern Scotland. Journal of Fish Biology 61. (Suppl. A) 78-80.

[385] Potter, I.C, Bird, D.J., Claridge, P.N., Clarke, K.R., Hyndes, G.A., Newton, L.C. (2001) Fish fauna of the Severn Estuary. Are there long-term changes in abundance and species composition and are the recruitment patterns of the main species correlated? Jour. Exp. Mar. Bio. & Ecol. 258; 15-37.

[386] Henderson, P.A. & Holmes, R.H.A. (1991) On the population-dynamics of dab, sole and flounder within Bridgwater Bay in the Lower Severn Estuary, England. *Netherlands Journal of Sea Research*, 27, 337-344.

[387] Langford, T.E.L. (1990). Ecological effects of thermal discharges. Elsevier Applied Sciences, London.

[388] Turnpenny, A.W.H, and Liney, K.E (2007). Review and development of temperature standards for marine and freshwater environments. Jacobs Report: 21960.

summer), Langford's (1990) review, 'Ecological Effects of Thermal Discharges', concludes that 'in view of the vast amount of literature dealing with thermal discharges, very few large-scale mortalities have occurred which can unequivocally be related to high temperature'.

It is indeed obvious that fish have the capacity to move in and out of the thermal plume and thus we would agree that no direct mortality would be expected.

A study by Potter et al (2001)[389] looked at whether large sets of correlations between patterns of recruitment in the estuary amongst abundant marine species (internal correlations), and between those patterns and salinity and water temperature within the estuary (cross-correlations), were significant. The correlation profile analysis found no evidence that annual recruitment strengths of these species were either inter-correlated, or correlated with either one or a combination of both environmental variables, so recruitment times could not be linked to salinity nor water temperature within the estuary, nor a combination of the two variables.

However, Analysis of the 28-year time series of monthly samples collected at Hinkley Point has shown that the fish community of Bridgwater Bay is responding rapidly to changes in seawater temperature, salinity and the North Atlantic Oscillation (NAO) (Henderson, 2007)[390]. Total fish species richness and abundance have increased smoothly with rising temperature and declining salinity.

There are clear indications that the fish of the estuary are responding to global changes in sea temperature. A further 2 ˚C increase in inshore seawater temperature has been predicted by Henderson (2007) to increase total species richness of fish in Bridgwater Bay by 10%, although most of this gain will be due to warm water tourists, who have expanded their range from a warmer climate.

Some species, such as the sea snail *Liparis liparis*, has been shown to decline in abundance with increasing water temperature (Henderson and Seaby, 1999)[391]. However, they have not become locally extinct because they are able to retreat into deeper or offshore cooler waters when temperatures become unacceptable (Henderson & Bird, 2010)[392].

It is known that certain species, such as sea bass, congregate near thermal plumes, suggesting that the presence of the thermal plume may be beneficial for this species. Increased temperature may also be beneficial for other Lusitanian (warmer-water) species present in the Inner Bristol Channel, but potentially of some detriment for species nearer the southern extent of their range (Arctic-Boreal or coldwater species) e.g. cod[393], especially with the added pressure of more severe global warming scenarios.

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[389] Potter, I.C, Bird, D.J., Claridge, P.N., Clarke, K.R., Hyndes, G.A., Newton, L.C. (2001) Fish fauna of the Severn Estuary. Are there long-term changes in abundance and species composition and are the recruitment patterns of the main species correlated? Jour. Exp. Mar. Bio. & Ecol. 258; 15-37.

[390] Henderson, P.A., 2007. Discrete and continuous change in the fish community of the Bristol Channel in response to climate change. Journal of the Marine Biological Association of the United Kingdom 87, 589–598.

[391] Henderson, P.A., Seaby, R.M., 1999. Population stability of the sea snail at the southern edge of its range. Journal of Fish Biology 54, 1161–1176.

[392] Henderson, P.A, and Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61; 100-114.

[393] BEEMS SAR 008. Thermal standards for cooling water from new build nuclear power stations. EDF BEEMS Scientific Advisory Report No. 008, Expert Panel, March 2011.

It is also understood that there are likely to be small-scale changes in the composition of the epibenthic fish assemblage within the footprint of the thermal plume, however, the coldwater species will avoid such hotspots, provided that the plume does not pervade the full channel width and depth (see barriers to migratory fish assessment). Many fish avoid warm inshore waters during the warmest summers and generally, summer months with temperatures >20˚C have the lowest fish abundance and species richness (Henderson & Bird, 2010). Furthermore, there is no evidence to suggest that the current HPB is impacting on the fish populations, and HPC will be of similar impact.

Considering the points above, it is agreed that whilst it is possible that some small-scale changes to the fish fauna within the footprint of the plume may occur, it is apparent that no large-scale changes in the fish assemblage would occur as a result of the predicted temperature change, so overall the fish assemblage would retain its existing composition.

We can therefore conclude that the thermal discharge will not have an adverse effect on the migratory fish and the fish assemblage of the Severn Estuary SAC and Ramsar.

Other temperature related impacts

Changes in salinity

A survey undertaken in 2009 for the Severn Estuary area to inform the Environmental Appraisal indicated salinity concentrations were within a normal range for coastal waters. There was also no evidence of stratification of dissolved oxygen from in-situ measurements throughout the depth of the water column at each sampling location (Haskoning, 2011). The only fish species likely to be indirectly affected by changes in salinity is the twaite shad. Within the estuary, juvenile twaite shad prey on mysids feeding at the salt wedge near the head of the tide. An increase in temperature could increase the salinity regime of the estuary and in turn affect the distribution of these prey species, which may have consequences for the juvenile shad species (NE & CCW, 2009)[394] in that they may not find enough food resources during a vital growing period.

However, the loss of water vapour from the thermal plume, which could increase the salinity within the estuary, will be insignificant and will not cause an adverse effect on the integrity of the site.

Increased toxicity

In general, the toxicity of contaminants in fish tends to increase with increasing temperature; *e.g.* zinc (Zitko & Carson 1977)[395] mainly as a result of a concomitant increase in metabolism that occurs in poikilotherms (cold-blooded animals)[396].

Toxic contaminants have been discussed within the previous section (a), and with exception of hydrazine and the resultant ammonia, toxic contaminants are unlikely to be at levels high enough to cause concern, even with an added 1-3°C. It has been

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394 Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regualtions 9, as amended. Severn Estuary/Mor Hafren European Marine Site. June 2009.

395 Zitko V. & Carson W.G. (1977) Seasonal and developmental variation in the lethality of zinc to juvenile Atlantic salmon (*Salmo salar*). *Journal of Fish Research Board, Canada* **34,** 139-141.

396 Bird, D.J. (2002) Environmental Factors Affecting Migratory Fish in the Severn Estuary – with particular reference to species of shad and lamprey. Report for the Environment Agency Wales. Severn Estuary Research Group. U.W.E. Bristol.

estimated that 2ha (0.003%) at seabed and 38ha (0.05%) at surface of the SAC would be affected by temperatures greater than 23°C, so only during a very hot summer or heat wave, will the temperatures go beyond the natural temperature range for the estuary and this will be over a small area of the estuary.

Increases in water temperature were found to enhance the toxicity of hydrazine for bluegills (Hunt *et al*, 1981)[397], so it is likely that hydrazine will enhance in toxicity for many fish species around the area of the thermal plume. In the previous toxic contamination assessment the potential area of the mixing zone for the maximum concentration of hydrazine in relation to the acute PNEC was assessed as being potentially significant, and could be more than 10% of the Estuaries feature, which may impact on the fish within the zone. It has therefore been recommended that some form of treatment to reduce the discharge of hydrazine must be in place prior to any discharges taking place.

Hydrazine breaks down rapidly into nitrogen and water storing it prior to discharge, discharge concentrations can be significantly reduced. Breakdown may also be enhanced by thermal degradation which also produce ammonia as a breakdown product. The equilibrium between ammonia and un-ionised ammonia is particularly sensitive to pH values around neutral: whereas a temperature increase of 10°C (from 10°C to 20°C) doubles the proportion of un-ionised ammonia, a pH increase from seven to eight produces an approximately tenfold increase (TR186)[398].

This is of potential concern due to the concentrations of ammonia naturally existing in seawater and by using seawater in the quantities proposed and discharging at the increased temperature, there are concerns that the natural equilibrium of ammonia to un-ionised ammonia would be affected thus increasing concentrations of the toxic form (Haskoning, 2011)[399], which could have implications for fish.

The maximum resulting un-ionised ammonia concentration contour was calculated to be 11.2µg/l un-ionised ammonia for Hinkley Point C discharging alone. This value is less than the EQS of 21 µg/l annual average for un-ionised ammonia and will not cause an adverse impact.

Conclusion

On the above information, with the exception of hydrazine, we can conclude that increase toxicity from thermal discharge will not have an adverse effect on the migratory fish and fish assemblage of the SAC and Ramsar.

We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Required mitigation

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

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[397] Hunt, T.P., Fisher, J.W., Livingston, J.M., & Putnam, M.E. (1981). Temperature effects on hydrazine toxicity to bluegills. *Bull. environ. Contam. Toxicol.,* **27**: 588-595.

[398] BEEMS Technical Report 186 (TR186): Predicted effects of NNB on water quality at Hinkley Point. Cefas Report for EDF. April 2011

[399] Royal Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Section 6.2.334. Report prepared for EDF.

Dissolved Oxygen (DO)
An increase in temperature directly affects the amount of oxygen dissolved in water as the solubility of gases reduces. Due to the energetic demands of the upstream migration and the increased activity that takes place at spawning, the oxygen requirements of anadromous lampreys and migratory teleosts are very high at these times in the life cycle (Claridge & Potter 1975)[400]. Since the maximum amount of oxygen that will dissolve in water is inversely related to temperature, even in clean turbulent water, oxygen concentrations can fall to below the minimum level for survival (Bird 2002). Consequently, any factors that lower oxygen tensions could have a significant impact on fish populations.

Examination of 37 years of temperature and salinity data for the Severn Estuary and Bristol Channel indicate a highly mixed water column within the Hinkley Point area (Haskoning, 2011)[401]. Dissolved oxygen (DO) concentrations in the Hinkley Point area are relatively high (between 11mg/l and 12.5mg/l), with no indication of stratification.

BEEMS Technical Report 186 has reviewed available datasets on oxygen in the Bristol Channel and Severn Estuary from the Environment Agency and Cefas. A short review of the data indicates oxygen concentrations for the wider study area to be between 8mg/l and 10mg/l and the localised dataset indicates dissolved oxygen concentrations of between 11 and 12.5mg/l. Whilst these figures are considered to be relatively high, oxygen sags have been observed in the wider study area and are considered to be due to re suspension of organic matter combined with summer conditions exhibiting low flow and higher temperatures (Langston et al 2003)[402]. The DO levels within the sampling area when compared to the WFD standards for DO therefore have a High Status which accords with the current status indicated in the Bridgwater Bay waterbody description. The standard for Good status is for DO concentrations to be between 4.0mg/l to 5.7mg/l.

Haskoning (2011) has stated that dissolved oxygen levels would be maintained within threshold levels set for the Water Framework Directive and no adverse effect on marine life as a result of the small reduction in DO associated with the cooling water discharge is therefore anticipated.

Provided that that dissolved oxygen levels would be maintained within threshold levels set for the Water Framework Directive then we would agree that any reductions is DO will not have an adverse effect on migratory fish or the fish assemblage of the SAC and Ramsar.

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[400] Claridge P.N. & Potter I.C. (1975) Oxygen consumption, ventilatory frequency and heart rate of lampreys (*Lampetra fluviatilis*) during their spawning run. *Journal of Experimental Biology* **63,** 193-206.
[401] Royal Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.
[402] Langston, W.J., Chesmasn, B.S., Burt, G.R., Hawkins, S.J., Readman, J, Worsford, P. (2003) Site characterisation of the Severn Estuary pSAC and SPA. Marine Biological Association. Publication No.13.

d) Increased turbidity and suspended sediment

Conservation objectives (see Section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by changes in flows*

Natural England & Countryside Council for Wales, 2009

The proposed outfall will be discharging 125m^3 of cooling water per second at full load, so the large volume of water re-entering the estuary is likely to increase the turbidity and suspended sediment around a localised area of the outfall. The increase in turbidity and suspended sediments in the water column can affect the ability of fish gills to absorb dissolved oxygen, particularly in the case of salmonids or shad.

Excess sediment can profoundly affect the productivity of a salmon or trout stream (McHenry et al., 1994)[403], although the impact is more evident in freshwaters, particularly where there are spawning grounds and where juvenile species are present. Juvenile salmonids have been known to leave channels containing sedimented substrate which did not provide interstitial spaces for winter refuge (Bjornn et al. 1974)[404]. There are no spawning grounds near to Hinkley Point C and the area does not support juvenile salmon or sea trout.

With regards to migratory eels, the report to inform the HRA[405] used a paper by Boubée *et al to* demonstrate that through laboratory experiments, elvers showed no avoidance behaviour even at the highest turbidities. The lack of avoidance behaviour shown in elvers suggested that turbid waters are unlikely to impede their migration into adult habitats. Reports from other studies cited in Boubée *et al* indicated that migratory elvers appear to be attracted to somewhat turbid environments and are often prolific in turbid waters. It is likely that habitat rather than ability to migrate through turbid waters is more likely to affect the distribution of eels.

The Severn Estuary is one of the most turbid estuaries in the UK. The wide mouth of the Bristol Channel and the converging coastlines of the estuary create a very energetic system with very large tides and turbulent conditions[406]. The Severn contains more sediment in suspension than the visual annual inputs, and there is a continual exchange of material from areas of erosion to areas of deposition through turbidity maximum which occupies the whole of the estuary east of Bridgwater Bay (Dyer, 1984)[407]. Migratory fish of the Severn Estuary are therefore highly adapted to high suspended sediment content, as the estuary is naturally turbid.

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[403] McHenry, M.L., D.C. Morrill and E. Currence. 1994 . Spawning Gravel Quality, Watershed Characteristics and Early Life History Survival of Coho Salmon and Steelhead in Five North Olympic Peninsula Watersheds. Lower Elwha S'Klallam Tribe, Port Angeles, WA. and Makah Tribe, Neah Bay, WA. Funded by Washington State Dept. of Ecology (205J grant).

[404] Bjornn, T. C., Brusven, M.A. Molnau, M.M. Watts, F.J,. Wallace, R.L. Neilson, D.R. Sandine, M.F. and Stuehrenberg, I.C. 1974. Sediment in streams and its effect on aquatic life, OWRT Project No. B-025-IDA, Idaho Water Resources Research Institute, Moscow, Idaho. 47 p.

[405] Royal Haskoning. Report to inform the Habitats Regulations Assessment (HRA) July 2011. Version 11 - Draft Final. Section 7.2.45 Pg. 397. Report prepared for EDF.

[406] Langston, W.J. et al (2003). Characterisation of the Severn Estuary pSAC and SPA. Marine Biological Association.

[407] Dyer, K.R. (1984) Sedimentation Processes in the Bristol Channel/ Severn Estuary. Marine Pollution Bulletin 15: 53-57.

The discharge at HPC is only expected to create small-scale changes in siltation and turbidity around the outfall and will therefore not have an adverse effect the fish migratory fish and fish assemblage of the Severn Estuary SAC and Ramsar.

e) Competition from non-native species

Conservation objectives (see Section 1.5.1)

- *The size of the migratory fish and fish assemblage populations in the Severn Estuary and the rivers which drain into it, are at least maintained and are at a level that is sustainable in the long term;*
- *The abundance of prey species forming the migratory fish and fish assemblage food resource within the estuary is maintained.*

Natural England & Countryside Council for Wales, 2009

Thermal discharges have been associated with the establishment of introduced warm-water species for many years (Naylor, 1965[408]; Langford, 1983[409]; Bamber, 1993[410]). Potential effects of the successful invasion and establishment of exotic (non-native) species include replacement of indigenous species as a result of competition enhanced reproductive success, competition for space and food, alteration of habitat and introduction of diseases and parasites (Smith, 1995[411]; Langford, 1990[412]). Thus, animals may compete for habitats with preferential temperatures, to maximise growth and other fitness-enhancing traits that tend to be optimised when body temperature approaches the physiological thermal optimum for the species (Gilchrist, 1995)[413].

It is possible that changes to the thermal regime could encourage non-native species to be drawn into the area around Hinkley Point and Bridgwater Bay and compete for resources. These thermal niches could then harbour the ‘warm water tourist' populations and promote the eventual spread through the estuary, which in turn could affect the fish community composition. Temperatures in certain habitats will be optimum for any given organism and therefore the subject of potential competition (Attrill & Power, 2004)[414].

The number of species recorded for the Severn Estuary has been reported as 111 by Potts and Swaby (1993)[415]. This represents a cumulative total species list for the estuary that includes part of Bridgwater Bay (Potts and Swaby, 1993). Some of these species are not normally associated with estuaries and are probably ‘marine tourists' (Henderson and Bird, 2010)[416]. Species such as the basking shark (*Cetorhinus*

[408] Naylor, E., (1965). Biological effects of heated effluent in docks at Swansea, S. Wales, Proc. Zool. Lond., 144(2), 253-68.
[409] Langford, T.E., (1983) Electricity Generation and the Ecology of Natural Waters. Liverpool University Press, Liverpool.
[410] Bamber, R.N., (1993). Changes in the infauna of Sandy Beach. J. Exp. Mar. Biol. Ecol. 172, 93-107.
[411] Smith, J., (1995). Exotic marine organisms in the Milford Haven waterway: the potential for invasion. Field Studies Council. FSC/OPRU/12/95.
[412] Langford, T.E., (1990). Ecological effects of thermal discharges. Elsevier Applied Science, Lond. & NY. 468pp.
[413] Gilchrist, G.W., (1995). Specialists and generalists in changing environments. 1. Fitness landscapes of thermal sensitivity. American Naturalist 146, 252–270.
[414] Attrill, M.J., Power, M. (2004) Partitioning of temperature resources amongst an estuarine fish assemblage. Estuarine, Coastal and Shelf Science 61 (2004) 725–738.
[415] Potts, G. W. & Swaby, S. E. (1993) Review of the status of estuarine fishes. pp. 278. English Nature Research Report No. 34, Marine Biological Association/English Nature.
[416] Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.

maximus) and sunfish (*Mola mola*) are extreme examples that have rarely been observed in the estuary (Potts and Swaby, 1993).

In a report by Henderson *et al*. (2011)[417] it was noted that of the 30 most abundant species found at Hinkley Point, which together comprise more than 99% of the total species number and biomass collected, seventeen had shown a long-term trend in log abundance indicative of exponential change. Nine species had shown approximately exponential increases, and eight exponential decreases in abundance. This remarkable variation in individual species' abundance has been shown for some species to be related to changes in sea water temperature (climate change), the North Atlantic Oscillation Index, and salinity. Henderson *et al*. (2011) further reported that annual species richness had not increased, however the number of species present each month had, on average, increased. This has been caused by changes in seasonal presence, with summer–autumn species extending their presence further into the winter. For fish, the dominant species showed no trend, and it is argued they are likely to be under density-dependent control. The published data supports the view that the fish assemblage in the Severn Estuary is one of the most diverse in the UK (Potts and Swaby, 1991)[418].

So whilst it is possible that the thermal plume may cause some localised changes in species composition around the outfall, any changes to species diversity will be difficult to predict, especially since the Severn Estuary is highly diverse with many potential non-native species already present. Furthermore, diversity is likely to gradually change naturally with the effects of climate change and other environmental variables, especially since the Severn Estuary and Bristol Channel represent a boundary area between the north and south of the North Atlantic area.

Conclusion
It is therefore concluded that the changes to the thermal regime due to the cooling water discharge from HPC alone will not have a significant effect on the migratory fish or fish assemblage feature from the competition of non-native species, and will not have an adverse effect on site integrity.

f) Entrainment and impingement of fish, fish eggs and larvae

This is covered within the Estuaries section - Section 2.6.1.4

[417] Henderson, P.A, Seaby, R.M.H., Somes, J.R. (2011). Community level response to climate change: The long-term study of the fish and crustacean community of the Bristol Channel. Journal of Experimental Marine Biology & Ecology. 400; 78-89.

[418] Potts, G.W., Swaby, S.E., (1991). Evaluation of the conservation requirements of rarer British marine fishes. Nature Conservancy Council Report No. 1228, 22 pp.

Overall conclusion

Hazard assessed	Adverse effect on migratory fish and fish assemblage features?
Toxic contamination	Yes – Requirement to remove hydrazine via permit condition (see below)
Non-toxic contamination	No
Changes to thermal regime	No
Changes in turbidity and suspended sediment	No
Competition from non-native species	No
Entrainment & impingement	No
Overall conclusion	**With the permit condition in place we can conclude no adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Required mitigation *Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges*	Environment Agency	Operational Permit Ref: HP3228XT

2.6.6 Migratory Birds and Bird Assemblage

Introduction
The Severn Estuary has a good concentration of wildfowl and wading birds which feed on the productive inter-tidal areas for worms, molluscs and other invertebrates.

Despite being one of the third largest by area in the UK the density of wintering birds in the Severn Estuary is amongst the lowest of UK estuaries, ranking 38th out of 39 UK estuaries for which there is data. The Severn has a mean peak density of 4.1 birds/ha, compared to an average mean peak density for England & Wales west coast estuaries of 12.5 birds/ha (Osment, Halstead, Pontee & Harvey 2011) [419]. The reasons for the relative impoverishment of the Severn relate to the macro-tidal conditions, associated strong currents and high turbidity. These limit primary productivity and lead to an unusual (depleted) macro-invertebrate fauna.

The population estimates for the SPA and Ramsar birds designated under the Severn Estuary have been taken from the most up-to-date data where possible and are listed in Table 2.6.6S1 below.

Table 2.6.6S1 - Qualifying Features of the Severn Estuary SPA and Ramsar Site SPA qualifying species in bold.

	Severn Estuary SPA Citation[1]	Severn Estuary SPA Review (2001)[1]	Severn Estuary Ramsar Site[2]
Wintering assemblage	**93,986**	**93,986**	**70,919**
Wintering Bewick's (Tundra) Swan *Cygnus columbianus bewickii*	**280**	**280**	**229**
Wintering European white-fronted goose *Anser albifrons albifrons*	**2,664**	In assemblage	**2,076**[3]
Passage Ringed Plover *Charadrius hiaticula*	In assemblage	**655**	**655**[1]
Wintering Curlew *Numenius arquata*	In assemblage	**2903**	
Wintering Gadwall *Anas strepera*	**282**	In assemblage	**241**
Wintering Dunlin *Calidris alpina alpina*	**44,624**	**44,626**	**25,082**
Wintering Pintail *Anas acuta*	In assemblage	**599**	**599**[1]
Wintering Redshank *Tringa totanus*	**2,330**	**2330**	**2,616**
Wintering Shelduck *Tadorna tadorna*	**3,330**	**3330**	**3,223**
Wintering Wigeon *Anas penelope*	In assemblage	In assemblage	
Wintering Lapwing *Vanellus vanellus*		In assemblage	
Wintering Teal *Anas crecca*	In assemblage	In assemblage	4,456
Wintering Mallard *Anas platyrhynchos*		In assemblage	
Wintering Shoveler *Anas clypeata*		In assemblage	
Wintering Pochard *Aythya ferina*	In assemblage	In assemblage	
Wintering Tufted Duck *Aythya fuligula*	In assemblage	In assemblage	
Wintering Grey Plover *Pluvialis squatarola*	In assemblage	In assemblage	
Passage Whimbrel *Numenius phaeopus*	In assemblage	In assemblage	
Wintering Spotted redshank*Tringa erythropus*	In assemblage		
Passage Dunlin *Calidris alpina alpina*	In assemblage		
Passage Redshank *Tringa totanus*	In assemblage		
Breeding Lesser black-backed gull			4,167 occupied nests

Notes: *(1) Number of individual birds, 5 year peak mean count 1991/2 to 1995/6*
(2) Number of individual birds, 5 year peak mean count 1998/99 to 2002/03
(3) Number of individual birds, 5 year peak mean count 1996/97 to 2000/01

[419] Osment, J, Halstread, P, Pontee, N and Harvey, R, 2011, Reassessing the Severn Barrage: operational modes and their impacts. Coastal Management 2011, Belfast, 15-16 November 2011

WEBS data show that bird numbers in the Severn have reduced over the last 20 years (1990 to 2009) and the assemblage composition has changed (Osment *et al*., 2011). This is believed to relate to milder winters, causing more birds to remain on the east coast nearer their summer breeding grounds. This suggests that the Severn Estuary is not at ecological carrying capacity with respect to the overall assemblage of birds using it. The implication is that factors outside the estuary, for example availability of breeding territories or summer food supplies, are limiting bird population size.

Within the Severn Estuary, Bridgwater Bay makes an important contribution to supporting the populations of several SPA and Ramsar qualifying and assemblage bird species. It is one of the larger inter-tidal areas within the SPA (representing 10% of the area) and provides food and a slightly more sheltered environment than the rest of the estuary, which is highly exposed to prevailing south-west winds. Shelter is likely to be a principal factor in the use of the site by moulting shelduck.

Birds in the Hinkley point study area

To enable our assessment of the potential impacts from the Hinkley development on the Severn Estuary SPA and Ramsar we have analysed the bird data collected by the applicant in addition to making our own review of the Wetland Bird Surveys (WeBS) data for Bridgwater Bay. The applicant has undertaken two bird surveys of the inter-tidal land fronting Hinkley Point; one by Amec (Amec, 2010)[420]. And one by Entec (Entec 2011)[421]. The Amec study has been used to assess the potential impacts from disturbance whereas the Entec study, which covers a larger area of the mudflat habitat to the east of Hinkley Point, has been used to assess impacts from the discharge. The two surveys are incompatible as they use different locations (Hinkley Point frontage and Bridgwater Bay) and different methodologies. An additional Shelduck Survey was also undertaken by Amec in September 2011 to aid the impact assessment for the proposed jetty.

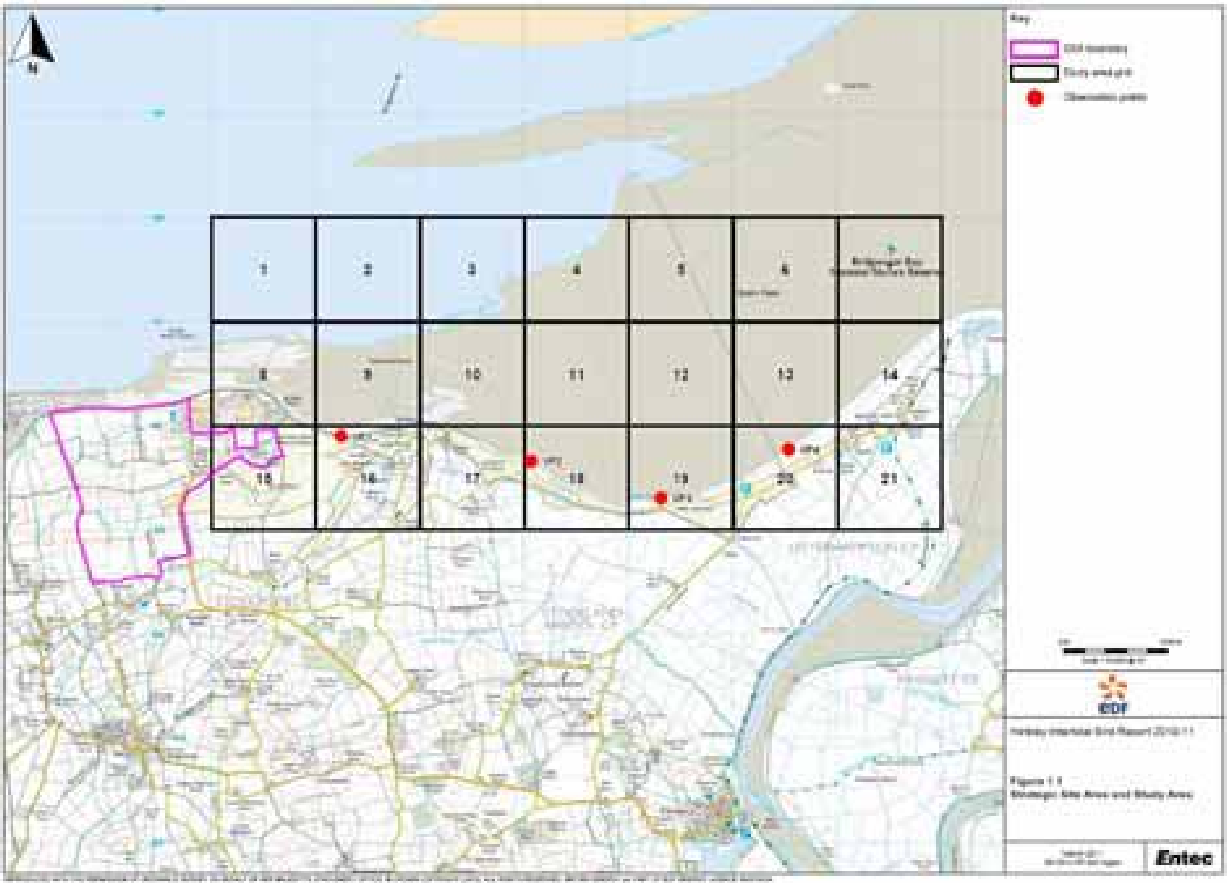
We have focused on the data collected by Entec for the Water Discharge Activity environmental permit assessment. The birds were surveyed using the frontage between April 2010 and January 2011 from 4 observation points. The survey area is shown in figure 2.6.6S2. Entec defined a study area grid of 21 km squares, of which approximately 12 km squares are inter-tidal. The survey omits the months of February and March from the count period. This is unfortunate, particularly as they fall within the peak season for several species of wintering wildfowl.

Peak counts of each species of which more than a few individuals were recorded are shown in Table 2.6.6S3 together with the percentage that this represents of the SPA total (numbers for qualifying species in bold including those species recommend to be qualifying species in the SPA and Ramsar Reviews) and the principal months when they are present in the study area.

[420] Amec, 2010, Ornithological Studies baseline report. Report produced for EDF Development Company Ltd

[421] Entec, 2011, Hinkley Intertidal Bird Report 2010-2011, Report produced for EDF

Figure 2.6.6S2. The Entec Bird Survey Area showing the 21 km grid squares and 4 observation points (Entec 2001)



The Entec survey identified that:

- Of the 9 individual species included in the SPA citation or recommended in the SPA Review, 6 (ringed plover, curlew, dunlin, pintail, redshank and shelduck) were recorded within the study area in numbers exceeding 1% of the SPA population.

- A further four species listed within the water bird assemblage (wigeon, mallard, grey plover and whimbrel) were recorded within the study area in numbers exceeding 1% of the SPA population.

- Five other species not listed within the SPA assemblage (little egret, oystercatcher, knot, bar-tailed godwit and turnstone) were recorded in significant numbers within the study area.

Table 2.6.6S3 Entec bird survey results
(Numbers for qualifying species in bold including those species recommend to be qualifying species in the SPA and Ramsar Reviews)

	Count in Survey Area (bird numbers)	% of Severn Estuary SPA population	Present	Peak months
Wintering Bewick's (Tundra) Swan *Cygnus columbianus bewickii*	**Not recorded**	**0%**	**n/a**	**n/a**
Wintering European white-fronted goose *Anser albifrons albifrons*	**Not recorded**	**0%**	**n/a**	**n/a**
Passage Ringed Plover *Charadrius hiaticula*	**687**	**105%**	**Apr-Aug**	**Apr, May, Aug**
Wintering Curlew *Numenius arquata*	**739**	**18.9%**	**All Year**	**Nov -Feb**
Wintering Gadwall *Anas strepera*	**2**	**<1%**	**Nov-Feb**	**Dec**
Wintering Dunlin *Calidris alpina alpina*	**12,590**	**28.2%**	**All Year**	**Oct - Mar**
Wintering Pintail *Anas acuta*	**158**	**26.4%**	**Sept-Mar**	**Nov-Feb**
Wintering Redshank *Tringa totanus*	**355**	**15%**	**Oct - Mar**	**Oct - Mar**
Wintering Shelduck *Tadorna tadorna*	**2049**	**61.5%**	**All Year**	**July-Nov**
Wintering Wigeon *Anas penelope*	312	3.7%	Sept-Mar	Nov-Feb
Wintering Lapwing *Vanellus vanellus*	412	No data	Sept - Dec	Oct - Dec
Wintering Teal *Anas crecca*	27	<1%	Dec	Dec
Wintering Mallard *Anas platyrhynchos*	87	2.6%	All Year	All Year
Wintering Shoveler *Anas clypeata*	90	No data	Nov	Nov
Wintering Pochard *Aythya ferina*	Not recorded	0%	n/a	n/a
Wintering Tufted Duck *Aythya fuligula*	Not recorded	0%	n/a	n/a
Wintering Grey Plover *Pluvialis squatarola*	975	>200%	Oct – Feb	Oct – Feb
Wintering Whimbrel *Numenius phaeopus*	254	>100%	Apr-Aug	Apr-May
Wintering Spotted redshank *Tringa erythropus*	Not recorded	0%	n/a	n/a
Passage Dunlin *Calidris alpina alpina*	462	No data	All year	Apr-Sept
Passage Redshank *Tringa totanus*	5	No data	All year	Apr-Sept
Breeding lesser black backed gull	Not recorded	0%	n/a	n/a

WeBS

The Environment Agency has independently analysed the WEBs data for Bridgwater Bay to aid assessment of impacts. The data used was the five year peak mean from 2004 to 2009. A summary of this information for the species surveyed in significant numbers by Entec is given in Table 2.6.3.7S4 below (Nicholas Pearson, 2011):

Table 2.6.6S4 - WeBS data for the Bridgwater Bay area[422]

Species	WeBS summary information
Ringed plover	Wetland Bird Surveys (WeBS) counts for Bridgwater Bay have indicated a five year mean of peaks count of 305 for this species, with highest numbers occurring in August. This represents 47% of the SPA population, indicating that Bridgwater Bay is an important resource within the estuary, 92% of the threshold for a nationally important population and 42% of an internationally important population. Relatively small numbers occur during the winter period, representing just 5% of a nationally important population. The peak count for the study area is 687, which exceeds the WeBS count for Bridgwater Bay and that for the whole of the Severn Estuary. Highest numbers occurred at the eastern end of the study area towards Steart.
Curlew	The WeBS five year mean of peaks count for Bridgwater Bay is 1228. This represents 42% of the SPA population, indicating that Bridgwater Bay is an important resource within the estuary, and 82% of a nationally important population. The peak count for the study area is 739, which is 18.9% of the SPA population.
Dunlin	Very large numbers (estimated at 15,000 - 20,000) are present in areas adjoining the peninsula during the winter months (Halcrow 2011)[423]. The WeBS five year mean of peaks count for Bridgwater Bay is 9200. This represents 21% of the SPA population, indicating that Bridgwater Bay is a significant resource within the estuary and 164% of the threshold for a nationally important population. The peak count for the study area is 12,590 which exceeds the peak WeBS count for Bridgwater Bay and represents 28.2% of the SPA population.
Pintail	The WeBS five year mean of peaks count for Bridgwater Bay is 22. This represents 4% of the SPA population, suggesting that Bridgwater Bay is not a major resource within the estuary, and 8% of the threshold for a nationally important population. The peak count for the study area is 158, which exceeds the peak WeBS count for Bridgwater Bay by a factor of seven and represents 26.4% of the SPA population and 57% of the threshold for a nationally important population.
Redshank	The WeBS five year mean of peaks count for Bridgwater Bay is 584. This represents 25% of the SPA population, indicating that Bridgwater Bay is a significant resource within the estuary, and 49% of the threshold for a nationally important population. The peak count for the study area is 355, which is 15% of the SPA population.

[422] WeBS: Number of individual birds, 5 year peak mean count 2004/5 and 2007/8
[423] Halcrow, 2011, Steart Coastal Management Project, HR02 Appropriate Assessment Report (Draft)

Species	WeBS summary information
Shelduck	Bridgwater Bay is of particular importance for shelduck, as it is one of only a few moulting sites in western Europe, with several thousand birds present during the late summer / autumn. Moulting birds are flightless for up to four weeks, generally within the period August to October. The WeBS five year mean of peaks count for Bridgwater Bay is 2287. This represents 69% of the SPA population, indicating that Bridgwater Bay is a particularly important resource within the estuary. This species occurs in nationally important numbers through winter, autumn and spring, with mean of peak counts representing 292%, 198% and 116% of the threshold for a nationally important population respectively. The autumn population represents 76% of an internationally important population. The peak count for the study area is 2049, which is 61.5% of the SPA population.
Wigeon	The WeBS five year mean of peaks count for Bridgwater Bay is 950, representing 19% of the threshold for a nationally important population. The peak count for the study area is 312 birds, which is 3.7% of the SPA population, suggesting that Bridgwater Bay is not a major resource within the estuary.
Mallard	The WeBS five year mean of peaks count for Bridgwater Bay is 70, representing 1% of the threshold for a nationally important population. The peak count was 87 birds, which is 2.6% of the SPA population.
Grey plover	The WeBS five year mean of peaks count for Bridgwater Bay is 243, representing 46% of a nationally important population. The peak count in the study area was 975 birds, which is more than double the recorded Severn Estuary SPA five year peak mean count.
Whimbrel	The WeBS five year mean of peaks count for Bridgwater Bay is 28. The peak count for the study area is 254, which exceeds the recorded SPA five year peak mean count.

Other existing bird data was also analysed by the applicant[424]. This included:

- Wetland Bird Survey (WeBS) Core counts for the five most recent years and Low tide counts for the most recent available winter
- Wetland Bird Survey (WeBS) high and low tide counts (Nov-Feb 2002-2003). The count sector fronting the HPC development is BV697 and the data indicates that **wigeon**, **curlew** and **redshank** are the species which feed or forage along the inter-tidal foreshore that directly fronts the Hinkley Point C site. However, these birds were observed in much lower numbers in

[424] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc Ref: 3.16 October 2011. Report prepared for EDF.

comparison to those occupying habitats further east of the Hinkley Point C site.

- Data from the West Hinkley Wind farm planning application, submitted December 2006.
- Night time surveys between December 2007 and March 2009. This information is represented in Volume 2, Chapter 20 of the ES. Birds were recorded in very low numbers along the inter-tidal foreshore fronting the seawall.
- Field surveys within the HPC development area from September 2007 until March 2009. Fields 1, 2, 3 and 4 adjoin the seawall development. Birds using these fields are roosting. Volume 2, chapter 20 of the ES provides detailed information on the locations and numbers of species recorded during the field surveys. It does not provide further information about fields 1, 2, 3 or 4 as species forming part of the cited interest of the designated SPA/Ramsar were not noted.
- Vantage Surveys for Shelduck undertaken in July and August 2011. Details are provided in the Environmental Statement Volume 2,Chapter 20, Appendix 20Q[425].

To evaluate the significance of the survey area, it is important to understand its scale within the context of the estuary. The Severn Estuary SPA is 24,701 ha in extent (JNCC 2001)[426]. The area of Bridgwater Bay National Nature Reserve is 2,559 ha (Natural England, undated), which is 10% of the SPA. The inter-tidal part of the Hinkley Point to Steart bird study area surveyed by Entec is approximately 12 km^2, which represents about 47% of Bridgwater Bay National Nature Reserve (NNR) and 5% of the Severn SPA.

The survey data makes it clear that Bridgwater bay is an important part of the Severn Estuary SPA particularly for shelduck, ringed plover and curlew. It also supports significant numbers of dunlin and redshank.

Bird prey availability

The survey data indicates that the most important foraging resource in the area is found east of Hinkley Point B power station and across the western fringe of the Stert mudflats (Entec 2011). The mudflats are largely dominated by the biotope '*Hediste diversicolor* and *Macoma balthica* in littoral sandy mud' (A2.312) which, at 3532 ha, is the second most common habitat in the Bridgwater Bay ecosystem (BEEMS TR184) [427]. Another biotope is 'Littoral sand and muddy sand' (A2.2) which occupies the high shore region of Berrow Flats and the low shore sediments surrounding the entrance of the River Parrett.

Bridgwater Bay is characterised by a low diversity of macrofaunal species. The seven most widely distributed macrofaunal taxa are *Hydrobia ulvae* (Gastropoda), *Macoma balthica* (Bivalvia), *Nephtys hombergii* (Polychaeta), *Pygospio elegans* (Polychaeta), nematodes, *Corophium volutator* (Amphipoda) and *Hediste diversicolor* (Polychaeta) (BEEMS TR68A)[428]. This is typical for the Severn estuary generally, within which macrofauna is limited by high turbidity, strong currents and low primary productivity.

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[425] Amec, 2011, Environment & Infrastructure UK Limited,Technical Note, Appendix 20Q - Shelduck Survey Baseline Information, September 2011. Report prepared for EDF.
[426] JNCC, 2001,SPA Review http://jncc.defra.gov.uk/page-2066, accessed 27 November 2011.
[427] BEEMS. TR184: Hinkley Point Marine Ecology Synthesis Report
[428] BEEMS Technical Report 68A (TR68A): Impact of New Nuclear Build at Hinkley Point on intertidal food availability for birds. (2010) Cefas. Report prepared for EDF

BEEMS TR068[429] reports that the average biomass of inter-tidal macrofauna in Bridgwater Bay was found to be 28g/m^2. The samples with the highest biomass were located along the upper shore region of Brean Down and Berrow Flats and at a number of stations towards the west of Stert Flats. The total biomass was disproportionately dominated by relatively few taxa: with *Macoma balthica* contributing 63%, *Hediste diversicolor* 15% and *Hydrobia ulvae* 8%. These three species represent the majority of food items (86% of the biomass) available to birds in the inter-tidal zone.

Macoma balthica is most abundant in the mid-upper shore of Berrow Flats and in the southwestern corner of Stert Flats, whilst *Hydrobia ulvae* is more uniformly distributed across the site (BEEMS, TR184).

IECS (2011)[430] reports the result of invertebrate sampling from five replicate cores at each of 25 stations in Bridgwater Bay, though the results are not converted to biomass. Of 125 samples, *Hydrobia ulvae* was recorded in 123, *Nephtys sp*. in 115, *Macoma balthica* in 68 and *Hediste diversicolor* in 35. Crustaceans were infrequent, with *Corophium volutator* recorded in only nine samples, whilst mysids were not recorded. The epibenthic shrimp *Crangon crangon* was recorded in trawls and baited traps.

BEEMS TR029[431] reports a similar survey result from 40 stations: *Hydrobia ulvae* and *Macoma balthica* were each observed at 36 stations, *Nephtys hombergii* at 28 stations, *Pygospio elegans* at 21 stations, nematodes at 19 stations, *Corophium volutator* at 17 stations and *Hediste diversicolor* at 13 stations. The remaining 33 taxa were sampled at less than 10 of the 40 sampling stations.

Macoma balthica is by far the dominant bivalve mollusc in the Severn and is present at a very high population density (mean of 492/m^2), representing a large proportion of the total macrofaunal biomass (BEEMS TR68A). Extrapolation of the measured macrofaunal biomass to the whole of Stert Flats would give a total macrofaunal standing stock of around 500 metric tonnes (wet weight). *Macoma balthica* has only a superficial burrow, often less than 5 cm, so is exposed to predation of surface feeding birds.

Table 2.6.6S5 lists the diet and food requirements for the bird species found in significant numbers at Hinkley Point (Entec 2011). This has mainly been determined from literature studies, rather than site-specific information. The applicant has carried out some molecular analyses work on bird faecal material (BEEMS TR164)[432]. Shelduck was mainly targeted as samples were easy to collect. The Shelduck are important in a conservation context however, some other species were included. The results showed a very diverse diet for the bird faeces analysed. *Macoma balthica* represents one of their food supplies as well as *Hydrobia ulvae*, *Hediste diversicolor* and marine nematodes. Marine nematodes and *Hydrobia ulvae* appear to be the most commonly encountered dietary components. The work identifies diet components but does not enable their relative significance to be quantified.

[429] BEEMS Technical Report 068 (BEEMS TR068): An initial review of the effects of new nuclear build on the marine ecology of Hinkley Point and Bridgwater Bay. Version 2 (2011) Cefas. Report prepared for EDF
[430] Institute of Estuarine and Coastal Studies (IECS), March 2011, Hinkley Intertidal Post Survey Report, Report to Cefas.
[431] BEEMS Technical Report 029 (BEEMS TR029): Ecological Characterisation of the Intertidal Region of Hinkley Point, Severn Estuary: Results from the 2008 Field Survey and Assessment of Risk. (2009) Cefas. Report prepared for EDF.
[432] BEEMS Technical report 164 (BEEMS TR164): Molecular Analysis of faecal material for diet analysis of protected inter-tidal birds (input to food web modelling). (2011) Cefas. Report prepared for EDF.

Table 2.6.6S5 - Food requirements of bird species observed in significant number at Hinkley Point

Bird Species	Diet
Ringed Plover	On passage, the species will feed on benthic invertebrates when exposed by the tide and also in fields adjacent to the Severn Estuary.
Curlew	Curlew mainly feed on larger size classes of polychaete worms, primarily *Hediste diversicolor*, but also *Nephtys spp*. and *Arenicola marina* (Goss-Custard *et al*., 1988)[433]. Curlew also take the larger size classes of *Macoma balthica*. Earthworms form a significant part of the diet to a greater extent than other shorebirds.
Dunlin	Dunlin feed predominantly on benthic invertebrates when exposed by the tide and also in fields adjacent to the Severn Estuary. Dunlin on the Severn estuary fed on the smaller size classes of polychaete worms, particularly *Hediste diversicolor*, the small bivalve *Macoma balthica*, and the gastropod mollusc *Hydrobia ulvae*, all of which are found in muddy inter-tidal flats (Worrall, 1984[434]; Goss-Custard et al., 1988).
Pintail	Pintail usually feed in shallow water, generally 20 to 30 cm, but up to 53cm deep (Cramp and Simmons, 1977)[435]. Pintail generally feed on vegetative material, particularly rhizomes, tubers and seeds, and also on insects, crustacea and molluscs (Cramp and Simmons, 1977). However, in estuaries, they feed mostly on Hydrobia and crustaceans such as Corophium volutator and Cyathura carinata.
Redshank	Red Shank use inter-tidal and freshwater wetland habitats. During the winter period they feed predominantly on benthic invertebrates when exposed by the tide and also in fields adjacent to the Severn Estuary. The main diet items are small and middle-sized polychaete worms and the crustaceans Corophium volutator and cathura carinata (Goss-Custard and Durell, 1986[436]; Goss-Custard *et al*., 1988).
Shelduck	Shelduck feed on benthic invertebrates in the inter-tidal area when they are exposed by the tide and also in shallow water. Over 80% of shelduck diet is known to consist of Hydrobia (Stroud et al., 2001), but they also eat small worms, both polychaetes and oligochaetes, and small bivalves (Goss-Custard *et al.*, 1988). Hence, shelduck can be described as an omnivorous bird in the mixed feeding category (Cefas, 2010). The molecular analysis work on inter-tidal faecal material from Hinkley Point BEEMS TR164, showed a very diverse diet for Shelduck. *Macoma balthica* represents one of their food supplies as well as *Hydrobia ulvae*, *Hediste diversicolor* and marine nematodes. Between these four sources, marine nematodes and H. ulvae appear to be the most commonly encountered dietary components.

[433] Goss-Custard, J.D., McGrorty, S., Pearson, B., Clarke, R.T., Rispin, W.E., Durell, S.E.A.L.V.d., Rose, R.J., 1988.Prediction of post-barrage densities of birds. Vol.4: Birds, Department of Energy.
[434]Worrall, D.H., 1984. Diet of the Dunlin Calidris alpina in the Severn Estuary. Bird Study 31, 203-212.
[435] Cramp, S., Simmons, K.E.L., 1977. Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Oxford University Press, Oxford.
[436] Goss-Custard, J.D., Durell, S.E.A.L.V.d., 1986.The effect of the Taff estuary barrage on overwintering shorebirds, Welsh Office.

Bird Species	Diet
Wigeon	Vegetarian diet of algae and grasses gathered on mudflats, however they also graze on land.
Mallard	Most of the mallard's diet is made up of plants. It eats the seeds of grasses and sedges and the leaves, stems, and seeds of aquatic plants. It occasionally eats insects and crustaceans and molluscs, especially when it is young.
Grey Plover	Grey plover is found only on coasts and prefers large muddy or sandy estuaries. In the summer its preferred food is invertebrates however in the winter it primarily eats marine worms, crustaceans and molluscs.
Whimbrel	Whimbrel congregate on the Somerset and Gwent Levels during their spring passage, feeding mainly on wireworms and caterpillars

Conservation objectives (see section 1.5.1)

Internationally important populations of regularly occurring migratory species (wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, gadwall, wintering Ringed Plover wintering Curlew* wintering Pintail*, wintering teal**, breeding Lesser Black-backed Gull) *recommended additions under the SPA review, **recommended under the Ramsar review*

- *The abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained;*

Internationally important assemblage of waterfowl

- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained;*

Natural England & Countryside Council for Wales, 2009[437]

a) Toxic contamination

This assessment is based on the potential impact to prey availability on the inter-tidal mudflats due to the chemical plume from the cooling water discharge. The only toxic contamination which could impact on the bird prey availability arise from the addition of chlorine as a biocide and hydrazine as a corrosion inhibitor and oxygen scavenger. The addition of chlorine to cooling water relates to the potential toxicity of Total Residual Oxygen (TRO) and the various chlorinated by-products produced following reaction with organic matter and seawater. The use of chlorination is allowed within the operational water discharge permit but is considered unlikely to be used in practice. The discharge is located 1.8 km offshore.

[437] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

We have looked at the information provided by the applicant which forms two parts, ie 1) toxicity testing of prey and modelling of prey reduction, and 2) chemical plume modelling and Environmental Quality Standards (EQS) / Predicted No Effect Concentrations (PNEC) exceedence.

1. Toxicity testing of prey and modelling of prey reduction
The applicant has carried out TRO toxicity testing on the abundant species of bird prey found in the inter-tidal mudflats (BEEMS TR163)[438]. The most sensitive component of the invertebrate assemblage were found to be the amphipod *Corophium volutator*, with extrapolated LC10 concentrations of approximately 0.03 to 0.04 mg/l TRO (BEEMS TR163).

Several bird species including dunlin, ringed plover, turnstone, redshank and shelduck rely upon the *Corophium volutator* as at least a component of their diet (BEEMS TR184)[439]. The applicant has used the Individual based Model MORPH to identify if bird species will be impacted by a reduction in prey. Further information about MORPH and the Environment Agency's interpretation of it are provided in Section 2.6.6A at the end of this section. A scenario was modelled with reduced *Macoma balthica* from thermal effects and a 10% reduction in peracarid crustacean abundance (of which *Corophium volutator* is the most abundant species) across approximately 40% of Stert Flats (BEEMS TR184). This may be considered analogous to a highly conservative scenario of potential effects due to both chlorination and thermal effects associated with the cooling waters.

The scenario had no discernable effect on survival of the modelled bird species for which amphipods form a component of the diet. Redshank and turnstone showed a slight switch to alternative prey (the gastropod *Hediste ulvae*) while the remaining species (dunlin, ringed plover and shelduck) were maintained by the reduced amphipod abundance. These three species fed on mixed diets under the reference conditions. Overall, the bird species included in the model are considered to be resistant to a conservative estimate of chemical effects on their *Macoma balthica* and *Corophium volutator* prey.

BEEMS TR184 reports that there is limited toxicological data available for hydrazine. The research that Cefas has carried out in the past on some species such as the crustacean Tisbe has shown that they are relatively resistant.

2. Chemical plume modelling
The Environment Agency has analysed the chemical plume modelling work carried out by the applicant to determine the potential impacts from the discharge of chlorinated water and hydrazine on the various habitats. This is discussed in Section 2.6.1.

Modelling of the chlorinated plume found that the only habitat at risk from TRO was the sub-tidal soft sediments in the immediate vicinity of the outfall (BEEMS TR186)[440]. The EQS was not exceeded anywhere on the intertidal flats.

For hydrazine, the modelling showed that only the sub-tidal soft sediments located adjacent to the outfall would be exposed to hydrazine concentrations that exceed the

438 BEEMS. TR163: Acute and behavioural effects of chlorinated seawater on inter-tidal mudflat species. EDF BEEMS (Cefas) 2011.
439 BEEMS. TR184: Hinkley Point Marine Ecology Synthesis Report
440 BEEMS. TR186: Predicted Effects of NNB on Water Quality at Hinkley Point. April 2011

chronic PNEC (BEEMS TR186). However, the modelling of hydrazine did not include the maximum loading scenario. It is not clear therefore what the size of the mixing zone would be for the acute PNEC. It is estimated that the acute PNEC would be exceeded on the intertidal flats, and that there could be an impact on the benthic invertebrates. Therefore, we cannot state that there will be no adverse impact on the bird prey species as a result of hydrazine discharges. However, within the environmental permit for the operational water discharge from the Hinkley Point C nuclear power station we are able to require the removal of hydrazine from all waste water streams prior to discharge. This will prevent hydrazine being released into the Severn Estuary. This control measure enables us to conclude that there will be no adverse impact on the habitat as a result of use of hydrazine at the Hinkley Point C nuclear power station.

Conclusion relating to toxic contaminants

As the modelling predicts that there is to be no adverse effect on the inter-tidal soft habitats then there will also be no adverse effect on the prey species for birds and therefore the bird species themselves. Ensuring through the environmental permit that the effluent is treated to remove hydrazine prior to discharge will ensure that no adverse impact on the prey species results.

The MORPH work provided by the applicant provides further support to this conclusion. The Environment Agency has based its decision of no adverse effect on the plume modelling work and has not used MORPH to support its conclusions.

We can therefore conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from toxic contamination as a result of discharges from HPC as the operational water discharge permit will ensure that hydrazine is removed from effluent streams prior to discharge..

b) Non toxic contamination (Nutrient enrichment and organic loading)

Potential exposure due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works.

It has been concluded in the section on the Estuaries feature that neither the increase in nutrient inputs nor the increase in organic load arising from the operational discharges from HPC were considered to have a likely significant effect on the integrity of the SAC. This conclusion was reached, because the discharges make a very small contribution, about 0.1% or less, to the overall annual loadings to the SAC and do not affect an area with habitat or species unique to the site.

Even at a local scale, the average increase in nutrients is considerably less than the ambient background values, being about 0.1% for N, about 3.8% for P, and less than 0.1% for oxygen demand. These increases are not considered to be significant.

Conclusion

We can therefore conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from nutrient enrichment or organic loading on the bird prey within the intertidal mudflats and sandflats as a result of discharges from HPC.

c) Changes to thermal regime

The survey work carried out by Entec identified 10 SPA species in numbers exceeding the SPA population (ringed plover, curlew, dunlin, pintail, redshank, shelduck, wigeon, mallard, grey plover and whimbrel) using the inter-tidal land between Hinkley Point and Steart. Surveys were also carried out by the applicant on the macrofaunal taxa in the littoral substrate (BEEMS TR029)[441]. Biomass was dominated by 3 taxa: the Baltic telling *Macoma balthica* – 63%, ragworm *Hediste diversicolor* – 15% and the laver spire shell *Hydrobia ulvae* – 8%. The obvious importance of the inter-tidal flats as foraging habitat for birds means that any impact on prey abundance or availability could have significant adverse impacts on the SPA population.

This assessment is based on the potential impact to prey abundance and/or availability on the inter-tidal mudflats due to the thermal plume from the cooling water discharge which could be up to 12.5°C above ambient.

The thermal modelling work is reviewed in section 2.6.1 above.

Sensitivity and impact on prey

The applicant has looked at the sensitivity of various prey to thermal increases (BEEMS TR184, BEEMS TR134[442]). The work revealed that the only infaunal species sensitive to an increase in seawater temperature is the Baltic tellin, *Macoma balthica.* Key results revealed:

(a) A reduction in the growth of *Macoma balthica* as a result of higher water temperatures. The effects within the area of temperature elevation exceeding 2°C may include:

- A lower recruitment and increased over winter weight loss with higher winter temperatures; and
- a greater mortality and increased offshore migration with higher summer temperatures.

As *Macoma balthica* is the only bivalve found within this area and dominates macrofaunal wet weight, any losses in the biomass of this species would not be compensated by an increased number of functionally-similar bivalve species with higher temperature tolerances. However, it is likely that a reduction in *Macoma* will lead to increases in other species.

(b) A potential increase in populations of the brown shrimp *Crangon crangon*, which are the main predator of *Macoma balthica* sprat. *Crangon crangon* is not an important food source for birds in the inter-tidal area but it is a competitor.

(c) The increased temperature will increase metabolic rates of benthic microalgae during periods of immersion. In Bridgwater Bay, this increase in metabolic rate would not be compensated by increased photosynthetic rates, as the high turbidity of the water column means that photosynthesis only occurs during periods of emersion. Therefore, the internal respiration of stored metabolites could increase whilst photosynthetically fixed carbon would remain the same. This could lead to a slight loss of algal production; however any effect will be small.

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441 BEEMS Technical Report 029 (BEEMS TR029) : Ecological Characterisation of the inter-tidal Region of Hinkley Point, Severn Estuary: Results from the 2008 Field Survey and Assessment of Risk. Cefas (2009).

442 BEEMS Technical Report 134 (TR134): Review of existing literature on temperature sensitivity in the Baltic telling, *Macoma Balthica.* Final . 2011

The applicant has also looked at the links between birds and infaunal communities and the potential effects of modelled thermal plume discharges (from various discharge locations) on prey availability over Stert Flats (BEEMS TR68A)[443]: This was achieved by mapping the Total Prey Availability, which is a quantitative measure of the quality of the inter-tidal habitat, against the modelled thermal plume at different configurations.

The extents of the mixing zones for a ∆T of 2ºC and a maximum temperature of 21.5ºC as a 98%ile are given for the surface and the sea bed for the SAC and the SPA in Table 2.6.6S6 below. The extents for the SPA give the effective area of intertidal zone affected by the mixing zones. Also included is the total area of the mixing zones, i.e. including that area lying outside the SAC. This data is derived from the model output from GETM, as this model is considered to be more precautionary than the Delft 3D model; i.e. the extents of the mixing zones are greater using GETM than those using Delft 3D. It should also be noted that the mixing zone for the maximum temperature of 21.5ºC as a 98%ile has been determined using a temperature differential of 1.1ºC, based on the fact that the 98%ile of mean monthly temperatures from the Hinkley long-term time series is 20.4ºC.

Table 2.6.6S6 - Extent of mixing zones for a ∆T of 2ºC and a maximum temperature of 21.5ºC as a 98%ile are given for the surface and the sea bed for the SAC and the SPA

	Extent of mixing zone for ∆T of 2ºC (ha)			**Extent of mixing zone for Max Temp of 21.5ºC as a 98%ile (ha)**		
	Total	SAC	SPA	Total	SAC	SPA
Surface	580	573	237	3388	2408	1377
Sea Bed	531	528	307	3277	2452	1510

It should be noted here that the Maximum Temperature target for an SPA in WQTAG Paper 160 is 28ºC and not 21.5ºC, although the lower target has been used here as the Severn Estuary is both a SAC and SPA. If the Severn Estuary was only designated as a SPA, the higher target would apply. In this case the mixing zone is modelled to be 0 ha; ie. the maximum is not exceeded anywhere.

The modelling predicts that the thermal plume will extend onto a section of the inter-tidal mudflat habitat (extent on Stert mudflats remains uncertain). Given the potential impacts to *Macoma* from thermal increases we have to consider the likely response to the habitat and supporting birds. It is likely that a reduction in *Macoma balthica* populations will lead to increased population densities/abundances of gastropods, small worms and meiofauna if they can utilise the algal food which is no longer consumed by a reduced *Macoma balthica* population. In addition, as given in Table 2.6.6S6 above, none of the SPA qualifying or listed bird species in the study area depend principally on *Macoma balthica* as a food source. It is likely that a shift in invertebrate community structure from bivalves to gastropods would not adversely effect the food resource available for any of the bird species.

Another significant part of this assessment is that monitoring of invertebrate populations within and outside the existing Hinkley Point B thermal plume found no 'discernible effects on *Macoma*' (BEEMS TR160)[444]. This was supported by

[443] BEEMS Technical Report 68A (TR68A): Impact of NNB at HP on intertidal food availability for birds
[444] BEEMS Technical Report 160 (TR160): Variability in population structure and condition of *Macoma balthica* along a portion of its geographical range

additional *Macoma balthica* work carried out by the applicant following a request for further information to enable us to carry out our assessment. This work looked at the M*acoma balthica* within the plume of HPB and compared it with that found elsewhere on Steart Flats and within the Severn Estuary. The summary of this work states:

- *In Bridgwater Bay the HPB thermal plume intersects with the lower part of Stert flats but not with Berrow flats. A comparison between the M. balthica populations on Stert and Berrow flats measured in 2008 showed no significant difference in size, age or density between the two populations but with a small number of larger (>10mm) individuals on Berrow flats.*

- *There is no clear correspondence between M. balthica population 'types' (cluster groups) on Stert flats and thermal uplift from HPB for any of the four seasonal surveys undertaken in 2010*

- *Macoma balthica populations are present elsewhere in the Severn Estuary.*

- *The M. balthica population at Hinkley Point does not have the smallest or youngest individuals in the Severn; we have found other populations with different or the same size and age characteristics, with the Hinkley Point population being within the measured range of variability and not at one extreme.*

- *The presence of M. balthica at neighbouring and up-river sites provides the potential for external recruitment to the Steart Flats, in the event of any thermal impacts on Steart flat populations*

Conclusion relating to thermal plume regime
The thermal plume modelling shows that there is likely to be elevated temperature of up to 3°C above ambient on the inter-tidal mudflats and that *Macoma balthica*, an important (but not the only) food source is adversely effected by temperature increases. The points above demonstrate that a small decrease in *Macoma balthica* biomass would not lead to a significant effect on the bird prey availability. In addition, the current discharge of cooling water from HPB is not having an impact on the SPA as Stert Flats which continues to support a significant proportion of the total population of a number of SPA designated species. This suggests that even if HPB is causing an impact on prey, there is sufficient prey to sustain this important prey population.

Given that the HPB discharge is at the low water mark, ie directly adjacent to the inter-tidal habitat, and there is no discernible effect on the SPA population then it is suffice to say that the discharge of cooling water from HPC, which is approximately 1.8km offshore, will also not have an impact. This is demonstrated by looking at the thermal plume modelling which shows the plume areas for HPB and HPC. Even if HPB and HPC (Phase I and II) were to run in parallel the maximum temperatures and temperature differentials experienced by the inter-tidal communities would not increase. It is only the area of impact that increases. Therefore, we can infer that as the HPB plume has not adversely impacted the prey availability for birds within the plume then there will be no adverse impact on prey availability as a result of the HPC development.

Conclusion
We can therefore conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from any changes to the thermal regime as a result of discharges from HPC.

**The applicant has used the MORPH model to identify if bird species will be impacted by a reduction in prey. MORPH is an individual based model developed by Bournemouth University to provide a quantitative approach to estimating population change in shore birds. We have not used the MORPH modelling work in our assessment as we have concerns with its validation. Further discussion on MORPH is provided in Section 2.6.3.7A below.

Overall conclusion

Hazard assessed	Adverse effect on migratory bird and bird assemblage features?
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Overall conclusion	**No adverse effect upon site integrity**

2.6.3.7A The MORPH model

MORPH – taken from the Nicholas Pearson Associates Report 'Hinkley Point C Nuclear Power Station Advice on appropriate Assessment of Permit Applications, December 2011'

Morph is an individual-based model (IBM) developed by Bournemouth University to provide a quantitative approach to estimating population change in shore birds through predicting predator and prey dynamics using the behavioural choices of individual birds and the impacts of these choices on prey populations (BEEMS TR184).

The applicants use of MORPH has provided support to their conclusion on adverse effect on integrity rather than being used to make a conclusion. The work, as summarised in the Final Report to inform the HRA, indicates that the biomass loss from an individual prey species would not lead to any increase in bird mortality. This is largely due to the fact that birds are capable of utilising other prey species that may be present and that the reduction in predicted biomass of *Macoma balthica* is very small in the context of overall prey biomass availability (Royal Haskoning, 2011).

The Environment Agency have taken the decision not to use MORPH to support our conclusions. This is because there are elements of the model that do not lead to quantitative results (some data is seriously deficient and some of the model assumptions are flawed). These elements are listed below:

- the MORPH model has been parameterised with site-specific bird and infauna distribution data. However, bird feeding types have mainly been determined from the literature, rather than based on site-specific information. Some validation has been done from analysis of faecal material, which identifies diet components but does not enable their relative significance to be quantified (Clement Garcia, Cefas, personal communication, 23 November 2011).

- much of the information on *Macoma balthica* thermal sensitivity and population dynamics (growth period, rate etc) is not site-specific and there is a lack of evidence on the long-term cumulative effects of a consistent reduction in growth on *Macoma balthica* (BEEMS TR161[445]). However, the assumptions made in relation to reductions in *Macoma balthica* dry weight as a result of thermal sensitivity (50% on Steart flats and 10% on Berrow Flats) are highly conservative and are considered sufficient to account for all these uncertainties.

- The modelling undertaken for Hinkley Point C did not incorporate Crangon or mysids as bird prey items (Clement Garcia, Cefas, personal communication, 23 November 2011). In this sense the modelling is conservative as Crangon and mysids represent an additional source of potential food. However, they are also competitors in that they feed on other invertebrates. If Crangon numbers increase in response to the thermal plume, competition with the birds for the food source may become greater.

- Consideration has also been given to the sensitivity of the results to changes in input data and assumptions. A decrease in bird resistance would not change the value / sensitivity score, which is already moderate (BEEMS TR161). Thus, the conclusion of the assessment relating to nine of the ten modelled species (dunlin, redshank, shelduck, knot, oystercatcher, grey plover, black-tailed godwit, turnstone and ringed plover) is insensitive to changes in the input parameters.

- The model is considered not to be accurate in relation to curlew because it does not include salt marsh and fields, which are significant feeding areas for this species. Whilst the model predictions of reduced curlew survival are not reliable, there remains uncertainty as to the effect on curlew survival of reducing *Macoma balthica*. The most robust way to address this issue would be to amend the model to include an estimate of food obtained by all species from salt marsh and fields. If the model were re-run, it is likely that the results would show that none of the modelled species are sensitive to thermal or chemical induced changes in food supply resulting from the operation of Hinkley Point C.

- Whimbrel (not modelled) and black-tailed godwit (modelled) are the other large wading species in the assemblage with a similar diet to curlew but a lower dependence on non-modelled food sources. If the model were extended to include salt marsh and fields and curlew were found to be unaffected by reduction in M. balthica, the same conclusion would follow for these two species. It would be worth checking this by including them in a re-run of the model.

- There is also a degree of uncertainty regarding pintail, which was not modelled, despite being one of the species included in the SPA Review for the Severn Estuary. BEEMS TR68A states that the reason for this is: “Not enough intake rate data available concerning wildfowl. Highly omnivorous and opportunistic species, the mudflat is only one among its numerous feeding grounds.” The decision to omit pintail would be reasonable in the light of WEBS data which indicate only small numbers (five year mean of peaks

[445] BEEMS Technical Report 161 (BEEMS TR161): Investigations of the links between inter-tidal macrofauna and their avian predators in Bridgwater Bay with an Individual Based Model

count 22) present in Bridgwater Bay. However, the counts undertaken by Entec (2011) for this project found much higher numbers (peak count 158) within the Hinkley Point study area. As this represents 26.4% of the SPA population and 57% of the threshold for a nationally important population Pintail should have been modelled. Given the dietary preference of this species, it is unlikely that the population would be affected by a reduction in Macoma balthica.

Hazard assessed	**Adverse effect on migratory bird and bird assemblage features?**
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Overall conclusion	**No adverse effect upon site integrity**

3. Combustion activities

3.1 Introduction

Installations which have a combined thermal input in excess of 50 megawatts thermal (MWth) require an Environmental Permit from the Environment Agency (EA) under the Environmental Permitting (England an Wales) Regulations 2010.

The Hinkley Point C Installation requires a permit and consists of twelve back-up diesel generators which have a combined net thermal input of 176 MWth, associated fuel storage tanks and interconnecting pipework. The generators will be housed in four purpose built concrete buildings each containing two 18.5 MWth Essential Diesel Generators (EDG) and one 7 MWth Station Blackout Diesel Generator (SBO).

The diesel generators are safety classified standby equipment and will only be operated in the event of a power failure and during periodic testing.

This assessment will consider whether the installation can be identified as likely to have a significant effect on the interest features of the Severn Estuary/Môr Hafren SPA, SAC and Ramsar and the Exmoor Quantock Oakwoods SAC, and in combination with any relevant plans or projects in the context of prevailing environmental conditions.

The Severn Estuary/ Môr Hafren SPA , SAC and Ramsar site boarders the proposed Hinkley C development area. The Exmoor Quantock Oakwoods SAC is approximately 6.7 km from the site boundary.

3.2 Generic sensitivity matrix

Table 3.2.1. Generic sensitivity matrix for the Severn Estuary/ Môr Hafren SPA, SAC and Ramsar sites in relation to Combustion activity.

Hazard	Habitat Groups		Species Groups	Bird Species Groups		
	Estuarine & intertidal habitats (1.12)	Submerged marine habitats (1.13)	Migratory fish (2.5)	Birds of lowland freshwaters and their margins (3.6)	Birds of coastal habitats (3.8)	Birds of estuarine habitats (3.9)
Toxic Contamination	✔	✔	✔	✔	✔	✔
Nutrient Enrichment	✔	✔	✔	✔	✔	✔
Acidification			✔			
Changes in Salinity Regime	✔	✔	✔	✔	✔	✔
Changes in Thermal Regime	✔	✔	✔	✔	✔	✔
Habitat Loss	✔		✔	✔	✔	✔
Physical Damage by combustion processes	✔	✔	✔	✔	✔	✔
Smothering	✔			✔	✔	✔
Turbidity	✔	✔	✔	✔	✔	✔
Siltation	✔	✔	✔	✔	✔	✔
Entrapment			✔		✔	✔
Noise and vibration Disturbance				✔	✔	✔

✔ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

Table 3.2.2. Generic sensitivity matrix for the Exmoor Quantock Oakwoods SAC site in relation to Combustion activity.

Hazard	Habitat Groups		Species Groups	
	Fens and wet habitats (1.1)	Woodlands (1.6)	Mammals of wooded habitats (2.8)	Mammals of riverine habitats (2.9)
Toxic Contamination	✔	✔	✔	✔
Nutrient Enrichment	✔	✔	✔	✔
Acidification	✔	✔	✔	✔
Changes in Salinity Regime	✔			✔
Changes in Thermal Regime	✔			✔
Habitat Loss	✔	✔	✔	✔
Physical Damage by combustion processes	✔	✔	✔	✔
Smothering	✔	✔	✔	
Turbidity	✔			
Siltation	✔			
Entrapment				✔
Noise and vibration Disturbance			✔	✔

✔ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

Note: These matrices are not comprehensive and are based on the judgment of staff in the Environment Agency, NE and CCW. There may be other hazards and sensitivities which will vary according to circumstances.

3.3 Potential hazards from the combustion activity

The main hazards from the combustion activity of the emergency diesel generators will be produced through emissions to air. Effects of air quality emissions, including long-range deposition from Environment Agency regulated sources, need to be considered. Releases of sulphur oxides (SO_x) and oxides of nitrogen (NO_x) are of particular concern in relation to European sites.

Table 3.2.3 below shows the likely hazards from the combustion activity and the mechanism by which the hazards could impact upon designated habitats.

Table 3.2.3. Contaminants and hazards matrix for Hinkley Point Combustion permission

	Toxic contamination (aerial emissions)	**Nutrient enrichment**	**pH**	**Smothering**	**Noise and vibration**	**Organic enrichment**
Emissions to air						
Oxides of Sulphur (SO_x)		✓	✓			
Oxides of Nitrogen (NO_x)		✓	✓			✓
Noise impacts						
Disturbance					✓	

3.4 Interest features sensitive to the hazard

Whilst the generic sensitivity matrices give us an idea of which features could be sensitive to the hazards, the species and habitats groups are very generalized and the hazards are based on a generic list.

In order to give us an understanding of specific sensitivities of the designated sites features, the habitat and species groups have been expanded and hazards have been defined with relevance in the form of a potential exposure assessment. The results of this assessment have been tabulated and can be found in Appendix 4.

<u>Summary</u>

In the potential exposure assessment of the Severn Estuary/Môr Hafren SPA, SAC and Ramsar for the **Environmental Permit for combustion activity, operational phase**, the following species and habitats are to be assessed:

- Estuaries
- Atlantic salt meadows /saltmarsh
- Intertidal mud and sand flats
- Subtidal sandbanks
- Reefs
- Shad
- Lamprey
- Salmonids
- Eel
- Geese/swans
- Ducks
- Waders

The above species and habitats are assessed against the following hazards:

- Toxic contamination
- Nutrient enrichment

- Acidification
- Smothering
- Noise disturbance

In the potential exposure assessment of Exmoor Quantock Oakwoods SAC for the **Environmental Permit for combustion activity**, **operational phase**, the following species and habitats are to be assessed:

- Alluvial forests
- Old sessile Oakwoods
- Bats
- Otters

The above species and habitats are assessed against the following hazards:

- Toxic contamination
- Nutrient enrichment
- Acidification
- Smothering
- Noise disturbance

3.5 Assessment methodology

Emissions to air

A benchmark of 1% of the relevant Environmental Quality Standards (EQS) will be used to assess aerial emission impacts.

The long term process contribution 1% threshold is based on the judgements that it is unlikely that an emission at this level will make a significant contribution to air quality since process contributions will be small in comparison to background levels, even if a standard is exceeded. The proposed 1% threshold is two orders of magnitude below the standard and provides a substantial safety margin to protect health and the environment.

Since the National Air Quality Objectives for the protection of vegetation and ecosystems are expressed in terms of annual average concentrations, the assessment has been made on the long-term predicted air concentrations of NO_x and SO_2 from the installation at the relevant ecological receptor locations.

The main emissions to air are via exhaust stacks approximately 30 metres in height. The combustion gases contain particulates and oxides of sulphur, nitrogen and carbon. For this assessment the relevant emissions are oxides of sulphur and nitrogen.

The following guidance will be used to assess air emission impacts:

- Stage 1 and 2 assessment of new Process Industry Regulation (PIR) permissions under the Habitats Regulations – *Operational Instruction 251_06,*

- Environment Agency paper **AQTAG06** – *Technical Guidance on a detailed modelling approach for an appropriate assessment for emissions to air,*
- Environment Agency paper **AQTAG 14** Guidance on identifying 'relevance' for assessment under the Habitats Regulations for PPC installations with combustion processes,
- Information on Ambient concentration of SO_x and sulphur dioxide and can be obtained from www.airquality.co.uk using SO_2 2001 data adjusted to predicted 2005 values,
- Information on Ambient concentration of NO_x and nitrogen dioxide and can be obtained from www.airquality.co.uk using predicted 2010 data,
- Information on annual averages for the protection of vegetation deposition – www.apis.ac.uk (2003 data) and EA Critical Load Database.

Noise Impacts

Noise from the diesel generators is not expected to be significant in the long term due to their intermittent operation and location within concrete buildings. However the short tem impacts of intermittent operation require assessment with respect to any potential effect on birds and mammals.

The following guidance will be used to assess noise disturbance impacts:

- Environment Agency paper **AQTAG09** - *Guidance on the effects of industrial noise on wildlife,*
- Environment Agency paper **AQTAG10** – *Agency's background statement on the effects of industrial noise on wildlife,*
- Construction and Waterfowl: Defining Sensitivity, Response, Impacts and Guidance - Institute of Estuarine and Coastal Studies University of Hull[446],
- Other desk based studies.

Assessment Scenarios

This assessment considers the following three operational Scenarios:

<u>Commissioning scenario</u>
This scenario recognises that only one EDG or SBO is likely to be in operation at any one time. The scenario uses emission rates from the EDG as these represent the worst case.

Long term impacts have been assessed on the basis of 4,892 operational hours over one year. This represents 8 EDGs operated for 242.5 hours each and 4 SBOs operated for 738 hours each per year.

[446] Cutts, N. Phelps, A. & Burdon, D. (2009) Construction and Waterfowl: Defining Sensitivity, Response, Impacts and Guidance, Institute of Estuarine and Coastal Studies University of Hull. Report: ZBB710-F-2008

Short term impacts are assessed on the basis that one EDG is operated continuously throughout the year.

Routine testing scenario
This scenario covers operation of the plant for maintenance and periodic safety tests and involves only a single generator operating at any one time.

Long term impacts have been assessed on the basis of 720 operational hours over one year. This represents 8 EDGs operated for 60 hours each per year.

Short term impacts are assessed on the basis that one EDG is operated continuously throughout the year.

LOOP scenario
This scenario covers an event resulting in loss of off-site power for 24 hours. This would result in the 8 EDGs operating for 25 hours. The scenario does not include operation of SBOs as these would only operate if the EDGs failed to start. The EDG's relative to the SBO's are the worst case scenario. No further assessment required.

3.6 Assessment of impacts

The predicted process contributions (PC) and predicted environmental concentrations (PEC) at the habitats sites are detailed below for each scenario.

In line with the Air Quality Modelling Assessment Unit (AQMAU) guidance the Air Dispersion Modelling used the "worst case scenario" approach in determining the conversion rate of NO_x to NO_2 that is 35% conversion for short term assessments and 70% conversion for long term assessments.

3.6.1 Initial Assessment

Commissioning scenario

Long term NO_2 : Severn Estuary SPA, SAC and Ramsar
The PC is 11.7ug/m^3 and the PEC is 23.2ug/m^3 which are 39% and 77% of the 30 ug/m^3 Air Quality Standard (AQS) respectively. Using the criteria of <1% for PC or <70% for PEC as having no likely significant effect, the emissions of NO_2 require further assessment. This is explained further in the appropriate assessment in section 3.6.2.

Short term NO_2: Severn Estuary SPA, SAC and Ramsar
The PC is >10% of the short term Environmental Assessment Level (EAL) of 75ug/m^3. The PEC is 230ug/m^3 which is 307% of the EAL. Therefore there is a likely significant effect and the short term emissions of NO_2 require further assessment. This is explained further in the appropriate assessment in section 3.6.1.1.

Long term NO_2: Exmoor and Quantock Oakwoods SAC
The SAC is 6.7km from the emission points. The isopleths supplied in the detailed air dispersion modelling show that the PC is below 0.5 ug/m^3 within 1.2km of the emission points. Given the distance of the SAC from the emission point we conclude

that the PC will be <1% and that there will be no likely significant effect. No further assessment is required.

Emissions of sulphur dioxide (SO_2) : Severn Estuary SPA, SAC and Ramsar
The PC is 1.1ug/m^3 and the PEC is 2.9ug/m^3 which are 5.7% and 14.7% of the 20 ug/m^3 AQS respectively. Using the criteria of <70% for PEC as having no likely significant effect. No further assessment is required.

Emissions of sulphur dioxide (SO_2): Exmoor and Quantock Oakwoods SAC
The Exmoor and Quantock Oakwoods SAC is 6.7km from the emission points compared with Severn Estuary SPA, SAC and Ramsar which is 0.3km from the emission points. We can therefore conclude that the PC will be <1% and the PEC <70% therefore there will be no likely significant effect. No further assessment required.

Subsequent information received on 31/10/11 as a response to a Schedule 5 Notice confirmed that emissions of sulphur dioxide will be 66 mg/m^3 based on fuel complying with The Sulphur Content in Liquid Fuels (England and Wales) Regulations 2007. The initial modelling was based on an emission of 182 mg/m^3 therefore the predicted impact detailed above will be further decreased. The PC is reduced to 0.25ug/m^3 and the PEC is 2.05ug/m^3 which is 10.3% of the AQS. We conclude that there will be no likely significant effect. No further assessment required.

Nutrient enrichment and acidification Severn Estuary SPA, SAC and Ramsar
The maximum nitrogen and acid deposition rates are predicted as 1.71kg N ha^{-1} y^{-1} and 0.26keq ha^{-1} y^{-1} respectively. The Severn Estuary SPA is not sensitive to nutrient nitrogen deposition however the SAC contains Salt meadows that have a critical load of 20 to 30kg N ha^{-1} y^{-1}. The predicted deposition equates to 8.6% of the lower critical load value and can not be regarded as insignificant. However taking the existing background deposition level from APIS of 13kg N ha^{-1} y^{-1} into consideration the predicted PEC is less than the lower critical level and therefore we conclude that there will be no likely significant effect. No further assessment required.

The Severn Estuary SPA, SAC and Ramsar is not sensitive to acid deposition so no assessment is required.

Nutrient enrichment and acidification: Exmoor and Quantock Oakwoods SAC
The Exmoor and Quantock Oakwoods SAC is 6.7km from the emission points compared to the Severn Estuary SPA, SAC, RAMSAR which is 0.3km from the emission points. The model predicts lower nitrogen deposition rates at the Exmoor and Quantock Oakwoods SAC than at the Severn Estuary. We conclude that there will be no likely significant effect. No further assessment required.

Acidification potential at the Exmoor and Quantock Oakwoods SAC can be extracted from the isopleths maps supplied with the Air Quality Modelling report. Total acid deposition is predicted at <0.1keq ha^{-1} y^{-1} which is less than the critical load. Therefore we conclude that there will be no likely significant effect. No further assessment required.

Routine testing scenario

Long term NO_2: Severn Estuary SPA, SAC, and Ramsar

The PC is 1.75ug/m^3 and the PEC is 13.25ug/m^3 which are 5.8% and 44.2% of the 30 ug/m^3 Air Quality Standard (AQS) respectively. Therefore as the PEC is <70% of the AQS we conclude that there will be no likely significant effect. No further assessment required.

Short term NO_2: Severn Estuary SPA, SAC, and Ramsar
The PC is >10% of the short term Environmental Assessment Level (EAL) of 75ug/m^3 and the PEC is 230ug/m^3 which is 307% of the EAL. There is a likely significant effect and the short term emissions of NO_2 require further assessment. This is explained further in the appropriate assessment in section 3.6.2.

Long term NO_2 Exmoor and Quantock Oakwoods SAC
The Exmoor and Quantock Oakwoods SAC is 6.7km from the emission points compared to the Severn Estuary SPA,SAC and RAMSAR which is 0.3km from the emission points. As the PEC is <70% of the AQS at the Severn Estuary we therefore conclude that there will be no likely significant effect at the Exmoor and Quantock Oakwoods SAC. No further assessment is required.

Emissions of sulphur dioxide (SO_2): Severn Estuary SPA, SAC and Ramsar
The PC is 0.17ug/m^3 and the PEC is 1.97ug/m^3 which are 0.85% and 9.85% of the 20 ug/m^3 AQS respectively. Therefore as the PC is <1% and the PEC is <70% of the AQS we conclude that there will be no likely significant effect. No further assessment required.

Emissions of sulphur dioxide (SO_2): Exmoor and Quantock Oakwoods SAC:
The Exmoor and Quantock Oakwoods SAC is 6.7km from the emission points compared to the Severn Estuary SPA,SAC and RAMSAR which is 0.3km from the emission points. We conclude that the PC will be <1% and the PEC <70% therefore there will be no likely significant effect.

Subsequent information received on 31/10/11 as a response to a Schedule 5 Notice confirmed that emissions of sulphur dioxide will be 66 mg/m^3 based on fuel complying with The Sulphur Content in Liquid Fuels (England and Wales) Regulations 2007. The initial modelling was based on an emission of 182 mg/m^3 therefore the predicted impact detailed above will be further decreased. The PC is reduced to 0.06ug/m^3 and the PEC is 1.85ug/m^3 which is 9.3% of the AQS and we conclude that there will be no likely significant effect.

Nutrient enrichment and acidification: Severn Estuary SPA, SAC and Ramsar
The maximum nitrogen and acid deposition rates are predicted as 0.25kg N ha^{-1} y^{-1} and 0.04keq ha^{-1} y^{-1} respectively and we conclude that as this is less than that shown in the Commissioning Scenario above which has screened out therefore there will be no likely significant effect. No further assessment is required.

The Severn Estuary SPA,SAC and Ramsar is not sensitive to acid deposition so no assessment is needed.

Nutrient enrichment and acidification: Exmoor and Quantock Oakwoods SAC
The Exmoor and Quantock Oakwoods SAC is 6.7km from the emission points compared to the Severn Estuary SPA, SAC and RAMSAR which is 0.3km from the emission points. The model predicts lower deposition rates than at the Severn Estuary which screens out. We conclude that there will be no likely significant effect. No further assessment required.

Acidification potential at the Exmoor and Quantock Oakwoods SAC can be extracted from the isopleths maps supplied with the Air Quality Modelling report and total acid deposition is predicted at <0.1keq ha^{-1} y^{-1} which is less than the critical load therefore we conclude that there will be no likely significant effect.

LOOP Scenario

Long term NO_x
The total operational hours for the LOOP scenario are 200 compared to the 4,892 hours for the Commissioning and 720 hours for the Routine Testing scenarios. Therefore any assessment will be covered by the Commissioning and Routine Testing scenarios. In addition annual mean concentrations resulting from LOOP events would be unlikely to contribute significantly on an annual average basis due to their short term nature. Therefore we conclude that there will be no likely significant effect.

Short term NO_2
The PC is >10% of the short term Environmental Assessment Level (EAL) of 75ug/m^3 and the PEC is 956ug/m^3 which is 1275% of the EAL. There is a likely significant effect and the short term emissions of NO_2 require further assessment. This is explained further in the appropriate assessment in section 3.6.2.

Summary
The initial assessment concluded that:

- In the Commissioning scenario the long and short term emissions of NO_x with respect to the Severn Estuary SPA, SAC, and RAMSAR are above the screening criteria; and
- In the Routine Testing scenario the short term emissions of NO_x in respect of the Severn Estuary SPA, SAC and RAMSAR are above the screening criteria.

3.6.1.1 Amended Initial assessment - after receipt of further information

This section will only detail those emissions which where found to require further assessment in section 3.6.1 Initial assessment, commissioning scenario)

The scenarios detailed above represent the worst case. In reality the hours of operation and actual ground level concentrations would be expected to be less adverse.

In the commissioning scenario it has been assumed that all generator testing will take place on site but in reality it is expected that annual commissioning hours will be less than predicted as some testing will occur prior to delivery of the generators and will bring the long term PEC below the 70% screening criteria. Further information concerning the commissioning hours received on 02/02/12 by e-mail and by post on 21/03/12 confirmed that the actual hours are likely to be in the order of

EDGs: 287 hours each (x 8 EDGs = 2,296 hours)
SBOs: 247 hours each (x 4 SBOs = 998 hours)

Total: 2,296 + 998 = **3, 294 hours** compared to the previous figure of **4,892** hours.

It should be noted that this is still a conservative figure as:

1) There may be scope for more testing to take place at the manufacturers site - this will be investigated during the procurement process.

2) It is likely that the commissioning process will take longer than 12 months (this is a conservative estimate) so the number of hours operated over a 12 month period is likely to be lower than stated here. This information will be reviewed during the procurement and design processes.

Commissioning scenario

Emissions of nitrogen dioxide (NO_2)

Long term

By applying the revised operating hours to the modelling inputs the PEC for NO_2 is 64.7% of the AQS which is below the significance screening threshold of 70%. No further assessment is required.

Short term

By applying the revised operating hours to the modelling inputs the PEC for NO_2 is 66ug/m^3 which is below the AQS. No further assessment is required.

Routine Testing scenario

Short term

By applying the revised operating hours to the modelling inputs the PEC for NO_2 is 66ug/m^3 which is below the AQS. No further assessment is required.

Summary

The amended initial assessment concluded that:

- In the Commissioning scenario the long and short term emissions of NO_2 with respect to the Severn Estuary SPA, SAC, and RAMSAR require no further assessment.
- In the Routine Testing scenario the short term emissions of NO_2 in respect of the Severn Estuary SPA, SAC and RAMSAR require no further assessment.

3.6.2 Appropriate Assessment

The scenarios detailed above represent the worst case. In reality the hours of operation and actual ground level concentrations would be expected to be less adverse.

The LOOP scenario is highly unlikely and represents the operation of the generators in the event of total power failure and is designed to prevent radioactive releases. This will result in short term emissions of NO_x above the EAL.

However the main risk of NO_x to the environment would be likely to be through its contribution to total nitrogen deposition (acidification and nutrient enrichment) to the habitats and vegetation rather than from aerial concentrations directly. Any impacts on the designated birds will be indirect through influences on plant and animal food sources, vegetation composition and cover, associated mainly with nutrient enrichment. The modelling has shown that nutrient N deposition is insignificant at the Severn Estuary for the three scenarios.

The above view is supported by information in the Air Pollution Information System and the 2001 report – Transboundary Air Pollution: Acidification, Eutrophication and Ground Level Ozone in the UK. However, considering aerial NO_x further as a precautionary approach, this report also mentions that direct effects of gaseous nitrogen oxides may also be important, especially in areas close to source. Moderate concentrations of NOx may produce both positive and negative growth responses, and there is also the potential for synergistic interactions with SO_2, the effects of NO_x being more likely to be negative in the presence of equivalent concentrations of SO_2. This is not the situation with the current proposal – the SO_2 level at the nearest point of the European site (obtained from the Air Pollution Information System) is 10.3% (Commissioning Scenario) of the EAL for the protection of vegetation (20 µg/m³). The report also identifies an influence of NO_x on insect populations, the performance of insect pests such as aphids being improved on plants grown in moderate concentrations of NO_2 and of SO_2. This effect is not considered relevant to the features of interest at the European site.

In summary, it is considered that the nutrient effect resulting from deposition of NO_x remains the strongest effect of NO_x emissions. Nitrogen deposition resulting in both acidification and nutrient enrichment, has already been assessed as not significant (see above), and no further assessment is considered necessary.

Noise Impact

The applicant submitted a detailed noise modelling report (reference NNB-OSL-RIO-000132 Appendix D) in response to a Schedule 5 Notice on 27/10/11. The report predicted the worst case noise emission levels from the operation of the emergency diesel generators. The report assumed that four of the eight EDGs and two of the four SBOs were in operation.

The modelling study utilised Cadna A Noise Prediction Model (Version 4) software and noise propagation calculations were undertaken in accordance with the International Standards Organisation guidance document ISO 9613: Part2:1966. The model incorporated the local topography, metrological conditions and existing and proposed buildings. Our Air Quality and Modelling Assessment Unit (AQMAU) audited the noise modelling submitted by the applicant and concluded that the consultant's conclusions relating to noise impacts due to generator operations can be used as a basis for permit determination.

The model predicted that beyond the site boundary the sound pressure from the generator buildings would not exceed 33dB $L_{Aeq,T.}$ and at the coastal footpath it predicted that the sound pressure level from the generators would not exceed 19dB $L_{Aeq,T}$. The results of the model indicated that even under worst case meteorological conditions (downwind) the operation of the generators would be inaudible at the foreshore and would have no likely significant effect on wintering birds using the intertidal zone.

We accept the Applicants conclusions and agree that noise either prolonged or intermittent will not have any significant effects on the habitats sites and further assessment is not considered necessary.

Conclusion

The operation of the diesel generators is not likely to have a significant effect on the interest features of the Severn Estuary/Môr Hafren SPA, SAC and Ramsar and the Exmoor Quantock Oakwoods SAC.

4. Environmental permits for radioactive substances activities

4.1 Introduction

During operation of Hinkley Point C (HPC), radioactive waste will be produced by activities either directly or indirectly associated with operating and maintaining the HPC reactors and ultimately from decommissioning the plant. As a result of all stages of operation of the site, during start up and operation at power and shutdown for refuelling of each reactor, the HPC site will produce:

- Liquid radioactive discharge;
- Gaseous radioactive discharge.

Liquid radioactive discharges are produced from effluents associated with systems for collecting and treating primary circuit water, fuel pool purification systems, operation of a radioactive laundry facility on site and washings from plant decontamination. After treatment to reduce the radioactive content of the effluent, it is sampled and monitored prior to final discharge to the sea in combination with water from the cooling water system. It is therefore subject to considerable dilution before entering the sea.

Gaseous radioactive waste is produced from de-gassing the water in the primary circuit of each reactor, with the off-gas treated by processing systems to reduce the radioactive content. Gaseous waste is also produced from maintenance and operations in building areas containing loose radioactive contamination. These areas are serviced by ventilation systems which filter the radioactive content of the waste before discharge to the atmosphere through dedicated stacks. Discharges from the stacks are continuously sampled and monitored.

The treatment of gaseous and liquid wastes and maintenance of radioactive plant and equipment produces solid radioactive waste. This includes spent ion exchange resins, spent filter media, worn-out components, contaminated protective clothing and tools, rags and waste oil. Some of these waste will be Low level Waste and be disposed of by transfer to treatment or disposal sites.

A Radioactive Substances Activities environmental permit will be required for the liquid and gaseous radioactive discharges for the operational phase.

Irradiated spent fuel and Intermediate Level Waste will require interim storage prior to disposal will be stored in secure facilities on the HPC site, These wastes are subject to control under the Nuclear Installations Act 1965 (as amended) and are not subject to Environmental Permits until the suitable disposal facilities become available. They are outside the scope of this HRA.

4.2 Generic sensitivity matrix

Table 4.2.1 *Generic sensitivity matrix for the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar sites in relation to RSR activity.*

Hazard	Habitat Groups		Species Groups	Bird Species Groups		
	Esturine and intertidal habitats (1.12)	Submerged marine habitats (1.13)	Migratory fish (2.5)	Birds of lowland freshwaters and their margins (3.6)	Birds of coastal habitats (3.8)	Birds of estuarine habitats (3.9)
Toxic Contamination (aqueous)	✔	✔	✔	✔	✔	✔
Toxic Contamination (air)	✔	✔	✔	✔	✔	✔
Acidification			✔	✔		
Changes in Salinity Regime	✔	✔	✔	✔	✔	✔
Changes in Thermal Regime	✔	✔	✔	✔	✔	✔
Habitat Loss	✔		✔	✔	✔	✔
Physical Damage by IPC/PPC processes	✔	✔	✔	✔	✔	✔
Smothering	✔			✔	✔	✔
Turbidity	✔	✔	✔	✔	✔	✔
Siltation	✔	✔	✔	✔	✔	✔
Entrapment			✔	✔	✔	✔
Noise and vibration Disturbance				✔	✔	✔

✔ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

Table 4.2.2 *Generic sensitivity matrix for the Exmoor Quantock Oakwoods SAC site in relation to RSR activity.*

Hazard	Habitat Groups		Species Groups	
	Fens and wet habitats (1.1)	Woodlands (1.6)	Mammals of wooded habitats (2.8)	Mammals of riverine habitats (2.9)
Toxic Contamination	✔	✔	✔	✔
Nutrient Enrichment	✔	✔		✔
Acidification	✔	✔		✔
Changes in Salinity Regime	✔			✔
Changes in Thermal Regime	✔			✔
Habitat Loss	✔	✔	✔	✔
Physical Damage by IPC/PPC processes	✔	✔	✔	✔
Smothering	✔	✔	✔	
Turbidity	✔			
Siltation	✔			
Entrapment				✔
Noise and vibration Disturbance				✔

✔ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

Note: These matrices are not comprehensive and are based on the judgment of staff in the Environment Agency, NE and CCW. There may be other hazards and sensitivities, which will vary according to circumstances.

4.3 Potential hazards from Radioactive Substances

The only hazards likely to impact as a result of the RSR activity are listed in the table below:

Table 4.3 - *Contaminants and hazards matrix for Hinkley Point RSR permission*

Radionuclide	HAZARD	
	Radiological Impact from discharges to air	Radiological Impact from discharges to water
Tritium (H-3)	✔	✔
Carbon-14 -(C-14)	✔	✔
Sulphur-35 (S-35)	✔	✔
Argon-41 (Ar-41)	✔	
Cobalt-58 (Co -58)C)	✔	✔
Cobalt-60 (Co-60)	✔	✔
Caesium-134 (Cs- 134)	✔	✔
Caesium-137 (Cs-137)	✔	✔
Iodine-131 (I-131I)	✔	✔
Iodine-133 (I-133)	✔	✔
Krypton-85 (Kr-85)	✔	
Xenon-133 (Xe-133)	✔	
Xenon-135 (Xe-135)	✔	
Xenon-131m (XeM-131)	✔	

4.4 Interest features sensitive to the hazard

For the potential exposure assessment for the Severn Estuary/Môr Hafren SAC/SPA/Ramsar for the **Environmental Permit for Radioactive Substances Activities** , the following species and habitats are to be assessed :

- *Atlantic salt meadows /saltmarsh;*
- *Reefs;*
- *Migratory fish;*
- *Fish assemblage;*
- *Internationally important populations of regularly occurring migratory species;*
- *Internationally important assemblage of waterfowl (>20,000) (under Article 4.2 of EU Birds Directive).*

Against the following hazards:

- Radiological impact from discharges to air;
- Radiological impact from discharges to water.

For the potential exposure assessment for the Exmoor Quantock Oakwoods SAC for the **Environmental permit**, the following species and habitats are to be assessed:

- Alluvial forests;
- Old sessile oakwoods;
- Bats;
- Otter.

Against the following hazards:

- Radiological impact from discharges to air;
- Radiological impact from discharges to water.

4.5 Assessment methodology

Guidance and methods to be used:

- OI 338_04 RSR permitting: Prospective radiological assessments for human health and wildlife (habitats);
- Environment Agency - Impact Assessment of Ionising Radiation on Wildlife RD 128;
- European Commission D-ERICA An Integrated approach to the assessment and Management of environmental risks from ionising radiation.

Four different representative habitats where species may be found will be used for the assessment and include:

- Habitat 1 – Terrestrial;
- Habitat 2 – Marine;
- Habitat 3 – Coastal;
- Habitat 4 – Freshwater;

The impact of discharges from Hinkley Point C and the combined impact of discharges from Hinkley A, B and C will be considered.

4.6 Assessment

We commissioned SKM Enviros to review and audit the habitat information in respect of potential impact of radionuclide discharges on the Severn Estuary habitat submitted to us by NNB GenCo in support of their applications for an EPR permit for radionuclide discharges to air and water.
This independent review and audit takes account of the discharge information, design and the site-specific information, provided by NNB GenCo in their submission. The aim of the independent assessment was to:

- Review and validate the assumptions made by NNB GenCo in their dose assessments;
- Verify and confirm the outcomes of the dose assessments made by NNB GenCo;
- Carry out independent dose assessments for a representative selection of Habitat features to verify the dose assessment calculations carried out by NNB GenCo are realistic.

4.6.1 Build up of radionuclides from atmospheric discharges

The results of the assessment of the build up of radionuclides from atmospheric discharges carried out by SKM Enviros were of a similar order of magnitude and generally within rounding differences of those reported by NNB GenCo for both Hinkley Point C and the total discharges from all three power stations at Hinkley Point. The predicted resultant concentrations of radionuclides in the environment from the assessments are summarised in Table 4.6S1 below

Table 4.6S1. - *Summary of verification assessment and NNB GenCo estimates of build-up of radionuclides in the environment due to atmospheric discharges from Hinkley Point C and all three power stations at Hinkley Point (Bq/m3 for air concentration; Bq/kg for soil concentration)*

Radionuclide	Repeat Assessment Results				NNB GenCo Results			
	Hinkley Point C		Hinkley Point A, B & C		Hinkley Point C		Hinkley Point A, B & C	
	Air conc (Bq/m3)	Soil Conc (Bq/kg)	Air conc (Bq/m3)	Soil Conc (Bq/kg)	Air conc (Bq/m3)	Soil Conc (Bq/kg)	Air conc (Bq/m3)	Soil Conc (Bq/kg)
Co-58	3.69E-06	9.00E-05	3.69E-06	9.00E-05	3.60E-06	8.80E-05	3.60E-06	8.80E-05
Co-60	4.35E-06	2.35E-03	2.70E-05	1.46E-02	4.30E-06	2.30E-03	2.70E-05	1.50E-02
I-131	2.19E-05	5.05E-04	4.89E-05	1.13E-03	2.10E-05	4.80E-04	4.80E-05	1.10E-03
I-133	2.63E-05	6.34E-05	2.63E-05	6.34E-05	2.60E-05	6.30E-05	2.60E-05	6.30E-05
Cs-134	3.39E-06	7.80E-04	3.39E-06	7.80E-04	3.30E-06	7.60E-04	3.30E-06	7.60E-04
Cs-137	3.04E-06	7.11E-03	3.04E-06	7.11E-03	3.00E-06	5.90E-03	3.00E-06	5.90E-03
S-35	0.00E+00	0.00E+00	6.50E-03	1.99E-01	0.00E+00	0.00E+00	6.50E-03	2.10E-01

These results were then used to determine the dose exposure of specific habitat features (see below)

4.6.2 Build up of radionuclides due to water discharges

The build up of radionuclides in sediment and unfiltered seawater as a result of radionuclide content of water discharges from the site were assessed using the same approach as outlined in the NNB GenCo submission. The results obtained are in agreement with the activity concentrations reported by NNB GenCo for both Hinkley Point C and for all three power stations at Hinkley Point.

Table 4.6S2. - *Summary of verification assessment and NNB GenCo estimates of build-up of radionuclides in the environment due to liquid discharges from Hinkley Point C and all three power stations at Hinkley Point (Bq/l for water; Bq/kg for sediment)*

	Repeat Assessment Results				NNB GenCo Result			
	Hinkley Point C		Hinkley Point A, B & C		Hinkley Point C		Hinkley Point A, B & C	
Radionuclide	water	sediment	water	sediment	water	sediment	water	sediment
H-3	1.56E+00	1.07E+00	8.35E+00	5.68E+00	1.57E+00	1.07E+00	8.38E+00	5.69E+00
C-14	1.99E-03	1.19E-01	1.99E-03	1.19E-01	2.00E-03	1.19E-01	2.00E-03	1.19E-01
S-35	0.00E+00	0.00E+00	1.78E-02	4.81E-03	0.00E+00	0.00E+00	1.78E-02	4.82E-03
Cr-51	8.26E-07	5.29E-07	8.26E-07	5.29E-07	8.28E-07	5.28E-07	8.28E-07	5.28E-07
Mn-54	5.34E-06	4.02E-05	5.34E-06	4.02E-05	5.34E-06	4.03E-05	5.34E-06	4.03E-05
Co-58	3.56E-05	6.20E-05	3.56E-05	6.20E-05	3.56E-05	6.20E-05	3.56E-05	6.20E-05
Co-60	6.20E-05	2.55E-03	1.65E-04	6.80E-03	6.20E-05	2.56E-03	1.65E-04	6.38E-03
Ni-63	2.01E-05	3.60E-03	2.01E-05	3.60E-03	2.01E-05	3.60E-03	2.01E-05	3.60E-03
Ag-110m	1.12E-05	1.17E-05	1.12E-05	1.17E-05	1.12E-05	1.17E-05	1.12E-05	1.17E-05
Sb-124	8.20E-06	2.10E-06	8.20E-06	2.10E-06	8.21E-06	2.10E-06	8.21E-06	2.10E-06
Sb-125	1.68E-05	6.62E-05	1.68E-05	6.62E-05	1.68E-05	6.60E-05	1.68E-05	6.60E-05
Te-123	2.16E-20	5.85E-18	2.16E-20	5.85E-18	2.16E-20	5.86E-18	2.16E-20	5.86E-18
Te-123m	4.80E-06	2.44E-06	4.80E-06	2.44E-06	4.81E-06	2.44E-06	4.81E-06	2.44E-06
Te-125m	1.05E-06	6.56E-05	1.05E-06	6.56E-05	1.05E-06	6.55E-05	1.05E-06	6.55E-05
I-131	3.87E-07	4.47E-09	3.87E-07	4.47E-09	3.89E-07	4.46E-09	3.89E-07	4.46E-09
Cs-134	1.15E-05	7.71E-05	8.00E-03	5.37E-02	1.15E-05	7.73E-05	8.00E-03	5.39E-02
Cs-137	1.98E-05	9.89E-04	1.15E-02	5.77E-01	1.98E-05	9.88E-04	1.15E-02	5.75E-01

These results were then used to determine the dose exposure of specific habitat features (see below)

4.6.3 Calculation of dose exposure for specific habitat features.

The doses from expected short-term releases, the potential impact of build-up of radionuclides in the environment and of dose rates to representative non-human biota were evaluated as part of this audit. These assessments of dose exposure for specific habitat features were undertaken using the ERICA Tool (May 2009 version) and the Environment Agency's R&D 128 assessment procedure for wildlife.

The NNB GenCo assessment of dose rates to representative non-human biota from maximum annual atmospheric and liquid discharges were repeated. The results were close to those presented by NNB GenCo, although there were some minor differences in the predicted dose rates to terrestrial organisms.

The assessment by SKM Enviros also included an assessment of :
(i) the total dose arising from future operations and decommissioning activities at Hinkley Point A, B and C stations and from historic operations at Hinkley Point and from other radionuclide sources in the area.
(ii) the dose rates to non-human biota from maximum annual atmospheric and liquid discharges, on the basis of a range of reference organisms in the terrestrial and marine environments.

The dose rates to the limiting organisms in these environments were predicted to be 0.007 and 0.008 μGy/h. These doses are about 4000 times lower than those at which effects on organisms would start to occur.

The dose rates calculated by the assessments are summarised in Table 4.6S3 below.

Table 4.6S3 - *Summary of verification assessment and NNB GenCo estimates of risk quotients and dose rates to the limiting reference organisms from atmospheric and liquid discharges from Hinkley Point C and all three power stations at Hinkley Point (µGy/h)*

		SKM Enviros Assessment Results				NNB GenCo Assessment Results			
		Hinkley Point C		Hinkley Point A, B & C		Hinkley Point C		Hinkley Point A, B & C	
Discharge Route	**Organism**	**RQ**	**Total dose rate**	**RQ**	**Total dose rate**	**RQ**	**Total dose rate**	**RQ**	**Total dose rate**
Atmospheric Discharges	Amphibian	4.32E-04	4.32E-03	9.55E-04	9.55E-03	3.62E-04	3.62E-03	7.01E-04	7.01E-03
	Bird	4.46E-04	4.46E-03	9.86E-04	9.86E-03	3.74E-04	3.74E-03	7.23E-04	7.23E-03
	Mammal (Deer)	4.47E-04	4.47E-03	9.86E-04	9.86E-03	3.74E-04	3.74E-03	7.24E-04	7.24E-03
	Mammal (Rat)	4.47E-04	4.47E-03	9.93E-04	9.93E-03	3.74E-04	3.74E-03	7.25E-04	7.25E-03
	Reptile	4.46E-04	4.46E-03	9.86E-04	9.86E-03	3.74E-04	3.74E-03	7.23E-04	7.23E-03
	Tree	4.34E-04	4.34E-03	1.00E-03	1.00E-02	3.64E-04	3.64E-03	7.05E-04	7.05E-03
	Badger	4.42E-04	4.42E-03	9.79E-04	9.79E-03	4.17E-04	4.17E-03	8.06E-04	8.06E-03
	Bat	4.41E-04	4.41E-03	9.75E-04	9.75E-03	3.69E-04	3.69E-03	7.14E-04	7.14E-03
Liquid Discharges	(Wading) bird	1.10E-04	1.10E-03	2.99E-04	2.99E-03	1.10E-04	1.10E-03	2.99E-04	2.99E-03
	Mammal	1.28E-04	1.28E-03	3.16E-04	3.16E-03	1.28E-04	1.28E-03	3.17E-04	3.17E-03
	Reptile	1.28E-04	1.28E-03	5.21E-04	5.21E-03	1.28E-04	1.28E-03	5.20E-04	5.20E-03

The results of the verification assessment for Habitat 1 (terrestrial) organisms were of a similar magnitude and generally within rounding differences of the dose rates predicted by NNB GenCo. The results of the verification assessment for Habitat 2 (marine) organisms were found to be in agreement with NNB GenCo's results. For Habitat 3 (coastal), the outcomes of the verification assessment for Hinkley Point C were similar to those reported by NNB GenCo, but higher for the total dose rates due to discharges from all three power stations at Hinkley Point.

The SRS model within ERICA was used by NNB GenCo to determine dose rates to organisms in habitat 4 (freshwater pond). The results of the verification assessment for freshwater organisms were of a similar magnitude, but greater than those predicted by NNB GenCo.

It was possible to verify the dose rates to non-human species in Habitat 2 (marine), calculated by NNB GenCo, due to discharges of liquids to the marine environment for both Hinkley Point C and all three power stations at Hinkley Point. Dose rates to organisms inhabiting terrestrial, coastal and freshwater environments were also verified, but with some minor discrepancies, especially for discharges of gaseous wastes from all three power stations.

SKM Enviros's assessment used the following models to assess the impact of radionuclides discharges:

(i) The activity concentrations in environmental media from discharges to atmosphere were derived from intermediate parameters from the PLUME and ASSESSOR modules of PC CREAM 08 as detailed in *Smith, J G and Simmonds, J R (Eds), The methodology for assessing the radiological consequences of routine releases of radionuclides to the environment used in PC-CREAM 08, HPA-RPD-058, HPA, Chilton (2009).*

(ii) Doses to representative reference organisms in the terrestrial and marine environments from maximum atmospheric and liquid discharges were calculated using the predicted environmental concentrations using the ERICA Tool (http://www.erica-tool.com) and the Environment Agency's R&D 128 methodology - Impact Assessment of Ionising Radiation on Wildlife. Reference terrestrial organisms were assumed to be located 500m from the release point, whilst reference marine organisms are assumed to inhabit the local marine compartment. Default assumptions regarding the concentration factors and dose calculation factors were applied.

An assessment of the potential combined impact of discharges from all three power stations at Hinkley Point has also been made. The limiting terrestrial organism for discharges to atmosphere was predicted to be a mammal (rat) from the maximum annual atmospheric discharges from all three power stations. The limiting organism for liquid releases to the marine environment is polychaete worm.

A summary of predicted dose rates to these organisms from all three power stations are given in Table 4.6S4. below.

Table 4.6S4. - *Independent assessment of dose rates to the worst affected terrestrial and marine organisms due to combined discharges from all three power stations at Hinkley Point (μGy/h).*

Organism	Total Dose Rate
Terrestrial organism: Mammal (Rat)	0.00655
Marine organism: Polychaete worm	0.00807

The dose rate associated with the maximum annual discharge to atmosphere from Hinkley Point C is predicted to be 0.003 μGy/h. The dose rate associated with the maximum annual liquid discharges from Hinkley Point C is predicted to be 0.001 μGy/h.

Overall conclusion

The assessed dose rates to all reference organisms from discharges from all three power stations at Hinkley Point are below the levels that would trigger further consideration of total impact on the Severn Estuary habitats and species.

- The dose rates are over a 1000x below the ERICA screening level of 10μGy/h, which is intended as a trigger for further assessment rather than an indicator of significant impact on non-human biota.
- The dose rates are over 4000x below the level of 40μGy/h stated by Environment Agency Operational Instruction 388_01 – RSR permitting – prospective radiological assessment for human health and wildlife as the level above which a more site specific assessment is required.

We therefore conclude that the impact of radionuclide discharges from the proposed Hinkley Point C power station alone and cumulatively with similar discharges from the other power stations at Hinkley Point can be regarded as trivial and have no adverse effect on the site integrity of the Severn Estuary SAC/SPA/Ramsar or the Exmoor Quantock Oakwoods SAC.

Hazard assessed	Adverse effect on Severn Estuary SAC/SPA/Ramsar features?
Radiological impact from discharges to air;	No
Radiological impact from discharges to water	No
Overall conclusion	**No adverse effect upon site integrity**

Hazard assessed	Adverse effect on Exmoor Quantock Oakwoods SAC features?
Radiological impact from discharges to air;	No
Radiological impact from discharges to water	No
Overall conclusion	**No adverse effect upon site integrity**

5. Flood defence consents

5.1 Introduction

During the construction of Hinkley Point C (HPC) the Environment Agency (EA) will be required to assess Flood Defence consent (FD consent) applications required under the provisions of the Water Resources Act 1991, Land Drainage Act 1991, and Land Drainage Byelaws.

Under the provisions of the Water Resources Act 1991, and associated Land Drainage Byelaws, any temporary or permanent works in, over, under, or within 8.0m of a main river require EA FD consent.

Additionally, works that could affect any existing fluvial and/or tidal flood defence structure will also require the consent approval of the Agency. Works that fall into this category are the construction of the proposed new sea wall at the Hinkley Point C. This coastline frontage will link to the existing sea wall serving the A and B stations and the modifications to defences around Combwich Wharf.

Under the provisions of the Land Drainage Act 1991, FD consent is also required for the erection or alteration of any culvert or flow control structure (like a weir or dam) that may obstruct flows in an ordinary watercourse (not a main river) e.g. the Hinkley Point C watercourse.

Where the ordinary watercourse(s) pass through an area administered by an Internal Drainage Board (IDB), FD consent will be required from the IDB rather than the Agency. The proposed culverting of the Holford Stream, which is not a main river and flows through an IDB area will therefore have to be consented by the local Internal Drainage Board rather than the EA.

Where FD consent applications are submitted to the Agency, we will be required to assess the implications of the proposals on European sites when making our determination.

5.1.1 Flood defence consents

There are three FD consents pertaining to the HPC development that are relevant to the Habitats Directive:

Type of permission	Activity	Reference No.	NGR
Flood Defence Consent (FDC)	Construction of sea wall	TBC	ST199461
Flood Defence Consent (FDC)	Refurbishment of Combwich Wharf and modifications to existing flood defences	TBC	ST216454
Flood Defence Consent (FDC)	Main site construction – Abandonment and diversion of HPC site drainage system	TBC	Various ST201458

The FD consent assessment is based on currently available information supplied to us through EDF's HRA and the Flood Risk Assessment (FRA). Flood Defence applications are not expected to be submitted until a later date, of which is not yet known.

The sea wall

A new sea wall is required along the shoreline in front of HPC to provide flood defence and to minimise the degree of wave overtopping on the site. The activity is within 8m of a main river and therefore FD consent is necessary under the provisions of the Water Resources Act 1991, and associated Land Drainage Byelaws.

The new sea wall will be a continuation of the existing wall and will be 760m in length and will have a crest height of 13.55mAOD. This height has been calculated to protect the site during a 1 in 10,000 extreme event. It's design life is 100 years to allow for 60 years of power station operation and 40 years of subsequent decommissioning.

At either end of the new defence the sea wall will turn through 90degrees inland for 50m. This is to prevent outflanking of the main sea wall by coastal erosion with the length having been calculated using an assumed rate of erosion of up to 0.5m/yr over the 100yr design life of the sea wall. The return walls will also retain the land which will be levelled at 14mAOD for the power station development site

Figure 5.1.1 Location of Sea wall in relation to European sites (figure taken from Haskoning, 2011)

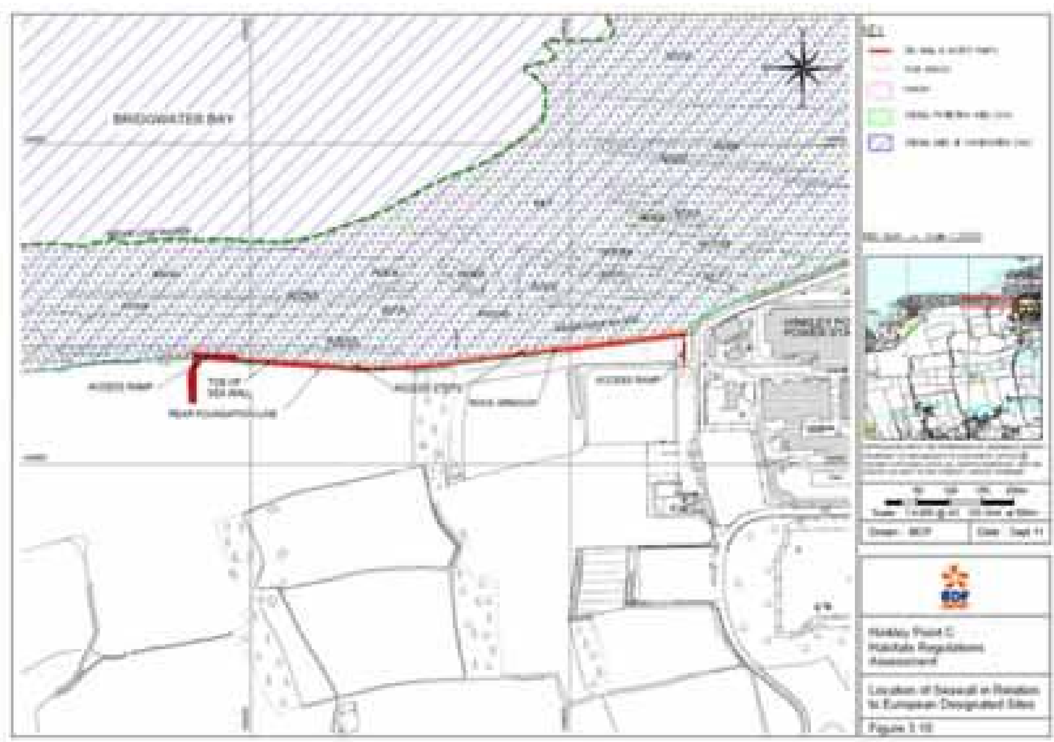
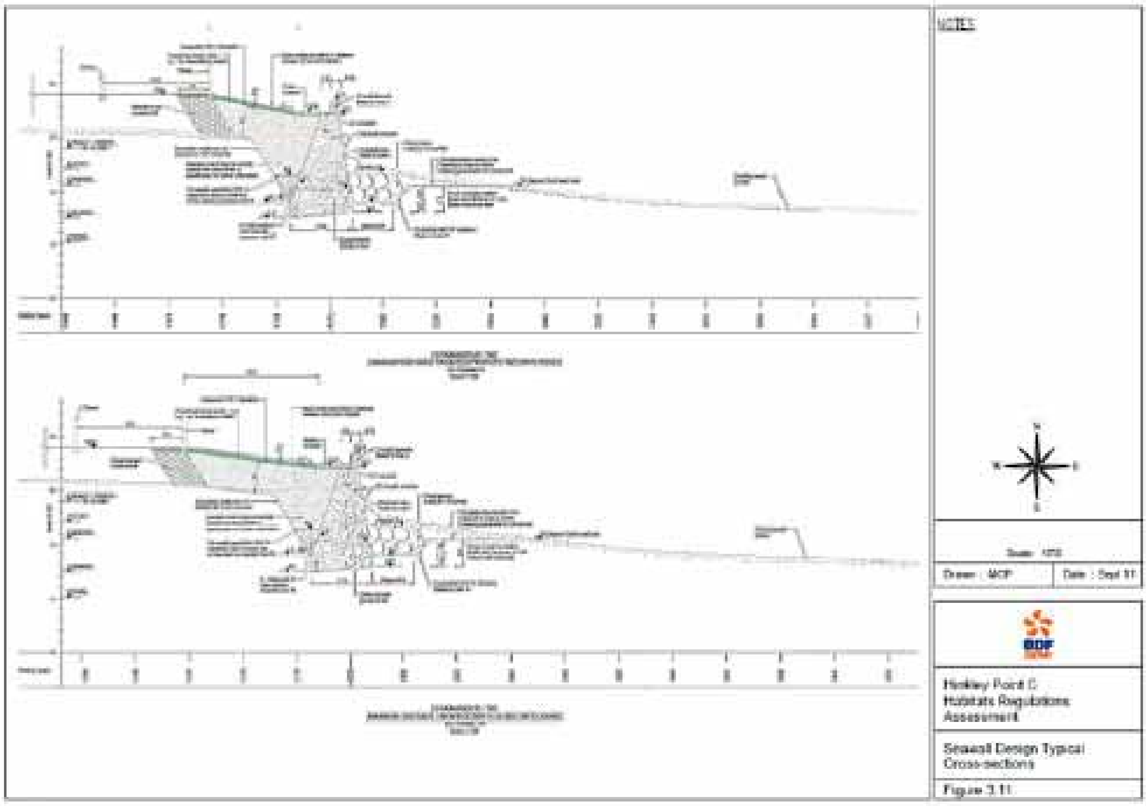


Figure 5.1.2. Sea Wall Design – Typical Cross-section (figure taken from Haskoning, 2011)



Information presented by EDF within the HRA and FRA gives the following details regarding the construction of the sea wall:

- The sea wall will be located at the top of the beach, above Mean High Water Spring tide level and will be designed to minimise encroachment onto the beach and the need for long-term maintenance. Figure 5.1.1. shows its location within the HPC development. It will be comprised of rock protection, made with boulders 1.35m mean diameter, at the foot in order to absorb wave impact during storm events and protect the foundation of the structure from scour and beach lowering.

- Barges will deliver the rock directly to the foreshore where it will be craned off and stored. Barges will be brought towards the shore during a high tide and allowed to ground when the tide falls.

- The rock armour layer will be based on a geotextile layer and will be 2.5m thick, 5m wide and set into the beach at 1m depth. The depth of the excavation for the sea wall has been determined on an estimation that the foreshore may lower due to erosion by up to 1.5m over its 100-year life design.

- The rock armour will extend 50m past the western end of the wall to provide increased erosion protection to the base of the natural cliff area. This will reduce the anticipated rate of coastal retreat and potential exposure of the return wall.

- The rock armour will extend 1m above the existing shore surface and will separate the wall visually and physically from the beach and cross shore rock platform so that 8m of wall will be visible above 1m of rock armour.

- On completion of the sea wall works the pre-existing beach profile will be replaced/restored.

- At the western end of the sea wall an access ramp will be provided to allow vehicles onto the foreshore for maintenance needs. The ramp will be on the front of the wall and tapered in width from 5m at the top to 5.4m at the bottom.

- The existing footpath will be diverted during construction and reopened to run between the rear of the wall and the security fence. Steps will be provided in the sea wall at locations 250m and 510m from the eastern end to allow public access to the shore.

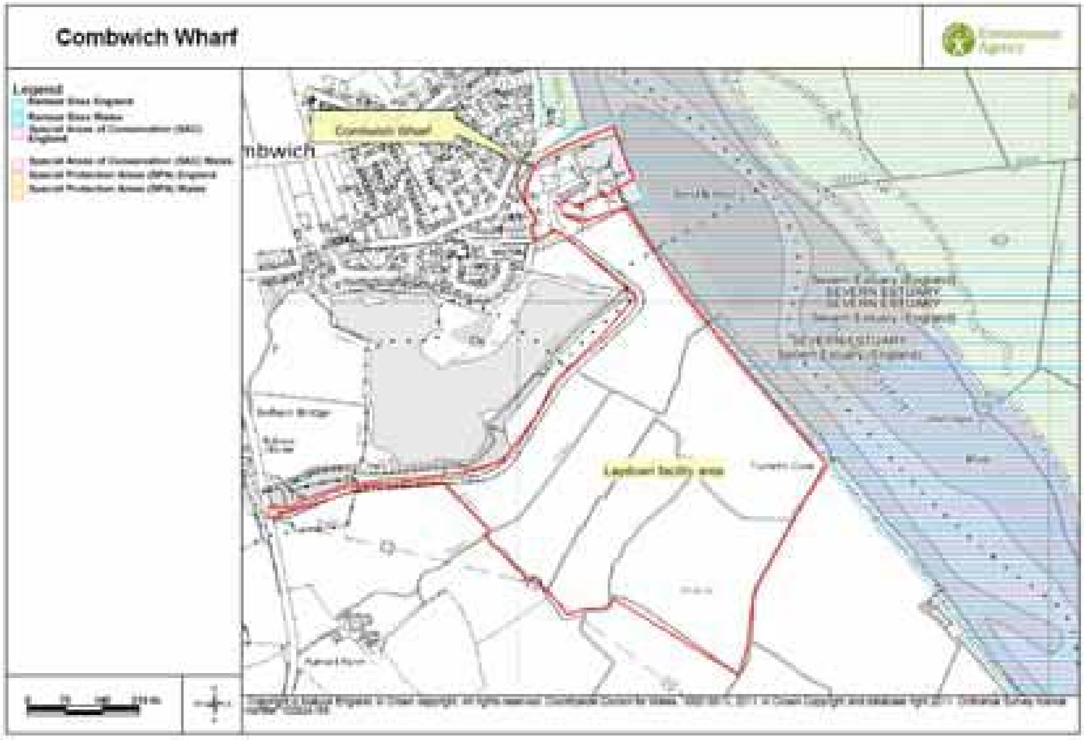
- The drainage of the sea wall will be controlled by placing permeable fill behind the wall with 150mm diameter drainage pipes every 10m along the wall. The drainage holes will have an invert level of between 4.5 to 5.5mAOD at the rear with the front invert level being 0.5m lower. Groundwater will therefore not exceed the 6m AOD sea wall level design. A geotextile layer will be positioned to prevent fine material blocking the pipes and both ends of the pipe will have a metal grille to prevent blocking. The pedestrian and vehicle access breaks in the crest will also provide benefits as they will act as spillways.

Refurbishment of Combwich Wharf

The Hinkley Point C (HPC) development will require the refurbishment of the existing Combwich Wharf facility to accommodate the arrival of approximately 180 Abnormal Indivisible Loads (AILs) and other construction related goods, over a period of approximately six years. A lay down area will also be provided adjacent to Combwich Wharf to manage the flow of personnel and freight to Hinkley Point C, and the current flood defences will need to be up-graded.

Combwich Wharf is located at the confluence of Combwich Pill and the River Parrett at the eastern edge of the village of Combwich approximately 4km upstream from the mouth of the River Parrett at the Severn Estuary. Whilst the wharf area is outside of the designated SAC/SPA/Ramsar areas, it lies directly adjacent to them (see Figure 5.1.3).

Figure 5.1.3 Location of Combwich Wharf development works (outlined in red) in relation to the Severn Estuary designated sites.



The FD consent for Combwich Wharf associated development will encompass any works within eight metres of the River Parrett and include developments in, under and over the main river. The consent would therefore include;

- The overall redevelopment of the wharf; including the demolition of parts of the old wharf (finger pier and unwanted piles etc.), construction of the new wharf area (extensions to dolphins, piling etc.) and dredging of berth bed;
- The construction and enhancements of flood defences around Combwich village and around the laydown facility area;
- Improvements to Tuckett's Clyce.

It is expected that these works will take approximately 18 months to complete.

The elements of the proposed development that could affect the designated features of the Severn Estuary SAC, SPA and Ramsar include the following:

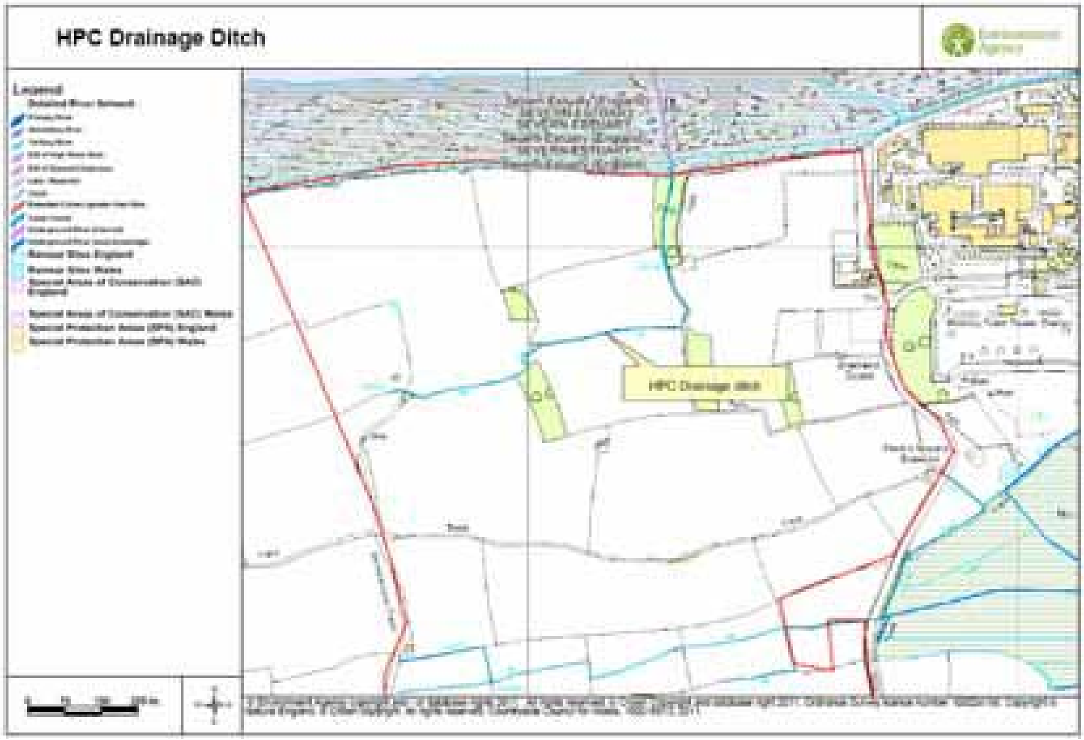
- removal of the existing finger jetty on the north side of the existing berth area and the associated dolphin;
- extension and raising of the existing barge bed;
- extension of the existing ro-ro Abnormal Indivisible Loads (AIL) jetty to the west to provide access for the approach road to the ro-ro berth for longer vehicles handling AIL;
- piling and infill for the refurbished and extended ro-ro wharf facility;
- construction of the goods wharf facility, including removal of two existing dolphins;
- construction of a new replacement slipway situated partly on top of the old slipway. Access to the old slipway will be blocked by the goods wharf facility;

- introduction of the parts of the new structures below Mean High Water Springs (MHWS);
- potential releases of polluting materials to Combwich Pill or the Parrett Estuary during construction;
- potential releases of polluting materials to the Parrett Estuary during operation, via drainage systems serving the wharf or the freight management and storage facility, and from vessels;
- potential releases of contaminants to the Parrett Estuary via Tuckett's Clyce.

Main site construction

In order to develop the HPC site, a small watercourse known as the Hinkley Point C drainage ditch will need to be abandoned, in-filled and then diverted via a new HPC site drainage system, all of which will need a Flood Defence (FD) Consent. The HPC drainage ditch currently runs along the top fields of the proposed development site and out to the foreshore (see figure 5.1.4 below).

Figure 5.1.4. Location of small watercourse to be in-filled and abandoned in relation to the Severn Estuary designated sites. Part of the HPC development area is outlined in red.



The HPC drainage ditch is approximately 1km in length and generally only flows after heavy rainfall during the winter periods (winterbourne). Although the ditch is not within the Severn Estuary designated area, it potentially provides freshwater flows into the area and the small copse out of which it flows, potentially providing a sheltered habitat for the Severn Estuary birds.

5.2 Generic sensitivities

The FD Consent will only be assessed against the designated features of the Severn Estuary SAC, SPA and Ramsar as there are no FD consents that have a pathway of impacting any other Natura 2000 site in or around the HPC area.

Table 5.2.1. Generic sensitivity matrix for the Severn Estuary/ Môr Hafren SAC, SPA and Ramsar sites in relation to Flood Defence activities.

	Habitat groups		Species groups	Bird species groups		
Hazard	**Estuarine and intertidal habitats (1.12)**	**Submerged marine habitats (1.13)**	**Migratory fish (2.5) & fish assemblage**	**Birds of lowland freshwaters and their margins (3.6)**	**Birds of coastal habitats (3.8)**	**Birds of estuarine habitats (3.9)**
Habitat loss	✓	✓	✓	✓	✓	✓
Changes to water chemistry (toxic contamination, nutrients, oxygenation)	✓		✓	✓		✓
Reduced surface water flows (change in salinity)				✓		✓
Changes to flow & velocity regime	✓	✓	✓	✓	✓	✓
Changes in turbidity (sedimentation)	✓	✓	✓	✓	✓	✓
Physical damage (abrasion, erosion, smothering)	✓	✓	✓	✓	✓	✓
Changes in physical regime	✓	✓	✓	✓	✓	✓
Disturbance (noise, visual, vibration)	✓		✓	✓	✓	✓
Competition from non-native species	✓					

✓ Indicates that at least one of the features in the group is potentially sensitive to the hazard.

Note: These matrices are not comprehensive and are based on the judgment of staff in the Environment Agency, NE and CCW. There may be other hazards and sensitivities, which will vary according to circumstances.

5.3 Potential hazards from activity

Table 5.3.1 Activity and hazards matrix for Flood Defence Consents for Hinkley Point C

ACTIVITY	**HAZARD**								
		Water related hazards							
	Habitat loss	Changes to water chemistry (toxic contamination, nutrients, oxygenation)	Reduced surface water flows (change in salinity)	Changes to flow & velocity regime	Changes in turbidity	Physical damage & abrasion (erosion, smothering)	Changes in physical regime	Disturbance (noise visual, presence, vibration)	Competition from non-native species
Activity: Sea defence works									
Consent: Construction of sea wall	✓	✓	✓	✓	✓	✓	✓	✓	
Activity: In-channel works and structures, channel diversions, construction of flood banks									
Consent: Refurbishment of Combwich Wharf including modifications to existing flood defences	✓	✓		✓	✓	✓	✓	✓	
Activity: Construction phase activities									
Consent: Main site operations – Abandonment and diversion of HPC site drainage system	✓	✓	✓	✓				✓	

✓ Indicates that at least one of the designated features is potentially sensitive to the hazard.

Indicates that the activity is not likely to have an impact on the designated features (see 5.4 below)

5.4 Interest features sensitive to hazard

Whilst the generic sensitivity matrices give us an idea of which features could be sensitive to the hazards, the species and habitats groups are very generalised and the hazards are based on a generic list.

During Stages 1 and 2 of the assessment under Habitats Regulations Assessment 1 (HR01) *'test of likely significance'*, the assessment scoped out those hazards that either had no source or no pathway to impact, or where the potential exposure to the hazard was unlikely to have any impact on the feature. The conclusions of those assessments have been recorded within an Environment Agency Appendix 11 form (see Annex 1 of this document).

The matrices below represent the outcome of the HR01 assessments for each FD Consent. A tick (✓) indicates that the hazard has been assessed as having the potential to impact on the feature, and a square (□) indicates that the hazard has been scoped out of the assessment as unlikely to impact on the designated feature alone.

5.4.1 Matrices

Sea wall

FEATURE		HAZARD								
			Water related hazards							
		Habitat loss	Changes to water chemistry (toxic contamination, nutrients, oxygenation)	Reduced surface water flows (change in salinity)	Changes to flow & velocity regime	Changes in turbidity	Physical damage & abrasion (erosion, smothering)	Changes in physical regime	Disturbance (noise visual, presence, vibration)	Competition from non-native species
Estuarine and inter-tidal habitats	Estuaries (including rocky shore)	✓	✓	✓	✓	✓	✓	✓	□	□
	Inter-tidal mud and sandflats	□	□	□	□	□	□	✓	□	□
	Atlantic salt meadows	□	□	□	□	□	□	✓	□	□
Submerged and marine habitats	Sub-tidal sandbanks	□	□	□	□	□	□	□	□	□
	Reefs	✓	✓	□	□	✓	✓	✓	□	□
Migratory fish & fish assemblages		□	□	□	□	□	□	□	✓	□
Migratory birds & bird assemblages		✓	□	□	□	□	□	□	✓	□

✓ Indicates that the designated features is potentially sensitive to the hazard.

□ Indicates that the hazard has been scoped out as not likely to have an impact on the designated feature.

Refurbishment of Combwich Wharf

FEATURE		HAZARD								
			Water related hazards							
		Habitat loss	Changes to water chemistry (toxic contamination, nutrients, oxygenation)	Reduced surface water flows (change in salinity)	Changes to flow & velocity regime	Changes in turbidity	Physical damage (abrasion, erosion, smothering)	Changes in physical regime	Disturbance (noise visual, presence, vibration)	Competition from non-native species
Estuarine and inter-tidal habitats	Estuaries	✓	✓	□	✓	✓	✓	✓	□	□
	Inter-tidal mud and sandflats	✓	✓	□	✓	□	✓	✓	□	□
	Atlantic salt meadows	✓	□	□	✓	□	✓	✓	□	□
Submerged and marine habitats	Sub-tidal sandbanks	✓	✓	□	✓	□	□	✓	□	□
	Reefs	□	□	□	□	□	□	□	□	□
Migratory fish & fish assemblages		✓	✓	□	✓	✓	✓	✓	✓	□
Migratory birds & bird assemblages		✓	✓	□	□	□	□	□	✓	□

✓ Indicates that the designated features is potentially sensitive to the hazard.

□ Indicates that the hazard has been scoped out as not likely to have an impact on the designated feature.

Main site construction

FEATURE		HAZARD								
			Water related hazards							
		Habitat loss	Changes to water chemistry (toxic contamination, nutrients, oxygenation)	Reduced surface water flows (Change in salinity)	Changes to flow & velocity regime	Changes in turbidity	Physical damage & abrasion (erosion, smothering)	Changes in physical regime	Disturbance (noise visual, presence, vibration)	Competition from non-native species
Estuarine and inter-tidal habitats	Estuaries (including rocky shore)	□	✓	✓	✓	□	□	□	□	□
	Inter-tidal mud and sandflats	□	□	□	□	□	□	□	□	□
	Atlantic salt meadows	□	□	□	□	□	□	□	□	□
Submerged and marine habitats	Sub-tidal sandbanks	□	□	□	□	□	□	□	□	□
	Reefs	□	□	□	□	□	□	□	□	□
Migratory fish & fish assemblages		□	□	□	□	□	□	□	□	□
Migratory birds & bird assemblages		✓	□	□	□	□	□	□	✓	□

✓ Indicates that the designated features is potentially sensitive to the hazard.

□ Indicates that the hazard has been scoped out as not likely to have an impact on the designated feature.

5.5 Assessment methodology

The methodology for carrying out assessments on the Flood Defence Consents required for the HPC development has been taken from the following guidance:

- Assessment of Flood and Coastal Risk Management Plans and Projects under the Habitats Regulations[447].
- Environment Agency guidance FDTAG21 - Flood and coastal management works required for the conservation of SPAs, SACs or Ramsar sites.

Further to EA guidance, we will be using information provided within EDF's report to support the HRA by Haskoning. (2011): Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. We will also be using a number of technical documents presented by the BEEMS programme (British Energy/EDF Estuarine and Marine Studies) that support the HRA.

All of the assessments will consider the Conservation Objectives of the Severn Estuary SAC, SPA and Ramsar features.

5.6 Assessment

The Flood Defence consent assessment is based on currently available information supplied to us through EDF's report to inform the Habitats Regulations Assessment (HRA) process and the Flood Risk Assessment (FRA). Flood Defence applications are not expected to be submitted until a later date, which is currently unknown at this time.

We understand that the information currently available to us is considered to be worst case scenario and that any proposal within a Flood Defence application will have no more impact on surrounding habitat than that being assessed within this document. This will need to be verified at the time as part of the Habitats Regulations Assessment linked to the applications received.

The Flood Defence Consents will only consent the construction works and are thus classed as 'engineering permissions'. However to enable us to assess the potential impacts from these consented construction works we have also had to consider the operation and life span of the structures.

All of the following assessments are considering impacts alone only. In combination impacts will be considered in chapter 6.

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[447] Using the Habitats Directive Handbook for Coastal Risk Management Permissions, Plans and Projects. Operational Instruction (OI) 53_02.

5.6.1 The sea wall

5.6.1.1 Estuaries

a) Habitat loss and physical damage (abrasion)

(sub feature: rocky shore)

Conservation objectives (see section 1.5.1)

- *The extent, variety and spatial distribution of estuarine habitat communities is maintained*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained*
- *The abundance of the notable estuarine species assemblages is maintained or Increased*

Natural England & Countryside Council for Wales, 2009[448]

Habitat loss and physical damage (abrasion) as a result of the position of the sea wall and construction zone
The sea wall will be fixed within the existing line of the cliffs bordering the upper shore. The scour protection at the toe of the sea wall will match the pre-existing cross shore profiles. The applicant has informed us that this is above Mean High Water Springs (MHWS) and the habitat at this location is "characterised by small boulders and rocks and is practically devoid of fauna and flora apart from some upper shore lichen species"[449]. The siting of the sea wall and associated scour protection will therefore not cause any loss of any notable communities of the SAC or cause any narrowing or loss of the inter-tidal area.

The construction works for the sea wall will require a total width of 30 metres from the top of the foreshore. This area is necessary for the storage of the rock to build the toe of the wall and for machinery to work. All access tracks and machinery will be contained within this area, so no other access routes across the foreshore are anticipated. The 30m construction zone equates to 26,000m^2 of habitat which equates to 0.17% of this feature within the SAC and 3.7% of this features at Hinkley Point (Haskoning 2011, section 6.2.178). The sea wall will be constructed at the beginning of the construction period and the area will be temporarily required for approximately 12-14 months.

For the purpose of our assessment we have assumed that all habitats and species within the 30m zone will be affected by the construction works for the sea wall.

The applicant has carried out an ecological survey of the 30m construction zone. The area has been classified into inter-tidal biotopes using the European nature information system (EUNIS). The inter-tidal biotopes in front of the sea wall are shown in figure 5.6.1.1

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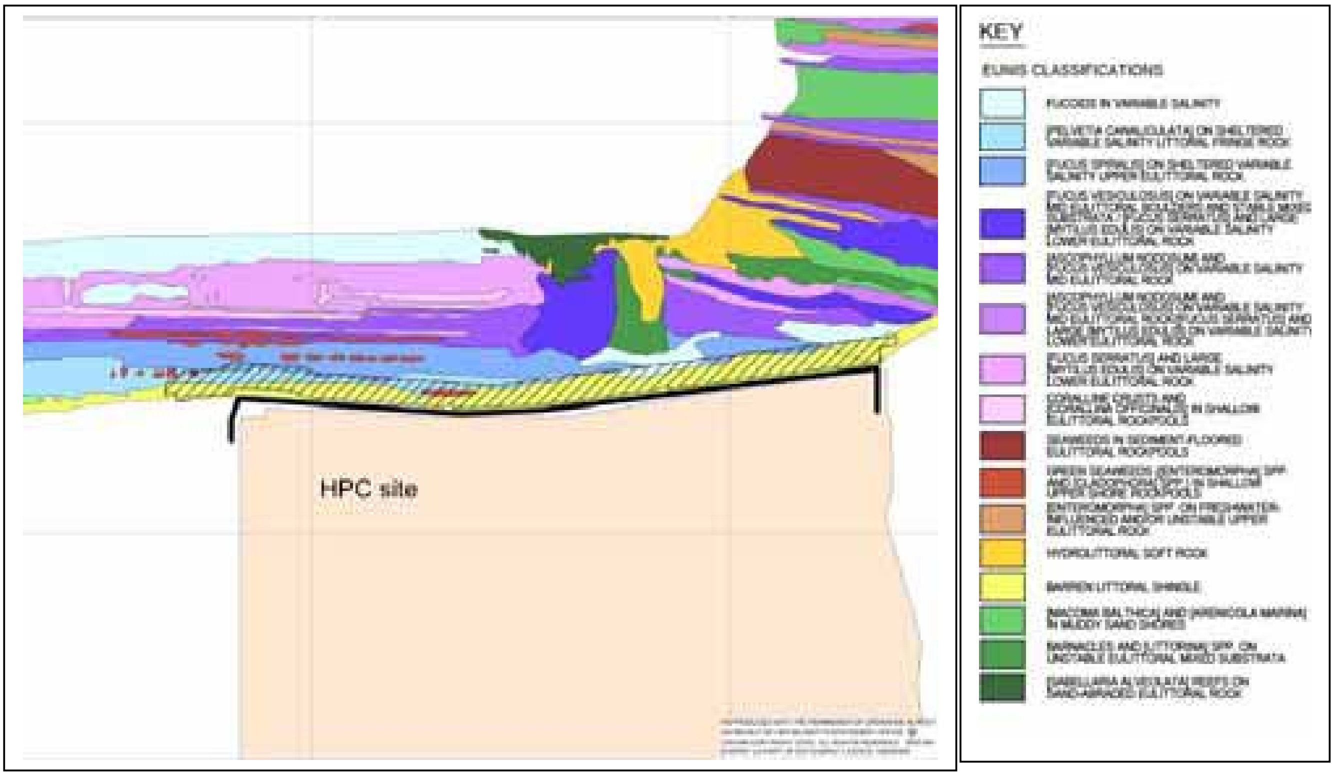
448 Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

449 Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc Ref: 333.16. October 2011. Report prepared for EDF

Figure 5.6.1.1. Intertidal Biotopes Fronting Site and Sea Wall Construction Zone (taken from Haskoning 2011)



The majority of the area is barren littoral shingle and is devoid of any inter-tidal fauna and flora. However, further down the shore, within the 30m zone, can be found a variety of wracks (consistent with zonation) with winkles and barnacles on exposed rocks. One shallow rockpool, characterised by ephemeral green alga, is found within this upper zone. Due to its location it is subject to widely fluctuating temperatures and salinity.

We agree with the applicant that in order to assess the severity of impact within the sea wall construction zone it is necessary to identify each habitats ability to recover from damage. The applicant has supplied us with the following information on the recoverability of each inter-tidal biotope, which is represented in table Sw1.

The majority of the area has no tolerance to disturbance as it is barren littoral shingle. The habitat with the longest time to recover is '*Pelvetia canaliculata* on sheltered variable salinity littoral fringe rock' which occurs within 17.4% of the construction zone.

Of those habitats that are to be impacted by construction their ability to recover will be significantly enhanced by ensuring that the physical attributes of the beach will be restored after works are complete. The EDFE 30th Sept 2001 "Sea wall Construction Area" report states that "Some of that shingle will be displaced and held elsewhere within this construction zone against the need to restore initial cross-shore profiles at the end of the works. No significant impact on the rock surfaces, except where excavating the trench for the rock armour toe, is anticipated".

Table 5.6.1.2. Biotopes found within the 30m construction zone on the HPC foreshore and their recoverability (Haskoning, 2011).

Area within 30m construction zone	EUNIS inter-tidal biotope	Recoverability
17,882 m^2 69.7%	Eunis A2.111: 'Barren littoral shingle'	no intolerance to disturbance.
4,533 m^2 17.4%	Eunis A1.321: '[*Pelvetia canaliculata*] on sheltered variable salinity littoral fringe rock'	moderate recoverability (full recovery up to 10 years).
1,713 m^2 6.6%	Eunis A1.322: '[*Fucus spiralis*] on sheltered variable salinity upper eulittoral rock'	high recoverability (full recovery within about 5 years).
1,203 m^2 4.6%	Eunis A1.32: 'Fucoids on variable salinity rock'	high recoverability (full recovery within about 5 years).
435 m^2 1.7%	Eunis A1.421: 'Green seaweeds [*Enteromorpha spp.*] and [*Cladophora spp.*] in shallow upper shore rockpools'	very high recoverability (full recovery within at most 6 months).

We agree with the applicants assessment that this habitat will recover fully within 10 years from construction. Within this time there will be some habitat simplification with pioneer species initially thriving but this will eventually lead to regeneration of the original habitat structure and biodiversity.

Conclusion
Our assessment concludes that there will be no loss of habitat from the footprint of the sea wall as it is above the Mean High Water Spring tide height and the habitat at the location of the sea wall toe is not one of the notable SAC communities.

There will be loss of habitat within the 30m construction zone, however the amount of rocky shore lost equates to approximately 0.17% of the rocky shore SAC and Ramsar feature, which is not considered to be significant. The habitats within the construction zone will recover fully within 6 months to 10 years. The 30m construction zone will not encroach into the area that supports the *Corallina* turf which, at its nearest point, is 40m from the sea wall construction zone.

We can therefore conclude that the positioning of the sea wall and construction zone will not have an adverse effect on the estuaries feature and sub-feature rocky shore designated to the Severn Estuary SAC and Ramsar.

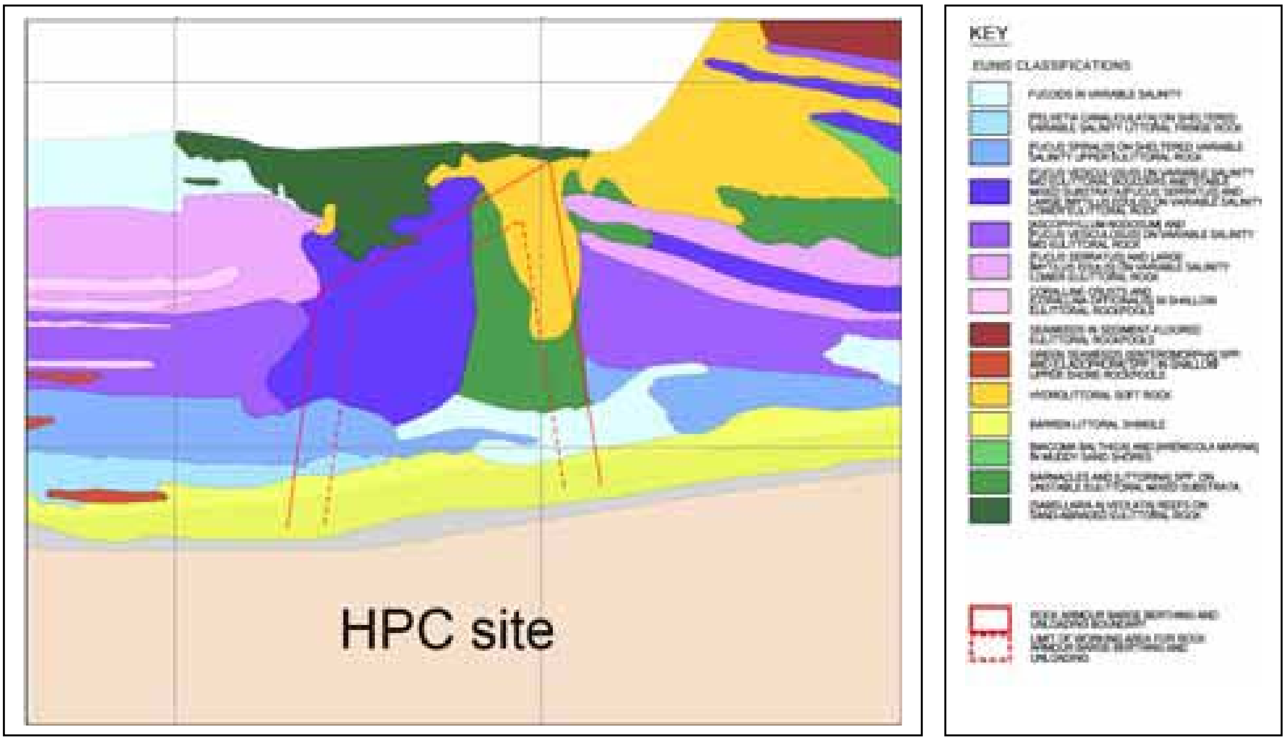
Physical damage (abrasion) and habitat loss as a result of enabling the construction of the sea wall (i.e. the delivery of the rock)
The delivery of the rock for the sea wall by barges could have a physical or disturbing impact on the rocky shore habitat. This activity will involve rock armour being delivered by flat-bottomed barge at high tide directly to the shore in front of HPC. Here, the rock will be removed by crane or tracked vehicle and stored on the

seaward perimeter of the 30m construction zone. When the tide ebbs the barges will rest on the rocky shore.

The selected location for the barge deliveries coincides with the historical graving dock developed during the construction of HPA and HPB. The bedrock within this area was excavated away and therefore the habitats are not representative of the other parts of the foreshore. The applicant has informed us that this area is selected because it avoids the rock platform habitats that hold the species of highest conservation importance such as *Sabellaria* and *Corallina.*

The applicant has mapped the inter-tidal biotopes of the shore using EUNIS and this is shown together with the barge berthing and unloading area in figure 5.6.1.3. Barge deliveries will be limited to within the inner perimeter and barges will not be allowed to ground outside of this area.

Figure 5.6.1.3. Rock Armour Barge Berthing and Unloading Area (Haskoning 2011)



Impact to the rocky shore habitat could potentially be caused by propeller scour or vessels grounding on the foreshore. This could result in the removal of wracks or molluscs from rocks and therefore a reduction in the biodiversity value of the habitat.

As discussed in section 5.6.1.1.(b), the *Sabellaria* reef (a qualifying interest features of the SAC) is found between the mean low water neap tide height and the mean low water spring tide height and extends into subtidal waters. Barges heading for the berthing area will traverse across the *Sabellaria* on the tide with the aim to ground on the designated berthing area as the tide ebbs. There should therefore be no physical damage to the *Sabellaria* reef, although it is noted that a small area of potential *Sabellaria* reef (with an approx. measurement of 5x2 meters) does fall within the rock armour barge berthing and unloading area, but it is not considered significant. However, it would not take much of a human error particularly during high winds or rough seas for the boat to go off course and potentially impact the area of *Sabellaria* reef down shore of the berthing area. To quantify that potential impact, the area of

Sabellaria reef (shown within figure Sw2 in dark green) has been estimated to be approximately 5000m² (0.5 ha) (likely over estimate). The total area of reef feature within the Severn Estuary SAC is 1474.3 ha (JNCC, 2011)[450], so 0.5ha equates to 0.034%, which is insignificant.

We agree with the applicant that in order to assess the severity of impact from barges resting on the rocky shore it is necessary to identify each habitats' ability to recover from damage. The applicant has supplied us with the following information on the recoverability of each inter-tidal biotope[451]:

Table 5.6.1.4. Biotopes found within the berthing area on the HPC foreshore and their recoverability (Haskoning, 2011).

Area within berthing area	EUNIS inter-tidal biotope	Recoverability
5,430 m^2 31.4%	Eunis A1.323/A1.326: '[*Fucus vesiculosus*] on variable salinity mid eulittoral boulders and stable mixed substrata/ [*Fucus serratus*] and [large *Mytilus edulis*] on variable salinity lower eulittoral rock'	high recoverability (full recovery within about 5 years).
3,500 m^2 20.2%	Eunis A2.43: 'Barnacles and [*Littorina spp.*] on unstable eulittoral mixed substrata'	(full recovery within about 5 years).
3,420 m^2 19.8%	Eunis A2.111: 'Barren littoral shingle'	no intolerance to disturbance.
1,190 m^2 6.9%	Eunis A1.46: 'Barren rock' or 'hydrolittoral soft rock'	no intolerance to disturbance.
1,490 m^2 8.6%	Eunis A1.322: '[*Fucus spiralis*] on sheltered variable salinity upper eulittoral rock'	high recoverability (full recovery within about 5 years).
1,960 m^2 11.3%	Eunis A1.32: 'Fucoids on variable salinity rock'	high recoverability (full recovery within about 5 years).
290 m^2 1.7%	Eunis A1.321: '[*Pelvetia canaliculata*] on sheltered variable salinity littoral fringe rock'	moderate recoverability (full recovery up to 10 years).

EDF's recoverability assessment identifies all habitat types, if tolerant to disturbance, will recover within 5 years except for '*Pelvetia canaliculata* on sheltered variable salinity littoral fringe rock' which could take up to 10 years. This habitat type only occurs within 1.7% of the area. We agree with this assessment.

The total area of rocky shore covered by the berthing area makes up a total of 17,280 m^2, which as a percentage of SAC rocky shore habitat (15,000,000 m²)

[450] JNCC (2011) Joint Nature Conservation Committee: UK SAC summary data spreadsheet. Severn Estuary SAC Reef feature. http://jncc.defra.gov.uk/page-1461
[451] EDF 30th Sept.2011 "Sea wall Construction Area" additional information report

equals 0.12%. The total rocky shore area potentially impacted is therefore insignificant in terms of the rocky shore area of the Severn Estuary SAC and Ramsar feature.

Furthermore, Chapter 20 of the Hinkley Point C Environmental Statement[452] reports on the surveys that were taken of water birds using the land within the development site and the upper inter-tidal habitat in front of the HPC site. The reports suggested that the areas were not being regularly used by large numbers of roosting or foraging birds.

Conclusion
Physical damage and disturbance could occur to the rocky shore habitat however we agree with the applicants assessment in that recoverability of damaged habitats will be within 5 years. We are satisfied that there will not be any damage to the *Sabellaria* reef as it only occurs at the low water mark outside of the area where barges will ground.

We can therefore conclude that the delivery of rock armour for the construction of the sea wall will not have an adverse effect on the estuaries feature and sub-feature rocky shore designated to the Severn Estuary SAC and Ramsar.

Combined impacts of the sea wall construction and rock armour delivery

The combined impacts of the sea wall construction area and the rock armour delivery area on the rocky shore SAC/Ramsar sub-feature is shown below in table Sw2.1. As a percentage of the whole rocky shore SAC/Ramsar feature of the Severn Estuary (at approx. 15,000,000 m²), the total area impacted equates to 0.29%, of which 49.2% is barren littoral shingle biotope. The remaining 50.8% is likely to recover within 1 – 10 years.

Table 5.6.1.5. Combined impacts of sea wall construction area and rock armour delivery area on SAC/Ramsar Rocky shore sub-feature

Activity	**Area rocky shore impacted (m²)**	**Percentage of SAC/ Ramsar rocky shore habitat (15,000,000 m²)**	**Area of 'barren littoral shingle' biotope of area impacted (m²) and as a (%) of area**
Sea wall construction	26,000	0.17%	17,882 (68.8%)
Barge berthing and unloading area	17,280	0.12%	3,420 (19.8%)
Total area impacted	**43,280**	**0.29%**	**21,302 (49.2%)**

As the total area affected is less than 1% and that a high proportion of the area potentially affected is barren littoral shingle, then the combined impacts of the construction area of the sea wall together with the barge berthing and unloading area are not considered to be significant.

Furthermore as stated before, Chapter 20 of the Hinkley Point C Environmental Statement[453] reports on the surveys that were taken of water birds using the land within the development site and the upper inter-tidal habitat in front of the HPC site.

[452] EDF. (2011). Hinkley Point C Environmental Statement: Chapter 20 Terrestrial Ecology and Ornithology. Doc. Ref: 4.3. October 2011. Section 20.5.45.
[453] EDF. (2011). Hinkley Point C Environmental Statement: Chapter 20 Terrestrial Ecology and Ornithology. Doc. Ref: 4.3. October 2011. Section 20.5.45.

The reports suggested that the areas were not being regularly used by large numbers of roosting or foraging birds.

Conclusion

We can therefore conclude that the combined impacts of the delivery of rock armour for the construction of the sea wall and the barge berthing and unloading area will not have an adverse effect on the estuaries feature and sub-feature rocky shore designated to the Severn Estuary SAC and Ramsar.

b) Changes to water chemistry (toxic contamination, non-toxic contamination, salinity, oxygenation), Changes in turbidity and physical damage (smothering)

(sub feature: rocky shore)

Conservation objectives (see section 1.5.1)

- *The extent, variety and spatial distribution of estuarine habitat communities is maintained;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or Increased;*
- *The physico-chemical characteristics of the water column support the ecological objectives;.*
- *Toxic contaminants in water column and sediment are below levels which would pose a risk to the ecological objectives.*

Natural England & Countryside Council for Wales, 2009[454]

Sea wall construction

The sea wall construction works could lead to the generation of relatively large quantities of sediment and high concentrations of suspended solids. The water may also be contaminated by concrete used for the construction of the sea wall leading to increase in pH, and oil/fuel from accidental spills from machinery.

The EDF report to inform the HRA (Haskoning 2011) does not state how drainage and dewatering activities will be managed during construction of the sea wall. However it identifies the two options available, i.e. to discharge directly to the foreshore or to pump the water up to the Water Management zone for pre-discharge treatment

Assuming that drainage and dewatering activities are not pumped to the Water Management Zone for treatment, to asses the potential impact on the habitat it has been necessary to understand the tidal heights across the foreshore. We have estimated that there is approximately a 30m variation between a high spring tide and a high neap tide with a high spring tide reaching approximately 2.5m below the toe of the sea wall. Therefore the construction site will not be inundated during the lowest

[454] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

of the high tides but all habitats below the construction site will be inundated twice every day.

At high tide any discharges, even if containing relatively high concentrations of suspended solids, will be highly diluted and dispersed and therefore the potential effects will be trivial.

At low water, discharges will infiltrate through the beach substrate and filter out a lot of the sediments. Water, depending on the degree of sediment, will run down the shore and collect on the rock platform and within pools and crevices. This will have more of an impact on habitats in the higher shore, particularly rock pools, rather than those in the mid or lower shore. Species tolerance to contaminants depends on the species and on the content, volume, concentration and exposure (duration and frequency) to the contaminant. *Corallina Officinalis* (species of calcareous red seaweed) is particularly sensitive to sediment as it provides a niche where it can collect. *Corallina* is located 40m away from the construction site. However, inter-tidal species, including *Corallina* and *fucoids* are tolerant, in the short-term, to changes in salinity, pH and oxygen and are adaptable to changes that may occur as a result of natural exposure to extreme conditions, e.g. heavy rainfall, high temperatures. Any changes that are long term or are above nationally recognised environmental quality standards (EQS) in terms of their toxicity or polluting level could potentially cause an adverse impact on the habitat.

However, upon review of the construction methods it is likely that there would be minimal amount of water discharge as a result of the construction of the sea wall. The water that would arise would be groundwater close to the surface which would flow when the hole for the base of the wall was being dug. This would be a shallow excavation as the sea wall proposed does not have a deep foundation. The water discharged would be in small amounts at any given time as a short patch would be excavated, then a wall constructed before moving on to the next part. Therefore, the expectation would be that there would be small amounts of water that would be subjected to dilution with the tide.

Whilst it is likely that discharges would be small and diluted with the tide, we have advised the competent authorities, in this case the Local Planning Authority (LPA) and Marine Management Organisation (MMO), that a surface/ tunnel water management scheme that will manage the contaminants associated with these construction activities is required.

Furthermore, we have advised the competent authority at the Development Consent Order stage to implement the following conditions:

No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.

No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to the Marine Management Organisation for approval.

Conclusion
We can therefore conclude that any changes to water chemistry as a result of the construction of the sea wall will not have an adverse effect on the estuaries feature and sub-feature rocky shore designated to the Severn Estuary SAC and Ramsar.

c) Reduced surface water flows (changes in salinity)

(sub feature rocky shore)

Conservation objectives (see section 1.5.1)

- *The extent, variety and spatial distribution of estuarine habitat communities is maintained*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained*
- *The abundance of the notable estuarine species assemblages is maintained or Increased*

Natural England & Countryside Council for Wales, 2009

Reduced surface water flooding (changes in salinity) across the rocky shore habitat as a result of the constructing the sea wall
The rocky shore area in front of HPC consists of a mix of algal (fucoid) species, green seaweeds, barnacles, and calcareous red seaweed *(Corallina spp.*), which all commonly support a community of invertebrate animals. Each of these species become inundated with estuarine water 1-2 times a day for varying lengths of time. The species also frequently become exposed to freshwater flows from on-shore run-off and precipitation, therefore they all have a reasonable tolerance to changes in salinity.

Once the sea wall is built, it is likely that there will be a reduction in surface water flows, which is likely to benefit the inter-tidal rocky shore species in several ways. Firstly it will reduce sediment loading to the shore. An example of this is *Corallina spp*., which accumulate more sediment than any other alga (Hicks 1985)[455]. Significant sediment cover of the middle to lower inter-tidal in a South Californian shore, resulting from fresh water runoff, caused substantial decline in *Corallina spp*. cover (Seapy & Littler 1982)[456].

Secondly, it will mean there is less dilution within the rocky pools, maintaining the salinity. *For example, Corallina officinalis* inhabits rock pools and gullies from mid to low water, therefore, it is likely to be exposed to short term hyposaline (freshwater runoff and rainfall) and hypersaline (evaporation) events (Tyler-Walters, 2008)[457].

[455] Hicks, G.R.F., (1985). Meiofauna associated with rocky shore algae. In *The Ecology of Rocky Coasts: essays presented to J.R. Lewis, D.Sc.*, (ed. P.G. Moore & R. Seed, ed.). pp. 36-56. London: Hodder & Stoughton Ltd.

[456]Seapy , R.R. & Littler, M.M., (1982). Population and Species Diversity Fluctuations in a Rocky Intertidal Community Relative to Severe Aerial Exposure and Sediment Burial. *Marine Biology*, 71, 87-96.

[457] Tyler-Walters, H. (2008). *Corallina officinalis*. Coral weed. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom. Available from: <http://www.marlin.ac.uk/speciesbenchmarks.php?speciesID=3039>

However, its distribution in the Baltic is restricted to increasingly deep water as the surface salinity decreases, suggesting that it requires full salinity in the long term (Kinne 1971)[458].

Conclusion
A reduction in surface (freshwater) flow and an increase in salinity is likely to benefit Corallina spp. and the other species on the inter-tidal foreshore, therefore we can conclude that reduced surface water flows and an increase in salinity as a result of the sea wall presence will not have an adverse effect on the species of the rocky shore SAC/Ramsar sub-feature.

d) Changes in physical regime and Changes to the flow & velocity regime

Conservation objectives (see section 1.5.1)

- *The characteristic physical form (tidal prism/cross sectional area) and flow (tidal regime) of the estuary is maintained;*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained;*

Natural England & Countryside Council for Wales, 2009[459]

Changes to the tidal prism and estuary cross section as a result of the sea wall
The sea wall is being located above the high spring tide mark and therefore only extreme condition tides will interact with the structure. The new wall will be less energy absorbing than the natural cliff and therefore the scour protection at the toe of the wall has been proposed to mitigate this effect.

The present Spring tidal prism of the Bristol Channel at the location of Hinkley is about 10^{10} cubic metres, while the Neap tidal prism is effectively half this at about 5×10^{9} cubic metres. Any changes to the tidal prism due to the sea wall over the life of the structure are only a few tens of cubic metres, and therefore only about a millionth of a percent of the tidal prism. Similarly any changes to the cross section of the Bristol Channel due to the sea wall are less than about a hundredth of a percent, as the mane tidal cross section of the Channel is about 300,000 square metres.

Any effects of the sea wall on the tidal prism or estuary cross section over the life time of the power station is therefore insignificant.

Changes to the sediment loading as a result of the sea wall
It is accepted that the sea wall will result in the loss of some sediment supply to the Bristol Channel as it will protect the cliffs fronting the power station from erosion. The contribution of sand and mud from the present cliff erosion at this location is considered to be insignificant compared with that from other sources. Assuming that

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[458] Kinne, O. (1971). Marine Ecology: A Comprehensive, Integrated Treatise on Life in Oceans and Coastal Waters. Vol. 1 Environmental Factors, Part 2. Chichester: John Wiley & Sons
[459] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

the sand and mud proportion of the cliff erosion is 75%, ie. about 900 m^3 per year, then this equates to about 2,000 tonnes of sediment. This is about 0.04% of the total annual sediment supply to the Severn Estuary which is between 4.16 and 5.4 million tonnes per year (EA 2006, Severn Estuary CHaMP). Therefore, the reduction in sediment introduction to the Severn Estuary as a result of the construction of the sea wall is considered to be insignificant.

It has been estimated that the supply of gravel to the Estuary due to the cliff erosion is about 300 m^3 per year, which after dissolution and attrition represents about 150 m^3 per year down-drift from the Hinkley site at the gravel ridges of Catsford And Wall Commons. In relation to the overall gravel budget of the Severn Estuary, this volume is also considered to be insignificant, given the existing volumes of gravel which occur over the whole site. However, the main inter-tidal features which are believed to receive the gravels from the cliff erosion at Hinkley are the local gravel pocket beaches, the gravel strips at high water, and the gravel ridge complexes to the east of Stolford; ie the gravel ridges of Catsford and Wall Commons.

The volume of gravel in the gravel ridges of Catsford and Wall Commons is estimated to be about 300,000 m^3. The potential loss from the cliff therefore equates to about 0.05% of the gravel volume. Over a 100 years, this volume could reach 5% of the estimated volume of the ridges. However, it is not clear how much of this cliff sediment actually reaches the gravel ridge complexes to the east, particularly with the line of coastal defences comprising large boulders which lie between Hinkley and Stolford. These could act as a trap for any gravels which are being transported to the east between Hinkley and Stolford. Also, additional gravel sediment will be provided by erosion of the cliffs to the west of Hinkley and by the erosion of the wave cut platform, so the loss of sediment from the cliffs behind the sea wall do not represent the only source of gravel sized sediment to the area.

Coastal squeeze

The potential loss of inter-tidal area due to the sea wall is essentially the loss of additional width which would have occurred by cliff erosion, but which will not occur because of the construction of the sea wall. This is estimated to be anywhere between 6 and 50 metres, but an estimate of 20 m has been assumed in relation to the sediment supply (see above). This loss estimate is not considered significant when compared with the potential loss of inter-tidal area in the Severn Estuary due to sea level rise.

There may be some small additional loss due to the down-cutting of the wave-cut platform, but how much of this is due to the sea wall rather than simply sea level rise is not clear. The report submitted by the applicant to inform our HRA suggests that this may be an additional 20 m loss, which again is not considered significant when compared with the potential loss of inter-tidal area in the Severn Estuary due to sea level rise.

Conclusion

We can therefore conclude that any changes to the sediment budget or changes to the physical form, i.e. tidal prism / cross sectional area, and the flow, ie tidal regime, as a result of the presence of the sea wall will not have an adverse effect on the Severn Estuary SAC and Ramsar features.

Overall conclusion

Hazard assessed	Adverse effect on estuaries feature?
Habitat loss & physical damage (abrasion)	No
Changes to water chemistry	No (see advice below)
Changes in turbidity and suspended sediment	No
Physical damage (smothering)	No
Reduced surface water flows	No
Changes in physical regime	No
Changes in flows and velocity regime	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Advice given *No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.* *No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to the Marine Management Organisation for approval.*	Local Planning Authority and Marine Management Organisation	Development Consent Order or Marine Licence

5.6.1.2 Reefs

a) Changes to water chemistry (toxic contamination, salinity, oxygenation), Changes in turbidity and physical damage (smothering)

Conservation objectives (see section 1.5.1)

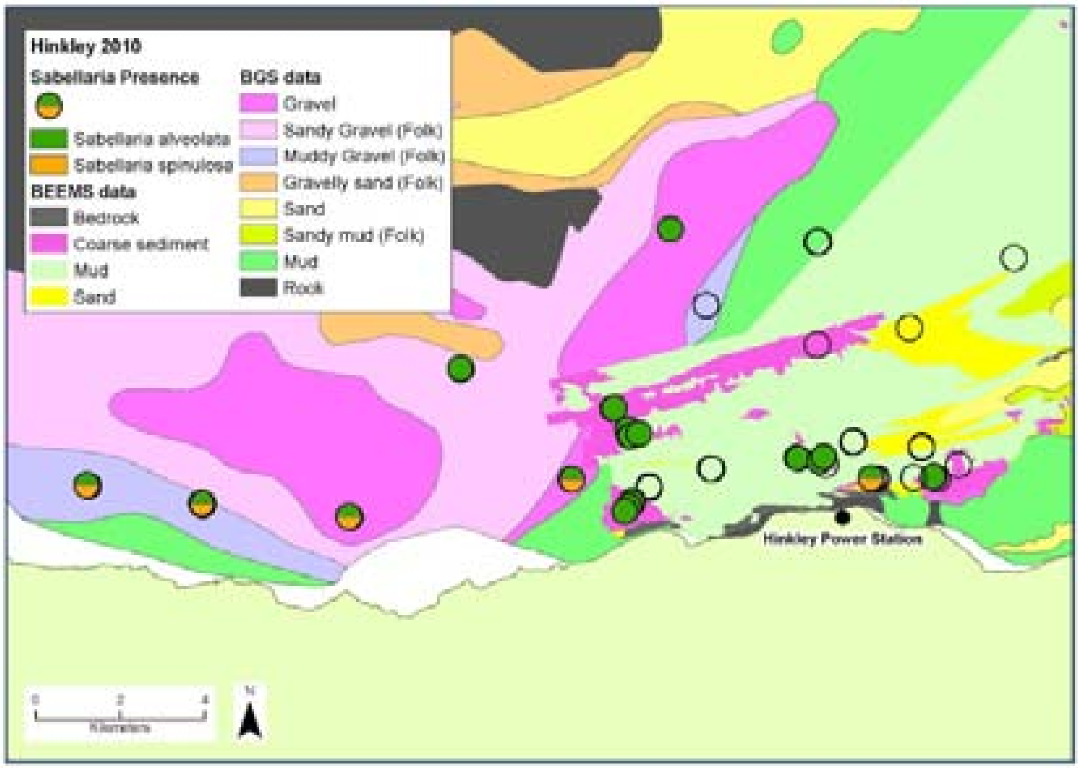
- *the total extent and distribution of Sabellaria reef is maintained;*
- *the community composition of the Sabellaria reef is maintained;*
- *the full range of different age structures of Sabellaria reef are present;*
- *the physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009[460]

Sea wall construction

The location of the potential areas of *Sabellaria* reef in relation to the sea wall and barge berthing area are shown on figures 5.6.1.1 and 5.6.1.3 respectively, with the dark green areas representing *S. alveolata.* Figure 5.6.1.2.1 shows the potential areas of *Sabellaria* reef beyond the inter-tidal area.

Figure 5.6.1.2.1 Presence of Sabellaria alveolata (green) and Sabellaria spinulosa (orange) across the Hinkley Point area surveys carried out in February and March 2010. Open circles indicate stations where no Sabellaria were observed in samples. Figure taken from TR141[461].



[460] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[461] BEEMS Technical Report TR141 (TR141). Hinkley Point Sabellaria assessment: analysis of survey data 2010. EDF BEEMS (Marine Ecological Surveys Ltd.), 2010.

The sea wall construction works could lead to the generation of relatively large quantities of sediment and high concentrations of suspended solids. There could also be significant increases in pH as large quantities of concrete are used in addition there could be oil or fuel from accidental spills from machinery.

As discussed within section 5.6.1.1(b) the EDF report to inform the HRA (Haskoning 2011) does not state how drainage and dewatering activities will be managed during construction of the sea wall. However it identifies the two options available, i.e. to discharge directly to the foreshore or to pump the water up to the Water Management zone for pre-discharge treatment

Assuming that drainage and dewatering activities are not pumped to the Water Management Zone for treatment, to asses the potential impact on the habitat it has been necessary to understand the tidal heights across the foreshore. We have estimated that there is approximately a 30m variation between a high spring tide and a high neap tide with a high spring tide reaching approximately 2.5m below the toe of the sea wall. Therefore the construction site will not be inundated during the lowest of the high tides but all habitats below the construction site will be inundated twice every day.

At high tide any discharges, even if containing relatively high concentrations of suspended solids, will be highly diluted and dispersed and therefore the potential effects will be trivial.

At low water, discharges will infiltrate through the beach substrate and filter out a lot of the sediments. Water, depending on the degree of sediment, will run down the shore and collect on the rock platform and within pools and crevices. This will have more of an impact on habitats in the higher shore, particularly rock pools, rather than those in the mid or lower shore such as *Sabellaria*.

Upon review of the construction methods it is likely that there would be minimal amount of water discharge as a result of the construction of the sea wall. The water that would arise would be groundwater close to the surface which would flow when the hole for the base of the wall was being dug. This would be a shallow excavation as the sea wall proposed does not have a deep foundation. The water discharged would be in small amounts at any given time as a short patch would be excavated, then a wall constructed before moving on to the next part. Therefore, the expectation would be that there would be small amounts of water that would be subjected to dilution with the tide.

Whilst it is likely that discharges would be small and diluted with the tide, we have advised the competent authorities, in this case the Local Planning Authority (LPA) and Marine Management Organisation (MMO), that a surface/ tunnel water management scheme that will manage the contaminants associated with these construction activities is required.

Furthermore, we have advised the competent authority at the Development Consent Order stage to implement the following conditions:

No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.

No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to the Marine Management Organisation for approval.

Conclusion

We can therefore conclude that any changes to water chemistry as a result of the construction of the sea wall will not have an adverse effect on the reef feature designated under the Severn Estuary SAC and Ramsar.

b) Physical damage (abrasion) and habitat loss

Conservation objectives (see section 1.5.1)

- *the total extent and distribution of Sabellaria reef is maintained;*
- *the community composition of the Sabellaria reef is maintained;*
- *the full range of different age structures of Sabellaria reef are present;*
- *the physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009[462]

Physical damage (abrasion) and habitat loss as a result of enabling the construction of the sea wall (i.e. the delivery of the rock)

Vessels grounding on the shore as the tide falls may cause some physical damage and habitat loss to the area of potential *Saballaria* reef down shore of the berthing footprint (see figure Sw2 with *Sabellaria alveolata* areas represented in dark green).

As discussed in section 5.6.1.1.(b), the *Sabellaria* reef (a qualifying interest features of the SAC) is found between the mean low water neap tide height and the mean low water spring tide height and extends into subtidal waters. Barges heading for the berthing area will traverse across the *Sabellaria* on the tide with the aim to ground on the designated berthing area as the tide ebbs. There should therefore be no physical damage to the *Sabellaria* reef, although it is noted that a small area of potential *Sabellaria* reef (with an approx. measurement of 5x2 meters) does fall within the rock armour barge berthing and unloading area, but it is not considered significant. However, it would not take much of a human error particularly during high winds or rough seas for the boat to go off course and potentially impact the area of *Sabellaria* reef down shore of the berthing area. To quantify that potential impact, the area of *Sabellaria* reef (shown within figure 5.6.1.1.3 in dark green) has been estimated to be approximately 5000m² (0.5 ha) (likely over estimate). The total area of reef feature within the Severn Estuary SAC is 1474.3 ha (JNCC, 2011)[463], so 0.5ha equates to 0.034%, which is insignificant.

[462] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[463] JNCC (2011) Joint Nature Conservation Committee: UK SAC summary data spreadsheet. Severn Estuary SAC Reef feature. http://jncc.defra.gov.uk/page-1461

The marine ecology chapter of the Environmental Statement (EDF, 2011)[464] states that as a precautionary measure, no vessel would be permitted to come to ground outside an inner perimeter set back 50m from each of these boundaries. This would permit flat bottomed barges to be brought close to shore during high tide, permitting them to ground over the subsequent low water period and be unloaded, without damaging sensitive receptors such as *Sabellaria.*

Conclusion
We can therefore conclude that any potential physical damage caused as a result of the barges berthing on the foreshore during construction will not have an adverse effect on the reef feature designated under the Severn Estuary SAC and Ramsar.

Overall conclusion

Hazard assessed	**Adverse effect on reef feature?**
Changes to water chemistry	No (see advice below)
Changes in turbidity and suspended sediment	No
Physical damage (smothering)	No
Habitat loss & physical damage (abrasion)	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	**Competent Authority**	**Method**
Advice given *No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.* *No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to the Marine Management Organisation for approval.*	Local Planning Authority and Marine Management Organisation	Development Consent Order or Marine Licence

[464] EDF. (2011) Hinkley Point C Environmental Statement: Volume 2, Chapter 19: Marine Ecology, October 2011. Section 19.6.54.

5.6.1.3 Migratory fish and fish assembalge

a) Physical damage and disturbance

Conservation objective (see section 1.5.1)

- *The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.*

Natural England & Countryside Council for Wales, 2009[465]

Impacts associated with the development of the sea wall could potentially result in temporary disturbance to the fish around HPC inter-tidal area in terms of noise and vibration and therefore avoidance of this area by fish. However, as the construction works for the Sea Wall would occur above Mean High Water Springs (MHWS) and out of the water at all times, the potential for any noise and vibration effects to occur in the water column would be extremely limited, with noise being generated on the uppermost sections of the shore and often at some distance from the water's edge. Noise disturbance is therefore unlikely to cause any mortality, and will thus not have an adverse effect on the migratory fish or fish assemblage populations.

Conclusion
We can therefore conclude that the construction of the sea wall will not have an adverse effect on the migratory fish and fish assemblage features designated under the Severn Estuary SAC and Ramsar.

Overall conclusion

Hazard assessed	Adverse effect on migratory fish and fish assemblage feature?
Physical damage and disturbance	No
Overall conclusion	**No adverse effect upon site integrity**

[465] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

5.6.1.4 Migratory birds and bird assemblage

a) Disturbance to birds as a result of constructing the sea wall

Conservation objectives (see section 1.5.1)

Internationally important populations of regularly occurring migratory species (wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, gadwall, passage ringed plover wintering curlew* wintering pintail*, wintering teal**—breeding Lesser Black-backed Gull**) *recommended additions under the SPA review, **recommended under the Ramsar review*

- *aggregations of wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, gadwall, wintering ringed plover, wintering curlew, wintering pintail, wintering teal and breeding Lesser Black-backed Gull at feeding or roosting sites are not subject to significant disturbance*

Internationally important assemblage of waterfowl

- *waterfowl aggregations at feeding or roosting sites are not subject to significant disturbance.*

Natural England & Countryside Council for Wales, 2009[466]

Introduction to disturbance
Disturbance includes activities which cause birds to cease feeding and/or move away, resulting in reduced energy intake. Displacement refers to longer term relocation away from core feeding areas. Both types of impact can result in reduced body condition that may affect winter survival or subsequent breeding success

There have been a number of studies into understanding the response of birds to visual and acoustic disturbance. Some of this information is collated with the report to inform the HRA (Haskoning, 2011 - sections 6.3.57 – 6.3.79)[467]. It considers:

- The type, level, visibility and frequency of disturbance
- The time of year, day and weather
- The bird species (habits/sensitivity/condition)
- The importance of the area for each species
- The availability and quality of other suitable habitat
- The level of competition of other suitable habitat

Visual cues tend to result in a greater impact than noise with visual impacts mainly arising from people, vehicles and vessels. With regards to noise, sudden or intermittent noise such as piling or generator start up are liable to cause birds to stop feeding and move away, whilst continuous noise such as generators in use after start-up would have a relatively low impact as birds would quickly adapt. People and vehicles within the inter-tidal zone have a continual disturbance effect.

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[466] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009
[467] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc Ref: 3.16 October 2011. Report prepared for EDF.

Studies in the Wadden Sea[468] identified the responses of waterbirds to both visual and aural stimuli based around construction of flood defences. It indicated that in general a buffer zone of 100m to 200m was required to prevent detectable disturbance effects.

This work also provides data on the levels of noise at which a bird response is elicited. It indicates that aural stimuli between approximately 50dB - 85dB appear to result in local behavioural change including cessation of feeding, taking up of alert postures and short distance movement; above this noise level displacement away from the area may occur.

Studies in the Humber[469] categorised disturbance impacts based on studies of construction work in the Humber Estuary. Activities listed as high produced a significant, often flight response, moderate a behavioural response and low, no observable response:

- Personnel and plant equipment on mudflat: High
- Third party on mudflat: High
- Personnel and plant equipment on seaward toe and face: High to Moderate
- Intermittent plant equipment and personnel on crest: High to Moderate
- Third party on bank: High to Moderate
- Irregular piling noise (above 70db): High to Moderate
- Long-term plant and personnel on crest: Moderate
- Regular piling noise (above 70db): Moderate
- Irregular noise (50db - 70db): Moderate
- Regular noise (50db - 70db): Moderate to Low
- Movement of crane and load above sight-line: Moderate to Low
- Noise below 50db: Low
- Long-term plant only on crest: Low
- Activity behind flood bank (inland): Low

The Environment Agency Air Quality Technical Advisory Group guidance[470] indicates that noise levels of 80 dB (maximum, LA_{max},) and 55 dB (1 hour, LA_{eq}) may be used as thresholds for impacts on birds.

Wading birds can adjust to disturbance by increasing feeding intake, by feeding at different times or by becoming habituated[471]. The applicant in their report to inform the HRA (Haskoning, 2011) has used a precautionary distance of 250m as most birds are sensitive to disturbance up to this range. This has been confirmed by Natural England as a suitable distance to base the assessments around[472]. Laursen *et al* (2005)[473] found that curlew and pintail may be susceptible to disturbance at distances up to 300m and this has been taken into account in our assessment.

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468 Cutts, N., Phelps & Burdon, 2009, Institute of Estuarine & Coastal Studies, Hull University, Report to Humber INCA ‘Construction and Waterfowl: Defining Sensitivity, Response, Impacts and Guidance’

469 Institute of Estuarine and Coastal Studies (IECS), 2008, Conservation goals for waterfowl in estuaries. Report to HARBASINS.

470 Environment Agency, 2004, AQTAG10 Agency's Background Statement on the effects of industrial noise on wildlife

471 Haskoning, 2011, Hinkley Point C report to inform the HRA (Final draft)

472 Bird Topic Meeting with Natural England, 9 Dec 2011

473 Laursen K., Kahlert, J and Frikke, J. (Laursen et al 2005). Factors affecting escape distances of staging waterbirds. 2005. Wildlife Biology, 11 (1):13-19.

Birds using the Hinkley Point frontage

Bird surveys were carried out by Amec between April 2007 and March 2009 (Amec 2011)[474]. The area was split into five count sectors and the counts included all birds on the foreshore and out to 500m (maximum threshold for standard recording). The count sectors are shown on figure 5.6.1.4.1 below. The surveys excluded birds flying through the area.

Figure 5.6.1.4.1 Inter-tidal and Inshore Count Sectors (Amec, 2011)

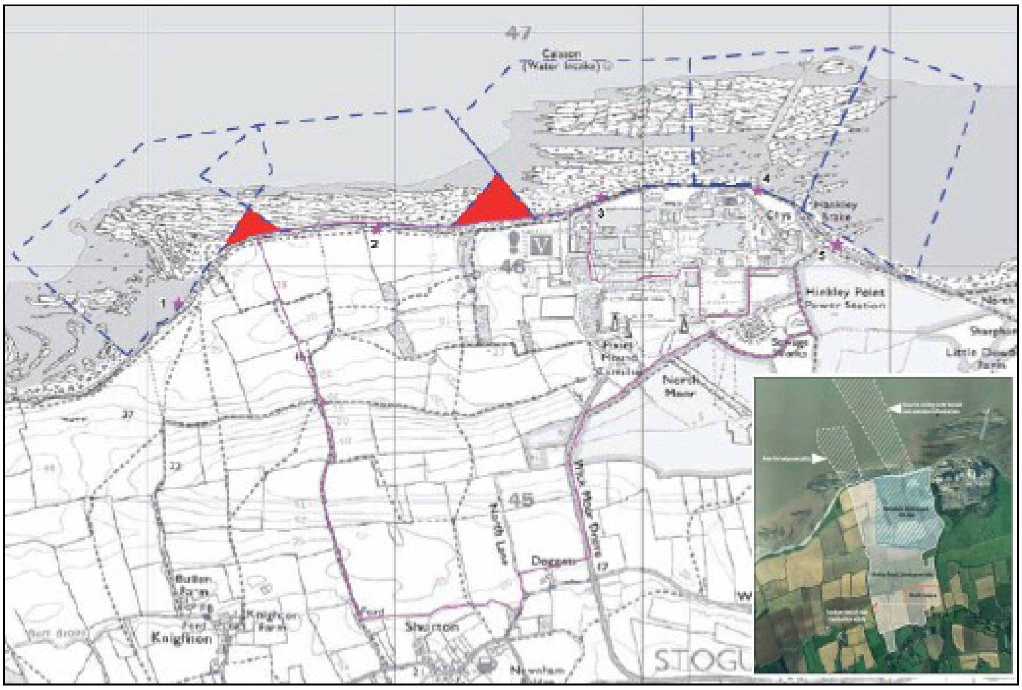

Table 5.6.1.4.2 Peak count of birds in each Hinkley Point count sector, 2007-2009 (Haskoning 2011)

	CS1	CS2	CS3	CS4	CS5	Notes
Ringed Plover *Charadrius hiaticula*	33	16	4	10	4	Mostly foraging in CS1
Curlew *Numenius arquata*	16	24	25	41	63	Mostly foraging in CS5 and roosting in CS4
Dunlin *Calidris alpina alpina*	7	13	0	0	9	Small numbers foraging
Pintail *Anas acuta*	0	4	60	35	48	Mostly CS4 and CS5, some in CS3, few in CS2
Redshank *Tringa totanus*	1	1	1	1	22	Mostly foraging in CS4 and CS5
Shelduck *Tadorna tadorna*	33	500	200	71	700	Foraging mostly in CS5, loafing on sea in all sectors
Teal *Anas crecca*	0	1	0	25	14	Sporadic
Wigeon *Anas penelope*	39	17	67	220	204	Mostly foraging and loafing in CS4 and CS5
Lapwing *Vanellus vanellus*	2	0	35	3	102	Vast majority in CS5
Mallard *Anas platyrhynchos*	33	4	3	2	51	Low level use, mostly CS4 and CS5
Shoveler *Anas clypeata*	0	0	4	0	4	Infrequent
Grey Plover *Pluvialis squatarola*	3	1	0	0	0	Very sporadic
Whimbrel *Numenius phaeopus*	1	5	1	4	16	Vast majority in CS5

[474] Amec, 2011, EDF Energy Hinkley Point C Associated Development, Combwich Wharf and Laydown Facility Baseline Bird Report

Each count sector was visited 182 times and lasted for 45 minutes. The data is shown in Table 5.6.1.4.2 . The data defines the total peak bird numbers within the entire count sector and does not differentiate between birds using the landward areas and seaward areas of each sector.

Entec[475] also surveyed birds using the frontage from Hinkley Point to Steart between April 2010 and January 2011 from four observation points, covering a frontage 7 km in length. The survey area focuses on the inter-tidal mudflats to the east of Hinkley Point. For the purpose of assessing disturbance to birds as a result of constructing the sea wall this data provides an indication of bird usage but is not comparable to the Amec data as different count sectors area used.

The Environment Agency has independently analysed the Wetland Bird Survey (WeBS) data for Bridgwater Bay to aid assessment of impacts. The data used was the five year peak mean from 2004 to 2009. A summary of this information for the species surveyed in significant numbers is given in Table 2.6.6S3 within Section 2.6.6 (Nicholas Pearson, 2011). The WEBS data for the Severn Estuary over the last 20 years (1990 to 2009) shows that bird numbers have reduced which suggests that the estuary may not be at ecological carrying capacity with respect to the overall assemblage of birds using it.

The other survey work that has been carried out for the purposed of this development proposal is listed in section 2.6.3.6.

The data indicates that Bridgwater Bay makes an important contribution to supporting the populations of several species of birds that are qualifying features for the SPA, particularly shelduck, ringed plover and curlew. It also supports significant numbers of dunlin and redshank. However, the resources found in the Bay are likely to be food (it is one of the larger intertidal areas within the SPA) and a slightly more sheltered environment than the rest of the estuary, which is highly exposed to prevailing south-west winds. Shelter is likely to be a principal factor in the use of the site by moulting shelduck.

Disturbance assessment
The construction of the 760m length sea wall at the top of the foreshore could cause significant disturbance to birds using the area directly in front of the sea wall. Disturbance is likely to arise as a result of:

- construction activities (excavation of the cliff, placement of vertical defence walls and rocks for scour protection) including noise and vibration caused by operation of machinery and rock removal;
- delivery of rock by barges (noise and visual impact as the delivery area will protrude fro the construction zone on the foreshore);
- transit of vehicles and operation of machinery (noise and visual);
- workforce activity on the cliff top and foreshore (visual);
- artificial lighting during 24 hour construction of the sea wall (visual).

The applicant has considered the need to restrict the movement of personnel outside the footprint of the works. It is proposed that the working area for the sea wall will be defined and demarcated – this is expected to be a 30m corridor above mean high water.

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[475] Entec, 2011, Hinkley Intertidal Bird Report 2010-2011. Report prepared for EDF

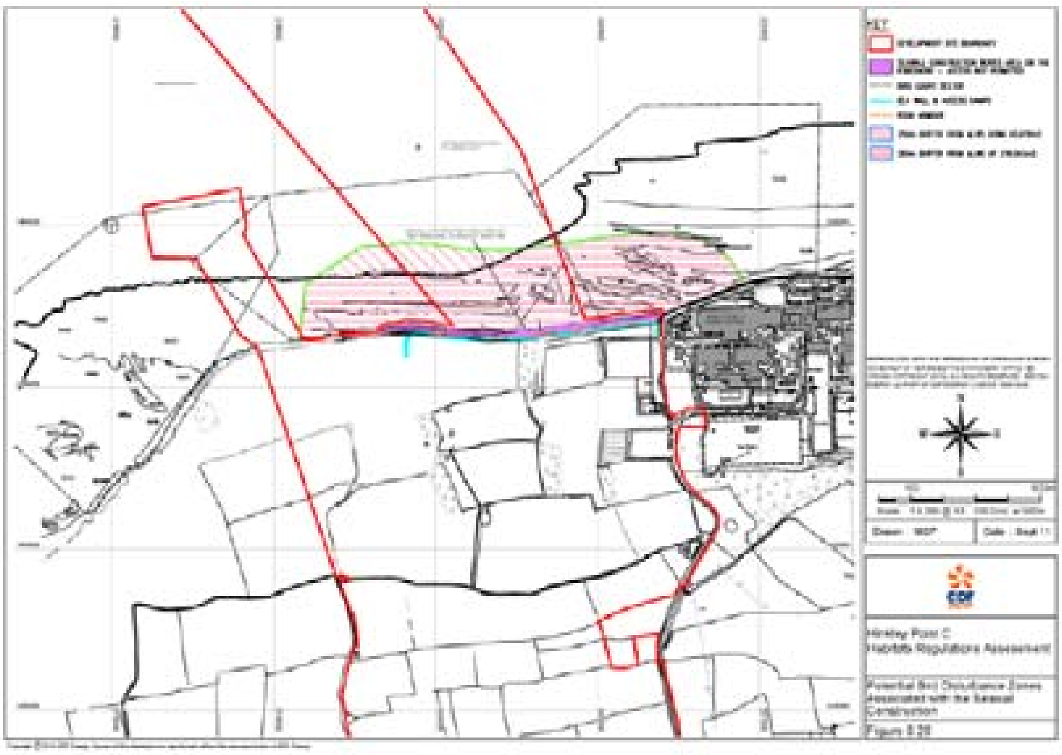
Count sectors 2 and 3 of the Amec bird survey (Amec 2011) are relevant to the construction of the sea wall.

Disturbance zones

The applicant has estimated that 70db will be the predicted noise level for the main site development (Haskoning 2011). The location of the sea wall at the top of the shore and the extending 30m construction zone means that any disturbance is likely to be significant compared with disturbances that arise from the main site. The potential intensity of disturbance however would decrease with distance away from the location of the sea wall.

The work carried out on visual and noise disturbance (see 'Introduction to disturbance' above) identifies that disturbance effects are generally confined to a zone of 250m around the activity. This is the approach used by the applicant and we agree that it is appropriate. Laursen *et al* (2005) observed that Pintail and Curlew flush at a longer distance when approached by people compared to other waterbirds and therefore we have taken a more precautionary approach and used 300m distance for these 2 species. Figure 5.6.1.4.3 shows a the 250m zone around the sea wall as defined in the Report by EDF to inform the HRA (Haskoning 2011). This figure does not include the area proposed to be used for the barges unloading the rocks.

Figure 5.6.1.4.3 Potential bird disturbance zones associated with the sea wall construction (Haskoning 2011)



Please note that a 300m disturbance zone does not extend into either count sectors 1 or 4.

The upper part of the shore in front of the sea wall is characterised by cobbles and boulders and is not utilised as foraging habitat for designated birds. Bird usage at the top of the foreshore is relatively low[476]. The effects of disturbance however will extend beyond this zone. The adjacent habitat affected by disturbance is a mixture of eulittoral rock types supporting) seaweeds (*Fucus* spp. and *Ascophyllum nodosum*) and mussels (*Mytilus edulis).*

We agree with the applicant that if birds are displaced from the foreshore there are large areas of available foraging habitat within their home-range into which birds can relocate without any significant implications for their energy expenditure or survival.

A calculation of the amount of available habitat beyond the 250m disturbance zone for each count sector is shown in table 5.6.1.4.4 below.

Table 5.6.1.4.4 Calculated area of available habitat beyond the 250m disturbance zone for count sectors 1, 2 and 3 (excluding rock delivery area) (Haskoning 2011)

Count Sector	Area of inter-tidal habitat	Sea Wall Construction works	
		Area of disturbance at 250m distance (ha)	% of Count Sector
1	33.05	0.00	0
2	17.70	13.90	79
3	34.10	10.79	32

This is supported by the WeBS data over the last 20 years which shows that the bird numbers using the Severn Estuary have declined over the years and the estuary is not at its ecological carrying capacity at present.

The barges (transit and unloading)
The delivery and unloading of the barges is likely to be a disturbance to birds because of the type of activity and its location. Barges would be brought towards the shore during high water and allowed to ground as the tide falls, their cargo would then be unloaded. Disturbance could arise to foraging birds within 250m of the unloading. In addition, the movement of the barges could impact on rafting and loafing shelduck.

EDF have confirmed[477] that the rock delivery will take place over a period of 2 months starting 15/08/2013 – 09/10/2013, although the specific dates are subject to change. This means that the delivery of rock will not take place over the winter period, although there may be Autumn migrants on passage. The rocks being unloaded from the barges will be stored on the front edge of the construction zone which will create a visual bund between the estuary and the sea wall construction zone, therefore limiting the visual disturbance (Haskoning 2011).

Overall assessment
In order to provide a thorough assessment of potential disturbance effects on the migratory birds and bird assemblage with the Severn Estuary SAC and Ramsar we have assessed each species observed in the Amec survey (Amec 2011) individually. Table 5.6.1.4.5 lists the designated species of the SPA and Ramsar that were observed in the survey and provides an assessment of the data obtained for count sectors 2 and 3. It also makes reference to the WeBS data for Bridgwater Bay.

[476] HPC waterbird disturbance issues – draft NE/RSPB discussion document for 15 July 2011'.
[477] EDF e-mail correspondence via Clare Proctor 26th March 2012.

Species that are observed in numbers less than 1% of the Severn Estuary SPA population have been assessed as not being susceptible to an impact that would lead to an adverse effect on site integrity. In other words, an impact on a population as small as 1% or less would not show any detectable population effects. Birds in populations above 1% are considered in further detail below. Species above 1% of the Severn Estuary SPA population have been further assessed. These species include shelduck, pintail and Ringed Plover and this analysis is provided after the table.

Table 5.6.1.4.5 Peak count for birds in count sectors 2 and 3

Species	**Status**	**CS2 (Peak count nos.)**	**CS3 (Peak count nos.)**	**Summary of records**	**Severn Estuary SPA population [478]**	**% of SPA population**
Annex 1 Species						
Bewick's swan	SPA Ramsar	Bewick's swan *Cygnus columbianus bewickii* have been screened out of this HRA as they are not influenced by the proposed construction and operation activities of the Hinkley Point C Project (Haskoning, 2011)				
Internationally important populations of regularly occurring migratory species:						
European White fronted goose	SPA Ramsar	This species has not been recorded either using the rocky shore in front of the development or across Stert flats (Haskoning, 2011)			2,664	N/A
Dunlin	SPA Ramsar	13	0	The WeBs data identifies Bridgwater Bay as a significant and important resource for dunlin. However, very low numbers were seen foraging on the foreshore in front of the HPC development site. This is mainly because dunlin feed predominantly on benthic invertebrates and so will be present on the inter-tidal flats at low tide and on adjacent fields at high tide. Very large numbers (estimated at 15-20,000) have been observed in areas adjoining the Steart peninsula during the winter months (Halcrow, 2011)[479] . Only 1 bird was seen roosting on 1 date in the Amec survey and therefore this area is not an important roost site. The numbers observed represent less than 1% of Severn Estuary SPA population.	44,624	<1%
Redshank	SPA Ramsar	1	1	The WeBs data identifies Bridgwater Bay as a significant and important resource for Redshank. However, very few redshank were observed in the	2,330	<1%

[478] WeBS: Number of individual birds, 5 year peak mean count 1991/2 and 1995/6.
[479] Halcrow, 2011, Steart Coastal Management Project, HR02 Appropriate Assessment Report (Draft)

Species	Status	CS2 (Peak count nos.)	CS3 (Peak count nos.)	Summary of records	Severn Estuary SPA population [478]	% of SPA population
				area in front of the HPC development. As for dunlin, their preferred feeding grounds are the inter-tidal mudflats. The numbers observed represent less than 1% of Severn Estuary SPA population.		
Shelduck	SPA Ramsar	500	200	The Shelduck seen on the foreshore in CS2 and CS3 were in very low numbers however, large congregations of moulting birds were seen loafing on the sea during high water. There are no regular onshore roost sites for Shelduck in CS2 or CS3. This species is discussed further in the section below.	3,330	>1%
Gadwall	SPA Ramsar	This species was not recorded in the Amec 2011survey however 2 birds were observed in the Entec survey (Entec 2011) indicating that bird usage is very small, probably because inter-tidal resources are not its main food.			282	<1%
Ringed Plover (passage)	SPA Ramsar	16	4	The majority of ringed plover observed were foraging or roosting on the rock platforms in CS1 (peak count 33) in all months of the year. A peak count of 16 birds was observed in CS2 which represents 2.4% of the SPA population. The report to inform the HRA states that in CSs1-3 on only 6 occasions numbers exceeded 1% of population (<7 individuals). However, ringed plover usage in CS2 and CS3 is limited for the majority of the time. This species is discussed further in the section below.	655	>1%
Curlew	SPA	24	25	The WeBs data identifies Bridgwater Bay as a significant and important resource for Curlew. The Amec data suggests that the site is used regularly by curlew for foraging and roosting but the numbers are low and do fluctuate suggesting that the birds use other sites. The peak count is less than 1% of the Severn Estuary population in CS2 and CS3.	2,903	<1%
Pintail	SPA Ramsar	4	60	Pintail were frequently observed between September and March across the whole survey area either feeding at low water or loafing at high water. Very low numbers were observed in CS2 and none in CS1. Pintail was noted using CSs1–3 on 3% of survey dates. On 3 occasions the number of birds exceeded 1% of the Severn Estuary SPA population (range 6 – 60 birds) –	599	>1%

Species	Status	CS2 (Peak count nos.)	CS3 (Peak count nos.)	Summary of records	Severn Estuary SPA population [478]	% of SPA population
				on the remaining occasions 2 and 4 birds were recorded. No foraging activity was recorded in CSs1–3 indicating that it is not a core foraging area; foraging by relatively large numbers of pintail was recorded in Count Sector 5. The data suggest that pintail do not habitually use Count Sectors 1 – 3. *This species is discussed further in the section below.*		
Teal	SPA Ramsar	1	0	Teal were only observed on 5 dates across the whole survey area. The numbers observed represent less than 1% of the Severn Estuary population.	4,456[480]	<1%

Waterfowl assemblage (listing birds observed in the Amec survey)

Species	Status	CS2 (Peak count nos.)	CS3 (Peak count nos.)	Summary of records	Severn Estuary SPA assemblage population [481]	% of SPA population
Wigeon	SPA	17	67	Despite a peak count of 67 birds in CS3 this number is less than 1% of the Severn Estuary population. Wigeon were observed regularly during the winter months but the highest numbers were seen foraging at low water and loafing at high tide in CS4 and CS5. No regular roost sites were found. Birds observed in CS2 and CS3 are likely to be the same population using CS4 and CS5, therefore any disturbance to wigeon from the construction of the sea wall will simply move these birds to areas already within their home range. The WeBS five year mean peak numbers do not suggest that	In assemblage (8,466)	<1%

[480] WeBS: Number of individual birds, 5 year peak mean count 1998/99 and 2002/03
[481] WeBS data: Severn Estuary 5 year peak mean 2004/05 – 2008/9.

				Bridgwater bay is an important resource for this species.		
Whimbrel (passage)	SPA	5	1	Whimbrel were predominantly observed during the spring passage period (April –May) and in August. The peak count observed in CS2 is greater than 1% of the Severn Estuary population. However, Whimbrel congregate at a small number of key sites on migration and the low numbers in CS2 and CS3 indicate that the area does not represent a key re-fuelling site. Along with Curlew, their dependency on inter-tidal food resources is lower than many other waders and wildfowl. This species is not discussed further for these reasons.	In assemblage (171)	>1%
Mallard	SPA Ramsar	4	3	Very small numbers seen in CS2 and CS3 which represent less than 1% of the Severn Estuary population. Mallard are widespread in fresh and saltwater	In assemblage (3,385)	<1%
Shoveler	SPA	0	4	Very small numbers seen in CS2 and CS3 which represent less than 1% of the Severn Estuary population.	In assemblage (561)	<1%
Grey Plover	SPA	1	0	Very small numbers seen in CS2 and CS3 which represent less than 1% of the Severn Estuary population.	In assemblage (655)	<1%
Lapwing	SPA	0	35	Very small numbers seen in CS2 and CS3 which represent less than 1% of the Severn Estuary SPA population.	In assemblage (15,217)	<1%

Further detail and assessment has been considered for Shelduck, Pintail and Ringed Plover:

Shelduck:
The WeBS five year mean of peaks count for Bridgwater Bay is 2,287. This represents 69% of the SPA population, indicating that Bridgwater Bay is a particularly important resource within the estuary.

The Shelduck seen on the foreshore in CS2 and CS3 were recorded in very low numbers. In addition, the habitat within the sea wall construction zone does not provide suitable foraging grounds for shelduck justifying why this species is in small numbers. It is also reported that there are no regular onshore roost sites for Shelduck in CS2 or CS3.

Large congregations of moulting birds have been recorded loafing on the sea during high water and therefore the applicant has carried out an additional shelduck survey in July 2011 (Amec 2011a)[482]. This survey specifically related to the jetty development however it is also applicable, to some extent, to the sea wall construction area, albeit that the latter is further to the east and does not extend as far out to sea. This survey noted a peak count number of 450 birds and also noted that the majority of rafting birds are beyond 500m offshore. On one occasion birds came within 190m of the proposed development site and on two occasions they were within 500m of the development site. The survey also noted that birds predominantly move with the tide but they can swim against the tide and are not adversely effected by walkers on the shore.

The WeBS five year mean of peaks count for Bridgwater Bay is 2287. This represents 69% of the SPA population, indicating that Bridgwater Bay is a particularly important resource within the estuary. This species occurs in nationally important numbers through winter, autumn and spring, with mean of peak counts representing 292%, 198% and 116% of the threshold for a nationally important population respectively. The autumn population represents 76% of an internationally important population. The peak count for the study area is 2049, which is 61.5% of the SPA population

The construction activity and the rock delivery operation could effect these birds. We agree that the 250m disturbance zone is appropriate for this species and therefore it has been necessary to assess the impact of loafing birds coming into this zone.

Impact assessment:
The habitat (at low water) within the 250m disturbance zone does not contain the correct resource for Shelduck and therefore the foreshore in front of the sea wall is unlikely to be a core area of the home-ranges of Shelduck. The key consideration is moulting loafing birds which were seen in large aggregations on the sea during the summer months. Construction activity, in particular the delivery of the rock by barges, has the potential to impact shelduck within the 250m zone.

We agree with the applicant that the development of the sea wall alone is unlikely to have an adverse effect on the integrity of the shelduck population in the Severn estuary. We have based this assessment of the following points:

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[482] Amec, 2011. (Amec 2011a). Environment & Infrastructure UK Limited,Technical Note, Appendix 20Q - Shelduck Survey Baseline Information, September 2011

- The habitat within the construction zone does not provide the correct resource to sustain shelduck
- A working area will be defined and demarcated on the ground to restrict personnel accessing the inter-tidal rock platforms
- Shelduck only occasionally come into the 250m disturbance zone and there is extensive open water beyond this zone that will remain undisturbed
- Much of the disturbance zone for the sea wall will be screened by the rocks that are to be stored at the seaward edge of the 30m construction zone
- Shelduck can swim away from disturbance (this is dependent on tidal strength, weather and bird condition)
- The sea wall construction works are for 12-14 months and will only cover one season

Under the Harbour Empowerment Order for the jetty, additional mitigation has been requested by Natural England to ensure no adverse effect on moulting shelduck from vessel movements to / from the temporary jetty and the refurbished Combwich wharf. The agreed approach is a Shelduck Monitoring and Mitigation scheme. Whilst not being related to the sea wall works, this agreement will provide additional information and protection for shelduck.

We advise that best practice should be incorporated in the form of mitigation (see below) if the rock being delivered by barge coincides at the same time as the shelduck are moulting. As Bridgwater Bay is an important resource for moulting shelduck this action would further protect them.

Pintail:
We consider that it is more appropriate and precautionary to use a 300m disturbance zone for Pintail (Laursen *et al* 2005). Compared to a 250m zone, this means that within the count sectors there will be less habitat available outside of the disturbance zone for birds that have been dispersed than that which is shown in table 5.6.1.4.5 above.

Taking this into account and also the fact that the disturbance zone has not incorporated the rock delivery area, it is likely that the whole of CS2 will be a potential disturbance area for Pintail. Therefore it is necessary to consider the use of the area by Pintail.

The WeBS five year mean of peaks count for Bridgwater Bay is 22. This represents 4% of the SPA population, suggesting that Bridgwater Bay is not a major resource within the estuary, and 8% of the threshold for a nationally important population. The peak count from the Entec survey (Entec 2011) is 158, which exceeds the peak WeBS count for Bridgwater Bay by a factor of seven and represents 26.4% of the SPA population and 57% of the threshold for a nationally important population.

Pintail were frequently observed between September and March across the whole survey area either feeding at low water or loafing at high water. Very low numbers were observed in CS1 and CS2 however in CS3 60 birds were observed loafing (10% of SPA population). It is not known how often exceptionally high numbers of this species come into close proximity of the HPC development. However pintail were only observed on 6 dates (3% of the survey dates) between CS1 and CS3 during the survey period and only 3 of these were greater than the 1% of the SPA population (range 6 – 60 birds) – on the remaining occasions 2 and 4 birds were recorded. We have therefore assessed this as being a very occasional occurrence. There was no foraging activity by Pintail in CS 1-3 indicating that it is not a core foraging area; foraging by relatively large numbers of pintail was recorded in Count Sector 5. The data suggest that pintail do not habitually use Count Sectors 1 – 3. The occasional large numbers relate to infrequent visits.

Impact assessment : The activity of constructing the sea wall could potentially impact Pintail within a 300m zone however, considering the above points we do not think that the construction of the sea wall alone will cause an adverse effect on Pintail. We have based this assessment of the following points:

- Birds were recorded in numbers above 1% of the SPA population on only 3 survey dates
- All birds observed were loafing and not foraging. The habitat within the construction zone does not provide the correct resource to sustain Pintail
- During the survey birds were more frequently observed in CS4 and CS5 indicating that these areas are preferred.
- The birds observed in CS3 are likely to also be using CS4 and CS5 and therefore any disturbance in CS3 will move birds to within their home-range.
- The sea wall construction works are for 12-14 months and will only cover one season
- A working area will be defined and demarcated on the ground to restrict personnel accessing the inter-tidal rock platforms
- All areas seaward of the construction zone will be screened by the rocks that are to be stored at the seaward edge of the construction zone. This will reduce the impact of sudden movements.

Ringed Plover:
The majority of ringed plover observed were foraging or roosting on the rock platforms in CS1 in all months of the year. A peak count of 16 birds was observed in CS2 this represents 2.4% of the SPA population.

Wetland Bird Surveys (WeBS) counts for Bridgwater Bay have indicated a five year mean of peaks count of 305 for this species, with highest numbers occurring in August. This represents 47% of the SPA population, indicating that Bridgwater Bay is an important resource within the estuary, 92% of the threshold for a nationally important population and 42% of an internationally important population. Relatively small numbers occur during the winter period, representing just 5% of a nationally important population. The peak count from the Entec survey (Entec 2011) is 687, which exceeds the WeBS count for Bridgwater Bay and that for the whole of the Severn Estuary. Highest numbers occurred at the eastern end of the study area towards Steart.

There is a potential for impact to roosting ringed plover. We do not have the detail of how the sea wall will be constructed so it is assumed that the entire length of the sea wall will be impacted for the whole construction duration. The data shows that ringed plover numbers exceeded 1% of population on only 6 occasions(<7 individuals) in CS2.

The construction activity for the sea wall could effect these birds. We agree that the 250m disturbance zone is appropriate for this species and therefore it has been necessary to assess the impact of birds within this zone.

Impact assessment: The activity of constructing the sea wall has the potential to impact Ringed plover within the 250m zone. We however agree with the applicant that the development of the sea wall alone is unlikely to have an adverse effect on the integrity of the Ringed Plover population in the Severn estuary. We have based this assessment of the following points:

- The majority of birds are observed in CS1 as this provides a more appropriate habitat for the species
- The sea wall construction works are for 12-14 months and will only cover one season
- Much of the disturbance zone for the sea wall will be screened by the rocks that are to be stored at the seaward edge of the construction zone

Ringed plover numbers fluctuate considerably between years and numbers can comfortably exceed the SPA population level. It is for this reason that ringed plover is considered under the SPA review to be included as a qualifying species.

Overall conclusion

The evidence shows that Count Sectors 2 and 3 do not provide any critical resource for any of the species recorded. Only shelduck were recorded in large numbers and these were offshore. Moulting shelduck are potentially more vulnerable to disturbance than other species as they are flightless; however they are still capable of moving away.

We therefore conclude that the construction of the sea wall will cause some temporary displacement of birds to other areas but would not adversely affect the integrity of the Severn Estuary Special Protection Area and Ramsar Site.

We conclude that the construction of the sea wall will not cause an adverse effect on the integrity of the migratory bird and bird assemblage features designated under the Severn Estuary SPA and Ramsar as a result of disturbance.

Nonetheless, we strongly advise that the competent authorities, in this case the Local Planning Authority (LPA) and Marine Management Organisation (MMO) ensure that further mitigation is incorporated in the project to ensure protection of the migratory birds and bird assemblage. These mitigation measures are:

Construction of the sea wall should cease in the event of severe winter weather leading to a wildfowling ban by the Secretary of State

Mitigation should be adopted to further safeguard shelduck from the barges delivering the rock for the sea wall

b) Habitat loss

Conservation objectives (see section 1.5.1)

Internationally important population of regularly occurring migratory species (wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, passage Ringed Plover, wintering Curlew*, wintering Pintail*, wintering teal**, breeding Lesser Black-backed Gull**) *recommended additions under the SPA review, **recommended under the Ramsar review:*

- *The extent of hard substrate habitats is maintained*
- *the abundance and macro-distribution of suitable invertebrates in hard substrate habitats is maintained (except shelduck)*

Internationally important assemblage of waterfowl:

- *The extent of hard substrate habitats is maintained*
- *the abundance and macro-distribution of suitable invertebrates in hard substrate habitats is maintained*

Natural England & Countryside Council for Wales, 2009

Habitat loss as a result of the position of the sea wall and construction zone
It is proposed that the sea wall will be located above the mean high water level. As stated in section 5.6.1.1 the habitat is characterised by small boulders and rocks and is practically devoid of fauna and flora apart from some upper shore lichen species Haskoning, 2011). We agree with the applicant that there is no evidence within the supporting survey work to claim that this location of the shore is significantly used by birds for foraging. This is confirmed as the survey work also found no prey species. We also agree that there is no indication that this location is used for roosting birds.

The habitat within the construction zone is shown on figure 5.6.1.1.1 The majority of the area is littoral shingle and is devoid of any inter- tidal fauna and flora. However, further down the shore, within the 30m zone, can be found a variety of wracks (consistent with zonation) with winkles and barnacles on exposed rocks. One shallow rockpool, characterised by ephemeral green alga, is found within this upper zone.

The report to inform the HRA does not specifically address bird usage within this zone however the area will be adversely impacted for 12 months and will recover within 10 years from construction.

Conclusion
We can therefore conclude that the construction of the sea wall will not cause an adverse effect on the integrity of the migratory bird and bird assemblage features designated under the Severn Estuary SPA and Ramsar as a result of habitat loss.

Overall conclusion

Hazard assessed	**Adverse effect on migratory birds and bird assemblage feature?**
Disturbance	No (see comment below)
Habitat loss	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	**Competent Authority**	**Method**
Advice on bird disturbance *Construction of the sea wall should cease in the event of severe winter weather leading to a wildfowling ban by the Secretary of State* *Mitigation should be adopted to further safeguard shelduck from the barges delivering the rock for the sea wall*	Local Planning Authority and Marine Management Organisation	Via development Consent Order or Marine Licence

5.6.2 Refurbishment of Combwich Wharf

5.6.2.1 Estuaries

The tidal River Parrett is a macro-tidal estuary extending for 34km from Bridgwater Bay in the Bristol Channel to Burrow Bridge. The estuary mouth lies immediately north of Stolford and is defined by a complex tidal delta with flood and ebb channels and a well-defined ebb bar[483]. The tidal River Parrett is characterised by elevated levels of suspended sediments, which are a result of strong tidal velocities causing disturbance and re-suspension of bed silts; the shallow bed gradient of the exacerbates the effect (Haskoning, 2011) [484].

a) Habitat loss and physical damage

Conservation objectives (see section 1.5.1)

- *The extent, variety and spatial distribution of estuarine habitat communities is maintained.*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained.*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009[485]

The main habitat loss via construction will be discussed within the inter-tidal and sub-tidal habitats assessments in section 5.6.2.2.

b) Changes to water chemistry, changes to turbidity

Conservation objectives (see section 1.5.1)

- *The physico-chemical characteristics of the water column support the ecological objectives.*
- *Toxic contaminants in water column and sediment are below levels, which would pose a risk to the ecological objectives.*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained.*

Natural England & Countryside Council for Wales, 2009

Impacts on water quality from construction activities
The construction works for the refurbishment of Combwich Wharf could cause an impact on water quality of the SAC/Ramsar due to potential releases of polluting materials to the River Parrett from work areas and areas of hard-standing. (e.g. site

[483] Halcrow. (2009). Steart Peninsula Managed Realignment. Preliminary Geomorphological Assessment. Environment Agency.
[484] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.
[485] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

clearance, excavation, etc.). Furthermore there could be potential releases of polluting materials to the Parrett estuary during operation, via drainage systems serving the wharf or the freight management and storage facility, and from vessels.

The information within the Combwich Environmental Statement (ES) Vol.7 Chap.18 (Section 18.6.6 pg.30), supplied by EDF, states that the construction activities will be managed through a range of control measures and monitoring procedures which will be outlined in an Environmental Management and Monitoring Plan (EMMP), specific to the Combwich Wharf developments. The EMMP will include a Water Management Plan (WMP) a Site Waste Management Plant (SWMP) an Environmental Incident Control Plan (EICP) for containment of any large spills, ensuring that the potential releases of polluting material is kept to a minimum. The majority of surface water run-off (including any potential pollutants) would be directed into drains with oil/ grit interceptors and then discharged onto the rhynes to the east, before flowing into the River Parrett via Tuckett's Clyce.

There is the potential that accidental releases of contaminants could find their way into the River Parrett during the refurbishment of the wharf and subsequently impact on the water quality of the SAC. For example; accidental deposition and run-off from concrete could cause pH changes in the receiving water, or oil and chemicals from machines could cause contamination. However, the applicant has stated within the Combwich ES Vol.7 Chap.18 (Section 18.6.5 pg.30) that a manner of Best Practice Techniques in line with the Environment Agency's latest Pollution Prevention Guidelines, particularly PPG1 *General Guide to the Prevention of Pollution*[486] PPG 5 *Works and Maintenance in or Near Water*[487] and PPG 6 *Working at Construction and Demolition Sites*[488], will be put in place to reduce the risk of such incidents arising and for the control and management of any potential releases of pollutants.

The guidance specifies procedures for storage of fuel and cement in properly contained facilities away from the water's edge, the storage of stockpiles and materials away from watercourses, ring fencing with either sediment fencing or sediment tubes to retain sediment run-off and possibly covering of sediment piles with geo-textile material to prevent rainfall erosion. Where continued earthworks are being undertaken, perimeter drainage ditches may also be established to collect surface water drainage which would then either be discharged to a general surface drain through a sediment settlement facility or to a soak away[489]. It is agreed that this will substantially limit the risk.

The applicant has anticipated that similar issues will arise from the operational phase as identified for the construction phase and therefore all proposed management measures in terms of best practice will also be implemented during the operational phase, which we would support.

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[486] *General Guide to the Prevention of Pollution* (PPG1): Pollution Prevention Guidelines, Environment Alliance produced by the Environment Agency for England & Wales, the Scottish Environment Protection Agency and the Environment and Heritage Service in Northern Ireland.
[487] *Works and Maintenance in or Near Water* (PPG5): Pollution Prevention Guidelines (2007) Environment Alliance produced by the Environment Agency for England & Wales, the Scottish Environment Protection Agency and the Environment and Heritage Service in Northern Ireland.
[488] *Working at Construction and Demolition Sites (PPG6):* Pollution Prevention Guidelines (2010) Environment Alliance produced by the Environment Agency for England & Wales, the Scottish Environment Protection Agency and the Environment and Heritage Service in Northern Ireland.
[489] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

To ensure that all surface and foul waters are managed correctly we have advised the competent authority at the Development Consent Order stage to implement the following conditions with regards to Combwich Wharf:

Condition C11

(1) The development shall not commence until written details of the surface and foul water drainage system (including means of pollution control, culverts and future responsibility of maintenance arrangements) have, after consultation with the Environment Agency, the sewerage authority and drainage authority (Parrett Internal Drainage Board), been submitted to and approved by Sedgemoor District Council.

(2) The surface and foul water drainage system shall be constructed in accordance with the approved details.

Condition C12

(1) The development shall not commence until a scheme to treat and remove suspended solids from surface water run-off during construction works has, following consultation with the Environment Agency, been submitted to and approved by Sedgemoor District Council.

(2) The scheme referred to in paragraph (1) above shall be implemented as approved.

With the above conditions in place we can conclude that the water quality of the Severn Estuary SAC and Ramsar at Combwich will not be adversely affected by construction activities in the development at combwich Wharf.

Impacts of sediment mobilisation on water quality resulting from construction activities

The overall water quality conditions of the tidal River Parrett are highly turbid and characterised by elevated concentrations of suspended solids, which are as a result of strong tidal velocities causing disturbance and re-suspension of bed silts, which can naturally contain up to several thousand milligrams per litre (BEEMS TR60)[490].

The removal of the existing finger jetty on the north side of the existing berth area and the associated dolphin along with several other construction activities, including increased vessel movements, could cause temporary mobilisation of sediments within the River Parrett and around Combwich Pill. The applicant has also estimated that refurbishment of Combwich Wharf will require the dredging of approximately 5,000m3 of bank materials and sediment, which will also cause a temporary mobilisation of sediments, and which have the potential to be contaminated and thus cause water quality issues.

In the last 30 years, effluent discharges have been reduced and there is evidence that metal pollution has generally declined within the Severn Estuary (Ellis, 2002[491] and Langston et al., 2003[492]). This is partly the result of a regional decline in industrial activity, but environmental legislation has also had a significant impact, particularly the Environmental Protection Act 1990 and the Pollution Prevention

[490] BEEMS Technical Report 060 (TR60): Hinkley Point – Hydrodynamics, Climatology, Sedimentology and Coastal Geomorphology – An initial assessment of coastal hazards related to potential new nuclear build. v4. 2009.

[491] Ellis, J.C. (2002) Water Quality Trends in the Severn Estuary. R&D Technical Report No. E133, 138 pp. Environment Agency, Bristol.

[492] Langston, W.J. et al (2003). Characterisation of the Severn Estuary pSAC and SPA. Marine Biological Association.

Control Act 1999 (Duquesne, 2005)[493]. Although there is no specific up-to-date water quality sampling from the lower section of the River Parrett and Parrett Estuary available, the water quality of the Parrett has greatly increased over the past decade due to some of the larger industrial discharges ceasing[494]. Industrial discharges such as those from the UCB Cellophane Factory and Royal Ordnance Factory (BAE Systems) are no longer discharging to the River Parrett, *however it is likely that historical contaminants, such as metals, still exist within the sediments.*

It has been stated within the report to inform the Habitats Regulations Assessment (Haskoning, 2011)[495] that sampling of the sediments in the location of the works indicated generally low levels of contamination throughout the depths of the cores. A report by CEFAS (2003)[496] noted that there are occasional exceedances of CEFAS Action Level 1 for individual contaminants but no exceedances of CEFAS Action Level 2 were recorded, with the exception of nickel (Ni) and Lead (Pb) which indicated levels were just above CEFAS Action Level 1.

CEFAS's guideline action levels for the disposal of dredged material are not statutory contaminant concentrations for dredged material but are used as part of a weight of evidence approach to decision-making on the disposal of dredged material to sea[497]. In general, contaminant levels in dredged material below action level 1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above action level 2 is generally considered unsuitable for sea disposal.

It is our understanding that there will be no requirement to dispose of dredged material from Combwich to the sea. The applicant has stated within the report to inform the HRA (Haskoning, 2011)[498] that if there is the need for the disposal of dredged silts, it will take place at a licensed disposal site, conducted under a permit, which will require an assessment under the Habitats Regulations.

Given the localised nature of the disturbance and that most of the contaminant levels are below action level 1, apart from slightly elevated levels of Pb and Ni along with some PAH compounds around the wharf[499], sediment disturbance during the construction works is unlikely to lead to the release of contaminants into the water column at concentrations that would result in an adverse effect on water quality. Further to this, the sediments are likely to be either re-deposited within the Parrett system or flushed out into Bridgwater Bay by effective tidal flushing, where there will be significant dilution in the system so that the concentration of contaminants would be low.

Because of the naturally highly turbid environment, benthic invertebrates are naturally accustomed to the high suspended sediment content within the River

[493] Duquesne, S. et al, (2005) Evidence of declining levels of heavy-metals in the Severn Estuary and Bristol channel, U.K. and their spatial distribution in sediments, Environmental Pollution 143 (2006) 187-196.

[494] Severn Estuary Review of Consents carried out by the Environment Agency 2007 – 2010 under Regulation 63 (previously Regulation 50) of the Conservation of Habitats and Species Regulations 2010.

[495] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

[496] CEFAS (2003). The use of action levels in the assessment of dredged material placement at sea and in estuarine areas under FEPA (II). Report AE0258.

[497] Cefas Guideline Action Levels for the Disposal of Dredged Material. Port of London Authority Website www.pla.co.uk

[498] Haskoning (2011) Report to inform the Habitats Regulations Assessment (HRA) July 2011. Version 11 - Draft Final. Section 7.2.66. Report prepared for EDF.

[499] Combwich Environmental Statement (ES) Vol.7 Chap.18 (Section 18.6.75 pg.44) supplied by EDF.

Parrett, so any increases in sediment within the water column or elsewhere within the system are highly unlikely to cause smothering or other related impacts.

Conclusion
We do not foresee any impacts as a result of changes to water quality. Furthermore, sediment mobilisation has been assessed an unlikely to cause an impact to water quality within the River Parrett.

We therefore conclude that any changes to water quality or turbidity from the development of Combwich Wharf will not have an adverse effect on the estuaries feature of the Severn Estuary SAC and Ramsar.

c) Changes to flow and velocity regime, changes in physical regime

Conservation objectives (see section 1.5.1)

- *The characteristic physical form (tidal prism/cross sectional area) and flow (tidal regime) of the estuary is maintained;*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained.*

Natural England & Countryside Council for Wales, 2009

Impacts of the alteration to tidal properties (prism and cross-section) due to the presence of the upgraded Combwich Wharf facility
The refurbishment of Combwich Wharf has the potential to alter the tidal properties of the River Parrett, particularly by the introduction of new structures below Mean High Water Spring, causing a permanent alteration of tidal currents. The present Spring tidal prism of the Parrett Estuary up-estuary of Burnham is about 33 x 10^6 cubic metres, while the Neap tidal prism is just over half this at about 18 x 10^6 cubic metres. Any changes to the tidal prism due to the refurbishment of Combwich Wharf and the life of the structure are only a few tens of cubic metres, and therefore only about a ten thousandth of a percent of the tidal prism.

Any effects of Combwich refurbishment on the tidal prism or estuary cross section over the life time of the wharf is therefore insignificant and would not affect the tidal properties of the designated estuary feature.

Impacts of the alteration to the tidal regime (flow) and sediment transport due to the presence of the upgraded Combwich Wharf facility
Construction activities along the margin of the River Parrett such as the removal of the existing finger jetty on the north side of the existing berth area and the associated dolphin, have the potential to cause the temporary mobilisation of sediments, which in turn could have an impact on the marine ecology within the water column. Furthermore, the introduction of new structures below Mean High Water Springs (MHWS), have the potential to cause a permanent alteration of tidal and fluvial flows, potentially resulting in changes to the sediment erosion and deposition regime in the Parrett Estuary and in Combwich Pill.

BEEMS Technical Report 118 (TR188)[500] assessed the predicted changes to tidal flows and sediment scour for the refurbished berth at Combwich Wharf, which concluded that localised scour would occur around the berthing dolphins to a

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[500] BEEMS (2010) Technical Report 118: Scour assessment at Hinkley Point Structures. HR Wallingford.

predicted scour depth of 1.2m. It is therefore agreed that the volume of sediment released through scour around the new dolphins would be negligible in the context of the total volume of sediment transported within the tidal River Parrett. It is also agreed that the new wharf will have a similar footprint to the original wharf where there is no evidence to suggest that the existing facility has had, or is having, any adverse impacts on the hydrodynamics of tidal properties of the River Parrett.

It can therefore be concluded that the refurbishment works will not lead to any apparent changes to the tidal flow and velocity regime, or the sediment transport processes of the tidal River Parrett.

Conclusion
Any changes to the tidal prism as a result of the refurbishment works have been assessed as being insignificant and will not lead to any apparent changes to the tidal flow, velocity regime, or the sediment transport processes of the tidal River Parrett.

We can therefore conclude that any changes to flow and velocity regime, or the physical regime from the development of Combwich Wharf will not have an adverse effect on the estuaries feature of the Severn Estuary SAC and Ramsar.

Overall conclusion

Hazard assessed	Adverse effect on estuaries feature?
Habitat loss & physical damage	No
Changes to water chemistry	No (see advice below)
Changes in turbidity and suspended sediment	No
Reduced surface water flows	No
Changes in physical regime	No
Changes in flows and velocity regime	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Conditions advised *(1) The development shall not commence until written details of the surface and foul water drainage system (including means of pollution control, culverts and future responsibility of maintenance arrangements) have, after consultation with the Environment Agency, the sewerage authority and drainage authority (Parrett Internal Drainage Board), been submitted to and approved by Sedgemoor District Council.* *(2) The surface and foul water drainage system shall be constructed in accordance with the approved details.*	Environment Agency, Local Planning Authority, Sewerage Authority and Drainage Board	Development Consent Order condition

Advice / Requirements (continued…)	Competent Authority	Method
(1) The development shall not commence until a scheme to treat and remove suspended solids from surface water run-off during construction works has, following consultation with the Environment Agency, been submitted to and approved by Sedgemoor District Council. *(2) The scheme referred to in paragraph (1) above shall be implemented as approved.*	Environment Agency, Local Planning Authority	Development Consent Order

5.6.2.2 Inter-tidal mud and sandflats not covered by seawater at low tide and sub-tidal sandbanks slightly covered by sea water all the time

The extensive mudflats and sand flats support vast numbers of benthic invertebrates and these in turn provide food for fish and internationally important numbers of wading birds and wildfowl (Ferns, 1984)[501]. The high suspended solid loadings provide an abundant surface area for microbial processes, whilst at the same time limiting light penetration and primary productivity.

The inter-tidal and sub-tidal mud and sand flats of the River Parrett are dominated by similar species to the Severn Estuary and include; polychaetes such as *Hediste diversicolor* and *Streblospio* sp., oligochaetes, and the clam *Macoma balthica.* Other species present are the laver spire shell *Hydrobia ulvae*, and the polychaete *Nepthys hombergii* and all of these species provide a food source for birds.

a) Habitat loss and physical damage

Conservation objectives (see section 1.5.1)

- *The total extent of the mudflats and sandflats feature is maintained.*
- *The variety and extent of individual mudflats and sandflats communities within the site is maintained.*
- *The community composition of the mudflats and sandflats feature within the site is maintained.*
- *The distribution of individual mudflats and sandflats communities within the site is maintained.*

Natural England & Countryside Council for Wales, 2009[502]

[501] Ferns, P.N. (1984) Birds of the Bristol Channel and Severn Estuary. Marine Pollution Bulletin, 15, 76-81.

[502] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

Impacts via direct and/or indirect loss or alteration of inter-tidal mudflat habitats due to the upgrade of Combwich Wharf

The Combwich ES[503] states that the refurbishment of Combwich Wharf will entail several construction activities that could impact on the inter-tidal habitats, some of which include;

- the extension and raising of the existing barge bed, causing direct loss of intertidal habitat on the margin of the main channel of the Parrett Estuary and within the Combwich Pill inlet;
- extension of the existing ro-ro Abnormal Indivisible Loads (AIL) jetty to the west to provide access for the approach road to the ro-ro berth for longer vehicles handling AIL;
- the piling and infill for the refurbished and extended ro-ro wharf facility, which could cause small permanent loss of benthic habitat and the construction of the goods wharf facility, including removal of two existing dolphins, leading to permanent loss of intertidal area in the area occupied by the new facility.

Increased movements of vessels containing construction material may add to the impact, by potentially eroding areas of mudflat around the banks of the Parrett.

The applicant has stated within their report to inform the HRA[504] that the wharf re-development would require a small area of sloping bank and adjacent intertidal area at the mouth of Combwich pill to be in filled, however, the area is 0.05ha in size and is outside of the designated area. The location of the proposed wharf re-development is also outside of the designated SAC/Ramsar area, and is not expected to extend into the SAC/Ramsar habitat.

The movements of vessels up and down the river during construction could cause erosion on the north side of Combwich and potentially cause further erosion on the adjacent bank of the River Parrett, mainly as a result of backwash from the large vessels. These areas of mud bank are within the SAC/Ramsar area so any potential losses need to be assessed.

The Combwich jetty has been designed to accommodate one vessel at a time. The applicant has then stated within their HRA Clarification Report[505] that there should typically be about 8-9 vessel calls per month carrying Abnormal Indivisible Loads (AILs), peaking to around 14-15 per month as a worst case scenario. For the construction of HPC, there will need to be deliveries made to the wharf over a four-year period and in that time 174 vessel calls are assumed, with an average of 44 vessel calls per year.

Since the HRA clarification report was issued a further report has been issued by EDF Enery (2012)[506] in response to Natural England's specific request for clarification to boat movements at Combwich. The report clarifies specific vessel numbers likely to use Combwich Wharf in the development of HPC and vessel speeds. The report states that approximately 180 AILs will be delivered to Combwich Wharf for the construction of HPC, which amounts to an average of 3.75 deliveries (7.5 movements to and from the wharf) per month over the 4 year construction

[503] Hinkley Point C: Combwich Environmental Statement (ES) Vol.7 Chap.18 supplied by EDF.
[504] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Section 7.2.35 & 7.2.107. Report prepared for EDF.
[505] Royal Haskoning/EDF. Clarifications arising from Habitats Regulations Assessment (HRA) feedback. August 2011. Report prepared for EDF.
[506] EDF Engery (2012) Clarification on vessel movements to Combwich Wharf. Letter to Natural England. 15th June 2012.

period. In addition to AIL deliveries, ‘other goods’ deliveries to the wharf could bring the total up to 15-16 deliveries (30-32 movements) per month at peak, over the 4 years. Small tug boats will also be required further down river to guide the larger boats out of the River Parrett. It is important to note that these figures are limited by the availability of suitably high tides.

To deal with any potential issues, such as excessive wash and large currents caused by high speed freight vessels, the applicant has stated that vessel movements would only occur at or around high water, and thus exposure of inter-tidal areas would be at a minimum. Some of the vessels carrying AILs will require high water and tides of greater than 4.5m to access the wharf, meaning in some cases spring tides will be the only option. General cargo vessels, used in transporting materials, will require tides with a maximum draft of 3.3m and would generally be of a relatively small size (in order to be able to navigate into and out of the estuary) and would also be restricted to travelling at speeds of between 4 to 6 knots.

Furthermore the Harbourmaster of Bridgwater Port has powers to regulate vessel movements and exercises these powers in accordance with the port’s Marine Operations Plan (Sedgemoor DC, 2009)[507].

We can therefore conclude that there will be no adverse effect on the inter-tidal and sub-tidal habitat features of the Severn Estuary SAC and Ramsar from habitat loss as a result of works at Combwich.

Whilst it can be agreed that the vessel wash will not cause an adverse effect on the SAC habitat, it is suggested that some form of monitoring of the inter-tidal and saltmarsh habitats is carried out around the Combwich Wharf area during operation of the wharf to ensure that no loss of habitat occurs.

We have therefore advised the competent authority at the Development Consent Order stage to implement the following conditions with regards to Combwich Wharf:

Condition C1A

1. Work no 8A shall not commence until a marine monitoring and contingency plan has, after consultation with the Environment Agency, Countryside Council for Wales and Natural England, been submitted to and approved by the Marine Monitoring Organisation. The monitoring and contingency plan shall include:

a) A plan identifying the geographical extent of monitoring of the topography of the intertidal shore and the associated flood defences.

b) Provision for the monitoring of (i) sediment type and character and (ii) changes to intertidal habitats (including changes in the type and extent of vegetation associated with those habitats)

c)The identification environmental baseline information that will be collected prior to the commencement of Work no 8A

d) Frequency and format of monitoring reports

e) Appropriate contingency measures that will be implemented should monitoring indicate that erosion of the inter tidal and / or damage to flood

[507] Sedgemoor District Council (2009). Port of Bridgwater Marine Operations Plan (Compliance with the Port Marine Safety Code). Revision 5, July 2009.

defences has occurred or is likely to occur and may be attributed to NNB GenCo activities at Combwich.

2. In the preparation of the monitoring and contingency plan, the undertaker shall establish a marine technical review group to review the draft Combwich monitoring and contingency plan.

3. The Combwich marine monitoring plan shall be implemented as approved.

* Work 8A = development of Combwich Wharf – HPC associated development

Impacts from the erosion/scour or deposition of fine sediment as a result of the presence of the new wharf and increased vessel movements in the River Parrett

During the operation of the wharf the presence of the upgraded structures could cause some erosion of the inter-tidal habitats, particularly to the muddy banks on the north side of the wharf (left bank) where Combwich Pill meets the River Parrett and of which is a included within the SAC/Ramsar habitat designation. Further to this, the movements of vessels up and down the river could add to the erosion on the north side of Combwich and potentially cause further erosion on the adjacent bank of the River Parrett, mainly as a result of backwash from the large vessels.

With regards to the movement of vessels, as with the construction side, vessels will only be moving in or around to high tides, so inter-tidal mudflats will not be exposed, and vessel speeds will be controlled by a protocol in line with the Harbourmaster of Bridgwater Port. Slower speeds will reduce the impact of vessel wash and erosion.

Whilst it can be agreed that the vessel wash will not cause an adverse effect on the SAC habitat, it is suggested that some form of monitoring of the inter-tidal and saltmarsh habitats is carried out around the Combwich Wharf area during operation of the wharf to ensure that no loss of habitat occurs. **See Condition C1A above**

Conclusion

We agree that there will be no direct loss of SAC/Ramsar mudflat habitat as a result of the construction works at Combwich, however we believe that there may be a potential for some erosion of inter-tidal habitat around Combwich Wharf, but not to the extent of causing an adverse effect.

We can therefore conclude that there will be no adverse effect on the inter-tidal and sub-tidal habitat features of the Severn Estuary SAC and Ramsar from habitat loss and physical damage as a result of works at Combwich.

b) Changes to water chemistry, Changes to flow and velocity regime and changes in physical regime

Conservation objective (see section 1.5.1)

- *The topography of the inter-tidal flats and the morphology (dynamic processes sediment movement and channel migration across the flats) are maintained*

Natural England & Countryside Council for Wales, 2009[508]

As discussed in section 5.6.2.1 b and c, the effects of the works at Combwich Wharf on hydrodynamics and sediment transport would be confined to the immediate vicinity of the wharf and would not represent a significant change from the existing situation. Any changes to water chemistry were not considered to be significant, thus, there are not likely to be any consequential effects that would impact on the inter-tidal and sub-tidal mudflat communities.

Any increase in vessel movements and dredging activities may have the potential to increase suspended sediment concentration. However, it is accepted that any rise would be localised to the vicinity of Combwich and would quickly fall back to background levels. As mudflat habitats and communities in the River Parrett are generally highly exposed to natural high suspended sediment concentrations they have a high tolerance to natural fluctuations in suspended sediment concentrations. We would therefore conclude that there would be no adverse effects on inter-tidal and sub-tidal mudflat habitat from an increase in suspended sediment.

To support this we have advised the competent authority at the Development Consent Order stage to implement a condition, as stated within 5.6.2.2 (a) above, that relates to the monitoring of the habitats and bank around Combwich Wharf.

Conclusion

There would be no direct loss of inter-tidal mudflat habitat from within the Severn Estuary SAC/SPA/Ramsar as a result of the refurbishment works at Combwich Wharf. The speed of vessels will be controlled during the construction and operation of Combwich Wharf, so erosion will be minimised and an increase in suspended sediment is unlikely to impact on the features of the inter-tidal and sub-tidal mud and sand flats.

We can therefore conclude that there will be no adverse effect on the inter-tidal and sub-tidal habitat features of the Severn Estuary SAC and Ramsar from changes to water chemistry, flow and velocity regime, or physical regime as a result of works at Combwich.

[508] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

Overall conclusion

Hazard assessed	Adverse effect on inter-tidal and sub-tidal features?
Habitat loss & physical damage	No
Changes to water chemistry	No
Changes in physical regime	No (see advice below)
Changes in flows and velocity regime	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Conditions advised *1. Work no 8A shall not commence until a marine monitoring and contingency plan has, after consultation with the Environment Agency, Countryside Council for Wales and Natural England, been submitted to and approved by the Marine Monitoring Organisation. The monitoring and contingency plan shall include:* *a) A plan identifying the geographical extent of monitoring of the topography of the intertidal shore and the associated flood defences.* *b) Provision for the monitoring of (i) sediment type and character and (ii) changes to intertidal habitats (including changes in the type and extent of vegetation associated with those habitats)* *c)The identification environmental baseline information that will be collected prior to the commencement of Work no 8A* *d) Frequency and format of monitoring reports* *e) Appropriate contingency measures that will be implemented should monitoring indicate that erosion of the inter tidal and / or damage to flood defences has occurred or is likely to occur and may be attributed to NNB GenCo activities at Combwich.* *2. In the preparation of the monitoring and contingency plan, the undertaker shall establish a marine technical review group to review the draft Combwich monitoring and contingency plan.* *3. The Combwich marine monitoring plan shall be implemented as approved.* * Work 8A = development of Combwich Wharf – HPC associated development	Environment Agency, Natural England, Marine Management Organisation	Development Consent Order condition

5.6.2.3 Atlantic salt meadows/ saltmarsh

The saltmarsh habitat within the Severn Estuary covers approximately 1,400ha, however, climate change is threatening the survival of salt marshes, which are being squeezed between immovable sea defences and rising sea levels.

The Severn Estuary saltmarsh provides feeding grounds for very high numbers of wildfowl and waders throughout the winter. At low tide, inter-tidal areas along the upper reaches of the tidal River Parrett comprise of relatively steep mud banks. More extensive areas of open mud and sand are present further downstream of Combwich.

Along the edge of the River Parrett in places, scrub gives way to coastal grassland and a narrow band of saltmarsh species, including reflexed saltmarsh grass, sea aster (*Aster tripolium*) and spear-leaved orache (*Atriplex prostrata*), with common cord-grass (*Spartina anglica*), hoary cress (*Lepidium draba*), sea beet (*Beta vulgaris subsp. maritima*) and greater sea-spurrey (*Spergularia media*) found closer to the open mud; sea plantain (*Plantago maritima*) is present in places[509].

a) Habitat loss and physical damage

Conservation objectives (see section 1.5.1)

- *The total extent of Atlantic salt meadow and associated transitional vegetation communities within the site is maintained.*
- *The extent and distribution of the individual Atlantic salt meadow and associated transitional vegetation communities within the site is maintained.*
- *The relative abundance of the typical species of the Atlantic salt meadow and associated transitional vegetation communities is maintained.*
- *The abundance of the notable species of the Atlantic salt meadow and associated transitional vegetation communities is maintained.*
- *The characteristic stepped morphology of the salt marshes and associated creeks, pills, drainage ditches and pans, and the estuarine processes that enable their development, is maintained.*

Natural England & Countryside Council for Wales, 2009[510]

The saltmarsh areas comprise a narrow fringe on the upper shore on the north bank of Combwich Pill and around the head of the pill to the inland margin of the ro-ro jetty, as well as along the banks of the Parrett Estuary, with larger areas seaward of Combwich.

Saltmarsh could be lost through the direct effects of construction of structures on the marsh and also due to changes in the sediment regime leading to erosion of the marsh, particularly where the upgraded flood protection will lie behind the saltmarsh.

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[509] Royal Haskoning. Report to inform the Habitats Regulations Assessment (HRA) July 2011. Version 11 - Draft Final. Section Pg. 424. Report prepared for EDF.

[510] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

Combwich ES[511] states that there will be a small area of saltmarsh lost (estimated at 40m2) due to the westward extension of the ro-ro jetty to achieve an improved approach road alignment, however this section of saltmarsh is outside of the designated SAC area. It has been estimated that this loss amounts to a very small proportion (0.0005%) of the total saltmarsh habitat in the SAC/Ramsar (737ha), however because, in relation to this legislation, it is outside of the SAC/Ramsar area no direct loss of habitat will occur.

Further to this, the applicant has predicted that no discernible change to the hydrodynamic, geomorphological, or sediment transport processes would occur as a result of the installation and operation of the facility at Combwich Wharf such that there would be any consequential loss or change to the existing extent of saltmarsh vegetation in the River Parrett, and we would support this view.

Any alterations to the flood defences will be built in-line with the original defences, so no direct saltmarsh habitat will be lost through these works.

Conclusion
We agree that there will be no direct loss of SAC saltmarsh habitat within the designated site as a result of the construction works at Combwich, however we believe that there may be a potential for some erosion of saltmarsh habitat around Combwich Wharf, but not to the extent of causing an adverse effect.

We can therefore conclude that there will be no adverse effect on saltmarsh feature of the Severn Estuary SAC and Ramsar from habitat loss or physical damage as a result of works at Combwich.

b) Changes to flow and velocity regime and changes to physical regime

Conservation objectives (see section 1.5.1)

- *The topography of the intertidal flats and the morphology (dynamic processes sediment movement and channel migration across the flats) are maintained.*
- *The zonation of Atlantic salt meadow vegetation communities and their associated transitions to other estuary habitats is maintained.*

Natural England & Countryside Council for Wales, 2009[512]

The movement of vessels to and from the wharf during the construction and operation stages has the potential to lead to erosion of fringing areas of saltmarsh due to excessive wash and large currents. As discussed within section 5.6.2.2 inter-tidal habitats assessment, vessel movements will be limited to moving in or around high tides, however saltmarsh habitat may still be slightly exposed.

The saltmarsh feature around Combwich Wharf and directly opposite is currently in unfavourable condition (Natural England, 2011)[513], mainly due to coastal squeeze effects. Whilst it can be agreed that the vessel wash will not cause an adverse effect

[511] Combwich Environmental Statement (ES) Vol.7 Chap.18 (Section 18.6.92 – 18.6.98 pg.47) supplied by EDF.
[512] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009
[513] Natural England - Nature on the Map. June 2011. www.naturalengland.org.uk

on the SAC habitat, it is suggested that some form of monitoring of the inter-tidal and saltmarsh habitats is carried out around the Combwich Wharf area during operation of the wharf to ensure that no loss of habitat occurs.

We have therefore advised the competent authority at the Development Consent Order stage to implement the following conditions with regards to Combwich Wharf:

Condition C1A
1. Work no 8A shall not commence until a marine monitoring and contingency plan has, after consultation with the Environment Agency, Countryside Council for Wales and Natural England, been submitted to and approved by the Marine Monitoring Organisation. The monitoring and contingency plan shall include:

a) A plan identifying the geographical extent of monitoring of the topography of the intertidal shore and the associated flood defences.

b) Provision for the monitoring of (i) sediment type and character and (ii) changes to intertidal habitats (including changes in the type and extent of vegetation associated with those habitats)

c)The identification environmental baseline information that will be collected prior to the commencement of Work no 8A

d) Frequency and format of monitoring reports

e) Appropriate contingency measures that will be implemented should monitoring indicate that erosion of the inter tidal and / or damage to flood defences has occurred or is likely to occur and may be attributed to NNB GenCo activities at Combwich.

2. In the preparation of the monitoring and contingency plan, the undertaker shall establish a marine technical review group to review the draft Combwich monitoring and contingency plan.

3. The Combwich marine monitoring plan shall be implemented as approved.

* Work 8A = development of Combwich Wharf – HPC associated development

An increase in vessel movements are also likely to cause an increase in suspended sediment as discussed within the assessment for the estuaries feature under section 5.6.2.1 c). Also construction and maintenance dredging are also expected to increase sediment load. However, it is accepted that any rise would be localised to the vicinity of Combwich and would quickly fall back to background levels.

Saltmarsh vegetation in the River Parrett and the wider Severn is moderately to highly exposed to natural high suspended sediment concentrations. As such there is a high tolerance to natural fluctuations in suspended sediment concentrations and no adverse effects on saltmarsh vegetation would be expected from short duration, localised pulses in suspended sediment[514].

[514] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Section 7.2.124. Report prepared for EDF.

Conclusion
On the basis of the above assessment we can therefore conclude that there will be no adverse effect on saltmarsh feature of the Severn Estuary SAC and Ramsar from changes to flow and velocity regime and changes to physical regime as a result of works at Combwich.

Overall conclusion

Hazard assessed	Adverse effect on saltmarsh feature?
Habitat loss & physical damage	No
Changes in physical regime	No (see advice below)
Changes in flows and velocity regime	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Conditions advised *1. Work no 8A shall not commence until a marine monitoring and contingency plan has, after consultation with the Environment Agency, Countryside Council for Wales and Natural England, been submitted to and approved by the Marine Monitoring Organisation. The monitoring and contingency plan shall include:* *a) A plan identifying the geographical extent of monitoring of the topography of the intertidal shore and the associated flood defences.* *b) Provision for the monitoring of (i) sediment type and character and (ii) changes to intertidal habitats (including changes in the type and extent of vegetation associated with those habitats)* *c)The identification environmental baseline information that will be collected prior to the commencement of Work no 8A* *d) Frequency and format of monitoring reports* *e) Appropriate contingency measures that will be implemented should monitoring indicate that erosion of the inter tidal and / or damage to flood defences has occurred or is likely to occur and may be attributed to NNB GenCo activities at Combwich.* *2. In the preparation of the monitoring and contingency plan, the undertaker shall establish a marine technical review group to review the draft Combwich monitoring and contingency plan.* *3. The Combwich marine monitoring plan shall be implemented as approved.* * Work 8A = development of Combwich Wharf – HPC associated development	Environment Agency, Natural England, Marine Management Organisation	Development Consent Order condition

5.6.2.4 Reefs

There are no recorded natural hard substrates or substrates that would constitute reef habitat in the Parrett Estuary or around the Combwich Wharf area (Natural England, 2009)[515].

We can therefore conclude that the development and operational works at Combwich will not have an adverse effect on the reef feature of the Severn Estuary SAC and Ramsar.

5.6.2.5 Migratory fish and fish assemblage

There is limited information on the fish assemblage of the tidal River Parrett. Apart from eel and potentially salmon, no other migratory fish populations designated under the SAC and Ramsar features are known to use the River Parrett for migration and spawning.

a) Habitat loss

Conservation objectives (see section 1.5.1)

- *The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.*

Natural England & Countryside Council for Wales, 2009[516]

Ongoing studies of fish populations in estuaries throughout the UK clearly demonstrates that many marine fish species use the fringing estuarine habitats as nursery grounds and that transitional waters of estuaries play a major part in their lifecycle (Colclough, 2010)[517]. The fringing saltmarsh habitat of the Severn Estuary is thought to be an important nursery ground for species such as shad and sea bass.

Any losses to this fringing habitat around Combwich from the refurbishment of the Wharf has the potential to impact on juvenile fish populations, however, as highlighted within section 5.6.2.3 a) above, there will be no direct loss of SAC saltmarsh habitat as a result of the construction works at Combwich. Although we believe that there may be a potential for some erosion of saltmarsh habitat around the North bank opposite Combwich Wharf, there will be no loss of fringing saltmarsh habitat.

Conclusion
We can therefore conclude that there will be no adverse effect on the migratory fish and fish assemblage features of the Severn Estuary SAC and Ramsar from habitat loss as a result of works at Combwich.

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[515] Natural England and Countryside Council for Wales. (2009). Habitat maps produced as part of the Severn Estuary / Môr Hafren European Marine Site Advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats,&c.) Regulations 1994, as amended.
[516] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009
[517] Colclough, S. (2010) Marine juvenile fish in estuaries – a contribution to finding sanctuary. Environment Agency.

b) Changes to water chemistry, changes to flow and velocity regime, changes in turbidity and physical regime

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adult and juvenile migratory fish species through the Severn Estuary between the Bristol Channel and any of their spawning rivers is not obstructed or impeded by poor water quality, physical barriers or changes in flows.*
- *Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives described above.*
- *The abundance of prey species forming the river lamprey's food resource within the estuary is maintained.*

Natural England & Countryside Council for Wales, 2009

Migratory fish can be affected by a change in water quality due to discharges from land-based activities (e.g. site clearance, excavation, etc.) and due to accidental or emergency discharges of polluting substances causing toxic effects, changes in pH and by secondary effects, such as de-oxygenation or changes in ammonia toxicity with changes in pH.

They can also be affected by disturbance to existing fine sediment and changes in turbidity during the refurbishment of the wharf including the removal and replacement of the mooring dolphins in the river. The increase in turbidity and suspended sediments in the water column can affect the ability of fish gills to absorb dissolved oxygen, particularly in the case of salmonids or shad.

All of the migratory fish are sensitive to toxic contamination and some form of non-toxic contamination. The re-mobilisation of metals is possible whenever sediments are disturbed (Hitchcock & Thomas 1992[518]). This is unlikely to be a problem in the estuary system since sediment redistribution occurs naturally. As discussed in section 5.6.2.1 b) the water quality in the River Parrett is not a concern and the discharges into the River Parrett as a result of the refurbishment of Combwich Wharf will not lead to any detrimental impact on water quality such that the condition of the estuaries feature would be put at risk.

Poor water quality, high temperatures and lowered water levels can lead to low dissolved oxygen (DO) within the riverine and estuarine environments. However, it is unlikely that estuarine waters, such as the tidal River Parrett, will reach DO levels sufficiently low to limit migratory fish distribution and the high turbidity within the Severn Estuary has helped to minimise this impact.

Migratory fish of the Severn Estuary are highly adapted to high suspended sediment content, and the same situation applies for the tidal River Parrett, which is naturally turbid. Although the migratory fish within the Parrett Estuary are likely to be accustomed to elevated turbidity or levels of suspended solids, the high levels may still induce avoidance reactions and may modify natural movements and migration

[518] Hitchcock D.R. & Thomas B.R. (1992) Some trace metals in sediments from Cardiff Bay, UK. *Marine Pollution Bulletin* **24,** 464-466.

patterns. Furthermore, unlike the main estuary, the section of the River Parrett at Combwich may not provide ample space for the fish to avoid such elevated sediment and turbidity levels.

Excess sediment can profoundly effect the productivity of a salmon or trout stream (McHenry et al., 1994)[519], although the impact is more evident in freshwaters, particularly where there are spawning grounds and where juvenile species are present. Juvenile salmonids have been known to leave channels containing sedimented substrate which did not provide interstitial spaces for winter refuge (Bjornn *et al*. 1974)[520].

There are no spawning grounds near to Combwich Wharf and the area does not support juvenile salmon or sea trout. Salmon and sea trout smolts will pass by the area to complete their life cycle in the transition to marine waters, but these fish will be exposed to high turbidity and suspended sediment load once they reach the estuary, so it is not thought that slightly increased levels will significantly effect migrating smolt populations.

With regards to migratory eels, the report to inform the HRA (Haskoning, 2011)[521] used a paper by Boubée *et al to* demonstrate that through laboratory experiments, elvers showed no avoidance behaviour even at the highest levels of turbidity. The lack of avoidance behaviour shown in elvers suggested that turbid waters are unlikely to impede their migration into adult habitats or impede silver eels migrating out to sea. Reports from other studies cited in Boubée *et al* indicated that migratory elvers appear to be attracted to somewhat turbid environments and are often prolific in turbid waters. It is likely that habitat rather than ability to migrate through turbid waters is more likely to affect the distribution of eels.

Conclusion
On the basis of the above assessment, we do not believe the migratory fish of the Severn Estuary SAC/Ramsar feature will be adversely impacted by slight changes to the chemistry, flow or turbidity of the tidal River Parrett from the developments at Combwich Wharf.

We can therefore conclude that there will be no adverse effect on the migratory fish and fish assemblage features of the Severn Estuary SAC and Ramsar from changes to flow and velocity regime and changes to physical regime as a result of works at Combwich.

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[519] McHenry, M.L., D.C. Morrill and E. Currence. 1994 . Spawning Gravel Quality, Watershed Characteristics and Early Life History Survival of Coho Salmon and Steelhead in Five North Olympic Peninsula Watersheds. Lower Elwha S'Klallam Tribe, Port Angeles, WA. and Makah Tribe, Neah Bay, WA. Funded by Washington State Dept. of Ecology (205J grant).

[520] Bjornn, T. C., Brusven, M.A. Molnau, M.M. Watts, F.J,. Wallace, R.L. Neilson, D.R. Sandine, M.F. and Stuehrenberg, I.C. 1974. Sediment in streams and its effect on aquatic life, OWRT Project No. B-025-IDA, Idaho Water Resources Research Institute, Moscow, Idaho. 47 p.

[521] Haskoning (2011). Hinkley Point C Project: Report to inform the Habitats Regulations Assessment (HRA). Section 7.2.45 Pg. 397. Report prepared for EDF.

c) Physical damage and disturbance

Conservation objectives

- *The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.*

Natural England & Countryside Council for Wales, 2009[522]

An increase in underwater noise and vibration from piling works could extend across the whole cross-sectional area of the River Parrett and for some distance up and downstream of Combwich, which could act as an auditory barrier to the movement of migratory fish. Direct mortality may also occur as a result of a significant increase in underwater noise levels. However, information on the effects of pile driving on fish is limited. Differences in approach, design, site conditions, and the absence of a consistent approach to monitoring and measurement of sound produced, make drawing conclusions from the available data difficult (Hardyniec & Skeen, 2005)[523].

In order to determine whether fish will be impacted by an emitted sound, information is needed to establish whether they can actually detect it. All fish appear to be sensitive to sound in the frequency range 50 to 3000 Hz (Henderson, 2008)[524]. The hearing capability of fish is dependent upon the physiology of individual species in terms of both the presence/absence of a swim-bladder and the connection between the swim-bladder and inner ear. Species fall into three broad categories; *non-specialists* which have no swim bladder, *generalists* which have a swim-bladder but no special connection between it and the inner ear and *specialists* which not only have a swim-bladder but also a connection between it and the inner ear which can extend their upper hearing ability by several kilohertz (AMEC, 2003)[525].

Shad as well as other alosids appear to also be unique in that they can detect sound of far higher frequencies than other hearing specialists. Salmon and trout are classed as hearing *generalists* and as such cannot hear high frequencies within the ultrasound band but are able to hear low frequency sound and infrasound. Eel which have a swim-bladder but no connection to the inner ear as with salmon are classed as hearing *generalists*. As lamprey lack a swim-bladder they fall within the *non-specialist* hearing group.

A literature review, undertaken by Peter Henderson[526], looked at the possible effects of impact and vibratory piling on fish in the Severn Estuary. The review suggested that all fish appear to be sensitive to sound in the frequency range 50 to 3000 Hz. A number of authors suggested that the upper threshold sound pressure to avoid all

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[522] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[523] Hardyniec, S. and Skeen, S. (2005). Pile driving and barotraumas effects. *Journal of Transportation Research Board*, No. 1941: 184-190.

[524] Henderson, P.A.(2008). A Literature review of the possible effects of impact and vibratory piling on fish in the Severn Estuary. Pisces Conservation Ltd.

[525] AMEC (2003). Severn Tidal Power SEA Scoping Topic Paper – Fish. December 2003. Black and Veatch & Parsons Brinckerhoff.

[526] Henderson, P.A. (2008). A Literature review of the possible effects of impact and vibratory piling on fish in the Severn Estuary. Pisces Conservation Ltd.

physical harm to fish is 150 dB. Clear physical damage may be observed at above 180 dB, transient stunning occurred at 192-198 dB and instantaneous death above 229 dB.

The review further suggested that impact piling produces source sound levels in the vicinity of 195 dB. In enclosed waters, the sound pressure probably declines approximately linearly with distance so that a sound level below 150 dB would be reached within 295 m of the source (Henderson, 2008). The literature review concluded that while there is still considerable uncertainty about the effects of piling on migratory fish, the available data suggest that sound levels sufficient to cause death or serious physical injury are unlikely to be experienced by fish further than 5 metres from the source.

As the River Parrett at Combwich is approximately 250 meters across, the fish could steer clear of the 5 metre threshold to avoid physical injury, provided that they have a warning that the noise will occur. The applicant has stated[527] that soft start up techniques will be used during piling works, which will minimise the impacts on fish by undertaking lower energy blows (with lower peak pressure) initially in order to give the animals time to flee from the sound source. However, Pile driving sound has the potential to produce longer term impacts on behaviour, such as the inability of fish to reach quality habitat upstream of a continuous noise source (Caltrans, 2009)[528]. The noise disturbance and vibration from piling works therefore have the potential to cause an auditory barrier to fish migration as the river may not be of sufficient width to enable migratory fish to pass by.

Due to the *specialist* hearing capacity of shad and as a result the large range over which they can hear, migratory shad are considered to be most at risk of disruption from noise and vibration. There are no data available on the response of allis shad to sound (Henderson, 2008). However, Turnpenny *et al*. (1994)[529] give information on the closely-related (possibly even the same species) twaite shad, *Alosa fallax*. These authors found that using a sound source of 158 dB and a ramped frequency range of 100 to 500 Hz, the fish undertook an avoidance reaction at 138 dB, which was > 40 dB above ambient noise levels. Miran Aprahamian, our EA shad expert, has confirmed that shad are not known to use or migrate up the River Parrett and are therefore unlikely to be impacted by piling works at Combwich.

Salmon and trout are only sensitive to low frequency sound and could not be made to react to frequencies above 380 Hz. They detect particle motion rather than pressure change. The lowest response threshold and presumably the frequency of greatest sensitivity is between 100 and 160 Hz, at which the salmonids response threshold is 99 dB (Henderson, 2008).

The auditory thresholds of juvenile eels 50cm in length were measured by Jerkø *et al* (1989)[530] who found that eel were most sensitive to sounds at 80Hz and sensitivity declined sharply at higher frequencies and the highest frequency at which reliable thresholds could be obtained was 320Hz. It is therefore agreed that pile driving has the potential to cause an increase in noise levels that could potentially cause

[527] Royal Haskoning. Report to inform the Habitats Regulations Assessment (HRA) July 2011. Version 11 - Draft Final. Section 7.2.40 Pg. 396. Report prepared for EDF.
[528] Caltrans (2009). Technical guidance for assessment and mitigation of the hydroacoustic effects of pile driving on fish. *Report for the Californian Department of Transportation*.
[529] Turnpenny, A. W. H., Thatcher, K. P., and Nedwell, J. R. (1994). The effects on fish and other marine animals of high-level underwater sound. Report FRR 127/94, Fawley Aquatic Research Laboratories, Ltd., Southampton, UK.
[530] Jerkø, K. Turunen-Rise, I. Enger, P.S. & Sand, O. (1989) Journal of Comparative Physiology. Volume: 165, Issue: 4, Publisher: Springer-Verlag, Pages: 455-459

disturbance (e.g. avoidance reaction) to migratory eels.

Combwich ES[531] states that a protocol is proposed that will be drawn up in consultation with the contractor to ensure that any percussive piling required will be carried out in the dry or at suitable times in relation to daily and seasonal fish migration patterns. Use of trench placement or drill and drive methods, where suitable, and soft start techniques for any percussive piling that does take place in the water will be considered in drawing up the protocol. The piling protocol will be in line with new EA policy guidance, which states that such a development will only be acceptable if a licensing condition is imposed requiring piling works to be programmed to avoid impacting on sensitive fish. The EA policy states that for salmon the work should be performed in the *winter months* of the year avoiding piling activity in the key spawning and migration periods. *For smolts, this will be March to June and between June and October for adult salmon*. However, performing the piling works during the winter months is likely impact on the over wintering birds via disturbance. Since most of the fish migrations happen during the night, it would seem appropriate to ensure that there is an suitable window of opportunity for the fish to migrate during the night so piling can be restricted.

We have therefore advised the competent authorities, in this case the Local Planning Authority and marine Management Organisation to restrict the use of piling techniques to daylight hours only (defined as sunrise and sunset), to ensure the migrating fish have an appropriate window of opportunity to migrate without being impacted by piling noise. Also where possible, Silent' or 'vibrational' piling methods should be used. We have also advised the competent authority to ensure that all main site piling shall be carried out using soft start up techniques.

Furthermore we have advised the competent authority to implement the following requirements:

No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.

No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation.

Conclusion
Suitable mitigation, such as soft start up techniques and the restriction on piling times will prevent the piling works from adversely impacting on the designated SAC and Ramsar fish species migrating up and down the River Parrett.

We can therefore conclude that there will be no adverse effect on the migratory fish and fish assemblage features of the Severn Estuary SAC and Ramsar from physical damage or disturbance as a result of works at Combwich.

[531]Hinkley Point C Combwich Environmental Statement (ES) Vol. 7, Chapter 18. Document Reference 4.8. (section 18.7.6 Pg.58).

Overall conclusion

Hazard assessed	Adverse effect on migratory fish and fis assemblage feature?
Habitat loss & physical damage	No
Physical damage, disturbance	No (see advice below)
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Conditions advised *No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.* *No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation.*	Environment Agency, Local Planning Authority, Marine Management Organisation	Development Consent Order condition

5.6.2.6 Migratory birds and bird assemblage

The Severn Estuary SPA and Ramsar site extends up the River Parrett approximately 5km upstream of Combwich wharf. In addition, the Pawlett Hams peninsula is a part of the European designated site. This is a low lying area of agricultural land with a network of drainage ditches. It is an important site as a high tide roost site and for grazing wildlfowl.

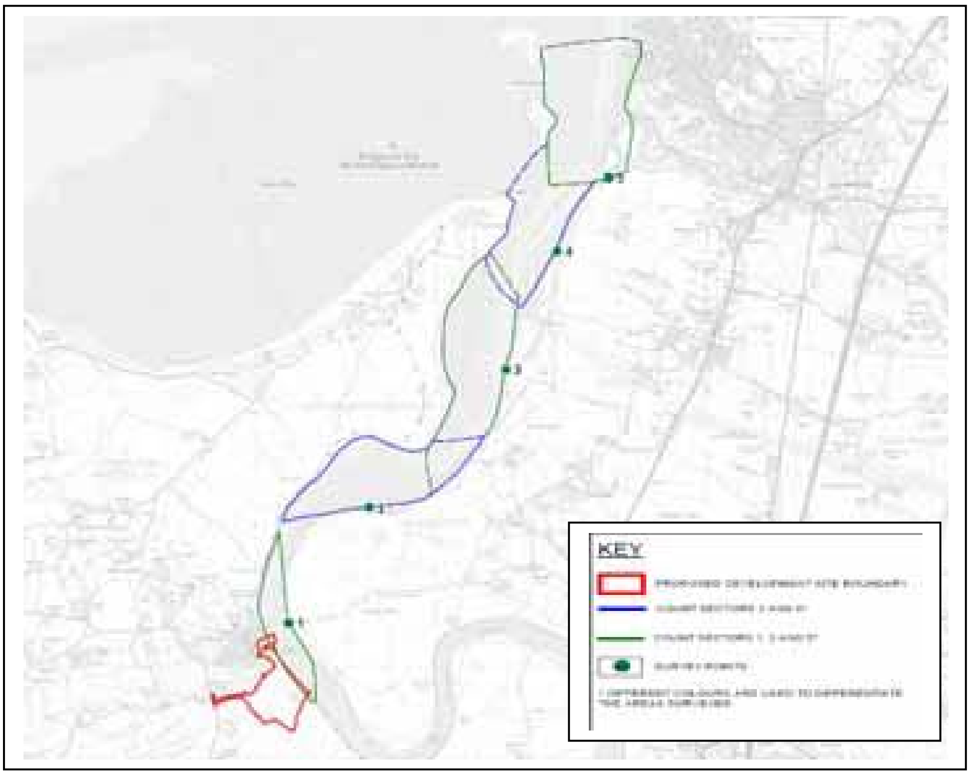
Along the tidal River Parrett, observations along the inter-tidal areas indicate that the lower reaches of the River Parrett (south of Combwich Wharf) support large numbers of regular occurring dunlin, wigeon, teal, ringed plover, grey plover, lapwing, curlew, and redshank (which favour river mouths), that are important in terms of the Severn Estuary SPA / Ramsar. All other designated bird species (curlew, shelduck, mallard, teal, wigeon, gadwall, ringed plover, black-tailed godwit, and whimbrel) generally occur in low numbers, particularly in comparison to numbers using inter-tidal habitats further downstream.

a) Disturbance to birds as a result of the refurbishment of Combwich Wharf

A summary of disturbance effects on birds is discussed in section 5.6.1.4.

Birds using the River Parrett and Combwich
Bird surveys within the River Parrett were carried out by Amec between April 2009 and March 2010 inclusive (Amec 2011b)[532]. The survey was carried out on 18 dates, in 5 count sectors. Figure 5.6.2.6.1 below shows the count sectors and the data is shown in table 5.6.2.6.2.

Figure 5.6.2.6.1. Survey of count sectors along the River Parrett (Haskoning, 2011).



532 Amec. (Amec 2011b). Combwich Wharf and Laydown Facility Baseline Bird Report. Report produced for EDF Development Company Ltd. 2011.

Table 5.6.2.6.2 Peak Count of Birds in each Combwich Count Sector, 2009-2010 (Haskoning 2011)

	CS1	CS2	CS3	CS4	CS5
Shelduck*Tadorna tadorna*	6	195	784	1024	434
Wigeon *Anas penelope*	575	1425	1978	1730	348
Gadwall *Anas strepera*	11	2	2	4	3
Teal *Anas crecca*	4	360	205	715	60
Mallard *Anas platyrhynchos*	103	90	60	44	4
Pintail *Anas acuta*	1	5	1	4	-
Ringed plover *Charadrius hiaticula*	2	12	4	45	52
Golden plover *Pluvialis apricaria*	770	1350	300	300	1
Lapwing *Vanellus vanellus*	1558	2500	1500	1250	223
Curlew *Numenius arquata*	7	69	74	393	161
Dunlin *Calidris alpina alpina*	86	6060	650	3000	2165
Whimbrel *Numenius phaeopus*	2	19	39	15	34
Redshank *Tringa totanus*	43	388	670	424	325
Lesser black-backed gull *Larus fuscus (these were non breeding)*	5	4	12	10	30

Seven of the nine qualifying species listed in the SPA/Ramsar citation or the SPA/Ramsar review were recorded along the Parrett.

Other surveys carried out by the applicant in the vicinity of Combwich included:

- Day-light field surveys within 1km around Combwich (undertaken on 2 visits) carried out by AMEC between April 2009 and March 2010 (Amec 2011b). These surveys found that most of the designated bird species are found along the River Parrett.
- Entec. (2010). Ornithological survey of River Parrett. Report produced for EDF Development Company Ltd.

In addition we have analysed the River Parrett Wetland Bird Survey (WeBS) data for the 5 most recent years to enable our assessment.

Conservation objectives (see section 1.5.1)

Internationally important population of regularly occurring migratory species (wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, gadwall, passage Ringed Plover wintering Curlew* wintering Pintail*, wintering teal**, breeding Lesser Black-backed Gull**) *recommended additions under the SPA review, **recommended under the Ramsar review*

- *aggregations of wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck and gadwall, passage Ringed Plover wintering Curlew wintering Pintail, wintering teal and breeding Lesser Black-backed Gull at feeding or roosting sites are not subject to significant disturbance*

Internationally important assemblage of waterfowl

- *waterfowl aggregations at feeding or roosting sites are not subject to significant disturbance.*

Natural England & Countryside Council for Wales, 2009[533]

Combwich Wharf will be reconstructed and an adjacent laydown facility built to service Abnormal Indivisible Loads arriving during construction. These will not result in habitat loss within the Severn Estuary SPA or Ramsar Site but there will be disturbance during construction. Construction is expected to take 18 months. Disturbance to birds could arise as a result of:

- Construction activities including the demolition of parts of the old wharf (finger pier and unwanted piles etc.);
- Construction of the new wharf area (extensions to dolphins, piling etc.);
- Extension and raising of the existing barge bed;
- Extension of the existing ro-ro Abnormal Indivisible Loads (AIL) jetty;
- Piling and infill for the refurbished and extended ro-ro wharf facility;
- Construction of the goods wharf facility;
- Construction of a new replacement slipway ;
- Dredging of berth bed;
- Construction and enhancements of flood defences around Combwich village and around the laydown facility area;
- Improvements to Tuckett's Clyce;
- Noise, lighting and human activity;
- Traffic movement;
- Operation traffic movement;

The laydown facility will involve a loss of fields used for roosting adjacent to the SPA. This proposal is outside the scope of the alone assessment as the facility does not require an Environment Agency permit.

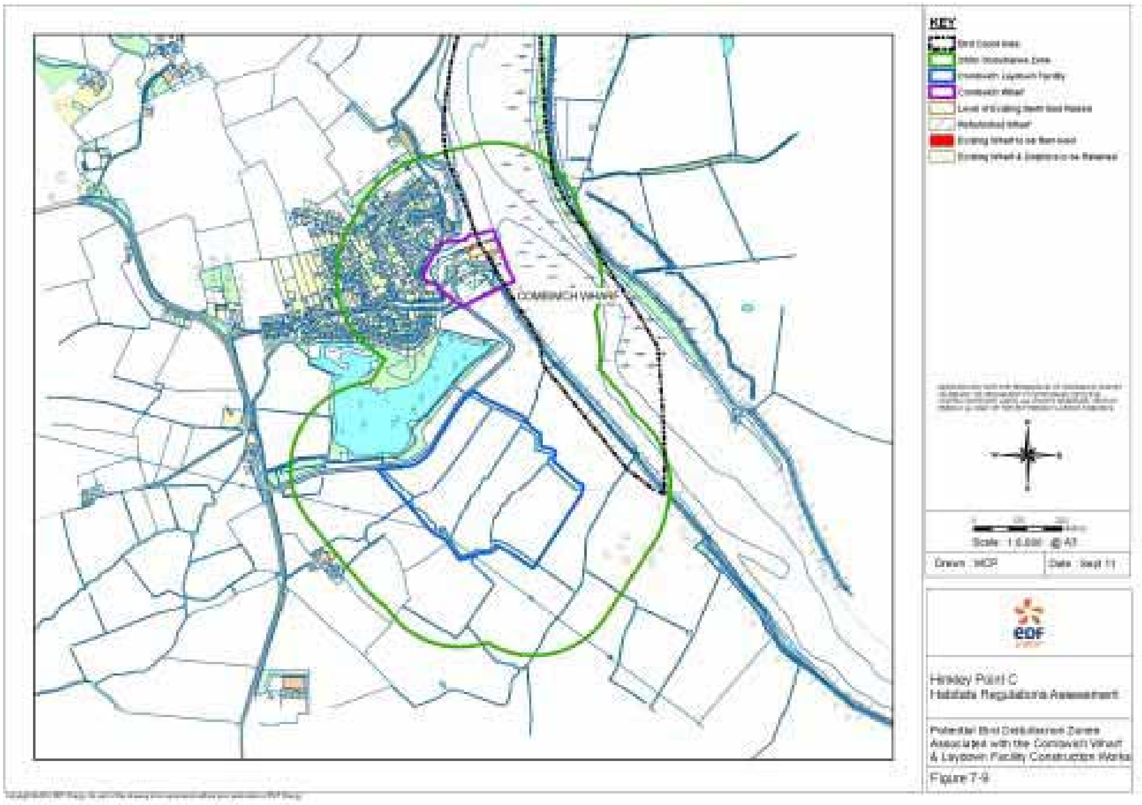
Count Sector 1 (CS1) of the Amec Survey (Amec 2011b), which is about 1.5 km in length, is adjacent to the Combwich wharf and will be the only count sector subject to disturbance from works at Combwich wharf. This count sector also extends beyond

[533] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

the distance which disturbance impacts would be endured. As discussed in section 5.6.1.4, disturbance effects are generally confined to a zone of 250m around the activity. Figure 5.6.2.6.3 below shows a 250m disturbance zone around Combwich wharf.

*Please note, as used for the sea wall disturbance assessment, we have used a more conservative distance of 300m for pintail and curlew as these birds have been observed to flush at a longer distance when approached by people compared to other water birds (Laursen *et al* 2005)[534].

Figure 5.6.2.6.3 . Potential bird disturbance zones associated with the Combwich Wharf and Laydown facility construction works (Haskoning 2011)



Pawlett Hams, at 3km^2, is an important high tide roost and is used by wildfowl as a feeding area. Figure 5.6.2.6.3 above shows that the site is beyond 250m from the development site. In addition, this site is protected by a flood bank which will screen birds from visual disturbance. Any birds using Pawlett Hams during refurbishment, if disturbed, will easily move to locations within the site away from disturbance.

The Report to Inform the HRA (Haskoning 2011) concludes that of the qualifying SPA/Ramsar species, only redshank use the area adjacent to Combwich Wharf in significant numbers (more than 1% of the SPA population within 250m of the wharf). The report goes on to conclude that these birds would be able to move away to other areas along the Parrett to avoid disturbance, much of which will be short-lived in nature (Haskoning 2011). This conclusion may be reasonable but it is not fully

[534] Laursen K., Kahlert, J and Frikke, J. (Laursen et al 2005). Factors affecting escape distances of staging waterbirds. 2005. Wildlife Biology, 11 (1):13-19.

supported by the data presented as the report also says that curlew, lapwing, wigeon and mallard also occur regularly in significant numbers in Count Sector 1. It is therefore apparent that the Count data needs to be disaggregated into smaller units to justify the conclusion that species other than redshank do not use areas within 250m of the wharf in significant numbers (Nicholas Pearson, 2011).

We have obtained the mapped data prepared by Amec (Amec 2011b) which presents bird count data for the Parrett in 200m grid squares. The data are recorded in bands, with tabulated peak numbers of each bird species within each square adjacent to Combwich wharf (Nicholas Pearson, 2011). This is shown in table 5.6.2.6.4 below. The wharf itself is situated centrally within square A, all of which is therefore within 100m of construction. The 5 adjacent squares (B, C, D, E and F) are also with 250m of the construction activity.

Table 5.6.2.6.4 Peak count of birds in 200m squares adjacent to Combwich wharf

SPA Ramsar species	Within 100m	Within 250m of construction activity					SPA population[535]	Highest count no. as % SPA population
	A	B	C	D	E	F		
Shelduck	0	0	0	0	0	1-17	3,330	0.51
Gadwall	0	6-11	0	0	0	0	282	3.9
Teal	0	0	0	0	0	0	4,456	0
Pintail	0	0	0	0	0	0	599	0
Ringed plover	1-2	1-2	0	0	0	0	655	0.3
Curlew	0	0	0	0	0	0	2,903	0
Dunlin	1-60	1-60	1-60	61-125	1-60	0	44,624	0.3
Redshank	24-47	1-11	24-47	24-47	1-11	0	2,330	2
Lesser black-backed gull	0	0	0	0	0	0	unknown	0
Wigeon	1-5	1-5	86-171	0	0	0	8,466*	2
Mallard	34-52	34-52	0	16-33	1-5	6-15	3,385*	1.5
Lapwing	65-129	21-64	65-129	65-129	21-64	0	15,217	0.9
Whimbrel	0	1	1	0	1	0	171*	0.06

* WeBS data: Severn Estuary 5 year peak mean 2004/05 – 2008/9

The data show that in relation to SPA qualifying species:

- Shelduck roost on land south of Combwich wharf within 250m in numbers less than 1% of the SPA population;
- Gadwall occupy the estuary north of Combwich Wharf within 250m in numbers more than 1% of the SPA population;
- Ringed plover occupy the area within 100m of the wharf and to the north (within 250m) in numbers less than 1% of the SPA population;
- Dunlin occupy the area within 100m of the wharf and adjacent parts of the estuary to the north, east and south (within 250m) in numbers less than 1% of the SPA population;
- Redshank occupy the area within 100m of the wharf and adjacent parts of the estuary to the east (within 250m) in numbers greater than 1% of the SPA

[535] WeBS: Number of individual birds, 5 year peak mean count 1991/2 to 1995/6.

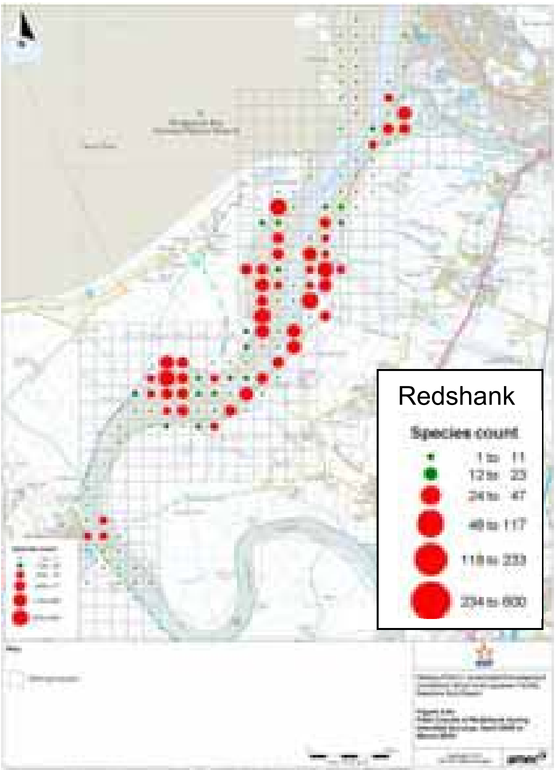
population, as well as areas to the north and south in numbers less than 1% of the SPA population;
- Curlew have been observed to flush at a longer distance and therefore we have made our assessment using 300m. The mapped data indicates that curlew are likely to occupy this area with a peak count of 40-78 birds. This is above 1% of the SPA population (2.7%).

In relation to SPA assemblage species:
- Wigeon are present in small numbers within 100m of the wharf and in adjacent parts of the estuary to the east (within 250m) in numbers exceeding 1% of the SPA population;
- Mallard occupy the area within 100m of the wharf and adjacent parts of the estuary to the north (within 250m) in numbers greater than 1% of the SPA population, as well as areas to the east and south in numbers less than 1% of the SPA population;
- Whimbrel are present as single individuals within 250m of the wharf;
- Lapwing occupy the area within 100m of the wharf and adjacent parts of the estuary to the north, east and south (within 250m) in numbers close to 1% of the SPA population.

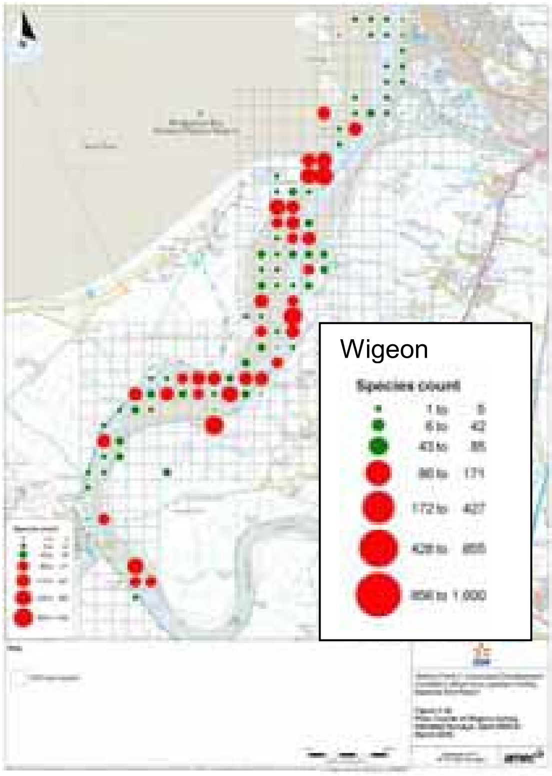
Species that are observed in numbers less than 1% of the Severn Estuary SPA population have been assessed as not being susceptible to an impact that would lead to an adverse effect on site integrity of the SPA. In other words, an impact on a population as small as 1% or less would not show any detectable population effects. Birds in populations above 1% of 250m of Combwich wharf include gadwall, redshank, wigeon and Mallard. Lapwing is very close to 1% and curlew are observed within 300m. Further detail and assessment has been considered for these species:

Figure 5.6.2.6.5 The mapped data for a) redshank, b) wigeon, c) mallard, d) lapwing and e) curlew and f) gadwall are shown below (Amec 2011b).

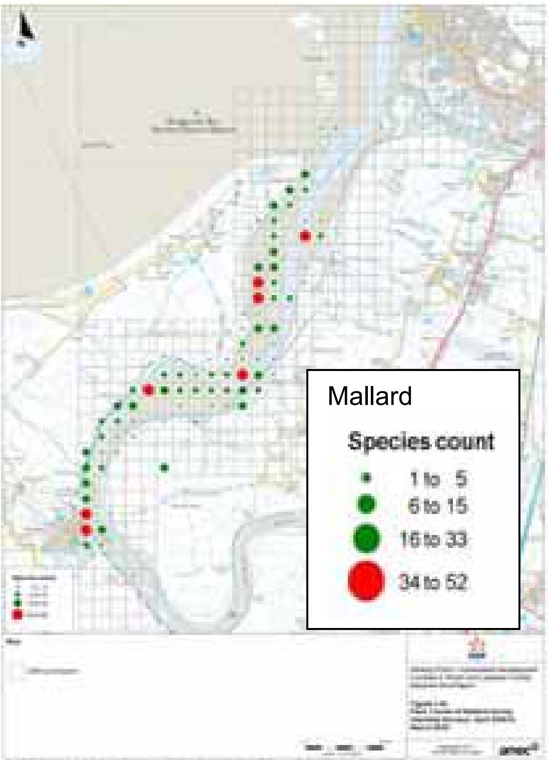
a) Redshank



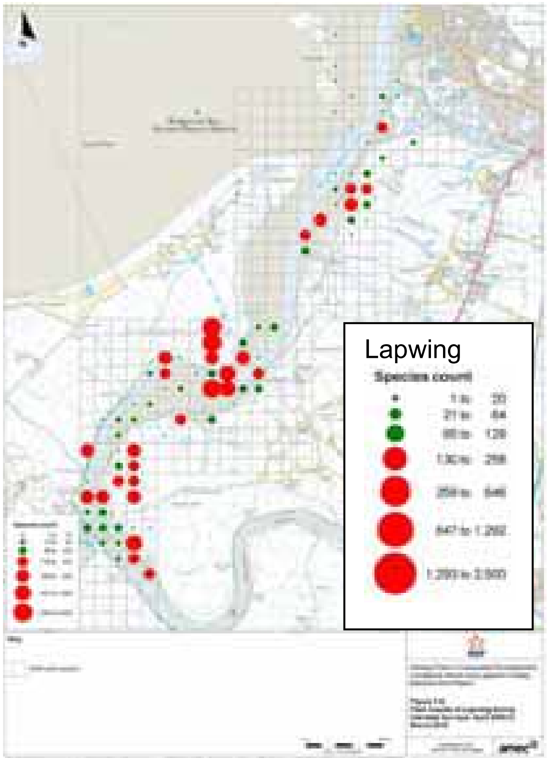
b) Wigeon



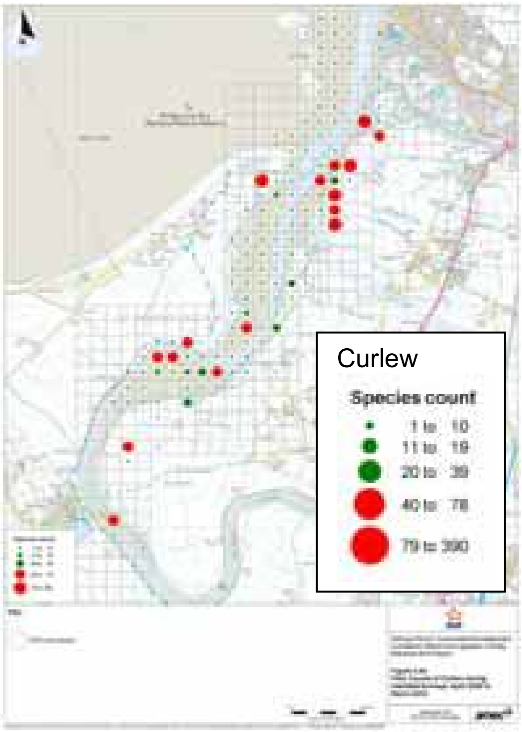
c) Mallard



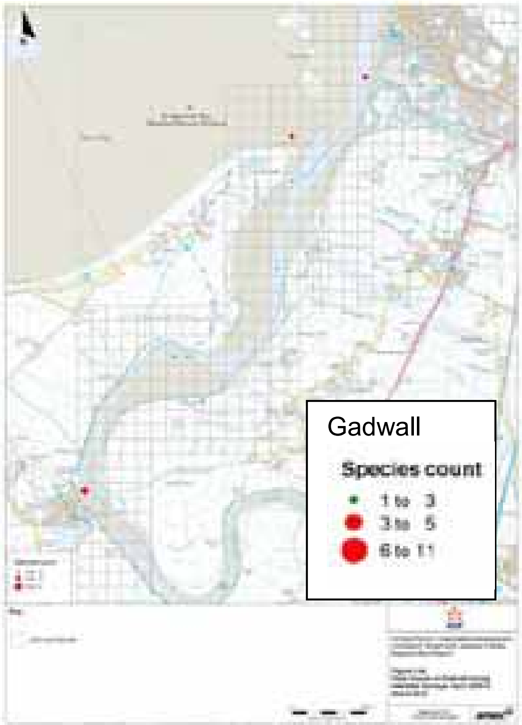
d) lapwing



e) Curlew



f) Gadwall



Redshank:
The area is particularly important during autumn passage and during the winter with numbers regularly in excess of 1% of the SPA population. A peak count of 43 birds was observed within CS1 which represents 2% of the Severn Estuary SPA population. Up to 20 roosting birds were regularly seen on the river banks adjacent to Combwich village during the survey times. Foraging predominantly took place within 2 hours of low tide.

<u>Impact assessment:</u> The use of the 250m disturbance zone is appropriate for this species. Between 24-47 birds were recorded within 250m of Combwich wharf which represents between 1 - 2% of the SPA population. Key findings were:

- Redshank were observed regularly in important numbers close to the wharf;
- Redshank are relatively tolerant to disturbance. Laursen *et al.* (2005)[536] reports that Redshank flush at 137m when disturbed by people);
- The largest populations of redshank observed in the estuary were located approximately 2.3km down stream of Combwich and out towards the mouth of the Parrett Estuary (north of Pawlett Hams), therefore Combwich is not a major site for redshank (see Figure 5.6.2.6.5 (a) above);
- There is available habitat close by for any redshank that are disturbed.

[536] Laursen K., Kahlert, J and Frikke, J. (Laursen et al 2005). Factors affecting escape distances of staging waterbirds. 2005. Wildlife Biology, 11 (1):13-19.

Wigeon:
The River Parrett Wetland Bird Survey (WeBS) data for the five most recent years shows good numbers of widgeon using the mudflats close to Combwich wharf (peak count of 600 birds noted in CS BV683, Haskoning 2011). This is supported by the Amec survey which noted a peak count of 575 birds in CS1 however, birds in numbers greater than 1% of the SPA population were only noted on 4 survey dates. Wigeon are mainly seen further downstream than Combwich wharf in the Parrett estuary (see Figure 5.6.2.6.5 (b) above) indicating that the area close to Combwich is not a strong hold.

Impacts assessment: The use of the 250m disturbance zone is appropriate for this species. Between 86-171 birds were recorded within 250m of Combwich wharf, which represents 2% of the SPA population. Key findings were:

- Birds are seen close to the wharf sporadically but occasionally in significant numbers (birds in numbers greater than 1% of the SPA population were only noted on 4 survey dates);
- Wigeon prefer the estuary habitat further downstream from Combwich wharf and therefore this is not an important site for Wigeon;
- There is available habitat close by for any Wigeon that are disturbed.

Mallard:
Mallard are regularly observed in important numbers close to the wharf with a peak count of 34-52 within 100m. Figure 5.6.2.6.5 (c) above indicates that the wharf area is one of the favoured areas for mallard in the estuary.

Impact assessment: The use of the 250m disturbance zone is appropriate for this species. Counts in excess of 1% of the Severn Estuary SPA population were seen on 10 dates (55% of the time). Key findings were:

- Mallard were observed in important numbers close to the wharf on approximately half the survey dates;
- The data suggests that the wharf areas is one of the favoured areas within the estuary for mallard;
- There is available habitat within the estuary for Mallard.

Lapwing:
Lapwing were noted in CS1 on a regular basis with a peak count of 1558 birds. In addition large congregations of birds were observed using fields adjacent to the estuary (see figure 5.6.2.6.5 (d) above). The data suggests that the wharf areas is one of the favoured areas within the estuary for lapwing. This is possibly because it is adjacent to important high tide roost sites such as Pawlett Hams.

Impact Assessment: The use of the 250m disturbance zone is appropriate for this species. Between 65-129 birds were recorded within 250m of Combwich wharf, which represents just under 1% of the SPA population. Key findings were:

- Lapwing are regularly observed in important numbers close to the wharf;
- The data suggests that the wharf area is one of the favoured areas within the estuary for lapwing;
- Lapwing are relatively tolerant to disturbance (Laursen *et al.* (2005) reports that lapwing flush at 142m when disturbed by people.

Curlew:
Curlew were sporadically observed near Combwhich wharf with occasional occurrence of the species in important numbers. The majority of the curlew were observed further down stream from Combwich wharf suggesting the wharf area is not an important site for this species (see figure 5.6.2.6.5 (e) above).

Impact assessment: The use of the 300m disturbance zone is appropriate for this species. Between 40-78 birds were recorded within 300m of Combwich wharf which represents 1.3-2.7% of the SPA population. Key findings were:

- Curlew were sporadically observed in important numbers adjacent to the wharf;
- The majority of curlew observed in the estuary were further down stream and therefore this is not an important site for curlew;
- There is available habitat close by for any redshank that are disturbed.

Gadwall:
Gadwall were sporadically observed near Combwhich wharf with occasional occurrence of the species in important numbers. Three main groups were noted, one adjacent to Combwich Wharf and two out on the mouth of the River Parrett (see figure 5.6.2.6.5 (f) above).

Impact Assessment: The use of the 250m disturbance zone is appropriate for this species. Between 6-11 birds were recorded within 250m of Combwich wharf, which represents 3.9% of the SPA population. Key findings were:

- Gadwall were recorded in small numbers in all count sectors
- Although no gadwall were recorded within 100m of Combwich Wharf figure MB3 (f) suggests they were very close to 100m.
- A potentially large population of gadwall has been known to occupy Combwich Brickpits County Wildlife Site (CWS) adjacent to Combwich Wharf, which has not been considered within the assessment.

Conclusion
There are extensive areas of suitable habitat for waders and wildfowl immediately adjacent to Combwich wharf that would not be affected by disturbance during its refurbishment. The WeBS data shows that the Parrett Estuary and SPA are not at full carrying capacity. In addition, it is unlikely that birds are confined to separate locations within the Parrett estuary and that they move around to benefit feeding and roosting areas.

However, the estuary remains an important site for birds and the data indicates that significant numbers are present within 250m of the wharf construction area, including three SPA qualifying species (gadwall, redshank and curlew) and three SPA listed species (wigeon, mallard and lapwing) in numbers exceeding 1% (or close to) of the SPA populations. Further to this, Combwich Brickpits CWS situated adjacent to Combwich Wharf is known to contain further significant numbers of SPA birds, which were not included within the counts. This means that the bird counts do not represent total counts for the whole river area. Whilst the CWS is situated outside of the designated area, it still should be considered as part of an 'off-site' impact as it is regularly used by SPA birds. There are a number of options available to mitigate the potential impact of disturbance and without this mitigation it is not possible for us to conclude no adverse impact on the SPA/Ramsar bird interests.

In the absence of mitigation we are unable to conclude no adverse effect on the integrity of the Severn Estuary SPA/Ramsar migratory bird and bird assemblage populations from disturbance during the reconstruction of Combwich wharf.

Mitigation
Mitigation should take the form of a construction window confined to April to September; however for an 18 month construction period this would increase the programme to three seasons, which is unlikely to be acceptable.

We therefore strongly advise that the competent authorities, in this case the Local Planning Authority (LPA) and Marine Management Organisation (MMO) ensure that further mitigation is incorporated in the project to ensure protection of the migratory birds and bird assemblage. These mitigation measures are:

Piling be confined to between April and September to avoid the winter months when birds are feeding on exposed mudflats;

Construction should cease in the event of severe winter weather leading to voluntary wildfowling restraint by BASC (i.e. after seven days of freezing conditions).

Furthermore we have advised the competent authority to implement the following requirements:

No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.

No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation

b) Habitat loss

Conservation objectives (see section 1.5.1)

Internationally important population of regularly occurring migratory species (wintering dunlin, wintering redshank, wintering shelduck, gadwall, Ringed Plover Curlew* Pintail*) *recommended additions under the SPA review*

- *the extent of intertidal mudflats and sandflats is maintained;*
- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained*

Internationally important assemblage of waterfowl

- *the extent of intertidal mudflats and sandflats is maintained*
- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained;*

Natural England & Countryside Council for Wales, 2009[537]

The inter-tidal mudflats in the River Parrett are important feeding grounds for the designated bird species. The potential for impacts via direct and/or indirect loss or alteration of inter-tidal mudflat habitats due to the upgrade of Combwich Wharf is discussed in section 5.6.2.2 of this report. In summary, there will be 0.05ha of inter-tidal habitat lost at the mouth of Combwich Pill. This area is outside of the SAC and SPA/Ramsar.

The importance of this area of habitat has not been assessed by the applicant however, we are able to conclude that we do consider its loss as significant to birds by nature of it size and location and by comparing this to the other available habitat within the River Parrett.

Conclusion

We can therefore conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from habitat loss as a result of works at Combwich.

[537] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

c) Changes to water chemistry (toxic contamination, salinity, nutrients, oxygenation)

Conservation objectives (see section 1.5.1)

Internationally important population of regularly occurring migratory species (wintering dunlin, wintering redshank, wintering shelduck, gadwall, Ringed Plover Curlew* Pintail*) *recommended additions under the SPA review*

- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained*

Internationally important assemblage of waterfowl

- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained;*

Natural England & Countryside Council for Wales, 2009

Refurbishment of Combwich Wharf
The construction works for the refurbishment of Combwich Wharf could cause an impact on water quality of the SAC/Ramsar. As stated in section 5.6.2.1.b, provided that an Environmental Management and Monitoring Plan is agreed with the EA through the Flood Defence Consent then Water quality in the Parrett Estuary will be protected.

Conclusion
We can therefore conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from changes to water chemistry as a result of works at Combwich.

Overall conclusion

Hazard assessed	**Adverse effect on migratory bird and bird assemblage feature?**
Physical damage, disturbance	Yes (see advice below)
Habitat loss	No
Changes to water chemistry	No (see advice below)
Overall conclusion	**Without required mitigation there is a potential adverse effect upon site integrity**

Advice / Requirements	**Competent Authority**	**Method**
Required mitigation *Piling be confined to between April and September to avoid the winter months when birds are feeding on exposed mudflats;* *Construction should cease in the event of severe winter weather leading to voluntary wildfowling restraint by BASC (i.e. after seven days of freezing conditions).*	Local Planning Authority, Marine Management Organisation	Development Consent Order, Marine licence

Advice / Requirements	Competent Authority	Method
Further advice given *No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.* *No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation*	Environment Agency, Local Planning Authority, Marine Management Organisation	Development Consent Order condition

5.6.3 Main site construction (abandonment of HPC drainage ditch)

The HPC drainage ditch is supplied with water from surface drainage running off from surrounding agricultural land. Its water quality status is characterised by highly variable water quality conditions, including elevated concentrations of suspended solids. In addition, it is known to dry out during prolonged periods without rainfall, which means that it is unable to support fish or other species reliant on water all year round.

Concrete wash water arising from washing out of wagons used to move concrete around the site will initially be discharged for 6-12 months to the HPC drainage ditch. Thereafter, following commissioning of the first of two on-site concrete batching plants, any nonrecyclable wash water will be discharged via the new outfall to the Severn Estuary.

At an early stage of construction, Water Management Zones (WMZs) will be created along the ditch to attenuate flow (which will be restricted to greenfield run-off rates) and suspended solids concentration (which will be restricted to 250 mg/l within the construction discharge consent). Once the spine drains (the central drainage channels) have been installed, this ditch will be removed and a new discharge point to the foreshore will be installed.

5.6.3.1 Estuaries (sub feature rocky shore)

The infilling of the drainage ditch has the potential to cause a loss of designated bird habitat, changes to water quality and reduced surface water flows to the foreshore. The construction activities also have the potential to cause disturbance to SPA and Ramsar birds.

a) Changes to water chemistry

Conservation objectives (see section 1.5.1)

- *The physico-chemical characteristics of the water column support the ecological objectives.*
- *Toxic contaminants in water column and sediment are below levels, which would pose a risk to the ecological objectives.*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained.*

Natural England & Countryside Council for Wales, 2009[538]

A drainage strategy will be in place that involves the construction of a number of Water Management Zones (WMZ) across the site. The WMZ's are designed to attenuate flow, settle out suspended material, and to allow for the provision of additional treatment if necessary, for example, chemical dosing to control metal contaminated groundwater. This will ensure that any potential pollutants will be treated or removed prior to discharing to the foreshore.

[538] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

The Environment Agency construction permit (Ref: JP3122GM) contains pre-operational measures under Schedule 3 in relation to surface water drainage and concrete washwater that support the activities associated with HPC drainage ditch. The following pre-operational measures apply:

Surface Water Drainage

At least 3 months prior to commencement of Activities A-C specified in schedule 1 table S1.1, the operator shall submit to the Environment Agency a Surface Water Drainage System report following completion of detailed contractor design. The report shall include:

(a) an overview of the final proposals for the surface water drainage system serving the development site;
(b) output from a suitable drainage model which reflects the attenuation provided by the WMZ's and the overall hydraulic performance of the pipe network;
(c) the minimum design criteria in respect of environmental protection that the contractors used in producing their detailed design, highlighting elements of the design that will ensure that the limits within table S3.1 are achieved; and
(d) details of your proposals for high level overflows on the WMZ's, both within the Built Development Area (BDA) and the Southern Construction Phase Area (SCPA).

The operator shall re-assess the maximum estimated flow rate through the new foreshore outfall for the 1 in 30 year return period rainfall event based on the detailed design presented.

Concrete Wash Water

At least 2 months prior to commencement of Activity F specified in schedule 1 table S1.1, the operator shall submit to the Environment Agency a Concrete Wash Water Characterisation report, which will include the following information:

(a) the nature and composition of the concrete(s) used on site, including additives;
(b) the characteristics of the resultant wash water, for both concrete from the off-site supplier and from the on-site batching plant(s); and
(c) performance data on the proposed treatment system(s) for all relevant substances identified within the wash water.

The report should (i) take into consideration those substances listed in the Environment Agency's H1 Guidance on Environmental Risk Assessment, Annex D, (ii) make clear how the information has been derived and (iii) describe any assumptions or limitations associated with preparation of the report.

The Concrete Wash Water Characterisation report shall be audited by the Environment Agency and used to establish operational compliance (numeric) limits for any contaminants present in the wash water at environmentally significant levels.

Conclusion

With the preoperational measures secured within the construction permit we can conclude that there will be no adverse effect on the estuaries feature or rocky shore sub-feature of the Severn Estuary SAC and Ramsar from changes to water chemistry as a result of the infilling of HPC drainage ditch.

b) Reduced surface water flooding & Changes to flow and velocity regime

Conservation objectives (see section 1.5.1)

- *The characteristic physical form (tidal prism/cross sectional area) and flow (tidal regime) of the estuary is maintained;*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained.*

Natural England & Countryside Council for Wales, 2009

The Hinkley Point C drainage ditch, which comprises entirely of surface water run-off, crosses a variety of intermediate inter-tidal biotopes before reaching the lower shore. The runoff percolates through an extensive downshore slope of low grade *Sabellaria* reef and a few areas of varying *Fucus* species.

The drainage ditch is a winterbourne stream and will only contain water after prolonged wet periods, which are generally over the winter period. Infilling of the ditch and reducing the freshwater flows to the foreshore is likely to cause some slight alterations in salinity over part of the foreshore, however it is not considered that this would be at such a spatial extent that the current distribution and structure of the communities present on the foreshore would be adversely affected. Especially since the freshwater flows are considered to be periodic. Furthermore, the species on the inter-tidal rocky foreshore are likely to be highly adapted to rapid and significant changes in salinity because of exposure of freshwater from heavy rainfall and brackish water from daily tidal exposure.

Conclusion

We can therefore conclude that there will be no adverse effect on the estuaries feature or rocky shore sub-feature of the Severn Estuary SAC and Ramsar from reduced surface water flooding and changes to flow and velocity regime as a result of the infilling of HPC drainage ditch.

Overall conclusion

Hazard assessed	Adverse effect on estuaries feature?
Changes to water chemistry	No (see advice below)
Reduced surface water flooding	No
Changes to flow and velocity regime	No
Overall conclusion	**No adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Conditions (in brief) *At least 3 months prior to commencement of Activities A-C specified in schedule 1 table S1.1, the operator shall submit to the Environment Agency a Surface Water Drainage System report following completion of detailed contractor design.* *The operator shall re-assess the maximum estimated flow rate through the new foreshore outfall for the 1 in 30 year return period rainfall event based on the detailed design presented.*	Environment Agency	Construction permit Ref: JP3122GM
At least 2 months prior to commencement of Activity F specified in schedule 1 table S1.1, the operator shall submit to the Environment Agency a Concrete Wash Water Characterisation report. *The report should (i) take into consideration those substances listed in the Environment Agency's H1 Guidance on Environmental Risk Assessment, Annex D, (ii) make clear how the information has been derived and (iii) describe any assumptions or limitations associated with preparation of the report.*	Environment Agency	Construction permit Ref: JP3122GM
The Concrete Wash Water Characterisation report shall be audited by the Environment Agency and used to establish operational compliance (numeric) limits for any contaminants present in the wash water at environmentally significant levels.	Environment Agency	Construction permit Ref: JP3122GM

5.6.3.2 Migratory birds & bird assemblage

a) Habitat loss and disturbance

Conservation objectives (see section 1.5.1)

Internationally important population of regularly occurring migratory species (wintering dunlin, wintering redshank, wintering shelduck, gadwall, Ringed Plover Curlew* Pintail*) *recommended additions under the SPA review*

- *the extent of intertidal mudflats and sandflats is maintained;*
- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained*

Internationally important assemblage of waterfowl

- *the extent of intertidal mudflats and sandflats is maintained*
- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained;*

Natural England & Countryside Council for Wales, 2009

Chapter 20 of the Hinkley Point C Environmental Statement[539] reports on the surveys that were taken of water birds using the land within the development site and the upper intertidal habitat. The reports suggested that the areas were not being regularly used by large numbers of roosting or foraging birds, although there was consistent use of the coastal fields by a small number of golden plover, a concentration of foraging snipe in a field (field 66) on one occasion, and regular use of count sector 1 by moderate numbers of roosting oyster catcher (peak of 100 birds), however none of these species are designated under the SPA or Ramsar.

The infilling of the drainage ditch is planned at a time when heavy construction will be going on across the whole of the Hinkley C area so there will be some disturbance of machines filling in the ditch, but it is likely to be negligible in the scheme of the whole development works.

Conclusion

As none of the species potentially using the area around HPC drainage ditch are designated under the SPA or Ramsar site, we can conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from habitat loss and disturbance as a result of the infilling of HPC drainage ditch.

Overall conclusion

Hazard assessed	**Adverse effect on migratory fish and fish assemblage feature?**
Disturbance	No
Habitat loss	No
Overall conclusion	**No adverse effect upon site integrity**

[539] EDF. (2011). Hinkley Point C Environmental Statement: Chapter 20 Terrestrial Ecology and Ornithology. Doc. Ref: 4.3. October 2011. Section 20.5.45.

6. In combination assessment

6.1 Overview

This section considers in combination and cumulative effects on the *Severn Estuary SAC and SPA* as part of the assessment of effects on integrity of those sites from plans and projects. In-combination effects must be considered as part of this appropriate assessment.

6.2 PPP considered 'in combination'

In-combination effects can be one of the following:

- additive - the total effect of a number of effects is equal to the sum of the individual effects.
- synergistic - the effect of the interaction of a number of effects is greater than the sum of the individual effects.
- neutralistic - the effects counteract each other, reducing the overall effect.
- overlapping - affecting the same spatial area of a feature and/or the same attributes of the feature. For example the mixing zones of two separate discharges overlap.
- discrete - affecting different areas and different attributes of the feature. For example two separate discharges affect geographically discrete areas of a habitat within a site. In combination, the total area of habitat affected may be unacceptable in terms of site integrity.

The Regulations limit the scope of the in combination test to "other plans or projects". These include:

- approved but as yet uncompleted plans or projects;
- permitted ongoing activities such as discharge consents or abstraction licences, and
- plans and projects for which an application has been made and which are currently under consideration but not yet approved by competent authorities.

The key aspects for consideration for in combination effects are:

- the temporal and geographic boundaries of the effects of activities;
- the interactions between the activities and the overall ecosystems;
- the environmental effects of the project, and past and future projects and activities; and
- the thresholds of sensitivity of the existing environment.

To be considered within the in-combination assessment other permissions, plans or projects
should meet the following criteria:

- Generate their own residual impacts of at least minor significance;
- Be likely to be constructed or operate over similar time periods;

- Be spatially linked to the proposed development (for example using the same local road network)

Table 6.2. S1 lists all the permissions plans or projects PPPs that have been considered for in combination assessment with the proposed HPC Point C nuclear power station environmental permits. This indicates distances and potential pathways for each PPP and whether they have been considered within the in combination assessment.

The list of PPPs in Table 6.1 S1 has been sourced from the following:

Local Authorities: Welsh Government; British Council; Cardiff Council; North Somerset Council and Somerset Council.

Internal Drainage Boards: Caldicott and Wentlooge levels; Lower Axe; Lower Brue; Lower Severn; Parrett & West Mendip.

Devon and Severn Inshore Fisheries and Conservation Authority

Ports and Harbour Authorities: Bristol Port company; Associated British Ports; Cardiff Harbour Authority; Navigation Directorate

Water Companies: Welsh Water,; Thames Water

Natural England

Countryside Council for Wales

Marine Management Organisation

Welsh Government

To ensure that the list of possible PPP to be considered for the in combination assessment was appropriate we have regard to:

whether the PPP was a construction or works project that is now complete – if so, the PPP will have already been considered as part of the prevailing environmental conditions (through monitoring of environmental parameters such as temperature, nutrients etc.) and effectively taken into consideration in the 'alone' assessment. As a result it will not be considered further in the in combination assessment to avoid double counting;

whether the PPP is an ongoing permission and also those that could potentially be revoked or changed in future – if so the PPP has been considered in the in combination assessment if a potential pathway or mechanism for in combination effects could be identified;

If there is a potential pathway or mechanism for in combination effects. If none could be identified then this will be excluded from consideration.

- Identified mechanisms for in combination effects include;
- zones of overlap between similar effects on an interest feature arising from different PPPs (for instance overlapping thermal plumes);
- zones of overlap of different types of effect arising from different PPPs (for example thermal plumes and toxic plumes overlapping);
- the cumulative effects of different PPPs acting in different locations on the same interest feature, leading to a potential adverse effects on the interest feature in terms of the proportion of the total resource of that interest feature within the SAC that is affected.

Table 6.2 S1 – PPP considered and PPP included in the in combination assessment

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
HINKLEY POWER STATION											
Hinkley Point B power station	British Energy Generation Ltd	EA	GP3532HF	Environmental permit for Waste incineration; non hazardous waste not in an incineration or co incineration plant and > 50kg/hr <1t/hr	Consented	ST21044592 Adjacent to HPC	Directly adjacent	Nutrients	Potential air plume Considered to be background Considered to be insignificant in combination with Hinkley C.	Included in Review of consents. Outcome of no adverse effect on site integrity.	No
Hinkley Point B power station	British Energy Generation Ltd	EA	GP3532HF	Combustion; any fuel =>50mw	Consented	ST21044592 Adjacent to HPC	Directly adjacent	Nutrients	Potential air plume Considered to be background	Included in Review of consents. Outcome of no adverse effect on site integrity. Considered in combination with Hinkley C there is no adverse effect.	No
Hinkley Point A – Discharge of trade effluent from de-commissioning	Magnox Limited	EA	102980	Water Discharge permit (max. 500m3/d of trade effluent from decommissioning of the A station)	Consented	ST2082046860 (outlet). Adjacent to HPC. Just offshore the A station frontage at the intake for HPB	Within the SAC (Severn Estuary). 0.1km north of SPA/Ramsar (Severn Estuary)	Toxic Contamination	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect.	Yes
Hinkley Point A & B	British Energy Generation Limited	EA	70408	Water discharge permit (max. 1000m3/d of treated sewage effluent only)	Consented	ST2150046530 (outlet). Adjacent to HPC. Just offshore the B station frontage, into the B station main discharge channel	Within the SAC/SPA/Ramsar (Severn Estuary)	Toxic Contamination Nutrients	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect on site integrity	Yes
Hinkley Point A & B	Magnox Limited	EA	102737	Water discharge permit (max. 27400m3/d of site drainage and trade effluent)	Consented	ST2076046260 (outlet). Adjacent to HPC. Through sea wall onto the foreshore in front of A station	Within the SAC/SPA/Ramsar (Severn Estuary)	Toxic Contamination	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect on site integrity	Yes
Hinkley Point A & B	Magnox Limited	EA	102738	Water discharge permit (max. 27400m3/d of site drainage and trade effluent)	Consented	ST2113046350 (outlet). Adjacent to HPC. Through sea wall onto the foreshore between A and B station	Within the SAC/SPA/Ramsar (Severn Estuary)	Toxic Contamination	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect on site integrity	Yes

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Hinkley Point B	British Energy Generation Limited	EA	101266	Cooling water discharge permit (max. 3040000m3/d of cooling water, trade effluent and site drainage via 2 outfalls)	Consented	ST2150046500 (outlet 1). Adjacent to HPC. Offshore the B station frontage, into the B station main discharge channel. ST2127046350 (outlet 2). Adjacent to HPC. Through sea wall onto the foreshore in front of B station	Within the SAC/SPA/Ramsar (Severn Estuary)	Thermal Toxic Contamination	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect on site integrity	Yes
Hinkley Point B	British Energy Generation Limited - EDF	EA	Linked to permit number 101266	35.2 cumecs intake	Abstraction not licensed but see water discharge permit above	ST2086346853	Within the SAC	Entrainment and Impingement	Potential	Included in Review of Consents. Permit change requested and in progress.	Yes
Hinkley Point B	British Energy Generation Limited	EA	Various	RSR environmental permit	Consented	On Site	Adjacent	Toxic contamination	Aerial Plume	HRA alone section has assessed interaction of various consents – no likely significant effect alone and no potential for in combinations effects	No
Hinkley Point A nuclear power station decommissioning	British Energy	EA		Environmental permits (water disharge, installation & RSR)	Early phases have begun De-commissioning would result in modification or ending of permits	On site	Directly adjacent	Toxic Contamination	Interaction with Hinkley C would cease	Severn Estuary RoC assessed as no likely significant effect However these will be assessed in combination as they have not been considered as operational.	Yes
Hinkley Point B decommissioning	British Energy	IPC		Environmental permits (water disharge, installation & RSR)	De-commissioning would result in ending of permits	On site	Directly adjacent	Toxic Contamination	Interaction with Hinkley C would cease	Severn Estuary RoC assessed as no likely significant effect.	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Bridgwater – Seabank 440kV electricity transmission line upgrade	National Grid	IPC		Development Consent Order	Application due 2013 Construction due 2014 to 2017	ST1972545483	Adjacent	Disturbance	Considered minor risk due to location and lack of potential impact on feeding grounds in association with the sea wall construction however will be considered in combination for clarity with the sea wall permit.	Yes	Yes
Temporary Jetty	EDF	MMO		Harbour Empowerment Order	Applied	ST1945546227	Adjacent and within	Disturbance Toxic Contaminants Siltation/Turbidity	Potential	Included in EDFs HRA. MMO will be competent authority for the HEO.	Yes
Combwich Development	EDF	EA, Local Planning Authority		Flood Defence Consent, Planning permission	Applied	ST2621042108	Adjacent	Disturbance Habitat loss of roosting habitat.	Potential	Included in EDFs HRA.	Yes
EA ONGOING PERMISSIONS											
Claylands Corner Poultry Unit	Halberton Poultry Ltd	EA	SP3836MA	Environmental permit Intensive farming; > 40,000 poultry	Consented	ST22744295	2km	Nutrient - ammonia	Potential Air plume	No significant effect in permit assessment. Considered no likely significant effect in combination.	No
Knaplock Poultry Farm	Knaplock Ltd	EA	RP3232KR	Environmental permit Intensive farming; > 40,000 poultry	Consented	ST23674215 4.8km	2.4km (Parrett)	Nutrient - ammonia	Potential Air plume	No significant effect in permit assessment. Considered no likely significant effect in combination.	No
Yeo Valley Farms(Production) Ltd, Cannington	Yeo Valley Farms (Production) Limited	EA	LP3738XP	Environmental permit Animal vegetable and food; treating etc milk >200t/day	Consented	ST24903890	3km (Parrett)	Nutrient - ammonia	Potential Air plume	No significant effect in permit assessment. Considered no likely significant effect in combination.	No
Steart Farms Ltd	Steart Farms Ltd.	EA	PP3536MT	Environmental permit Intensive farming; > 40,000 poultry	Consented	ST2720945887	Directly adjacent	Nutrient - ammonia	Potential Air plume	No significant effect in permit assessment. Considered no likely significant effect in combination.	No
Oldbury Power Station Tidal lagoon	Nuclear Decommissioning Authority	EA	18/54/020/5 /234	Abstraction licence for cooling	Consented	ST6041594631	Within the SAC	Entrainment and Impingement	Potential	Included in Review of Consents. Permit change requested and in progress.	Yes
Watchet STW	Wessex Water	EA	101940	Water Discharge permit	Consented	ST0652044550 (outlet) 14km	11.5km	Toxic Contamination Nutrients	No - distance	Included in Review of consents. Outcome of no adverse effect on site integrity	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Kilve STW,	Wessex Water	EA	102917	Water Discharge permit	Consented Review date 31-Mar-2014	ST1428044740 (outlet) 6km	3.7km	Toxic Contamination Nutrients	Potential plume interaction. Not taken further due to distance and no likely interaction.	Included in Review of consents. Outcome of no adverse effect on site integrity	No
Weston-super-Mare STW	Wessex Water	EA	100334/FU/01	Water Discharge permit	Consented	ST3058058690 (outlet) 18km	Direct to SAC/SPA/ Ramsar	Toxic Contamination Nutrients	Potential plume interaction. Not taken further due to distance and no likely interaction.	AA completed Included in Review of consents but outcome of no adverse effect on site integrity.	No
West Huntspill STW	Wessex Water	EA	100881	Water Discharge permit	Consented	ST2942046840 (outlet)	Within the SAC/SPA/Ramsar (R Parrett)	Toxic Contamination Nutrients	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect on site integrity	No
Combwich STW	Wessex Water	EA	103336	Water Discharge permit	Consented Review date 01-Apr-2013	ST2621042190 (outlet). Adjacent to Combwich works, 6.5km from HPC	Within the SAC/SPA/Ramsar (R Parrett)	Toxic Contamination Nutrients	Plume interaction Ongoing	Included in Review of consents. Outcome of no adverse effect on site integrity	No
Walpole Landfill Site	Viridor Waste (Somerset) Ltd	EA	PP3733HS	Environmental permit for waste landfilling; >10 t/d with capacity >25,000t excluding inert waste	Consented	ST30894264 10km from HPC, 4.7km from Combwich (landfill is situated to the east of the Parrett)	1.3km to r Parrett SAC/SPA	Toxic Contamination Nutrients	No	n/a	No
Wansborough Paper Mill	DS Smith Paper Limited	EA	TP3435GL	Environmental permit for paper, pulp and board producing pulp from timber etc	Consented	ST0652044550 (outlet) (same discharge location as Watchet STW) 14km	11.5km	Toxic Contamination Nutrients	Plume interaction Ongoing	N/a	No
ENVIRONMENT AGENCY MANAGEMENT PLANS AND STRATEGIES											
Severn River Basin Management Plan	n/a	EA		River Basin Management Plans	Plan complete	Plan covers area adjacent to Hinkley	Covers parts of Severn Estuary N2K	No specific works identified	n/a too high level	n/a	No
Severn Estuary Shoreline Management Plan	n/a	EA		Flood Risk Management Plan	Plan complete	Western Super Mare is nearest policy unit ~15km east	Covers parts of Severn Estuary N2K	Policy is "hold the line". Considered in - combination effects very unlikely	n/a too high level	HRA completed but not approved. Conclusion of potential adverse effect. IROPI case in progress	No
South West River Basin Management Plan	n/a	EA		River Basin Management Plans	Plan complete	Plan covers Hinkley Location	Covers parts of Severn Estuary N2K	No specific works identified	n/a too high level	Overview of HRA for RCMPs completed nationally for EA	No
Western Wales River Basin Management Plan	n/a	EA		River Basin Management Plans	Plan complete	Plan covers area adjacent to Hinkley	Covers parts of Severn Estuary N2K	No specific works identified	n/a too high level	Overview of HRA for RCMPs completed nationally for EA	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Severn Estuary/ Môr Hafren Coastal Flood Risk Strategy	n/a	EA		Flood Risk Management Plan	Plan complete	Plan covers area adjacent to Hinkley	Covers parts of Severn Estuary N2K	No specific works identified	n/a too high level and too distant	Overview of HRA for RCMPs completed nationally for EA	No
Capital Flood Risk Management Scheme. WestonSuper Mare	North Somerset Council	North Somerset Council	n/a	Capital Flood Risk Management Scheme	Complete	20km NE of site	Adjoining	Habitat loss	No – compensation is at Downlands farm, freshwater habitat	HRA completed retrospectively to works	No
Parrett Estuary Flood management strategy	n/a	EA		Flood management strategy	Plan complete	Strategy includes area of some HPC works	Covers parts of Severn Estuary N2K	No specific works identified. May be small in combination mechanism via hydrodynamic change and sediment transport at Combwich and open sea.	Potential Permanent	Completed and approved	No
ENVIRONMENT AGENCY FLOOD AND COASTAL RISK MANAGEMENT WORKS											
Steart coastal management project (EA project	n/a	EA		Flood Risk Management Plan. Construction due to start 2012 with breach planned in 2013. (approx 200m wide with inundation area of 250ha)	Project ongoing Planning permission in place	ST2722544528 (location of proposed breach site)	6km East of site	Toxic Contamination Nutrients Siltation/turbidity Disturbance	Potential.	Yes	Yes
Routine maintenance activities and asset management	EA	EA		n/a	Ongoing	None applicable	n/a	Not considered significant	n/a	n/a	No
OTHER MANAGEMENT PLANS AND STRATEGIES											
N Devon and Somerset Shoreline Management Plan (SMP2) review Halcrow for the N Devon and Somerset Coastal Advisory Group (2010) supercedes the original SAP	n/a	Sedgemo or District Council		Flood Risk Management Plan	Plan complete	Plan includes area of some HPC works	Covers parts of Severn Estuary N2K	Potential for in combination with Hinkley C but no specific projects identified to assess.	Discharge Direct impact on features Smothering Temporary	HRA completed but not approved. Conclusion of potential adverse effect. IROPI case in progress	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Development plans for growth in SW Region	n/a	n/a		n/a	Assessment of Sustainability complete	AoS does not identify any specific projects	n/a	n/a	n/a	HRAs devolved to Councils - In progress	No
Welsh Water Resource Management Plan	n/a	WW		Water Resource Management Plan	Plan complete	Covers Welsh input to Severn Estuary	Covers waters feeding into Estuary	Potential in-direct impact on features High level plan no specific activities	n/a too high level	n/a	No
Severn Thames Transfer currently being assessed by Thames Water Utilities Ltd	Thames Water Utilities	EA		Abstraction licence	In development. Thames Water Utilities have produced scoping report Jan 2012.	Proposed transfer from Severn to Thames	Not specific location but includes SAC	Potential impact on features 200ml/d approx 47 days/yr	Nutrient enrichment due to low flows	Scope for Assessment is complete but not enough information to make any judgements on impact on site integrity.	No
Welsh Water Drought Plan	n/a	WW		Drought Plan	Plan complete	Covers Welsh input to Severn Estuary	Covers waters feeding into Estuary	Potential in-direct impact on features Nothing to suggest negative impact	potential reduced water affecting fish.	Yes	No
Strategic Flood Risk Assessment for West Somerset Council and Exmoor National Park Authority (2009)	n/a	West Somerset Council		Flood Risk Management Plan	Plan complete	Strategy covers areas adjacent to HPC site	Covers parts of Severn Estuary N2K	Potential in-direct impact on features High level strategy	n/a too high level	No	No
Rural Development Program for England 2007-13 Defra 2007	n/a	RDP		Development Plan	Plan complete	Overarching document for development.	Not specific location but includes SAC	Potential in-direct impact on features	n/a too high level	No	No
MARINE WORKS AND LICENCES											
Aggregate extraction licence area 472 in the Bristol Channel	Hanson Aggregates Cemex UK Marine Ltd Tarmac Marine Ltd	Marine Management Organisation		Aggregate Extraction. Marine licence	Complete	35km West of Site Offshore. Covers 3.8km2	approx 30km west Offshore	Turbidity, suspended sediment and siltation	Yes. But considered insignificant	Yes	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Development of a container terminal at Bristol Port, Avonmouth (the Bristol Deep Sea Container Terminal – BDSCT	Bristol Port Company	Department of Transport		Various	Complete Expected to be operational 15/16	ST4379678456 Dredge area 45km north east, within Severn Estuary	Dredging will go to within 30km of site within SAC Loss of 13.5ha of SAC	Toxic Contamination (potential increase of 20cm in Bridgwater bay over 3 years) Disturbance Habitat Loss/Physical) 13.5ha of SAC intertidal habitat) Siltation/turbidity	Yes Temporary	IROPI case: Compensation, mitigation and monitoring agreement in place.	Yes
Shipping – Marine commercial vessels	Bridgwater Port	Sedgemoor District Council Harbour Authority	n/a	Not permitted	Not permitted	Bridgewater Bay and River Parrett – adjacent to site	Activity is within SAC area	Disturbance Toxic Contaminants in emergency spills. This will be covered through “oil pollution preparedness and response plans” Physical damage	It is felt that it is unreasonable to asses pollution or extreme incidents in combination. Disturbance is considered minor and so not included. Physical damage to habitats from erosion is considered.	No	Yes
Recreation	n/a	n/a	n/a	Not permitted. Activities around the Hinkley Point and Bridgwater Bay area include; bird watching, sea angling, walking along trails (including the Parrett trail) and some boating activities off Burnham-on-sea.	n/a	Adjacent	Adjacent	Disturbance Physical damage to habitat	Considered minimal and therefore will not be considered further in combination		
FISHING											
Natural England "excepted area" for fishing in front of the power station	Individual	Natural England		Fishing Licence	Complete	ST21044592 Adjacent to HPC	Within Estuary SAC	Disturbance	Potential permanent	No but considered of no significant effect due to minimal activity	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Natural England "mud horse" fishing Licences at Stolford	Individual	Natural England		Fishing Licence	Complete	ST21044592 Adjacent to HPC	Within Estuary SAC	Disturbance	Potential permanent	No but considered of no significant effect due to minimal activity	No
Bait Digging	n/a	n/a	n/a	Not permitted	n/a	Bait digging is carried out in Bridgwater Bay along the Stert flats at Burnham-on-Sea, but it is restricted to personal use only.	Within the SAC	Disturbance	Potential but limited and no commercial activity so will not be considered further	No	No
RENEWABLES											
Proposed wind farm at Withy End, Puriton, Somerset	EDF renewables	Sedgemoor District Council		Planning. . 5 Turbine wind farm	Applied	13km east of Hinkley site 6km east of Combwich	Inland >5km from Severn Estuary designated site	Disturbance	Potential Permanent	In development	No
Severn Tidal Range power schemes, Severn Estuary	Severn Tidal Power Group	IPC		Various: tidal generators, tidal lagoons and barrages proposed.	In development	Tbc	Would sit within site	Disturbance	Potential Permanent	In development. Latest government announcement is "it is not expected that a review would take place before 2015" so this has not been taken further.	No
Proposed Black Ditch Wind Farm (Ecotricity) at East Huntspill	Ecotricity	Sedgemoor District Council		Planning 4 turbines capacity 9.2MW	Applied 2010	12km east of Hinkley site 5km east of Combwich	Inland >2km from Severn Estuary designated site	Disturbance	Potential Permanent	In development	No
MAINLY LAND BASED PROPOSALS											
Compensation habitat creation at Steart for the Bristol Deep Sea Container Terminal	Bristol Port Company	Sedgemoor District Council		In development. Planning permission not granted at 19th March 2012	Applied	ST2852146545 7km East of Hinkley Site	Part within and part adjoining	Nutrients Toxic Contamination Siltation/Turbidity Disturbance	Yes	Complete but not approved	Yes
Decommissioning of the existing nuclear power station at Oldbury, G'shire	Magnox Limited	IPC		Development Control Order + various others	complete - operation extended to mid 2012	ST60699438 60km North of site	Directly adjacent	Decommissioning would be largely linked to footprint of site and therefore distance between sites indicates no potential for in combination effects.	No	Assessed in RoC with conclusion of no adverse effect.	No

PPP	Applicant	Comp. authority	Permit No	Consent type	Status (e.g. applied for/complete)	NGR - emission or activity Location relative to Hinkley	Location relative to SAC	Mechanism for in combination effect?	Pathway for in combination effect? Duration of effect	HRA info available i.e. has an HRA been done for this consent	Assess In-combination
Aberthaw power station abstraction	RWEN power	EA Wales	AP3437FF (Old No RP3133LD)	Environmental Permit: Average abstraction of 3,110,000 m^3 (~36 m^3/sec),	Consented	ST0220366315	20km West	Thermal Entrainment and impingement	Yes in terms of potential for impact on estuaries and fish entrainment and impingement with other power stations	Yes	Yes
Uskmouth Power Station	Uskmouth Power Co Ltd	EA Wales	LP3131SW	Development Control Order and various permits. Abstraction from Welsh Water sewage treatment works and discharge of process effluent. Flow limit of 19872m3/day. Tested for zinc, ph, max 30C. lead, zinc, chromium, cadmium, mercury, copper, nickel	Consented	ST 32508370 40km North of Site	Directly adjacent	Thermal Toxic Contamination	No	Appendix 12 completed. Conclusion of no adverse effect	Yes
Severn Power Station	Siemens	EA Wales	DP3938FS	Discharge. Process effluent from the water demineralisation and condensate polishing plants. Tested for Ph and ammonia prior to discharge but does not have a flow limit	Consented	ST 32508370 40km North of Site	Directly adjacent	Thermal Toxic Contamination	Not considered significant enough to act in combination with other permissions, plans and projects.	Appendix 12 completed. Conclusion of no adverse effect	No
Development of a new nuclear power station at Oldbury, G'shire	Horizon Nuclear power ltd	IPC		Development Control Order + various others. Main potential for effect will be abstraction	in development	ST6091195389 60km North of Hinkley Point C site	Directly adjacent	Impingement and Entrainment	Potential	Will be conducted as part of development	Yes

Table 6.2 S2 – Types of permission relating to PPPs included in the assessment

Plan, project or permission (PPP)	Type of PPP	Permission	Reference
Hinkley Point A (Discharge)	On-going permission	Environmental permit issued	102980
Hinkley Point A & B (Discharge)	On-going permission	Environmental permit issued	70408
Hinkley Point A & B (Discharge)	On-going permission	Environmental permit issued	102737
Hinkley Point B (Discharge)	On-going permission	Environmental permit issued	102738
Hinkley Point B (Abstraction)	Not permitted as an abstraction but linked to permit below (Hinkley Point B Discharge)	n/a	101266
Hinkley Point B (Discharge)	On-going permission	Environmental permit issued	101266
Hinkley Point A nuclear power station de-commissioning (Various PPC & RSR)	Future de-commissioning	Future environmental permits de-commissioning	Various
Oldbury Power Station Tidal Lagoon (Abstraction)	On-going permission	Environmental Permit	18/54/020/5/234
Bridgwater – Seabank 440kV electricity transmission line upgrade	Project	Development consent	n/a
Steart coastal management project (EA)	Ongoing project	Flood Risk Management	n/a
Development of container terminal at Bristol Port. Avonmouth (Bristol deep sea container terminal – BDSCT.	Project	Development	n/a
Compensation habitat creation at Steart for the BDSCT	Project	Compensation for development	n/a
Aberthaw power station abstraction	On-going permission	Environmental permit (abstraction)	AP3437FF (Old No RP3133LD)
Development of a new nuclear power station at Oldbury. Gloucestershire	Project	Various permits	Various
Uskmouth Power Station	On-going permission	Environmental Permit	LP3131SW
Temporary Jetty	Applied for	Harbour Empowerment Order	n/a
Combwich development (laydown facility)	Applied for	Development Consent Order	n/a
Shipping – Marine commercial vessels	Not permitted	n/a	n/a

The resultant PPP included in this permission

Table 6.2 S2 shows the PPPs that have remained within this in combination assessment, based on the criteria in section 6.2.

All the details described below have been considered within the in-combination assessments for the relevant features of the site. These paragraphs aim to give an overview summary of the plans, permissions or projects being considered, there may be more detail within each of the more detailed assessment sections.

HPB current abstraction and de-commissioning
Due to operate until at least 2016 and may be extended a further 5 years to 2021. Current abstraction point uses a maximum of 3040000m^3/d of cooling water. This would mean an overlap of approximately 2 year between Hinkley B and Hinkley C on the basis that HPC is proposed to operate from 2014. Key hazards would be thermal plumes and toxic contamination in the discharge waters. The combined effect on abstraction of cooling waters for both plants may also present a potential impact on fish (entrainment and impingement).

HPA decommissioning
Ceased generation in 2000, and is currently being de-fuelled and decommissioned. Main feature of relevance is the installation of a new active effluent discharge pipeline.

Jetty

Proposed start date: mid 2012 dependent on the development consent order (DCO) and flood defence consent. Dredging expected to happen approximately 12 months from start of construction and take 1 month.

Proposed end date: mid/late 2013 for construction. Jetty indicated to be operational for approximately 7.5 years, then dismantled over a period of approximately 12 months.

As part of the development at HPC a jetty is to be built to allow for delivery of aggregate material. The jetty will be a 490m long by 11.5m wide, extending into Bridgwater Bay. There will be a berthing pocket at the head of the jetty to allow lay down of vessels at all tidal ranges. The total area of disturbance will be 160m long, 27m wide and 3m deep, around 1.2ha and dredged materials of around 38,000 tonnes. The intention is to dispose of sediments within the estuary system if not contaminated and if assessment deems that the disposal would not effect any designated habitats or features. If this is not possible then material will be transported to an offshore disposal site (tbc)

Around 16-18 vessels a month are anticipated to be using the facility at peak demand.

Sea Wall Construction

Proposed start date: Early 2013 (once DCO has been granted, conditions agreed and preparation works are complete). At time of writing full details of construction and method/design have not been received.

Proposed end date: Early 2014 – construction expected to take one year.

The new sea wall will be a continuation of the existing wall and will be 760m in length and will have a crest height of 13.55mAOD. This height has been calculated to protect the site during a 1 in 10,000 extreme event. It's design life is 100 years to allow for 60 years of power station operation and 40 years of subsequent decommissioning.

At either end of the new defence the seawall will turn through 90degrees inland for 50m. This is to prevent outflanking of the main seawall by coastal erosion with the length having been calculated using an assumed rate of erosion of up to 0.5m/yr over the 100yr design life of the seawall. The return walls will also retain the land which will be levelled at 14mAOD for the power station development site. The depth of excavation of the sea wall has been determined on an estimation that the foreshore may lower due to erosion by 1.5m over its 100 year design life.

There is a 30m construction zone for the seawall, it is not anticipated that there will be any additional access routes across the rocky shore.

Minimal water discharge expected as a result of the construction of the sea wall which would be diluted with the tide. The water arising would be groundwater close to the surface which would flow when the hole for the base of the wall was being dug. This would be a shallow excavation as the sea wall proposed does not have a deep foundation.

Combwich Development (laydown facility)
Proposed start date: 2013
Proposed end date: 12 months from start date

The lay down facility is being built to service abnormal indivisible loads arriving during construction. These loads are too big to be transported directly to the site and so are being brought to the lay down facility. The creation of the laydown facility was not considered in the alone assessment as the facility does not require Environment Agency permit.

This part of the development at Combwich will use 6 large fields which in itself will not cause a loss of habitat to the designated site but will cause the loss the fields that will have been used for roosting adjacent to the SPA. There will also be some disturbance.

The laydown facility is anticipated to take 12 months to construct and commence when the DCO has been granted.

New Nuclear build at Oldbury, Gloucestershire
Proposed start date: 2023-25 for commissioning and operation
Proposed end date: undefined

The draft National Policy Statement for Nuclear Energy identifies a site immediately North East of the existing Oldbury nuclear power station as a potential site for development of a new nuclear power station. The site is being progressed by Horizon Nuclear Power Ltd and covers an area of approximately 150ha at NGR ST6091195389 which is 60km North of Hinkley Point C site. Relevant to this assessment will be a new cooling water abstraction, and although cooling will be aided by four cooling towers, there will be a potential for combined effects though entrainment and impingement.

Work is anticipated to start on the construction phase in 2016 and would therefore overlap with the construction work for Hinkley Point C.

Oldbury Nuclear Power Station (Oldbury A)
Oldbury Nuclear Power Station is an existing power station located in the upper parts of the Severn Estuary in South Gloucestershire at ST6041594631. The plant ceased operating on the 29th of February 2012, and although the amount of water abstracted has significantly reduced, a licence for abstraction will remain until around 2026, so there will be a potential for combined effects though entrainment and impingement.

Uskmouth Power Station
Uskmouth is an existing power station on the edge of the Severn Estuary approximately 40km north of the proposed HPA on the opposite bank of the Severn estuary at NGR ST 32508370. The site abstracts water from an adjacent welsh water sewage treatment works and has a discharge of process effluent. Flow limit of 19872m^3/day and is tested for zinc, pH, max 30^{0}C, lead, zinc, chromium, cadmium, mercury, copper and nickel.

Aberthaw Power Station.
Aberthaw is an existing (coal-fired) power station located to the west of Cardiff, in the Vale of Glamorgan on the north bank of the Bristol Channel at NGR ST0220366315. Aberthaw abstracts water from an adjacent stream for various operations including condenser cooling, and like HPB, does not have an abstraction licence to abstract water from the Bristol Channel.

The average volume of water abstracted per day is 3,110,000 m^3 (~36 m^3/sec), with the maximum volume being 4,320,000 m^3 (~50 m^3/sec), which is a larger amount than the current HPB. The water is abstracted approximately 650 m off-shore via a tunnel, and the large abstraction head has bars across to prevent debris entering the tunnel. There is no fish deterrent system at this site.

Bridgewater – Construction of National Grid station (Seabank 400kV Transmission Infrastructure Connection)
Proposed start date: 2014
Proposed end date: 2017

The proposed HPC would be connected to the national high voltage electricity transmission via new lines. A number of corridors were identified in 2011, and the National Grid intend to apply for development consent in 2013.

Four overhead gantries will be situated on the south side of the main HPC compound with a further two overhead gantries to the east of the compound forming the overhead line to the HPB substation. The six overhead line gantries connect to the national grid system via overhead lines, to three terminal towers situated outside the substation compound to the South and East.

Bristol Deep Sea Container Terminal (Dredging)
Proposed start date: not defined

Proposed end date: Approx 6.5 years made up of 3 phases:
Phase 1, 6 months
Phase 2, 39 months
Phase 3, 39 months
Maintenance: Continual

This is a proposal for a deep sea container terminal 45km north of the proposed development of HPC The activity most relevant to this in combination assessment with Environment Agency consents is the dredging proposal.

The Bridgwater proposal also involves dredging to deepen and widen an approach channel – the footprint of this dredged area would extend from Avonmouth in the east approximately 20km to the west.

The western limit of the dredged channel is approximately 30km N of the proposed HPC. The capital dredging would release approximately 10.5 million tonnes of fine sediment the estuary; require deposition of approximately 16.9 million tonnes of mudstone to the deepwater disposal site at Holm Deep and release approximately 2.05 million tonnes of sand sized mudstone to the estuary.

Maintenance dredging would require removal of muddy and sandy sediments that accumulate in the turning area and berths. Muddy sediments would be deposited locally and sediments deposited at the new deepwater disposal site at Holm Deep.

In total, the Bridgewater proposal has the potential for an increase of 20cm of silt in Bridgwater Bay over 3 years.

Bridgwater Port - Commercial shipping
Sedgemoor District Council is the Competent Harbour Authority for Bridgwater Port, which currently regulates commercial shipping vessels from the Bristol Channel and Severn Estuary to and from Dunball Wharf on the River Parrett. The Harbour master of Bridgwater Port has powers to regulate vessel movements and exercises these powers in accordance with the port's Marine Operations Plan.

The movement of vessels to and from the wharf during the construction and operation stages has the potential to cumulatively impact with the current shipping already taking place along the River Parrett, which could lead to erosion of fringing areas of saltmarsh due to excessive wash and large currents.

Environment Agency Steart Coastal Management Project
Proposed start date: mid 2012
Proposed end date: 2014 for physical works

The Environment Agency is developing a coastal re-alignment project at the Steart peninsula, 7km east of the proposed HPC at ST2722544528 . It is flanked to the west by Bridgwater Bay and to the east by the River Parrett Estuary. The project aims to manage flood risk and provide compensatory habitat in the form of wetland/intertidal habitat.

The preferred option is to undertake breaches to existing defences along the River Parrett and it is hoped that the breach would take place in mid 2013. It is anticipated that there will be an increase in tidal volume (prism), localised alteration of tidal flows in and around the breach site and small changes in sediment deposition in and adjacent to the re-alignment site. The breach will be approximately 200m wide with an inundation area of approximately 250ha.

The works will release some sediments into the estuary and may cause some disturbance during the period when plant will be on site carrying out the works.

Bristol Port compensatory habitat at Steart
Proposed start date: not yet defined
Proposed end date: not yet defined

Bristol Port Company will be creating compensatory habitat on the Steart peninsula as a result of its consented port expansion at Avonmouth. The area comprises approximately 150ha of land to the NW end of the peninsula at NGR ST2852146545 that would be breached through the existing defences of the Severn estuary.

Excavation works to lower the height of some areas and allow flow of a creek network would release sediments to the estuary during construction works and may create disturbance on site. Planning has not yet been granted and no date is yet proposed for the start of the works.

6.3 Overview by type of effect

The Environmental Permits for the proposed HPC if issued, will regulate emissions to air and water, as well as vibration and noise. Emissions to air have already been assessed as having no likely significant effect in the Appendix 11 document EPR-ZP3238FH-A001 dated 29/11/11. Although within this document there was an indication that the NO_2 short term Air Quality Standards may be exceeded in some areas close to the site the nitrogen deposition at the closest habitat that is sensitive to eutrophication will be at a level that enables the Environment Agency to conclude no likely significant effect.

Noise and vibration will be associated with construction and operation of the HPC itself and there will be emissions of noise and vibration directly to the Severn Estuary SAC and SPA as a result of the construction of the site and local associated developments such as the jetty. Boat traffic will increase as a result of the development of the jetty for construction deliveries and the Combwich Wharf development. This increase in boat traffic has been included within this assessment.

Fig 6.3 S1 – Other plans permissions and projects in relation to the proposed HPC nuclear power station.

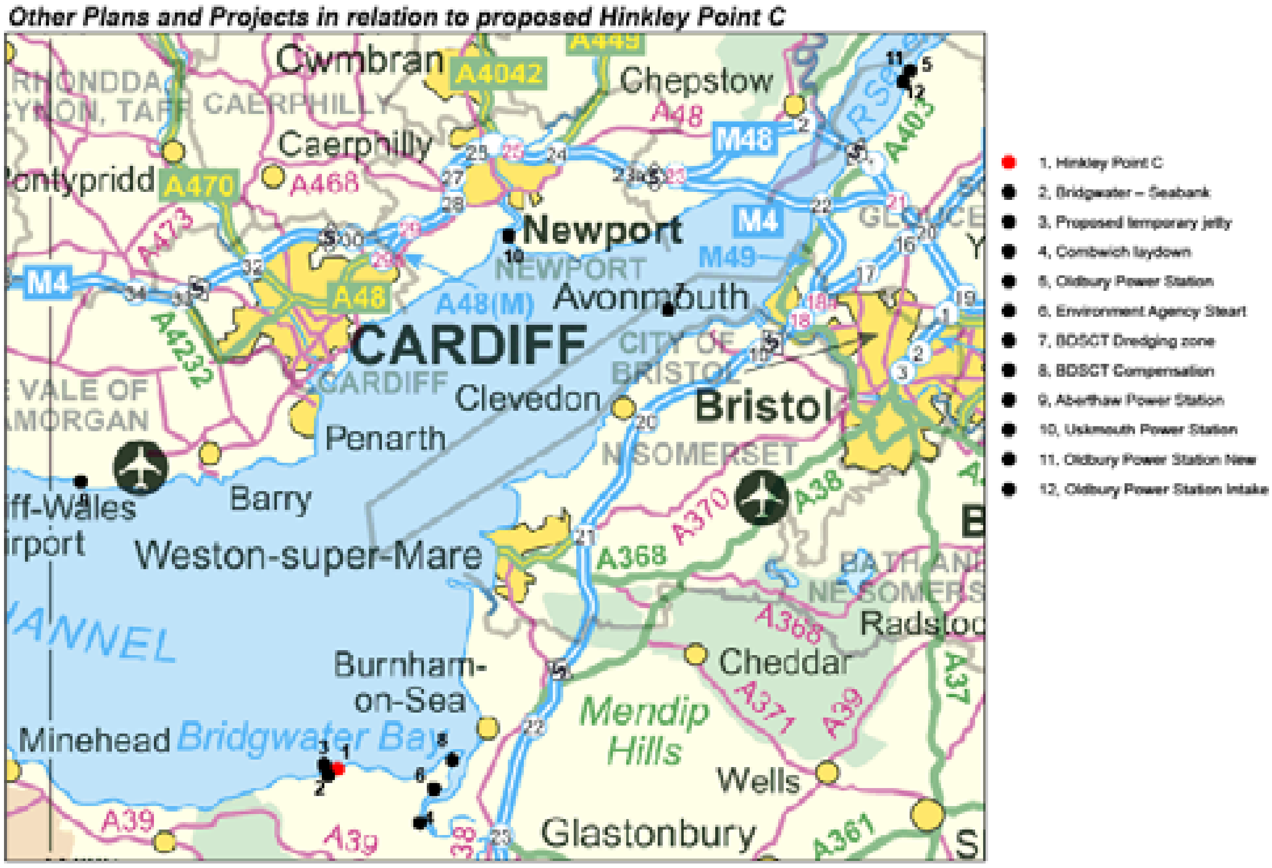


Table 6.3 S2 – Hazards associated with PPPs included in the in combination assessment

Plan, project or permission (PPP)	Toxic contamination	Changes to thermal regime	Nutrient enrichment*	Habitat loss or physical damage to interest features	Siltation and turbidity	Entrainment and Impingement	Disturbance (visual, noise, vibration)
Hinkley Point A (Discharge)	✓						
Hinkley Point A & B (Discharge) 70408	✓						
Hinkley Point A & B (Discharge) 102737	✓						
Hinkley Point B (Discharge) 102738	✓						
Hinkley Point B (Discharge) 101266	✓	✓					
Hinkley Point A nuclear power station de-commissioning (Various PPC & RSR)	✓						
Hinkley B Abstraction						✓	
Hinkley C Abstraction						✓	
Hinkley Point B de-commissioning (Various PPC & RSR)							
Oldbury Power Station Tidal Lagoon (Abstraction)						✓	
Steart coastal management project (EA)	✓		✓		✓		✓
Development of container terminal at Bristol Port. Avonmouth (Bristol deep sea container terminal – BDSCT.	✓		✓	✓	✓		✓
Compensation habitat creation at Steart for the BDSCT	✓		✓		✓		✓
Decommissioning of the existing nuclear power station at Oldbury, Gloucestershire						✓	
Aberthaw power station abstraction		✓				✓	
Development of a new nuclear power station at Oldbury. Gloucestershire						✓	
Bridgwater – Seabank 440kV electricity transmission line upgrade							✓
Uskmouth Power Station		✓				✓	
Temporary Jetty	✓			✓	✓		✓
Combwich development (laydown facility)							✓
Shipping – Marine Commercial Vessels				✓			

6.4. Relative timeline for Permissions, plans and projects directly associated with the HPC nuclear power station.

The relative timelines for the PPP within the overall development of the HPC nuclear power station and the potential in-combination impacts are shown relevant sections.

6.5 Estuaries (including rocky shore)

6.5.1 Activities resulting in a potential impact on the Estuaries feature (including Rocky Shore)

	Construction activities											Operational activities														
Potential sources of hazard	**EA consents**				**Existing plans and other plans & projects**							**EA Consents**														
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Jetty construction	Construction of cooling water infrastructure	Nuclear island construction	Bristol deep sea container terminal	EA Steart development	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge	Jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning
Toxic contamination	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	✓	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thermal impact	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Salinity	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Turbidity, suspended sediment & siltation	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	✓	×	×	✓	✓	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	×
Competition with non-native species	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	✓	×	×	×	×	×

Note: permissions relating to HPC development assessed within the alone section of this document are highlighted in green

6.5.2 Toxic contamination (changes to water chemistry)

Conservation objectives:

- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *Toxic contaminants in water column and sediment are below levels, which would pose a risk to the ecological objectives.*

Natural England & Countryside Council for Wales, 2009[540]

Environment Agency permissions, plans or projects that could have an impact on the Estuaries feature in terms of toxic contamination include the following:

- Water discharges during construction of HPC site
- Sea wall construction FDC
- Combwich Wharf development FDC
- Discharges during cold commissioning of HPC
- HPC cooling water discharge

Which could act in combination with toxic contamination from the following other permissions, plans or projects:

- Jetty construction
- Construction of cooling water infrastructure
- Bristol deep sea container terminal
- EA Steart development
- Bristol Ports compensatory habitat at Steart
- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Relevant Proposed Plans and Projects and Existing Permits

It is considered that the present loadings of toxic contaminants to the Severn Estuary SAC are not having a significant effect on site integrity and constitute the background for the present 'in combination' assessment.In terms of background levels . This is based on an 'in combination' assessment of the impact of toxic contamination from all permitted activities and proposed plans or projects, as known in 2008, which was undertaken in the Habitats Directive Review of Consents (RoC) (EA 2009, 2010)[541] [542]. The permits for 2 discharges were reviewed as a result of the RoC process, in relation to their potential input of toxic contaminants, and these reviews have been completed. All other permitted discharges were considered to have no adverse effect on site integrity either alone or in combination. Several discharges containing toxic contaminants have subsequently ceased since the RoC (see Alone Assessment), so that the overall loadings of toxic contaminants to the Severn Estuary SAC have decreased

[540]Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[541] Environment Agency. Severn Estuary SAC and SPA Habitats Directive Review of Consents. Stage 3. November 2009.

[542] Environment Agency. Severn Estuary SAC and SPA Habitats Directive Review of Consents. Stage 4. January 2010.

In terms of contaminant data to feed into this assessment there are a variety of sources for the bed sediments in the Severn Estuary in general and also for the specific areas of those proposed plans and projects where disturbance of bed sediments is expected to occur. The metal data on bed sediments for sites related to the HPC and also sites related to the Bristol Deep Sea Container Terminal have been compared with the levels on suspended sediments from various sites sampled by the EA in 2004 and 2005 (Jonas et al 2006)[543]. These figures are displayed in table 6.5.2 S1 The metal levels on the suspended sediments have been based on the difference between the total metals and dissolved metals, with the resulting levels on the particulates being related to the suspended sediment concentrations, using the following equation: Suspended sediment metal concentration (mg/kg) = (Total metal concentration (µg/l) – Dissolved metal concentration (µg/l)) / (Suspended sediment concentration (mg/l) x 10^{-3})

Where the dissolved metal concentrations were below the level of detection, half the value was used. For some metals it was not possible to determine the suspended sediment metal concentration as the total metal concentration was below the level of detection.

The data in table 6.5.2 S1 indicate that metal levels are relatively similar throughout the Severn Estuary system, and that the metal levels on bed sediments also reflect the metal levels on suspended sediments.

There have been 2 recent assessments of the differences between metal concentrations on bed sediments and the suspended sediments in the Severn Estuary (Duquesne et al 2006[544], and Langston and Millward 2008[545]). Both assessments concluded that there was no strong evidence of significant differences of metal concentrations in the sediments and suspended sediments, and the metal concentrations on the suspended sediments showed a remarkable consistency, as a consequence of the estuarine dynamics. Sediment concentrations of PAHs are also relatively homogeneous throughout much of the Severn Estuary system, presumably as a result of the estuarine dynamics (Langston and Millward 2008).

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543 Jonas P.J.C., Hudson R., Simpson M., and Waite M. 2006. Phase 2 Severn Estuary Water Quality Investigations. EA Internal Report. Final Draft. 40 pp.

544 Duquesne, S., Newton, L.C., Guisti, L., Marriott, S.B., Stärk, H-J. and Bird, D.J. 2006. Evidence for declining levels of heavy-metals in the Severn Estuary and Bristol Channel, U.K. and their spatial distribution in sediments. *Environmental Pollution* 143: 187-196.

545 Langston W.J. and Millward G. 2008. A review of contaminant levels in the Severn Estuary SAC, SPA. A report for the Environment Agency.by the Plymouth Marine Science Partnership. 95 pp.

Table 6.5.2 S1

Contaminant Levels on Sea Bed Sediments mg/kg

HPC Sites		**Mercury**	**Cadmium**	**Lead**	**Copper**	**Zinc**	**Chromium**	**Nickel**	**Arsenic**
Offshore Core Data for HPC	Measured Maxima	0.67	1.5	141	51	307	67	59	30
Combwich Vibrocore Samples (near surface layer)	Measured Maxima	0.29	0.18	64	18	120	32	24	15
Combwich Grab Samples	Measured Maxima	0.3	0.3	78	26	148	31	25	29
Bristol Deep Sea Container Terminal Sites									
Sediment data for south deep water channel	Mean	nd	0.08	13.5	3.4	41.5	6.4	9.1	10.1
	Max	0.59	0.11	21.2	7.1	67.8	25.8	21.1	14.0
Sediment data for north deep water channel	Mean	nd	0.31	26	11.6	71.1	11.6	9.6	13.5
	Max	3.56	0.93	63.1	46.2	156	16.9	18.3	14.2
Sediment data for turning area	Mean	0.27	0.51	53.8	21.5	162.3	24.1	23.1	17.9
	Max	0.76	1.53	101.7	38.8	289	39.7	33.6	11.4
Intertidal Sediments at Steart related to Bristol Port Compensation Scheme	Mean	0.2	0.2	43.7	19.5	134.8	22.5	21.9	14.1
	Max	0.3	0.3	56	26	180	30	28	16
Terrestrial surface soils at Steart related to Bristol Port Compensation Scheme	Mean	<1	<1	27.07	14.14	103.86	42.21	34.21	12.86

Suspended Sediment Levels mg/kg

		Mercury	Cadmium	Lead	Copper	Zinc	Chromium	Nickel	Arsenic
EA Sites in Bridgwater Bay	Average	0.41	nd	61.28	21.04	217.54	36.85	22.62	13.84
	Median	0.22	nd	60.86	17.17	214.64	35.61	19.81	13.83
	95%ile	1.47	nd	87.01	34.34	292.05	53.79	26.21	22.27
	Maximum	5.21	nd	113.37	157.22	329.34	115.85	133.72	28.94
EA Sites between Sand Bay and Portishead Point	Average	0.30	0.31	60.90	19.08	205.65	33.11	21.42	11.53
	Median	0.21	0.29	58.42	16.23	204.28	32.96	18.94	11.42
	95%ile	0.49	0.56	92.36	44.66	295.49	45.31	40.89	19.94
	Maximum	4.10	0.68	142.96	97.03	465.67	67.28	68.98	57.52

(Note: "nd" indicates no data due to number of samples below the level of detection)

The information above has informed the next stage of the assessment where each of the proposed plans and projects and existing permits as shown in Table 6.2 S1 is assessed in the Table 6.5.2 S2 in terms of its significance alone in relation to the specific hazard 'toxic contamination (changes to water chemistry)'.

Table 6.5.2 S2

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Jetty Construction and operation (maintenance dredging)	The pathway for toxic contamination from the jetty construction is through the release of contaminants associated with bed sediments put into the water column during dredging and piling operations.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The dredging operations are an initial dredge of some 25,140 m^3 from the berthing pocket followed by an unknown amount of maintenance dredging. Some local increase in the suspended sediment levels is expected during dredging operations, which is assumed to be 500 mg/l (see Table 6.4 Section 6.2.221 p 208 of EDF Report (Haskoning 2011[546]). The levels of contaminants on the bed sediments are similar to those on the suspended sediments which are found at present, so that no significant impact is considered likely (see Table 6.5.2 S1). The sediments which will need to be removed during maintenance dredging will have the same contaminant levels as those in suspension at present, so that no significant impact is considered likely. There will be a small localised increase in the suspended sediments due to piling in the sub-tidal sediments. However, the levels of contaminants on the bed sediments are similar to those on the suspended sediments which are found at present, so that no significant impact is considered likely. There may be some temporary localised oxygen demand in the water column due to the increase in suspended sediments related to the initial dredge, maintenance dredging, and piling activities, but this is not considered to be significant in relation to any of the activities.	About 15 months during the construction phase of HPC. Indicated to be from mid 2012 to mid 2013. Dredging activities are expected to occur over a period of one month, after about 12 months from the start of construction. The jetty is indicated to be operational for about 90 months (7½ years), and then dismantled and removed over a period of 12 months.	The impact on the toxic contaminant levels in the water column from the construction activities is considered to be negligible, given the similarity in the contaminant levels on the bed sediments with those on the suspended sediments, and the existing sediment cycling which occurs over the spring-neap tidal cycle and over the year.
Sea wall construction	The pathway for toxic contamination from the sea wall construction is through the discharges to the foreshore occurring during the construction operations.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	There will be an unknown volume of water discharged to the foreshore during the construction of the sea wall. This water may contain very low levels of contaminants which can be related either to groundwater or to sediments within the water discharge. The levels of contaminants related to the groundwater or to the sediments arising from the construction are not expected to be any different from those which already occur in the groundwater of the cliff strata or the sediments forming the cliffs.	About 12 months during the construction phase of HPC. Indicated to be from early 2013 to early 2014. The sea wall will then be in place for at least 720 months (60 years).	The impact on toxic contaminant levels is considered to be negligible, as any discharge is considered to arise primarily from water sources which already enter the nearshore waters. There is therefore no additional input to the SAC.
Construction Discharges to Foreshore	The pathway for toxic contamination is through the discharge of surface water, pumped groundwater, and concrete plant washdown water to the foreshore initially through the existing drainage ditch and subsequently the new outfall structure in the cliff.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The levels of contaminants in these discharges have been assessed as low risk. There will also be treatment of the operational discharges for hydrocarbons and suspended solids, as well as pH balancing, which will reduce the levels of any toxic contaminants reaching the Severn Estuary. No contaminants are expected to be above EQS or the PNEC in the discharges. However, if they were, there could be a very small mixing zone related to the discharges across the foreshore, as the discharges are to the intertidal zone. However, this mixing zone will be very small, being estimated to be at most about 100 m^2. This is insignificant in relation to the Estuaries feature (about 0.00001%). In the nearshore waters the discharge will be dispersed rapidly by the tidal currents, so that the only mixing zone will relate to the intetidal zone. It is assumed that once the cooling water system is constructed and operational, any discharges arising from the construction of the second EPR unit will be discharged through the cooling water outfall and not across the foreshore. There will then be no potential	About 60 months. Indicated to be from mid to late 2012 to mid 2017 when the cooling water infrastructure is indicated to be complete.	While there may be a likely significant effect from the construction discharges to the foreshore because they are intertidal, the extent of any mixing zone will be negligible.

546 Haskoning 2011.Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA). Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. 1056 pp.

			mixing zone.		
Construction of cooling water infrastructure including water discharge from tunnel construction	The pathway for toxic contamination is through the discharge of groundwater and other water generated from the tunnelling activities to the foreshore through the new outfall structure in the cliff.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The method of drilling the intake tunnels and the outfall tunnel has yet to be decided. However, whatever method is chosen, the discharge will require some treatment prior tp discharge. The levels of any contaminants are expected to be similar, and certainly no worse, than those in the construction discharges to the foreshore. There may therefore also be a very small mixing zone related to the discharges across the foreshore, as the discharges are to the intertidal zone. However, this mixing zone will be very small, being estimated to be at most about 100 m^2. This is insignificant in relation to the Estuaries feature (about 0.00001%). In the nearshore waters the discharge will be dispersed rapidly by the tidal currents, so that the only mixing zone will relate to the intetidal zone. There will also be drilling operations offshore at the intake and outfall structures to provide vertical shafts to the intake and outfall tunnels. These operations could disturb bed sediments, and there will be water discharges related to the drilling. However, these discharges will be controlled as far as possible. In addition, any discharge from the drilling will be rapidly dispersed by the strong tidal currents offshore, so that the extent of any impact will be negligible. The contaminant levels on the bed sediments are similar to the present levels on suspended sediments (see Table 6.5.2 S1), so that it is considered that any impact due to disturbance of the bed sediments during construction or from scouring due to the intake and outfall structures will be negligible.	About 54 months to complete the construction. Indicated to be from early 2013 to mid 2017. The drilling of the vertical shafts offshore and the emplacement of the intakes and outfall structures is expected to be towards the end of the construction period. Operational phase for the tunnels and infrastructure is about 720 months (60 years), commencing in mid 2017.	While there may be a likely significant effect from the construction discharges to the foreshore because they are intertidal, the extent of any mixing zone will be negligible. The impact of offshore construction activities on the levels of toxic contaminants in the water column is considered to be negligible, given the similarity in the contaminant levels on the bed sediments with those on the suspended sediments, and the existing sediment cycling which occurs over the spring-neap tidal cycle and over the year.
Combwich Development associated with HPC	The pathway for toxic contamination is through the release of contaminants associated with bed sediments put into the water column during piling operations and construction work for a new barge bed and Goods Wharf. Contaminants may be released during the operational use of the berthing platform, either due to vessels using the platform, or through maintenance dredging to clear the platform of sediments. In addition there may some scouring of the intertidal and bed sediments due to the presence of the new structures.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	There will be some minimal temporary disturbance of bed sediments during the removal of existing infrastructure and piling and in-filling operations. The sediments disturbed are mostly similar to those in other parts of the Parrett estuary and Severn Estuary (see Table 6.5.2 S1), although the levels of PAHs are slightly elevated off the existing wharf (BEEMS Report TR127[547]). Sediments will only be removed from the existing berthing mattress to land, and no dredging is expected to occur in the Parrett Estuary. Any sediments which are disturbed during the operation of the Goods Wharf will be essentially the same as those in the Parrett Estuary and Severn Estuary, so that no significant impact is considered likely. Any increase in suspended sediments during the construction of the new structures, or from subsequent scouring, will be very localised, so that given the nature of the bed sediments compared with the existing suspended sediments any impact on toxic contaminant levels will be negligible.	About 12 months construction. Indicated to be during 2013. Operational phase is about 720 months (60 years), commencing at the start of 2014.	The impact of construction activities at Combwich on the levels of toxic contaminants in the water column is considered to be negligible, given the similarity in the contaminant levels on the bed sediments with those on the suspended sediments, and the existing sediment cycling which occurs over the spring-neap tidal cycle and over the year..
HPC Cold commissioning discharges	The pathway for toxic contamination is through the discharge of water containing conditioning chemicals to the	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities	The concentrations of the toxic contaminants in the cold commissioning discharges will be above relevant EQSs or PNECs. It has been stated in the ES and the Report to inform the HRA that the effluent from the cold commissioning would be treated prior to	About 24 months for each EPR unit. Indicated to be from early 2016 to mid? 2017 for the first EPR unit, and late	No mixing zones are expected to be related to the HPC cold commissioning discharges, so that there will be no measurable impact on the foreshore and

[547] BEEMS Technical Report TR127. Hinkley Point; Combwich Hydrographic Survey. Including Appendix F - Water, sediment and benthic sampling. EDF BEEMS (Cefas/Titan) 2010.

	foreshore through the new outfall structure in the cliff for the first EPR unit, and through the cooling water outfall for the second EPR unit.	either through direct toxicity or due to bioaccumulation.	discharge (see eg. Section 6.2.298, p.221 of the EDF Report(Haskoning 2011[548])). On this basis, there will be no mixing zones related to the discharge for any of the toxic contaminants, which are ammonia, iron, hydrazine, and ethanolamine. Any potential impact will therefore be due to the additional loading from the discharge relative to existing loadings to the Severn Estuary SAC. Hydrazine and ethanolamine remaining in the discharge will decompose relatively rapidly, so that their additional loading is more relevant as a nutrient input. Ammonia is similarly relevant as a nutrient input, although it may contribute to the overall levels of ammonia in the SAC. As there are no mixing zones, the scale of any impact is negligible. The maximum loading of ammonia is estimated from the given flow of 275 m^3/d and the expected maximum concentration of 3.33 mg/l to be 0.92 kg/d. The maximum loading of iron is estimated to be 8.02 kg/d, assuming that the iron and iron oxide concentration of 29.17 mg/l is as iron. The ammonia load is less than 0.01% of the total ammonia load to the Severn SAC, while the iron load is about 0.05 % of the total iron load from the Rivers entering the SAC. The contaminant loads are therefore insignificant. It should be noted here that the iron load is likely to be significantly less than the estimated load, as the concentration would be expected to be less than the expected, as a result of treatment prior to discharge.	2017 to late 2019 for the second EPR unit.	nearshore water column in relation to toxic contaminants. The load of toxic contaminants within the cold commissioning discharges are insignificant compared with the present loads of toxic contaminants, so that their impact is insignificant.
HPC Operational discharges	The pathway for toxic contamination is through the discharge of contaminants into the cooling water system, and also contaminants added directly to the cooling water.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The concentrations of the toxic contaminants in the operational discharges have been considered in the alone assessment. The levels of all contaminants except total residual oxidant (TRO) and hydrazine are below the relevant EQS or PNEC in the cooling water discharge. There are no mixing zones related to the operational discharges therefore, except for TRO and hydrazine. For other toxic contaminants, any potential impact is therefore due to the additional loadings from the discharge relative to existing loadings to the Severn Estuary SAC. The size of the mixing zones for TRO was estimated to be 63 ha at the sea bed and 157 ha at the surface. These represent 0.09 and 0.22% of the Estuaries feature. The discharge of TRO needs to be assessed for HPC because it may be used in the event of biofouling problems occurring. However, since the start of HPA in 1965, chlorination has never been used, at HPA or HPB. The mixing zones for hydrazine are similar being estimated to be 77 ha at the sea bed and 191 ha at the surface. These represent 0.11 and 0.26% of the Estuaries feature. However, the modelling of the hydrazine mixing zone does not include modelling of the short-term scenario when hydrazine concentrations are predicted to be at a maximum. As the loading of hydrazine for the short-term scenario is about 40 times that for the average scenario, it was concluded that the mixing zone for hydrazine could be considerably bigger than that estimated for the average scenario. It was therefore not possible to conclude that a discharge of hydrazine was not having an adverse effect on site integrity from the alone assessment. Mitigation of the adverse effect could be achieved through the provision of treatment of the hydrazine, and therefore a reduction of the hydrazine	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	There is a measurable mixing zone for the toxic contaminants, TRO and hydrazine, in the HPC operational discharges, so that there is a likely significant effect from the discharges. The sizes of the mixing zones are predicted to be small, being 0.22% of the Estuaries feature for TRO at the surface, and 0.26% of the Estuaries feature for hydrazine at the surface. Given the size of the mixing zone, the discharge of TRO is not considered to have an adverse effect on site integrity. However, the potential maximum impact of the discharge of hydrazine has not been modelled, so that the predicted size of mixing zone is considered to be significantly underestimated. It was therefore not possible to conclude that the discharge of hydrazine was not having an adverse effect on site integrity. Mitigation of the potential impact of hydrazine is consequently required to remove the potential adverse effect; this mitigation is likely to be treatment of the discharge. It is considered that the additional inputs of toxic contaminants to the Severn

[548] Haskoning 2011.Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA). Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. 1056 pp.

			concentration in the discharge. The annual loads of other contaminants in the operational discharges from HPC are all less than 0.1% of the total measured load to the SAC, with the exception of iron, which is 0.85% (see alone assessment). However, iron is very abundant in the Severn Estuary system, being a major component of the sediments at between 2 and 3% by weight. The additional input of iron and the other toxic contaminants from the HPC operational discharges are therefore considered to be insignificant.		Estuary from the HPC operational discharges are all insignificant, being mostly less than 0.1%, except for iron, which is 0.85%. However iron is ubiquitous and very abundant in the Severn Estuary.
HPB Operational discharges	The pathway for toxic contamination is through the discharge of contaminants into the cooling water system, and also contaminants added directly to the cooling water.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The only consented toxic contaminant in HPB operational discharges is total residual oxidant (TRO). The consented level of TRO is 0.3 mg/l, and applies to both the main cooling water discharge of 3,000,000 m^3/d and also various trade discharges and cooling water during outages with a combined dry weather flow of 40,000 m^3/d. The main cooling water flow for HPB is discharged through the intertidal culvert. The other smaller discharge is made to the upper intertidal area in front of the HPB site. As the consented levels in both discharges are above the EQS of 0.01 mg/l, there will be mixing zones related to both discharges. It should be noted that although the HPB discharges are consented for TRO, chlorination has never been used at HPB. Its use in the future is also not expected to occur, but the potential impact from a discharge needs to be assessed, because it is consented. The size of the potential mixing zone for TRO due to HPB operational discharges has been modelled using GETM. The mixing zone area at the sea bed is estimated to be 69 ha and the area at the surface to be 92 ha. These represent 0.09 and 0.13% of the Estuaries feature respectively. As there are no other consented toxic contaminants in the operational discharges for HPB, the input of toxic contaminants other than TRO from these discharges is taken to be negligible.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges..	There is a measurable mixing zone for the toxic contaminant, TRO, in the HPB operational discharges, so that there is a likely significant effect from the discharges. The predicted mixing zone for TRO from the HPB discharge is small, being 0.13% of the Estuaries feature at the surface. Hydrazine is not used at HPB, so there is no hydrazine discharge and therefore no mixing zone. The loads of other toxic contaminants from the HPB operational discharges are not measurable and are considered to be negligible, as the only consented toxic contaminant is TRO.
HPA Decommissioning discharges	The pathway for toxic contamination is through the discharge of contaminants from outfall or the HPB cooling water system	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	There are no discharges for the decommissioning of HPA which are consented for toxic contaminants, so that the input of toxic contaminants from these discharges is taken to be negligible.	Time period unknown, although decommissioning discharges of some form are likely until final site clearance in 2080 to 2090.	As there are no discharges for the decommissioning of HPA which are consented for toxic contaminants, the input of toxic contaminants from these discharges is taken to be negligible.
Bristol Deep Sea Container Terminal Development	The pathway for toxic contamination is through the release of contaminants associated with bed sediments put into the water column during dredging and disposal operations for both the capital dredge and future maintenance dredging.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The total volume of sediment and Mercia mudstone to be dredged for the capital dredge is estimated to be some 24 million m^3 (or about 46 million tonnes). The dredged area includes an area off Avonmouth and the main channel leading to Avonmouth from the Kings Roads. About 14.2 million tonnes of sand and gravel from the dredging operations will be used in the proposed reclamation at Avonmouth. Some 13.6 million tonnes of sediment are expected to be put into the water column during the dredging operations, while a further 1.37 million tonnes are predicted to be put into the water column during the disposal of 18.29 million tonnes of Mercia mudstone at the proposed Holm Deep disposal site. Future maintenance dredging is estimated to be about 5 million m^3 of muddy sediments and between 4 and 9.5 million m^3 of sands.	Based on information in the ES for the Bristol Deep Sea Container Terminal (BDSCT ES 2008[549]) (Sections 3.2.3 and 3.2.4 pp. 45 – 46), there will be about 78 to 80 months (6½ years) in total of dredging, in 3 phases. Phase 1 – 6 months .. Phase 2 – 35 months…. Phase 3 – 36 months… However, it is stated that taking account of the overlap	The impact of dredging and disposal operations on the levels of toxic contaminants in the water column is considered to be negligible, given the similarity in the contaminant levels on the bed sediments with those on the suspended sediments, and the existing sediment cycling which occurs over the spring-neap tidal cycle and over the year.

[549] Bristol Deep Sea Container Terminal. Environmental Statement. The Bristol Port Company. Final Report 9R4093. 21 July 2008. 763 pp.

			There will be increases in suspended sediments during both the capital and maintenance dredging operations. However, given that, for about half of the bed sediments during the capital dredged, and all the bed sediments for maintenance dredging, the levels of toxic contaminants on the bed sediments are similar to those on the suspended sediments which are found at present (see Table 6.5.2 S1), no significant impact is considered likely in relation to toxic contamination. With respect to the Mercia mudstone dredged during the capital dredge, it is not expected that there will be any release of toxic contaminants, although the levels of any toxic contaminants (effectively metals) within the Mercia mudstone, and their leachability, is not known. The plumes of suspended sediment generated by the capital dredging activity are predicted to extend from about Sand Point down the Severn Estuary to just north of Oldbury up the Estuary. However, the toxic contaminant levels on the suspended sediments will be similar to existing levels on the suspended sediments, because of the general homogeneity of contaminant levels in the Severn Estuary, so that the impact on levels in the water column is considered to be negligible. The impact of sediment plumes related to maintenance dredging is similarly considered to have a negligible impact on the toxic contaminant levels in the water column.	of different phases the maximum duration of the main dredging will be 39 months. Disposal of Mercia mudstone in the new disposal site in Holm Deep would occur over about 36 months (Phase 3). There is no defined start date yet for the dredging. Once the capital dredging and quay construction are completed, maintenance dredging will commence and continue indefinitely.	
EA Steart Managed Realignment	The pathway for toxic contamination is through the release of contaminants from the soils which become periodically inundated by estuarine waters following the opening of the breach in the tidal embankments, as well as through the erosion of any estuarine sediments following the breach.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The area over which the tidal inundation will occur is about 250 ha. There may be some remobilisation of toxic contaminants from the soils which will be inundated following the breach in the tidal embankment. However, the levels of contaminants in the soils are expected to be very similar to the present ambient concentrations on the surface bed sediments and suspended sediments (see Table 6.5.2 S1 above for data on adjacent managed realignment site at Steart), so that it is considered that any release of contaminants will not be significant. It is likely that some ammonia will be released from the soils following the breach, due to the breakdown of organic material in anaerobic conditions, so that outflowing water will have slightly elevated ammonia levels compared with the inflowing water (Blackwell *et al* 2004[550]). However, the time period over which the elevated ammonia levels are expected to occur is only a few months. The outflowing water will also be diluted rapidly by the water in the Parrett Estuary, so that the extent of any elevated ammonia levels will be negligible. It is not possible to predict the level of elevated ammonia which may occur, but from comparisons with other sites it is not expected to exceed about 1 mg/l (Unpublished EA data for Wadebridge site, Camel Estuary). It should be noted that the potential for leaching of toxic contaminants will also limited by deposition of sediments within the managed realignment site. Deposition is expected to be rapid, as the area will act as a sediment sink.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is about one month in mid 2013. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	The impact of the potential remobilisation of toxic contaminants from the managed realignment site, and the erosion of estuarine sediments in the region of the breach, on the levels of toxic contaminants in the water column are considered to be negligible. This is because of the similarity in the contaminant levels on the terrestrial soils and estuarine bed sediments with those on the suspended sediments, and the existing sediment cycling which occurs over the spring-neap tidal cycle and over the year.
Bristol Port Compensation Habitat Creation at	The pathway for toxic contamination is through the release of contaminants from the	Increased levels of toxic contaminants in the water column could impact on the subtidal and	The area over which the tidal inundation will occur is 140ha. There may be some remobilisation of toxic contaminants from the soils which will be inundated following the breach in the tidal	The expected date for the activities related to the breaching of the tidal	The impact of the potential remobilisation of toxic contaminants from the managed realignment site, and the erosion of

[550] Blackwell, M.S.A., Hogan, D.V., Maltby, E., 2004. The short-term impact of managed realignment on soil environmental variables and hydrology. Estuarine Coastal and Shelf Science 59, 687-701.

Steart	soils which become periodically inundated by estuarine waters following the opening of the breach in the tidal embankments.	intertidal benthic communities either through direct toxicity or due to bioaccumulation.	embankment. However, the levels of contaminants in the soils are very similar to the present ambient concentrations on the surface bed sediments and suspended sediments (see Table 6.5.2 S1, so that it is considered that any release of contaminants will not be significant. It is likely that some ammonia will be released from the soils following the breach, due to the breakdown of organic material in anaerobic conditions, so that outflowing water will have slightly elevated ammonia levels compared with the inflowing water (Blackwell *et al* 2004[551]). The time period over which the elevated ammonia levels are expected to occur is only a few months. The outflowing water will also be diluted rapidly by the water in Bridgwater Bay, so that extent of any elevated ammonia levels will be minimal. It is not possible to predict the level of elevated ammonia which may occur, but from comparisons with other sites it is not expected to exceed 1 mg/l (Unpublished EA data for Wadebridge site, Camel Estuary). It should be noted that the potential for leaching of toxic contaminants will also limited by deposition of sediments within the managed realignment site. Deposition is expected to be rapid, as the area will act as a sediment sink.	embankments and the profiling of the intertidal area related to the breach is not yet defined. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	estuarine sediments in the region of the breach, on the levels of toxic contaminants in the water column are considered to be negligible. This is because of the similarity in the contaminant levels on the terrestrial soils and estuarine bed sediments with those on the suspended sediments, and the existing sediment cycling which occurs over the spring-neap tidal cycle and over the year.

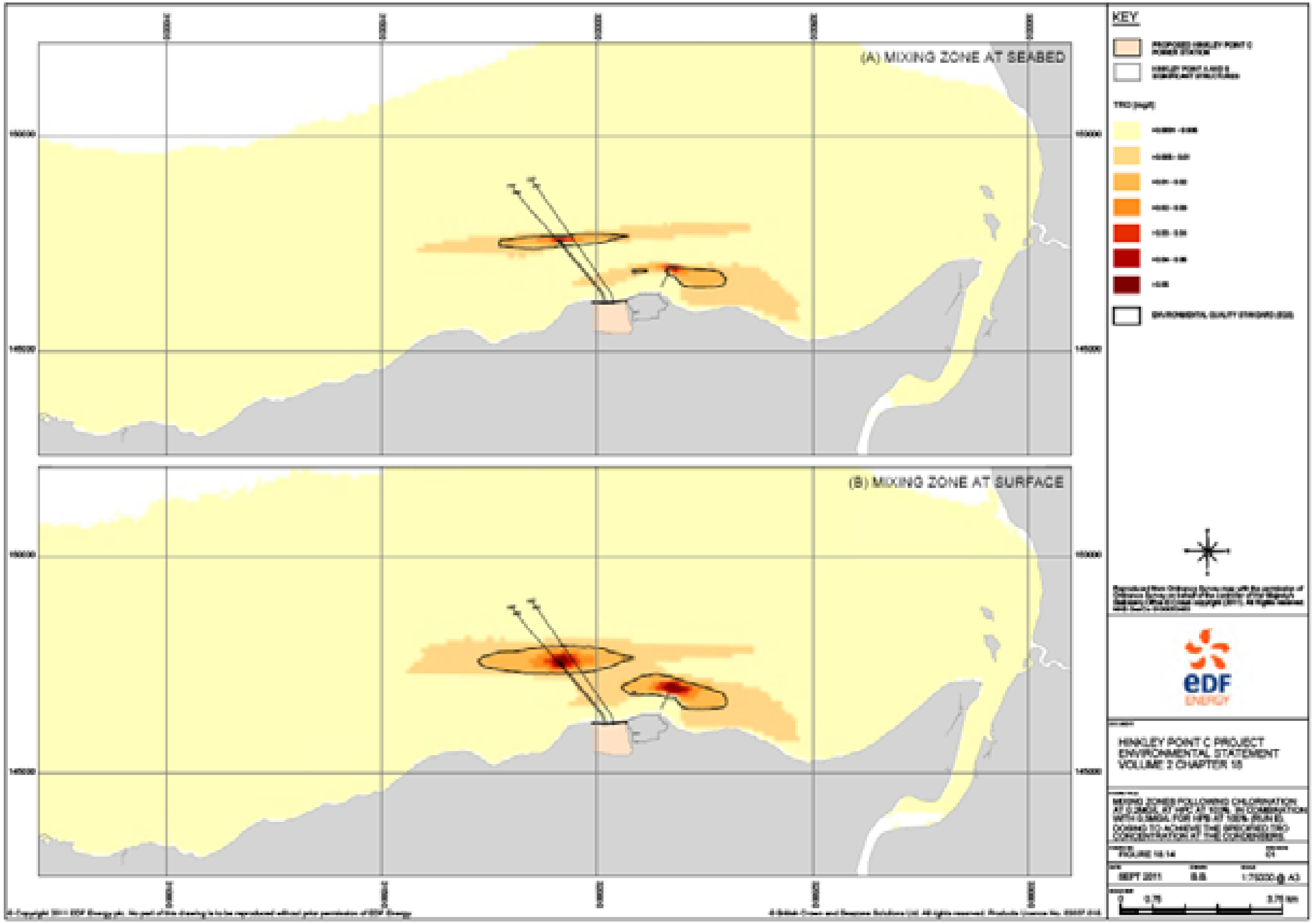
The time relationship of the different PPPs or permit is shown in Table 6.5.2 S3 in 3 month blocks to 2022, together with the scale of impact. 'N' signifies a negligible impact, 'L' signifies a likely significant effect, and 'A' signifies an adverse effect. It is apparent that not all the impacts of the PPPs and existing permits are additive, as they are not all coincident in time. Also most of the impacts are considered to be negligible or not measurable. However, there are some overlapping activities having likely significant effects during the construction period, as well as during the operational period.

[551] Blackwell, M.S.A., Hogan, D.V., Maltby, E., 2004. The short-term impact of managed realignment on soil environmental variables and hydrology. Estuarine Coastal and Shelf Science 59, 687-701.

Table 6.5.2 S3

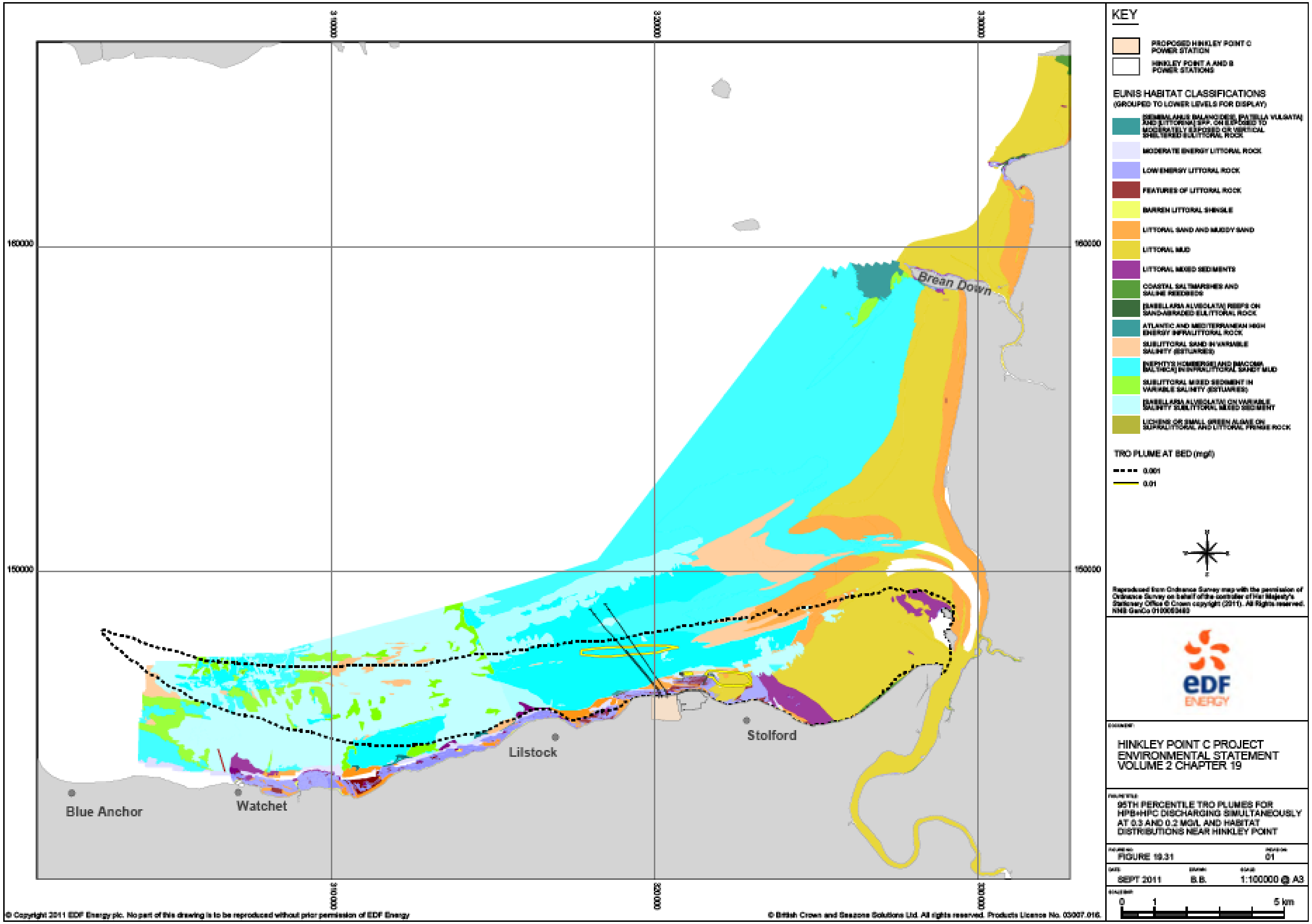
Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
Toxic Contamination	PPP or Permit	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	Jetty construction and operation (maintenance dredging)			Construction				Operation																														Demolition							
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N			
	Sea wall construction						Construction			Operation continues indefinitely																																			
							N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Construction Discharges to Foreshore				Construction																																								
					L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L																						
	Construction of cooling water infrastructure including water discharge from tunnel construction						Construction																																						
							L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L																						
	Combwich Development associated with HPC					Construction				Operation continues to end of life of HPC																																			
						N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	HPC Cold commissioning discharges																		Discharge to foreshore						Discharge into cooling water flow																				
																			N	N	N	N	N	N	N	N	N	N	N	N	N	N													
	HPC Operational discharges																								Hot commissioning					Operation continues for about 60 years															
																									N	N	N	N	N	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	HPB Operational discharges	Existing discharge. Continues to end of 2023																																											
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	I L	L	L	L	L	L
	HPA Decommissioning discharges	Time period unknown. 2080 to 2090?																																											
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Bristol Deep Sea Container Terminal Development													?Dredging and Construction? Start date not yet known													Operation																		
														N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	EA Steart Managed Realignment			Construction				Operation																																					
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Bristol Port Compensation Habitat Creation at Steart									?Construction? Date not yet known				Operation																															
										N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Figure 6.5.2 S4



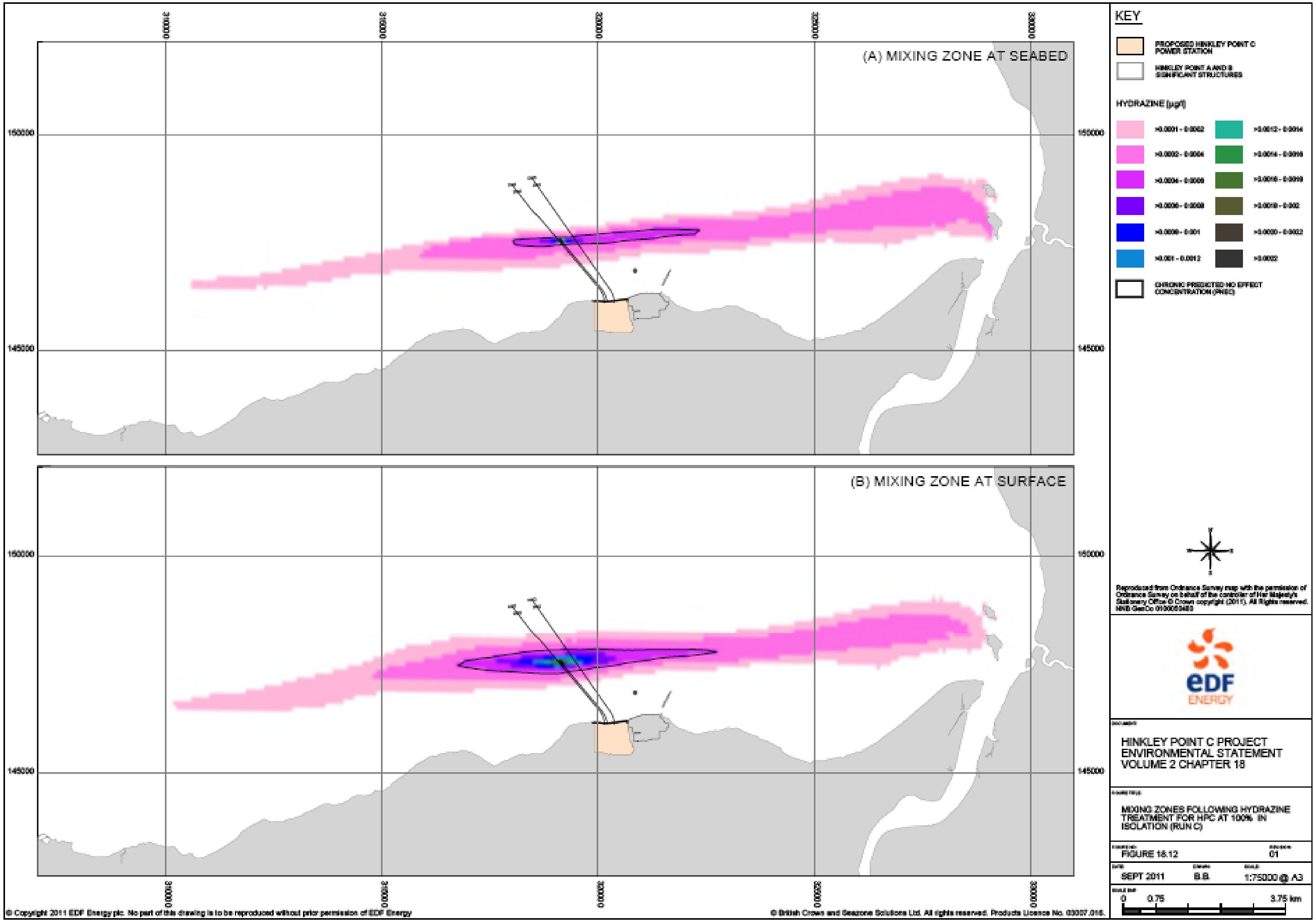
The second period when there are measurable ‘in combination’ impacts is when the HPC operational discharges start, as the HPB operational discharges are expected to be continue until 2023. The toxic contaminants in these discharges which can have an ‘in combination’ effect are TRO, which can be in both cooling water discharges, and hydrazine, which is only in the HPC cooling water discharge. The extent of the combined mixing zones for TRO from the HPB and HPC operational discharges are shown in Fig 6.5.2 S4 above. In relation to the habitats, the combined plumes at the sea bed are shown in Figure 6.5.2 S5 below.

Figure 6.5.2 S5 Combined plumes at the sea bed



The mixing zone for hydrazine from the HPC operational discharge is shown in Figure 6.5.2 S6 below.

Figure 6.5.2 S6



Assessment of 'In combination' Effects

There are 2 periods when PPPs or permits are overlapping in time and have a measurable effect. The first is during construction, when there are potential mixing zones for the construction discharges across the foreshore which have an 'in combination' impact with the potential mixing zone of TRO from the HPB operational discharges. The mixing zones from the permitted construction discharges and the yet un-permitted tunnelling water discharge will be coincident in time (see above) as well as coincident in location, as the discharges will occur from the same place on the foreshore. The mixing zone of TRO for HPB is shown in Fig 6.5.2 S4. This shows the surface and sea bed mixing zones for operational discharges for both HPB and HPC. The operational discharge from HPC does not overlap in time with the construction discharges. The mixing zone of TRO for HPB does not appear to coincide spatially with the construction discharges across the foreshore, so the effects are potentially additive. The potential mixing zone from the construction discharges is only about 100 m^2 (0.01 ha), so that this combined with the mixing zones for TRO from the HPB operational discharges gives an 'in combination' impact from the mixing zones is effectively 69.01 ha at the sea bed and 92.01 ha at the sea surface. This increase is in impact is minimal.

Given that the extent of the combined mixing zones equates to 0.09% and 0.13% of the Estuaries feature for the mixing zone at the sea bed and at the surface respectively, the 'in combination' impact is considered to be insignificant.

It is apparent that the mixing zones of TRO and hydrazine from the HPC operational discharges are not quite coincident spatially, while that for TRO from the HPB operational discharges is spatially separate. It should also be noted that the modelling of the hydrazine plume for the HPC operational discharges alone was only for the discharge scenario for average concentrations (see alone assessment). What has not been modelled is the maximum concentration against the acute PNEC. The maximum concentration in the cooling water is predicted to be 1.53 µg/l, based on a cooling water flow of 60.4 m^3/s (see alone assessment). The loading from this scenario is about 40 times greater than that for the average scenario. The size of the potential mixing zone related to this initial concentration is therefore certainly larger that in Table 6.5.2 S6, and in the order of about 40 times. It was therefore concluded from the alone assessment that the potential size of the mixing zone for hydrazine for the maximum concentration scenario could be significant. Consequently, it was not possible from the available information to conclude that the discharge of hydrazine does not have an adverse effect on the integrity of the site. It was recognised that the best option to manage the uncertainty was to mitigate the discharge of hydrazine through treatment of Waste Stream B,C, & D and reduce the concentration of hydrazine at source. On the basis that treatment of hydrazine at source in the HPC operational discharges reduces the size of any hydrazine mixing zone to an insignificant area, then the 'in combination' effects of the HPB and HPC operational discharges become the additive areas of the mixing zones for TRO. The combined mixing zone areas become 132 ha at the sea bed and 249 ha at the surface. These equate to 0.18% and 0.34% respectively of the Estuaries feature. . It has been stated in the Alone assessment for the Estuaries feature (section 2.6.1) that the mixing zone for bromoform, the main by-product of chlorination, is effectively coincident with the mixing zone for TRO. The combined mixing zone therefore has the same total area as that for TRO, with 2 distinct mixing zones related to HPB and HPC. It should be noted for the potential mixing zone for TRO and bromoform that the use of chlorination for the cooling water discharge at HPC may not be required, as chlorination has never been used at HPB. The requirement for the use of any chlorination at HPC will be carefully monitored and there will have to be a demonstrable need for its use, before it will be used. The combined plume area is therefore only a potential area which could be affected, and in the context of the Estuaries feature, this potential area is not considered to be significant.

The increases in the load of toxic contaminants to the Severn Estuary SAC from the discharges are not significant, as they are mostly less than 0.1%. Only the load of iron from the HPC operational is greater than 0.1%, being 0.85%, although this is not considered to be significant given the ubiquitous distribution of iron and its abundance in the sediments of the Severn Estuary SAC.

Conclusions for Toxic contamination in relation to Estuaries – In combination
It is therefore concluded that the impact of toxic contaminants from the relevant PPPs and permits will not compromise the conservation objectives for Estuaries feature when considered 'in combination', with the exception of hydrazine in the HPC operational discharges.

We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

6.5.3 Non toxic contamination (Nutrient enrichment and organic loading)

Conservation objectives:

- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009

Relevant Proposed Plans and Projects and Existing Permits

An 'in combination' assessment of the impact of non-toxic contamination from all permitted activities and proposed plans or projects, as known in 2008, was undertaken in the Habitats Directive Review of Consents (EA 2009[552], 2010[553]). No permits were reviewed as a result of the RoC process, in relation to their potential input of non-toxic contaminants. All other permitted discharges were considered to have no adverse effect on site integrity either alone or in combination. Several discharges containing non-toxic contaminants have subsequently ceased since the RoC (see Alone Assessment) with a subsequent overall decrease in loading to the Severn Estuary SAC. It is considered that the present loadings of toxic contaminants

[552] Environment Agency. Severn Estuary SAC and SPA Habitats Directive Review of Consents. Stage 3. November 2009.
[553] Environment Agency. Severn Estuary SAC and SPA Habitats Directive Review of Consents. Stage 4. January 2010.

to the Severn Estuary SAC are not having a significant effect on site integrity and constitute the background for the present 'in combination' assessment.

Each of the proposed plans and projects and existing permits as shown in Table 6.2 S1 is assessed in Table 6.5.3 S1 below.

Assessment of 'In combination' Effects

The only discharge with a likely significant effect is the combined discharges from the Package STWs, as these discharges will be to the foreshore. However, the size of the mixing zone related to this feature is considered to be negligible, being about 0.00004%.

There is overlap of several of the discharges for which there are measurable loads. The first period is during the construction phase, when the Package STWs discharges, the HPC cold commissioning discharges, and the HPB STW discharge overlap. The total combined loads in kg/d of BOD, ammonia, total inorganic nitrogen, and total inorganic phosphorus for these 3 discharges equate to 0.05%, 0.10%, 0.031%, and 0.19% respectively of the total loads to the Severn Estuary SAC.

The second period is during the operational phase, when the HPC cold commissioning discharges, the HPB STW discharge, and the HPC operational discharges overlap. The total combined loads in kg/d of BOD, ammonia, total inorganic nitrogen, and total inorganic phosphorus for these 3 discharges equate to 0.05%, 0.14%, 0.041%, and 0.28% respectively of the total loads to the Severn Estuary SAC. The combined total loads for these 3 discharges should be less than these here, as the overlap between the HPC cold commissioning discharge and HPC operational discharges can only relate to one EPR unit for the HPC operational discharges, although the calculated loads relate to 2 EPR units.

Conclusion

Based on the relative loadings of nutrients and the size of any mixing zones, it is concluded that the conservation objectives for Estuaries feature are not compromised by the effects of non-toxic contamination (nutrient enrichment and organic loading) from the relevant PPPs and permits when considered 'in combination'. It is therefore concluded that there is no adverse effect on site integrity.

Table 6.5.3 S1

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Package STWs discharges to the foreshore	The pathway for non-toxic contamination is through the discharge of nutrients and an organic load to the foreshore through the new outfall structure in the cliff.	The discharge could increase the growth of macroalgae on the foreshore locally, or increase the phytoplankton productivity in the water column, through the input of nitrogen and phosphorus. It could also generate a local oxygen demand and therefore a deficit in the dissolved oxygen in the water column.	The potential impact is defined by the relative contribution of nutrients to the overall nutrient loading to the Severn Estuary SAC, and the size of the mixing zone in relation to oxygen demand. There is also an area of localised impact on the foreshore due to the elevated nutrients in the discharge, which occurs due to the outfall being above the Mean High Water Spring Tidal level. The discharges in total will have a daily flow of 660 m^2/d and expected permit levels of 20 mg/l BOD, 30 mg/l Suspended Solids, and 5 mg/l Ammonia. The foreshore at the location of the outfall is about 300 m wide for mean tides, so that the area of intertidal affected by the discharges is about 300 m^2, assuming the discharge has a width of one metre. This area represents that which could be affected by the discharges without any dilution. The area equates to about 0.00004% of the Estuaries feature which is insignificant. The area equates to 0.02% of the mixed sediment and rocky intertidal area fronting the HPC site (area estimated to be 1.6 km^2). In the context of the area of rocky shores in the SAC, which is 15 km^2, the area equates to 0.002%. The mixing zone for the discharges once the effluent crosses the intertidal zone and enters the nearshore waters is less than 1 m^2, assuming a BOD concentration of 20 mg/l and a target value of 1 mg/l in the nearshore waters. The loadings in kg/d of BOD, Ammonia as N, Nitrogen as N, and Phosphorus as P from the discharge are 13.20, 3.30, 19.80, and 3.30 respectively. These are based on the proposed consented 95%ile vales of 20 mg/l for BOD and 5 mg/l for Ammonia, and assumed representative values for Total Inorganic Nitrogen of 30 mg/l and Total Inorganic Phosphorus of 5 mg/l. These equate to 0.02% of the total load of BOD to the Severn Estuary, 0.03% of the total load of Ammonia, 0.01% of the total load of inorganic N, and 0.03% of the total load of inorganic P (see Alone Assessment for Total Loads).	About 48 months. Indicated to be from mid 2013 to mid 2017. It is assumed that these discharges will be transferred to the cooling water outfall, the completion of which is indicated to be mid 2017.	There is a mixing zone across the foreshore related to the discharge, so that it has a likely significant effect. However, in the context of the Estuaries feature, the size of this mixing zone is negligible. The inputs of nutrients and oxygen demand in relation to the Estuaries feature are also negligible.
HPC Cold commissioning discharges	The pathway for non-toxic contamination is through the discharge of nutrients to the foreshore through the new outfall structure in the cliff for the first EPR unit, and through the cooling water outfall for the second EPR unit. .	The discharge could increase the growth of macroalgae on the foreshore locally, or increase the phytoplankton productivity in the water column, through the input of nitrogen and phosphorus.	Based on data on flows and concentrations in Table 6.5 (p.221) of the Hinkley Point C Project Report to Inform the Habitats Regulations Assessment (Haskoning 2011[554]), the maximum loadings of total nitrogen and total phosphorus are 2.23 kg/day and 3.58 kg/d, taking account of the proportion of N in the various conditioning substances. These loads are not expected to be change significantly, even though the effluent will be treated, as treatment is only expected to breakdown the substances into less toxic inorganic compounds. These loads equate to 0.001% of the total load of inorganic N to the Severn Estuary SAC, and 0.04% of the total load of inorganic P. As the cold commissioning effluent will be discharged through the new outfall sited above Mean High Water Spring Tidal level, there will be a zone across the foreshore which will be influenced by elevated nutrients in the effluent. This zone is the same zone as that defined for the Package STWs discharge; ie. an estimated area of foreshore of about 300 m^2. This area does not constitute an additional area to that from the Package STWs discharges.	About 24 months for each EPR unit. Indicated to be from early 2016 to mid 2017 for the first EPR unit, and late 2017 to late 2019 for the second EPR unit.	Although there is a zone of influence across the foreshore related to the discharge, in the context of the Estuaries feature, the size of this is negligible. The inputs of nutrients in relation to the Estuaries feature are also negligible.
HPC Operational discharges	The pathway for non-toxic contamination is through the discharge of nutrients and an organic load into the cooling water system.	The discharge could increase the phytoplankton productivity in the water column or increase the growth of macroalgae on the foreshore through the input of nitrogen and phosphorus to the Severn Estuary SAC. It could also generate a local oxygen demand and therefore a deficit in the dissolved oxygen	The nutrients and organic load input to the cooling water will be discharged through the outfall structures about 1.8 km offshore. The concentration of oxygen demand in the cooling water discharged is considerably less than 0.1 mg/l (see data in the Alone Assessment), so that no effective oxygen demand is expected to be exerted in the receiving waters. The total annual loads in kg/day from all waste streams for BOD and COD, Ammonia, Total Nitrogen , and Total Phosphorus were defined in the Alone	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second	The inputs of nutrients and oxygen demand in relation to the Estuaries feature are negligible.

[554] Haskoning 2011.Hinkley Point C Project Report to inform the Habitats Regulati0ons Assessment (HRA). Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. 1056 pp.

		in the water column.	Assessment as 17.34, 6.74, 34.36, and 11.34 respectively. These annual loads equate to 0.03% of the total BOD load to the Severn Estuary SAC, 0.07% of the total Ammonia load, 0.02% of the total Inorganic N load, and 0.12% of the total Inorganic P load.	EPR unit are indicated to start in mid 2020.	
HPB STW discharge	The pathway for non-toxic contamination is through the discharge of nutrients and an organic load to the foreshore at the head of the cooling water culvert.	The discharge could increase the growth of macroalgae on the foreshore locally, or increase the phytoplankton productivity in the water column, through the input of nitrogen and phosphorus. It could also generate a local oxygen demand and therefore a deficit in the dissolved oxygen in the water column.	The consented flow for this STW is 1000 m^2/d , while the consented 95%ile for BOD is 60 mg/l. As the discharge is to the head of the cooling water culvert, it will be diluted by the cooling water which is in the order of 3 million m^2/d. The concentration of BOD in the receiving waters will therefore be considerably less than 0.1 mg/l, so that no effective oxygen demand is expected to be exerted in the receiving waters. Based on data from the Review of consents, the consented loads in kg/day from the STW are 19.62 for BOD and 15.99 for Ammonia, while the mean loads in kg/day were 21.20 for total Inorganic N and 4.81 for total inorganic P. These equate to 0.04% of the total BOD load to the Severn Estuary SAC, 0.15% of the total ammonia load, 0.01% of the total Inorganic N load, and 0.05% of the total Inorganic P load.	The operational discharges from HPB are not expected to cease until 2023. This discharge will therefore continue at least until then and also during any subsequent period of decommissioning.	The inputs of nutrients and oxygen demand in relation to the Estuaries feature are negligible.
EA Steart Managed Realignment	The pathway for non-toxic contamination is through the release of nutrients to the water column from the breakdown of organic material in the managed realignment site.	Increased nutrient levels in the water flowing out of the managed realignment site could provide an additional nutrient load to the estuarine waters. An additional organic load could also occur from the organic material in the outflowing water.	It is likely that some ammonia will be released from the soils following the breach, due to the breakdown of organic material in anaerobic conditions, so that outflowing water could have slightly elevated ammonia levels compared with the inflowing water (Blackwell *et al* 2004[555]). However, the time period over which the elevated ammonia levels are expected to occur is only a few months. The outflowing water will also be diluted rapidly by the water in the Parrett Estuary, so that the extent of any elevated ammonia levels will be negligible. It is not possible to predict the level of elevated ammonia which may occur, but from comparisons with other sites it is not expected to exceed about 1 mg/l (Unpublished EA data for Wadebridge site, Camel Estuary). Similarly, any increase in organic load will only occur over a short period of a few months, and will also be diluted rapidly by the water in the Parrett Estuary. It should be noted that the potential for leaching of toxic contaminants will also limited by deposition of sediments within the managed realignment site. Deposition is expected to be rapid, as the area will act as a sediment sink.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is about one month in mid 2013. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	The inputs of nutrients and oxygen demand in relation to the Estuaries feature are negligible.
Bristol Port Compensation Habitat Creation at Steart	The pathway for non-toxic contamination is through the release of nutrients to the water column from the breakdown of organic material in the managed realignment site.	Increased nutrient levels in the water flowing out of the managed realignment site could provide an additional nutrient load to the estuarine waters. An additional organic load could also occur from the organic material in the outflowing water.	It is likely that some ammonia will be released from the soils following the breach, due to the breakdown of organic material in anaerobic conditions, so that outflowing water will have slightly elevated ammonia levels compared with the inflowing water (Blackwell *et al* 2004). The time period over which the elevated ammonia levels are expected to occur is only a few months. The outflowing water will also be diluted rapidly by the water in Bridgwater Bay, so that extent of any elevated ammonia levels will be minimal. It is not possible to predict the level of elevated ammonia which may occur, but from comparisons with other sites it is not expected to exceed 1 mg/l (Unpublished EA data for Wadebridge site, Camel Estuary). Similarly, any increase in organic load will only occur over a short period of a few months, and will also be diluted rapidly by the water in Bridgwater Bay. It should be noted that the potential for leaching of toxic contaminants will also limited by deposition of sediments within the managed realignment site. Deposition is expected to be rapid, as the area will act as a sediment sink.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is not yet defined. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	The inputs of nutrients and oxygen demand in relation to the Estuaries feature are negligible.

The time relationship of the different PPPs or permit is shown in Table 6.5.3 S2 below in 3 month blocks to 2022, together with the scale of impact. 'N' signifies a negligible impact, and 'L' signifies a likely significant effect.

[555] Blackwell, M.S.A., Hogan, D.V., Maltby, E., 2004. The short-term impact of managed realignment on soil environmental variables and hydrology. Estuarine Coastal and Shelf Science 59, 687-701.

Table 6.5.3 S2

Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
Non-Toxic Contamination	**PPP or Permit**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	Package STWs discharges							Discharge to foreshore																																			
								L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L																						
	HPC Cold commissioning discharges																		Discharge to foreshore						Discharge into cooling water flow																			
																			N	N	N	N	N	N	N	N	N	N	N	N	N	N													
	HPC Operational discharges																								Hot commissioning					Operation continues for about 60 years															
																									N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	HPB STW discharge	Existing discharge. End date not known but beyond 2023																																											
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	EA Steart Managed Realignment			Construction				Operation continues indefinitely																																			
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Bristol Port Compensation Habitat Creation at Steart									?Construction? Date not yet known				Operation continues indefinitely																													
										N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Conservation objectives (see section 1.5.1)

- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009[556]

Environment Agency permissions, plans or projects that could have a thermal impact on the Estuaries feature include the following:

- HPC cooling water discharge

which could act in combination with toxic contamination from the following other permissions, plans or projects:

- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Relevant Proposed Plans and Projects and Existing Permits

It is considered that the present thermal loadings to the Severn Estuary SAC are not having a significant effect on site integrity and constitute the background for the present 'in combination' assessment.

Relevant background information has been taken from the Environment Agencys Habitats Directive Review of consents (EA 2009[557], 2010[558]) in combination assessment of the impact of toxic contamination from all permitted activities and proposed plans or projects, as known in 2008. This review also assessed the permit for Oldbury A Power station discharge in relation to its potential change to the thermal regime. The Power Station has just stopped generating (27th Feb 2012) so that any thermal discharge now relates to decommissioning work. All other permitted discharges were considered to have no adverse effect on site integrity either alone or in combination

Four existing thermal discharges are considered here 'in combination' with the proposed HPC discharge on account of their location or potential to impact on specific interest features in common with those impacted by the proposed HPC discharge, including the Estuaries feature.

[556] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

[557] Environment Agency. Severn Estuary SAC and SPA Habitats Directive Review of Consents. Stage 3. November 2009.

[558] Environment Agency. Severn Estuary SAC and SPA Habitats Directive Review of Consents. Stage 4. January 2010.

Table 6.5.4S1 displays further information to inform the assessment related to the predicted sizes of the mixing zones for the HPC and HPB cooling water discharges from modelling. The predicted sizes of the mixing zones are given for the various targets for the Severn Estuary SAC and SPA.

Table 6.5.4S1

Areas of Mixing Zones for Habitats Related Targets in hectares

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA
HPB 70% Surface	144	144	135	607	607	518	0	1	1	0.1	4.1	4.1	0
HPB 70% Bed	84	84	83	536	536	490	0	0.03	0.03	0	0.4	0.4	0
HPB 100% Surface	406	406	368	988	988	773	0	87	87	79	197	197	79
HPB 100% Bed	336	336	322	903	903	758	0	42	42	41	108	108	105
HPC 100% Surface	580	573	237	3388	2408	1377	0	9	9	0	38	38	0
HPC 100% Bed	531	528	307	3277	2452	1510	0	0.4	0.4	0	2	2	0

Table 6.5.4S2

Areas of Mixing Zones for Habitats Related Targets as percentages of features

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA
HPB 70% Surface	0.20	0.20	0.55	0.82	0.82	2.10	0.00	0.00	0.00	0.00	0.01	0.01	0.00
HPB 70% Bed	0.11	0.11	0.34	0.73	0.73	1.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HPB 100% Surface	0.55	0.55	1.49	1.34	1.34	3.13	0.00	0.12	0.12	0.32	0.27	0.27	0.32
HPB 100% Bed	0.46	0.46	1.31	1.23	1.23	3.07	0.00	0.06	0.06	0.17	0.15	0.15	0.43
HPC 100% Surface	0.79	0.78	0.96	4.60	3.27	5.58	0.00	0.01	0.01	0.00	0.05	0.05	0.00
HPC 100% Bed	0.72	0.72	1.24	4.45	3.33	6.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The information above has informed the next stage of the assessment where each of the proposed plans and projects and existing permits as shown in Table 6.2 S1 is assessed in Table 6.5.4 S3 in terms of its significance alone in relation to the specific hazard 'changes to thermal regime'.

Table 6.5.4 S3

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the outfall about 1.8 km offshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge from modelling are given for the various targets for the Severn Estuary in the Table 6.5.4 S1 above. It is clear that the discharge has a likely significant effect on the Estuaries feature, with the greater relative impact occurring in the intertidal mudflats and sandflats represented by the SPA feature (see Figure ?? below). The significance of the impact of the thermal plume from HPC on the interest features of the Severn Estuary SAC has been assessed in detail in the alone assessment, and is not repeated here. There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	The greatest potential impact is on the intertidal mudflats and sandflats feature, and the benthic invertebrate community, notably *Macoma balthica*. However, it was concluded that the likely impact of the thermal plume on the intetidal mudflats and sandflats from HPC alone was similar to that from the HPB thermal plume. There appears to be no significant difference between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without. Therefore it has been concluded that there is no adverse effect on the integrity of the Estuaries feature from the HPC thermal plume alone.
HPB Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the culvert across the foreshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge from modelling are given for the various targets for the Severn Estuary in the Table 6.5.4 S1 above. It is clear that the discharge has a likely significant effect on the Estuaries feature, with the greater relative impact occurring in the intertidal mudflats and sandflats represented by the SPA feature. There have been various studies of the intertidal benthic invertebrates on Stert Flats related to the impact of the proposed HPC thermal discharge. These have shown that no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without (BEEMS Reports SPP062[559] and SPP073/S[560]). There is no thermal barrier to fish movement created by the HPB cooling water discharge alone.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges. No thermal load is expected from the decommissioning discharges.	The HPB cooling water disharge has an existing permit. Based on the available information on the impact of the existing thermal plume from HPB, it has been concluded that there is no significant effect on the Estuaries feature HPB thermal plume alone.
Aberthaw Power Station Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through an outfall to the Bristol	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities.	The sizes of the mixing zones for Aberthaw cooling water discharge are estimated to be in the order of 100 to 200 ha, based on plots of the modelled thermal plume provided in an RWE report to support the permit application. The plume does not extend more than about 1 km offshore.	About 240 months (20 years) based on the expected operational life of the power station.	The cooling water discharge from Aberthaw Power Station has an existing permit. The thermal plume does not impact on the Severn Estuary SAC.

[559] BEEMS Scientific Position Paper SPP062. Macoma balthica population structure at Hinkley Point and elsewhere in the Severn Estuary. EDF BEEMS (Cefas), 2011.
[560] BEEMS Scientific Position Paper SPP073/S. The potential in combination effects of HP B and HP C thermal plumes upon the intertidal mudflat ecology of Bridgwater Bay. EDF BEEMS (Cefas). 2012

	Channel.	There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	It does impact on the intertidal zone towards the SAC boundary, but the plume does extend into the SAC. There is no thermal barrier to fish movement created by the Aberthaw cooling water discharge alone.		
Uskmouth Power Station Thermal discharge	The pathway for changes to the thermal regime is through the discharge of heated effluent to the Usk estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The size of the mixing zone of the thermal discharge from Uskmouth Power Station was estimated to be less than 0.1 ha in the Review of Consents. This represents less than about 0.0001% of the Estuaries feature. There is no thermal barrier to fish movement created by the Uskmouth thermal discharge alone.	About 240 months (20 years) based on the expected operational life of the power station.	The thermal discharge from Uskmouth Power Station has an existing permit.
Oldbury B Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through an outfall to the Severn Estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, it is expected that any proposed development will utilise cooling towers, so that the cooling water discharge will be significantly less than that for a direct cooled power station. The expected thermal load to the upper Severn Estuary should be considerably less than that from the cooling water for Oldbury A, but its actual impact can only be assessed when more information is available.	It is not known when the Oldbury B cooling water discharge would start, as the development of the site is at an early stage. It is expected that the start date could be about 2025.	It is not possible to define the actual extent of any impact from the proposed Oldbury B cooling water discharge, as not all relevant details on the proposals are available.
Oldbury A Decommissioning Thermal discharge	The pathway for changes to the thermal regime is through the discharge of heated effluent to the Severn estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The cooling water discharge has very recently ceased (27/02/12), so that the discharge now only relates to any cooling water arising from the decommissioning activities. The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, the discharge flow is expected to be over a quarter of the existing cooling water flow, while the temperature differential and maximum temperature are also expected to decrease. Based on the estimated size of the mixing zone in the Review of Consents (about 120 ha), the estimated size of any mixing zone related to the decommissioning discharge from Oldbury is between 20 and 30 ha. This represents about 0.04 % of the Estuaries feature. As the discharge is into the main channel of the Severn Estuary, most of the impact is expected to be in the main channel in the vicinity of Oldbury, and therefore the subtidal area. The extent of any impact on the intertidal mudflats and sandflats is expected to of a similar order to that for the Estuaries feature, ie. about 0.04%. The cooling water discharge from Oldbury did not appear to create a barrier to fish migration in the upper Severn Estuary, as migratory fish appeared to move unhindered up into the freshwater rivers above Oldbury. Any reduction in the thermal loading from Oldbury can only reduce any potential thermal barrier in the upper Estuary.	About 180 months (15 years) based on the expected time scale of decommissioning of the power station. The projected end date is the end of 2026.	The cooling water discharge from Oldbury Power Station has an existing permit which was under review. The cooling water discharge has very recently ceased (27/02/12), so that the discharge now only relates to any cooling water arising from the decommissioning activities. The exact volume of the discharge and its maximum temperature difference above ambient is not yet known, but the extent of any impact is expected to be insignificant with respect to the Estuaries feature.

Table 6.5.4S6
Areas of Mixing Zones for Habitats Related Targets as percentages of features

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA
HPB 70% & HPC 100% Surface	2.50	2.50	4.53	5.91	3.68	6.55	0.00	0.58	0.58	1.47	1.44	1.44	1.47
HPB 70% & HPC 100% Bed	2.45	2.45	4.78	5.71	3.64	6.79	0.00	0.53	0.53	1.50	1.27	1.27	3.47
HPB 100% & HPC 100% Surface	2.79	2.67	4.89	6.30	3.81	6.78	0.00	2.67	2.67	2.72	1.93	1.93	2.71
HPB 100% & HPC 100% Bed	2.70	2.59	5.08	6.09	3.76	6.98	0.00	2.59	2.59	3.03	1.67	1.67	4.14

Table 6.5.4S6

Areas of Mixing Zones for Habitats Related Targets as percentages of features

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Area in the SPA	Total Area	Area in the SAC	Area in the SPA	Total Area	Area in the SAC	Area in the SPA
HPB 70% & HPC 100% Surface	2.50	2.50	4.53	5.91	3.68	6.55	0.00	0.58	0.58	1.47	1.44	1.44	1.47
HPB 70% & HPC 100% Bed	2.45	2.45	4.78	5.71	3.64	6.79	0.00	0.53	0.53	1.50	1.27	1.27	3.47
HPB 100% & HPC 100% Surface	2.79	2.67	4.89	6.30	3.81	6.78	0.00	2.67	2.67	2.72	1.93	1.93	2.71
HPB 100% & HPC 100% Bed	2.70	2.59	5.08	6.09	3.76	6.98	0.00	2.59	2.59	3.03	1.67	1.67	4.14

Assessment of 'In combination' effects of thermal plume from other Power Stations

A major factor in the assessment of the 'in combination' effects for the thermal discharges is the proximity of the other discharges to the proposed cooling water discharge from HPC. The HPB cooling water discharge is very close, about 2.5 km, to that from the proposed HPC site. Aberthaw Power Station is on the Welsh coast of the Inner Bristol Channel, about 25 km from the proposed HPC development. Uskmouth Power Station is about 38 km away up the Severn Estuary at the mouth of the Usk Estuary, on the Welsh coast. Oldbury A and B are both about 65 km away up the Severn Estuary on the English coast.

The cooling water discharge from Aberthaw PS does not impact on the Severn Estuary SAC, so there is no 'in combination' impact on the Estuaries feature from this site. The only other potential 'in combination' effect between the thermal discharges is that from Aberthaw and HPB and HPC and the possible thermal occlusion of the Inner Bristol Channel and its effect on fish movement. Given that cross-section of the Inner Bristol Channel is about 22 km, the combined width of the thermal plume affecting this cross-section is about 2.5 km, which represents about 11%. Given that the sites on either side of the Inner Bristol Channel are offset, then this percentage is highly precautionary. There is no thermal barrier to fish movement due to the thermal discharges from Aberthaw and HPB and HPC 'in combination'. It is therefore concluded that there are no impacts from any of the themal plumes in combination on fish migration in the Severn Estuary SAC

The scale of impact in terms of a mixing zone for a ΔT of 2ºC from Uskmouth Power Station is about 0.1 ha, while that from the Oldbury A Decommissioning discharge is about 20 to 30 ha as a maximum. Given that the discharge from Oldbury B will be effectively at the same location as Oldbury A, the thermal plumes will be coincident, although the thermal load will be increased. As it is not known whether there will be any overlap in time between Oldbury A and B, the size of the mixing zone has been assumed to be about 30 ha.

The combined areas of the mixing zones for HPB and HPC are given below in Table 6.5.4 S5, and their percentages relative to the Estuaries feature or the SPA are given in Table 6.5.4 S6. The expected end date for Hinkley B is now 2023. Hinkley B at present is operating at about 70% of its total output (British Energy website[561]). While it is possible that HPB could achieve 100% output, this is stated to be unlikely, and the maximum expected output from HPB is believed to be 80%. Once power generation ceases at HPB, there will be no thermal load in the subsequent decommissioning discharges.

The relative additional contribution from the mixing zones for Uskmouth PS and Oldbury A and B to the overall scale of the mixing zones is not significant, given their size and also their distance from Hinkley. The main 'in combination' effect is therefore only related to that arising from the combined thermal plumes from HPB and HPC. This is discussed in more detail below.

[561] http://www.british-energy.com

Assessment of in combination Effect of The Thermal Plume from HPB and HPC

Macoma Balthica

As discussed in the alone assessment, the species considered to be the most likely to be affected by the potential rise in water temperature from the combined thermal plumes from HPB and HPC is the Baltic tellin, *Macoma balthica*. This bivalve is a significant component of the benthic community of the intertidal mudflats and sandflats, and is also found in the subtidal soft sediments, particularly the subtidal sandbanks (eg. Gore Sand at the mouth of the Parrett Estuary) (BEEMS TR184 2011[562]).

Existing research

There have been various reports provided on the influence of water temperatures on the physiology of *Macoma balthica*, including BEEMS TR134 (2011)[563] BEEMS TR160 (2011)[564], BEEMS SPP062 (2011)[565], and BEEMS SPP073/S (2012)[566]. A lot of the earlier reports focussed on the relationship between the feeding behaviour of *Macoma balthica* and water temperature, and the assumption that *Macoma balthica* ceased growing when seawater temperatures exceeded 15 ºC (BEEMS TR184 (2011)[567] p.107). This assumption has then led to the view that *Macoma balthica* lying within the combined thermal plume would exhibit a greater reduction in body mass than those occurring outside the influence of the thermal plume, on account of the effect of a reduced growing period.

In addition, the combined thermal plume may affect the time of spawning of *Macoma balthica*, as this is known to related to temperature (see eg. Philippart *et al* 2003[568]). There are also other potential influences from changes in the thermal regime, including predator-prey relationships, as the main predator on juvenile *Macoma balthica* is the shrimp *Crangon crangon*. The population of *Crangon crangon* is reported to be increasing in the Severn Estuary, apparently as a result of warming over-winter temperatures (Henderson and Bird 2010[569]).

Available evidence does not indicate that the HPB thermal plume is affecting the *Macoma balthica* populations in Bridgwater Bay (BEEMS SPP062 2011).

The HPB Station is at present running at about 70% of capacity (British Energy website[570]). The thermal plume has a modelled mean temperature distribution as

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[562] BEEMS Technical Report 184: Hinkley Point Site. Hinkley Point Marine Ecological Synthesis Report. EDF BEEMS (Cefas) 184. 2011.

[563] BEEMS Technical Report TR134. Macoma balthica temperature sensitivity review. EDF BEEMS (Cefas), 2011.

[564] BEEMS Technical Report TR160,. Variability in population structure and condition of Macoma balthica along its geographical range. EDF BEEMS (Cefas), 2011.

[565] BEEMS. Scientific Position Paper SPP062: Macoma balthica population structure at Hinkley Point and elsewhere in the Severn Estuary. EDF BEEMS (Cefas). 2011.

[566] BEEMS Scientific Position Paper SPP073/S. The potential in combination effects of HP B and HP C thermal plumes upon the intertidal mudflat ecology of Bridgwater Bay. EDF BEEMS (Cefas). 2012.

[567] BEEMS Technical Report 184: Hinkley Point Site. Hinkley Point Marine Ecological Synthesis Report. EDF BEEMS (Cefas) 184. 2011.

[568] Philippart C.J.M., van Aken H.M., Beukema J.J., Bos O.G., Cadée G.C., and Dekker R. 2003 Climate-related changes in recruitment of the bivalve *Macoma balthica*. Limnology and Oceanography 48, 2171-2185.

[569] Henderson P.A. and Bird D.J. 2010 Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-110.

[570] http://www.british-energy.com

shown in 6.5.4 S10 and areas of mixing zones for relevant targets as shown in Table 6.5.4 S5. Any combined thermal plume will be the result of HPB running at 70% (or possibly 80%) and HPC running at 100%. The combined thermal plume will then have a mean temperature distribution as shown in Figure 6.5.4 S10, and areas of mixing zones for relevant targets as shown in Table 6.5.4 S6. There is not only an increase in the area affected by the mixing zones for a temperature of 21.5 ºC as a 98%ile and for a temperature differential of 2 ºC, but also the mixing zones for a temperature of 23 ºC as a 98%ile and for a temperature differential of 3 ºC.

Growth in relation to temperature

The *Macoma balthica* population in Bridgwater Bay and elsewhere in the Severn Estuary consists largely of first year individuals of comparatively small size (Boyden and Little 1973[571], Ferns 1977[572], and BEEMS SPP062 2011). This would suggest that the population turn-over of *Macoma balthica* in the Severn Estuary is rapid, presumably due to a combination of predation, and mortality from physical stressing related to the extreme environmental conditions. However, the fact that the *Macoma balthica* population is continually being replenished would indicate that there is a continuous source of spat available from *Macoma balthica* in the Severn Estuary which are sexually mature and in a viable condition for spawning.

Macoma balthica is found along both the Welsh and English shores of the Severn Estuary SAC at least as far as the old Severn Motorway Bridge. In addition, *Macoma balthica* is a broadcast spawner, and the planktonic larval stage lasts for at least 2 weeks (BEEMS SPP073/S 2012[573]). There is a range of lengths given for the planktonic stage from various sources, varying from 14 to 25 days (BEEMS SPP073/S 2012, BEEMS SPP063Ed2/S 2012[574], up to 7 to 8 weeks (Fish and Fish 1996[575]),. Even at the shortest duration for the larval stage, distribution along the Severn Estuary could reach 10s of kms, given the spring tidal excursions of 20 to 30 kms. Also cross-estuary transport is potentially only a few days, so that exchange between the Welsh and English shores is achievable during the shortest duration of the larval stage. This evidence indicates that *Macoma balthica* spat settling on the intertidal flats in Bridgwater Bay could originate from anywhere in the Severn Estuary, and not simply from local spawning stock in the Bay.

Spawning and effect of temperature

Sexual maturity for *Macoma balthica* is reached within 1 to 2 years, depending on growth rate in the first year (MARLIN website[576]), and therefore presumably food supply. This suggests that some of the first year *Macoma balthica* in the Severn Estuary could have reached sexual maturity, and therefore be supplying new larval stock. However, the spawning behaviour of *Macoma balthica* in the Severn Estuary is not known. In the Seine (Beukema and Deprez 1986[577]), the Thames (MARLIN

[571] Boyden C. R. and Little C.1973 Faunal distributions in soft sediments of the Severn Estuary. Estuarine and Coastal marine Science 1, 203-223.
[572] Ferns P.N. 1977 Wading Birds of the Severn Estuary. Report to the Nature Conservancy Council. University College, Cardiff. 114 pp

[573]BEEMS Scientific Position Paper SPP073/S. The potential in combination effects of HP B and HP C thermal plumes upon the intertidal mudflat ecology of Bridgwater Bay. EDF BEEMS (Cefas). 2012.
[574]BEEMS Scientific Position Paper SPP063 Edition 2/S Entrainment impact on organisms at Hinkley Point – supplementary note. EDF BEEMS (Cefas). 2012.
[575]Fish J.D. and Fish S.1996 A Student's Guide to the Seashore. Second Edition. Cambridge University Press, Cambridge. 564 pp.
[576]http://www.marlin.ac.uk/
[577]Beukema, J.J. and Deprez, M., 1986. Single and dual growing seasons in the tellinid bivalve *Macoma balthica* (L.) J. Exp. Mar. Biol. Ecol. 102, 35–45

website), and West Wales (Fish and Fish 1996), *Macoma balthica* spawns in both the spring and the autumn. In the Gironde Estuary, *Macoma balthica* has a protracted spawning period from spring to autumn giving 2 or 3 settlements in a year.(Bachelet 1980[578]). In contrast, in the Wadden Zee spawning is once a year in the spring, and the spawning has been related to a trigger temperature (Philippart *et al* 2003[579]). However, food supply may also be a factor, as occasionally spawning also occurs in the summer (Gunther *et al* 1998[580]).

Regardless of the uncertainties in the spawning times and triggers for spawning for *Macoma balthica* in the Severn Estuary, once the spat has settled, the growth of juveniles does not appear to be temperature limited. In the Gironde Estuary, the maximum growth of juveniles is between April and July/August (Bachelet 1980), and from available data on water temperatures, these are consistently above 15 ºC during this period (Beguer et al 2011[581],Jansen *et al* 2007[582]). This suggests that food supply could be the most significant aspect for feeding and growth of *Macoma balthica*, particularly for juveniles following settlement. Primary production by the microphytobenthos in the intertidal zone will be at or near its maximum during the summer, in response to the length of daylight and the intensity of solar radiation. Other work on the population dynamics of *M. balthica* in the Westeschelde (Bouma *et al* 2001[583]) and the western Dutch Wadden Sea (Cardoso *et al* 2007[584]) shows that in the intertidal zone, *M. balthica* (and particularly the juveniles) are growing throughout the summer, and tend to show less growth in the winter. These studies also suggest that food supply, and not water temperature, is the most critical factor concerning the growth of *M. balthica*.

Food sources for *Macoma balthica*

It is known that there are no suspension feeders in the Severn Estuary (Warwick *et al* 1991[585]), which suggests that food availability in the water column is limited. In fact primary productivity is mainly driven by the microphytobenthos, particularly the intertidal benthic diatoms (Underwood 2010[586]). Available data on the productivity of phytoplankton in the water column of the Inner Bristol Channel indicates annual

[578] Bachelet G. 1980. Growth and Recruitment of the Tellinid Bivalve *Macoma balthica* at the Southern Limit of Its Geographic Distribution, the Gironde Estuary (SW France). Marine Biology 59, 105-117.
[579]Philippart C.J.M., van Aken H.M., Beukema J.J., Bos O.G., Cadée G.C., and Dekker R. 2003 Climate-related changes in recruitment of the bivalve *Macoma balthica*. Limnology and Oceanography 48, 2171-2185
[580]Gunther C.-P., Boysen-Ennen E., Niesel V. , Hasemann C., Heuers J., Bittkau A., Fetzer I., Nacken M., Schluter M., and Jaklin S. 1998 Observations of a mass occurrence of *Macoma balthica* larvae in midsummer. Journal of Sea Research 40, 347-351.
[581]Beguer M., Berge J., Martin J., Martinet J., Pauliac G., Girardin M., and Boet P. 2011 Presence of *Palaemon macrodactylus* in a European estuary: evidence for a successful invasion of the Gironde (SW France). Aquatic Invasions 6, 301-318.
[582] Jansen J.M., Pronker A.E., Kube S., Sokolowski A., Carlos Sola J., Marquiegui M.A., Schiedek D., Bonga S.W., Wolowicz M., and Hummel H. 2007 Geographic and seasonal patterns and limits on the adaptive response to temperature of European *Mytilus* spp. and *Macoma balthica* populations. Oecologia 154, 23-34.
[583]Bouma H., de Vries P.P., Duiker J.M.C., Herman P.M.J., Wolff W.J. 2001 Migration of the bivalve *Macoma balthica* on a highly dynamic tidal flat in the Westerschelde estuary, The Netherlands. Marine Ecology Progress 224, 157-170
[584] Cardoso J.F.M.F., Witte J.IJ., van der Veer H.K. 2007 Habitat related growth and reproductive investment in estuarine waters, illustrated for the tellinid bivalve *Macoma balthica* (L.) in the western Dutch Wadden Sea . Marine Biolog 152, 1271-1282.
[585] Warwick R.M., Goss-Custard J.D., Kirby R., George C.L., Pope N.D., Rowden A.A. 1991 Static and dynamic environmental factors determining the community structure of estuarine macrobenthos n SW Britain: why is the Severn Estuary different? Journal of Applied Ecology 28, 329-345.
[586] Underwood G.J.C. 2010 Microphytobenthos and phytoplankton in the Severn estuary, UK: Present situation and possible consequences of a tidal energy barrage. Marine Pollution Bulletin 61, 83-91.

primary production of between 0.73 to 6.8 g C m^{-2} y^{-1} (Joint 1984[587], Underwood 2010). In comparison, annual primary production of the microphytobenthos ranges from 17.5 g C m^{-2} y^{-1} on intertidal sand to 52.5 g C m^{-2} y^{-1} on intertidal mud, with an overall intertidal value of 33.12 g C m^{-2} y^{-1} (Underwood 2010). These data indicate that the primary productivity of the intertidal zone is about 5 to 50 times greater than that in the water column of the Severn Estuary. This difference explains the significance of the intertidal areas for benthic invertebrates, as the intertidal areas contain the major source of food for deposit feeders.

Mixing Zones and temperature increase at HPB/HPC in comparison to Gironde Estuary, France.

The areas of the mixing zones for various different targets are shown in Tables 6.5.4 S5 and 6.5.4 S6 for the 2 different potential in combination scenarios; HPC 100% and HPB 70%, and HPC 100% and HPB 100%. At present, HPB is running at about 70% of full output (British Energy website[588]). While it is possible that HPB could achieve 100% output, this is stated to be unlikely, and the maximum expected output from HPB is believed to be 80%. While there is a relatively large increase in the areas of the mixing zones for the 2 targets of 21.5 ºC as a 98%ile and ∆T 2 ºC , the effect of these mixing zones on the estuarine communities is not considered to be significant, based on the available evidence on the impact of the current thermal discharge from HPB, operating at 70% output. However, for the combined thermal plumes, there are now sizeable areas where the 2 targets of 23 ºC as a 98%ile and ∆T 3 ºC (see Figures 6.5.4 S10 and 6.5.4 S11, and compare with Figures 6.5.4 S13 to 6.5.4 14 for the single plumes, HPB 70%, HPB 100%, and HPC 100%) . What do these temperature increases mean in relation to the estuaries feature and the conservation objectives?

There is no available evidence to assess the potential effect of this temperature increase, as there was for the assessment of the effect of the HPC thermal plume alone. However, the potential effect can be considered in the context of the changes to the ambient temperature regime that an increase in water temperature of 3 ºC represents, coupled with the available information on the temperature variation in the Gironde Estuary, which is the most southerly occurrence of a viable *Macoma balthica* population.

The mean seawater temperature in the Gironde Estuary is quoted to be 14.7 ºC (Hummel *et al* 1995[589]) . The mean seawater temperature at Hinkley at present is 12.6 ºC. This indicates that an increase in temperature of 2ºC would result in a mean seawater temperature of 14.6 ºC , and an increase of 3 ºC would result in a mean seawater temperature of 15.6 ºC. This indicates that the mean seawater temperature at Hinkley would be similar to that in the Gironde Estuary for a 2ºC increase, but slightly greater for a 3 ºC increase.

The resulting increases in mean monthly seawater temperatures for a ∆T 2 ºC and a ∆T 3 ºC are shown in Figure 6.5.4 S7.

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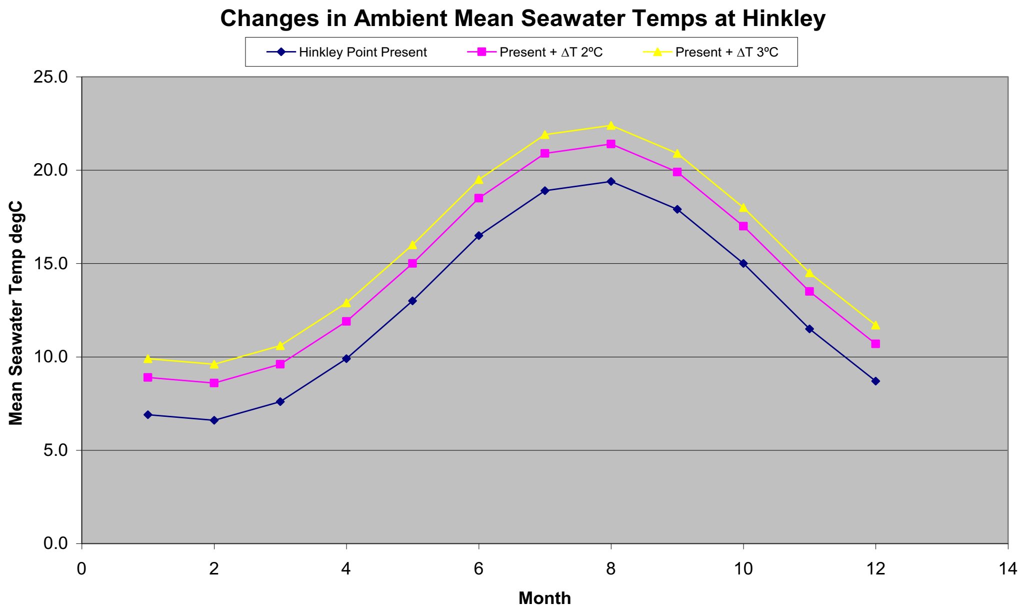
[587] Joint I.R. 1984 The Microbial Ecology of the Bristol Channel. Marine Pollution Bulletin 15, 62-66.

[588] http://www.british-energy.com

[589] Hummel H., Amiard-triquet C., Bachelet G., Desprez M., Marchand J., Sylvand B., Amiard J.C., Rybarczyk H., Bogaards R.H., and de Wolf L. 1995 Comparison of ecophysiological, biochemical and genetic traits in the estuarine bivalve *Macoma balthica* from areas between the Netherlands and its southern limits (Gironde): geographic clines parallel effects of starvation and copper exposure. Proc. 30th European Marine Biological Symposium. Southampton, UK. September 1995, 15-20.

Figure 6.5.4S7



Seawater temperature data from the Gironde Estuary are given in a paper by Beguer *et al* 2011[590], in which annual ranges of water temperatures are provided for sites across several transects in the main part of the Gironde Estuary. The data are from monthly sampling of the surface and near bed temperatures for the period 1998 to 2007. Interestingly, the data were collected for a monitoring programme related to a nuclear power station on the Gironde Estuary. The temperature ranges for the Gironde Estuary given in Table 6.5.4 S8 are for the 2 outermost transects for which data are available for all years. They are compared with the range of mean seawater temperatures at Hinkley with a 3 ºC increase.

[590]Beguer M., Berge J., Martin J., Martinet J., Pauliac G., Girardin M., and Boet P. 2011 Presence of *Palaemon macrodactylus* in a European estuary: evidence for a successful invasion of the Gironde (SW France). Aquatic Invasions 6, 301-318.

Table 6.5.4S8

Outer Mid Gironde Estuary		
Year	**Minimum T ºC**	**Maximum T ºC**
1998	3.8	23.0
1999	5.0	23.0
2000	5.7	23.8
2001	5.9	24.6
2002	4.9	22.2
2003	6.9	26.3
2004	7.3	24.0
2005	5.3	23.6
2006	5.1	24.1
2007	8.8	22.6
Hinkley Monthly Means Present + 3 ºC	9.6	22.4

These data indicate that while minimum temperatures in the middle Gironde Estuary are lower than the minimum mean at Hinkley with a 3 ºC increase, the maximum temperatures are nearly always higher. This suggests that the summer seawater temperatures in the Gironde Estuary probably exceed or at least are similar to those that are likely to occur in the thermal plume from a combined HPB and HPC. However, this comparison of temperatures may not be the most appropriate, because of the difference in the sampling and analysis of the data. Mean seawater temperature data for the Bay of Biscay in Jansen *et al* 2007[591] indicates that the minimum mean seawater temperatures are about 11 ºC and the maximum mean seawater temperatures are about 22.5 ºC. These values are similar to those given for surfing beaches at the mouth of the Gironde Estuary (see eg. http://www.surf-forecast.com/breaks/Lacanau-Ocean/seatemp). These data for the seawater temperatures in the Bay of Biscay and the mouth of the Gironde Estuary therefore suggest that the range of mean seawater temperatures at Hinkley with a 3 ºC increase above ambient are probably similar to the range of mean seawater temperatures in the lower Gironde Estuary.

As a different comparison, the mean, maximum, minimum, and 98%ile seawater temperatures at the seabed from GETM model output for 4 intertidal sites across Stert Flats for the scenario of a combined thermal plume with HPC at 100% and HPB at 70% are given in Table 6.5.4 S9.

These data also suggest that the mean seawater temperatures and also the range of seawater temperatures across the intertidal area of Stert Flats are similar to those in the Gironde Estuary, at least for the scenario of a combined thermal plume with HPC at 100% and HPB at 70%.

[591] Jansen J.M., Pronker A.E., Kube S., Sokolowski A., Carlos Sola J., Marquiegui M.A., Schiedek D., Bonga S.W., Wolowicz M., and Hummel H. 2007 Geographic and seasonal patterns and limits on the adaptive response to temperature of European *Mytilus* spp. and *Macoma balthica* populations. Oecologia 154, 23-34

Table 6.5.4S9

	HPC 100% and HPB 70%			
	Station 12	**Station 35**	**Station 104**	**Station 106**
Mean	15.07	13.91	14.85	14.46
Max	27.73	25.51	25.86	25.97
Min	2.70	1.88	2.50	2.32
98%ile	24.39	23.62	24.15	23.87

These seawater temperature data suggest that the *Macoma balthica* in the subtidal and intertidal sediments off Hinkley which are affected by the higher temperatures in the combined thermal plume may be more stressed relative to those outside.

However, it is also suggested they may be no more stressed than the present populations of *Macoma balthica* in the Gironde Estuary which are viable. This implies that the *Macoma balthica* in the subtidal and intertidal sediments off Hinkley which are affected by the higher temperatures in the combined thermal plume would also remain viable.

A further factor lends support to this view. It is known that a significant proportion of the *Macoma balthica* in the Severn Estuary are first year individuals of comparatively small size. As this juvenile population is apparently replenished every year from sources of sexually mature individuals throughout the Severn Estuary, most of which is unaffected by the combined thermal plume from HPB and HPC, it is considered that this replenishment will continue to occur in the subtidal and intertidal areas both within and outside the area affected by the combined thermal plume.

What would be an interesting comparison, and a useful analogue for the proposed combined thermal plume from Hinkley B and C, is a study of the effect of the thermal plume from the present nuclear power station in the Gironde Estuary on the *Macoma balthica* populations there. It is not known if there have been any specific studies undertaken on this. In the absence of such studies, more detailed data on the seawater temperatures affecting the *Macoma balthica* populations in the Gironde Estuary would be helpful in understanding the ambient seawater temperature regime at which *Macoma balthica* populations remain viable.

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Historical operation of Hinkley A

A final piece of evidence relates to the historical operation of the 2 existing power stations at Hinkley, the A and B stations. HPA with two 221 MW reactors operated from 1965 to 2000. HPB with two 660 MW reactors started operating in 1976. There was therefore a period of about 24 years when there was a combined thermal plume discharged through the present outfall culvert across the intertidal zone. This combined thermal plume would have been similar in heat flux to the thermal plume from one EPR reactor, or to the HPB plume at about 133% output. Using the latter comparative figure of HPB at 133% output implies that significantly greater areas of the SAC and SPA could have been affected by the mixing zones for the 2 targets of 23 ºC as a 98%ile and ΔT 3 ºC than those predicted for HPB at 100% output, which are given in Table 6.5.4 S5 and 6.5.4 S6

This combined HPA and HPB thermal plume decreased to the present HPB alone thermal plume in 2000, when HPA ceased power generation. This change in the thermal plume was about 8 to10 years before the recent work on the intertidal and subtidal ecology commenced at Hinkley. Any potential effect on the *Macoma balthica* population which may have resulted from the combined HPA and HPB thermal plume has subsequently recovered, as no impact on the intertidal area of Stert Flats or the subtidal area off Hinkley is observed from the present thermal plume for HPB at 70% output. This would suggest that, if there had been a significant impact, any recovery was quite rapid, and certainly less than about 8 years. This not surprising given the significant juvenile component of the intertidal *Macoma balthica* which implies a continuous replenishment of the juvenile stock to Stert Flats as well as the other intertidal and subtidal areas of the Severn Estuary.

DO and Ammonia

As discussed in the Alone Assessment for the Estuaries feature, increasing temperature affects both the solubility of oxygen in seawater, as well as the speciation of ammonia. For dissolved oxygen (DO), increasing the seawater temperature reduces the amount of oxygen held in solution. For ammonia, increasing the seawater temperature increases the proportion of ammonia which is unionised; unionised ammonia (UIA) is the more toxic form.

However, the direct effect of raising the seawater temperature by 3ºC does not reduce the DO significantly, nor increase the proportion of UIA significantly (see Section 2.6.3.1 on the Alone Assessment for the Estuaries feature). It is therefore considered that the influence of increased temperature alone on DO and UIA is insignificant.

Conclusion for potential thermal effects in relation to Estuary feature – in combination.

Based on all the available evidence, it is concluded that the combined thermal plume from HPB and HPC which will exist until 2023 (with current information) will not compromise the conservation objectives for the Estuaries feature concerning estuarine communities and abundances of estuarine species assemblages and therefore not have an adverse effect on site integrity.

It is also concluded that if there were an unforeseen effect on the intertidal and subtidal communities, in particular the thermally sensitive species Macoma balthica, then recovery of the communities would be relatively rapid, ie expected to be from 5 to 8 years following the cessation of a thermal discharge from Hinkley B.

Figure 6.5.4S10 HPB 70% and HPC 100%

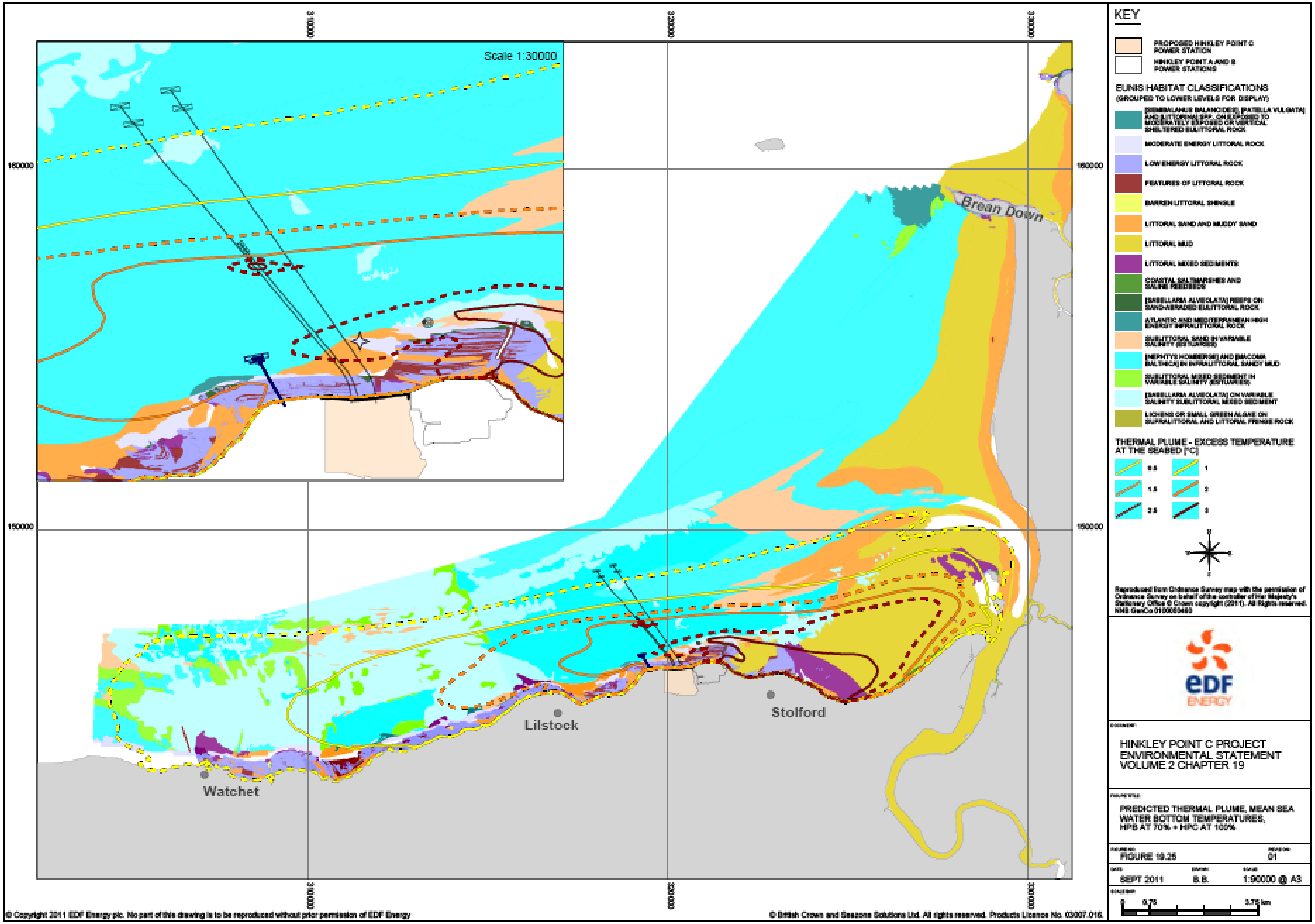


Figure 6.5.4S11   HPB 100% and HPC 100%

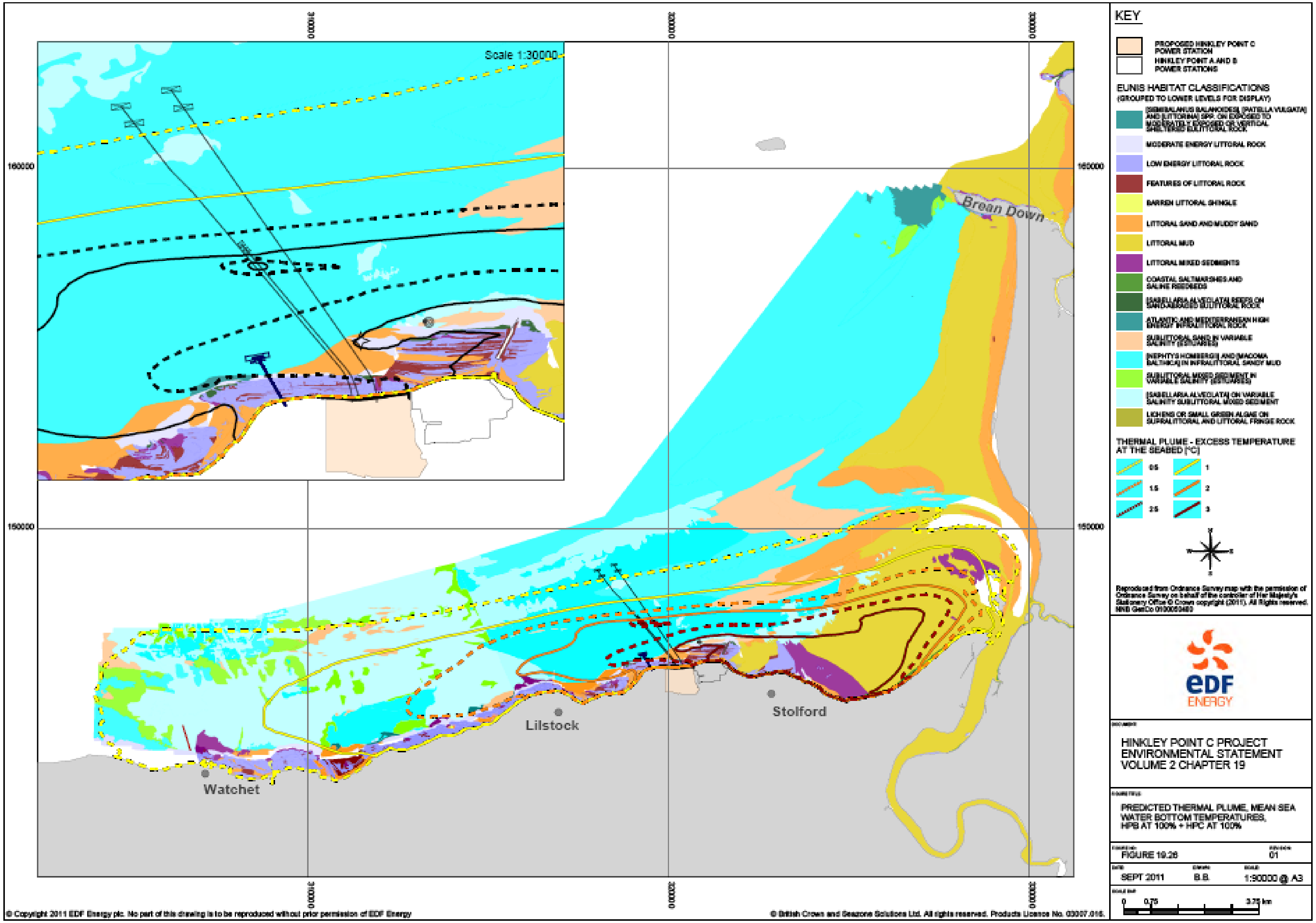


Figure 6.5.4S12 HPB 70%

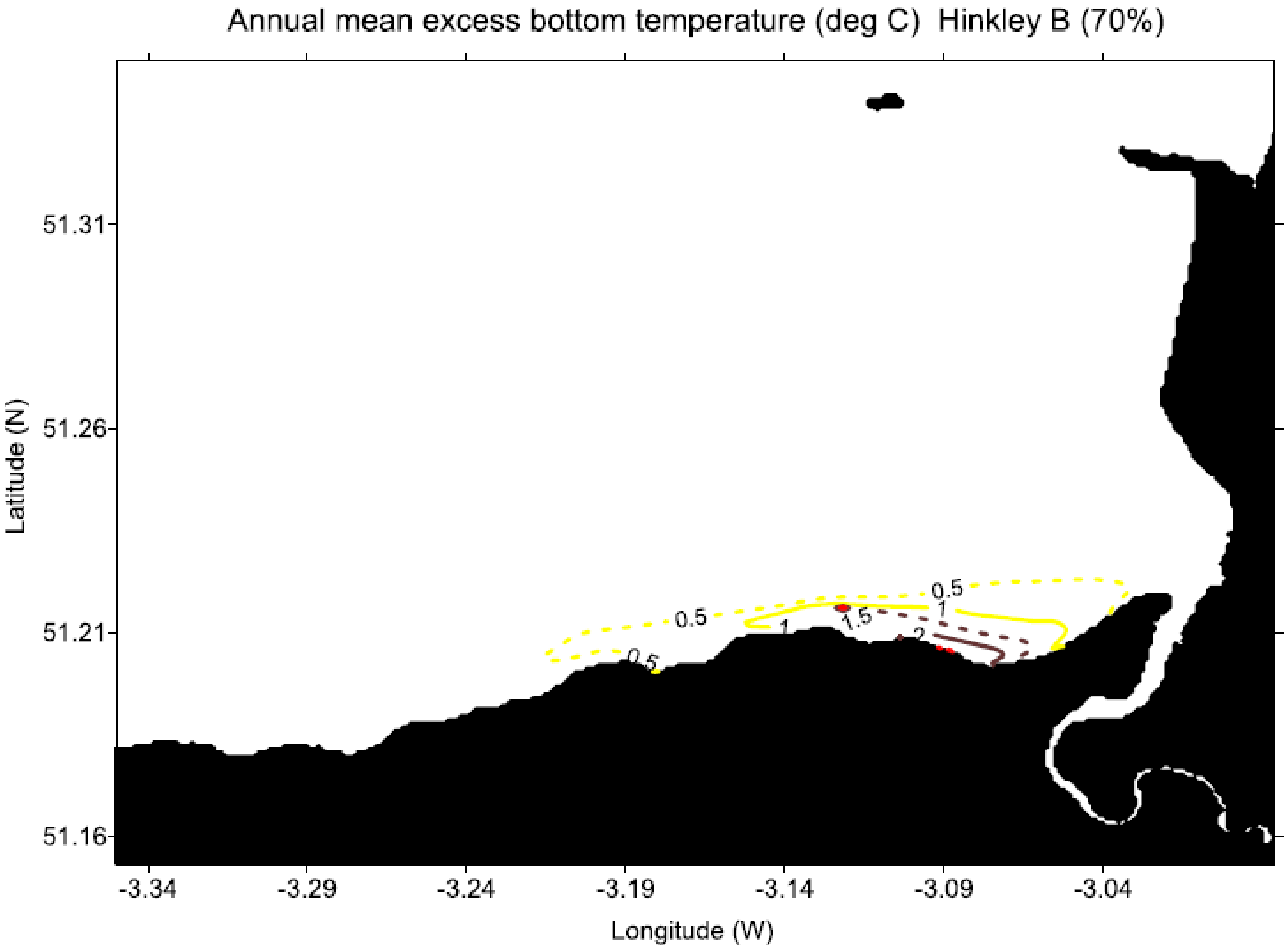


Figure 6.5.4S13 HPB 100%

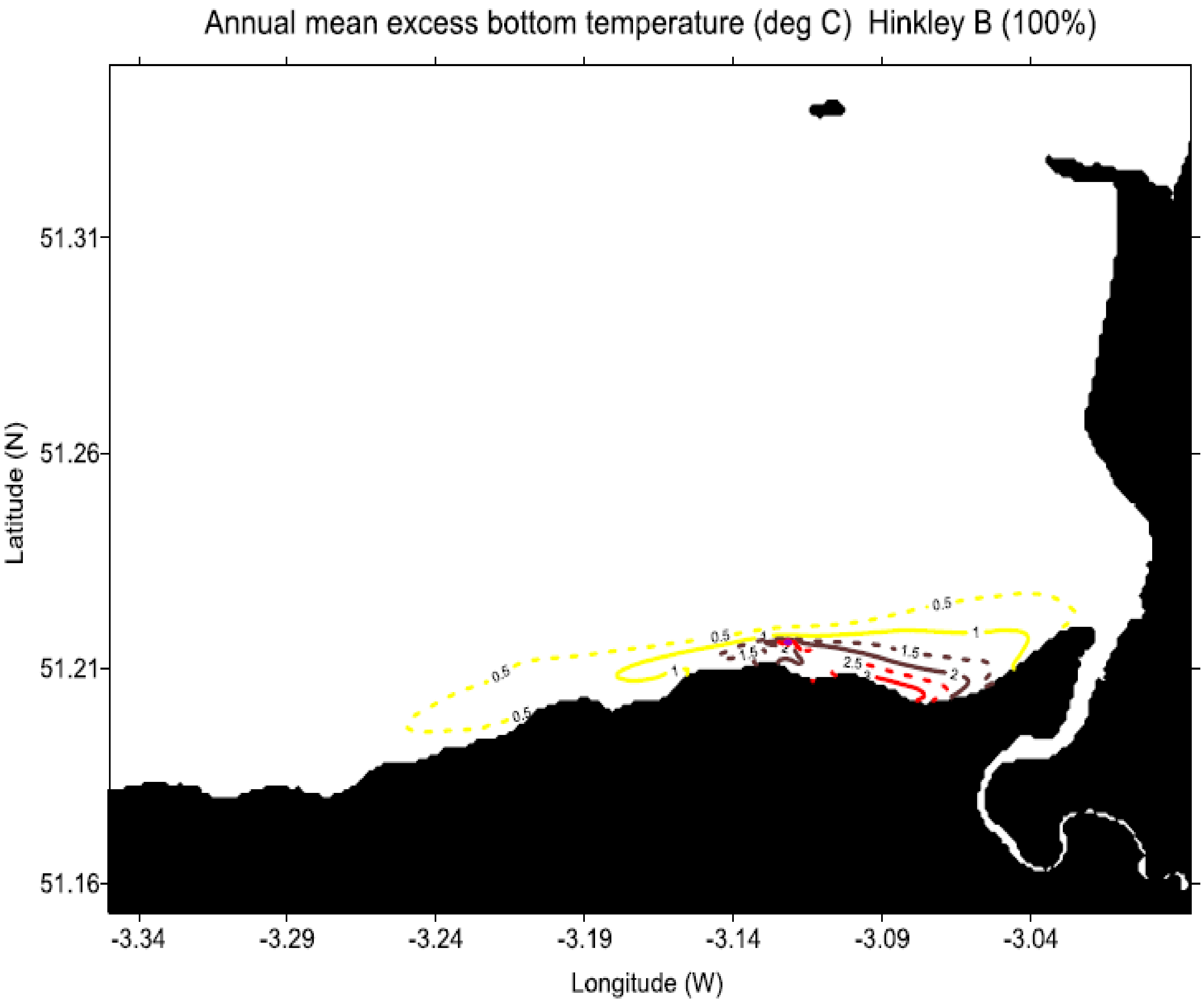
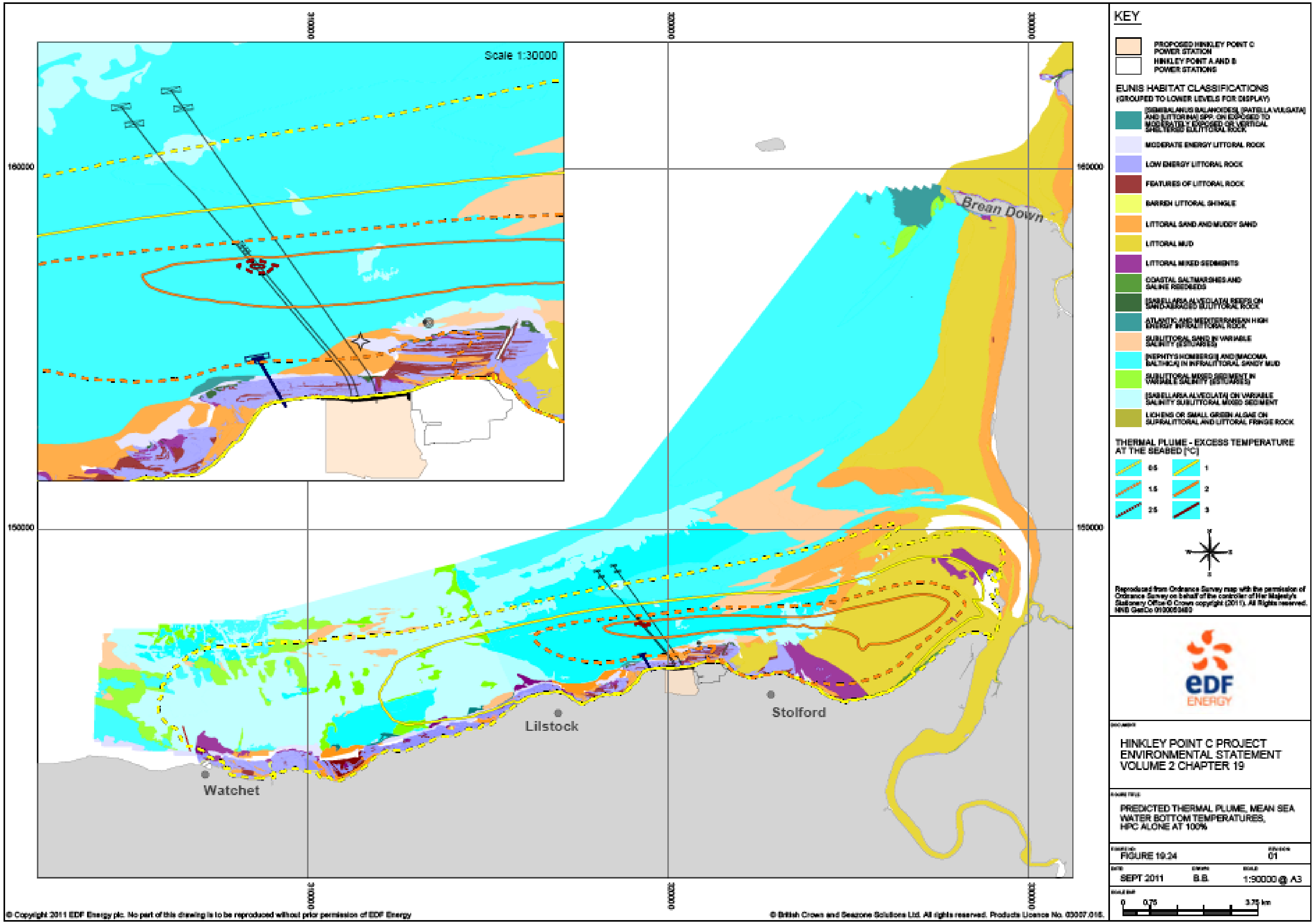


Figure 6.5.4 S14 HPC alone



6.5.5 Salinity

There are no Environment Agency permissions, plans or projects that could have an impact on the Estuaries feature in terms of salinity in combination with other permissions, plans or projects:

6.5.6 Increased turbidity and suspended sediment

Conservation objectives:

- *The characteristic physical form (tidal prism/cross sectional area) and flow (tidal regime)of the estuary is maintained;*
- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained;*
- *The extent, variety and spatial distribution of estuarine habitat communities within the site is maintained.*

Environment Agency permissions, plans or projects that could have an impact on the Estuaries feature in terms of turbidity, siltation and suspended sediment include the following:

- Water discharges during construction of HPC site
- Sea wall construction FDC
- Combwich Wharf development FDC

which could act in combination with turbidity, siltation and suspended sediment from the following other permissions, plans or projects:

- Jetty construction
- Construction of cooling water infrastructure
- Bristol deep sea container terminal
- EA Steart development
- Bristol Ports compensatory habitat at Steart

Relevant Proposed Plans and Projects and Existing Permits

There was no assessment of the impact of discharges on increased turbidity and suspended sediments in the Review of Consents as discharges were not considered to provide a significant input of suspended sediments to the Severn Estuary SAC and SPA, given the ambient suspended sediment regime.

Each of the proposed plans and projects and existing permits as shown in Table 6.2 S1 is assessed in the Table below in terms of its significance alone in relation to the specific hazard ‘increased turbidity and suspended sediments’.

Assessment of ‘In combination’ Effects

The time relationship of the different PPPs or permit is shown in Table 6.5.6 S2 in 3 month blocks to 2022, together with the scale of impact. ‘N’ signifies a negligible impact, ‘L’ signifies a likely significant effect, and ‘A’ signifies an adverse effect. It is apparent that not all the impacts of the PPPs and existing permits are additive, as they are not all coincident in time. Also most of the impacts are considered to be negligible or not measurable.

It is evident that most of the impacts related to increased turbidity and suspended sediments arising from the proposed plans and projects, and existing permits are very localised and temporary or intermittent and are considered to be negligible or not measurable, taking account of ambient background conditions. In combination, their combined impacts is therefore considered to be negligible. The only exception to this is the dredging and disposal operations for the Bristol Deep Sea Container Development where a measurable effect over a time period of a few years was predicted on the suspended sediment concentrations. The main area of impact of the increased suspended sediments was indicated to be between Sand Point and upstream of Oldbury, which outside the area affected by any of the activities related to Hinkley Point C. In addition, although there is a measurable effect on the suspended sediments, the impact was not considered to be significant, given the variation in natural background levels. The additional sediment input arising from the dredging and disposal operations for the Bristol Deep Sea Container Development is also measurable and predicted to be significant. However, its impact is not considered to be significant against the natural background sediment budget, and in fact could be beneficial by temporarily slowing the erosion of the intertidal mudflats.

Table 6.5.6 S1

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Jetty Construction and operation (maintenance dredging)	The pathway for increased turbidity and suspended solids from the jetty construction is through the release of bed sediments put into the water column during dredging and piling operations.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	The dredging operations are an initial dredge of some 25,140 m^3 from the berthing pocket followed by an unknown amount of maintenance dredging. Some local increase in the suspended sediment levels is expected during dredging operations. The increase in suspended sediments due to the dredging is assumed to be 500 mg/l (see Table 6.4 Section 6.2.221 p 208 of EDF Report (Haskoning 2011[592])). The measured range of ambient suspended sediment concentrations from the water quality surveys is 33 to 1795 mg/l (Amec Report 2010), so that this sediment concentration is within the range of sediment concentrations which are found at present. Any sediment plume will also be mixed and dispersed very rapidly, given the high current speeds and strong vertical mixing. In addition, the intertidal and subtidal fauna and flora reflects the ambient suspended sediment and hydrodynamic regime. It is therefore considered that there will be no measurable impact on the intertidal and subtidal fauna and flora due to the elevated turbidity and suspended solids. Maintenance dredging could also increase the turbidity and suspended sediments by a similar amount to the capital dredge. However, for the same reasons as those described above for the capital dredge, it is considered that there will be no measurable impact on the intertidal and subtidal fauna and flora due to the elevated turbidity and suspended solids. There will be a small localised increase in the suspended sediments due to piling in the sub-tidal sediments. However, the increase in suspended sediments are unlikely to raise the levels significantly above those which are found at present, and any plume will be rapidly dispersed, so that no measurable impact is considered likely. There may be some temporary localised oxygen demand in the water column due to the increase in suspended sediments related to the initial dredge, maintenance dredging, and piling activities. However, this will be minimal and very localised and is not considered to be significant in relation to any of the activities.	About 15 months during the construction phase of HPC. Indicated to be from mid 2012 to mid 2013. Dredging activities are expected to occur over a period of one month, after about 12 months from the start of construction. The jetty is indicated to be operational for about 90 months (7½ years), and then dismantled and removed over a period of 12 months.	There is potentially a localised impact from resuspended sediments due to dredging of the berthing pocket, as well as a very localised impact where the jetty piles are driven into the sea bed. However, it is considered that these impacts are not measurable. In addition, the capital dredge will only occur over a short period of about 1 month, while the impact from piling will occur intermittently for short periods over the 15 months of construction. Subsequent maintenance dredging has not been defined in terms of its duration and frequency, although it is considered that any impacts will also not be measurable. Based on the short duration of the activities, and the existing hydrodynamic and suspended sediment regime, it is concluded that there is no measurable impact due to elevated turbidity and suspended sediments from the jetty construction and operation on the intertidal and subtidal fauna and flora, the physical form and flow of the Estuary, the physico-chemical characteristics of the water column, and the sediment budget of the Estuary.
Sea wall construction	The pathway for increased turbidity and suspended solids from the sea wall construction is through discharges across the foreshore occurring during the construction operations.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	There will be an unknown volume of water discharged to the foreshore during the construction of the sea wall. This water will contain suspended sediments. It is not clear how the water discharge from the sea wall will be managed. It is stated in Section 6.2.244 p.212 of the EDF Report (Haskoning 2011) that that the water may either be discharged to the foreshore over the high water period, or be pumped into the water management system where it would be treated prior to discharge. Direct discharge over high water to the foreshore may lead to a very localised impact, although this likely to tbe insignificant given the ambient levels of suspended sediments in the coastal waters (range 33 – 1795 mg/l – Amec 2010[593]), and the rapid mixing which is expected to occur. Discharge following treatment in the water management system would be expected to result in levels of less than 250 mg/l in the discharge, which is less than the ambient mean suspended solids of 264 mg/l (Amec 2010).	About 12 months during the construction phase of HPC. Indicated to be from early 2013 to early 2014. The sea wall will then be in place for at least 720 months (60 years).	Any potential impact will be very localised and confined to the upper part of the intertidal zone. However, any suspended sediments in the discharge water will be very rapidly dispersed and diluted in the nearshore waters. Any potential impact will be restricted to the period of construction which is over a period of about 12 months. Based on the duration of the discharge, and the rapid mixing of any discharge in the nearshore waters, the impact of elevated turbidity and suspended sediments from the discharge on the intertidal fauna and flora is considered to be insignificant.

[592] Haskoning 2011.Hinkley Point C Project Report to inform the Habitats Regulati0ons Assessment (HRA). Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF. 1056 pp.
[593] AMEC 2010. Summary of Marine Surface Water Quality Non-Radiochemical Analysis Results (Campaigns 1-4 including WFD). Report reference 15011/TN/00081. August 2010.

					It is considered that there will be no measurable impact on the physical form and flow of the Estuary, the physico-chemical characteristics of the water column, and the sediment budget of the Estuary. Treating the discharge in the water management zone system would provide mitigation to any potential impact of the discharge.
Construction Discharges to Foreshore	The pathway for increased turbidity and suspended solids is through the discharge of surface water, pumped groundwater, and concrete plant washdown water to the foreshore, initially through the existing drainage ditch and subsequently the new outfall structure in the cliff.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	The permitted levels of suspended sediments in discharges to the foreshore under the permit number EPR/JP3122GM are 250 mg/l as a maximum. This level is less than the ambient mean suspended sediment concentration of 264 mg/l.	About 60 months. Indicated to be from mid to late 2012 to mid 2017 when the cooling water infrastructure is indicated to be complete.	As the permitted levels of suspended sediments in the discharge are less than the ambient average levels, it is considered that there will be no measurable impact of the construction discharges from elevated turbidity and suspended sediments on the intertidal fauna and flora, the physical form and flow of the Estuary, the physico-chemical characteristics of the water column, and the sediment budget of the Estuary.
Construction of cooling water infrastructure including water discharge from tunnel construction	The pathway for increased turbidity and suspended solids is through the discharge of groundwater and other water generated from the tunnelling activities to the foreshore through the new outfall structure in the cliff. There is also a pathway through the drilling of the vertical shafts for the intakes and outfall structures, as well as the emplacement of the intakes and outfall structures.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	For the discharge to the foreshore from the tunnelling activities, it is anticipated that the discharge flow rate will be 60 m^3/hour (about 3 l/s). The discharge may have up to 1 g/l after treatment (Section 6.2.230p. 213 of the EDF Report (Haskoning 2011)), depending on the method of tunnelling used. There will be an area of foreshore potentially affected by increased turbidity and suspended solids, but the expected levels in the discharge are within those measured in the coastal waters (range 33 – 1795 mg/l – Amec 2010), while rapid mixing will occur when the discharge enters the coastal waters. Any increase in turbidity and suspended sediments due to the drilling of the vertical shafts and the emplacement of the intakes and outfall structures is likely to be very localised. The increase in suspended sediments is unlikely to raise the levels significantly above those which are found at present, as any plume will be rapidly dispersed. There is expected to be some scouring of the bed sediments round the intakes and outfall structures due the presence of the structures and the cooling water discharge. However, the increase in suspended sediments is unlikely to raise the levels significantly above those which are found at present, as any plume will be rapidly dispersed.	About 54 months to complete the construction. Indicated to be from early 2013 to mid 2017. The drilling of the vertical shafts offshore and the emplacement of the intakes and outfall structures is expected to be towards the end of the construction period. Operational phase for the tunnels and infrastructure is about 720 months (60 years), commencing in mid 2017.	Based on the expected levels of suspended sediments in the discharge, it is considered that any impact on the estuaries feature will be negligible. It is also expected that any discharge will be permitted and treated in the water management zone system, therefore providing mitigation to any potential impact of the discharge. Any increase in turbidity and suspended sediments related to the offshore drilling and construction activities, including scour effects, will be very localised, so that any impact on the Estuaries feature will be minimal.
Combwich Development associated with HPC	The pathway for increased turbidity and suspended solids is through the release of bed sediments into the water column from both construction activities and operational use of the new Goods Wharf.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	The pathway for increased turbidity and suspended solids is through the release of bed sediments put into the water column during piling operations and construction work for a new barge bed and Goods Wharf. Sediments may also be put into the water column during the operational use of the berthing platform, either due to vessels using the platform, or through maintenance dredging to clear the platform of sediments. In addition there may some scouring of the intertidal and bed sediments due to the presence of the new structures. However, the range of ambient suspended sediment levels in the Parrett Estuary is very large, being from <100 mg/l up to >10,000 mg/l (10 g/l) (BEEMS Report TR127[594], EA Data, Uncles *et al* 2007[595])	About 12 months construction. Indicated to be during 2013. Operational phase is about 720 months (60 years), commencing at the start of 2014.	Any increase in turbidity and suspended solids related to the construction activities and perational use of the Wharf, including scour effects will be very localised, and negligible in the context of the existing sedimentary regime, so that any impact on the Estuaries feature will be minimal.

[594] BEEMS Technical Report TR127. Hinkley Point; Combwich Hydrographic Survey. Including Appendix F - Water, sediment and benthic sampling. EDF BEEMS (Cefas/Titan), 2010.
[595] Uncles R.J., Stephens J.A., and Harris C. 2007 Review of Salinity, Temperature and Suspended Sediments data for estuaries in the South West Region. Report to the EA SW Region. February 2007. 95 pp.

			Any localised elevation in turbidity and suspended sediments due to the construction or operation of the Wharf is therefore considered to have no measurable effect on the turbidity or suspended sediment regime in the Parrett Estuary.		
HPC Cold commissioning discharges	The pathway for increased turbidity and suspended solids is through the discharge of water containing conditioning chemicals to the foreshore through the new outfall structure in the cliff for the first EPR unit, and through the cooling water outfall for the second EPR unit.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	The estimated maximum concentrations of suspended sediments in the discharge are les than 25 mg/l (see Table 6.5 Section 6.2.297 p.220 of EDF Report (Haskoning 2011)), which his considerably less than the ambient levels of suspended sediments (range 33 – 1795 mg/l – Amec 2010). It is therefore considered that there will be no measurable effect on the turbidity or suspended sediment regime of the nearshore waters.	About 24 months for each EPR unit. Indicated to be from early 2016 to mid? 2017 for the first EPR unit, and late 2017 to late 2019 for the second EPR unit.	Based on the expected levels of suspended sediments in the discharge, it is considered that any impact on the estuaries feature will be negligible. It is also expected that any discharge will be permitted and treated in the water management zone system, therefore providing mitigation to any potential impact of the discharge.
Bristol Deep Sea Container Terminal Development	The pathway for increased turbidity and suspended solids is through the release of bed sediments put into the water column during dredging and disposal operations for both the capital dredge and future maintenance dredging.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	It is stated in the ES for the Bristol Deep Sea Container Terminal that the dredging may result in increased suspended sediments of between 100 and 500 mg/l (Section 7.7.2, p.214 of the ES (BDSCT ES 2008[596]) . The plumes of suspended sediment generated by the capital dredging activity are predicted to extend from about Sand Point down the Severn Estuary to just north of Oldbury up the Estuary. It is also predicted that background levels of suspended sediments throughout the Estuary could increase by about 10 to 20%, but that this will only occur after about 10 months of dredging. The ambient levels of suspended sediments in the area of the capital dredge range between about 100 mg/l to in excess of 10,000 mg/l (10 g/l) (see eg. Kirby 1986,[597] Jonas *et al* 2006[598]), reflecting the variation in hydrodynamic conditions between neap and spring tides, and the variation in tidal currents over the tidal cycle. There is also a large variation from the surface to bed concentrations. The nature of the sediments put into suspension by the dredging is not expected to be any different from the sediments already withjn the sedimentary regime. Deposition of suspended sediments is expected to occur both in the intertidal and subtidal areas affected by the sediment plumes, although the depositional regime is not expected to be significantly different from that occurring at present. The intertidal and subtidal faunal and floral communities are therefore not expected to be significantly affected by the deposition. The disposal of Mercia mudstone in the proposed new site at Holm Deep will result in elevated turbidity and suspended sediments due to both the actual disposal activity as well as erosion and redistribution of the disposed material due to the strong tidal currents. It is predicted that most of the sediment will be deposited in the existing subtidal sediment sink areas of Newport Deep and Bridgwater Bay, although there may also be some deposition on intertidal areas (see Section 7.9.2 pp.219 – 210 of the ES (BDSCT ES 2008)). The estimated suspended sediment load in transport during a spring tide in the Severn Estuary is some 30 million tons (see eg. Kirby 1986). The effective mass of sediments being added to this suspended sediment load due to the dredging and disposal is some 31½ million tons. 2.24 million tons will be sand-sized material released during the dredging (Section 7..6.7 p.212 of ES). This would equate to about 0.75 million	Based on information in the BDSCT ES 2008 (Sections 3.2.3 and 3.2.4 pp. 45 – 46), there will be about 78 to 80 months (6½ years) in total of dredging, in 3 phases. Phase 1 – 6 months .. Phase 2 – 35 months…. Phase 3 – 36 months… However, it is stated that taking account of the overlap of different phases the maximum duration of the main dredging will be 39 months. Disposal of Mercia mudstone in the new disposal site in Holm Deep would occur over about 36 months (Phase 3). There is no defined start date yet for the dredging. Once the capital dredging and quay construction are completed, maintenance dredging will commence and continue indefinitely.	It was concluded in the ES that, in the context of the conservation objectives for the Severn Estuary SAC, there were no significant effects due to the increased turbidity and suspended sediments arising from the dredging and disposal operations.

[596] Bristol Deep Sea Container Terminal. Environmental Statement. The Bristol Port Company. Final Report 9R4093. 21 July 2008. 763 pp.
[597] Kirby, R. 1986. Suspended fine cohesive sediment in the Severn Estuary and Inner
Bristol Channel, U.K. Department of Energy, Energy Technology Support Unit, Report
ETSU-STP-4042.
[598] Jonas P.J.C., Hudson R., Simpson M., and Waite M. 2006. Phase 2 Severn Estuary Water Quality Investigations. EA Internal Report. Final Draft. 40 pp.

			tons a year over the 3 year period of the capital dredge. The remainder has been assumed to be fines (or mud, ie. silt and clay sized material), some of which are produced through abrasion of sand sized Mercia mudstone (Table 7.13 in Section 7.9.1 p. 218 of the ES (BDSCT ES 2008)). The estimated annual input of fines is about 3.6 million tons per year during the dredge, and about 1.8 million tons following the dredge, assuming that all the Mercia mudstone in the disposal site is eroded and redistributed at a constant rate over a 10 year period (see Table 7.13 in Section 7.9.1 p. 218 of the ES). During the period of the dredge, the annual input of fines from the dredging activities represents about the same mass of fines which is estimated to be provided annually from all sources to the Severn Estuary (3.5 to 4.0 million tons . EA 2006 – Severn Estuary CHaMP[599]). Following the dredge, the annual input over the assumed 10 year period would represent about half of the present annual input of fines to the Severn Estuary. It is not known exactly how the Severn Estuary will respond to the additional sediment input from the dredging and disposal operations. It was concluded in the ES that the majority of the fines released into the Severn Estuary from the dredge and the disposal of the Mercia mudstone would accumulate, in the longer term, in the existing sediment sinks of Newport Deep and Bridgwater Bay, and particularly the subtidal areas of Bridgwater Bay. Any accumulations on the muddy intertidal areas were likely to be temporary, and any longer term accumulation would probably be lost once the increased sediment supply from the dredging and disposal operations ceased.		
EA Steart Managed Realignment	The pathway for increased turbidity and suspended solids is through the erosion of the sediments in the breach channel, and soils which become periodically inundated by estuarine waters following the opening of the breach in the tidal embankments.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	There could be a short-term elevation in turbidity and suspended solids following the breach, due to erosion and deposition in the tidal channels as they develop into an hydraulic equilibrium. However, the increased levels will be predominantly within the realighnment site, so that no significant effect is expected in the Parrett Estuary. In the long-term, once the realignment site is in hydraulic equilibrium, it is expected that there will be no measurable changes in the turbidity and suspended sediment levels compared with ambient levels in the Parrett Estuary.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is about one month in mid 2013. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	Any increase in turbidity and suspended solids related to the breach area and the managed realignment site will be very localised, and negligible in the context of the existing sedimentary regime, so that any impact on the Estuaries feature will be minimal.
Bristol Port Compensation Habitat Creation at Steart	The pathway for increased turbidity and suspended solids is through the erosion of the sediments in the breach channel, and soils which become periodically inundated by estuarine waters following the opening of the breach in the tidal embankments.	Elevated turbidity and suspended solids could result in increased sedimentation which could smother the intertidal and subtidal fauna and flora, or alter the physical form and flow of the Estuary. They could also affect the physico-chemical characteristics of the water column and alter the sediment budget of the Estuary.	There could be a short-term elevation in turbidity and suspended solids following the breach, due to erosion and deposition in the tidal channels as they develop into an hydraulic equilibrium. However, the increased levels will be predominantly within the realighnment site, so that no significant effect is expected in Bridgwater Bay. In the long-term, once the realignment site is in hydraulic equilibrium, it is expected that there will be no measurable changes in the turbidity and suspended sediment levels compared with ambient levels in Bridgwater Bay.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is not yet defined. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic	Any increase in turbidity and suspended solids related to the breach area and the managed realignment site will be very localised, and negligible in the context of the existing sedimentary regime, so that any impact on the Estuaries feature will be minimal.

[599] Environment Agency 2006. Severn Estuary Coastal Habitat Management Plan (CHaMP)

				equilibrium.	

Table 6.5.6 S2

Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022				
Elevated Turbidity and Suspended Solids	**PPP or Permit**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
	Jetty construction and operation (maintenance dredging)			Construction					Operation																													Demolition								
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N				
	Sea wall construction						Construction				Operation																																			continues indefinitely
							N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Construction Discharges to Foreshore				Construction																																									
					N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N																							
	Construction of cooling water infrastructure						Construction																	Operation																						continues to end of life of HPC
							N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Combwich Development associated with HPC					Construction				Operation																																				continues to end of life of HPC
						N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	HPC Cold commissioning discharges																		Discharge to foreshore						Discharge into cooling water flow																					
																			N	N	N	N	N	N	N	N	N	N	N	N	N	N														
	Bristol Deep Sea Container Terminal Development													?Dredging and Construction? Start date not yet known													Operation																			continues indefinitely
														L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	
	EA Steart Managed Realignment			Construction				Operation																																						continues indefinitely
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Bristol Port Compensation Habitat Creation at Steart									Construction Date not yet known ?				Operation																																continues indefinitely
										N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	

Conclusion for effects of turbidity and suspeneded sediments in combination in relation to the estuary feature

In conclusion, the conservation objectives of the Estuaries feature are not compromised by the increased turbidity and suspended sediments from all the proposed plans and projects and existing permits when considered 'in combination'. It is therefore concluded that there is no adverse effect on site integrity.

6.5.7 Habitat loss and physical damage

Conservation objectives:

- *The total extent of the estuary is maintained;*
- *The characteristic physical form (tidal prism/cross sectional area) and flow (tidal regime)of the estuary is maintained;*
- *The physico-chemical characteristics of the water column support the ecological objectives;*
- *The characteristic range and relative proportions of sediment sizes and sediment budget within the site is maintained;*
- *The extent, variety and spatial distribution of estuarine habitat communities within the site is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Environment Agency permissions, plans or projects that could have an impact on the Estuarine feature in terms of physical damage and/or habitat loss include the following:

- Sea wall construction FDC

which could act in combination with physical damage and/or habitat loss from the following other permissions, plans or projects:

- Jetty construction
- Construction of cooling water infrastructure
- Bristol deep sea container terminal

Relevant Proposed Plans and Projects and Existing Permits

There was no assessment of the impact of discharges on habitat loss and physical damage in the Environment Agency Review of Consents as discharges were not considered to result in habitat loss and physical damage.

Each of the proposed plans and projects and existing permits as shown in Table 6.2 S1 is assessed below in terms of its significance alone in relation to the specific hazard 'habitat loss and physical damage'.

Assessment of 'In combination' Effects

The total extent of the subtidal and intertidal areas damaged or lost due to the various PPPs is 702.06 of the subtidal, and 9.18 ha of the intertidal, of which about 3.05 to 4.05 ha is rocky shore. However, the actual areas of long-term habitat loss are: 0.6 ha of upper intertidal barren shingle and boulders which will be lost due to the construction of the seawall, and 0.18 ha of the subtidal area due to the intake and outfall structures. These areas are not considered to be significant in relation to the Estuaries feature. All other areas damaged by construction or dredging activities are expected to recover following completion of these works. This includes the jetty structure which is expected to be dismantled and removed after about 7½ years. The expected recovery period will vary depending on the extent of the physical damage and the habitat affected. The maximum recovery time has been stated to be about 10 years for some areas of the rocky shore affected by the seawall construction activitie (EDF HRA Report 2011). All other areas affected are expected to recover within about 5 years or less.

Based on the available information, it is concluded that the conservation objectives for the Estuaries feature are not compromised by habitat loss or physical damage due to all the relevant PPPs acting in combination. It is therefore concluded that there is no adverse effect on site integrity.

Table 6.5.7S1

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Jetty construction, operation, and demolition	The pathway for habitat loss and physical damage from the jetty construction is through the construction activities on the foreshore and in the sub-tidal area, through operational activities maintaining the jetty, eg. maintenance dredging, and the scouring of sediment due to the piles.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction and operational activities, as well as demolition activities. The permanent loss of habitat is through the placement of piles on the foreshore and the sub-tidal area. The temporary loss of habitat is through the dredging of a berthing pocket in the sub-tidal area.The loss of habitat and the presence of the jetty structure could influence the physical form and flow of the estuary and reduce the extent of the estuarine habitats. Physical damage to the habitat could occur through the use of vehicles on the foreshore, and the use of piling equipment both on the foreshore and in the sub-tidal area. The extent and variety of the intertidal and subtidal habitats could be reduced by the physical damage.	The total area of impact on the sea bed habitats due to the construction of the jetty, its presence during its operational life, and its demolition is about 2.5 ha, based on the areas of each of the 3 main elements; the jetty bridge, the jetty head, and the berthing pocket. About 0.8 ha of this area is intertidal (mostly rocky shore), while about 1.7 ha is subtidal. The total area of impact equates about 0.003% of the Estuaries feature (area 73678 ha), which is insignificant. The area of impact equates to about 0.05% of the total intertidal rocky shore habitat in the Severn Estuary SAC (area 1500 ha), which is also insignificant. The subtidal habitat most affected by the jetty is mud, and the biotope *Nephtys hombergii* and *Macoma balthica* infralittoral sandy mud. This habitat comprises about 7,600 ha of the subtidal area surveyed in Bridgwater Bay (Section 6.2.160 p.194 of EDF Report). The area of impact therefore equates to about 0.02% of this biotope in Bridgwater Bay, which is insignificant. In relation to the total extent of this biotope occurring in the Estuaries feature, the area of impact will be much less. Any impacts of the jetty structure on the physical form and flow of the estuary will be minimal and very local to the jetty structure, as the jetty is an open piled structure which should not create a significant obstruction to flow. The total cross-sectional area of the piles in the jetty is estimated to be about 1,500 m^2 at mean high water spring tides This equates to about 0.3% of the cross-sectional area of the Severn Estuary SAC at this part of the Inner Bristol Channel, which is about 450,000 m^2 at mean high water spring tides (see 2.6.1S3 in the Alone Assessment)	About 15 months during the construction phase of HPC. Indicated to be from mid 2012 to mid 2013. Dredging activities are expected to occur over a period of one month, after about 12 months from the start of construction. The jetty is indicated to be operational for about 90 months (7½ years), and then dismantled and removed over a period of 12 months.	The area of impact of the jetty and ancillary works is considered to be insignificant in relation to the Estuaries feature.

Table 6.5.7S1 (continued)

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Sea wall construction	The pathway for habitat loss and physical damage from the sea wall construction is through the construction activities on the foreshore, and through operational activities maintaining the sea wall, eg. Maintenance repairs.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction and operational activities. The permanent loss of habitat is through the placement of large boulders at the toe of the sea wall which will alter the nature of the uppermost part of the intertidal zone. The loss of habitat could reduce the extent of the estuarine habitats. Physical damage to the intertidal habitat could occur through several activities during the construction of the sea wall: the damage by vehicles and other plant using the working corridor; the damage by the barges bringing in the boulders for the toe of the sea wall; the stockpiling of boulders on the foreshore. The extent and variety of the intertidal habitats could be reduced by the physical damage. The construction of the sea wall will reduce the supply of sediment to the Severn Estuary SAC from the cliff face at Hinkley.	The total area of impact on the sea bed habitats due to the construction of the sea wall is about 43,280 m^2 or 4.38 ha. This equates to about 0.006% of the Estuaries feature. The area is entirely intertidal, although about 2.13 ha of the area is barren littoral shingle, so that about 2.25 ha is intertidal rocky shore. This area of impact equates to about 0.15% of the total intertidal rocky shore habitat (1500 ha). The area of intertidal habitat permanently lost through the construction of the sea wall is very small, as the sea wall is above highest astronomical tide level, although the rocks forming the toe and scour protection are in the upper intertidal zone. The estimated total area lost at the top of the foreshore is 0.6 ha of barren shingle and boulders (see Table 6.3.5 p.405 of EDF Report (Haskoning 2011)). The cross-section of the estuary is not materially altered due to the presence of the sea wall, given its location at the top of the foreshore. Also no reduction in the cross-section at the top of the foreshore is expected, as the scour protection at the toe of the sea wall will be finished to match the existing cross shore profiles (Section 6.2.389 p. 238 of the EDF Report (Haskponing 2011)). It is accepted that the sea wall will result in the loss of some sediment supply to the Bristol Channel as it will protect the cliffs fronting the power station from erosion. The contribution of sand and mud from the present cliff erosion at this location is considered to be insignificant compared with that from other sources. Assuming that the sand and mud proportion of the cliff erosion is 75%, ie. About 900 m^3 per year, then this equates to about 2,000 tonnes of sediment. This is about 0.04% of the total annual sediment supply to the Severn Estuary which is between 4.16 and 5.4 million tonnes per year (EA 2006, Severn Estuary ChaMP[600]). This is considered to be insignificant. It has been estimated that the supply of gravel to the Estuary due to the cliff erosion is about 300 m^3 per year, which after dissolution and attrition represents about 150 m^3 per year down-drift from the Hinkley site at the gravel ridges of Catsford And Wall Commons. In relation to the overall gravel budget of the Severn Estuary, this volume is also considered to be insignificant, given the existing volumes of gravel which occur over the whole site. However, the main intertidal features which are believed to receive the gravels from the cliff erosion at Hinkley are the local gravel pocket beaches, the gravel strips at high water, and the gravel ridge complexes to the east of Stolford; ie the gravel ridges of Catsford and Wall Commons. The volume of gravel in the gravel ridges of Catsford and Wall Commons is estimated to be about 300,000 m^3. The potential loss from the cliff therefore equates to about 0.05% of the gravel volume. Over a 100 years, this volume could reach 5% of the estimated volume of the ridges. However, it is not clear how much of this cliff sediment actually reaches the gravel ridge complexes to the east, particularly with the line of coastal defences comprising large boulders which lie between Hinkley and Stolford. These could act as a trap for any gravels which are being transported to the east between Hinkley and Stolford. Also, additional gravel sediment will be provided by erosion of the cliffs to the west of Hinkley and by the erosion of the wave cut platform, so the loss of sediment from the cliffs behind the sea wall do not represent the only source of gravel sized sediment to the area.	About 12 months during the construction phase of HPC. Indicated to be from early 2013 to early 2014. The sea wall will then be in place for at least 720 months (60 years).	In relation to the Estuaries feature, the area of impact is insignificant. In addition, most of the loss of intertidal habitat or physical damage to the intertidal habitat will be temporary, so that the habitat is expected to recover, although full recovery is expected to take between 5 and 10 years.

[600] Environment Agency 2006. Severn Estuary Coastal Habitat Management Plan (CHaMP)

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Sea wall construction	The pathway for habitat loss and physical damage from the sea wall construction is through the construction activities on the foreshore, and through operational activities maintaining the sea wall, eg. Maintenance repairs.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction and operational activities. The permanent loss of habitat is through the placement of large boulders at the toe of the sea wall which will alter the nature of the uppermost part of the intertidal zone. The loss of habitat could reduce the extent of the estuarine habitats. Physical damage to the intertidal habitat could occur through several activities during the construction of the sea wall: the damage by vehicles and other plant using the working corridor; the damage by the barges bringing in the boulders for the toe of the sea wall; the stockpiling of boulders on the foreshore. The extent and variety of the intertidal habitats could be reduced by the physical damage. The construction of the sea wall will reduce the supply of sediment to the Severn Estuary SAC from the cliff face at Hinkley.	The total area of impact on the sea bed habitats due to the construction of the sea wall is about 43,280 m^2 or 4.38 ha. This equates to about 0.006% of the Estuaries feature. The area is entirely intertidal, although about 2.13 ha of the area is barren littoral shingle, so that about 2.25 ha is intertidal rocky shore. This area of impact equates to about 0.15% of the total intertidal rocky shore habitat (1500 ha). The area of intertidal habitat permanently lost through the construction of the sea wall is very small, as the sea wall is above highest astronomical tide level, although the rocks forming the toe and scour protection are in the upper intertidal zone. The estimated total area lost at the top of the foreshore is 0.6 ha of barren shingle and boulders (see Table 6.3.5 p.405 of EDF Report). The cross-section of the estuary is not materially altered due to the presence of the sea wall, given its location at the top of the foreshore. Also no reduction in the cross-section at the top of the foreshore is expected, as the scour protection at the toe of the sea wall will be finished to match the existing cross shore profiles (Section 6.2.389 p. 238 of the EDF Report). It is accepted that the sea wall will result in the loss of some sediment supply to the Bristol Channel as it will protect the cliffs fronting the power station from erosion. The contribution of sand and mud from the present cliff erosion at this location is considered to be insignificant compared with that from other sources. Assuming that the sand and mud proportion of the cliff erosion is 75%, ie. About 900 m^3 per year, then this equates to about 2,000 tonnes of sediment. This is about 0.04% of the total annual sediment supply to the Severn Estuary which is between 4.16 and 5.4 million tonnes per year (EA 2006, Severn Estuary ChaMP). This is considered to be insignificant. It has been estimated that the supply of gravel to the Estuary due to the cliff erosion is about 300 m^3 per year, which after dissolution and attrition represents about 150 m^3 per year down-drift from the Hinkley site at the gravel ridges of Catsford And Wall Commons. In relation to the overall gravel budget of the Severn Estuary, this volume is also considered to be insignificant, given the existing volumes of gravel which occur over the whole site. However, the main intertidal features which are believed to receive the gravels from the cliff erosion at Hinkley are the local gravel pocket beaches, the gravel strips at high water, and the gravel ridge complexes to the east of Stolford; ie the gravel ridges of Catsford and Wall Commons. The volume of gravel in the gravel ridges of Catsford and Wall Commons is estimated to be about 300,000 m^3. The potential loss from the cliff therefore equates to about 0.05% of the gravel volume. Over a 100 years, this volume could reach 5% of the estimated volume of the ridges. However, it is not clear how much of this cliff sediment actually reaches the gravel ridge complexes to the east, particularly with the line of coastal defences comprising large boulders which lie between Hinkley and Stolford. These could act as a trap for any gravels which are being transported to the east between Hinkley and Stolford. Also, additional gravel sediment will be provided by erosion of the cliffs to the west of Hinkley and by the erosion of the wave cut platform, so the loss of sediment from the cliffs behind the sea wall do not represent the only source of gravel sized sediment to the area.	About 12 months during the construction phase of HPC. Indicated to be from early 2013 to early 2014. The sea wall will then be in place for at least 720 months (60 years).	In relation to the Estuaries feature, the area of impact is insignificant. In addition, most of the loss of intertidal habitat or physical damage to the intertidal habitat will be temporary, so that the habitat is expected to recover, although full recovery is expected to take between 5 and 10 years.

Table 6.5.7S1 (continued)

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Construction of cooling water infrastructure	The pathway for habitat loss and physical damage from the construction of the cooling water infrastructure is through the construction activities in the sub-tidal area at the intake and outfall structures, and scouring of sediment due the offshore intakes and outfall structures.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction activities. The permanent loss of habitat is through the drilling of the vertical shafts into the sea bed and the placement of the 4 intakes and 2 outfall structures. It could also occur through scouring of the sea bed round the structures and due to the discharge of cooling water. The loss of habitat and presence of the structures could influence the physical form and flow of the estuary and reduce the extent of the estuarine habitats. Some temporary loss of habitat and physical damage could occur from the drilling rigs and construction activities related to the drilling of the vertical shafts. The extent and variety of the subtidal habitats could be reduced by the physical damage.	The area of sub-tidal habitat which will be lost due the placement of the 4 intake structures and 2 outfall structures is about 0.18 ha (1,800 m^2) (see Section 6.2.392,p.239 of EDF Report). The subtidal habitat most affected by the intakeas and outfall structures is mud, and the biotope *Nephtys hombergii* and *Macoma balthica* infralittoral sandy mud. This habitat comprises about 7,600 ha of the subtidal area surveyed in Bridgwater Bay (Section 6.2.160 p.194 of EDF Report). The area of subtidal habitat loss therefore equates to about 0.002% of this biotope in Bridgwater Bay, which is insignificant. In relation to the total extent of this biotope occurring in the Estuaries feature, the area of impact will be much less. There is likely to be some scour of bed sediments surrounding the intakes and outfall structures, so this area of habitat loss may be greater. However, even assuming that the area of loss is doubled, this would still equate to only 0.004% of the *Nephtys hombergii* and *Macoma balthica* infralittoral sandy mud biotope in Bridgwater Bay. Similarly there will be disturbance of the subtidal habitat in the vicinity of the intakes and outfall structures during both their emplacement (including the drilling of the vertical shafts), and their removal during decommissioning of HPC. The area of subtidal habitat affected is not defined, but assuming that it is about twice that of the structures, then this area will also equate to about 0.0004% of the *Nephtys hombergii* and *Macoma balthica* infralittoral sandy mud biotope in Bridgwater Bay. The cross-sectional area of each intake and outfall structure is estimated to be about 50 m^2. Assuming that 2 of the intakes or outfall structures are affecting the flow in the cross-section of the Inner Bristol Channel, the total area is 100 m^2. This equates to about 0.02% of the cross-sectional area of the Severn Estuary SAC at this part of the Inner Bristol Channel, which is about 450,000 m^2 at mean high water spring tides (see Figure 2.6.1 S3 in the Alone Assessment)	construction period for the cooling water infrastructure indicated to be between 2013 and mid 2017. Operational phase is about 720 months (60 years), commencing in mid 2017.	The area of impact related to the construction and emplacement of the intake and outfall structures is considered to be insignificant in relation to the Estuaries feature.
Combwich Development associated with HPC	The pathway for habitat loss and physical damage is through the construction work for a new barge bed and Goods Wharf and scouring of sediment related to the new structures.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction activities. The loss of habitat could influence the physical form and flow of the estuary and reduce the extent of the estuarine habitats. The extent and variety of the intertidal and subtidal habitats could be reduced by the physical damage.	The works to be undertaken to upgrade Combwich Wharf are located outside the boundary of the Severn Estuary SAC. An area of intertidal habitat amounting to 0.23 ha (2,321 m^2) would be lost in Combwich Pill and at the mouth of the Pill, but this is stated to be outside the boundary of the SAC. No other losses are expected from the other works (see Sections 7.2.84 to 7.2.88 p.481 of EDF Report). No noticeable effects on sediment scour and deposition in the Parrett Estuary are expected from the new structures at Combwich Wharf (Section 7.2.89 p. 481 of EDF Report). Assuming that the area of habitat loss is within the Severn Estuary SAC, this would equate to about 0.05% of similar intertidal habitat in the Parrett Estuary which is estimated to have an area of about 449 ha. The cross-section and tidal volume of Combwich Pill will be affected by the new Goods Wharf, but this is not anticipated to have a significant impact on the physical form or flow in the Parrett Estuary. The reduction in tidal volume of Combwich Pill of 5,225 m^3 equates to about 0.015% 0f the tidal volume of the Parrett Estuary, which is estimated to be about 35 million m^3 (Sections 7.2.75 to 77 pp 458-9 of EDF Report). The change in cross-section of the Parrett Estuary due to the new barge bed is estimated to be 1.8% at a tidal level of 1 m above OD Newlyn, but this is reduced at higher tidal levels. Mean high water spring tide level at Combwich is nearly 6 m above OD Newlyn, so at this tide level the change will be considerably less than 1.8%.	About 12 months construction. Indicated to be during 2013. Operational phase is about 720 months (60 years), commencing at the start of 2014.	The area of impact related to the Combwich Development associated with HPC is considered to be insignificant in relation to the Estuaries feature.

Table 6.5.7S1 (continued)

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Bristol Deep Sea Container Terminal Development	The pathway for habitat loss and physical damage is through the dredging and disposal operations for both the capital dredge and future maintenance dredging, and the reclamation at Avonmouth for the new quay.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction activities. The permanent loss of intertidal habitat is through the reclamation and construction of a new quay at Avonmouth. There is also temporary loss of intertidal habitat at Avonmouth due to short to medium term functional change in the intertidal area at Avonmouth due to the new quay. The loss of habitat could influence the physical form and flow of the estuary and reduce the extent of the estuarine habitats. In addition there are potential temporary alterations of the subtidal habitats and benthic communities in the footprint of both the capital and maintenance dredging, as well as the zone of impact of the sediments disposed at the new disposal site at Holm Deep. The extent and variety of the subtidal habitats could be reduced by the physical damage related to the dredging and disposal activities.	An adverse effect on the integrity of the Severn Estuary SAC was concluded from the HRA for the Bristol Deep Sea Container Terminal Development. The adverse effects related to both direct loss of intertidal habitat at the Avonmouth site, as well as localised alteration of the hydrodynamic regime leading to short to medium term functional change, as a result of significant accretion of fine sediments above background rates, in the intertidal flats in the vicinity of the Avonmouth Site. A Mitigation, Compensation and Monitoring Agreement relating to the Bristol Deep Sea Container Terminal was therefore drawn up. The main element of the compensation package is the requirement for a managed realignment site. This is the Project known as the Bristol Port Compensation Habitat Creation at Steart. The total area of subtidal habitat directly affected by the capital dredge and the new disposal site at Holm Deep is about 700 ha. This equates to about 0.95% of the Estuaries feature, or about 1.4% of the total subtidal area of the Estuaries feature. The subtidal habitats affected by the dredge are known to have an impoverished fauna (Warwick et al. 2001[601], BDSCT ES 2008[602]), while the *Sabellaria* reefs feature is absent from the the footprints of the terminal, approach channel and disposal ground (Warwick 2008[603]).	Based on information in the BDSCT ES 2008 (Sections 3.2.3 and 3.2.4 pp. 45 – 46), there will be about 78 to 80 months (6½ years) in total of dredging, in 3 phases. Phase 1 – 6 months .. Phase 2 – 35 months…. Phase 3 – 36 months… However, it is stated that taking account of the overlap of different phases the maximum duration of the main dredging will be 39 months. Disposal of Mercia mudstone in the new disposal site in Holm Deep would occur over about 36 months (Phase 3). There is no defined start date yet for the dredging. Once the capital dredging and quay construction are completed, maintenance dredging will commence and continue indefinitely.	Although the scale of impact of the Bristol Deep Sea Container Terminal Development is measurable, no specific adverse effect was concluded in relation to the Estuaries feature due to the Development. It was concluded that there was an adverse effect on the intertidal mudflats and sandflats feature. This was due to a combination of direct habitat loss and short to medium term functional change in the intertidal mudflats in the vicinity of the Avonmouth Site.
EA Steart Managed Realignment	The pathway for habitat loss and physical damage is through the breach which will be made in the tidal embankments and associated intertidal sediments.	The nature of impact is a localised functional change to the intertidal sediments immediately fronting the breach zone in the tidal embankments, and temporary alterations in the intertidal habitats either side of the breach zone. The extent and variety of the intertidal habitats could be reduced by the physical damage related to the breaching of the tidal embankments.	The area of impact will be the intertidal area immediately fronting the site of the breach. The width of the breach is expected to be about 200 metres and the intertidal area will be re-profiled to provide an inflow/outflow channel for the site. It is expected that the intertidal area will re-adjust to the new hydraulic regime, so that although there will initially be damage to the intertidal area in the short term, in the longer term the intertidal area will re-establish, and there will be additional intertidal area provided by the realignment site. . How much area of the intertidal zone will be temporarily damaged is not known, although it is estimated to be about 1 to 2 ha. The inundation area for the site is stated to be 250 ha. There will also be some change to the physical form and flow of the estuary due to the realignment site, but this is considered to be beneficial, providing an increase to the tidal prism and additional intertidal habitat.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is about one month in mid 2013. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	The area of impact related to the construction and emplacement of the intake and outfall structures is considered to be insignificant in relation to the Estuaries feature. In addition, the long-term effect of the proposed project is beneficial to the Estuaries feature.

[601] Warwick R.M., Henderson P.A., Fleming J., Somes J.R. 2001. The impoverished fauna of the deep water channel and marginal areas between Flatholm Island and King Road, Severn Estuary. Report to the Bristol Port Company. 21 pp.
[602] Bristol Deep Sea Container Terminal. Environmental Statement. The Bristol Port Company. Final Report 9R4093. 21 July 2008. 763 pp
[603] Warwick 2008 BRISTOL DEEP SEA CONTAINER TERMINAL. Subtidal *Sabellaria alveolata* reefs in the Severn Estuary. Response to issues raised by consultees following submission of the Harbour Revision Order and Environmental Statement. 27 pp

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Bristol Port Compensation Habitat Creation at Steart	The pathway for habitat loss and physical damage is through the breach which will be made in the tidal embankments and associated intertidal sediments.	The nature of impact is a localised functional change to the intertidal sediments fronting the breach zone in the tidal embankments, and temporary alterations in the intertidal habitats either side of the breach zone. The extent and variety of the intertidal habitats could be reduced by the physical damage related to the breaching of the tidal embankments.	The area of impact will be the intertidal area immediately fronting the site of the breach. The width of the breach is expected to be about 200 metres and the intertidal area will be re-profiled to provide an inflow/outflow channel for the site. It is expected that the intertidal area will re-adjust to the new hydraulic regime, so that although there will initially be damage to the intertidal area in the short term, in the longer term the intertidal area will re-establish, and there will be additional intertidal area provided by the realignment site. How much area of the intertidal zone will be temporarily damaged is not known, although it is estimated to be about 1 to 2 ha. Part of this intertidal area could affect the rocky shore sub-feature, The inundation area for the site is stated to be 140 ha. There will also be some change to the physical form and flow of the estuary due to the realignment site, but this is considered to be beneficial, providing an increase to the tidal prism and additional intertidal habitat.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is not yet defined.. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	The area of impact related to the construction and emplacement of the intake and outfall structures is considered to be insignificant in relation to the Estuaries feature. In addition, the long-term effect of the proposed project is beneficial to the Estuaries feature.
Bristol Deep Sea Container Terminal Development	The pathway for habitat loss and physical damage is through the dredging and disposal operations for both the capital dredge and future maintenance dredging, and the reclamation at Avonmouth for the new quay.	The nature of impact includes both permanent and temporary loss of habitat, and physical damage during construction activities. The permanent loss of intertidal habitat is through the reclamation and construction of a new quay at Avonmouth. There is also temporary loss of intertidal habitat at Avonmouth due to short to medium term functional change in the intertidal area at Avonmouth due to the new quay. The loss of habitat could influence the physical form and flow of the estuary and reduce the extent of the estuarine habitats. In addition there are potential temporary alterations of the subtidal habitats and benthic communities in the footprint of both the capital and maintenance dredging, as well as the zone of impact of the sediments disposed at the new disposal site at Holm Deep. The extent and variety of the subtidal habitats could be reduced by the physical damage related to the dredging and disposal activities.	An adverse effect on the integrity of the Severn Estuary SAC was concluded from the HRA for the Bristol Deep Sea Container Terminal Development. The adverse effects related to both direct loss of intertidal habitat at the Avonmouth site, as well as localised alteration of the hydrodynamic regime leading to short to medium term functional change, as a result of significant accretion of fine sediments above background rates, in the intertidal flats in the vicinity of the Avonmouth Site. A Mitigation, Compensation and Monitoring Agreement relating to the Bristol Deep Sea Container Terminal was therefore drawn up. The main element of the compensation package is the requirement for a managed realignment site. This is the Project known as the Bristol Port Compensation Habitat Creation at Steart. The total area of subtidal habitat directly affected by the capital dredge and the new disposal site at Holm Deep is about 700 ha. This equates to about 0.95% of the Estuaries feature, or about 1.4% of the total subtidal area of the Estuaries feature. The subtidal habitats affected by the dredge are known to have an impoverished fauna (Warwick et al. Ref., BDSCT ES), while the *Sabellaria* reefs feature is absent from the the footprints of the terminal, approach channel and disposal ground (Warwick 2008).	Based on information in the ES (Sections 3.2.3 and 3.2.4 pp. 45 – 46), there will be about 78 to 80 months (6½ years) in total of dredging, in 3 phases. Phase 1 – 6 months .. Phase 2 – 35 months…. Phase 3 – 36 months… However, it is stated that taking account of the overlap of different phases the maximum duration of the main dredging will be 39 months. Disposal of Mercia mudstone in the new disposal site in Holm Deep would occur over about 36 months (Phase 3). There is no defined start date yet for the dredging. Once the capital dredging and quay construction are completed, maintenance dredging will commence and continue indefinitely.	Although the scale of impact of the Bristol Deep Sea Container Terminal Development is measurable, no specific adverse effect was concluded in relation to the Estuaries feature due to the Development. It was concluded that there was an adverse effect on the intertidal mudflats and sandflats feature. This was due to a combination of direct habitat loss and short to medium term functional change in the intertidal mudflats in the vicinity of the Avonmouth Site.
EA Steart Managed Realignment	The pathway for habitat loss and physical damage is through the breach which will be made in the tidal embankments and associated intertidal sediments.	The nature of impact is a localised functional change to the intertidal sediments immediately fronting the breach zone in the tidal embankments, and temporary alterations in the intertidal habitats either side of the breach zone. The extent and variety of the intertidal habitats could be reduced by the physical damage related to the breaching of the	The area of impact will be the intertidal area immediately fronting the site of the breach. The width of the breach is expected to be about 200 metres and the intertidal area will be re-profiled to provide an inflow/outflow channel for the site. It is expected that the intertidal area will re-adjust to the new hydraulic regime, so that although there will initially be damage to the intertidal area in the short term, in the longer term the intertidal area will re-establish, and there will be additional intertidal area provided by the realignment	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is about one month in mid 2013. It is assumed that it will take several years for	The area of impact related to the construction and emplacement of the intake and outfall structures is considered to be insignificant in relation to the Estuaries feature. In addition, the long-term effect of the proposed project is beneficial to the Estuaries feature.

		tidal embankments.	site. . How much area of the intertidal zone will be temporarily damaged is not known, although it is estimated to be about 1 to 2 ha. The inundation area for the site is stated to be 250 ha. There will also be some change to the physical form and flow of the estuary due to the realignment site, but this is considered to be beneficial, providing an increase to the tidal prism and additional intertidal habitat.	the channel morphology related to the breach to reach hydraulic equilibrium.	
Bristol Port Compensation Habitat Creation at Steart	The pathway for habitat loss and physical damage is through the breach which will be made in the tidal embankments and associated intertidal sediments.	The nature of impact is a localised functional change to the intertidal sediments fronting the breach zone in the tidal embankments, and temporary alterations in the intertidal habitats either side of the breach zone. The extent and variety of the intertidal habitats could be reduced by the physical damage related to the breaching of the tidal embankments.	The area of impact will be the intertidal area immediately fronting the site of the breach. The width of the breach is expected to be about 200 metres and the intertidal area will be re-profiled to provide an inflow/outflow channel for the site. It is expected that the intertidal area will re-adjust to the new hydraulic regime, so that although there will initially be damage to the intertidal area in the short term, in the longer term the intertidal area will re-establish, and there will be additional intertidal area provided by the realignment site. How much area of the intertidal zone will be temporarily damaged is not known, although it is estimated to be about 1 to 2 ha. Part of this intertidal area could affect the rocky shore sub-feature, The inundation area for the site is stated to be 140 ha. There will also be some change to the physical form and flow of the estuary due to the realignment site, but this is considered to be beneficial, providing an increase to the tidal prism and additional intertidal habitat.	The expected date for the activities related to the breaching of the tidal embankments and the profiling of the intertidal area related to the breach is not yet defined.. It is assumed that it will take several years for the channel morphology related to the breach to reach hydraulic equilibrium.	The area of impact related to the construction and emplacement of the intake and outfall structures is considered to be insignificant in relation to the Estuaries feature. In addition, the long-term effect of the proposed project is beneficial to the Estuaries feature.

The time relationship of the different PPPs or permit is shown in Table 6.5.7 S2 below in 3 month blocks to 2022, together with the scale of impact. ‘N’ signifies a negligible impact, ‘L’ signifies a likely significant effect, and ‘A’ signifies an adverse effect. It is apparent that the construction periods of all the PPS do not overlap in time. However, there may be residual effects from the construction activities, either from physical damage or habitat loss, so that the overall assessment needs to consider these.

Table 6.5.7 S2

Estuaries		2012				2013				2014				2015				2016				2017			
Habitat Loss and Physical Damage	**PPP or Permit**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	Jetty construction, operation, and demolition					Construction																	Operation		
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Sea wall construction							Construction																	
							N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Construction of cooling water infrastructure														Construction										
							N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Combwich Development associated with HPC						Construction																		
						N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Bristol Deep Sea Container Terminal Development																			?Dredging and Construction? Start date not yet known					
														N	N	N	N	N	N	N	N	N	N	N	N
	EA Steart Managed Realignment				Construction																				
				N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
	Bristol Port Compensation Habitat Creation at Steart										?Construction? Date not yet known														
										N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

Estuaries		2018				2019				2020				2021				2022				
Habitat Loss and Physical Damage	**PPP or Permit**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
	Jetty construction, operation, and demolition															Demolition						
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N				
	Sea wall construction			Operation																		continues indefinitely
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Construction of cooling water infrastructure										Operation											continues to end of life of HPC
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Combwich Development associated with HPC			Operation																		continues to end of life of HPC
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Bristol Deep Sea Container Terminal Development											Operation										continues indefinitely
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	EA Steart Managed Realignment	Operation																				continues indefinitely
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	
	Bristol Port Compensation Habitat Creation at Steart					Operation																continues indefinitely
		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	

6.5.8 Disturbance (noise, vibration and visual)

Due to its *location and known sensitivities* we are satisfied that there will be no adverse effect on the Estuaries feature of the Severn Estuary due to disturbance as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of disturbance on this feature has not been considered further.

6.5.9 Competition with non-native species

- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

Natural England & Countryside Council for Wales, 2009

Hinkley Point C (HPC) has the potential to have in combination effects in terms of Competition with non-native species with the following other permissions plans and projects (PPP):

- Hinkley Point B (HPB) power station thermal discharge
- Bristol Port - Bristol Deep Sea Container Terminal

Continued operation of HPB

The continued operation of HPB together with HPC may increase the risk of non-native (exotic) species establishing themselves around the Hinkey point and Stert Flats area due to the enlarged thermal footprint.

The thermal tolerances of many indigenous species are not understood well enough to predict how much a change in the thermal regime will affect them (Smith, 1995)[604]. Most importantly, little is known about the advective mechanisms involved in the establishment of exotic species and replacement faunas (Langford *et al.*, 1998)[605].

As discussed within the alone section (2.6.1.(f)), any changes to species diversity will be difficult to predict, especially since the Severn Estuary is highly diverse with many potential non-native species already present. Furthermore, diversity is likely to gradually change naturally with the effects of climate change and other environmental variables.

Bristol Deep Sea Container Terminal

There is a potential for the current Bristol Port Docks and new Bristol Deep Sea Container Terminal (BDSCT) to introduce non-native species into the Severn Estuary through the exchange of ballast water by large container ships. Ships use ballast water to provide stability and manoeuvrability during a voyage. Water is taken on at one port when cargo is unloaded and usually discharged at another port when the ship receives cargo. Because organisms ranging in size from viruses to twelve inch fish living in the surrounding water or sediments are taken on board with ballast water, there is a potential for the introduction of non-native organisms called bio-

[604] Smith, J., (1995). Exotic marine organisms in the Milford Haven waterway: the potential for invasion. Field Studies Council. FSC/OPRU/12/95.

[605] Langford, T.E., Hawkins, S.J., Bray, S., Hill, C., Wells, N., Yang, Z. (1998). Pembroke Power Station: Impact of cooling water discharge on the marine biology of Milford Haven. Countryside Council for Wales Science Report 302. No. UC285.

invaders[606]. These bio-invaders, whether fish or planktonic organisms, could be encouraged to thrive in areas potentially affected by changes to the thermal regime around HPC, particularly if the organisms are from warmer waters.

Although an International protocol (Ballast Water Convention) exists along with local arrangements, The Bristol Port Company (TBPC) does not currently undertake any specific measures to control ballast water exchange, only in so far as minimising contamination via discharge of dirty ballast water (TBPC, 2010)[607]. However, according to TBPC (2010), the majority of vessels unload at the port and, therefore, intake ballast water. There is only occasional discharge of ballast water in the port, as only around 10% of vessels arriving at Avonmouth and Portbury Docks load cargo. Many modern vessels, such as container ships, do not need to discharge ballast water, but instead are able to transfer ballast between separate tanks to achieve the stability they require. Although it is not clear what the arrangements will be for the new port, it is likely to be similar to the current port, in that its main use will be for unloading vessels rather than loading.

The current and proposed port at Bristol is situated approximately 45 km from the proposed HPC and whilst the possibility of non-native organisms finding their way down to Hinkley Point exists, it is unlikely that many different populations will colonise to the point of where the estuarine species are significantly affected.

This is supported by Smith (1995), who reviewed the potential for exotic species to invade and establish themselves in Milford Haven (Pembrokeshire, South Wales) and summarised the mechanisms through which invasion can occur. The overall conclusion was that although several exotic species had invaded the Haven there was little evidence of wider distribution away from the original site of introduction. In total Smith's (1995) review includes a list of 17 species of algae and 28 species of invertebrate introduced by various means to the UK waters. This is a relatively small number in relation to the very large numbers of species carried around the world, for example in ballast water on ships (Langford *et al*., 1998)[608].

Conclusion
It is therefore concluded that the changes to the thermal regime due to the cooling water discharge from HPC together with HPB and in combination with the BDSCT will not have a significant effect on the estuaries feature from the competition of non-native species, and will not have an adverse effect on site integrity.

6.5.10 Entrainment (planktonic organisms)

Conservation objectives (see section 1.5.1)

- *The total extent of the estuary is maintained;*
- *The extent, variety, spatial distribution and community composition of notable communities is maintained;*
- *The abundance of the notable estuarine species assemblages is maintained or increased.*

[606] Marine Bio-invasions Fact sheet – Ballast Water Treatment Options. Sea Grant.
[607] The Bristol Port Company (2010). Activity sheet - Ballast Water. www.bristolport.co.uk
[608] Langford, T.E., Hawkins, S.J., Bray, S., Hill, C., Wells, N., Yang, Z. (1998). Pembroke Power Station: Impact of cooling water discharge on the marine biology of Milford Haven. Countryside Council for Wales Science Report 302. No. UC285.

Hinkley Point C (HPC) has the potential to have in combination effects in terms of entrainment of organisms with the following other permissions plans and projects (PPP):

- Hinkley Point B (HPB) power station water abstraction
- Oldbury (Oldbury A) power station water abstraction
- Aberthaw Coal-fired Power Station water abstraction
- Development of a new nuclear power station at Oldbury (Oldbury B) - water abstraction

Entrainment of organisms

With the exception of HPB, no known data exists on the entrainment of organisms at any of the current power stations on the Severn Estuary, but we can assume that planktonic organisms are effected from the abstractions Oldbury A and Aberthaw as well as HPB. The amount abstracted by each of the other PPPs is listed within table 6.5.9 S1 along with their chlorination discharges, which need to be considered synergistically in relation to entrainment effects.

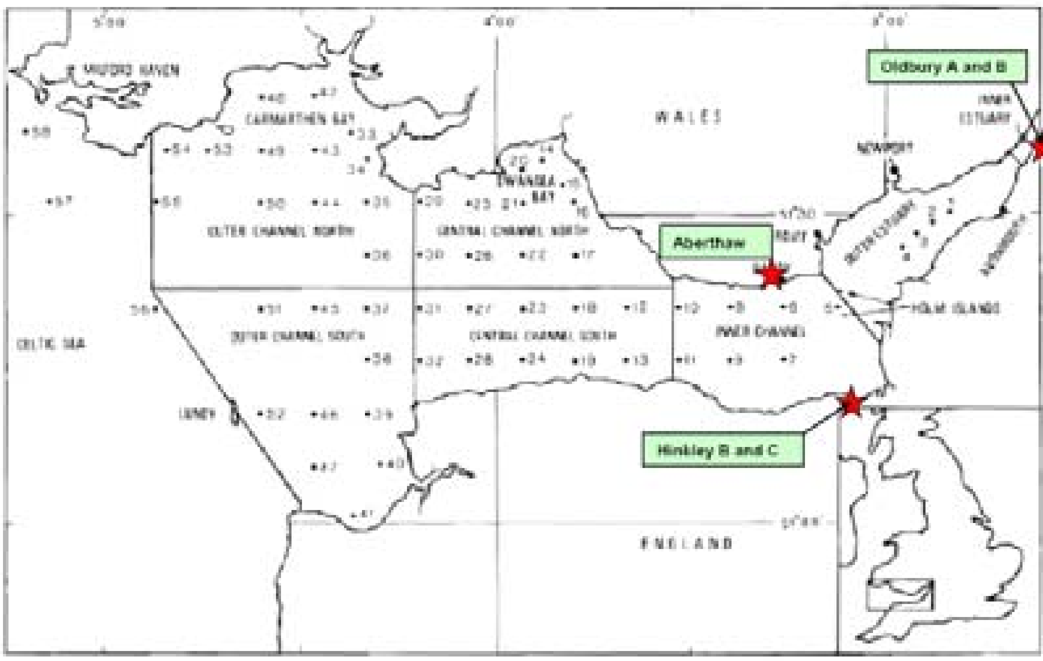
Table 6.5.9 S1. Abstraction and chlorination amounts of the power stations to be assessed in combination

Power station abstraction	Abstraction (m^2/sec)	Chlorination (mg/l)	Sub-region of Estuary	Overlap period with HPC
Hinkley C	125 (un-licensed)	0.2	Inner channel	-
Hinkley B	33.7 (un-licensed)	0.3	Inner channel	~ 2 years
Oldbury A	14 (licensed)	No chlorination	Inner estuary	~ 8 years
Aberthaw	50 (max. rate although un-licensed)	No chlorination	Inner channel	10 + years
Oldbury B	unknown	No chlorination	Inner estuary	10 + years

Before the cumulative entrainment effects of the current HPB, Oldbury A and Aberthaw can be assessed, their location in respect to the sub-regions of the Severn Estuary and Bristol Channel needs to be taken into consideration. Oldbury power station is located more than 60km up stream of Hinkley Point and is situated in the 'inner estuary' (see figure 6.5.9.1). This suggests that the location of Oldbury power station is subject to different environmental processes, such as temperature and salinity gradients, and therefore different species structure than the inner channel where HPB, Aberthaw and the proposed HPC are located. As discussed within section 2.6.4, entrainment effects are likely to be localised, which could include neighbouring sub-regions. Oldbury is located in the inner estuary, with the whole outer estuary region in-between the Hinkley Point area, entrainment effects will be different from those in the inner channel, and therefore they will be difficult to quantify cumulatively. For this assessment, and to get a complete picture of potential impacts across the whole estuary (particularly in relation to planktonic organisms), it can be assumed that Oldbury is also based within the inner channel (to represent worst case scenario), which can be quantified. However, when drawing up conclusions the sub-regions will be taken into consideration.

The entrainment of juvenile/small fish, fish larvae and ickthyoplankton is covered within section 6.10.9.

Figure 6.5.9 S2. Locations of the power stations to be assessed in combination in relation to the Bristol Channel and Severn Estuary sub-regions. Figure adapted from Collins and Williams (1982[609]).



With regards to assessing in combination effects with the potential Oldbury B, if the application for Oldbury B is successful, then the predicted start up for operation is around 2023-2025. No information is currently available on the potential effects of the proposed new nuclear power station at Oldbury with regard to entrainment impacts. However, the scoping report for the proposed new nuclear power station at Oldbury indicates that the new station would abstract less water from and discharge less water back to the Severn Estuary than the existing Magnox station. This suggests that if Oldbury B becomes operational before Oldbury A discharge licence expires, then the combined impacts could still be equal to or less than the current Oldbury A.

Although it is acknowledged that potential effects could occur, they are not possible to quantify at this point in time until more detailed information is available. Information will be added to the appropriate assessment as and when this information becomes available. However, the general conclusion is that there is more likely to be a decrease in pressure on the populations of conservation importance with the shutdown of the existing stations at Hinkley and Oldbury A and the introduction of new stations for which measures to avoid and minimise potential entrainment losses will be incorporated. Therefore Oldbury B will not be discussed further within the entrainment in combination assessment.

Entrainment of phytoplankton

Within section 2.6.4 it was concluded that in the absence of chlorination, the thermal effects of entrainment on primary production would appear to be negligible, however because the possibility of chlorination exists it was considered. Taking the worst case assumptions it was calculated that 0.7% of the phytoplankton cells in that plume volume would be killed per day, and assuming phytoplankton are uniformly

[609] Williams, R., and Collins, N.R. (1982). Zooplankton Communities in the Bristol Channel and Severn Estuary. Marine Ecology Vol.9: 1-11.

distributed over the entire inner channel, operation of HPC could lead to the loss of 0.05% of the inner channel phytoplankton abundance per day.

Taking a similar set of parameters to those used in the calculations for HPC and taking into account the abstraction rates of HPB, Oldbury A and Aberthaw in relation to HPC as a percentage (table 6.5.9 S3, then it can be calculated that the predicted phytoplankton entrainment is approximately 0.09% per day. This means that assuming 100% mortality, that the predicted worst case loss of phytoplankton from the cumulative effects of HPC, HPB, Oldbury A and Aberthaw has been calculated as 0.09% per day. Calculations for Aberthaw (50 m³/sec) are based on maximum abstraction rates when in reality only 36 m³/sec is abstracted daily, and that the impacts from Oldbury A are likely to be insignificant in relation to localised impacts.

Table 6.5.9 S3. Predicted phytoplankton entrainment from calculated abstraction rates of HPC.

Abstraction	**Abstraction rate (m³/sec)**	**% of HPC**	**Predicted phytoplankton entrainment (%) /day**
HPC Operational abstraction (100%)	~125 (unlicensed)	100	0.05
Hinkley Point B abstraction (100%)	~33.7 (unlicensed)	27	0.014
Oldbury A (50%)	~14 (max. licensed for decommissioning)	11	0.006*
Aberthaw Power Station (100%)	~50 (max. licensed rate)	40	0.02
Total cumulative			**0.09**

* based on the assumption that Oldbury A is located in the inner channel

Phytoplankton production is reported to be relatively low in the Severn due to high suspended sediment levels in the estuary (Kirby and Parker, 1977)[610]. Results for the Severn Estuary from the UK National Monitoring Programme (NMP) conducted between 1992 and 1995 also indicate relatively low concentrations of chlorophyll-*a* for both winter and summer (~5micro g l^{-1}) with maximum values occurring in the upper estuary (MPMMG, 1998)[611]. Distributions of chlorophyll-*a* are likely to be influenced in estuaries by a complex array of factors (Langston *et al.*, 2003)[612]. In the Severn Estuary, concentrations of nutrients may be sufficient for phytoplankton proliferation but high turbidity limits sunlight, which is essential for algal growth (MPMMG, 1998). The high levels of suspended sediment solids result in a euphotic zone which amounts to only ~ 3% of the water column in some stretches (Joint and Pomroy, 1981)[613].

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610 Kirby, R. Parker, W.R. (1977). Sediment dynamics in the Severn Estuary. In: An environmental appraisal of the Severn Barrage. (Ed Shaw, T.L) pp. 41-52

611 MPMMG (Marine Pollution Monitoring Management Group). (1988).National monitoring programme survey of quality of UK coastal waters. Aberdeen ISBN 0 9532838 36.

612 Langston, W. J., Chesman, B. S., Burt, G. R., Hawkins, S. J., Readman, J., & Worsfold, P. (2003) Characterisation of the South West European Marine Sites: The Severn Estuary pSAC, SPA. pp. 206. Marine Biological Association Occasional publication No.13.

613 Joint, I. Pomroy, A. (1981). Primary production in a turbid estuary. Estuary Coastal Shelf Science 13:303–316.

This is supported by Williams and Collins (1986)[614] who studied the seasonal composition of meroplankton and holoplankton in the Bristol channel, and observed a decreasing graduation in the plankton stock of the channel from the seaward section to the inner, less saline, reaches. Primary production in the inner channel was only 4% of that in the outer channel due to rapid light attenuation and the rate of vertical mixing in the turbid waters of the inner channel.

The total cumulative loss of 0.09% per day is not considered to be significant, because where localised effects occur, new blooms of phytoplankton from neighbouring sub-regions are likely to quickly replenish any losses, and since phytoplankton production is low within the inner channel, any impacts are not considered to be of significance in terms of effecting the integrity of the estuaries feature as a whole. Furthermore the figure of 0.09% represents the worst case scenario, when in reality the effects are likely to be far less, especially in respect to the location of Oldbury A and B within the estuary.

Conclusion for entrainment and impingement effect on planktonic organismsn in the estuaries feature in combination
It can therefore be concluded that there will be no adverse effect on the phytoplankton production of the Severn Estuary SAC and Ramsar, from entrainment in combination with other PPPs.

Entrainment of Zooplankton

The assessments carried out within section 2.6.4, and using BEEMS Scientific Support Paper 063 (SPP063)[615], will form the basis for assessing the cumulative entrainment effects of zooplankton in the Severn Estuary and Bristol Channel. It should be noted that the diversity of zooplankton was found to be relatively low in the Bristol channel compared to neighbouring shelf seas and even lower in the Severn Estuary (APEM, 2010)[616]. Annual patterns of abundance from HPB entrainment studies show that mysids and caridean decapods make up a significant proportion of the biomass within the Bristol Channel and Severn Estuary and are therefore key members of the marine food web in this estuarine system (Bamber & Henderson, 1994)[617].

Cumulative entrainment of Mysids
BEEMS Scientific Position Paper 063 (SPP063)[7] reported on very limited data availability on entrainment mortality for mysids and thus, as a precautionary measure, a 100% mortality rate has been assumed. The assessment presented in SPP063[7] calculated that the additional mortality in the Bristol Channel from entrainment losses associated with HPC would be 0.08% per day (predominantly to juveniles), and this was assuming a ratio of plume volume to volume of the Inner Channel as 7.2% and assuming mysids are uniformly distributed throughout the Inner Channel.

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614 Williams, R., Collins, N.R. (1986). Seasonal composition of meroplankton and holoplankton in the Bristol Channel. Marine Biology 92; 93-101.
615 BEEMS Scientific Position Paper 063 (SPP063). Entrainment impact on organisms at Hinkley Point – supplementary note. October 2011. Cefas report prepared for EDF
616 APEM (2010) Severn Tidal Power Feasibility Study Strategic Environmental Assessment (SEA) – Migratory and estuarine fish (2010). (P&B, B&V consultants) Report prepared for DECC.
617 Bamber, R.N and Henserson, P.A. (1994). Seasonality of caridean decapod and mysid distribution and movements within the Severn Estuary and Bristol Channel. Biological Journal of the Linnean Society volume 51, Issue 1-2, pages 83–91.

Taking a similar set of parameters to those used in the calculations for HPC and taking into account the abstraction rates of HPB, Oldbury A and Aberthaw in relation to HPC as a percentage (table 6.5.9 S4), then it can be calculated that the predicted mysid entrainment is approximately 0.14% per day. This means that assuming 100% mortality, that the predicted worst case loss of mysids from the cumulative effects of HPC, HPB, Oldbury A and Aberthaw has been calculated as 0.14% per day. It should be noted that the calculations for Aberthaw (50 m³/sec) are based on maximum abstraction rates, when in reality only 36 m³/sec is abstracted daily, and also that the impacts from Oldbury A are likely to be insignificant in relation to localised impacts.

Table 6.5.9 S4. Predicted mysid entrainment from calculated abstraction rates of HPC.

Abstraction	**Abstraction rate (m³ sec)**	**% of HPC**	**Predicted mysid entrainment (%) /day**
HPC Operational abstraction (100%)	~125 (unlicensed)	100	0.08
Hinkley Point B abstraction (100%)	~33.7 (unlicensed)	27	0.022
Oldbury A (50%)	~14 (max. licensed for decommissioning)	11	0.009*
Aberthaw Power Station (100%)	~50 (max. licensed rate)	40	0.032
Total cumulative			**0.143**

* based on the assumption that Oldbury is located in the inner channel

As the natural mortality of mysids is 4% per day (adults) to 6% per day (juveniles) (Clutter and Theilacker, 1971)[618]; the worst case scenario cumulative impacts from the PPPs of <0.2% is considered to be negligible, so the cumulative effects from entrainment will not adversely effect the mysid populations within the Severn Estuary and Bristol Channel.

Conclusion for entrainment and impingement effect onmysids in the estuaries feature in combination

It can therefore be concluded that there will be no adverse effect on the mysid populations of the Severn Estuary SAC and Ramsar, from entrainment in combination with other PPPs.

Cumulative entrainment of copepods

As discussed within section 2.6.4 the dominant members of the plankton at Hinkley Point are members of the genus *Acartia* (*Acartia spp.). Acartia tonsa* has shown to have several useful characteristics to play the role of test-species in ecotoxicology in the procedure of “risk assessment” concerning different chemicals (Pane *et al.*, 2011)[619] and is therefore an estuarine species used as a standard test organism in ecotoxicological studies. Since the *Acartia Spp*. has value in terms of indicating the likely scale of impact on the local holoplanktonic assemblage as a whole, it can be used to assess the likely impact on the genus alone.

618 Clutter, R., Theilacker, G.H. (1971) Ecology efficiency of a pelagic mysid shrimp: estimates for growth, energy budgets and mortality studies. Fishery bulletin 69(1) 93-114.

619 Pane, L., Agrone, C., Giacco, E., Somà, A., and Mariottini , G.L.(2011) Utilization of Marine Crustaceans as Study Models: A New Approach in Marine Ecotoxicology for European (REACH) Regulation. *DIP.TE.RIS, University of Genova, Genova,*

Using the mortality estimates from Bamber and Seaby (2004)[620] the stresses of entrainment under standard power station operating levels would result in the order of 20% mortality of *Acartia tonsa*. The assessment presented in SPP063[7] calculated that with the 20% mortality rate, the entrainment mortality in summer months (June - August) at Hinkley Point would represent 0.016% of the inner channel population per day. The population of *Acartia spp*. is distributed over the entire central and inner channels in the summer (Williams & Collins, 1986)[621] and, therefore, the percentage of the Bristol Channel population that would be killed by HPC has been calculated to be less than 0.004% of the estimated population.

Taking a similar set of parameters to those used in the calculations for HPC and taking into account the abstraction rates of HPB, Oldbury A and Aberthaw in relation to HPC as a percentage (table 6.5.9 S5), then it can be calculated that the predicted copepod entrainment is approximately 0.03% per day. This means that assuming 100% mortality, that the predicted worst case loss of copepods from the cumulative effects of HPC, HPB, Oldbury A and Aberthaw has been calculated as 0.03% per day. It should be noted that the calculations for Aberthaw (50 m³/sec) are based on maximum abstraction rates, when in reality only 36 m³/sec is abstracted daily, and also that the impacts from Oldbury A are likely to be insignificant in relation to localised impacts.

Table 6.5.9 S5. Predicted copepods entrainment from calculated abstraction rates of HPC.

Abstraction	**Abstraction rate (m³ sec)**	**% of HPC**	**Predicted copepods entrainment (%) /day**
HPC Operational abstraction (100%)	~125 (unlicensed)	100	0.016
Hinkley Point B abstraction (100%)	~33.7 (unlicensed)	27	0.004
Oldbury A (50%)	~14 (max. licensed for decommissioning)	11	0.002*
Aberthaw Power Station (100%)	~50 (max. licensed rate)	40	0.006
Total cumulative			**0.028 (0.03)**

* based on the assumption that Oldbury is located in the inner channel

As discussed within section 2.6.4, the study by Williams and Collins (1986)[6], copepods in the Inner Channel only comprised just over 9% of the total biomass compared to the Outer Channel, with the total zooplankton in the Inner Channel being only 14% of the total zooplankton in the Outer Channel. The studies suggest that zooplankton play a minor role in the Inner channel, and that benthic filter-feeding communities are presumed better adapted to the estuary.

[620] Bamber, R.N., and Seaby, R.M.H. (2004) The effects of power station entrainment passage on three species of marine planktonic crustacean, *Acarti tonsa* (Copepoda), *Crangon crangon* (Decapoda) and *Homarus gammarus* (Decapoda). Marine Environmental Research. 57, 281-294.
[621] Williams, R., and Collins, N.R. (1986). Seasonal composition of meroplankton and holoplankton in the Bristol Channel. Marine Biology. 92, 93-101.

This is supported by Burkill and Kendall (1982)[622] who studied the production of *Eurytemora affinis* in the Bristol Channel. They noted that the population density and production of *E. affinis* was low (range of 0.2 to 4.8 m^{-3}) in a region with a salinity higher than at the centre of abundance. However, the species was capable of growing with a Production/Biomass quotient of 33 $yr^{-}1$, which is higher than many recorded values for copepods. Temperature, food availability (nutrition) and predation were the key environmental factors influencing production, with salinity and flushing being of less importance.

The cumulative entrainment mortality in the summer (June - August) at Hinkley Point, which is estimated at 0.03% per day for the Inner Channel is considered to be negligible and will be far less when considering the distribution of *Acartia spp*. population across the entire central and inner channels in the summer.

Conclusion for entrainment and impingement effect on copepods in the estuaries feature in combination

Given the natural productivity of the species and the evidence that a higher proportion of copepods are found in the outer channel rather than the inner channel and inner estuary where HPC and the other power stations considered are located, then it can be concluded that the number of copepods entrained cumulatively from HPC and the other PPPs will not have an adverse effect on the overall population within Bridgwater Bay or the Bristol Channel.

Cumulative entrainment of Decapods (+ impingement estimates)

Within section 2.6.4 the Common or brown shrimp, *Crangon crangon* was used as a key species to assess decapods within the Severn Estuary. With the 5mm screening mesh proposed at HPC it has been calculated that approximately 90% of animals will be impinged and 10% entrained (SPP063[7]). Both HPB and Oldbury A have a 10 mm mesh and whilst not confirmed, it is likely that Aberthaw also has a 10 mm mesh, which means that a higher percentage of *C. crangon* will be entrained rather than impinged. Within BEEMS Scientific Position Paper 063 (SPP063[7]) it was calculated that the predicted loss of Bristol Channel annual *C. crangon* production from entrainment together with impingement would be 1.2% with chlorination. The predicted loss of Bristol Channel annual *C. crangon* production from entrainment together with impingement for HPB was estimated at 1%.

Taking a similar set of parameters to those used for HPB, since the other power stations are likely to have a mesh similar to HPB, and taking into account the abstraction rates of both Oldbury A and Aberthaw in relation to HPB as a percentage (table 6.5.9 S6, then it can be calculated that the predicted annual *C. crangon* loss from entrainment together with impingement is 4.08% within the Bristol Channel.

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[622] Burkill, P.H. and Kendall, T.F. (1982). Production of the copepod *Eurytemora affinis* in the Bristol Channel. Marine Ecology Progress Series Vol.7: 21-31.

Table 6.5.9 S6. Predicted C.crangon entrainment from calculated abstraction rates of HPB.

Abstraction	**Abstraction rate (m^3 sec)**	**% of HPB**	**Predicted (%) loss of annual *C. crangon* production**
HPC Operational abstraction (100%)	~125 (unlicensed)	N/A	1.2
HPB abstraction (100%)	~33.7 (rounded up to 34 unlicensed)	100	1
Oldbury A (50%)	~14 (max. licensed for decommissioning)	41	0.41*
Aberthaw Power Station (100%)	~50 (max. un-licensed rate)	147	1.47
Total cumulative			**4.08**

* based on the assumption that Oldbury is located in the inner channel

Because 4.08% could be considered significant (being >1% of the population), it warrants a less conservative and more realistic estimate. Based on the time line in table 6.5.9 S7 the main over lap of the power station abstractions is between 2018 – 2023 and during this time more realistic abstraction rates should be considered. These estimates are based on the following:

- HPC will be running with one European Pressurised Reactor (EPR) for the first 2-3 years @ **65 m^3/sec (50% capacity)**
- HPB could be running at less than 100% but it is not yet confirmed
- Oldbury A will only be running with one pump @ **7 m^3/sec** for the next 13 years
- Aberthaw average abstraction is **36 m^3/sec**

Table 6.5.9 S7. timeline for the relevant PPPs

<table>
<tr><th>PPP</th><th>2012 - 2017</th><th>2018</th><th>2019</th><th>2020</th><th>2021</th><th>2022</th><th>2023</th><th>2024</th><th>2025</th><th>2026</th><th>2027</th></tr>
<tr><td>HPC abstraction</td><td></td><td colspan="2">65 m^3/sec</td><td colspan="7">125 m^3/sec</td><td>⇨</td></tr>
<tr><td>HPB abstraction</td><td colspan="7">< 33.7 m^3/sec</td><td colspan="3">Decommissioning at a reduced volume</td><td>⇨</td></tr>
<tr><td>Oldbury A abstraction</td><td colspan="8">7 m^3/sec</td><td>Stop</td><td></td><td></td></tr>
<tr><td>Aberthaw abstraction</td><td colspan="10">36 m^3/sec</td><td>⇨</td></tr>
</table>

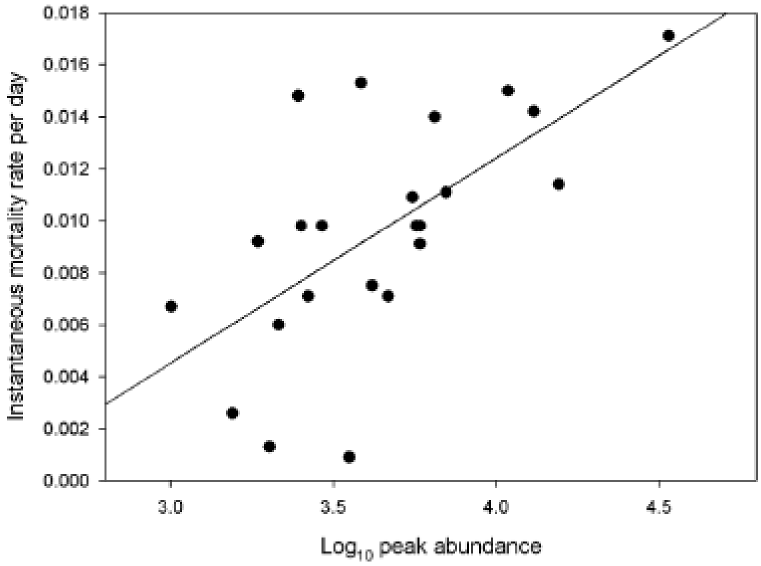
Taking the above re-estimates of abstraction rates during the main overlap period between 2018 and 2023 into consideration, it can be calculated that the predicted annual *C. crangon* loss from entrainment together with impingement is 2.87% (see table 6.5.9 S5). Furthermore, because of the location of Oldbury A in relation to the Inner Channel, Oldbury A will have a minimal influence on the localised impacts around Hinkley Point, therefore potentially reducing the losses further. However, there is still a risk that HPB may continue operation and therefore overlap with HPC, with both plants operating at 100% during 2020-2023.

Table 6.5.9 S8. Re-estimated predicted C.crangon entrainment from calculated abstraction rates of HPB during the main overlap period of 2018-2020.

Abstraction	**Realistic abstraction rate during overlap period of 2018 – 2020 (m^3 sec)**	**% of HPB**	**Predicted (%) loss of annual *C. crangon* production**
HPC Operational abstraction (100%)	~ 65	N/A	0.6
Hinkley Point B abstraction (100%)	~ 33.7 (rounded up to 34)	100	1
Oldbury A (50%)	~ 7	20.6	0.21*
Aberthaw Power Station (100%)	~ 36	106	1.06
Total cumulative			**2.87**

As discussed within section 2.6.4, the past 25 years the adult population of *C. crangon* within Bridgwater Bay has been notably stable, however, average *C. crangon* abundance has increased because recruitment has increased with average seawater temperature. This has resulted in a clear example of density-dependent control as the mortality rate of recruits over their first winter increases with recruitment (See figure 6.5.9. S6 taken from Henderson *et al.*, 2006)[623]. It is envisaged that increased *C. crangon* abundance is associated with increased predator and competitor abundance, and it is thought that a fixed physical constraint, such as the amount of available habitat, is setting an upper limit on the adult population.

Figure 6.5.9 S9. The variation in mortality rate with population size for shrimp, Crangon crangon in Bridgwater Bay. Population size is the peak number of recruits in autumn. Instantaneous mortality rate was calculated using regression analysis. The straight line was fitted by linear regression. Figure taken from Henderson et al., (2006[11]).



623 Henderson, P.A, Seaby, R.M., Somes, J.R. (2006) A 25-year study of climatic and density-dependent population regulation of common shrimp *Crangon crangon* (Crustacea: Caridea) in the Bristol Channel. J. Mar. Biol. Ass. U.K. 86, 287^298

Conclusion for entrainment and impingement effect on decapods (*crangon crangon)* in the estuaries feature in combination

Evidence from HPB impingement surveys suggests that the production/ biomass ratio of *C. crangon* has increased over the past 25 years, despite potential effects from entrainment or impingement. It would also seem that due to the populations of *C. crangon* being density dependant, any reductions in the population size due to entrainment and impingement will be rapidly filled by new recruits.

It can therefore be concluded that the cumulative effects from entrainment together with impingement impacts, will not adversely affect the C. crangon (decapod) populations within the Severn Estuary and Bristol Channel.

Fish, fish eggs and larvae is covered within section 6.10.8 (migratory fish and fish assemblage)

Overall conclusion for entrainment and impingemnent for organisms for estuaries feature in combination

HPA and HPB have been running since 1976, Aberthaw since 1971, and Oldbury A since 1967 and over this period, the estuarine system has been relatively stable and increasing in biodiversity despite the potential effects from entrainment, so in reality they could be considered as 'back ground'. The main in combination effects are likely to arise from the cumulative effects of HPC running alongside HPB both at 100% operation, which appears to be scheduled in for a period of 3 years (2020-2023). However, Beaugrand and Reid (2003)[624] noted that changes in the phytoplankton are linked to large-scale changes in ocean productivity caused by climatic variables such as the North Atlantic Oscillation and surface seawater temperature. This change in plankton is then part of a series of changes down the food chain and will be the likely causes of variations in abundance of fish and macro invertebrates within the estuary rather than effects from power station abstractions such as at HPB and HPC.

It can therefore be concluded that the cumulative effects from entrainment together with impingement will not adversely affect the integrity of the Severn Estuary SAC, SPA and Ramsar.

Outcome of entrainment and impingement assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC operational discharges (abstraction)	No
HPB cooling water abstraction	No
Aberthaw cooling water abstraction	No
Oldbury A abstraction	No
Oldbury B abstraction	No
Overall in combination effects	**No adverse effect upon site integrity**

[624] Beaugrand, G., Reid, P.C. (2003). Long-term changes in phytoplankton, zooplankton and salmon related to climate. Glob. Change Biol. 9, 1–17.

Overall conclusion of in combination assessment of estuaries feature

Hazard assessed	Adverse effect on estuaries feature?
Toxic contamination	Yes – Requirement to remove hydrazine via permit condition (see below)
Non-toxic contamination	No
Changes to thermal regime	No
Salinity	No
Siltation turbidity and suspended sediment	No
Habitat loss & physical damage	No
Competition from non-native species	No
Entrainment of planktonic organisms	No
Overall conclusion	**With the permit condition in place we can conclude no adverse effect upon site integrity**

Advice / Requirements	Competent Authority	Method
Required mitigation *Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges*	Environment Agency	Operational Permit Ref: HP3228XT

6.5 Sub-tidal sandbanks

6.6.1 Activities resulting in a potential impact on the Sub-tidal sandbanks

	Construction activities											Operational activities														
Potential sources of hazard	**EA consents**				**Existing plans and other plans & projects**							**EA Consents**														
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Jetty construction	Construction of cooling water infrastructure	Nuclear island construction	Bristol deep sea container terminal	EA Steart development	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge	Jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning
Toxic contamination	×	×	×	×	×	×	×	×	✓	✓	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thermal impact	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Salinity	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Turbidity, suspended sediment & siltation	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	✓	×	×	✓	✓	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Note: permissions relating to HPC development assessed within the alone section of this document are highlighted in green

6.6 Subtidal Sandbanks Feature

6.6.2 Toxic contamination (changes to water chemistry)

Conservation objectives:

- *the total extent of the subtidal sandbanks within the site is maintained;*
- *the extent and distribution of the individual subtidal sandbank communities within the site is maintained;*
- *the community composition of the subtidal sandbank feature within the site is maintained;*
- *the variety and distribution3 of sediment types across the subtidal sandbank feature is maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency permissions, plans or projects that could have an impact on the sub-tidal sandbanks feature in terms of toxic contamination include the following:

- HPC cooling water discharge

These could act in combination with toxic contamination from the following other permissions, plans or projects:

- EA Steart development
- Bristol Ports compensatory habitat at Steart
- HPB cooling water discharge

Relevant Proposed Plans and Projects and Existing Permits

Based on the assessment undertaken for the Estuaries feature (Section 6.5, the only PPPs or existing permits which are considered to potentially affect the subtidal sandbanks feature in combination in relation to toxic contamination are the operational discharges from HPB and HPC.

Each of the proposed plans and projects and existing permits as shown in Table 6.2 S1 assessed in the Table below in terms of its significance alone in relation to the specific hazard toxic contamination.

Assessment of 'In combination' Effects

The period when there is a potential 'in combination' effect is when the HPC operational discharges start, as the HPB operational discharges are expected to be continue until 2023. The toxic contaminant in these discharges which can have an 'in combination' effect is TRO, which can be in both cooling water discharges. Hydrazine is not considered here, as it has already been concluded that treatment to remove hydrazine prior to discharge will be a requirement of the permit for the HPC operational discharges.

Based on the combined mixing zones for TRO from the discharges of HPB and HPC, it is clear that the main impact from the combined discharges is on subtidal muds and variable mixed sediments. The combined mixing zones do not appear to affect the subtidal sandbanks at the mouth of the Parrett Estuary. The total subtidal area affected by the combined mixing zone is estinmated to be 214 ha at the surface and

99 ha at the bed. These areas equate to 0.42% and 0.20% of the subtidal area of the SAC. The seabed habitat most affected by the TRO mixing zones is muds/sandy muds with *Nephtys hombergii* and *Macoma balthica*. Most of the subtidal area of Bridgwater Bay has a benthic macrofauna which is low in abundance and diversity (BEEMS TR067 Ed2 2010[625]). These findings agree with earlier studies of the Severn Estuary and Bristol Channel (Warwick *et al* 2001[626], Warwick and Summerfield 2010[627]). There is an area of increased abundance of *Macoma balthica* and other species at 2 sites in Bridgwater Bay which are related to the subtidal sandbanks feature. However, this area is outside the mixing zone for TRO.

While the levels of TRO which may affect the sub-tidal communities are greater than those affecting the intertidal flats, the levels will be below lethal concentrations which have been quoted to be between 0.193mg/l and 0.360mg/l (BEEMS TR 163 (2011)[628]), as the maximum concentration of TRO in the thermal plume at the point of discharge will be 0.200mg/l. It is therefore accepted that there could be some effect from TRO on the sub-tidal communities, where the EQS is exceeded. The main behavioural effect of increased TRO on *Macoma balthica* which was noted in BEEMS TR163 (2011) was the potential for reduced siphon activity, and therefore feeding, at TRO levels of 10 to 20 µg/l. This level is at or marginally higher than the TRO EQS of 10 µg/l, although this is as a 95%ile. The size of the mixing zone for a TRO of 10 µg/l as a mean value is considerably smaller than as a 95%ile, and confined to the immediate area of the discharges.

This indicates that the any persistent effects from TRO on the subtidal benthic communities will be very localised. The mixing zone for bromoform, the main by-product of chlorination, has an estimated extent which is coincident with that for TRO. This would also suggest that any potential effect from bromoform will be confined to very localised areas in the immediate vicinity of the discharges. It should also be borne in mind that the use of chlorination has never been used during the operational life of HPB or HPA, ie. since 1965.

The effect of any TRO discharge therefore remains a potential effect only, although it has been assessed since a permit will be required for HPC, and exists for HPB. However, the use of chlorination at HPC will only be allowed if a demonstrable need should arise.

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[625] BEEMS Technical Report TR067 (Edition 2). Hinkley Point nearshore communities: Results of the day grab surveys 2008 - 2010. EDF BEEMS (Cefas), 2010.
[626] Warwick R.M., Henderson P.A., Fleming J., Somes J.R. 2001. The impoverished fauna of the deep water channel and marginal areas between Flatholm Island and King Road, Severn Estuary. Report to the Bristol Port Company. 21 pp.
[627] Warwick R. M. and Somerfield P.J. 2010. The structure and functioning of the benthic macrofauna of the Bristol Channel and Severn Estuary, with predicted effects on a tidal barrage. Marine Pollution Bulletin 61, 92-99.
[628] BEEMS Technical Report TR 163. Acute and behavioural effects of chlorinated seawater on inter-tidal mudflat species. EDF BEEMS (Cefas), 2011.

Table 6.6.2 S1

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Operational discharges	The pathway for toxic contamination is through the discharge of contaminants into the cooling water system, and also contaminants added directly to the cooling water.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The concentrations of the toxic contaminants in the operational discharges have been considered in the alone assessment. The levels of all contaminants except total residual oxidant (TRO) and hydrazine are below the relevant EQS or PNEC in the cooling water discharge. There are no mixing zones related to the operational discharges therefore, except for TRO and hydrazine. For other toxic contaminants, any potential impact is therefore due to the additional loadings from the discharge relative to existing loadings to the Severn Estuary SAC. The size of the mixing zones for TRO was estimated to be 63 ha at the sea bed and 157 ha at the surface. The mixing zone does not affect the intertidal mudflats and sandflats feature, so that any effect is on the subtidal area of the SAC (see Figure ??). These represent 0.12 and 0.31% of the subtidal area of the SAC respectively. The mixing zone does not appear to the subtidal sandflats feature at the mouth of the Parrett Estuary The mixing zones for hydrazine are similar being estimated to be 77 ha at the sea bed and 191 ha at the surface. These represent 0.15 and 0.38% of the subtidal area of the SAC. However, the modelling of the hydrazine mixing zone does not include modelling of the short-term scenario when hydrazine concentrations are predicted to be at a maximum. As the loading of hydrazine for the short-term scenario is about 40 times that for the average scenario, it was concluded that the mixing zone for hydrazine could be considerably bigger than that estimated for the average scenario. It was therefore not possible to conclude on the available evidence that a discharge of hydrazine was not having an adverse effect on site integrity from the alone assessment without mitigation through treatment of the hydrazine prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the permit for HPC operational discharges. The annual loads of other contaminants in the operational discharges from HPC are all less than 0.1% of the total measured load to the SAC, with the exception of iron, which is 0.85% (see alone assessment). However, iron is very abundant in the Severn Estuary system, being a major component of the sediments at between 2 and 3% by weight. The additional input of iron and the other toxic contaminants from the HPC operational discharges are therefore considered to be insignificant.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	There is a measurable mixing zone for the toxic contaminants, TRO and hydrazine, in the HPC operational discharges, so that there is a likely significant effect from the discharges. The sizes of the mixing zones are predicted to be small, being 0.22% of the Estuaries feature for TRO at the surface, and 0.26% of the Estuaries feature for hydrazine at the surface. Given the size of the mixing zone, the discharge of TRO is not considered to have an adverse effect on site integrity. However, the potential maximum impact of the discharge of hydrazine has not been modelled, so that the predicted size of mixing zone is considered to be significantly underestimated. It was therefore not possible to conclude that the discharge of hydrazine was not having an adverse effect on site integrity. Mitigation of the potential impact of hydrazine is consequently required to remove the potential adverse effect; this mitigation is likely to be treatment of the discharge. It is considered that the additional inputs of toxic contaminants to the Severn Estuary from the HPC operational discharges are all insignificant, being mostly less than 0.1%, except for iron, which is 0.85%. However iron is ubiquitous and very abundant in the Severn Estuary.

Table 6.6.2 S1 (continued)

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPB Operational discharges	The pathway for toxic contamination is through the discharge of contaminants into the cooling water system, and also contaminants added directly to the cooling water.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The only consented toxic contaminant in HPB operational discharges is total residual oxidant (TRO). The consented level of TRO is 0.3 mg/l, and applies to both the main cooling water discharge of 3,000,000 m^3/d and also various trade discharges and cooling water during outages with a combined dry weather flow of 40,000 m^3/d. The main cooling water flow for HPB is discharged through the intertidal culvert. The other smaller discharge is made to the upper intertidal area in front of the HPB site. As the consented levels in both discharges are above the EQS of 0.01 mg/l, there will be mixing zones related to both discharges. It should be noted that although the HPB discharges are consented for TRO, chlorination has never been used at HPB. The size of the potential mixing zone for TRO due to HPB operational discharges has been modelled using GETM. The total mixing zone area at the sea bed is estimated to be 69 ha and the total area at the surface to be 92 ha. However, the mixing zone affects both the intertidal and subtidal area. The area of the mixing zone affecting the subtidal area of the SAC is estimated to be 55 ha at the surface and 36 ha at the bed. These areas represent 0.11% and 0.07% of the subtidal area of the SAC respectively. As there are no other consented toxic contaminants in the operational discharges for HPB, the input of toxic contaminants other than TRO from these discharges is taken to be negligible.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges.	There is a measurable mixing zone for the toxic contaminant, TRO, in the HPB operational discharges, so that there is a likely significant effect from the discharges. The predicted mixing zone for TRO from the HPB discharge is small, being 0.13% of the Estuaries feature at the surface. Hydrazine is not used at HPB, so there is no hydrazine discharge and therefore no mixing zone. The loads of other toxic contaminants from the HPB operational discharges are not measurable and are considered to be negligible, as the only consented toxic contaminant is TRO.

The time relationship of the different PPPs or permit is shown in Table 6.6.2S2 in 3 month blocks to 2022, together with the scale of impact. 'N' signifies a negligible impact, 'L' signifies a likely significant effect, and 'A' signifies an adverse effect.

Table 6.6.2 S2

Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
Toxic Contamination	**PPP or Permit**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	HPC Operational discharges																										Hot commissioning							Operation						continues for about 60 years					
																									N	N	N	N	N	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	HPB Operational discharges																			Existing discharge. Continues to end of 2023																									
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

Conclusion for effects of toxic contamination for subtidal sandbanks in combination

Based on the limited extent of any potential impact of toxic contamination on the subtidal area of the Severn Estuary SAC, and the lack of clear impact on the subtidal sandbanks feature, it is concluded that the conservation objectives for the subtidal sandbanks feature are not compromised. It is therefore concluded that there is no adverse effect on site integrity.

6.6.3 Non-toxic contamination (nutrient enrichment and organic loading)

Due to its *location and known sensitivities* we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to non-toxic contamination as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of non-toxic contamination on this feature has not been considered further.

6.6.4 Changes to thermal regime

Conservation objectives:

- *the total extent of the subtidal sandbanks within the site is maintained;*
- *the extent and distribution of the individual subtidal sandbank communities within the site is maintained;*
- *the community composition of the subtidal sandbank feature within the site is maintained;*
- *the variety and distribution**3** of sediment types across the subtidal sandbank feature is maintained.*
-

Environment Agency permissions, plans or projects that could have a thermal impact on the sub-tidal sanbanks feature include the following:

- HPC cooling water discharge

which could act in combination with thermal impact from the following other permissions, plans or projects:

- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Relevant Proposed Plans and Projects and Existing Permits

Based on the assessment undertaken for the Estuaries feature (Section 6.5), the only PPPs or existing permits which are considered to potentially affect the subtidal sandbanks feature in combination in relation to changes to the thermal regime are the operational discharges from HPB and HPC, Uskmouth Power Station, decommissioning discharges from Oldbury A power station, and potential operating discharges from Oldbury B power station.

Section 6.5.4 discusses information to inform the assessment related to the predicted sizes of the mixing zones for the HPC and HPB cooling water discharges from modelling. The predicted sizes of the mixing zones in relation to the intertidal sandflats and mudflats feature and subtidal sandbanks feature are given for the various targets for the Severn Estuary SAC and SPA.

The information above has informed the next stage of the assessment where each of the proposed plans and projects and existing permits as shown in 6.2 S1 assessed in Table 6.6.4 S1 in terms of its significance alone in relation to the specific hazard ‘changes to thermal regime’.

Table 6.6.4 S1

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the outfall about 1.8 km offshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge with respect to the subtidal area of the It is clear from that the thermal plume does affect the subtidal sandbanks feature at the mouth of the Parrett Estuary, although the level of temperature uplift is only about 1 to 1.5 ºC. The significance of the impact of the thermal plume from HPC on the interest features of the Severn Estuary SAC has been assessed in detail in the alone assessment, and is not repeated here. There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	The greatest potential impact is on the intertidal mudflats and sandflats feature, and the benthic invertebrate community, notably *Macoma balthica*. However, it was concluded that the likely impact of the thermal plume on the intetidal mudflats and sandflats from HPC alone was similar to that from the HPB thermal plume. As no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without, it has been concluded that there is no significant adverse effect on the integrity of the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPC thermal plume alone.
HPB Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the culvert across the foreshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge with respect to the subtidal area of the It is apparent that the thermal plume does not appear to significantly affect the subtidal sandbanks feature at the mouth of the Parrett Estuary, and the greater relative impact occurs on the intertidal mudflats and sandflats. There have been various studies of the intertidal benthic invertebrates on Stert Flats related to the impact of the proposed HPC thermal discharge. These have shown that no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without (BEEMS SPP062 (2011)[629], and BEEMS SPP073/S (2012)[630]). There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges.	The HPB cooling water disharge has an existing permit. Based on the available information on the impact of the existing thermal plume from HPB, it has been concluded that there is no significant impact on the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPB thermal plume alone.

[629] BEEMS. Scientific Position Paper 062: Macoma balthica population structure at Hinkley Point and elsewhere in the Severn Estuary. EDF BEEMS (Cefas). 2011.
[630] BEEMS Scientific Position Paper SPP073/S. The potential in combination effects of HP B and HP C thermal plumes upon the intertidal mudflat ecology of Bridgwater Bay. EDF BEEMS (Cefas). 2012

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the outfall about 1.8 km offshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge with respect to the subtidal area of the It is clear from that the thermal plume does affect the subtidal sandbanks feature at the mouth of the Parrett Estuary, although the level of temperature uplift is only about 1 to 1.5 ºC. The significance of the impact of the thermal plume from HPC on the interest features of the Severn Estuary SAC has been assessed in detail in the alone assessment, and is not repeated here. There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	The greatest potential impact is on the intertidal mudflats and sandflats feature, and the benthic invertebrate community, notably *Macoma balthica*. However, it was concluded that the likely impact of the thermal plume on the intetidal mudflats and sandflats from HPC alone was similar to that from the HPB thermal plume. As no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without, it has been concluded that there is no significant adverse effect on the integrity of the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPC thermal plume alone.
HPB Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the culvert across the foreshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge with respect to the subtidal area of the It is apparent that the thermal plume does not appear to significantly affect the subtidal sandbanks feature at the mouth of the Parrett Estuary, and the greater relative impact occurs on the intertidal mudflats and sandflats. There have been various studies of the intertidal benthic invertebrates on Stert Flats related to the impact of the proposed HPC thermal discharge. These have shown that no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without (BEEMS SPP062 (2011), and BEEMS SPP073/S (2012)). There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges.	The HPB cooling water disharge has an existing permit. Based on the available information on the impact of the existing thermal plume from HPB, it has been concluded that there is no significant impact on the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPB thermal plume alone.

Table 6.6.4 S1

Uskmouth Power Station Thermal discharge	The pathway for changes to the thermal regime is through the discharge of heated effluent to the Usk estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The size of the mixing zone of the thermal discharge from Uskmouth Power Station was estimated to be less than 0.1 ha in the Review of Consents. The area has been assumed to affect the subtidal area of the Severn Estuary SAC, as the discharge appears to be close to the low water mark. There is no thermal barrier to fish movement created by the Uskmouth thermal discharge alone.	About 240 months (20 years) based on the expected operational life of the power station.	The thermal discharge from Uskmouth Power Station has an existing permit.
Oldbury B Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through an outfall to the Severn Estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, it is expected that any proposed development will utilise cooling towers, so that the cooling water discharge will be significantly less than that for a direct cooled power station. The expected thermal load to the upper Severn Estuary should be considerably less than that from the cooling water for Oldbury A, but its actual impact can only be assessed when more information is available.	It is not known when the Oldbury B cooling water discharge would start, as the development of the site is at an early stage. It is expected that the start date could be about 2025.	It is not possible to define the actual extent of any impact from the proposed Oldbury B cooling water discharge, as not all relevant details on the proposals are available.
Oldbury A Decommissioning Thermal discharge	The pathway for changes to the thermal regime is through the discharge of heated effluent to the Severn estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The cooling water discharge has very recently ceased (27/02/12), so that the discharge now only relates to any cooling water arising from the decommissioning activities. The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, the discharge flow is expected to be over a quarter of the existing cooling water flow, while the temperature differential and maximum temperature are also expected to decrease. Based on the estimated size of the mixing zone in the Review of Consents (about 120 ha), the estimated size of any mixing zone related to the decommissioning discharge from Oldbury is between 20 and 30 ha. As the discharge is into the main channel of the Severn Estuary, most of the impact is expected to be in the main channel in the vicinity of Oldbury, and therefore the subtidal area. The extent of the mixing zone has therefore been taken to be about 20 to 30 ha. However, the subtidal sandbanks feature does not occur in the Severn Estuary until about 15 km down-estuary of the outfall for Oldbury, below the new Motorway crossing of the Severn Estuary . The scale of any effect on the subtidal sandbanks feature is therefore expected to be very small. The cooling water discharge from Oldbury A did not appear to create a barrier to fish migration in the upper Severn Estuary, as migratory fish appeared to move unhindered up into the freshwater rivers above Oldbury. Any reduction in the thermal loading from Oldbury can only reduce any potential thermal barrier in the upper Estuary.	About 180 months (15 years) based on the expected time scale of decommissioning of the power station. The projected end date is the end of 2026.	The cooling water discharge from Oldbury Power Station has an existing permit which was under review. The cooling water discharge has very recently ceased (27/02/12), so that the discharge now only relates to any cooling water arising from the decommissioning activities. The exact volume of the discharge and its maximum temperature difference above ambient is not yet known, but the extent of any impact is expected to be insignificant with respect to the subtidal sandbanks feature which are about 15 km down-estuary from the outfall for the Oldbury discharges. Although the thermal plume may extend this far on the ebb, the temperature uplift in the plume is expected to be below 2ºC.

The time relationship of the different PPPs or permits is shown in Table 6.6.4 S2 below in 3 month blocks to 2022, together with the scale of impact. 'N' signifies a negligible impact, 'L' signifies a likely significant effect, and 'A' signifies an adverse effect. It is apparent that there is the potential for nearly all the discharges to overlap in time, except the cooling water discharge from HPB with the proposed cooling water discharge from Oldbury B. However, it is also evident that there could be minimal or no overlap between the Oldbury A and Oldbury B discharges.

Table 6.6.4 S2

Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
Changes to Thermal Regime	**PPP or Permit**	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	HPC Cooling Water Discharge																													Operation continues for about 60 years															
																														L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	HPB Cooling Water discharge	Existing discharge. Continues to end of 2023																																											
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Uskmouth Power Station Thermal discharge	Existing discharge End date not known but expected to be about 2030																																											
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Oldbury B Cooling Water discharge	Expected start date 2025																																											
	Oldbury A Decommissioning Thermal discharge	Existing discharge Continues to Q4 2026																																											
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

Assessment of 'In combination' Effects of thermal plumes from other Power Stations

As discussed in the in combination assessment for the Estuaries feature, a major factor in the assessment of the 'in combination' effects for the thermal discharges is the proximity of the other discharges to the proposed cooling water discharge from HPC. The HPB cooling water discharge is very close, about 2.5 km, to that from the proposed HPC site. Uskmouth Power Station is about 38 km away up the Severn Estuary at the mouth of the Usk Estuary, on the Welsh coast. Oldbury A and B are both about 65 km away up the Severn Estuary on the English coast.

The scale of impact in terms of a mixing zone for a ΔT of 2ºC from Uskmouth Power Station is about 0.1 ha, while that from the Oldbury A Decommissioning discharge is about 20 to 30 ha as a maximum. Given that the discharge from Oldbury B will be effectively at the same location as Oldbury A, the thermal plumes will be coincident, although the thermal load will be increased. As it is not known whether there will be any overlap in time between Oldbury A and B, the size of the mixing zone has been assumed to be about 30 ha.

The combined areas of the mixing zones for HPB and HPC are given in Table 6.5.4 S5, and their percentages relative to the subtidal area of the Severn Estuary SAC are given in Table 6.5.4 S6. It is apparent that the thermal plume form the combined HPB and HPC discharges covers a greater extent than either HPB or HPC alone.. The expected end date for Hinkley B is now 2023. Hinkley B at present is operating at about 70% of its total output (British Energy website[631]). While it is possible that HPB could achieve 100% output, this is stated to be unlikely, and the maximum expected output from HPB is believed to be 80%. Once power generation ceases at HPB, there will be no thermal load in the subsequent decommissioning discharges.

The nature of the subtidal area in the vicinity of Oldbury is mostly rock and fine sand, which is probably very mobile in the prevailing tidal currents (Langston *et al* 2007[632], Admiralty Chart 1166[633]). The benthic community is therefore likely to be very depauperate, with most benthic invertebrates being found in the intertidal sandbanks and mudflats, which occur on the margins and within the channel (Langston *et al* 2007). The subtidal sandbanks feature is about 15 km down-estuary from the present Oldbury A discharge point. Assuming that this location will also be used for the operational discharges from Oldbury B, then neither Oldbury A or B is considered to have any significant effect on the subtidal sandbanks feature. Similarly the additional potential contribution of Uskmouth PS is considered to be insignificant relative to the extent of the thermal plume from the combined HPB and HPC cooling water discharges.

Assessment of The In combination Effect of The Thermal Plumes from HPB and HPC

There is an area of the subtidal sandbanks feature in Bridgwater Bay, although the major extent of the feature is to the north, up-estuary of the Holm islands. The combined plumes do affect the area of the subtidal sandbanks feature in Bridgwater Bay, but the mean temperature uplift is generally less than 1.5 ºC. The main subtidal habitat affected by the combined thermal plume is sandy mud with *Nephtys hombergii* and *Macoma balthica*, although some mixed sediments with *Sabellaria* are

[631] http://www.british-energy.com
[632] Langston W.J., Chesman B.S., Burt G.R., Campbell M., Manning A. & Jonas P.J.C. 2007 The Severn Estuary: Sediments, contaminants and biota. Marine Biological Association of the United Kingdom Occasional Publication (19). 176 pp.
[633] Admiralty Chart 1166 dated 2002

also affected . *Sabellaria* is tolerant of increased temperatures, and the most sensitive component of the subtidal benthic community to thermal effects is *Macoma balthica,* which is also the most abundant component of the depauperate subtidal benthic community (BEEMS TR067 Ed2 2010[634], BEEMS TR184 2011[635]). The *Macoma balthica* in the subtidal area of the Severn Estuary are not considered to be any different in their response to changes in the thermal regime than those in the intertidal area. It would also appear that there is a rapid turnover of the *Macoma balthica* in the subtidal area of the Severn Estuary, as numbers are maintained (BEEMS TR067Ed2 2010), despite the dynamic nature of the Estuary. This suggests that like the intertidal *Macoma balthica,* the subtidal *Macoma balthica* off Hinkley are also being replenished from all the available productive sources in the Severn Estuary.

Conclusion of effects of thermal plumes on subtidal sandbanks in combination

Based on the available evidence, therefore, and the expected continuing operation of the HPB power station until about 2023, it is concluded that the combined thermal plume from HPB and HPC will not compromise the conservation objectives for the subtidal sandbanks feature concerning the subtidal communities, and the extent of the feature, and therefore not have an adverse effect on site integrity.

It is also concluded that if there were an unforeseen effect on the subtidal communities, in particular the thermally sensitive species Macoma balthica, then recovery of the communities would be relatively rapid, ie expected to be from 5 to 8 years following the cessation of a thermal discharge from Hinkley B.

6.6.5 Salinity

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to salinity changes as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of salinity changes on this feature has not been considered further.

6.6.6 Siltation, turbidity and suspended sediment

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to siltation, turbidity and suspended sediment as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of siltation, turbidity and suspended sediment on this feature has not been considered further.

6.6.7 Physical damage / Habitat loss

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to physical damage and/or habitat loss as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact physical damage and/or habitat loss on this feature has not been considered further.

[634] BEEMS Technical Report TR067 (Edition 2). Hinkley Point nearshore communities: Results of the day grab surveys 2008 - 2010. EDF BEEMS (Cefas), 2010.
[635] BEEMS Technical Report 184: Hinkley Point Site. Hinkley Point Marine Ecological Synthesis Report. EDF BEEMS (Cefas) 184. 2011.

6.6.8 Disturbance (noise, vibration and visual)

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to disturbance as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of disturbance on this feature has not been considered further.

6.6.9 Entrainment and Impingement

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to entrainment and impingement as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of entrainment and impingement on this feature has not been considered further.

Overall conclusion of in combination assessment on sub-tidal sandbanks assessment

Hazard assessed	**Adverse effect on sub-tidal sandbanks feature?**
Toxic contamination	No – with operational permit in place
Non-toxic contamination	No
Changes to thermal regime	No
Salinity	No
Siltation turbidity and suspended sediment	No
Habitat loss & physical damage	No
Entrainment	No
Overall conclusion	**No adverse effect upon site integrity**

6.6 Intertidal mudflats and sandflats

6.7.1 Activities resulting in a potential impact on the Inter-tidal mudflats and sandflats

Potential sources of hazard	Construction activities															Operational activities											
	EA consents				Existing plans and other plans & projects							EA Consents														
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Jetty construction	Construction of cooling water infrastructure	Nuclear island construction	Bristol deep sea container terminal	EA Steart development	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge	Jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning
Toxic contamination	×	×	×	×	×	×	×	×	✓	✓	×	✓	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thermal impact	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Salinity	✓	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Turbidity, suspended sediment & siltation	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Note: permissions relating to HPC development assessed within the alone section of this document are highlighted in green

6.7 Intertidal Mudflats and Sandflats

6.7.2 Toxic contamination (changes to water chemistry)

Conservation objectives:

- *the total extent of the mudflats and sandflats feature is maintained;*
- *the variety and extent of individual mudflats and sandflats communities within the site is maintained;*
- *the distribution of individual mudflats and sandflats communities within the site is maintained;*
- *the community composition of the mudflats and sandflats feature within the site is maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency permissions, plans and projects that could have an impact on the inter-tidal mudflats and sandflats feature in terms of toxic contamination include the following:

- Discharges during cold commissioning of HPC
- HPC cooling water discharge

These could act in combination with toxic contamination from the following other permissions, plans or projects:

- EA Steart development
- Bristol Ports compensatory habitat at Steart
- HPB cooling water discharge

Relevant Proposed Plans and Projects and Existing Permits

Based on the assessment undertaken for the Estuaries feature (Section 6.5), the only PPPs or existing permits which are considered to potentially affect the intertidal mudflats and sandflats feature in combination in relation to toxic contamination are the operational discharges from HPB and HPC.

Each of the proposed plans and projects and existing permits as shown in 6.2 S1 is assessed in the Table below in terms of its significance alone in relation to the specific hazard toxic contamination.

Assessment of 'In combination' Effects

The period when there is a potential 'in combination' effect is when the HPC operational discharges start, as the HPB operational discharges are expected to be continue until 2023. The toxic contaminant in these discharges which can have an 'in combination' effect is TRO, which can be in both cooling water discharges. Hydrazine is not considered here, because treatment to remove hydrazine prior to discharge will be a requirement of the permit for the HPC operational discharges.

Based on the combined mixing zones for TRO from the discharges of HPB and HPC, it is clear that the main impact on the intertidal mudflats and sandflats could arise from the potential mixing zone for HPB. The total area of the intertidal mudlfats and sandflats affected by the combined mixing zone is the same as that for HPB alone, ie. 37 ha at the surface and 33 ha at the bed, which equate to 0.18% and 0.16% respectively this feature. There may be some stressing of the intertidal flat community, due to the combined mixing zone for TRO. However, although there is a potential area above EQS due to the discharge from HPB, the concentrations are still below any levels considered to be significant from a literature review of the chlorination responses of key intertidal species (BEEMS TR 162 (2010[636]).

Laboratory experiments on the sensitivity of three intertidal species (*Corophium, Hydrobia,* and *Macoma*) to chlorinated seawater showed that that *Corophium* was the most sensitive species (BEEMS TR 163 (2011)[637]) . Lethal concentrations were in the range 0.193 to 0.360 mg/l TRO, although some influence was observed at concentrations of 0.032 to 0.039 mg/l. These concentrations are well above expected concentrations over the intertidal flats at the bed, which is the most critical area for intertidal benthic fauna and flora. However, there could be some effect on *Macoma balthica*, at levels close to the EQS of 0.01 mg/l, as reduced siphon activity was recorded at TRO levels between 0.01 and 0.02 mg/l.

However, the EQS for TRO relates to a 95%ile, so that the extent of persistent values at or above 0.01 mg/l are better defined as a mean. The extent of the combined mixing zone for a mean TRO of 0.01 mg/l shows that any persistent effect from TRO will be restricted to a small area in the vicinity of the HPB discharge point. As the mixing zone for bromoform, the main by-produce of chlorination, is considered to be coincident with the mixing zone for TRO (see Section 2.6.3 on the Alone Assessment for HPC in relation to the Estuaries feature), any effect from bromoform will also be restricted to a small area in the vicinity of the HPB discharge point. Any effect from the TRO mixing zone does not appear to extend into the intertidal sandflats and mudflats feature, and is very localised, so that impacts from TRO are therefore not considered to significantly affect the intertidal mudflats and sandflats feature. It should also be noted that while the discharge of TRO is consented for HPB, chlorination has never been used since the plant commenced operation in 1976.

Conclusion of effects of toxic contamination for Intertidal Mudflats and Sandflats
Based on the extent of the combined mixing zones for TRO, and the removal of hydrazine from the HPC operational discharges prior to discharge, it is concluded that the conservation objectives for the intertidal mudflats and sandflats feature are not compromised by toxic contamination from relevant PPPs and existing permits when considered in combination. It is therefore concluded that there is no adverse effect on site integrity.

[636] BEEMS Technical Report TR162, 2010. Hinkley Point chlorination responses of key intertidal species - literature review. EDF BEEMS (Cefas), 2010.
[637] BEEMS Technical Report TR 163. Acute and behavioural effects of chlorinated seawater on intertidal mudflat species. EDF BEEMS (Cefas), 2011.

Table 6.7.2 S1

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Operational discharges	The pathway for toxic contamination is through the discharge of contaminants into the cooling water system, and also contaminants added directly to the cooling water.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The concentrations of the toxic contaminants in the operational discharges have been considered in the alone assessment. The levels of all contaminants except total residual oxidant (TRO) and hydrazine are below the relevant EQS or PNEC in the cooling water discharge. There are no mixing zones related to the operational discharges therefore, except for TRO and hydrazine. For other toxic contaminants, any potential impact is due to the additional loadings from the discharge relative to existing. The mixing zone for TRO from HPC alone does not affect the intertidal mudflats and sandflats feature The mixing zones for hydrazine does not affect the intertidal mudflats and sandflats feature. However, the modelling of the hydrazine mixing zone does not include modelling of the short-term scenario when hydrazine concentrations are predicted to be at a maximum. As the loading of hydrazine for the short-term scenario is about 40 times that for the average scenario, it was concluded that the mixing zone for hydrazine could be considerably bigger than that estimated for the average scenario. The annual loads of other contaminants in the operational discharges from HPC are all less than 0.1% of the total measured load to the SAC, with the exception of iron, which is 0.85% (see alone assessment). However, iron is very abundant in the Severn Estuary system, being a major component of the sediments at between 2 and 3% by weight. The additional input of iron and the other toxic contaminants from the HPC operational discharges are therefore considered to be insignificant.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	There is a measurable mixing zone for the toxic contaminants, TRO and hydrazine, in the HPC operational discharges and a likely significant effect from the discharges. The sizes of the mixing zones are predicted to be small, being 0.22% of the Estuaries feature for TRO at the surface, and 0.26% of the Estuaries feature for hydrazine at the surface. Discharge of TRO is not considered to have an adverse effect on site integrity. However, the potential maximum impact of the discharge of hydrazine has not been modelled and the predicted size of mixing zone is considered to be significantly underestimated. We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation to remove hydrazine prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement It is considered that the additional inputs of toxic contaminants to the Severn Estuary from the HPC operational discharges are all insignificant, being mostly less than 0.1%, except for iron, which is 0.85%. However iron is ubiquitous and very abundant in the Severn Estuary.

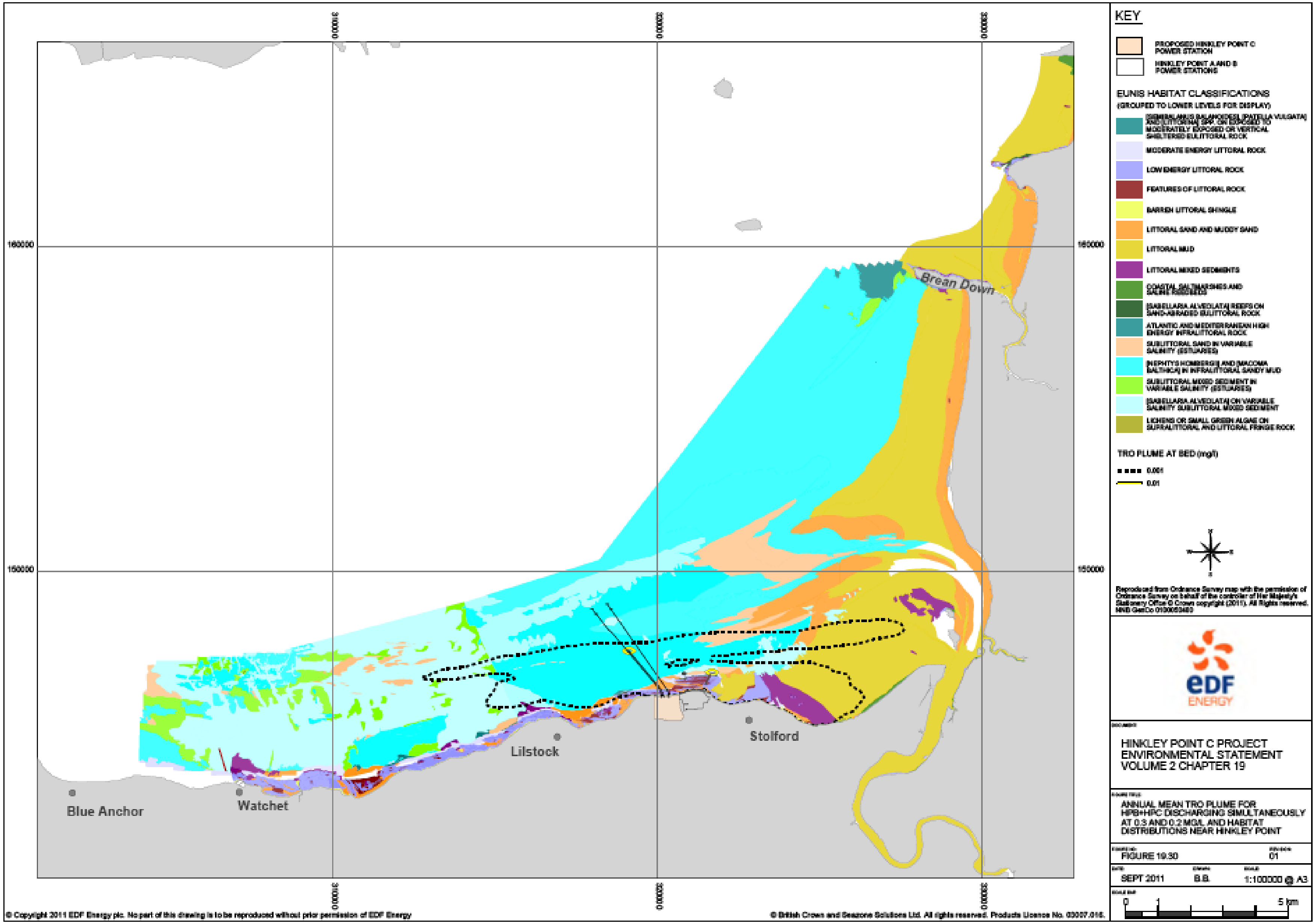
PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPB Operational discharges	The pathway for toxic contamination is through the discharge of contaminants into the cooling water system, and also contaminants added directly to the cooling water.	Increased levels of toxic contaminants in the water column could impact on the subtidal and intertidal benthic communities either through direct toxicity or due to bioaccumulation.	The only consented toxic contaminant in HPB operational discharges is total residual oxidant (TRO). The consented level of TRO is 0.3 mg/l, and applies to both the main cooling water discharge of 3,000,000 m^3/d and also various trade discharges and cooling water during outages with a combined dry weather flow of 40,000 m^3/d. The main cooling water flow for HPB is discharged through the intertidal culvert, a smaller discharge to the upper intertidal area in front of the HPB site. As the consented levels in both discharges are above the EQS of 0.01 mg/l, there will be mixing zones related to both discharges. It should be noted that although the HPB discharges are consented for TRO, chlorination has never been used at HPB. The size of the potential mixing zone for TRO due to HPB operational discharges has been modelled using GETM. The total mixing zone area at the sea bed is estimated to be 69 ha, and the total area at the surface to be 92 ha. The areas potentially affecting the intertidal mudlfats and sandflats are 33 ha at the bed, and 37 ha at the surface (based on figures quoted for the SPA, and assuming that the SPA is equivalent to the intertidal mudflats and sandflats feature). These areas equate to 0.16% and 0.18% respectively of the intertidal mudflats and sandflats feature, or 0.13% and 0.15% respectively of the SPA. As there are no other consented toxic contaminants in the operational discharges for HPB, the input of toxic contaminants other than TRO from these discharges is taken to be negligible.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges.	There is a measurable mixing zone for the toxic contaminant, TRO, in the HPB operational discharges, so that there is a likely significant effect from the discharges. The predicted mixing zone for TRO from the HPB discharge is small, being 0.13% of the Estuaries feature at the surface. Hydrazine is not used at HPB, so there is no hydrazine discharge and therefore no mixing zone. The loads of other toxic contaminants from the HPB operational discharges are not measurable and are considered to be negligible, as the only consented toxic contaminant is TRO.

The time relationship of the different PPPs or permit is shown in Table 6.7.2 S2 in 3 month blocks to 2022, together with the scale of impact. 'N' signifies a negligible impact, 'L' signifies a likely significant effect, and 'A' signifies an adverse effect.

Table 6.7.2S2

Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
Toxic Contamination	PPP or Permit	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	HPC Operational discharges																										Hot commissioning						Operation						continues for about 60 years						
																									N	N	N	N	N	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	HPB Operational discharges																					Existing discharge. Continues to end of 2023																							
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

Figure 6.7.2 S3



6.7.3 Non-toxic contamination (nutrient enrichment & organic loading)

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the sub-tidal sandbanks feature of the Severn Estuary due to non-toxic contamination as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of non-toxic contamination on this feature has not been considered further

6.7.4 Intertidal Mudflats and Sandflats

Changes to thermal regime

Conservation objectives:

- *the total extent of the mudflats and sandflats feature is maintained;*
- *the variety and extent of individual mudflats and sandflats communities within the site is maintained;*
- *the distribution of individual mudflats and sandflats communities within the site is maintained;*
- *the community composition of the mudflats and sandflats feature within the site is maintained.*

Environment Agency permissions, plans and projects that could have a thermal impact on the inter-tidal mudflats and sandflats include the following:

- HPC cooling water discharge

These could act in combination with thermal impact from the following other permissions, plans or projects:

- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Relevant Proposed Plans and Projects and Existing Permits

Based on the assessment undertaken for the Estuaries feature (Section 6.5), the only PPPs or existing permits which are considered to potentially affect the intertidal mudflats and sandflats feature in combination in relation to changes in thermal regime are the operational discharges from HPB and HPC, the decommissioning discharge from Oldbury A, and the potential operating discharges from Oldbury B.

Table 6.7.4 S1 display further information to inform the assessment related to the predicted sizes of the mixing zones for the HPC and HPB cooling water discharges from modelling in relation to the intertidal sandflats and mudflats feature and subtidal sandbanks feature . The predicted sizes of the mixing zones as a percentage of the intertidal sandflats and mudflats feature and subtidal sandbanks feature are also for the various targets for the Severn Estuary SAC and SPA.

Table 6.7.4 S1

Areas of Mixing Zones for Habitats Related Targets in hectares

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone
HPB 70% Surface	144	9	135	607	89	518	0	1	0.9	0.1	4.1	4.1	0
HPB 70% Bed	84	1	83	536	46	490	0	0.03	0.03	0	0.4	0.4	0
HPB 100% Surface	406	38	368	988	215	773	0	87	8	79	197	118	79
HPB 100% Bed	336	14	322	903	145	758	0	42	1	41	108	3	105
HPC 100% Surface	580	343	237	3388	2011	1377	0	9	9	0	38	38	0
HPC 100% Bed	531	224	307	3277	1767	1510	0	0.4	0.4	0	2	2	0

Table 6.7.4 S2

Areas of Mixing Zones for Habitats Related Targets as percentages of features

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone
HPB 70% Surface	0.29	0.02	0.67	1.20	0.18	2.56	0.00	0.00	0.00	0.00	0.01	0.01	0.00
HPB 70% Bed	0.17	0.00	0.41	1.06	0.09	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HPB 100% Surface	0.80	0.08	1.82	1.96	0.43	3.81	0.00	0.17	0.02	0.39	0.39	0.23	0.39
HPB 100% Bed	0.67	0.03	1.59	1.79	0.29	3.74	0.00	0.08	0.00	0.20	0.21	0.01	0.52
HPC 100% Surface	1.15	0.68	1.17	6.71	3.98	6.79	0.00	0.02	0.02	0.00	0.08	0.08	0.00
HPC 100% Bed	1.05	0.44	1.51	6.49	3.50	7.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The information above has informed the next stage of the assessment where each of the proposed plans and projects and existing permits as shown in 6.2 S1 assessed in Table 6.7.4 S3 in terms of its significance alone in relation to the specific hazard 'changes to thermal regime'.

Table 6.7.4 S3

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the outfall about 1.8 km offshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge with respect to the intertidal mudflats and sandflats feature of the Severn Estuary SAC for various temperature targets are given in Table 2.6.1S23. The extent of the mixing zone at the bed in relation to the habitats in Bridgwater Bay is shown in Figure 2.6.1.S22. The significance of the impact of the thermal plume from HPC on the interest features of the Severn Estuary SAC has been assessed in detail in the alone assessment, and is not repeated here. There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	The greatest potential impact is on the intertidal mudflats and sandflats feature, and the benthic invertebrate community, notably *Macoma balthica*. However, it was concluded that the likely impact of the thermal plume on the intetidal mudflats and sandflats from HPC alone was similar to that from the HPB thermal plume. As no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without, it has been concluded that there is no adverse effect on the integrity of the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPC thermal plume alone.
HPB Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the culvert across the foreshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	There have been various studies of the intertidal benthic invertebrates on Stert Flats related to the impact of the proposed HPC thermal discharge. These have shown that no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without (BEEMS SPP062 (2011)[638], and BEEMS SPP073/S (2012)[639]). There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges.	The HPB cooling water disharge has an existing permit. Based on the available information on the impact of the existing thermal plume from HPB, it has been concluded that there is no adverse impact on the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPB thermal plume alone.
Oldbury B Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through an outfall to the Severn Estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, it is expected that any proposed development will utilise cooling towers, so that the cooling water discharge will be significantly less than that for a direct cooled power station. The expected thermal load to the upper Severn Estuary should be considerably less than that from the cooling water for Oldbury A, but its actual impact can only be assessed when more information is available.	It is not known when the Oldbury B cooling water discharge would start, as the development of the site is at an early stage. It is expected that the start date could be about 2025.	It is not possible to define the actual extent of any impact from the proposed Oldbury B cooling water discharge, as not all relevant details on the proposals are available.

[638] BEEMS. Scientific Position Paper 062: Macoma balthica population structure at Hinkley Point and elsewhere in the Severn Estuary. EDF BEEMS (Cefas). 2011.
[639] BEEMS Scientific Position Paper SPP073/S. The potential in combination effects of HP B and HP C thermal plumes upon the intertidal mudflat ecology of Bridgwater Bay. EDF BEEMS (Cefas). 2012.

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
HPC Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the outfall about 1.8 km offshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The predicted sizes of the mixing zones for the HPC cooling water discharge with respect to the intertidal mudflats and sandflats feature of the Severn Estuary SAC for various temperature targets are given in Table ??. The extent of the mixing zone at the bed in relation to the habitats in Bridgwater Bay is shown in Figure ??. The significance of the impact of the thermal plume from HPC on the interest features of the Severn Estuary SAC has been assessed in detail in the alone assessment, and is not repeated here. There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	About 720 months (60 years). Indicated to commence with hot testing of the first EPR unit from mid 2017, followed by operational discharges at the start of 2019. Operational discharges from the second EPR unit are indicated to start in mid 2020.	The greatest potential impact is on the intertidal mudflats and sandflats feature, and the benthic invertebrate community, notably *Macoma balthica*. However, it was concluded that the likely impact of the thermal plume on the intetidal mudflats and sandflats from HPC alone was similar to that from the HPB thermal plume. As no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without, it has been concluded that there is no adverse effect on the integrity of the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPC thermal plume alone.
HPB Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through the culvert across the foreshore.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	There have been various studies of the intertidal benthic invertebrates on Stert Flats related to the impact of the proposed HPC thermal discharge. These have shown that no significant difference is apparent between the populations of *Macoma balthica*, and other benthic invertebrates, on Stert Flats, which are within the zone of impact of the HPB thermal plume and those without (BEEMS SPP062 (2011), and BEEMS SPP073/S (2012)). There is no thermal barrier to fish movement created by the HPC cooling water discharge alone.	It is expected that the operational discharges will continue until 2023, when they would become decommissioning discharges.	The HPB cooling water disharge has an existing permit. Based on the available information on the impact of the existing thermal plume from HPB, it has been concluded that there is no adverse impact on the Estuaries feature (and the subtidal sandflats feature and the intertidal mudflats and sandflats feature) from the HPB thermal plume alone.
Oldbury B Cooling Water discharge	The pathway for changes to the thermal regime is through the discharge of heated cooling water through an outfall to the Severn Estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, it is expected that any proposed development will utilise cooling towers, so that the cooling water discharge will be significantly less than that for a direct cooled power station. The expected thermal load to the upper Severn Estuary should be considerably less than that from the cooling water for Oldbury A, but its actual impact can only be assessed when more information is available.	It is not known when the Oldbury B cooling water discharge would start, as the development of the site is at an early stage. It is expected that the start date could be about 2025.	It is not possible to define the actual extent of any impact from the proposed Oldbury B cooling water discharge, as not all relevant details on the proposals are available.

PPP or Permit	Pathway	Nature of Impact	Scale of Impact	Time frame of Impact	Conclusion
Oldbury A Decommissioning Thermal discharge	The pathway for changes to the thermal regime is through the discharge of heated effluent to the Severn estuary.	The nature of impact is the change to the thermal regime in the water column due to the thermal plume, and the potential functional changes in the subtidal and intertidal benthic communities. There are also potential impacts on fish assemblages if the thermal plume causes any thermal barriers to fish movements.	The cooling water discharge has very recently ceased (27/02/12), so that the discharge now only relates to any cooling water arising from the decommissioning activities. The exact volume of the discharge and its maximum temperature difference above ambient is not yet defined. However, the discharge flow is expected to be over a quarter of the existing cooling water flow, while the temperature differential and maximum temperature are also expected to decrease. Based on the estimated size of the mixing zone in the Review of Consents (about 120 ha), the estimated size of any mixing zone related to the decommissioning discharge from Oldbury is between 20 and 30 ha. As the discharge is into the main channel of the Severn Estuary, most of the impact is expected to be in the main channel in the vicinity of Oldbury, and therefore the subtidal area. However, as a worst case, the extent of any impact on the intertidal mudflats and sandflats has been assumed to be of a similar order to that for the Estuaries feature, ie. about 20 and 30 ha. The cooling water discharge from Oldbury did not appear to create a barrier to fish migration in the upper Severn Estuary, as migratory fish appeared to move unhindered up into the freshwater rivers above Oldbury. Any reduction in the thermal loading from Oldbury can only reduce any potential thermal barrier in the upper Estuary.	About 180 months (15 years) based on the expected time scale of decommissioning of the power station. The projected end date is the end of 2026.	The cooling water discharge from Oldbury Power Station has an existing permit which was under review. The cooling water discharge has very recently ceased (27/02/12), so that the discharge now only relates to any cooling water arising from the decommissioning activities. The exact volume of the discharge and its maximum temperature difference above ambient is not yet known, but the extent of any impact is not expected to be significant with respect to the intertidal mudflats and sandflats feature.

The time relationship of the different PPPs or permits is shown in Table 6.7.4 S4 below in 3 month blocks to 2022, together with the scale of impact. 'N' signifies a negligible impact, 'L' signifies a likely significant effect, and 'A' signifies an adverse effect. It is apparent that there is the potential for nearly all the discharges to overlap in time, except the cooling water discharge from HPB with the proposed cooling water discharge from Oldbury B. However, it is also evident that there could be minimal or no overlap between the Oldbury A and Oldbury B discharges.

Table 6.7.4 S4

Estuaries		2012				2013				2014				2015				2016				2017				2018				2019				2020				2021				2022			
Changes to Thermal Regime	PPP or Permit	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	HPC Cooling Water Discharge																													Operation continues for about 60 years															
																														L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	HPB Cooling Water discharge	Existing discharge. Continues to end of 2023																																											
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	Oldbury B Cooling Water discharge	Expected start date 2025																																											
	Oldbury A Decommissioning Thermal discharge	Existing discharge Continues to Q4 2026																																											
		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

Tables 6.7.4 S5 amd S6 display further information to inform the assessment related to the predicted sizes of the mixing zones for the combined HPC and HPB cooling water discharges from modelling. There are two scenarios for the combined thermal discharges; HPC 100% and HPB 70% (Run D), and HPC 100% and HPB 100% (Run E). The predicted sizes of the mixing zones in relation to the intertidal sandflats and mudflats feature and subtidal sandbanks feature are given for the various targets for the Severn Estuary SAC and SPA in terms of area (Table 6.7.4 S5 and as a percentage of the relevant feature (Table 6.7.4 S6).

Table 6.7.4 S5

Areas of Mixing Zones for Habitats Related Targets in hectares

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone
HPB 70% & HPC 100% Surface	1843	725	1118	***4351***	2736	1615	0	429	66	363	1058	221	***837***
HPB 70% & HPC 100% Bed	1802	622	1180	4208	2534	1674	0	393	22	371	939	84	855
HPB 100% & HPC 100% Surface	***2057***	853	1204	***4639***	2967	1672	0	845	175	670	1424	509	***915***
HPB 100% & HPC 100% Bed	1990	737	1253	4487	2766	1721	0	811	63	748	1232	210	1022

Table 6.7.4 S6

Areas of Mixing Zones for Habitats Related Targets as percentages of features

	ΔT 2 ºC			Max 21.5 ºC as 98% ile			Max 28 ºC as 98%ile	ΔT 3 ºC			Max 23 ºC as 98%ile		
	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone	Total Area	Area in the Subtidal Zone	Area in the Intertidal Zone
HPB 70% & HPC 100% Surface	3.65	1.44	5.52	8.62	5.42	7.97	0.00	0.85	0.13	1.79	2.10	0.44	4.13
HPB 70% & HPC 100% Bed	3.57	1.23	5.82	8.33	5.02	8.26	0.00	0.78	0.04	1.83	1.86	0.17	4.22
HPB 100% & HPC 100% Surface	4.07	1.69	5.94	9.19	5.88	8.25	0.00	1.67	0.35	3.31	2.82	1.01	4.51
HPB 100% & HPC 100% Bed	3.94	1.46	6.18	8.89	5.48	8.49	0.00	1.61	0.12	3.69	2.44	0.42	5.04

Assessment of 'In combination' Effects of thermal plumes from other Power Stations

As discussed in the in combination assessment for the Estuaries feature, a major factor in the assessment of the 'in combination' effects for the thermal discharges is the proximity of the other discharges to the proposed cooling water discharge from HPC. The HPB cooling water discharge is very close, about 2.5 km, to that from the proposed HPC site. Oldbury A and B are both about 65 km away up the Severn Estuary on the English coast.

The scale of impact in terms of a mixing zone for a ΔT of 2ºC from the Oldbury A Decommissioning discharge is estimated to be about 20 to 30 ha as a maximum. Given that the discharge from Oldbury B will be effectively at the same location as Oldbury A, the thermal plumes will be coincident, although the thermal load will be increased. As it is not known whether there will be any overlap in time between Oldbury A and B, the size of the mixing zone has been assumed to be about 30 ha. This area has been considered to potentially affect both the intertidal area as well as the subtidal area; ie. the maximum extent of the thermal plume could affect both the subtidal and intertidal areas.

The combined areas of the mixing zones for HPB and HPC are given in tables 6.7.4 S5, and their percentages relative to the intertidal mudflats and sandflats feature of the Severn Estuary SAC are given in Table 6.7.4 S6 It is apparent that the thermal plume from the combined HPB and HPC discharges covers a greater extent than either HPB or HPC alone . The expected end date for Hinkley B is now 2023. Hinkley B at present is operating at about 70% of its total output (British Energy website). While it is possible that HPB could achieve 100% output, this is stated to be unlikely, and the maximum expected output from HPB is believed to be 80%.Once power generation ceases at HPB, there will be no thermal load in the subsequent decommissioning discharges.

The intertidal mudflats and sandbanks in the immediate vicinity of Oldbury and down-estuary comprise a similar benthic invertebrate community to that in Bridgwater Bay, although amphipod crustaceans (*Corophium* spp, *Bathyporeia* spp) and the polychaete, *Arenicola marina,* may be relatively more abundant than *Hydrobia ulvae* and *Macoma balthica* (Ferns 1977[640], Davies 1998[641], Langston *et al* 2007[642]). However, in terms of sub-features of the intertidal mudflats and sandflats feature, the intertidal area in the vicinity of Oldbury is defined as intertidal gravel and clean sands, while the intertidal area affected by the combined thermal plume from HPB and HPC is predominantly intertidal (see Fig. 6.7.4 S7 below). Despite the difference in sub-features, the thermal plume from Oldbury A is potentially affecting a similar intertidal benthic community to the combined thermal plume from HPB and HPC, so that any effect will act in combination. However, the effective increase in the area of the intertidal mudflats and sandflats feature due to Oldbury is only about 0.15%., so that

[640] Ferns P.N. 1977 Wading Birds of the Severn Estuary. Report to the Nature Conservancy Council. University College, Cardiff. 114 pp

[641] Davies J. 1998 Bristol Channel and approaches (Cape Cornwall to Cwm yr Eglwys, Newport Bay) (MNCR Sector 9). In: Marine Nature Conservation Review. Benthic marine ecosystem of great Britain and the north-east Atlantic, ed. K. Hiscock, 255-295. Peterborough, Joint Nature Conservation Committee. (Coasts and Seas of the United Kingdom. MNCR Series).

[642] Langston W.J., Chesman B.S., Burt G.R., Campbell M., Manning A. & Jonas P.J.C. 2007 The Severn Estuary: Sediments, contaminants and biota. Marine Biological Association of the United Kingdom Occasional Publication (19). 176 pp.

any effect on the intertidal mudflats and sandflats feature in relation to changes in the thermal regime will be dominated by the combined thermal plume from HPB and HPC.

Assessment of The In combination Effect of The Thermal Plumes from HPB and HPC

The predicted sizes of the mixing zones given in Tables 6.5.4 S1 and shown in Figures 6.5.4 S5 and S6 indicate that the main effect of the combined thermal plumes is to generate an area in the intertidal mudflats and sandflats feature in Bridgwater Bay where the temperature differential exceeds 3ºC for a considerably larger area than was predicted for either HPB or HPC alone. The consequences of this on the expected seawater temperature regime has been discussed in the in combination assessment of the Estuaries feature (Section 6.5), together with the potential impact on the benthic invertebrate species considered to be most sensitive to temperature change, *Macoma balthica*. In relation to the intertidal mudflats and sandflats feature perhaps the most significant evidence concerns the apparent lack of impact on the intertidal mudflat and sandflat communities from the present HPB discharge. In addition, when the historical situation is considered, which consisted of a combined HPA and HPB thermal plume discharging from the present intertidal outfall culvert, the potential impact on the intertidal mudflat and sandflat communities would have been considerably greater. The extent of any thermal plume would then have been considerably larger than that modelled for the present HPB disharge at 100% Since the combined HPA and HPB discharges stopped when HPA ceased generating in 2000, any possible impact had subsequently recovered by the time intertidal surveys for the proposed HPC station commenced in 2008. It should also be borne in mind here that the turnover time of organisms in the intertidal (and subtidal) areas of the Severn Estuary appears to be rapid, at least for species important to the intertidal ecology, for example *Macoma balthica*.

Conclusion of effects of thermal regime on intertidal mudflats and sandflats in combination
Based on the available evidence, therefore, and the expected continuing operation of the HPB power station until about 2023, it is concluded that the combined thermal plumes from HPB and HPC, and Oldbury A and B, will not compromise the conservation objectives for the Intertidal mudflats and sandflats feature concerning the variety, extent, distribution, and composition of intertidal communities, and therefore not have an adverse effect on site integrity.

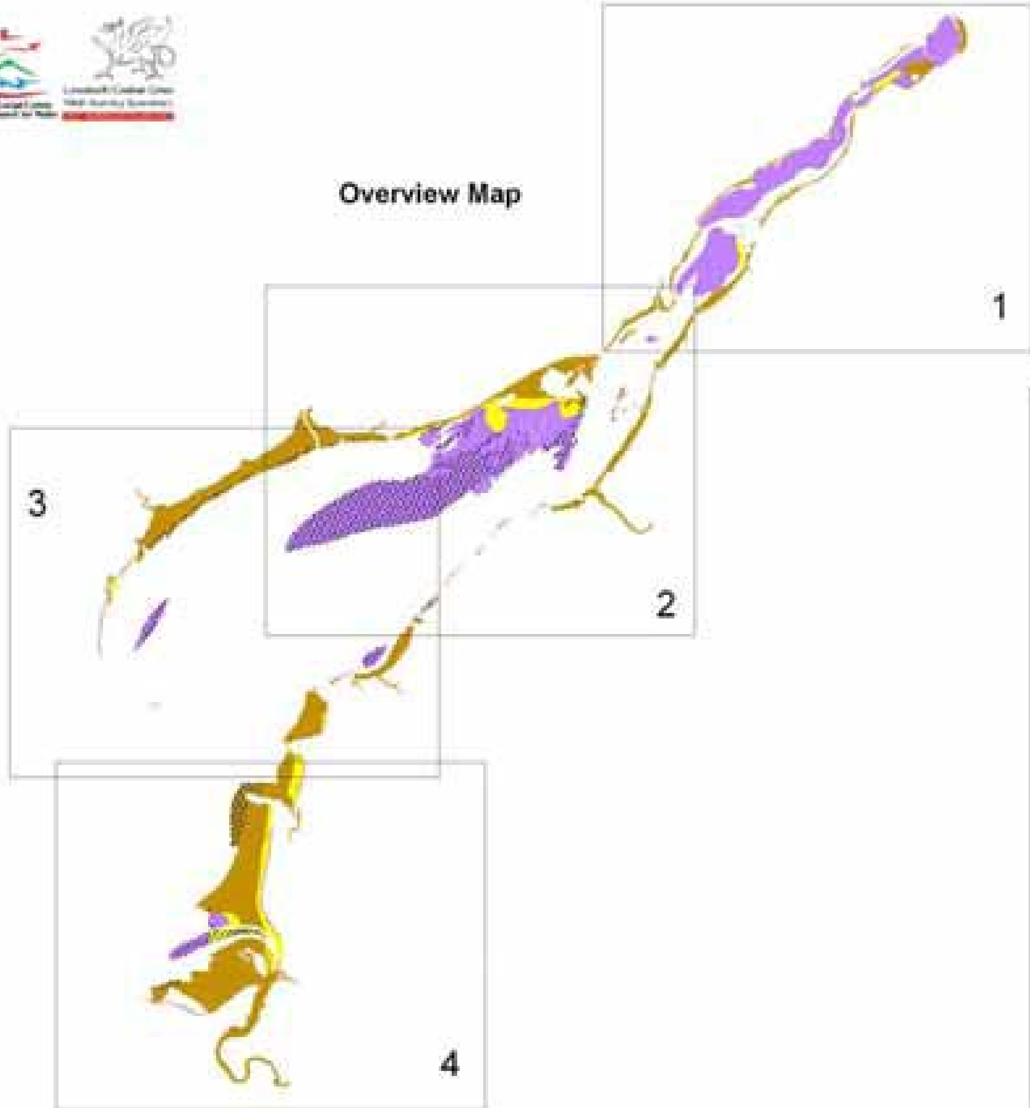
It is also concluded that if there were an unforeseen effect on the intertidal communities, in particular the thermally sensitive species Macoma balthica, then recovery of the communities would be relatively rapid, ie expected to be from 5 to 8 years following the cessation of a thermal discharge from Hinkley B.

Figure 6.7.4 S7

Appendix 4a Maps showing the subfeatures of the "intertidal mudflats & sandflats" feature of the Severn Estuary SAC

As well as being a feature of the SAC in its own right the intertidal mudflats and sandflats are also both a subfeature of the "estuaries" feature of the Ramsar Site and a component of the supporting habitats of the bird interest features of the SPA and Ramsar Site. These maps therefore also indicate areas where these habitats fall outside the SPA and Ramsar Site boundary

Overview Map



Key

- Intertidal muds
- Intertidal muddy sands
- Intertidal gravel and clean sands
- Intertidal habitats outside of the SPA & Ramsar Site boundary

This map is indicative only and subject to review in the light of further information. Full detailed information on the biotopes of these habitats is available on request from CCW or Natural England.

Drawn by: Charlotte Pagendam
Date: 29/1/2009
Ref: Reg 33 App 4a (O) - Feb 09
© Natural England 2009

Grid North

Scale 1:580000

6.7.5 Salinity

There are no Environment Agency permissions, plans and projects that could have an impact on the inter-tidal mudflats and sandflats feature in terms of salinity changes include the following (or act in combination with salinity changes from the following other permissions, plans or projects)

6.7.6 Turbidity, siltation and suspended sediment

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the inter-tidal mudflats and sandflats feature of the Severn Estuary due to turbidity, siltation and suspended sediment as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of turbidity, siltation and suspended sediment on this feature has not been considered further

6.7.7 Physical damage / Habitat loss

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the inter-tidal mudflats and sandflats feature of the Severn Estuary due to physical damage and/or habitat loss as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of physical damage and/or habitat loss on this feature has not been considered further

6.7.8 Disturbance (noise, vibration and visual)

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the inter-tidal mudflats and sandflats feature of the Severn Estuary due to disturbance as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of disturbance on this feature has not been considered further

6.7.9 Entrainment and Impingement

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the inter-tidal mudflats and sandflats feature of the Severn Estuary due to entrainment and impingement as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of entrainment and impingement on this feature has not been considered further.

Overall conclusion of in combination assessment on inter-tidal features

Hazard assessed	**Adverse effect on inter-tidal mud and sand flats feature?**
Toxic contamination	No – with operational permit in place
Non-toxic contamination	No
Changes to thermal regime	No
Salinity	No
Siltation turbidity and suspended sediment	No
Habitat loss & physical damage	No
Entrainment	No
Overall conclusion	**No adverse effect upon site integrity**

6.8 Atlantic Salt meadow / Saltmarsh

6.8.1 Activities resulting in a potential impact on the Atlantic salt meadow / saltmarsh

	Construction activities											Operational activities														
Potential sources of hazard	EA consents				Existing plans and other plans & projects							EA Consents														
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Jetty construction	Construction of cooling water infrastructure	Nuclear island construction	Bristol deep sea container terminal	EA Steart development	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge	Jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning
Toxic contamination	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	✓	×	×	×	×	×	×	×	✓	✓	×	✓	✓	✓	×	✓	×	×	×	×	×	×	×	×	×	✓
Thermal impact	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Salinity	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Turbidity, suspended sediment & siltation	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

Note: permissions relating to HPC development assessed within the alone section of this document are highlighted in green

Table 6.8S2 Timeframe of activities that could impact on the migratory fish and fish assemblage feature. Green indicates an EA permission for HPC.

PPP	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Combwich development (FDC)											➪
HPC Construction discharges											
EA Steart habitat creation											
Bristol Port Steart habitat creation											
Cold commissioning discharge (HPC)											
HPC Operational discharge											➪
HPC combustion discharges											➪
HPB operational discharge											➪
HPA decommissioning discharge											➪
Shipping activities											

Note: ➪ = ongoing

6.8.2 Toxic contamination

to its location and known sensitivities we are satisfied that there will be no adverse effect on the Atlantic salt meadow / saltmarsh feature of the Severn Estuary due to toxic contamination as a result of any of the activities occurring as part of the HPC project. Therefore, impact of toxic contamination on this feature has not been considered further.

6.8.3 Non-toxic contamination (nutrient enrichment & organic loading)

Conservation objectives (see section 1.5.1)

- *The total extent of Atlantic salt meadow and associated transitional vegetation communities within the site is maintained;*
- *The extent and distribution of the individual Atlantic salt meadow and associated transitional vegetation communities within the site is maintained;*
- *the zonation of Atlantic salt meadow vegetation communities and their associated transitions to other estuary habitats is maintained;*
- *the relative abundance of the typical species of the Atlantic salt meadow and associated transitional vegetation communities is maintained;*
- *the abundance of the notable species of the Atlantic salt meadow and associated transitional vegetation communities is maintained;*

Natural England & Countryside Council for Wales, 2009

The Severn Estuary's saltmarshes have been assessed as being of high sensitivity to increases in nutrient loading and/or organic enrichment. Increased growth of certain seaweed species may result from elevated levels of nitrates and phosphates and cause local smothering which is known to have a detrimental effect on glasswort

(Salicornia Spp) in low marsh communities (NE & CCW, 2009)[643]. In addition, the species composition may be altered leading to a change in the sward.

Environment Agency consents that could have an impact on the Atlantic salt meadow / saltmarsh feature in terms of non-toxic contamination include the following:

- Construction discharges (initial treated sewage discharges from package plants)
- Cold commissioning discharges
- HPC Operational discharges - cooling water discharge potential discharges of ammonia from the primary and secondary circuits
- Environmental Permit Regulations (EPR) combustion permission - NOx emissions from back-up diesel generators

These could act in combination with each other and non-toxic contamination from the following other permissions, plans or projects:

- Hinkley Point B discharges (STW)
- Hinkley Point A decommissioning discharge (STW)
- EA Steart development - compensatory habitat at Steart
- Bristol Ports Steart development - compensatory habitat at Steart

During the construction and operation of HPC, treated sewage effluent will be discharged into the estuary which will have the potential to increase the nutrient content and oxygen demand to a localised area of the estuary in combination with the treated sewage effluent discharges from HPA and HPB. Both Steart developments have the potential to act in combination with the construction activities as the historic land use of each of the Steart sites appears to have been limited mainly to agricultural use, thus there is potential for the transport of nutrients (nitrates and phosphates) into the wider estuarine system when the land becomes inundated with seawater.

Both the primary and secondary circuits have the potential to release ammonia, which can lead to elevated levels of nitrates in the water column, along with NO_X emissions from combustion emissions, during cold commissioning and operational stages.

Construction and HPB discharges
The pathway for non-toxic contamination from construction discharges is through discharge of nutrients and an organic load to the foreshore through the new outfall structure in the cliff. There is a mixing zone across the foreshore related to the discharge, however in the context of the estuaries feature, the size of this mixing zone is negligible. The input of nutrients and oxygen demand in relation to the estuaries feature are also negligible and will therefore not impact in combination to loadings on the saltmarsh habitat.

HPC and HPB operational discharges and EPR combustion permission
The operational discharges from HPC and HPB will be as a result of ammonia discharges to water and from the STWs, whereas the EPR permission will be in the form of aerial deposition from NOx due to proposed combustion activities. The Marine Ecology ES[644] states that the total nitrogen discharged is 10tpa assuming two European Pressurised Reactors (EPRs) are in operation. This represents an elevation of 2.6 μ gN/l in the discharge. The WFD requirement for turbid coastal waters to achieve high quality status is less than 18 μ mol = 252 μ gN/l. Currently the Bridgwater

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643 Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 9, as amended. Severn Estuary/Mor Hafren European Marine Site. June 2009.
644 Marine Ecology ES Volume 2 Chapter 19. (Pg. 113 Section 19.6.222). EDF

Bay WFD Coastal Water-body is described as being of moderate status for inorganic nitrogen.

Total Inorganic Nitrogen (TIN) loadings from HPC has been calculated to be 34.36kg/day, and loadings from HPB have been calculated at 21.20kg/day, thus the cumulative TIN from both power stations is 55.56kg/day. In the context of the estuaries feature (for loadings to saltmarsh) this equates to 7.5×10^{-8}units, which is negligible, and will not act in combination with the aerial emissions from the combustion activity.

EA Steart development and the Bristol Port Steart development - compensatory habitat

The historic land use of each of the Steart sites appears to have been limited mainly to agricultural use. Therefore, there is potential for the transport of nutrients (nitrates/ phosphates) into the wider estuarine system when the land becomes inundated with seawater to impact in combination with the sewage treatment plant discharges.

The annual phosphate discharge during the operational phase of HPC is estimated as 800kgP/yr, elevating the concentration at the discharge by 0.2µgP/l. Potentially of more significance are short-term discharges during commissioning when a maximum of 340kgP/day could be discharged.

It is likely that some ammonia will be released from the soils following the breaches at either or both Steart sites, due to the breakdown of organic material in anaerobic conditions, so that out flowing water will have slightly elevated ammonia levels compared with the inflowing water.

However, the time period over which the elevated ammonia levels are expected to occur is only a few months. The out flowing water will also be diluted rapidly by the water in the Parrett Estuary and Bridgwater Bay, so that the extent of any elevated ammonia levels will be negligible. It is not possible to predict the level of elevated ammonia which may occur, but from comparisons with other sites it is not expected to exceed 1 mg/l.

Similarly, any increase in organic load will only occur over a short period of a few months, and will also be diluted rapidly by the water in the Parrett Estuary and Bridgwater Bay.

It should be noted that the potential for leaching of toxic contaminants will also be limited by deposition of sediments within the managed realignment sites. Deposition is expected to be rapid, as the area will act as a sediment sink.

The inputs of nutrients and oxygen demand in relation to the Estuaries feature are negligible.

Summary of non - toxic contamination assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC construction discharges	No
HPC Commissioning discharges	No
HPC operational discharges	No
EPR combustion permit	No
HPB discharges (STW)	No
HPA discharges (STW)	No
EA Steart development	No
Bristol Port Steart development	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of non-toxic contamination assessment for Atlantic salt meadow feature

There will be no adverse effect on the integrity of the Atlantic salt meadow / saltmarsh feature of the Severn Estuary SAC and Ramsar, from non-toxic contaminants in combination with other Permissions, Plans and Projects (PPPs).

6.8.4 Thermal

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the Atlantic salt meadow / Saltmarsh feature of the Severn Estuary due to thermal impact as a result of any of the activities occurring as part of the HPC project. Therefore, thermal impact on this feature has not been considered further.

6.8.5 Salinity

Environment Agency consents that could have an impact on the Atlantic salt meadow / saltmarsh feature in terms of salinity include the following:

- Construction discharges to Holford stream

There are no other permissions, plans or projects in the area that could act in-combination with the Environment Agency consents stated above in respect of salinity changes.

6.8.6 Turbidity, siltation and suspended sediment

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the Atlantic salt meadow / saltmarsh feature of the Severn Estuary due to turbidity, siltation and suspended solids as a result of any of the activities occurring as part of the HPC project. Therefore, impact of turbidity, siltation and suspended solids on this feature has not been considered further.

6.8.7 Physical damage / Habitat loss

Conservation objectives (see section 1.5.1)

- *The total extent of Atlantic salt meadow and associated transitional vegetation communities within the site is maintained;*
- *The extent and distribution of the individual Atlantic salt meadow and associated transitional vegetation communities within the site is maintained;*
- *The zonation of Atlantic salt meadow vegetation communities and their associated transitions to other estuary habitats is maintained;*
- *The relative abundance of the typical species of the Atlantic salt meadow and associated transitional vegetation communities is maintained;*
- *The abundance of the notable species of the Atlantic salt meadow and associated transitional vegetation communities is maintained;*
- *The characteristic stepped morphology of the salt marshes and associated creeks, pills, drainage ditches and pans, and the estuarine processes that enable their development, is maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact on the Atlantic salt meadow / saltmarsh feature in terms of physical damage / habitat loss include the following:

- Combwich Wharf FDC

Which could act in combination with physical damage / habitat loss from the following other permissions, plans or projects:

- Commercial shipping

The movement of vessels to and from the wharf during the construction and operation stages has the potential to cumulatively impact with the current shipping regime already taking place along the River Parrett, which could lead to erosion of fringing areas of saltmarsh due to excessive wash and large currents.

Combwich Pill, has been used for shipping since the 14th century. Historically the River Parrett was used for riverine bulk transportation of people and supplies to Bridgwater Port and for smaller loads to Langport. At its peak, in the 19th century (around 1880) an average of 3,600 ships would enter Bridgwater Port, but by the mid 1850s shipping slowed on the River Parrett due to the development of railways. By the1950s shipping increased again due to development of the nuclear industry, HPA and HPB, and the development of Dunball Wharf, the only part of the Port of Bridgwater still in commercial use today.

Combwich jetty has been designed to accommodate one vessel at a time. The Combwich ES (2011)[645] states that there are at present approximately 14 vessel movements related to the existing Hinkley Point complex up and down the River Parrett each month. It has been further stated within the HRA Clarification Report[646] that there should typically be 8-9 vessel calls per month carrying Abnormal Indivisible Loads (AILs), peaking to 14-15 per month as a worst case scenario. For the construction of HPC, there will need to be deliveries made to the wharf over a four-year period and in that time 174 vessel calls are proposed, with an average of 44 vessel calls per year. Added to that will be the vessels to and from Dunball Wharf, of which Sedgemoor District Council is the Competent Harbour Authority.

Since the HRA clarification report was issued a further report has been issued by EDF Enery (2012)[647] in response to Natural England's specific request for clarification to boat movements at Combwich. The report clarifies specific vessel numbers likely to use Combwich Wharf in the development of HPC and vessel speeds. The report states that approximately 180 AILs will be delivered to Combwich Wharf for the construction of HPC, which amounts to an average of 3.75 deliveries (7.5 movements to and from the wharf) per month over the 4 year construction period. In addition to AIL deliveries, 'other goods' deliveries to the wharf could bring the total up to 15-16 deliveries (30-32 movements) per month at peak, over the 4 years. Small tug boats will also be required further down river to guide the larger boats out of the River Parrett. It is important to note that these figures are limited by the availability of suitably high tides.

To deal with any potential issues, such as excessive wash and large currents caused by high speed freight vessels, the applicant has stated that vessel movements would only occur at or around high water, and thus exposure of inter-tidal areas would be at a minimum. Some of the vessels carrying AILs will require high water and tides of greater than 4.5m to access the wharf, meaning in some cases spring tides will be the only option. General cargo vessels, used in transporting materials, will require tides with a maximum draft of 3.3m and would generally be of a relatively small size (in order to be able to navigate into and out of the estuary) and would also be restricted to travelling at speeds of between 4 to 6 knots.

Furthermore the Harbourmaster of Bridgwater Port has powers to regulate vessel movements and exercises these powers in accordance with the port's Marine Operations Plan (Sedgemoor DC, 2009)[648].

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645 Hinkley Point C: Combwich Environmental Statement (ES) Volume 7 Chapter 18. supplied by EDF. 2011.

646 Royal Haskoning/EDF. Clarifications arising from Habitats Regulations Assessment (HRA) feedback. August 2011. Report prepared for EDF.

647 EDF Engery (2012) Clarification on vessel movements to Combwich Wharf. Letter to Natural England. 15th June 2012.

648 Sedgemoor District Council (2009). Port of Bridgwater Marine Operations Plan (Compliance with the Port Marine Safety Code). Revision 5, July 2009.

It is acknowledged that the saltmarsh feature around Combwich Wharf and directly opposite is currently in unfavourable condition[649], mainly due to coastal squeeze effects. Whilst it can be agreed that the vessel wash will not cause an adverse effect on the SAC/Ramsar habitat, it is suggested that some form of monitoring of the saltmarsh and intertidal habitats is carried out around the Combwich Wharf area during operation of the wharf to ensure that no loss of saltmarsh occurs.

As discussed within section 5.6.2.3 of the saltmarsh habitat assessment, we have advised the competent authority (Infrastructure Planning Commission) to ensure that the Pill (tidal inlet), saltmarsh and inter-tidal habitats around the Combwich Wharf area should be monitored to ensure that erosion rates remain acceptable and no further loss of saltmarsh (or other inter-tidal habitat) occurs.

Summary of physical damage assessment

Plan, permission, project (PPP)	**Conservation objectives compromised?**
Combwich Wharf FDC	No
Shipping activities	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of habitat loss / physical damage assessment for Atlantic salt meadow feature

It is therefore concluded that no direct loss of SAC/Ramsar saltmarsh habitat is likely to occur during the construction works at Combwich, in combination (cumulatively) with shipping vessels currently moving along the Parrett.

6.8.8 Disturbance (noise, vibration and visual)

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the Atlantic salt meadow / saltmarsh feature of the Severn Estuary due to disturbance as a result of any of the activities occurring as part of the HPC project. Therefore, impact of disturbance on this feature has not been considered further.

6.8.9 Entrainment and Impingement

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the Atlantic salt meadow / saltmarsh feature of the Severn Estuary due to entrainment and impingement as a result of any of the activities occurring as part of the HPC project. Therefore, impact of entrainment and impingement on this feature has not been considered further.

[649] Natural England - Nature on the Map. June 2011. www.naturalengland.org.uk

Overall coclusion of in combination assessment on saltmarsh feature

Hazard assessed	Adverse effect on saltmarsh feature?
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Salinity	No
Siltation turbidity and suspended sediment	No
Habitat loss & physical damage	No
Entrainment	No
Overall conclusion	**No adverse effect upon site integrity**

6.9 Reefs

6.9S1 Activities resulting in a potential impact on the Reefs

	Construction activities											Operational activities														
Potential sources of hazard	EA consents				Existing plans and other plans & projects							EA Consents														
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Jetty construction	Construction of cooling water infrastructure	Nuclear island construction	Bristol deep sea container terminal	EA Steart development	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge/abstraction	Jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning
Toxic contamination	✓	×	×	×	✓	×	×	×	×	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	✓	×	×	×	×	×	×	×	✓	✓	×	✓	✓	×	×	✓	×	×	×	×	×	×	×	×	×	✓
Changes to thermal regime	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×
Changes to Salinity	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Increased turbidity, suspended sediment & siltation	✓	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	×	✓	×	×	×	×	×	×	×	×

Note: permissions relating to HPC development assessed within the alone section of this document are highlighted in green

Table 6.9S2 Timeframe of activities that could impact on the reefs feature. Green indicates an EA permission for HPC.

PPP	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Jetty construction											
Sea wall construction (FDC)											
Construction CW infrastructure											
HPC Construction discharge (STW)											
EA Steart habitat creation											
Bristol Port Steart habitat creation											
Cold commissioning discharge (HPC)											
HPC Operational discharge (STW)											⇨
HPB operational discharge (STW)											⇨
HPA decommissioning discharge											⇨
EPR Permit											⇨

Note: ⇨ = ongoing

6.9.2 Toxic contamination

Conservation objectives (see section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009[650]

Environment Agency consents that could have an impact on the reefs feature in terms of toxic contamination include the following:

- Sea wall construction
- HPC Construction discharges (concrete wash-water)
- HPC Commissioning discharges
- HPC Operational discharges (cooling water)

These could act in combination with each other and from the following other permissions, plans or projects:

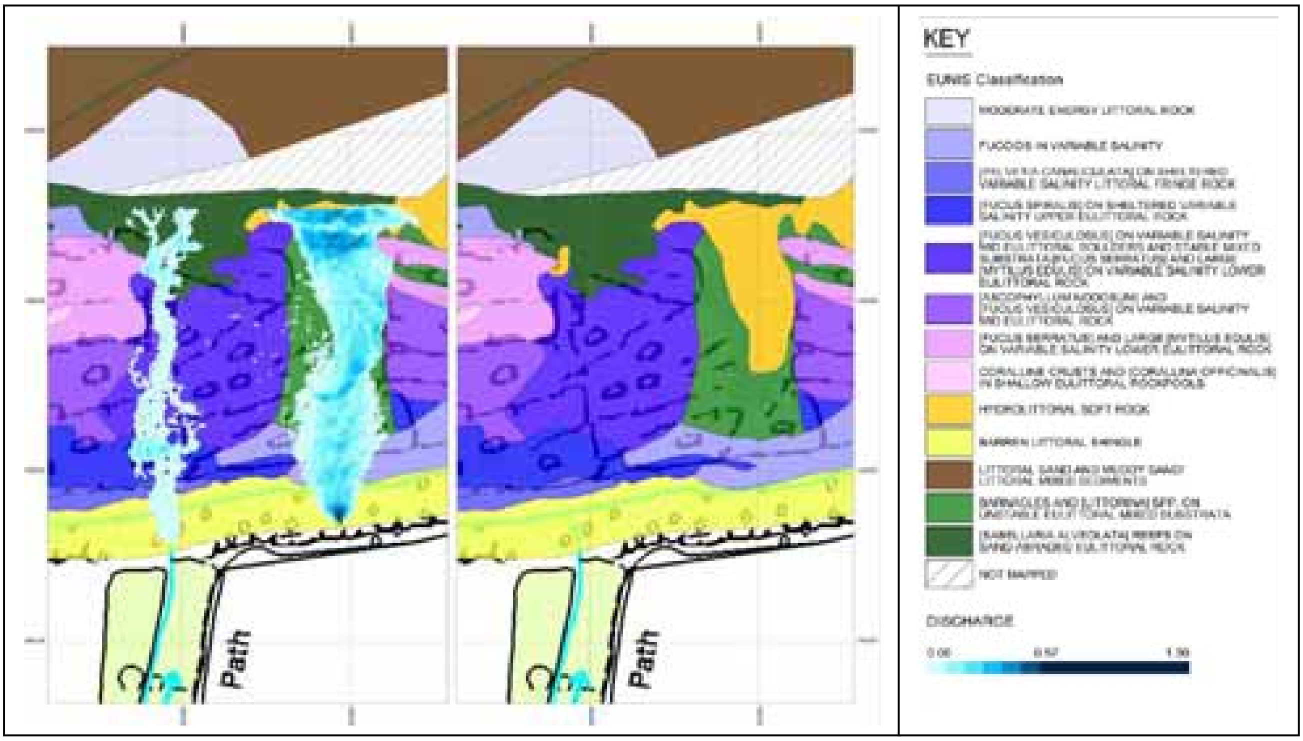
- Jetty construction
- Construction of cooling water infrastructure
- Hinkley Point B operational discharge

Construction discharges and cooling water infrastructure discharges

[650] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

Before the main spine drain is built, discharges from the construction will be released via Hinkley Point drainage ditch out on to the foreshore and potentially over an area of *Sabellaria* reef (see Figure 6.9S3) Discharges from the construction of the cooling water infrastructure will also be through the existing drainage ditch and subsequently the new outfall structure in the cliff. The discharge will include surface water, pumped groundwater, and concrete plant washdown water to the foreshore. Construction discharges, specifically the use of concrete (and dewatering), and residues of hydrocarbons from the working area (due to wash-off of lubricants from construction plant) have the potential to impact on water quality status given that concrete discharges can cause sharp increases in pH. Such discharges have been assessed as having a negligible effect alone (see section 2.6.3.4), as the discharges will be dispersed rapidly by tidal currents, below Mean Low Water. However they do have the potential to impact in combination with the jetty construction and sea wall construction. They could also act cumulatively with the current HPB discharges.

Figure 6.9S3 - construction discharges in relation to inter-tidal biotope communities. The discharge to the left is the current HPC drainage ditch discharge. The discharge to the left is the proposed spine drain discharge. Dark green areas are areas of Sabellaria reef (Haskoning, 2011)[651].



Jetty construction

There are no areas of inter-tidal or sub-tidal *Sabellaria* reef in close proximity to the proposed jetty location; this was confirmed both by an acoustic seabed survey and subsequent ground-truthing carried out to check this understanding locally (BEEMS TR104)[652]. The nearest area of *Sabellaria* reef is a small section within the inter-tidal >800m to the east (in front of Hinkley Point A station) and a wider area some 500m to the west and there will be almost 1km from the jetty construction area to the discharge point. There will be no additive or synergistic effects and the discharges will be very localised, therefore the scale of impact will be insignificant.

[651] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

[652] BEEMS Technical Report 104 (TR104). Hinkley Point *Sabellaria* assessment: analysis of survey data for 2009. EDF BEEMS (Marine Ecological Surveys Ltd.) Technical Report No. 104, January 2010.

Sea wall construction

The pathway for toxic contamination from the sea wall construction is through discharges to the foreshore occurring during the construction operations. There is a patch of *Sabellaria* reef directly on the foreshore adjacent to where the seawall will be built. However, the impact on toxic contaminant levels is considered to be negligible, as any discharge is considered to arise primarily from water sources which already enter the near shore waters. There is therefore no additional input to the SAC.

Since each of the construction discharges are deemed to be negligible, then the sum of all of the construction discharges will be insignificant.

Hinkley Point B (HPB)

The pathway for toxic contamination is through discharge of contaminants from the cooling water system. During the construction period, discharges have the potential to overlap with the HPB discharge, however the only consented toxic contaminant in HPB operational discharges is total residual oxidant (TRO). As there are no discharges of TRO from any of the construction activities, the discharges from HPB can only act in combination with the operational discharges from the proposed HPC.

HPC and HPB Operational discharges

The consented level of TRO for HPB is 0.3mg/l, and applies to both the main cooling water discharge of 3,000,000m^3/day and various trade discharges and cooling water during outages with a combined dry weather flow of 40,000 m^3/day. The main cooling water flow for HPB is discharged through the intertidal culvert approximately 200m from shore at NGR ST215465. The other smaller discharge is made to the upper intertidal area in front of the HPB site at NGR ST212463. As the consented levels in both discharges are above the Environmental Quality Standards (EQS) of 0.01mg/l, there will be mixing zones related to both discharges. A mixing zone can be defined as a point at which a discharge physically mixes with the receiving water with explicitly defined boundaries where water quality or biological objectives may not be met, but beyond which objectives (EQS) must be met.

In terms of assessing the in-combination effects of TRO in the discharge plumes, the GETM model was run with discharges from both power stations; with TRO concentrations of 0.2mg/l in the discharge from HPC and 0.3mg/l in the discharge from HPB. The percentage area of the SAC subject to an exceedance of the 0.1mg/l EQS (as a 95 percentile), is calculated to be 0.2% of the seabed, and 0.3% of the surface area within the SAC that would be affected (Haskoning, 2011)[653]. These exceedances would arise immediately adjacent to the point of discharge for both stations. As discussed within the estuaries section 6.5.2 . It is apparent that the TRO mixing zone from the HPC operational discharge is not quite coincident spatially, while that for TRO from the HPB operational discharges is spatially separate and only HPB plume impinges on the inter-tidal (SPA) area.

Investigations reported in BEEMS Technical Report 141 (TR141), and briefly discussed within section 2.6.3.4, show that there are reefs present around the HPB outfall, however, around the HPC proposed outfall location (where the TRO is likely to be of the highest concentration) is not known to support *Sabellaria* reefs, particularly since the substrata beneath the outfall is not of suitable reef building material.

The area of the TRO plume where annual mean concentrations are likely to rise to around 0.001mg/l, is likely to contain *Sabellaria* reefs, but the results form BEEMS

[653] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

Technical Report 153 (TR153)[654] would suggest that this would have a negligible effect on the *Sabellaria* around the Hinkley Point area.

As both discharges will be over 1km apart and both *S. alveolata* and *S. spinulosa* have a good tolerance of poor water quality conditions[655] (including TRO) they will not be adversely affected by the in combination effects of both HPB and HPC TRO water discharge permits, in the event that TRO dosing is ever used.

Summary of toxic contamination assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
Sea wall construction	No
HPC construction discharges	No
HPC Commissioning discharges	No
HPC operational discharges	No
Jetty construction	No
Construction of cooling water infrastructure	No
HPB operational discharges	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of toxic contamination assessment for Reefs feature

We can conclude that the toxic contaminants arising as a result of the in combination or combined permissions, plans or projects (PPPs) discussed above, will not have an adverse effect on the reef feature designated to the Severn Estuary SAC and Ramsar

6.9.3 Non-toxic contamination (nutrient enrichment & organic loading)

Conservation objective (see section 1.5.1)

➢ *The community composition of the Sabellaria reef is maintained;*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact on the reefs feature in terms of non-toxic contamination include the following:

- Construction discharges (initial treated sewage discharges from package plants)
- Cold commissioning discharge
- HPC Operational discharges - cooling water discharge potential discharges of ammonia from the primary and secondary circuits

These could act in combination with each other and from the following other permissions, plans or projects:

- Hinkley Point B discharges (STW)
- Hinkley Point A decommissioning discharge (STW)
- EA Steart development - compensatory habitat at Steart
- Bristol Port Steart development - compensatory habitat at Steart

[654] BEEMS Technical Report TR153 (TR153). Tolerance of *Sabellaria spinulosa* to Aqueous Chlorine; Final Report. EDF BEEMS (SAMS. 2010).
[655] Sabellaria Species Biodiversity Action Plan, http://www.ukbap.org.uk/UKPlans.aspx?ID=38

During the construction and operation of HPC, treated sewage effluent will be discharged into the estuary which will have the potential to increase the nutrient content and oxygen demand to a localised area of the estuary in combination with the treated sewage effluent discharges from HPA and HPB. Both Steart developments have the potential to act in combination with the construction activities as the historic land use of each of the Steart sites appears to have been limited mainly to agricultural use, meaning there is potential for the transport of nutrients (nitrates and phosphates) into the wider estuarine system when the land becomes inundated with seawater.

Both the primary and secondary circuits have the potential to release ammonia, which can lead to elevated levels of nitrates in the water column during the cold commissioning and operational stage.

Sabellaria spp are not known to be highly sensitive to increased levels of nutrients and are not sensitive to eutrophication (APIS, 2012)[656]. Walker & Rees (1980)[657] reported (in a study of the benthic ecology of Dublin Bay), that in the STW discharge area and down tide of this area, *Sabellaria spinulosa* was present in greater densities and diversities than elsewhere in the bay.

As assessed within the estuaries section 6.5 the sources of increased nutrients (N & P) have been assessed as being negligible.

Oxygen demands

Increasing temperature reduces the solubility of gases, particularly oxygen. High suspended sediment loads and the presence of sewage or other organic matter contribute an additional oxygen demand. Discharges of between 1°C and 3°C above ambient levels could decrease the solubility of oxygen by about 0.5ppm.

The report to inform the HRA (Haskoning, 2011)[658] states modelling work has been undertaken (using GETM) to determine the in-combination effect of temperature, dissolved oxygen (DO), pH and ammonia concentration. The model results are based on HPC and HPB running at 100% under normal operating conditions.

In comparison to HPC alone, the model indicates that DO concentration in the area immediately influenced by the thermal plumes would only be reduced below 5mg/l in the area of the HPB plume (see Figure 9.3 of Haskoning, 2011)[659]. The report states that there is limited interaction between the plumes from HPC and HPB, and the DO in the vicinity of the outfall for HPC remains above 5mg/l. The combined effect of both stations operating together is likely to cause a greater DO reduction, but that it is only HPB itself that leads to a reduction in DO below 5mg/l.

Since there have been no indications that the operation of HPB has had an adverse impact on estuarine ecology through lowered DO, we can conclude that an in-combination effect is not predicted. Furthermore, *Sabellaria* are not known to be sensitive to eutrophication and therefore they are unlikely to be sensitive to low DO.

[656] APIS - Air Pollution Information System (2012): Severn Estuary SAC www.apis.ac.uk

[657] Walker, A.J.M, & Rees, E.I.S. 1980. Benthic ecology of Dublin Bay in relation to sludge dumping: Fauna. Irish Fisheries Investigation. B Mar. 22.

[658] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

[659] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Figure 9.3, page 638. Report prepared for EDF.

Summary of dissolved oxygen assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
Construction discharges	No
Cold commissioning discharges	No
HPC operational discharges	No
HPB discharges (STW)	No
HPA discharges (STW)	No
EA Steart development	No
Bristol Port Steart development	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of decreases in dissolved oxygen for Reefs feature
We can conclude that a lowered Dissolved Oxygen arising as a result of the in combination or combined permissions, plans or projects (PPPs) discussed above, will not have an adverse effect on the reef feature designated to the Severn Estuary SAC and Ramsar

6.9.3 Changes to thermal regime

Conservation objectives (see section 1.5.1)

- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have a thermal impact on the reefs include the following:

- HPC operational discharge - cooling water discharge

These could act in combination with thermal impact from the following other permissions, plans or projects:

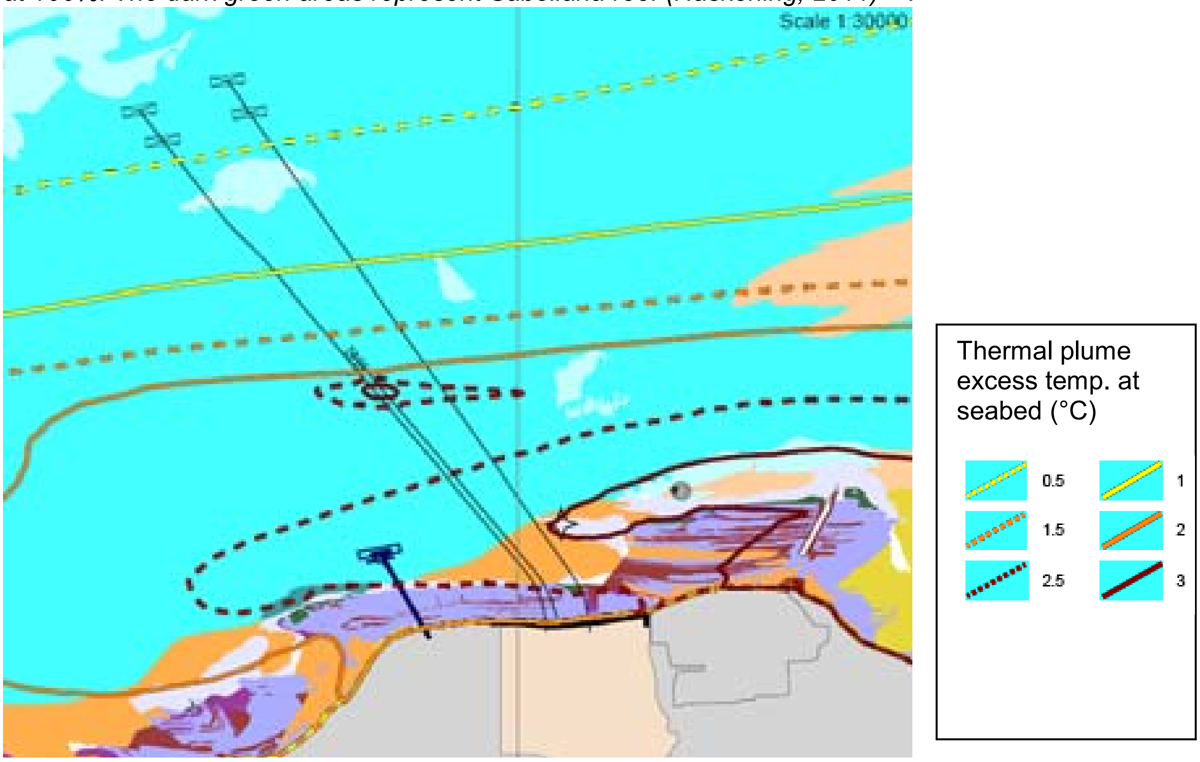
- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Both Uskmouth and Aberthaw discharge outfalls are >20km distance from the HPB and proposed HPC outfall. As reported in section 6.5 there will be no cross over of thermal plume mixing zones from either of these facilities. There is however the potential for HPB and HPC to act in combination synergistically with the Sabellaria reef *as S. alveolata* reefs are present on the lower shore along the rock platform fronting HPA, up to 2m above Mean Low Water Spring (MLWS), and are within the midfield dispersion pattern of HPB thermal plume. The *Sabellaria* reef could therefore be subject to a 3°C increase in water temperature immediately adjacent to HPA and HPB.

As discussed within section 2.6.3.4, Cunningham *et al.,* (1984)[660] reported increasing growth rates of *Sabellaria* reefs with temperatures up to 20°C and studies by Bamber & Irving (1997)[661] at HPB, found that growth of the tubes in the winter was considerably greater in the cooling water outfall, where the water temperature was raised by around 8-10°C, than at a control site; although the size of the individual worms themselves seemed to be unaffected. The growth of *Sabellaria alveolata* however, is severely restricted below 5°C (Gruet, 1982, cited in Holt *et al*., 1998)[662] so it is particularly vulnerable to the cold. For example, it has been recorded that there were many severe losses of *S. alveolata* in South and North Wales as well as Lyme Bay due to the severe winter of 1962-63[663].

There is evidence therefore, to suggest that *S. alveolata* and their reefs could benefit from the predicted increase in water temperature around the cooling water discharge plume.

Figure 6.9S4.- Predicted thermal plume, mean sea temperature rises HPB at 100% and HPC at 100%. The dark green areas represent Sabellaria reef (Haskoning, 2011)[664].



[660]Cunningham, P.N., Hawkins, S.J., Jones, H.D. & Burrows, M.T., (1984). The geographical distribution of *Sabellaria alveolata* (L.) in England, Wales and Scotland, with investigations into the community structure of and the effects of trampling on *Sabellaria alveolata* colonies. *Nature Conservancy Council, Peterborough, Contract Report* no. HF3/11/22., University of Manchester, Department of Zoology.

[661] Bamber, R.N. & Irving, P.W. 1997. The differential growth of *Sabellaria alveolata* (L.) reefs at a power station outfall, Polychaete research, 17, 9-14.

[662] Holt, T.J., Rees, E.I., Hawkins, S.J. & Seed, R., (1998). Biogenic reefs (Volume IX). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. *Scottish Association for Marine Science (UK Marine SACs Project)*, 174 pp.

[663] Crisp, D.J. 1964. The effects of the severe winter of 1962-63 on marine life in Britain, *Journal of Animal Ecology*, 32-33, 165-211.

[664] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

Summary of changes to thermal regime assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC operational discharges	No
HPB operational discharges	No
Uskmouth cooling water discharge	No
Aberthaw cooling water discharge	No
Overall in combination effects	**No adverse effect upon site integrity –** potentially beneficial effect

Overall conclusion of thermal impact assessment for Reefs feature
Given the potentially positive effects of an increase in temperature, it can therefore be concluded that there will be no adverse effect on the integrity of the reef feature of the Severn Estuary SAC and Ramsar, from changes to the thermal regime in combination with other PPPs.

6.9.5 Salinity

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the reefs feature of the Severn Estuary due to salinity changes as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of salinity on this feature has not been considered further.

6.9.6 Turbidity, siltation and suspended sediment

Conservation objectives (see section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact on the reefs feature in terms of turbidity, siltation and suspended sediment include the following

- Construction discharges - Water discharges during construction of HPC site (concrete washdown water to foreshore)
- Sea wall construction FDC

These could act in combination with impact from turbidity, siltation and suspended sediment as a result of the following other permissions, plans or projects:

- Jetty construction
- Bristol deep sea container terminal dredging
- Bristol Port Steart development

S. alveolata do not rely on visual sense for feeding, reproducing etc. so they are not likely to be impacted by an increase in turbidity (Jackson, 2008)[665]. The species require a certain amount of water movement to suspend coarse sand particles in order to build tubes and so they are generally found in quite exposed and turbid areas. They can tolerate burial for a period of days or even weeks, however, prolonged burial will cause mortality (Jackson, 2008). *S. alveolata* reefs are therefore potentially vulnerable to accumulations or losses of sand.

Construction discharges
The pathway for increased turbidity, siltation and suspended sediment is through the discharge of surface water, pumped groundwater, and concrete plant washdown water to the foreshore initially through the existing drainage ditch and subsequently the new outfall structure in the cliff. The construction discharges alone have been assessed as being unlikely to impact on the reef habitats, however they could act locally in combination with discharges from the sea wall and jetty construction, and potentially with the Bristol Port Steart development and Bristol Port deep sea dredging.

Sea wall construction (Flood Development Consent (FDC))
The seawall construction works could lead to the generation of sediment and high concentrations of suspended solids. As *Sabellaria* reef is currently present on the lower foreshore more than 200m from the construction area on the upper shore it is unlikely that any discharge from seawall construction works would reach the foreshore area supporting *Sabellaria*. In addition, any discharge would be either highly diluted or greatly dispersed by the time it reaches the *Sabellaria* and is therefore negligible.

Jetty construction
The pathway for increased turbidity, siltation and suspended sediment from the jetty construction is through the disturbance of bed sediments into the water column during dredging and piling operations. There are no areas of intertidal or subtidal *Sabellaria* reef in close proximity to the proposed jetty location; this was confirmed both by an acoustic seabed survey and subsequent ground-truthing carried out to check this understanding locally (BEEMS TR104)[666]. The nearest area of *Sabellaria* reef is a small section within the intertidal zone >500m to the east (in front of HPA) and a wider area some 500m to the west. As no *Sabellaria* reef habitat is located close to the proposed jetty any affects from increased turbidity, siltation and suspended sediment are thought to be minimal and will not act in combination.

Bristol Port Steart development
Although construction methods are yet to be defined, the inter-tidal area surrounding the breaches are likely to be impacted from deposition of residual sediment from the construction of creek systems, which may smother *Sabellaria* reefs in the inter-tidal zone adding to impacts from the HPC development, however the nearest *Sabellaria* reefs are more than 2km to the north west of the Bristol Port Steart breach site. Furthermore, breaches and development of the creek systems would be made at locations above Mean High Water Springs (MHWS). When the tide moves over the newly created breach and creek systems, the large volume and high flushing rates of the estuary mean that effects will be minimal and localised to the immediate area of the breach and for a short time frame only, and therefore any in combination effects will be negligible.

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665 Jackson, A. (2008). *Sabellaria alveolata*. Honeycomb worm. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom.

666 BEEMS Technical Report 104 (TR104). Hinkley Point *Sabellaria* assessment: analysis of survey data for 2009. EDF BEEMS (Marine Ecological Surveys Ltd.) Technical Report No. 104, January 2010.

Bristol Deep Sea Container Terminal (BDSCT) dredging
The likelihood of damage due to sediment plumes in areas adjacent to dredging is unclear, as there is no knowledge of the effects of differing particle size upon *Sabellaria* (Jones *et al.,* 2001)[667]. The report to inform the HRA (Haskoning, 2011) states that assessment work for the BDSCT identified that the large-scale dredging of the approach channel to the new container terminal at Avonmouth and the disposal of dredged material could affect *Sabellaria* reef habitat in the shallow sub-tidal zone of the estuary. Project-specific survey work and analysis of available data from literature however, suggests that while *S. alveolata* was present within parts of the footprint of the dredge and disposal area, the observed agglomerations did not constitute reef habitat as defined under the SAC, therefore in combination effects will be negligible.

Overall conclusion of turbidity , siltation and suspended sediment for reefs feature

The in combination impacts of the combined activities is likely to cause some localised increases in turbidity, suspended sediment and siltation within the estuary and Bristol Channel, but the impacts to Sabellaria reefs will be negligible. We can therefore conclude that any increased turbidity, siltation or suspended sediment as a result of the in combination or combined PPPs discussed above, will not have an adverse effect on the reef feature designated to the Severn Estuary SAC and Ramsar

Summary of turbidity, siltation and suspended sediment assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
Construction discharges	No
Sea wall construction FDC	No
Jetty construction	No
Bristol Port Steart Project	No
BDSCT dredging	No
Overall in combination effects	**No adverse effect upon site integrity**

6.9.7 Physical damage / Habitat loss

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the reefs feature of the Severn Estuary due to physical damage / habitat loss as a result of any of the activities occurring as part of the HPC project. Therefore, impact of physical damage / habitat loss on this feature has not been considered further.

6.9.8 Disturbance (noise, vibration and visual)

Due to its location and known sensitivities we are satisfied that there will be no adverse effect on the reefs feature of the Severn Estuary due to disturbance as a result of any of the activities occurring as part of the HPC project. Therefore, impact of disturbance on this feature has not been considered further.

[667] Jones, L.A., Hiscock, K. & Connor, D.W. (2001) Marine habitat reviews- A summary of ecological requirements and sensitivity characteristics for the conservation and management of marine SACs UK Marine SAC. JNCC

6.9.9 Physical damage (Entrainment of *Sabellaria* larvae)

Conservation objectives (see section 1.5.1)

- *The total extent and distribution of Sabellaria reef is maintained;*
- *The community composition of the Sabellaria reef is maintained;*
- *The full range of different age structures of Sabellaria reef are present;*
- *The physical and ecological processes necessary to support Sabellaria reef are maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact on the reefs feature in terms of entrainment and impingement include the following

- HPC Operational discharges (abstraction)

These could act in combination with impact from turbidity, siltation and suspended sediment as a result of the following other permissions, plans or projects:

- Hinkley Point B abstraction
- Aberthaw Power Station

There is no published data on the entrainment mortality of *Sabellaria* larvae. Section 2.6.4.2 BEEMS Support Paper 066 (SPP066)[668] was used to understand the potential impacts of entrainment of *Sabellaria* larvae, in relation to spawning sites and tidal stream lines within the estuary.

Modelling (by particle tracking in the HPC GETM model) predicted a 0.33% chance of larval entrainment per day for four intakes for HPC alone. Assuming 100% entrainment mortality, the predicted worst case loss of *S. alveolata* larvae has been calculated as 0.33% per day. In comparison, the daily natural mortality for larvae from field data has been estimated as 0.09 (9%) per day (Dubois *et al.,* 2007)[669]. Field observations performed in 2002 by Dubois *et al*., (2007) have shown that large scale spatial distribution of *S. alveolata* larvae was patchy and was mainly controlled by residual currents. Highest densities (up to 28,000 larvae m²) were generally located in near-shore waters close to the adult reefs (Ayata *et al.,* 2009)[670], but there still remains the possibility that larval dispersion happens in the wider channel, so the abstraction risk has the potential to be lower.

There is no specific data on the entrainment mortality associated with HPB or Aberthaw power station. Taking a similar set of parameters to those used in the calculations for HPC and taking into account the abstraction rates of both HPB and Aberthaw in relation to HPC as a percentage (Table 6.9.5), the predicted *Sabellaria* larvae entrainment is approximately 0.55%. Assuming 100% mortality, the predicted worst case loss of *S. alveolata* larvae from the cumulative effects of HPC, HPB and Aberthaw will be 0.55% per day. The calculations within SPP066 are conservative, and the calculations for Aberthaw are based on maximum abstraction rates, when in

[668] BEEMS Scientific Position Paper 066 (SPP066). Numerical simulation of the transport of Sabellaria eggs and the risk of entrainment by the proposed Hinkley Point C power station. October 2011. Cefas report for EDF.

[669] Dubois, S., Comtet, T., Retière, C., Thiébaut, E., 2007. Distribution and retention of *Sabellaria alveolata* larvae (Polychaeta: Sabellariidae) in the Bay of Mont-Saint-Michel, France. Marine Ecology Progress Series 346, 243254.

[670] Ayata, S-D., Ellien, C., Dumas, F., Dubois, S., Thiébaut, E. (2009). Modelling larval dispersal and settlement of the reef building polychete *Sabellaria alveolata*: Role of hydroclimatic processes on the sustainability of biogenic reefs. Continental Shelf Research 29; Issue 13; 1605-1623.

reality they only abstract on average of 36m³/sec and therefore the 0.55% figure represents a worst case scenario.

The overall loss (0.55%) is not considered to be significant at the population level, especially since this would be an over conservative estimate.

Table 6.9S5 Predicted *Sabellaria* larvae entrainment from calculated abstraction rates of HPC.

Abstraction	Abstraction rate (m^3 sec)	% of HPC	Predicted *Sabellaria* larvae entrainment (%) /day
HPC Operational abstraction (100%)	~125 (unlicensed)	100	0.33
Hinkley Point B abstraction (100%)	~33.7 (unlicensed)	27	0.09
Aberthaw Power Station (100%)	~50 (max. licensed rate)	40	0.13
Total cumulative			**0.55**

Summary of physical damage (entrainment) assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC operational discharges (abstraction)	No
HPB cooling water abstraction	No
Aberthaw cooling water abstraction	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of entrainment and impingement impact on Reefs feature

The resultant increase in natural mortality from 9% to less than 9.55% from in combination impacts from HPB and HPC is considered to be of negligible significance, and we can therefore conclude that any entrainment impacts as a result of the in combination or combined PPPs discussed above, will not have an adverse effect on the reef feature designated to the Severn Estuary SAC and Ramsar

Overall conclusion of incombination assessmet on reef feature

Hazard assessed	Adverse effect on reef feature?
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Salinity	No
Siltation turbidity and suspended sediment	No
Habitat loss & physical damage	No
Entrainment	No
Overall conclusion	**No adverse effect upon site integrity**

6.10 Migratory fish and fish assemblage in-combination assessment

Table 6.10.1 - Activities resulting in a potential impact on fish

	Construction activities											Operational activities															
Potential sources of hazard	EA consents				Existing plans and other plans & projects							EA Consents				Existing plans and other plans & projects											
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Jetty construction	Construction of cooling water infrastructure	Nuclear island construction	Bristol deep sea container terminal	EA Steart development	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge	Jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning	Commercial shipping
Toxic contamination	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	✓	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	✓	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thermal impact	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×
Salinity	×	×	×	×	×	×	×	×	×	×	×	✓	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×	×
Turbidity, suspended sediment & siltation	✓	✓	✓	×	✓	✓	×	✓	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	✓	×	×	✓	✓	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	✓	✓	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×	×
Competition with non-native species	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	✓	×	×	×	×	×	×

Table 6.10.2 Timeframe of activities that could impact on the migratory fish and fish assemblage feature.

PPP	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Jetty construction											
Sea wall construction (FDC)											
Construction CW infrastructure											
HPC Construction discharges											
Combwich development (FDC)											⇨
EA Steart habitat creation											
Bristol Port Steart habitat creation											
Bristol deep sea terminal (dredging)											⇨
Cold commissioning discharge (HPC)											
HPC Operational discharge											⇨
HPB operational discharge											⇨
HPA decommissioning discharge											⇨
Aberthaw abstraction											⇨
Uskmouth abstraction											⇨
Commercial shipping											

Note: ⇨ = ongoing, *Green indicates an EA permission for HPC.*

6.10.2 Toxic contamination

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by poor water quality*
- *The size of the populations of the migratory fish and assemblage species 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*
- *The abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary is maintained*
- *Toxic contaminants in the water column and sediment are below levels which would pose a risk to the ecological objectives*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact in terms of toxic contaminants include the following:

- Sea wall construction FDC
- Combwich Wharf development FDC
- Construction discharges - Pumping of groundwater during construction of HPC site
- HPC Commissioning discharge
- HPC Operational discharge

Which could act in combination with each other and the following other permissions, plans or projects:

- Jetty construction
- Construction of cooling water infrastructure
- HPB operational discharges
- Bristol deep sea container terminal
- EA Steart development
- Bristol Ports compensatory habitat at Steart

With the exception of HPB, all of the above PPPs have been assessed as being negligible within the estuaries toxic contamination assessment (see section 6.5.2). As the migratory fish and fish assemblage features all fall under the 'notable estuarine species assemblages' sub feature of the estuaries feature[671], it can be concluded that even in combination with each other the above permissions, with the exception of HPB, will have no adverse effect on the integrity of the site.

HPB and HPC cooling water discharge

The TRO concentration at the HPC outfall is expected to be of the order of 100-200μg/l with an EQS of 10μg/l. HPB has a permit to discharge 0.3μg/l TRO although it does not currently discharge TRO, and is not expected to in the future, but it is there for precautionary measure and so it will be considered.

There is a measurable mixing zone for the toxic contaminant, TRO, in the HPB operational discharges. The predicted mixing zone is small, being 0.13% of the estuaries feature at the surface. The loads of other toxic contaminants from the HPB operational discharges are not measurable and are considered to be negligible, as the only consented toxic contaminant is TRO. Hydrazine is not used at HPB, so there is no hydrazine discharge and therefore no

[671] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations'' , as amended. Severn Estuary/Mor Hafren European Marine Site. June 2009.

mixing zone, however there is potential for the TRO from the combined HPB and HPC to act in combination with the hydrazine, to impact on fish.

Fish may show a range of behavioural, chronic and acute effects on exposure to chlorine and hydrazine; and impacts will depend on the metabolism of the individual species. As discussed in section 6.5.2, the mixing zones of TRO and hydrazine from HPC operational discharges are not quite coincident spatially, while that for TRO from the HPB operational discharges is spatially separate. The modelling of the hydrazine plume for HPC operational discharges alone, was for a discharge scenario at average concentrations (see estuaries alone assessment section 2.6.3.1). Modelling has not been provided for the maximum concentration against the acute 'predicted no effect concentration' (PNEC). The maximum concentration in the cooling water is predicted to be 0.72µg/l, based on a cooling water flow of $64m^3/s$. The loading from this scenario is approximately 40 times greater than that for the average scenario. It was therefore concluded from the alone assessment that the potential size of the mixing zone for hydrazine for the maximum concentration scenario could be significant and could therefore have an impact on benthic invertebrates. Consequently, it was not possible from the available information to conclude that the discharge of hydrazine does not have an adverse effect on the integrity of the site.

Adult fish are mobile animals and can be assumed to respond to a chemical plume by avoiding it. For migratory fish, a chemical plume could act as a physical barrier to the migratory passage, disrupting the species' life cycle and potential ability to reproduce. Such an effect appears unlikely in Bridgwater Bay given the relatively small areas of combined chemical impact relative to the available habitat.

The increases in the load of toxic contaminants to the Severn Estuary SAC from the discharges is not significant, as they are mostly less than 0.1%. Only the load of iron from the HPC operational water discharge is greater than 0.1%, being 0.85%, although this is not considered to be significant given the ubiquitous distribution of iron and its abundance in the sediments of the Severn Estuary SAC.

Summary of toxic contamination assessment

Plan, permission, project (PPP)	**Conservation objectives compromised?**
Sea wall construction	No
Combwich Wharf development	No
HPC construction discharges	No
HPC Commissioning discharges	No
HPC operational discharges	No – with permit condition in place
Jetty construction	No
Construction of cooling water infrastructure	No
HPB operational discharges	No
Bristol deep sea container terminal	No
EA Steart development	No
Bristol Port Steart development	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of combined impacts of toxic contamination

It is therefore concluded that the impact of toxic contaminants from the relevant permissions, plans and projects (PPPs) on the conservation objectives for the migratory fish and fish assemblage features is not significant when considered 'in combination', with the exception of hydrazine in the HPC operational discharge, which will be removed from the discharge by a permit condition.

Required mitigation

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

6.10.3 Non-toxic contamination (nutrient enrichment and organic loading)

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by poor water quality*
- *The abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary is maintained*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact in terms of non-toxic contaminants include the following:

- Construction discharges (initial treated sewage discharges from package plants)
- Commissioning discharges
- HPC Operational discharges - cooling water discharge potential discharges of ammonia from the primary and secondary circuits

These could act in combination with each other and from the following other permissions, plans or projects:

- Hinkley Point B discharges (STW)
- Hinkley Point A decommissioning discharge (STW)
- EA Steart development - compensatory habitat at Steart
- Bristol Port Steart development - compensatory habitat at Steart

During the construction and operation of HPC, treated sewage effluent will be discharged into the estuary which will have the potential to increase the nutrient content and oxygen demand to a localised area of the estuary in combination with the treated sewage effluent discharges from HPA and HPB. Both Steart developments have the potential to act in combination with the construction activities as the historic land use of each of the Steart sites appears to have been limited mainly to agricultural use, meaning there is potential for the transport of nutrients (nitrates/ phosphates) into the wider estuarine system when the land becomes inundated with seawater.

Also, both the primary and secondary circuits have the potential to release ammonia, which can lead to elevated levels of nitrates in the water column during the cold commissioning and operational stage.

It is possible that changes in nutrient levels may affect the food supply of lamprey and shad species, however due to the high turbidity of the system and the volumes of water involved, it is thought that any effects would be minimal (NE & CCW, 2009)[672]. Furthermore, the turbidity is considered to be such that although concentrations of nutrients within the estuary could potentially give rise to increased phytoplankton growth, the availability of light is the limiting factor.

[672] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regualtions 9, as amended. Severn Estuary/Mor Hafren European Marine Site. June 2009.

As discussed within section 6.6, based on the relative loadings of nutrients and the size of any mixing zones, the impact of non-toxic contamination (nutrient enrichment and organic loading) from the relevant permissions, plans and projects (PPPs) is not significant when considered 'in combination'.

Dissolved oxygen (DO)
Increasing temperature reduces the solubility of gases, particularly oxygen. High suspended sediment loads and the presence of sewage or other organic matter contribute an additional oxygen demand. Discharges of between 1°C and 3°C above ambient levels could decrease the solubility of oxygen by about 0.5ppm.

The report to inform the HRA (Haskoning, 2011) states that GETM modelling work has been undertaken to determine the in-combination effect of temperature, DO, pH and ammonia concentration. The model results are based on HPC and HPB running at 100% under normal operating conditions. In comparison to HPC alone, the model outputs indicate that DO in the area immediately influenced by the thermal plumes would only be reduced below 5mg/l in the area of the HPB plume.

In comparison to HPC alone, the model indicates that DO concentration in the area immediately influenced by the thermal plumes would only be reduced below 5mg/l in the area of the HPB plume (see Figure 9.3 of Haskoning, 2011)[673]. The report states that there is limited interaction between the plumes from HPC and HPB, and the DO in the vicinity of the outfall for HPC remains above the 5mg/l. The combined effect of both stations operating together is likely to cause a greater DO reduction, but that it is only HPB itself that leads to a reduction in DO below 5mg/l.

Since there have been no indications that the operation of HPB has had an adverse impact on estuarine ecology through lowered DO, we would can conclude that an in-combination effect is not predicted.

Summary of non-toxic contamination assessment

Plan, permission, project (PPP)	**Conservation objectives compromised?**
HPC construction discharges	No
HPC Commissioning discharges	No
HPC operational discharges	No
HPB operational discharges	No
HPA decommissioning discharges	No
EA Steart development	No
Bristol Port Steart development	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of combined impacts of non-toxic contamination
It can be concluded that levels of non-toxic contamination released via discharges during the operation of HPC in combination with the other PPPs will not cause an adverse effect on the migratory fish and fish assemblage features of the Severn Estuary SAC and Ramsar.

[673] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. **Figure 9.3, page 638**. Report prepared for EDF.

6.10.4 Changes to thermal regime

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded*
- *the abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary, in particular at the salt wedge, is maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have a thermal impact on fish include the following:

- HPC cooling water discharge

Which could act in combination with thermal impact from the following other permissions, plans or projects:

- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Both Uskmouth and Aberthaw discharge outfalls are >20km distance from the HPB and proposed HPC outfall. As reported in section 6.5 there will be no cross over of thermal plume mixing zones from these power stations with either HPB or the proposed HPC thermal plume. There is however the potential for HPB and HPC to act in combination.

HPC and HPB cooling water discharges
The cumulative operation of HPB and HPC is likely to result in higher plume temperatures extending both offshore and west of Hinkley Point, due to the increased thermal loading.

In accordance with Environment Agency guidance (Turnpenny *et al.*, 2010)[674] two different hydrodynamic models (Delft3D and GETM) setup by two independent subcontractors were used within BEEMS Technical Report 186 (T186)[675] to predict the temperature changes off Hinkley Point that may result from different HPC power station cooling water intake and outfall combinations. The models outputted a selected set of variables every hour that were used to produce time series, means and averages. The five runs A to E were used to produce detailed thermal predictions from both models, however only runs D and E are relevant to the in combination assessment:

Run D: HPB (running at 100%) + HPC
Run E: HPB (running at 70%) + HPC

For European Marine Sites the thermal threshold of 21.5°C as a 98%ile and temperature uplift 2ºC from the 2006 WQTAG 160[676] interim guidelines applies to SACs and SPAs. It is also acknowledged that the WFD UKTAG[677] standards could also be considered appropriate to be applied to SACs and SPAs with a thermal threshold of 23°C as a 98%ile and temperature uplift 3ºC, however this has not yet been formally adopted into Environment Agency practice. For the alone assessment these criteria were met by HPC with some very small areas affected in Bridgwater Bay. The assessment of HPC and HPB in combination

[674] Turnpenny, A.W.H., Coughlan, J, Ng, B., Crews, P. Bamber, R.N., Rowles, P. (2010). Cooling water options for the new generation of nuclear power stations in the U.K. Environment Agency Science Report SC070015.
[675] BEEMS Technical Report 186 (TR186): Predicted Effects of NNB on Water Quality at Hinkley Point. April 2011.
[676] Water Quality Technical Advisory Group 160 (WQTAG 160): Guidance on assessing the impact of thermal discharges on European Marine sites. Environment Agency 2006.
[677] UK Technical Advisory Group (UK TAG) on the Water Framework Directive (2008). UK Environmental Standards and conditions Phase II (SRI-2007). March 2008.

(Runs D and E) indicated that there are likely to be moderately large areas, in particular the Parrett, for which exceedence of the 98%ile and the uplift standard are likely to occur. For Run E for example, the 2ºC uplift effects 2.67% SPA and 4.88% SAC at the surface and 2.59% SPA, and 5.08% SAC at the bed (see table 6.10.3A and 6.10.3B). When using the WFD UKTAG standards (23 ºC as 98%ile with ∆T 3ºC) the thermal plume effects much smaller areas.

Table 6.10.3A - Extent of thermal plume within the estuaries SAC and SPA (b) areas using 2006 WQTAG 160 standards (21.5ºC as 98%ile with ∆T 2ºC) compared with WFD UKTAG standards (23 ºC as 98%ile with ∆T 3ºC). (modelled from Run E - HPC running at 100% together with HPB running at 100%).

Severn Estuary SAC					
Area		**21.5 ºC as 98%ile**	**∆T 2ºC**	**23 ºC as 98%ile**	**∆T 3ºC**
(ha)	**Surface**	2810	1966	1424	845
	Bed	2767	1906	1232	811
as a %tage	**Surface**	3.81	2.67	1.93	1.15
	Bed	3.76	2.59	1.67	1.10

Table 6.10.3B - Extent of thermal plume within the estuaries SPA areas using 2006 WQTAG 160 standards (21.5ºC as 98%ile with ∆T 2ºC) compared with WFD UKTAG standards (23 ºC as 98%ile with ∆T 3ºC). (modelled from Run E - HPC running at 100% together with HPB running at 100%).

Severn Estuary SPA					
Area		**21.5 ºC as 98%ile**	**∆T 2ºC**	**23 ºC as 98%ile**	**∆T 3ºC**
(ha)	**Surface**	1672	1204	669	670
	Bed	1721	1253	1022	748
as a %tage	**Surface**	6.78	4.88	2.71	2.72
	Bed	6.98	5.08	4.14	3.03

As discussed in section 2.6.3.5, none of the migratory fish designated under the SAC or Ramsar are likely to have any eggs or planktonic early life stages that will be present in or around Bridgwater Bay and the River Parrett. Ichthyoplankton studies carried out in BEEMS Technical reports 83[678] and 83a[679] suggest that local fish egg and larval abundances are chronically low, however Bridgwater Bay is considered to be an important nursery area for juvenile fish and a number of fish species utilise the inter-tidal areas. The fringing saltmarsh is of particular significance and it provides a feeding, refuge and nursery area for fish life (Colclough *et al.*, 2004)[680], with fish populations moving into the high inter-tidal and saltmarsh areas during flood tides returning to deeper water on the ebb (Lyndon *et al.*, 2002)[681]. Few species are able to complete their life cycles solely in estuarine systems (Potter *et al.,*

[678] BEEMS TR083 (Edition 3). Hinkley Point nearshore communities: Results of the 2 m beam trawl and plankton surveys 2008 – 2010. EDF BEEMS (Cefas) Technical Report No. 083, November 2010.
[679] BEEMS TR083a. Hinkley Point nearshore communities: plankton surveys 2010. EDF BEEMS (Cefas) Technical Report No. 083a, November 2010.
[680] Colclough, S. Fonseca, L. Astley, T. Thomas, K & Watts, W. (2005). Fish utilisation of managed realignments. Fisheries Management and Ecology, 12, 351-360.
[681] Lyndon, A.R., Bryson, J.G., Holding, N. & Moore, C.G. (2002) Feeding relationships of fish using inter-tidal habitats in the Forth Estuary, eastern Scotland. Journal of Fish Biology 61. (Suppl. A) 78-80.

2001)[682], with many species moving into the outer Bristol channel to spawn. For some species, temperature is a trigger for these movements between the different zones within the estuary. Data from Hinkley Point, has shown that the abundance of juvenile sole in Bridgwater Bay is positively correlated with the seawater temperature in April and May, the time when young fish are migrating back inshore (Henderson & Holmes,1991)[683], so any changes in temperature could also impact on these movements.

In British waters no fish species would tolerate temperatures as high as 40°C, although eel can survive to 38°C and some freshwater cyprinids can tolerate temperatures in the high-thirties (Langford, 1990)[684]. Since bulk temperatures (i.e. outside any thermal plume) in Britain are unlikely to exceed around 25°C outside the mixing zone of thermal discharges, it is unlikely that fish kills would occur due to temperature alone (Turnpenny, 2007)[685]. Even within the combined thermal plumes, where temperatures can reach 10-14°C above background (which might reach ≥22 °C in an estuary during a warm summer), Langford's review (1990) concludes that 'in view of the vast amount of literature dealing with thermal discharges, very few large-scale mortalities have occurred which can unequivocally be related to high temperature'. It is also apparent that fish have the capacity to move in and out of the thermal plume and thus we would agree that no direct mortality would be expected.

Analysis of the 28-year time series of monthly samples collected at Hinkley Point has shown that the fish community of Bridgwater Bay is responding rapidly to changes in seawater temperature, salinity and the North Atlantic Oscillation (NAO) (Henderson, 2007)[686]. There are clear indications that the fish of the estuary are responding to global changes in sea temperature. A further 2˚C increase in inshore seawater temperature has been predicted by Henderson (2007) to increase total species richness of fish in Bridgwater Bay by 10%, although most of this gain will be due to warm water tourists, who have expanded their range from a warmer climate.

It is known that certain species such as sea bass, congregate near thermal plumes, suggesting that the presence of the thermal plume may be beneficial for this species. Increased temperature may also be beneficial for other Lusitanian (warmer-water) species present in the Inner Bristol Channel, but potentially of some detriment for species nearer the southern extent of their range (Arctic-Boreal or coldwater species) e.g. cod (BEEMS SAR008)[687], especially with the added pressure of more severe global warming scenarios.

It is understood that there are likely to be small-scale changes in the composition of epibenthic fish assemblages within the footprint of both plumes, however the coldwater species will avoid such hotspots, provided that the plume does not pervade the full channel width and depth (see barriers to migratory fish assessment below). Many fish avoid warm inshore waters during the warmest summers and generally, summer months with temperatures >20˚C have the lowest fish abundance and species richness (Henderson & Bird, 2010). Furthermore, any changes due to the in combination overlap of HPB and HPC, such as slight declines in the cold-water species within the Hinkley point area, are likely to recover once HPB ceases operation.

[682] Potter, I.C, Bird, D.J., Claridge, P.N., Clarke, K.R., Hyndes, G.A., Newton, L.C. (2001) Fish fauna of the Severn Estuary. Are there long-term changes in abundance and species composition and are the recruitment patterns of the main species correlated? Jour. Exp. Mar. Bio. & Ecol. 258; 15-37.

[683] Henderson, P.A. & Holmes, R.H.A. (1991) On the population-dynamics of dab, sole and flounder within Bridgwater Bay in the Lower Severn Estuary, England. *Netherlands Journal of Sea Research*, 27, 337-344.

[684] Langford, T.E.L. (1990). Ecological effects of thermal discharges. Elsevier Applied Sciences, London.

[685] Turnpenny, A.W.H, and Liney, K.E (2007). Review and development of temperature standards for marine and freshwater environments. Jacobs Report: 21960.

[686] Henderson, P.A., 2007. Discrete and continuous change in the fish community of the Bristol Channel in response to climate change. Journal of the Marine Biological Association of the United Kingdom 87, 589–598.

[687] BEEMS SAR 008. Thermal standards for cooling water from new build nuclear power stations. EDF BEEMS Scientific Advisory Report No. 008, Expert Panel, March 2011.

Conclusion

Considering the points above, we consider that whilst it is possible that some small-scale changes to the fish fauna within the footprint of both plumes may occur for the overlap period, it is apparent that no large-scale changes in the fish assemblage would occur as a result of the predicted temperature change, so overall the fish assemblage would retain its existing composition.

It can therefore be concluded that there will be no adverse effect on the integrity of the migratory fish and fish assemblage feature of the Severn Estuary SAC and Ramsar, from changes to the thermal regime in combination with other PPPs.

Barriers to migratory fish

As discussed within section 2.6.3.5, Environment Agency (EA) local fisheries experts have confirmed that only eel and salmon are known to use the River Parrett for migrating to and from spawning grounds. Salmon migrate up the River Parrett and spawn in the River Tone and its tributaries; whilst eel move upstream into the many tributaries of the River Parrett to return to their home grounds. Both salmon and eel could therefore be impacted by the combined HPC and HPB thermal plumes, which may cause thermal occlusion or a barrier for fish movements in and out of the Parrett Estuary.

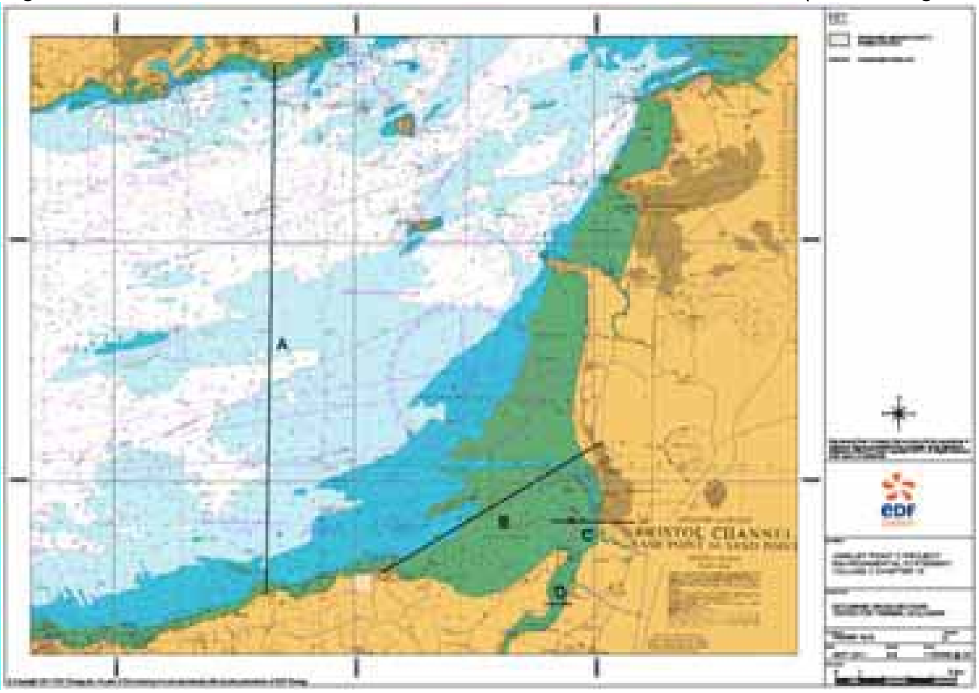
Technical Report 182 (TR182)[688] uses the standard proposed by Turnpenny and Liney (2006)[689] to estimate potential in combination affects from both HPC and the current HPB. The standard requires that estuaries should not be subjected to temperature increases of >2°C across >25% of a cross section for >5% of the time. A detailed description of the history of how these standards have been determined and their subsequent application to Transitional and Coastal (TraC) waters is provided in BEEMS T186[690].

As within the alone assessment, four sections were considered (see Figure 6.10.4):

Section A) From Lilstock, Somerset to Sully in the Vale of Glamorgan, Wales, covering any migration through the width of the estuary.
Section B) From Hinkley to Berrow, Burnham, covering migration through Bridgwater Bay.
Section C) Across the mouth of the River Parrett within Bridgwater Bay.
Section D) Across the Parrett Estuary.

[688] BEEMS Technical Report 182 (TR182) HP Thermal Plume Modelling: Delft 3D - Stage 3a Results with the Final CW Configuration. February 2011. Cefas report for EDF.
[689] Turnpenny, A.W.H & Liney, K.E. (2006). Review and development of temperature standards for marine and freshwater environments. Jacobs Engineering Consultancy Report No. 21960.
[690] BEEMS Technical Report 186 (TR186): Predicted Effects of NNB on Water Quality at Hinkley Point. April 2011.

Figure 6.10.4 - Estuarine cross sections tested for thermal occlusion (Haskoning, 2011)[691]



TR182 calculated that the cross sectional area criteria of >2°C difference. >25% of the cross section was exceeded for one section (section B) but only for the combined B (100%) + C (100%) scenario Run E (see table 6.10.5). When HPB is operating at 70% load in-combination with HPC (Run D) the percentage of Section B exceeding a 2°C rise in temperature was less than 25% throughout both the spring and neap tide. At high water on neap tides, 30% of Section B exceeded a temperature rise of 2°C when HPB is operating at 100% load in-combination with HPC. This is reduced to 22% when HPB is operating at only 70% load (see table 6.10.5).

However, upon examination of the cross section plots, there was an indication that the north-east channel of the Parrett remains unaffected by significant temperature rises, with excess temperatures of less than 1ºC throughout the tide. As such, a clear channel into the Parrett for migratory fish is maintained. This is confirmed by the fact that the uplift is less than 2ºC across all of Section C, which considers the entrance of this channel into the River Parrett.

Table 6.10.5 - Percentage of Section B exceeding a 2^{o}C rise in temperature

Run ID	**Spring tide**				**Neap tide**			
	Low water	**Peak flood**	**High water**	**Peak ebb**	**Low water**	**Peak flood**	**High water**	**Peak ebb**
A: HPB at 70%	0	0	0	0	0	0.14	0	0
B: HPB at 100%	0	1.92	0	0	0	0.85	0.31	0
C: HPC	0	0	0	0	0	0	0	0
D: HPC plus HPB at 70%	0	1.93	0	0	7.64	0	21.83	0
E: HPC plus HPB at 100%	0	2.59	2.98	0	0	14.36	30.20	2.76

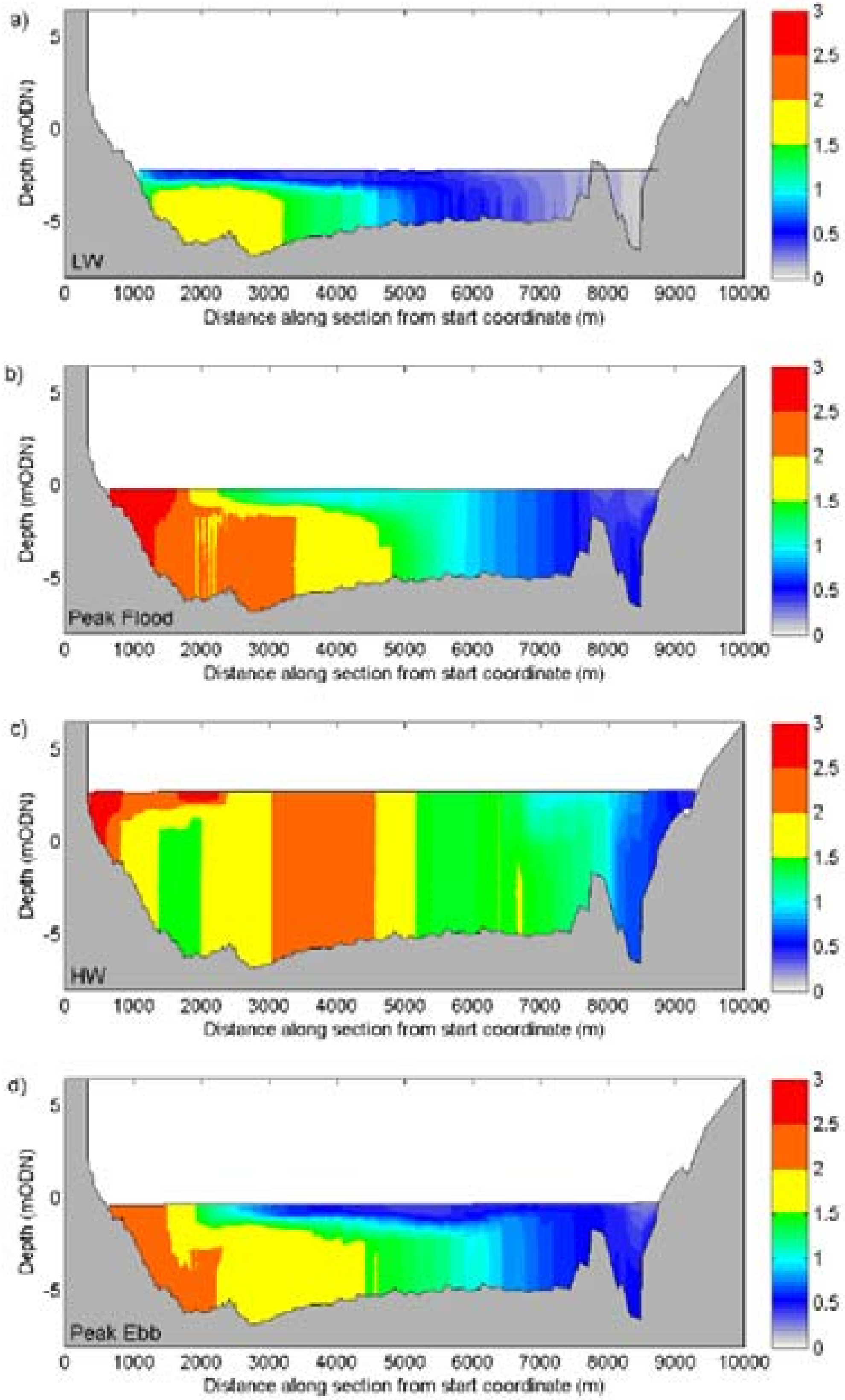
[691] Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Section 6.2.328-9. Report prepared for EDF.

The estuary is highly dynamic however, and the extent of the plume is likely to depend on environmental factors such as meteorological conditions which may out-weigh such statistics during certain key migratory periods. For example, if a particular tide direction or size caused the plume to steer East and inland towards the mouth of the River Parrett. This area is particularly important for glass eels and elvers as this interface (where the sea water and fresh water mix) is a trigger area for the species.

A number of meteorological conditions, have therefore been considered (full details on the justification for these scenarios is provided in BEEMS Technical Report TR187)[692]. For the in combination scenario of HPB and HPC working at 100% capacity, westerly winds were applied in combination with a large freshwater flow from the River Parrett, using bathymetry data from 2008. The scenarios were chosen to consider a worst case with respect to either recirculation or plume impact on sensitive inter-tidal areas and potential for occlusion. All meteorological scenarios were undertaken in 3D, with a time varying discharge rate, temperature and momentum applied at the outfall sites and with the westerly wind driving both the heat exchange and the hydrodynamics.

[692] BEEMS Technical Report 187 (TR187). Hinkley Point Thermal Plume Modelling: Selection of meteorological and geomorphological modelling. Cefas report for EDF. September 2011.

Figure 6.10.6 - Excess temperature (˚C) across Section B, neap tide, for the in combination Scenario with 2008 bathymetry for HPB and HPC. Taken from figure 67 of TR121.



Results are presented in BEEMS Technical Report (TR121)[693]. For the meteorological in combination scenario, surface excess temperatures are reduced, because the freshwater flux drives the plume away from the River Parrett and affects vertical mixing by changing the relative buoyancy of the plume. The application of winds increases both the loss of heat to the atmosphere and the mixing of the plume through the water column, reducing the maximum excess temperatures and the stratification across Section B. For this scenario more than 25% of Section B exceeded a 2ºC rise in temperature at peak flood and high water on neap tides (see Figure 6.10.6). On spring tides, the stronger tidal mixing reduces excess temperatures and a significantly smaller area (2-3%) of the section exceeds a 2ºC rise. The percentage time when there is more than a 2ºC rise across more than 25% of Section B was calculated for a spring and neap tide. Excess temperatures are elevated more than 2ºC above background, across more than 25% of Section B for 31% of a neap tide, but for none of a spring tide when the meteorological conditions applied in the in combination scenario are prevalent. Despite this, excess temperatures into the north-easterly channel of the River Parrett remain below 1.5ºC for all scenarios, maintaining a pathway for migratory fish (see Figure 6.10.6).

Other GETM modelling results from an annual analysis (BEEMS Technical Report 177)[694] also indicate that there is a breach of the 25% criteria for Section B but only for limited periods of time and much less than the 5% criteria.

Whilst the in combination impacts exceed the recommended guidance for thermal occlusion, excess temperatures across the north-easterly channel into the River Parrett remain low even under certain meteorological scenarios maintaining a sufficient channel into and out of the River Parrett for migratory fish.

Summary of changes to thermal regime assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC operational discharges	No
HPB operational discharges	No
Uskmouth cooling water discharge	No
Aberthaw cooling water discharge	No
Overall in combination effects	**No adverse effect upon site integrity –** potentially beneficial effect

Overall conclusion of combined impacts of thermal impacts related to migratory fish and fish assemblage

It can be concluded that the thermal impact of water discharges during the operation of HPC in combination with the other PPPs will not cause an adverse effect on the migratory fish and fish assemblage features of the Severn Estuary SAC and Ramsar.

[24] BEEMS Technical Report 121 (TR121) Thermal Plume Dispersion at Hinkley Point in the Severn Estuary: Stage 3 - Additional Modelling Results (January 2011) R\3987 13 R.1758. Produced for EDF.

[694] BEEMS Technical Report 177 (TR177). Hinkley Point Thermal Plume Modelling: GETM Stage 3a results with the final Cooling Water configuration. Cefas report for EDF. June 2011.

6.10.5 Changes in salinity

Conservation objective (see section 1.5.1)

- *the abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary, in particular at the salt wedge, is maintained.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact on fish in terms of salinity changes include the following:

- HPC cold commissioning discharge
- HPC cooling water discharge

Which could act in combination with salinity changes from the following other permissions, plans or projects:

- HPB cooling water discharge
- Uskmouth cooling water discharge
- Aberthaw cooling water discharge

Both Uskmouth and Aberthaw discharge outfalls are >20km distance from the HPB outfall and proposed HPC outfall. As reported in section 6.5 there will be no cross over of thermal plume mixing zones from these power stations with either HPB or the proposed HPC thermal plume and therefore no in combination effects in terms of a change in salinity. There is however the potential for HPB and HPC to act in combination synergistically.

A survey undertaken in 2009 for the Severn Estuary area to inform the Environmental Appraisal indicated salinity concentrations were within a normal range for coastal waters. There was also no evidence of stratification of DO from *in-situ* measurements throughout the depth of the water column at each sampling location (Haskoning, 2011). The only fish species likely to be indirectly affected by changes in salinity is the twaite shad. Within the estuary, juvenile twaite shad prey on mysids feeding at the salt wedge near the head of the tide. The salt wedge can be defined as the area within the estuary where fresh and saline water meet and where the abundance of prey species is particularly important to the twaite shad population. An increase in temperature could increase the salinity regime of the estuary and in turn affect the distribution of these prey species, which may have consequences for the species (NE & CCW, 2009)[695].

Summary of salinity assessment

Plan, permission, project (PPP)	**Conservation objectives compromised?**
HPC cooling water discharge	No
HPB cooling water abstraction	No
Aberthaw cooling water abstraction	No
Uskmouth discharge	No
Aberthaw discharge	No
Overall in combination effects	**No adverse effect upon site integrity**

[695] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regualtions 9, as amended. Severn Estuary/Mor Hafren European Marine Site. June 2009.

Overall conclusion of combined impacts of salinity changes in relation to migratory fish and fish assemblage

The loss of water vapour from the thermal plume, which could increase the salinity within the estuary, will be insignificant and will be of no concern and will therefore not cause an adverse effect in combination.

6.10.6 Changes in turbidity, suspended sediment and siltation

Conservation objective (section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded by changes in flows*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact in terms of physical damage and habitat loss include the following:

- Sea wall construction FDC
- Combwich Wharf development FDC
- HPC Construction discharges

Which could act in combination with each other and the following other permissions, plans or projects:

- Jetty construction
- Construction of cooling water infrastructure
- Bristol deep sea container terminal
- Environment Agency (EA) Steart development
- Bristol Ports Steart development

Construction of the Sea wall,

Any potential impacts from the construction of the sea wall will be localised and confined to the upper part of the intertidal zone. However, any suspended sediments in the discharge water will be very rapidly dispersed and diluted in the nearshore waters. Any potential impact will be restricted to the period of construction which is over a period of about 12 months. Based on the duration of the discharge, and the rapid mixing of any discharge in the nearshore waters, the impact of elevated turbidity and suspended sediments from the discharge on the intertidal fish communities is considered to be insignificant.

Construction of the Jetty

There is potential for a localised impact from re-suspended sediments due to dredging of the berthing pocket for the jetty, as well as a localised impact where the jetty piles are driven into the sea bed, which could impact on fish; however it is considered that these impacts are not measurable. The capital dredge will only occur over a short period of about 1 month, while the impact from piling will occur intermittently for short periods over the 15 months of construction. Subsequent maintenance dredging has not been defined in terms of its duration and frequency, although it is considered that any impacts will also not be measurable. Based on the short duration of the activities, and the existing hydrodynamic and suspended sediment regime, it is concluded that there is no measurable impact due to elevated turbidity and suspended sediments from the jetty construction and operation on the migratory fish and fish assemblage features.

Construction of the cooling water infrastructure
Based on the expected levels of suspended sediments in the discharge, it is considered that any impact on the estuaries feature will be negligible. It is also expected that any discharge will be permitted and treated in the water management zone system, therefore providing mitigation to any potential impact of the discharge. Any increase in turbidity and suspended sediments related to the offshore drilling and construction activities (including scour effects) will be localised, so that any impact on the migratory fish and fish assemblage features will be minimal.

Discharges to foreshore
As the permitted levels of suspended sediments in the discharge are less than the ambient average levels, it is considered that there will be no measurable impact of the construction discharges from elevated turbidity and suspended sediments on the migratory fish and fish assemblage features.
The synergistic in combination effects of all construction activities is considered minimal due to the short duration of the impacts and the fact that fish are mobile and can move away from areas of high sedimentation.
The localised nature of changes in flows around the marine infrastructures of HPC (temporary jetty, sea wall and off-shore cooling water system) indicate that the presence of the structures would not affect the suspended sediment or bed load sediment transport systems. The open structure of the temporary jetty reduces any influence on sediment transport along the foreshore and therefore any impacts would be extremely limited if at all discernible.

Combwich Wharf and EA Steart development
Although it is not yet known whether these two projects will overlap in timeframe, both of these developments have the potential to have a synergistic or overlapping impact on increasing turbidity, suspended sediment and deposition within the River Parrett. Migratory fish of the Severn Estuary are highly adapted to high suspended sediment content, and the same applies for the tidal River Parrett, which is naturally turbid. However, the high levels may still induce avoidance reactions and may modify natural movements and migration patterns and unlike the main estuary, the section of the River Parrett at Combwich together with the proposed EA Steart breach site may not provide ample space for the fish to avoid such elevated sediment and turbidity levels.

Excess sediment can profoundly effect the productivity of a salmon or trout stream (McHenry *et al.,* 1994)[696], although the impact is more evident in freshwaters, particularly where there are spawning grounds and where juvenile species are present. Juvenile salmonids have been known to leave channels containing sedimented substrate which did not provide interstitial spaces for winter refuge (Bjornn *et al.,* 1974)[697].

There are no spawning grounds near to Combwich Wharf or the EA Steart breach site, and the area does not support juvenile salmon or sea trout. Salmon and sea trout smolts will pass by the area to complete their life cycle in the transition to marine waters, but these fish will be exposed to high turbidity and suspended sediment load once they reach the estuary, so it is not thought that slightly increased levels will adversely effect migrating smolt populations.

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[696] McHenry, M.L., D.C. Morrill and E. Currence. 1994 . Spawning Gravel Quality, Watershed Characteristics and Early Life History Survival of Coho Salmon and Steelhead in Five North Olympic Peninsula Watersheds. Lower Elwha S'Klallam Tribe, Port Angeles, WA. and Makah Tribe, Neah Bay, WA. Funded by Washington State Dept. of Ecology (205J grant).

[697] Bjornn, T. C., Brusven, M.A. Molnau, M.M. Watts, F.J,. Wallace, R.L. Neilson, D.R. Sandine, M.F. and Stuehrenberg, I.C. 1974. Sediment in streams and its effect on aquatic life, OWRT Project No. B-025-IDA, Idaho Water Resources Research Institute, Moscow, Idaho. 47 p.

With regards to migratory eels, the report to inform the HRA (Haskoning, 2011)[698] used a paper by Boubée *et al.* (1997)[699] *to* demonstrate that elvers showed no avoidance behaviour even at the highest turbidity. The lack of avoidance behaviour shown in elvers suggests that turbid waters are unlikely to impede their migration into adult habitats or impede silver eels migrating out to sea. Reports from other studies cited in Boubée *et al.* (1997) indicated that migratory elvers appear to be attracted to somewhat turbid environments and are often prolific in turbid waters. It is likely that habitat rather than ability to migrate through turbid waters, is more likely to affect the distribution of eels.

Bristol deep sea container terminal (BDSCT)

The large spatial separation between the BDSCT development and the other projects within the locality of HPC indicate that any impacts with regards to changes to turbidity and sediments will be minimal in combination. Only dredging works for the main shipping channel are likely to impact in combination. The dredging and dredge disposal areas are still of sufficient distance from the HPC development area, however the potential effects of dredging induced suspended sediment plumes, has been identified as sources of concern with regards to fish, which could add to localised impacts around HPC.

The report to support the BDSCT Environmental Statement (Haskoning, 2008)[700] states the general material that will be sent into suspension from the proposed dredge will be mobile bottom sediments of the estuary and ground particles derived from the mudstone underlying the mobile sediments. In the case of the mobile surface sediments, these are not expected to cause smothering because they are the same particles that are already in suspension in high amounts within the estuary. The same can be said for the mudstone-derived material, because it is not known to contain any organic or other compound that fish are sensitive to.

EA Steart development and the Bristol Port Steart development

Although the construction methods are yet to be defined, the inter-tidal area surrounding the breaches are likely to be impacted from deposition of residual sediment from the construction of the creek systems, which may smother existing flora and fauna in the inter-tidal zone adding to impacts from HPC developments, however, the breaches and development of the creek systems would be made at locations above Mean High Water Springs (MHWS). When the tide moves over the newly created breach and creek systems, the large volume and high flushing rates of the Estuary mean that effects will be minimal and localised to the immediate area of the breach and for a short time frame only.

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[698] Haskoning. (2011). Hinkley Point C Project - Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Section 7.2.45 Report prepared for EDF.

[699] Boubée, J.A.T., Dean, T.L., West, D.W. and Barrier, R.F.G. (1997). Avoidance of suspended sediment by the juvenile migratory stage of six New Zealand native fish species. New Zealand Journal of Marine and Freshwater Research, 31. pp. 61-69.

[700] Haskoning (2008). Bristol Deep Sea Container Terminal - Natural Fish Resources Including Migratory Species in the Severn Estuary. Response to Issues Raised by Consultees Following the Submission of the Harbour Revision Order and Environmental Statement. Royal Haskoning.

Summary of changes in turbidity, suspended sediment and siltation assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
Sea wall construction FDC	No
Combwich Wharf development FDC	No
HPC Construction discharges	No
Jetty construction	No
Construction of cooling water infrastructure	No
Bristol deep sea container terminal	No
EA Steart development	No
Bristol Ports compensatory habitat at Steart	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of combined impacts of changes in turbidity, suspended sediment and siltation related to migratory fish and fish assemblage.

Migratory fish of the Severn Estuary are highly adapted to high suspended sediment content, and the same applies for the tidal River Parrett, which is naturally turbid. Some localised in combination impacts may occur at each of these developments, but they will not be significant and will not cause an adverse effect on the migratory fish and fish assemblage of the Severn Estuary SAC and Ramsar.

6.10.7 Physical damage, habitat loss

Conservation objective (see section 1.5.1)

- *The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.*

Natural England & Countryside Council for Wales, 2009

Environment Agency consents that could have an impact in terms of physical damage and habitat loss include the following:

- Sea wall construction FDC
- Combwich Wharf development FDC

Which could act in combination with each other and the following other permissions, plans or projects:

- Jetty construction
- Construction of cooling water infrastructure
- Bristol deep sea container terminal
- EA Steart development
- Bristol Ports compensatory habitat at Steart

Sea wall construction FDC, jetty construction and construction of cooling water infrastructure

During the lifetime of the HPC project, the estuaries feature would be potentially affected in response to the construction of the temporary jetty, sea wall and cooling water infrastructure through loss and disturbance. Disturbance to habitats would occur during the construction of the jetty and the sea wall (such as disturbance to sub-tidal habitat due to dredging of the berth for the temporary jetty). Together, this would potentially result in a cumulative habitat disturbance of less than 37,200m^2 or substantially less than 0.01% of the estuaries feature (Haskoning, 2011)[701].

These elements of work occur across three habitat zones and communities: supratidal, inter-tidal, and sub-tidal, and thus affect different estuarine communities and thus different fish. The communities are common and in some cases support limited estuarine habitat communities (such as the supratidal areas). Additionally, some disturbance would be temporary (for six months) and may not coincide, as the majority of the jetty construction is programmed for completion prior to commencement of the sea wall construction.

It is stated within the report to inform the HRA (Haskoning, 2011) that medium-term habitat loss due to the presence of the jetty and sea wall would combine with the disturbance and loss of habitat due to construction of the cooling water infrastructure. For approximately six years, up to 10,120m^2 (or <0.01%) of the estuaries feature would be affected both by loss and by disturbance. Scouring in relation to the permanent cooling water infrastructure would combine with the loss of sub-tidal habitat associated with the temporary jetty berthing pocket to result in cumulative loss or disturbance to localised areas of sub-tidal estuarine habitat communities for the duration of the operational phase of the temporary jetty, which would be substantially less than 0.01% of the estuaries feature and thus fish habitat. The combined in combination effects are therefore thought to be negligible.

EA Steart development and the Bristol Port Steart development

Whilst some short-term loss of inter-tidal habitat may occur around each of the breach areas at both sites, there will be a substantive gain in inter-tidal habitat (including saltmarsh habitat) which will benefit a variety of fish, including twaite shad and bass as they are known to use such areas as a fish nursery. The in combination effect will thus be beneficial rather than negative.

Bristol deep sea container terminal

During the Habitats Regulations assessment for the Bristol Port, it was concluded that there was an adverse effect on the intertidal mudflats and sandflats feature due to a combination of direct habitat loss and short to medium term functional change in the intertidal mudflats in the vicinity of the Avonmouth Site. The loss of habitat is however being compensated for under the Bristol Port Steart project and as stated above the effects will be beneficial and will not be considered in combination.

[701] Royal Haskoning. (2011). Hinkley Point C Project Report to inform the Habitats Regulations Assessment (HRA) Final copy. Doc. Ref: 3.16. October 2011. Report prepared for EDF.

Summary of physical damage & habitat loss assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
Sea wall construction FDC	No
Combwich Wharf development FDC	No
Jetty construction	No
Construction of cooling water infrastructure	No
Bristol deep sea container terminal	No
EA Steart development	No
Bristol Ports compensatory habitat at Steart	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of combined impacts from physical damage and habitat loss related to migratory fish and fish assemblage.

It can therefore be concluded that the in combination effects of physical damage and habitat loss at HPC along with other permissions, plans and projects will not cause an adverse effect on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

6.10.8 Competition with non-native species

Conservation objectives (see Section 1.5.1)

- *The size of the migratory fish and fish assemblage populations in the Severn Estuary and the rivers which drain into it, are at least maintained and are at a level that is sustainable in the long term;*
- *The abundance of prey species forming the migratory fish and fish assemblage food resource within the estuary is maintained.*

Natural England & Countryside Council for Wales, 2009

Hinkley Point C (HPC) has the potential to have in combination effects in terms of Competition with non-native species with the following other permissions plans and projects (PPP):

- Hinkley Point B (HPB) power station thermal discharge
- Bristol Port - Bristol Deep Sea Container Terminal

Continued operation of HPB
The continued operation of HPB together with HPC may increase the risk of non-native (exotic) species establishing themselves around the Hinkey point and Stert Flats area due to the enlarged thermal footprint.

The thermal tolerances of many indigenous species are not understood well enough to predict how much a change in the thermal regime will affect them (Smith, 1995)[702]. Most importantly, little is known about the advective mechanisms involved in the establishment of exotic species and replacement faunas (Langford *et al.*, 1998)[703].

[702] Smith, J., (1995). Exotic marine organisms in the Milford Haven waterway: the potential for invasion. Field Studies Council. FSC/OPRU/12/95.
[703] Langford, T.E., Hawkins, S.J., Bray, S., Hill, C., Wells, N., Yang, Z. (1998). Pembroke Power Station: Impact of cooling water discharge on the marine biology of Milford Haven. Countryside Council for Wales Science Report 302. No. UC285.

As discussed within the alone section (2.6.5(e)), any changes to species diversity will be difficult to predict, especially since the Severn Estuary is highly diverse with many potential non-native species already present. Furthermore, diversity is likely to gradually change naturally with the effects of climate change and other environmental variables.

Bristol Deep Sea Container Terminal

There is a potential for the current Bristol Port Docks and new Bristol Deep Sea Container Terminal (BDSCT) to introduce non-native species into the Severn Estuary through the exchange of ballast water by large container ships. Ships use ballast water to provide stability and manoeuvrability during a voyage. Water is taken on at one port when cargo is unloaded and usually discharged at another port when the ship receives cargo. Because organisms ranging in size from viruses to twelve inch fish living in the surrounding water or sediments are taken on board with ballast water, there is a potential for the introduction of non-native organisms called bio-invaders[704]. These bio-invaders, whether fish or planktonic organisms, could be encouraged to thrive in areas potentially affected by changes to the thermal regime around HPC, particularly if the organisms are from warmer waters.

Although an International protocol (Ballast Water Convention) exists along with local arrangements, The Bristol Port Company (TBPC) does not currently undertake any specific measures to control ballast water exchange, only in so far as minimising contamination via discharge of dirty ballast water (TBPC, 2010)[705]. However, according to TBPC (2010), the majority of vessels unload at the port and, therefore, intake ballast water. There is only occasional discharge of ballast water in the port, as only around 10% of vessels arriving at Avonmouth and Portbury Docks load cargo. Many modern vessels, such as container ships, do not need to discharge ballast water, but instead are able to transfer ballast between separate tanks to achieve the stability they require. Although it is not clear what the arrangements will be for the new port, it is likely to be similar to the current port, in that its main use will be for unloading vessels rather than loading.

The current and proposed port at Bristol is situated approximately 45 km from the proposed HPC and whilst the possibility of non-native organisms finding their way down to Hinkley Point exists, it is unlikely that many different populations will colonise to the point of where the migratory fish and fish assemblage are significantly affected.

This is supported by Smith (1995), who reviewed the potential for exotic species to invade and establish themselves in Milford Haven (Pembrokeshire, South Wales) and summarised the mechanisms through which invasion can occur. The overall conclusion was that although several exotic species had invaded the Haven there was little evidence of wider distribution away from the original site of introduction.

Conclusion

It is therefore concluded that the changes to the thermal regime due to the cooling water discharge from HPC together with HPB and in combination with the BDSCT will not have a significant effect on the migratory fish and fish assemblage features from the competition of non-native species, and will not have an adverse effect on site integrity.

[704] Marine Bio-invasions Fact sheet – Ballast Water Treatment Options. Sea Grant.
[705] The Bristol Port Company (2010). Activity sheet - Ballast Water. www.bristolport.co.uk

6.10.9 Entrainment and impingement

Conservation objectives (see section 1.5.1)

- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded*
- *The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.*
- *the abundance of prey species forming the principle food resources for the migratory fish and assemblage species within the estuary, in particular at the salt wedge, is maintained.*

Natural England & Countryside Council for Wales, 2009

HPC has the potential to have in combination impacts in terms of impingement and entrainment with the following other plans and projects:

- Continued operation of Hinkley Point B (HPB) water abstraction
- Continued operation of the current Oldbury (Oldbury A) water abstraction
- Continued operation of Aberthaw Coal-fired Power Station water abstraction
- Development of a new nuclear power station at Oldbury, Gloucestershire (Oldbury B) water abstraction
- Bristol Deep Sea Container Terminal operation of dredger

Continued operation of HPB
It is likely that EDF will extend the operation of HPB beyond the planned closure date of 2016, to approximately 2023 (see table 6.10.7) . Current construction plans for HPC envisage a staged operation with the first reactor operational in 2018, followed by the second reactor in 2020.

- Present – 2017: HPB impact alone (33.7 cumecs).
- 2018 – 2020: HPB plus one HPC reactor: Approximately 1.5 times that of HPB (33.7 m^3/sec + ~65 m^3/sec).
- 2020 – 2023: HPB plus HPC at full operational power: Approximately up to 80% that of HPB.
- 2023 onwards: Similar to or less than HPB.

Table 6.10.7. timeline for HPB and HPC

PPP	2012 - 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
HPC abstraction		65 m^3/sec		125 m^3/sec							⇨
HPB abstraction	< 33.7 m^3/sec							Decommissioning at a reduced volume			⇨

Table 6.10.8 – Predicted annual in combination impacts of HPB plus HPC on population / fisheries from combined impingement and entrainment data

Species	HPC estimated annual impact with EAV, AFD/low velocity intake and FRR		HPB estimated annual impact numbers (EAV)	HPB plus HPC annual impact		Change over HPB (HPB plus HPC at 100%)	Change over HPB (HPC alone)	Comparable data on population estimates in the Severn Estuary / Bristol Channel (Spawning Stock Biomass (SSB) & local fishery (lf))		Percentage of population estimate HPB plus HPC		
	No. of fish	**(t)**	**No. of fish**	**No. of fish**	**(t)**	**(%)**	**(%)**	**Local fishery (t)**	**SSB (t) or fish numbers**	**% tage of Local fishery (%)(t)**	**%tage of SSB (%)(t)**	**%tage of Populat i-on (%)**
Sprat	405,702	3.16	936,386	1,342,088	7.3	43.3	-57.0	0.19	N/A	**2632**	**N/A**	
Whiting	64,818	11.50	79,253	144,071	14	81.8	-18.0	33.5	1,724	**41.8**	**0.8**	
Dover sole	5,448	1.24	8,559	14,007	1.95	63.7	-36.0	263	3,240	**0.74**	**0.06**	
Cod	527*	2.30	638	1,165	5.1	82.6	-17.0	25.2	975	**20.2**	**0.52**	
Herring	2,240	0.28	12,570	14,810	1.57	17.8	-82.0	119.4		**1.3**	**N/A**	
Plaice	83	0.04	129	212	0.06	64.3	-36.0	84	952	**0.07**	**0.01**	
Blue whiting	36	0.01	46	82	0.01	78.3	-22.0	37,900	5,360,000	**0.00**	**0.00**	
Eel	261	0.08	351	612	0.1	74.4	-26.0	26	133.4	**0.39**	**0.08**	
Twaite shad	273	Not available	646	919		42.3	-58.0		100,000			**0.92**
Allis shad	8	Not available	22	30		36.4	-63.0		100,000			**0.03**
Sea lamprey	41	Not available	42	83		97.6	-3.0		15,269			**0.54**
River lamprey	16	Not available	18	34		88.9	-9.0		116,109			**0.03**
Salmon	0	Not available	0	0		0.0	0.0		0			**0.00**
Sea trout	0	Not available	0	0		0.0	0.0		0			**0.00**

* recalculated figures from 2004-2008 data

The estimated in combination impacts of HPB and HPC on fish population and fisheries for a few selected species is presented in Table 6.10.8.

Migratory fish species

The results from table 6.10.8 suggest that for all of the designated migratory fish species less than 1% of each population is predicted to be affected by the combined effects of impingement and entrainment at HPC in combination with HPB. It should be noted that no eggs or juvenile species are thought to be impacted by entrainment. Twaite shad (*Alosa fallax*) is the species predicted to be most affected by the combined HPC and HPB abstractions and with a potential 0.92% of the population affected this figure could be considered close enough to 1% to cause concern.

In BEEMS Technical Report TR148[706], predictions of shad impingement rates were provided for HPB and for HPC (with and without impingement mitigation measures). Because of a lack of information on the life cycle of the two species at the time of writing the report, an assumption had to be made that the catches of juvenile fish were equivalent to those of mature adults, i.e. the calculation took no account of natural mortality and assumed that the number of equivalent adults that would be expected to survive from the loss of a juvenile fish was 1. This was an overly conservative assumption because neither species spawns until they are about 4–5 years old, and they suffer considerable natural mortality before then.

BEEMS Scientific Position Paper SPP071 (2012)[707] reanalysed the impact of predicted shad impingement on the adult population, in the case of *A. fallax,* using life-cycle information obtained from literature. The expected catches of *A. fallax* were recalculated using approximate estimates of natural mortality that were calculated from the small HPB impingement dataset and by comparison with other larger UK populations. The impact of the specific impingement mitigation measures proposed for HPC were also considered in more depth.

After correcting the predicted impingement losses at HPC for natural mortality before the juvenile fish at risk from impingement at Hinkley Point enter the adult population, revised impingement predictions are shown in table 6.10.9 below.

Table 6.10.9. Predicted annual impingement of equivalent adult A. fallax with and without adjustments for natural mortality (calculated at age 3 for compatibility with the population estimate). AFD = Acoustic Fish Deterrent. Taken from SPP071.

Site	**Neglecting natural mortality**		**Including natural mortality**	
	Numbers	**Percentage of population estimate**	**Numbers**	**Percentage of population estimate**
HPB	646	0.35%	8	0.004%
HPC (no AFD)	2,276	1.24%	28	0.015%
HPC (with AFD)	273	0.15%* 0.27%**	3	0.002% 0.003%
HPB + HPC (with AFD			11	0.006%* 0.011%**

* River Severn River Basin District (RBD) population estimate of 184,000
** Joint Nature Conservation Committee (JNCC) population estimate of 100,000

The designated migratory fish species are not thought to be affected by entrainment, therefore 0.006% or worst case 0.011% represents an insignificant percentage of the population potentially affected by the combined effects of HPC and HPB.

706 BEEMS Technical Report 148 (TR148 Ed.2): A synthesis of impingement and entrainment predictions for NNB at Hinkley Point. Report for EDF (Cefas). March 2011
707 BEEMS Scientific Position Paper SPP071 (2012). Shad (*Alosa fallax* and *Alosa alosa*) impingement predictions for HPC. Cefas report for EDF.

Conclusion of effects of impingement and entrainment on cod with HPB and HPC operating together

On the basis of the information above we can conclude that the combined effects of HPC together with HPC will not have an adverse effect on the designated migratory fish as a result of impingement and entrainment.

Fish Assemblage

The results from table 6.10.8 suggest that sprat, whiting and cod are likely to be the only populations impacted, however the extent of impact is difficult to quantify. Sprat was also the only species which showed that the combined impacts of entrainment and impingement could be magnified.

Sprat (*Sprattus sprattus*)

The impingement from HPC alone concluded that although numbers of sprat impinged appeared high, the current sprat population has remained relatively stable in the past 20 years, despite the presence of HPB, however, together with the results from the combined assessment of impingement plus entrainment, for both HPB and HPC the numbers impacted could be significant. The results suggest that the number of sprat impinged would be 26 times that of the local fishery, although it is noted that the local fishery is currently very small. The loss of eggs and larvae from entrainment of both HPB and HPC could magnify this impact.

While sprat may live for up to a total of six years, at the end of which time the total length can exceed 150 mm, the fishery in British waters is based primarily on the second, third and fourth year classes (Robertson, 1938[708]; De Silva, 1973[709]). Historically, the sprat was a major contributor to the fishery of the Bristol Channel and Severn Estuary (Matthews, 1933[710]; Lloyd, 1941[711]). Although this fishery has declined during recent decades, the sprat has remained an important component of the teleost fauna of the region (Potter & Claridge, 1985)[712]. This is illustrated by the observation that *S. sprattus* was by far the most abundant of all teleosts in plankton samples taken throughout the Bristol Channel between the spring and autumn of 1974 (Russell, 1980)[713] and in the sampling carried out for HPC in 2008 – 2010 (TR083a)[714].

Potter *et al.,* (2001) studied the fish collected at Oldbury Power Station cooling water intake screens, North of Hinkley Point along the Severn Estuary in the 1970s and 1990s to look at long-term changes in abundance of species. The annual catches demonstrated that the abundance of fish was far greater in the 1990s than 1970s, with the annual catches of sprat in 1996/98 being greater than the maximum annual catch recorded in 1972/77. This is thought to be due to a marked increase in water quality of the Severn Estuary between these decades.

Henderson *et al.,* (2011) reported on a long-term study of fish and the crustacean community of the Bristol Channel, which showed that the permanently present species showed notable

[708] Robertson, J.A. (1938) The sprat and sprat fishery of England. Fishery Investigations, Ministry of Agriculture, Fisheries and Food (ser.2), 16, 1-103.

[709] De Silva, S.S. (1973) Aspects of the reproductive biology of the sprat, *Sprattus sprattus* (L.) in inshore waters of the west coast of Scotland. Journal of Fish Biology. Volume 5, Issue 6, pages 689–705.

[710] Matthews, L.H. (1933). The seafish and fisheries of the Bristol district. Proceedings of the Bristol Naturalists' Society 7, 442–462.

[711] Lloyd, A.J. (1941). Studies on the biology of the Bristol Channel. V. The marine fish fauna of the southern shores of the Bristol Channel. Proceedings of the Bristol Naturalists' Society 9, 202–230.

[712] Potter, I.C, Claridge, P.N.(1985). Seasonal Catches, Size and Meristic Data for Sprat, *Sprattus Sprattus*, in the Severn Estuary. Journal of the Marine Biological Association of the United Kingdom. 65:pp 667-675.

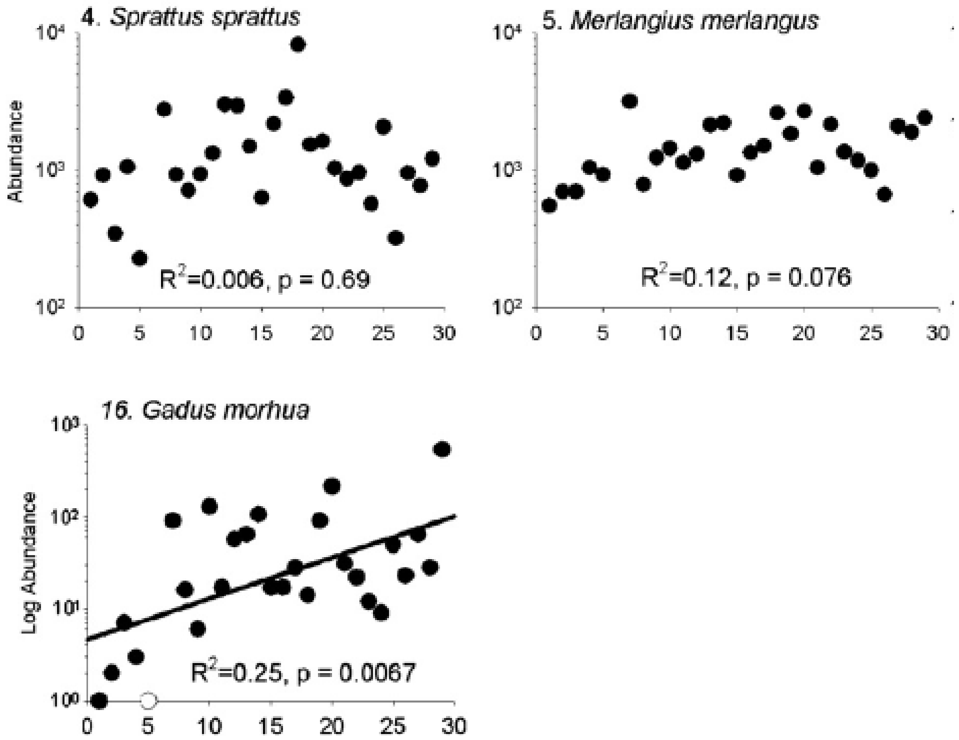
[713] Russell, F.S. (1980) On the distribution of post-larval fish in the Bristol Channel. Bulletin of Marine Ecology, 8, 283-290.

[714] BEEMS TR083a. Hinkley Point nearshore communities: plankton surveys 2010. EDF BEEMS (Cefas) Technical Report No. 083a, November 2010.

stability over the years. The results also suggested that the core species assemblage had proven to be highly resilient to change and even though these species change position in the species ranking, the community maintained the same pattern of rank abundance. However, it was noted that the dominant fish species in terms of number and biomass - sprat, whiting and sand gobies - showed no trend over the years, and that it is the species lower down the rank order which show a greater tendency to exponential change. This suggests that the dominant forms are more likely to be constrained by resources and under density-dependent regulation. An alternative possibility is that their populations are continuously supplied with recruits from large populations in the Celtic and Irish Seas (Henderson *et al.,* 2006).

Whiting (*Merlangius merlangus*)
The impingement from HPC alone concluded that although numbers impinged appeared high (see section 2.6.3.5), data from 1980s to present day suggested that whiting shows a remarkable consistency in abundance from year to year with a very stable population despite any pressures from the current HPB (see Figure 6.10.10).

Figure 6.10.10. - The temporal variation in annual log abundance for sprat (sprattus sprattus), whiting (Merlangius merlangus) and cod (Gadus morhua) caught at Hinkley Point between 1981 and 2009 inclusive. A curve was fitted to each time series by linear regression and the coefficient of determination (r2) and the significance of each fitted curve is shown on plot. Only significant regression curves have been plotted on the graphs. ***Y axis = Years since 1980.*** *Taken from Henderson et al, (2011)*[715]



However, in combination impacts from 2018 – 2023 has the potential to put pressure on the whiting populations within the estuary.

The gadoids, and whiting in particular, make an extremely important contribution to the fish fauna of the Severn Estuary. The whiting population in the Bristol Channel was found to comprise 0-group juveniles which only remain in the region for about 10 months before moving offshore (Henderson & Holmes, 1989)[716]. The whiting thus depend on the estuary as

[715] Henderson, P.A, Seaby, R.M.H., Somes, J.R. (2011). Community level response to climate change: The long-term study of the fish and crustacean community of the Bristol Channel. Journal of Experimental Marine Biology & Ecology. 400; 78-89.
[716] Henderson, P.A., Holmes, R.H.A. (1989). Whiting migration in the Bristol Channel: a predator-prey relationship. Journal of Fish Biology. Volume 34, Issue 3, pages 409–416.

a nursery in the early years of life and this fact is critical to the management of whiting which are an important commercial fish in Europe and one of the principal items of inshore boat fisheries (Bird, 2008).

Like sprat, whiting was also a species to show a remarkable increase in abundance in the long-term studies reported by Potter *et al.,* (2001). Henderson and Holmes (1989) noted that the distribution and abundance of whiting and the common shrimp, (*Crangon crangon)* was found to be clearly related. The authors hypothesised that whiting depended on the common shrimp because it is the only abundant prey species in the winter, however both the whiting and shrimp populations were found to not follow any long-term trend in numbers. It is suggested that the whiting population is stable because it is constrained by shrimp abundance which is, in turn, limited by physical constraints.

Table 6.10.11 - ICES area VII quota for 2012 for four species of white fish compared with the combined HPC and HPB impinged fish weight. Tonnes in live weight (t).

Species	ICES VII UK total annual quota (t) [717]	HPB plus HPC (t)	Area VII stocks	% of annual quota from ICES VIIb-d
Cod	846	5.1	VIIB-K excl.D	0.6
Whiting	2276	14	VIIB-K	0.62
Sole	336	1.95	VIIFG	0.58
Plaice	49	0.06	VIIFG	0.1

As discussed under the entrainment assessment (section 2.6.4), the evidence from the HPB impingement surveys is that the production/ biomass ratio of *C. crangon* has increased over the past 25 years (Henderson & Bird, 2010)[718], however average abundance has increased because recruitment has increased with average seawater temperature. This has resulted in a clear example of density-dependent control as the mortality rate of recruits over their first winter increases with recruitment (Henderson *et al.*, 2006)[719]. It envisaged that increased *C. crangon* abundance is associated with increased predator (whiting) and competitor abundance, and it is thought that a fixed physical constraint, such as the amount of available habitat, is setting an upper limit on the adult population. Any reductions in the population size due to entrainment will be rapidly filled by new recruits. Since the whiting population will be dictated by prey availability (in the case of *C. crangon* appears to be such a prolific and stable prey species with a high natural productivity) it is likely that whiting will remain stable despite any pressures from HPB or HPC.

Furthermore, the International Council for the Exploration of Seas (ICES) sector allocations for area VII, with the Bristol Channel being ICES VIIf [720], have been studied in detail for whiting and other species listed in Table 6.10.11. The combined predicted tonnage of fish loss from HPB and HPC equates to <1% of the 2012 quotas for each listed species, meaning that both power stations together appear to only make a tiny dent in the allowable catch.

Conclusion on sprat and whiting

[717] UK total annual quota taken from White fish statistics database: Total landings (tonnes live weight) in 2012 for area VII. Data supplied by Marine Management Organisation. May 2012.
[718] Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.
[719] Henderson, P.A, Seaby, R.M., Somes, J.R. (2006) A 25-year study of climatic and density-dependent population regulation of common shrimp *Crangon crangon* (Crustacea: Caridea) in the Bristol Channel. J. Mar. Biol. Ass. U.K. 86, 287^298
[720] ICES VII = number division f = area associated to the Bristol Channel and the north Devon and Cornwall coast. http://www.ices.dk/indexfla.asp

If density-dependant control is acting on both sprat and whiting, with populations continuously supplied with recruits from the large populations in the Celtic and Irish seas, then it is highly unlikely that impacts from HPB and HPC will significantly impact on the sprat or whiting populations within the Bristol Channel. On the contrary, those species that are exposed to entrapment that survive by either freeing themselves of the intake velocity or that survive through the fish recovery and return system or entrainment process are likely to be better selected for a stronger gene pool to breed with new recruits from the Celtic and Irish seas.

The correlations reported by Henderson *et al.,* (2011) between temperature, the North Atlantic Oscillations (NAO) and the abundance of individual fish species are a product of a causal chain in which physical conditions change phytoplankton productivity, which then alters the zooplankton community and in turn affects larval fish abundance. Abstraction impacts from the proposed HPC (whether alone or in combination) thus play a minor role in the overall picture of defining the population structure of fish in general within the Severn Estuary and Bristol Channel. Although it is accepted that some species impacts from HPC and or HPB may not necessarily go un-noticed, it is clear that the populations of both species exist beyond the zone of impact for both HPB intake and the proposed intake at HPC and any thus populations are likely to recover.

Conclusion of impingement and entrainment effects on sprat and whiting with HPB and HPC operating together

On the basis of the information above we can conclude that the combined effects of HPC together with HPB will not have an adverse effect on both whiting and sprat as a result of impingement and entrainment.

Cod (*Gadus morhua*)
Cod has been in gradual decline across Europe and a significant number of fish stocks are currently in a poor state. This is due to a complex mix of over-fishing, high natural mortality (low numbers of fish surviving to a size where they are taken commercially) and other environmental factors (Defra, 2012)[721]. There are serious problems with EU cod stocks and measures have been put in place to halt and ultimately reverse this decline. These apply in the Irish Sea, North Sea, Eastern Channel and the West of Scotland. The fisheries departments of the Marine Management Organisation (MMO), Marine Scotland (MS), Department of Agriculture and Rural Development (DARD) and the Welsh Assembly Government (WAG) undertake monitoring and control activities within British fishery limits and throughout the sea areas covered by the multiannual plan for cod (Regulation (EC) 1342/2008). To ensure the fisheries are accurately monitored and control resources are deployed effectively, the UK and other relevant member states compile an annual National control action programme in respect of cod in the North Sea, Eastern Channel, Irish Sea and West of Scotland (MMO, 2008)[722]. The annual numbers of cod impinged in combination from HPC and HPB equate to 1,165, which is just over 3 cod a day. In comparison to the local fishery, it appears high (20.2%), however the numbers appear low compared to both the spawning stock biomass (0.52%) and the ICES sector allocations for the area (see Table 6.10.10) being <1% of the quota, both being insignificant. Furthermore, Figure 6.10.9 shows that the abundance of cod in the Bristol Channel has increased over the past 30 years, despite pressures from HPB.

Changes in estuarine systems are particularly important, as they are nurseries for coastal fish, including many of the key commercial species of temperate waters. The discrete change in the relative abundance of the permanent members of the community in the mid to late

[721] Defra (2012): http://www.defra.gov.uk/environment/marine/cfp/fish-stocks/
[722] Marine Management Organisation (MMO). (2008). The United Kingdom National Control Action Programme for Cod Stocks of the North Sea, Eastern Channel, Irish Sea and West of Scotland 2011.

1980s coincided with changes in the plankton of the northeast Atlantic (Henderson *et al*., 2011). Henderson et al (2011) noted that the observed change in the Bristol Channel fish community occurred contemporaneously with this "regime shift" (Beaugrand, 2004)[723] in the plankton. Beaugrand and Reid (2003)[724] also noted that changes in the phytoplankton are linked to large-scale changes in ocean productivity caused by climatic variables such as the NAO and surface seawater temperature. As stated above, this suggests that the correlations reported here between temperature, the NAO and the abundance of individual fish species are a product of a causal chain in which physical conditions change phytoplankton productivity, which then alters the zooplankton community, which in turn affects larval fish abundance. Beaugrand *et al.* (2003)[725] concluded that such a causal chain is a determinant of cod recruitment in the North Sea. Effects from both HPC and HPB are therefore not considered to be a significant to impact on the cod populations of the Bristol Channel.

Cod impingement impacts plus temperature

Although cod are thought to be a cold-adapted species, research conducted by Righton *et al.,* (2010)[726] to measure the thermal niche of cod, found that cod are an adaptable and tolerant species capable of surviving and growing in a wide range of temperate and marine climates. The total thermal niche ranged from 1.5 -19 ºC, although this range was narrower during the spawning season. The authors concluded that adult cod will be able to tolerate warming seas, but climate change will affect the earlier life stages. According to a Cefas report by Ellis *et al*. (2012)[727] there are no known cod spawning sites or known nursery grounds near to Hinkley Point, therefore temperature effects are unlikely to be of concern as covered in sections 2.6.3.5 and section 6.10.4 above. It is noted however that Ellis *et al*. (2012) concluded that more data was required for the inter-tidal areas around the Bristol Channel as the data was taken from a 1990 set.

Conclusion of effects of impingement and entrainment on cod with HPB and HPC operating together

On the basis of the information above we can conclude that the combined effects of HPC together with HPC will not have an adverse effect on cod as a result of impingement and entrainment.

Oldbury A decommissioning

During the Environment Agency Review Consents under Regulation 63 of the Conservation of Natural Habitats and Species Regulations 2010 (previously Regulation 50), the EA reviewed Oldbury A Abstraction Licence No. 18/54/020/S/234 against the SAC features for entrainment and impingement impacts.

Estimates were made on the numbers impinged using fish count data from Bird (2008)[728]. The data from 1996 – 1998 concluded that twaite shad made up 0.8% (mean of 729 individuals per year) of the total number of fish caught and River Lamprey made up 0.1% (mean of 109 individuals per year) of the fish caught. Sea Lamprey were rarely caught. See Table 6.10.12.

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[723] Beaugrand, G. (2004). The North Sea regime shift: evidence, causes, mechanisms and consequences. Prog. Oceanogr. 60, 245–262.

[724] Beaugrand, G., Reid, P.C. (2003). Long-term changes in phytoplankton, zooplankton and salmon related to climate. Glob. Change Biol. 9, 1–17.

[725] Beaugrand, G., Brander, K., Lindley, J.A., Souissi, S., Reid, P.C. (2003). Plankton effect on cod recruitment in the North Sea. Nature 426, 661–664.

[726] Righton, D.A., Andersen, K.H., Neat, F., Thorsteinsson, V., Steingrund, P., Sveding, H., Michalsen, K., Hinrichsen, H-H., Bendall, V., Neuenfeldt, S., Wright, P., Jonsson, G.H., Van der Kooij, J., Mosegaard, H., Hussy. K., Metcalf, J. (2010). Thermal niche of Atlantic cod Gadus morhua: limits, tolerance and optima. Marine Ecology Progress Series. V420 pg 1-14.

[727] Ellis, J.R., Milligan, S.P., L. Readdy, L., Taylor, N., and Brown, M.J. (2012). Spawning and nursery grounds of selected fish species in UK waters. Cefas Science Series - Technical Report 147. Cefas Lowestoft, 147: 56 pp.

[728] Bird, D.J. (2008) The Biology and Conservation of the Fish Assemblage of the Severn Estuary cSAC, for CCW.

Although the population size of twaite shad and river lamprey within the Severn Estuary is unknown, the JNCC species accounts for the twaite shad, roughly estimate the UK population to be approximately 100,000 fish (best guess)[729]. As the mean number of individual twaite shad caught in Oldbury power station intake was 729 then that accounted for 0.729% of the UK population. As that was <1% it was considered to be insignificant. However, the number did not include the young shad fry and eggs that are thought to be present in the upper estuary and lower River Severn that could be entrained through the screens and go un-noticed. Due to the uncertainty on whether shad could survive the entrainment process it was considered that impacts to shad could therefore be significant.

Table 6.10.12 -. Ranks, mean annual abundances and percentage contributions of the most abundant species of fish collected at Oldbury in the five years between July 1972 and June 1977 and between July 1996 and June 1998, and the proportional difference between the mean abundances in the former and latter periods. Taken from Bird (2008) and adapted from Potter et al (2001)[730].

Common name	1972/1977			1996/1998			Difference
	Rank	Mean	%	Rank	Mean	%	
Sand goby	1	8572	29.2	1	36129	37.7	+4.2
Whiting	2	8294	28.2	3	17714	18.5	+2.1
Flounder	3	2896	9.9	7	1899	2.0	-1.5
Bass	4	2156	7.3	2	22585	23.6	+10.5
Sea snail	5	1980	6.7	8	1466	1.5	-1.4
Poor cod	6	846	2.9	17	35	<0.1	-24.2
Thin-lipped mullet	7	779	2.7	6	2477	2.6	+3.2
Twaite shad	8	776	2.6	11	729	0.8	-1.1
European eel	9	737	2.5	10	949	1.0	+1.3
Herring	10	574	2.0	9	1444	1.5	+2.5
Sprat	11	360	1.2	4	5402	5.6	+15.0
3 spined stickleback	12	254	0.9	14	178	0.2	+1.4
River lamprey	13	191	0.7	16	109	0.1	-1.8
Bib	14	182	0.6	13	184	0.2	0
Common goby	15	149	0.5	15	159	0.2	+1.1
Norway pout	20	48	0.2	5	2944	3.1	+61.3
Dover sole	17	75	0.3	12	345	0.4	+4.6
Total (all species)		29366			95828		

Similarly, the mean number of river lamprey caught at Oldbury was 109 individuals, and whilst one may consider the amount of lamprey caught to be insignificant in comparison to the numbers of shad, it was noted that lamprey transformers pass through the intake screen on the main drum and were entrained through the cooling water system (Dr. D. Bird personal Observation), meaning that the recorded number for lamprey was likely to be an underestimate. With no evidence of whether lamprey transformers can survive the entrainment process and with insufficient information available to make a judgement on population sizes for river lamprey in the UK and therefore no comprehensive population size estimates available for this species[731] it was not possible to conclude 'no adverse effect'.

Although sea lamprey were rarely caught, it was considered possible that sea lamprey transformers may also be entrained along the abstraction intake of Oldbury and go unnoticed.

[729] Second Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2001 to December 2006 Conservation status assessment for : S1103: *Alosa fallax* - Twaite shad. http://www.jncc.gov.uk/article17

[730] Potter, I.C., Bird, D.J., Claridge, P.N., Clarke, K.R., Hyndes, G.A. & Newton, L.C. (2001) Fish fauna of the Severn Estuary. Are there long-term changes in abundance and species composition and are the recruitment patterns of the main marine species correlated? *Journal of Experimental Marine Biology and Ecology*, 258, 15-37.

[731] Second Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2001 to December 2006 Conservation status assessment for : S1099: *Lampetra fluviatilis* - River lamprey, http://www.jncc.gov.uk/article17

It was acknowledged that Oldbury A is due for closure (safety case and fuel availability limitations)[732] and the running time of the abstraction was set to decrease over time, however there was no legal agreement within the licence. Without a legal agreement within the licence to state a definite end date the EA could not conclude no adverse effect on the migratory fish features of the Severn Estuary SAC. Ramsar fish features were not included within the Review of Consents process and were therefore not assessed.

In consultation with Natural England and Magnox[733] it was agreed that the preferred way forward would be to vary the abstraction licence with phased time limits (downward variation), so that the impacts would reduce significantly within 4 steps and gradually reduce to zero. The agreed water usage over time is shown within Table 6.10.13 and Figure 6.10.13.5.

Table 6.10.13 - Agreed water requirements for Oldbury A cooling water abstraction

Step	Maximum abstraction per day	Number of pumps required	Required until	Reasoning
1	2.33×10^6 m^3 (27 $m^{3/sec}$) Based on 4 pumps and 2 reactors 24hr operation	4	31st July 2011	Required until shut down of R2 and initial cool-down period
2	1.30×10^6 m^3 (15 $m^{3/sec}$) Based on 3 pumps and 1 reactor 24hr operation	3	31st March 2013	Required until R1 shut down and for initial post trip cooling
3	1.21×10^6 m^3 (14 $m^{3/sec}$) Based on 2 pumps and 1 reactor 24hr operation	2	31st May 2015	Required during de-fuelling
4	0.61×10^6 m^3 (7 $m^{3/sec}$) Based on 1 pump and 1 reactor 24hr operation	1	31st December 2025	Water required for operational reasons other than cooling of the reactor. 24hr running of pumps required to prevent silting.

However, since this plan was agreed Oldbury A has prematurely closed as of March this year (2011), therefore Steps one and two of the reduction processes have already taken place with two pumps being turned off and the water abstraction reducing from $27m^3/s$ to $14m^3/s$. HPC is scheduled to begin operating in 2018, which means that Oldbury A will be at step 4 of the reduction process and abstracting at approximately $7m^3/s$, which is a reduction of three quarters of the original abstraction. We can therefore assume that any impacts will be reduced by this figure, as presented in Table 6.10.14.

- Present – 2017: HPB impact alone (33.7 cumecs) plus Oldbury A (27 cumecs) – no evidence of impacts on fish populations within the estuary.
- 2018 – 2020: HPB plus one HPC reactor: Approximately 1.5 times that of HPB + Oldbury A at 7 cumecs ($33.7\ m^3/s + \sim 65\ m^3/s + 7\ m^3/s$)
- 2020 – 2023: HPB plus HPC at full operational power: plus Oldbury at 7 cumecs
- 2021 onwards: Similar to or less than HPB plus similar to or less than Oldbury A

[732] Under the requirements the Nuclear Installations Act 1965 the standard licence conditions for a nuclear site licence require the operator to provide and maintain a valid safety case for the operation of all nuclear and nuclear related plant. The regulator for this act is the Nuclear Installations Inspectorate(NII), a branch of the HSE.
[733] Habitats Directive Severn Estuary (Oldbury/Magnox) meeting Thursday 6th August 2009. Meeting Minutes: SE Oldbury meeting Aug 09_Final

Figure – 6.10.13.5 - Timescales for reduced water abstraction at Oldbury A

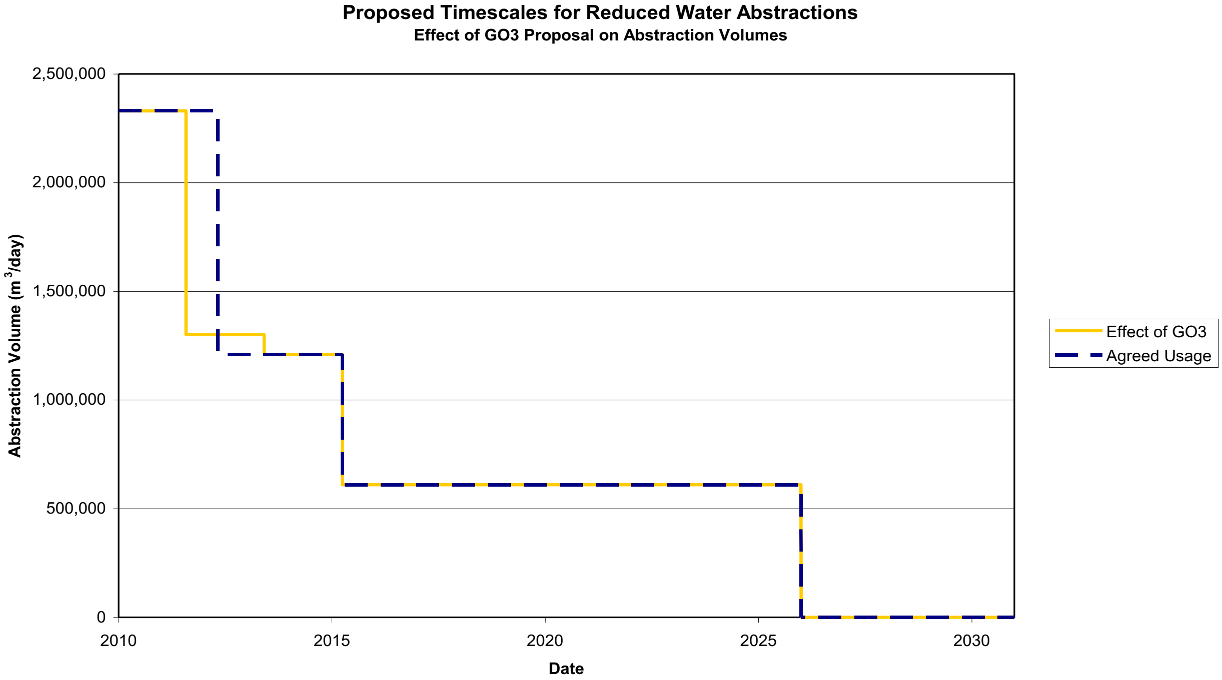


Table 6.10.14 - Mean Annual Abundance of Selected Species of Fish Collected at Oldbury in the five years between July 1972 and June 1977 and in the two years between July 1996 and June 1998 together with estimated numbers for future predictions in combination with HPB and HPC.

	Mean annual Number Impinged individuals at Oldbury A 1996/98	**Mean annual Calculated Number Impinged individuals at Oldbury A 2015 – 2025**	**Estimated annual HPB + HPC impinged individuals 2018 - 2021**	**Total cumulative impact impinged individuals 2018 - 2021**
Sand goby	36,129	9,032	-	-
Whiting	17,714	4,428	144,071	148,499
Flounder	1,899	475	-	-
Bass	22,585	5,646	-	-
Sea snail	1,466	367	-	-
Poor cod	35	9	-	-
Thin-lipped mullet	2,477	619	-	-
Twaite shad	729	182	919	1,101
European eel	949	237	612	849
Herring	1,444	361	14,810	15,171
Sprat	5,402	1,351	1,342,088	1,343,439
3 spined stickleback	178	45	-	-
River lamprey	109	27	34	61
Bib	184	46	-	-
Common goby	159	40	-	-
Norway pout	2,944	736		
Dover sole	345	86	14,007	14,093

Together with HPC and HPB for the period between 2018 and 2021 for those species where estimates are available, numbers are not significant. Furthermore, the period when most of the overlap will occur is actually only between 2020-2021, so it is highly likely that if any impact on the fish populations is caused during that one-year period then they will recover during the next few years.

Conclusion of cumulative, in combination effects of HPB, HPC and Oldbury A on migratory fish and fish assemblage.
It can therefore be concluded that the cumulative in combination effects of HPB, HPC and Oldbury A will not cause an adverse affect on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

Aberthaw Power Station
Aberthaw (coal-fired) power station is located to the west of Cardiff, in the Vale of Glamorgan (NGR: ST022622), on the north bank of the Bristol Channel. Aberthaw abstracts water for various operations including condenser cooling, and like HPB, does not have an abstraction licence to abstract water from the Bristol Channel.

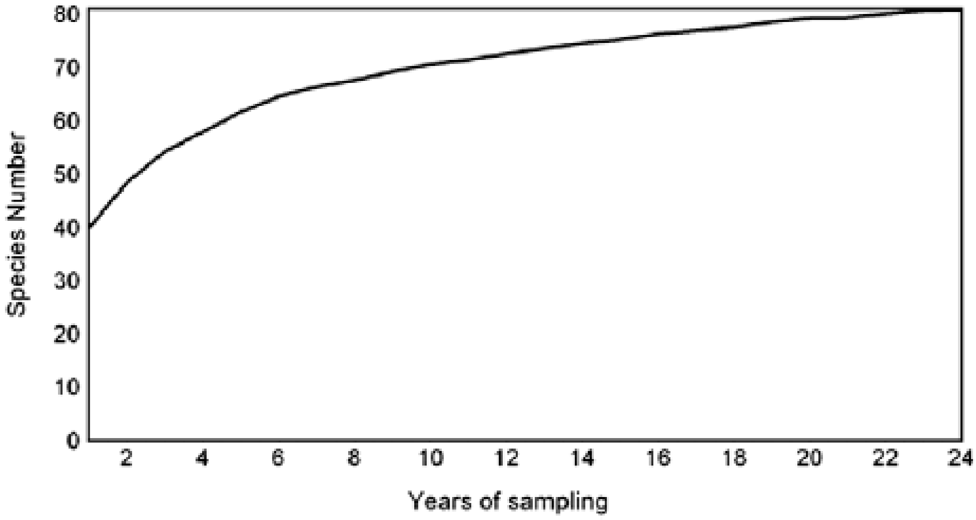
The average volume of water abstracted per day is 3,110,000 m^3 (~36 m^3/s), with the maximum volume being 4,320,000 m^3 (~50 m^3/s), which is a larger amount than the current HPB. The water is abstracted at a velocity of 0.32m/s (intake head 156m^2) approximately 650km off-shore via a tunnel, and the large abstraction head has bars across to prevent debris entering the tunnel. The Aberthaw intake has a pressure filter as the primary filter on the downstream side of the main cooling water (CW) pumps. This design was known as the Deptford strainer and consists of an internal rotating filter element that was back-flushed using a portion of CW flow at the discharge pressure generated by the main CW pumps (Ref: cooling water guide). There are no fish protection measures in place, however there is no history of fish being impinged on the mesh just before the water pumps. There is however, evidence that fish are living in the tunnels, but with no confirmation of numbers. Although no information on fish entrainment / impingement issues exist, it should be assumed that fish are being impinged and entrained.

In section 2.6.4b of the alone assessment, the general fish populations of the Severn Estuary were considered using a paper by Henderson & Bird (2010)[734]. For a complete picture of the impacts via impingement, the top 18 fish impinged during the BEEMS comprehensive impingement monitoring programme (CIMP), 2009-2010 were assessed against their annual abundance derived from data collected between 1981 and 2008 during regular monthly sampling at HPB (Pisces Conservation Ltd.) The results suggested that all of the fish species studied (with the exception of sea snail and dab), appeared to have had a stable population over the past 25 years in Bridgwater Bay, despite the presence of the HPB and Aberthaw abstractions. However, it was noted that there was considerable inter-annual variations in abundance over the years, which can be associated to temperature and salinity changes and in some cases the North Atlantic Oscillation Index (NAOI) (Henderson *et al.*, 2011)[735].

Although not part of the top 18 species impinged, eel, shads, lamprey and salmon show a long-term gradual decline in abundance from 1981 – 2008 and it is thought that the declines are related to other factors including the introduction of parasites and obstructions to migration in the rivers (Henderson & Bird, 2010), rather than impacts from power station cooling water intakes.

[734] Henderson, P.A., Bird, D.J. (2010). Fish and macro-crustacean communities and their dynamics in the Severn Estuary. Marine Pollution Bulletin 61, 100-114.
[735] Henderson, P.A, Seaby, R.M.H., Somes, J.R. (2011). Community level response to climate change: The long-term study of the fish and crustacean community of the Bristol Channel. Journal of Experimental Marine Biology & Ecology. 400; 78-89.

Figure 6.10.15. The smoothed fish species accumulation curve for Hinkley Point, Bridgwater Bay. The data set records the species number for each year between 1981 and 2008 inclusive. For each year, 12 monthly samples are taken. Data for 1986 have been excluded because only seven samples were obtained. The curve has been smoothed by finding the average of 20 randomisations of sample order. Taken from Henderson & Bird, (2010).



Despite the potential impact of water-intake screens on fish mortality, between the 1970s and 1990s, the abundance of many species of fish has increased (see figure 6.10.15) at Hinkley Point (Henderson & Bird, 2010). Where the data indicates some population changes, these would appear to have been the consequence of a change in species abundance across the northeast Atlantic broadly rather than losses to impingement or entrainment at the various power stations (TR148).

It can therefore be concluded that the cumulative in combination effects of HPB, HPC, Oldbury A and Aberthaw will not cause an adverse affect on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

Oldbury B - Development of a new nuclear power station at Oldbury, Gloucestershire

If the application for Oldbury B is successful then the predicted start up of operations is around 2023-2025. No information is currently available on the potential effects of the proposed new nuclear power station at Oldbury with regard to entrainment and impingement impacts. However, the scoping report for the proposed new nuclear power station at Oldbury indicates that the new station would abstract less water from and discharge less water back to the Severn Estuary than the existing Magnox station. This suggests that the potential impingement of fish could be less than that recorded for the existing station. There is also the potential that behavioural deterrents and a return system could be employed at the new Oldbury station so that in all likelihood potential impingement and entrainment losses could be further reduced.

Unlike at Hinkley Point there is no long-term monitoring of the entrainment of fish on the water intake screens at Oldbury. The available data for the existing Oldbury covers two short periods of five years in the 1970s and two years in the 1990s.

Analysis of this data has determined whether there have been any long-term changes in the abundance and composition of the fish fauna at Oldbury (Potter *et al.,* 2001)[736]. Research found that between the 1970s and 1990s, the abundance of many species of fish increased at Oldbury, possibly due to the effects of increasing water temperature related to climate change. Available data from these monitoring periods for a few selected fish of conservation interest is provided in table 6.10.16.

Table 6.10.16.- Mean Annual Abundance of Selected Species of Fish Collected at Oldbury in the five years between July 1972 and June 1977 and in the two years between July 1996 and June 1998 (The Annual Abundances Represent the Sum of the Number of Fish in four 24-h Samples per Month after those Numbers had been Adjusted to the Same Sampling Effort for the Two Periods)

Species	**Mean annual abundance**	
	1972-1977	**1996-1998**
Twaite shad	776	729
Eel	737	949
River lamprey	191	109

It is justifiable to conclude that the total losses of fish in a future where both HPC and a new station at Oldbury were operating would be less than the past and current situation with HPB and Oldbury A operating together, as there is unlikely to be any overlap in operation of Oldbury A and B. There is a potential for impact, however it is not possible to quantify at this point in time until more detailed information is available. Information will be added to the appropriate assessment as it becomes available.

The general conclusion is that there is more likely to be a decrease in pressure on the populations of conservation importance with the shutdown of the existing stations at Hinkley and Oldbury and the introduction of new stations for which measures to avoid and minimise potential entrainment and impingement losses will be incorporated.

Conclusion of effects of cumulative, in combination effects of a new power station at Oldbury with other plans and projects on migratory fish and fish assemblage.
It can therefore be concluded that, on the basis of best available data, the cumulative in combination effects of a new power station at Oldbury along with other permissions, plans and projects will not cause an adverse affect on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

[736] Potter, I.C, Bird, D.J, Claridge, P.N, Clarke, K.R., Hyndes, G.A., Newton, L.C. (2001) Fish fauna of the Severn Estuary. Are there long-term changes in abundance and species composition and are the recruitment patterns of the main marine species correlated? Journal of Experimental Marine Biology and Ecology. 258: 15-37.

Bristol deep sea container terminal (BDSCT) dredging

The effect of dredging induced hydraulic entrainment has been identified as a source of concern with regards to fish. Entrainment by suction dredgers will typically result in death for fish of all sizes and stages of development for a variety of reasons including burial in the sediment, impact damage, pressure change and abrasion. Few studies have comprehensively addressed fish entrainment by dredgers (Ault *et al.,* 1998)[737].

Both demersal and pelagic fish eggs and larvae are susceptible to entrainment in suction dredges as they are unable to escape from the flow in the vicinity of the suction pipe (McNair & Banks, 1986[738]).

The report to support the BDSCT Environmental Impact Assessment (Haskoning, 2008)[739] considers the entrainment mortality of these young stages to be minimal in the area to be dredged, because it is not used as a spawning site by fish. This is because the high suspended sediment loads and the seabed instability (mobility) make the region unsuitable for fish eggs and larvae.

Avoidance of dredging activity was also demonstrated by Armstrong *et al*., (1982)[740] who reported species-specific capture rates ranging from 0.001 to 0.135 fish per cubic yard of dredged material. While fish up to 234mm in length were entrained, trawl data indicated that many species living in the area were apparently capable of escaping the dredge.

In the Severn Estuary, Haskoning (2008) anticipated that small bottom spawning fish such as sand goby (*Pomatoschistus minutus*), common goby (*Pomatoschistus microps*) and the pelagic transparent gobies (*Aphia minuta*) are likely to be the most vulnerable fish to dredger entrainment. This is because they are small with modest swimming ability and the sand and common gobies inhabit surface sediments. Gobies are particularly abundant in British estuaries and it is not considered that the numbers that would be killed would impact the populations. Data for the Severn Estuary indicates that all of the goby species mentioned above are abundant in extensive areas outside of the proposed area to be dredged.

Much of the evidence available on dredging suggests entrainment is not a significant problem for many species of fish in many bodies of water that require periodic dredging (Reine & Clarke, 1998)[741]. The dredging operations to be carried out as part of the Bristol Project will be carried out at a relatively wide point within the estuary (at least 10km), which will allow migratory species to pass well away from the working dredge head. Based on findings from other entrainment studies reviewed above, it is unlikely that either entrainment of migratory fish species would occur or that if some entrainment were to occur that the numbers involved would be extremely small and will be negligible in the context of the in combination assessment.

[737] Ault, J. S., Lindeman, K. C., and Clarke, D. G. (1998). “FISHFATE: Population dynamics models to assess risks of hydraulic entrainment by dredges,” DOER Technical Notes Collection (TN DOER-E4), U.S. Army Engineer Research and Development Center, Vicksburg, MS. www.wes.army.mil/el/dots/doer

[738] McNair, E. C. and G. E. Banks, 1986. Prediction of flow fields near the suction of a cutterhead dredge. American Malacological Bulletin, Special Edition. 3:37–40.

[739] Haskoning (2008) Bristol Deep Sea Container Terminal: Natural Fish Resources Including Migratory Species in the Severn Estuary: Response to Issues Raised by Consultees Following the Submission of the Harbour Revision Order and Environmental Statement

[740] Armstrong, D.A., B.G. Stevens and J.C. Hoeman. 1982. Distribution and abundance of Dungeness crab and Crangon shrimp, and dredging-related mortality of invertebrates and fish in Grays Harbor, Washington. Tech. Rpt. by School of Fisheries, Univ. Wash. To Wash. Department of Fisheries and U.S. Army Corps of Engineers, Seattle District Office, 349 pp.

[741] Reine, K., and Clarke, D. (1998). “Entrainment by hydraulic dredges–A review of potential impacts.” Technical Note DOER-E1. U.S. Army Engineer Research and Development Center, Vicksburg, MS.

Summary of entrainment and impingement assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC operational discharges (abstraction)	No
HPB cooling water abstraction	No
Aberthaw cooling water abstraction	No
Oldbury A abstraction	No
Oldbury B abstraction	No
Bristol deep sea terminal dredging	No
Overall in combination effects	**No adverse effect upon site integrity**

Overall conclusion of combined impacts of entrainment and impingement.

It can therefore be concluded that the in combination effects of entrainment and impingement will not cause an adverse affect on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

6.10.9 Disturbance (noise, visual, vibration)

Conservation objectives

- *The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.*
- *The migratory passage of both adults and juveniles through the Severn Estuary between the Bristol Channel and their spawning rivers is not obstructed or impeded*

Environment Agency consents that could have an impact in terms of disturbance include the following:

- Sea wall construction FDC
- Combwich Wharf development FDC

Which could act in combination with each other and the following other permissions, plans or projects:

- Jetty construction
- Construction of the cooling water infrastructure
- EA Steart Project
- Commercial shipping

In section 5 of the alone assessment for flood defence consents, both the construction of Combwich Wharf and the construction of the sea wall had the potential to impact on fish via increased noise, visual and vibration disturbance. Other impacts associated with the main HPC marine infrastructure works, particularly the temporary jetty and the construction of the off-shore cooling water system, which are scheduled to over lap for at least one year, have the potential for a synergistic in combination effect. Such effects could potentially result in temporary disturbance in terms of noise and vibration and therefore avoidance of this area by fish or a change in behaviour that could lead to a disruption in the lifecycle.

In relation to noise and vibration, the construction works for the sea wall would occur above Mean High Water Springs (MHWS) and out of the water at all times, so the potential for any noise and vibration effects to occur in the water column would be extremely limited, with noise being generated on the uppermost sections of the shore and often at some distance from the waters edge. There is therefore unlikely to be any synergistic effects with regards to the seawall development under the flood defence consent.

Furthermore, Combwich development is considered to be of significant distance from the seawall development for any overlapping to occur, and whilst it may be possible for the same fish to be disturbed from the jetty developments and cooling water infrastructure construction only to move on and be disturbed from Combwich developments, mortality is highly unlikely to occur at any stage and as such the fish populations will not be adversely impacted.

It is possible for the Combwich development to cause noise related impacts in combination with developments from the EA Steart breach on the River Parrett if the works were to be carried out in the same time-frame. However, the breaches and development of the creek systems at the EA Steart site would be made at locations above MHWS and therefore at sufficient distance from the waters edge. No work is expected to be carried out sub-tidally, therefore noise impacts in combination will be limited.

In relation to the visual impacts, there is the potential for artificial lighting around the sea wall and foreshore area to cause some disturbance to fish together with artificial lighting that is proposed around the jetty construction area and cooling water construction area. A common reaction of fish groups to the presence of artificial light is to school and move towards the light source (Ben-Yami, 1976)[742]. Functional explanations for such a reaction include predator avoidance and enhancement of feeding efficiency (Pitcher and Parrish, 1993)[743]. Levels of aggregation and attraction to light vary among species. Such differences are related to both phylogenetic and ecological factors, and are also affected by the physical characteristics of light, especially by its intensity and wavelength (Marchesana *et al.,* 2005)[744]. The artificial lighting is likely to affect each species differently, but only a very small percentage of the Inner Bristol Channel would be affected by the lighting. The areas around the HPC foreshore, sub-tidal areas around the jetty and cooling water infrastructure area are not specifically known to be important nursery areas for fish, so many species, including migrating fish, would avoid any lit areas if needed.

Commercial shipping

The development works at Combwich, particularly piling and boat movements have the potential to act in combination with commercial boat movements along the River Parrett and cause disturbance to migratory fish.

As discussed within section 5.6.2.5 (c) we have advised the competent authorities, in this case the Local Planning Authority (LPA) and Marine Management Organisation (MMO), to restrict the use of piling techniques to daylight hours only (defined as sunrise and sunset), to ensure the migrating fish have an appropriate window of opportunity to migrate without being impacted by piling noise. Also where possible, Silent' or 'vibrational' piling methods should be used. We have also advised the competent authority to ensure that all main site piling shall be carried out using soft start up techniques.

Furthermore we have advised the competent authority to implement the following requirements:

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[742] Ben-Yami, M., 1976. Fishing with light. In: FAO of the United Nations. Fishing News Books, Oxford.
[743] Pitcher, T.J., Parrish, J.K., 1993. Functions of shoaling behaviour in teleosts. In: Pitcher, T.J. (Ed.), Behaviour of Teleost fishes, 2nd ed. Chapman & Hall, London, pp. 363–439.
[744] Marchesana, M., Spotob, M., Verginellab, L., Ferreroa, E.A. (2005). Behavioural effects of artificial light on fish species of commercial interest. Fisheries Research 73 (2005) 171–185.

No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.

No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation.

Summary of disturbance assessment

Plan, permission, project (PPP)	Conservation objectives compromised?
HPC Sea wall construction FDC	No
Combwich Wharf development FDC	No
Jetty construction	No
Construction of the cooling water infrastructure	No
A Steart development	No
Overall in combination effects	**No adverse effect upon site integrity**

Conclusion of in combination effects for disturbance related to migratory fish and fish assemblage.
In combination effects are therefore thought to be negligible in terms of disturbance and will not adversely affect the fish designated to the SAC and Ramsar.

Overall impact on site integrity in respect of the migratory fish and fish assemblage features.

Hazard	Adverse effect on site integrity?	Comments
Toxic contamination	No	
Non-toxic contamination	No	
Changes to thermal regime	No	
Changes to salinity	No	
Increased turbidity, suspended sediment & siltation	No	
Physical damage & habitat loss	No	
Entrainment and impingement	No	
Disturbance	No	
Overall in combination effects	**No adverse effect upon site integrity**	

6.11 Migratory birds and bird assemblage

Table 6.11.1S1 – Activities that can potentially impact on birds

	Construction activities												Operational activities														
Potential sources of hazard	**EA consents**				**Existing plans and other plans & projects**								**EA Consents**														
Hazard	Construction discharges	Seawall FDC	Combwich Wharf FDC	Main site FDC	Temporary jetty construction	Construction of cooling water infrastructure	Construction of main site infrastructure	Bristol deep sea container terminal	EA Steart development	Construction of National Grid station	Bristol Ports compensatory Habitat at Steart	Construction spent fuel store	HPC Cold Commissioning discharges	HPC cooling water discharge	PPC EPR permit – back up diesel generators	RSR EPR permit – nuclear island discharges	HPB cooling water discharge	Uskmouth cooling water discharge	Aberthaw cooling water discharge	Temporary jetty operation	Combwich Wharf operation	HPB cooling water discharge	Oldbury A water abstraction	Oldbury B water abstraction	Aberthaw water abstraction	HPB water abstraction	HPA decommissioning
Toxic contamination	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×
Non-toxic contamination (nutrient enrichment & organic loading)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Thermal impact	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	✓	✓	✓	×	×	×	×	×	×	×	×
Salinity	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Turbidity, suspended sediment & siltation	✓	✓	✓	×	✓	✓	×	✓	✓	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Physical damage / Habitat loss	×	✓	×	×	✓	✓	×	✓	×	×	×	×	×	×		×	×	×	×	×	×	×	×	×	×	×	×
Disturbance (noise vibration & visual)	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	✓	✓	×	×	×	×	×	×
Entrainment & impingement	×	×	×	×	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×	✓	✓	✓	✓	✓	×

Note: permissions relating to HPC development assessed within the alone section of this document are highlighted in green

Table 6.11.1S2 - Timeframe of activities that could impact on the migratory birds and bird assemblage features. Green indicates an EA permission for HPC.

PPP	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Jetty construction											
Sea wall construction (FDC)											
Construction CW infrastructure											
HPC Construction discharges											
Combwich development (FDC)											⇨
EA Steart habitat creation											
Bristol Port Steart habitat creation											
Bristol deep sea terminal (dredging)											⇨
Cold commissioning discharge (HPC)											
HPC Operational discharge											⇨
HPB operational discharge											⇨
HPA decommissioning discharge											⇨
Aberthaw abstraction											⇨
Uskmouth abstraction											⇨

Conservation objectives (see section 1.5.1)

Internationally important populations of regularly occurring migratory species (wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, gadwall, wintering Ringed Plover wintering Curlew* wintering Pintail*, wintering teal**, breeding Lesser Black-backed Gull) *recommended additions under the SPA review, **recommended under the Ramsar review*

- *The abundance and macro-distribution of suitable invertebrates in inter-tidal mudflats and sandflats is maintained;*

Internationally important assemblage of waterfowl

- *the abundance and macro-distribution of suitable invertebrates in intertidal mudflats and sandflats is maintained;*

Natural England & Countryside Council for Wales, 2009[745]

6.11.2 Toxic contamination

Environment Agency consents that could have an impact on birds in terms of toxic contamination include the following:

- HPC cooling water discharge (via food chain)

which could act in combination with toxic contamination from the following other permissions, plans or projects:

- HPB cooling water discharge (via food chain)

Any impacts to birds from toxic contaminants will be via impact to prey availability on the inter-tidal mudflats due to the chemical plume from the cooling water discharge, in combination with HPB discharge. The only toxic contamination which could impact on the bird prey availability arise from the addition of chlorine as a biocide and hydrazine as a corrosion inhibitor and oxygen scavenger.

The TRO concentration at the HPC outfall is expected to be of the order of 100-200µg/l with an EQS of 10µg/l. HPB has a permit to discharge 0.3µg/l TRO although it does not currently discharge TRO, and is not expected to in the future, but it is there for precautionary measure and so it will be considered.

There is a measurable mixing zone for the toxic contaminant, TRO, in the HPB operational discharges. The predicted mixing zone is small, being 0.13% of the estuaries feature at the surface. The loads of other toxic contaminants from the HPB operational discharges are not measurable and are considered to be negligible, as the only consented toxic contaminant is TRO. Hydrazine is not used at HPB, so there is no hydrazine discharge and therefore no mixing zone, however there is potential for the TRO from the combined HPB and HPC to act in combination with the hydrazine, which could impact on bird prey, such as benthic invertebrates (as discussed in section 2.6.3.6).

As discussed in section 6.5.2, the mixing zones of TRO and hydrazine from HPC operational discharges are not coincident spatially, while that for TRO from the HPB operational

[745] Natural England (NE) & Countryside Council for Wales (CCW)' advice given under Regulation 33(2)(a) of the Conservation (Natural Habitats, &c.) Regulations 1994, as amended. Severn Estuary/Môr Hafren European Marine Site. June 2009

discharges is spatially separate. The modelling of the hydrazine plume for HPC operational discharges alone, was for a discharge scenario at average concentrations. Modelling has not been provided for the maximum concentration against the acute ‘predicted no effect concentration’ (PNEC). The maximum concentration in the cooling water is predicted to be 0.72µg/l, based on a cooling water flow of $64m^3/s$ (see alone assessment section 2.6.3.5). The loading from this scenario is approximately 40 times greater than that for the average scenario. It was therefore concluded from the alone assessment that the potential size of the mixing zone for hydrazine for the maximum concentration scenario could be significant and could therefore have an impact on the estuaries and inter-tidal features, and the benthic invertebrates that are supported by them. Consequently, it was not possible from the available information to conclude that the discharge of hydrazine does not have an adverse effect on the integrity of the site. However, within the environmental permit for the operational water discharge from the Hinkley Point C nuclear power station we are able to require the removal of hydrazine from all waste water streams prior to discharge.

This will prevent hydrazine being released into the Severn Estuary. This control measure enables us to conclude that there will be no adverse impact on the habitat as a result of use of hydrazine at the Hinkley Point C nuclear power station.

Overall conclusion of combined impacts for toxic contamination in relation to birds

It is therefore concluded that the impact of toxic contaminants from the relevant permissions, plans and projects(PPPs) on the conservation objectives for the migratory birds and bird assemblage features is not significant when considered ‘in combination’, as long as the environmental permit requires hydrazine to be removed from waste water streams prior to discharge.

We have not been able to conclude, based on the available information, that the discharge of hydrazine in the HPC operational discharge would not have an adverse effect on the Estuaries feature and the integrity of the Severn Estuary SAC without mitigation.

Required mitigation

Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.

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6.11.3 Non-toxic contamination (nutrient enrichment & organic loading)

Due to their location and known sensitivities we are satisfied that there will be no adverse effect on the bird population of the Severn Estuary due to non-toxic contamination as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of non-toxic contamination on this feature has not been considered further.

6.11.4 Thermal

Environment Agency consents that could have a thermal impact on birds include the following:

- HPC cooling water discharge (via food chain)

which could act in combination with thermal impact from the following other permissions, plans or projects:

- HPB cooling cooling water discharge (via food chain)
- Uskmouth power station cooling water discharge (via food chain)

- Aberthaw power station cooling water discharge (via food chain)

Both Uskmouth and Aberthaw discharge outfalls are >20km distance from the HPB outfall and that proposed for HPC. As reported in section 6.5 there will be no cross over of thermal plume mixing zones from these power stations with either HPB or the proposed HPC thermal plume. There is however the potential for HPB and HPC to act in combination synergistically.

HPB and HPC cooling water discharges

The cumulative operation of HPB and HPC is likely to result in higher plume temperatures extending both offshore and west of Hinkley Point, due to the increased thermal loading. The estuaries and inter-tidal in combination sections 6.5 and 6.7 respectively, provide the results of the thermal modelling work for the cooling water discharge from HPC together with HPB and the implications of this with respect to the invertebrate communities of the inter-tidal mudflats to the east of Hinkley Point.

The assessment of HPB and HPC in combination (Runs D and E) indicated that there are likely to be moderately large areas, in particular the Parrett, for which exceedence of the 98%ile and the uplift standard are likely to occur. For Run E for example, the 2ºC uplift effects 2.67% of the SPA and 4.89% at the surface and 2.59% of the SPA, and 5.08% at the bed (see table 6.11.4S1 and 6.11.4S2).

This water temperature increase could lead to a small reduction in the biomass of the bivalve *Macoma balthica* occupying the mudflats in this area, although on the basis of direct evidence of the characteristics of the *Macoma p*opulation at Stert flats it would appear that the existing thermal discharge from HPB is not having a discernible effect upon *Macoma* and thus HPC alone will not adversely affect *Macoma* (see alone assessment section 2.6.3.6).

As it is apparent from the available waterbird count data that Stert flats supports a very significant proportion of the total population of a number of SPA designated species, which suggests that even if the raised water temperatures associated with HPB were having an effect, that the availability of prey, including *Macoma*, is sufficient to maintain large numbers of waterbirds.

Table 6.11.4S1 - Areas of Mixing Zones for Habitats Related Targets in hectares as a percentage of Severn Estuary SAC.

	ΔT 2 ºC			Max 21.5 ºC as 98%ile			Max 28 ºC as 98%ile
Run E	**Total Area**	**Area in the SAC**	**Area in the SPA**	**Total Area**	**Area in the SAC**	**Area in the SPA**	**Area in the SPA**
HPB 100% & HPC Surface	1990	1966	1205	4487	2810	1672	0
HPB 100% & HPC Bed	1929	1906	1253	4418	2767	1721	0

Table 6.11.4S2 - Areas of Mixing Zones for Habitats Related Targets in hectares as a percentage of Severn Estuary SPA features.

	ΔT 2 °C			Max 21.5 °C as 98%ile			Max 28 °C as 98%ile
Run E	**Total Area**	**Area in the SAC**	**Area in the SPA**	**Total Area**	**Area in the SAC**	**Area in the SPA**	**Area in the SPA**
HPB 100% & HPC Surface	2.70	2.67	4.89	6.09	3.81	6.78	0.00
HPB 100% & HPC Bed	2.62	2.59	5.08	6.00	3.76	6.98	0.00

As discussed within the alone section 2.6.3.6 Monitoring of invertebrate populations within and outside the existing HPB thermal plume found no 'discernible effects on *Macoma*' (BEEMS TR160)[746]. This was supported by additional *Macoma balthica* work carried out by the applicant following a request for further information to enable us to carry out our assessment. This work looked at the M*acoma balthica* within the plume of HPB and compared it with that found elsewhere on Stert Flats and within the Severn Estuary. The summary of this work states:

- *In Bridgwater Bay the HPB thermal plume intersects with the lower part of Stert flats but not with Berrow flats. A comparison between the M. balthica populations on Stert and Berrow flats measured in 2008 showed no significant difference in size, age or density between the two populations but with a small number of larger (>10mm) individuals on Berrow flats.*

- *There is no clear correspondence between M. balthica population 'types' (cluster groups) on Stert flats and thermal uplift from HPB for any of the four seasonal surveys undertaken in 2010*

- *Macoma balthica populations are present elsewhere in the Severn Estuary.*

- *The M. balthica population at Hinkley Point does not have the smallest or youngest individuals in the Severn; we have found other populations with different or the same size and age characteristics, with the Hinkley Point population being within the measured range of variability and not at one extreme.*

- *The presence of M. balthica at neighbouring and up-river sites provides the potential for external recruitment to the Stert Flats, in the event of any thermal impacts on Stert flat populations*

The points above demonstrate that a small decrease in *Macoma balthica* biomass would not lead to a significant effect on the bird prey availability. However, to support this a detailed assessment on the potential temperature effects on *Macoma balthica* have been discussed in detail within section 6.5.4.

Overall conclusion of combined impacts for thermal effects in relation to birds
We can therefore conclude that there will be no adverse effect on the migratory birds and bird assemblage features of the Severn Estuary SPA and Ramsar from any changes to the thermal regime as a result of HPC together with other PPPs.

[746] BEEMS Technical Report 160 (TR160): Variability in population structure and condition of *Macoma balthica* along a portion of its geographical range

6.11.5 Salinity

Due to their location and known sensitivities we are satisfied that there will be no adverse effect on the bird population of the Severn Estuary due to changes in salinity as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of changes in salinity on this feature has not been considered further.

6.11.6 Turbidity, siltation and suspended sediment

Due to their location and known sensitivities we are satisfied that there will be no adverse effect on the bird population of the Severn Estuary due to changes in turbidity, siltation and suspended sediment as a result of any of the activities occurring as part of the Hinkley Point C project. Therefore, impact of changes in turbidity, siltation and suspended sediment on this feature has not been considered further.

6.11.7 Physical damage / Habitat loss

Environment Agency consents that could have an impact on birds in terms of physical damage and habitat loss are:

- Sea wall construction (including rock delivery) FDC

which could act in combination with disturbance from the following other permissions, plans or projects:

- Temporary jetty construction

Sea wall and temporary jetty
Construction of the seawall will lead to a loss of the upper shore habitat from the footprint of the seawall. This habitat is not a critical resource for any of the SPA or Ramsar bird species. The seawall will also lead to a temporary loss of between 6 months to 10 years of 26,000m^2 habitat within the 30m construction zone. The temporary jetty development will result in a loss of approximately 20m^2 to 30m^2 of intertidal habitat as a result of the piles. This additional scale of loss is insignificant in comparison to the rest of the intertidal habitat along the Hinkley frontage. Furthermore, the intertidal habitat fronting Hinkley Point is not a critical resource for birds.

Therefore the impacts on habitat caused by the seawall and temporary jetty in combination will not cause an adverse effect on the integrity of the Severn SPA and Ramsar.

6.11.8 Disturbance (noise, vibration and visual)

Environment Agency consents that could have an impact on birds in terms of Disturbance (noise, vibration and visual) are:

- Sea wall construction (including rock delivery) FDC
- Combwich Wharf development FDC

which could act in combination with disturbance from the following other permissions, plans or projects:

- Construction of main site infrastructure and spent fuel store
- Construction of cooling water infrastructure
- Temporary jetty construction, including piling and dredging
- Construction of Combwich Freight Laydown Facility

- Temporary jetty operation
- Combwich Wharf operation
- Bristol deep sea container terminal
- EA Steart development
- Bristol Ports compensatory habitat at Steart
- Construction of National Grid station
- Bait collecting
- EA flood defence maintenance

Within section 5 of the alone assessment for Flood Defence Consents, we concluded that both the construction of Combwich Wharf and the construction of the sea wall have the potential to cause disturbance to feeding or roosting birds. Section 3 also discussed the potential for disturbance to birds from the operation of the standby generators. Section 3 concluded that the generators would be inaudible at the bird feeding areas on the foreshore . The potential for in combination effects from the operation of the generators does, therefore, not need to be considered further in this assessment. Disturbance impacts may also arise from other developments associated with the Hinkley Point C Main Site, including construction of the temporary jetty (expected to take up to 18 months), construction of cooling water infrastructure (expected to take up to 30 months) and construction of the main site infrastructure (expected to take up to several years). Adjacent to the Parrett estuary further disturbance impacts could arise from the construction of the Combwich freight laydown facility (expected to take 18 months).

Disturbance impacts to birds could be cumulative if they occur in different areas at the same time or in the same area during the same winter season. Table 6.11.8S1 showing the indicative timescale for the development phases of the Hinkley Point C project identifies that there are overlaps in construction time of the activities. If activities occur over different winter seasons then there are unlikely to be cumulative effects because bird fitness at the start of each winter depends on conditions in their summer habitat rather than those during the previous winter.

Impacts relating to construction (sea wall, temporary jetty, Combwich wharf and boat traffic) will occur in years prior to those relating to operation (thermal and chlorinated plume and standby generator testing). Provided mortality is not occurring, cumulative impacts are not expected to be an issue for activities occurring sequentially in different years because, as stated above, bird fitness at the start of each winter season is a function of conditions during the breeding season rather than conditions during the previous winter season.

Seawall construction and construction of main site / spent fuel store
Construction works within the main development site are likely to be the least disturbing activities because these works are land based and will mostly take place at a considerable distance from the cliff edge. The majority of the works will not be visible to birds using the intertidal area and would not result in unpredictable loud noises (70dB predicted noise level). Therefore during much of this period birds using the Severn Estuary SPA/Ramsar Site would habituate to the activity within the main site and would not be displaced and therefore not act in combination with any foreshore works.

Seawall and cooling water infrastructure
The cooling water infrastructure is predicted to take 30 months to construct and is programmed to overlap with both the seawall and temporary jetty construction works. The tunnelling works will take place from behind the seawall and therefore there will be little visual disturbance to birds. Tunnelling under the sea will not cause a disturbance effect on birds. The works would also not result in unpredictable loud noises and birds will habituate to the noise of the main site works. During the overlap period, the in combination impact of the foreshore works and the tunnelling works will not be intensified, i.e. birds will be disturbed

by the seawall and temporary jetty works (as these are closer and are the more disturbing activities) but this will not be exasperated by the tunnelling works. In addition, there will not be an increase in intensity of disturbance as a result of the extended duration of works once the foreshore works are completed and the tunnelling is being constructed in isolation.

Overall, construction of the cooling water infrastructure in combination with the construction of the seawall will not cause an adverse effect on the integrity of the Severn Estuary SPA/ Ramsar Site

Seawall construction and temporary jetty construction
Due to their locations, the most likely in combination impacts to birds using the frontage at Hinkley Point would arise from the construction of the seawall and the temporary jetty. Analysis of the survey data collected by Amec between April 2007 and March 2009 (Amec, 2011) shows that birds using the frontage at Hinkley Point were in insignificant numbers for the majority of species but pintail, passage ringed plover and shelduck were observed in numbers greater than 1% of the SPA population (see Table 5.6.1.4S2 - Peak count of birds in each Hinkley Point count sector, 2007-2009 in section 5.6.1).

The temporary jetty and seawall construction works are programmed to overlap by 6 months and overall, construction works on the foreshore could occur for a total of 24 months.

Within the 6 month overlap period, if during the temporary jetty works birds are displaced to the west then there are unlikely to be an increase in the intensity of disturbance from the seawall works because the temporary jetty works alone would displace the birds from the area meaning that there would be very few birds present that could be disturbed by the seawall construction works. Therefore the in combination impact would be no greater than that of the temporary jetty works in isolation. If during the temporary jetty construction birds are displaced to the east then the seawall works could increase the intensity of disturbance as birds could be disturbed twice.

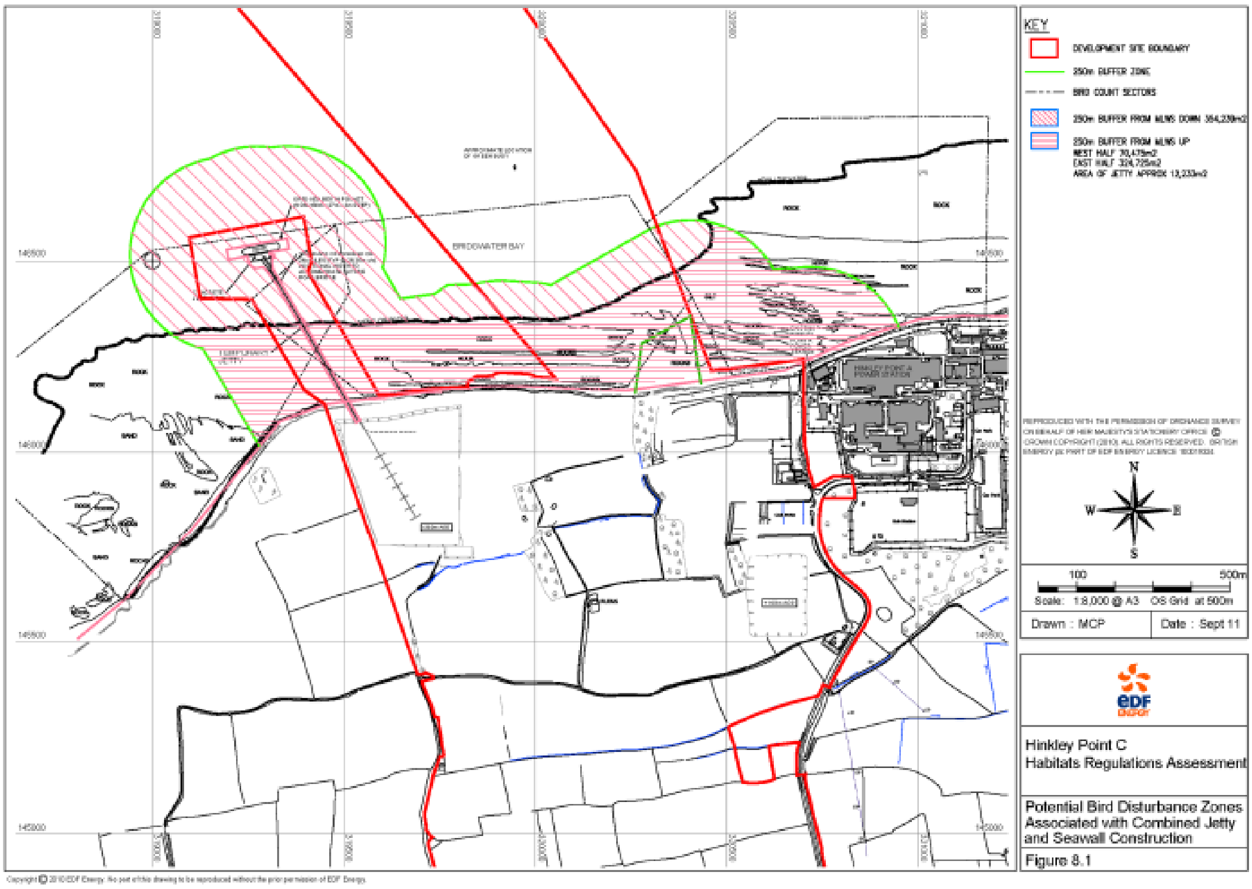
Outside the overlap period, the likely impact is no different from that of either the temporary jetty or seawall constructions in isolation. Despite the 2 construction activities extending works on the foreshore for up to 24 months, ie 2 winter seasons, cumulative impacts will not be possible because bird fitness is refreshed at the start of each season.

As presented in section 5.6.1.4, construction of the sea wall will cause disturbance impacts within count sectors 2 and 3. Construction of the temporary jetty will cause disturbance impacts within count sectors 1 and 2. In combination, this means that there are greater areas of intertidal habitat that would potentially be disturbed along the foreshore fronting the Hinkley Point C site, predominately within close proximity to the proposed temporary jetty and sea wall. Using 250m as a defined disturbance zone, the area of habitat in which disturbance effects could be significant is shown in figure 6.11.8S1 and table 6.11.8S2 below. The sea wall disturbance zone takes into account the full 30m construction area.

Table 6.11.8S1 - Calculated area of available habitat beyond the 250m disturbance zone for count sectors 1, 2 and 3 (excluding rock delivery area) for the temporary jetty and sea wall (Haskoning 2011)

Count sector	Area of intertidal habitat (ha)	Sea wall and temporary jetty construction works	
		Area of disturbance at 250m distance (ha)	% of count sector
1	33.05	6.17	19
2	17.70	17.16	97
3	34.10	9.19	27

Figure 6.11.8S2 - Potential bird disturbance zones associated with the combined temporary jetty and seawall construction (Haskoning 2011)



The majority (97%) of count sector 2 falls within the zone of disturbance. The degree of impact depends on whether there are critical resources in these zones that birds cannot obtain elsewhere. The bird survey data shows low level use for count sectors 1, 2 and 3 indicating that they do not provide any critical resource for any of the species recorded (see Table 5.6.1.4S2 - Peak count of birds in each Hinkley Point count sector, 2007-2009 in section 5.6.1).. Ringed plover, Pintail and shelduck were recorded in significant numbers and are discussed further below:

Shelduck:
Shelduck were seen loafing offshore. Moulting shelduck are potentially more vulnerable to disturbance than other species as they are flightless and potentially birds could be within close proximity of the temporary jetty works. However birds are likely to habituate to continued construction activity and noise and are capable of moving away (Amec 2011a)[747]. There are large expanses of water that are equally suitable for shelduck.

Pintail:
Pintail were observed very infrequently in significant numbers and only in count sector 3 as discussed in section 5.6.1.4 above. There were no pintail observed in count sector 1 and therefore no further in combination assessment is required for this species.

Passage ringed plover
Passage ringed plover were observed in significant numbers in CS1 feeding on the mobile sands. A peak count of 33 birds was recorded however on all but 5 of 46

[747] Amec, 2011. (Amec 2011a). Environment & Infrastructure UK Limited,Technical Note, Appendix 20Q - Shelduck Survey Baseline Information, September 2011

occasions when the species was recorded, numbers were much lower (five birds or less) which indicates that this is not a critical resource for this species.

Another consideration is the lighting of temporary jetty. Despite construction works generally taking place during the day, there may be times when activity occurs at night and the opportunity for in combination effects exists. In addition, prolonged disturbance throughout a 24 hour timeframe will add to the depletion of energy reserves. As stated in the report to inform the HRA (Haskoning 2011) lighting will be constantly lit during construction with directional spot lights. Therefore only the temporary jetty and immediate works area will be lit and not the adjacent intertidal feeding or roosting grounds. Birds will habituate to this lighting rather than being displaced each time lighting is motion or switch activated. Lighting on the temporary jetty is therefore assessed as not likely to add to the impact of disturbance.

It is therefore reasonable to conclude that construction of the temporary jetty and sea wall, whether undertaken sequentially or concurrently, would cause temporary displacement of birds to other areas but would not adversely affect the integrity of the Severn Estuary SPA/Ramsar Site.

In section 5.6.1.4 for the sea wall assessment we have recommended to the competent authority (Local Planning Authority) that in order to adopt a precautionary approach to disturbance, construction should cease in the event of severe winter weather leading to voluntary wildfowling restraint by the British Association of Shooting and Conservation (BASC).

Refurbishment of Combwich wharf

It has not been possible for us to conclude no adverse effect on the integrity of the Severn Estuary SPA/Ramsar from the refurbishment of Combwich wharf alone (section 5.6.2.6). However the extent of impact could be exacerbated through cumulative impacts in relation to construction disturbance if the temporary jetty and sea wall at Hinkley Point and Combwich wharf refurbishment were all constructed simultaneously. The geographical separation of Combwich wharf from Hinkley Point and the different habitats at each location means that this is unlikely to be significant. Birds displaced from Combwich wharf would move elsewhere along the Parrett whilst those displaced from Hinkley Point would move elsewhere in Bridgwater Bay.

Combwich laydown facility

There is also potential for cumulative effects from construction of the new laydown facility at Combwich with the refurbishment of Combwich wharf. The report to inform the HRA (Haskoning, 2011) reports that the fields around the site for the laydown facility are used by relatively small numbers of birds. Of the internationally important species, only redshank (peak of 9; <0.5% of the designated SPA population) and dunlin (peak of 131; <0.3% of the designated SPA population) were recorded in proximity to the laydown site. Haskoning concludes that use of this area by birds is sporadic and that any displaced birds can be accommodated elsewhere in the Parrett area. We agree with this conclusion. Moreover the habitat affected by the laydown facility is fields and fulfils a quite different function from the intertidal habitat affected by wharf construction. Accordingly no in combination effects with wharf construction are foreseen.

Vessel movements (operation of temporary jetty and Combwich)

The operational use of temporary jetty, and therefore increase in boat traffic, has the potential to cause a disturbance to birds in combination with other sources of disturbance arising from the construction of the development. The temporary jetty is at the western end of Bridgwater Bay and will be accessed by boat traffic arriving from the Bristol Channel. During months of peak demand for aggregates and cement, there are anticipated to be 16 to 18 vessels making return movements. Maximum predicted traffic is 36 to 43 return movements per month (Royal

Haskoning/EDF, 2011)[748]. The impact of the increased vessel movements on birds within the Severn Estuary is considered to be low as there are already a large number of vessels operating in this area and the birds within the estuary are accustomed to vessel movement. Furthermore, vessel movements will not cross close to the intertidal area of Bridgwater Bay. The impact on birds within the intertidal area of Bridgwater Bay will therefore be low.

The only potentially significant interaction identified is with rafts of moulting shelduck, which are present offshore in Bridgwater Bay in late summer and autumn. Vessel movements into and out of the berthing facility for the temporary jetty will be undertaken at low speeds. The clarifications arising from the HRA Feedback report (Royal Haskoning/EDF, 2011) states that it is possible that large rafts of shelduck may be present on the water during the movement of vessels to and from the temporary jetty berth but it is not envisaged that these movements would lead to disturbance and displacement that would have a detrimental effect on these rafting birds. Rafts of shelduck usually occur well offshore and outside the immediate area of the temporary jetty, suggesting that they are unlikely to interact with the temporary jetty in the first place. If a raft of birds were present on the water in the vicinity of the temporary jetty during the movement of a vessel to or from the temporary jetty, any interaction would be short-lived. Moulted shelduck can swim and flap their wings to aid movement. At the speeds at which the vessels would be operating, only relatively limited adjustments by birds would be required in order to avoid a moving vessel.

Combwich wharf will be accessed by marine traffic arriving up the Parrett Estuary. There will be an average of 8-9 vessel calls per month, with a peak of around 14-15 per month. Over a four year construction period, 174 vessel calls are assumed, an average of 44 per year (Haskoning/EDF, 2011). This represents approximately a doubling of the existing return vessel movements from about 40 to 84 per year. It typically takes 2 hours 40 minutes for a vessel to travel from Stert Point to Combwich. Vessels carrying abnormal indivisible loads require tides of greater than 4.5m to access Combwich Wharf and the navigation window is typically within 1.5 hours of high tide. Vessel movements are therefore not likely to occur when intertidal flats are exposed and birds are feeding.

The Harbourmaster of Bridgwater Port has powers to regulate vessel movements and exercises these powers in accordance with the port's Marine Operations Plan[749]. This requires vessels to provide a passage plan and it is recommended that an operational protocol be prepared for freight vessels using Combwich Wharf, to only operate within 2 hours of high water to avoid disturbance to birds feeding on the intertidal mudflats. It is also recommended that vessel speed is limited when crossing Bridgwater, approaching the temporary jetty or navigating the Parrett estuary during the months when moulted shelduck may be present. Ogilvie (1975) states that normal swimming speeds by ducks are around 4km/h to 5km/h and that fast swimming (for example to avoid a predator when flightless) might double this. As large, strong ducks, shelduck would be expected to be towards the top end of the range of speeds. It is therefore proposed that a speed limit (relative to the water) of 4 knots (7.4km/hour) be enforced during the months June to October for vessels entering Bridgwater Bay, the Parrett Estuary or within 1 km of the temporary jetty. This will enable moulted shelduck to take avoidance action if approached by a vessel. The Combwich Environmental Statement[750] states that an updated protocol and passage plans should be developed, in discussion with the Harbourmaster of Bridgwater Port, for navigation of large vessels to Combwich to formalise good practice operations.

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[748] Royal Haskoning/EDF. (Royal Haskoning/EDF, 2011). Clarifications arising from Habitats Regulations Assessment (HRA) feedback. August 2011. Report prepared for EDF.
[749] Sedgemoor District Council, 2009. (Sedgemoor District Council). Port of Bridgwater Marine Operations Plan (Compliance with the Port Marine Safety Code). Revision 5, July 2009.
[750] Combwich Environmental Statement (ES) Vol.7 Chap.18 (Section 18.7.12/13 Pg.59) supplied by EDF

Furthermore, EDF and Natural England have agreed an adaptive monitoring strategy to ensure that moulting shelduck will not be negatively affected by vessel movements to and from the temporary jetty and the refurbishment of Combwich wharf when judged in combination. The adaptive monitoring strategy will enable the value of shelduck data collected to be maximised, allow for trigger points to be identified and provide for mitigation to be implemented should those trigger points be exceeded (Natural England)[751].

Adoption of the measures discussed above would enable a conclusion of no adverse effect on integrity of the Severn Estuary SPA/Ramsar from vessel movements to the temporary jetty and Combwhich wharf.

Bristol Deep Sea Container Terminal (BDSCT)
These works are 45km north of the Hinkley Point C development and will cause disturbance to birds. The proposed start date is not defined however if disturbance to birds at both the BDSCT and Hinkley Point C were to occur at the same time, the displacement effect would be negligible. This is because there is a significant distance between the two projects (60km) and it is highly unlikely that disturbance from the two projects would combine since, for the majority of species, the two projects would affect different sub-populations of birds and their home ranges (Haskoning, 2011).

As stated in the Report to inform the HRA (Haskoning, 2011) the ornithology work to inform the BDSCT ES identified that only a small number of birds would be subject to disturbance. Species included are Redshank which were observed in significant populations (up to 1% of the SPA population). This species was also observed in significant numbers in the Parrett estuary and are likely to be disturbed during the Combwich wharf refurbishments. However, as stated in Section 5, there is available habitat close by for any redshank that are disturbed and it is likely that birds move around within the Parrett estuary to benefit feeding and roosting areas. Therefore it is unlikely that birds will be disturbed by both the Combwich wharf works and the BDSCT works. Shelduck were also observed in the BDSCT area of disturbance but in very small number (<5 birds) and therefore displacement would be negligible.

There will be a continual maintenance dredge with the BDSCT but this will not act in combination with the operational discharges of Hinkley Point C as these are not considered to have a disturbance effect and birds will become habituated to the operation of the power station.

Environment Agency Steart development
There is potential for spatial and temporal in combination impacts between the EA Steart coastal management project and the Hinkley Point C project.

The breach of the defences will be on the Parrett estuary and therefore there will not be a spatial overlap of these works with the construction of the seawall and temporary jetty if they occur at the same time. This is because the seawall is approximately 8km to the east of the mouth of the river Parrett and the birds disturbed from these works would be displaced within the immediate area of the Hinkley frontage. As stated in Section 5 any birds disturbed would be moved beyond the 250 disturbance zone and there is plenty of available habitat close by.

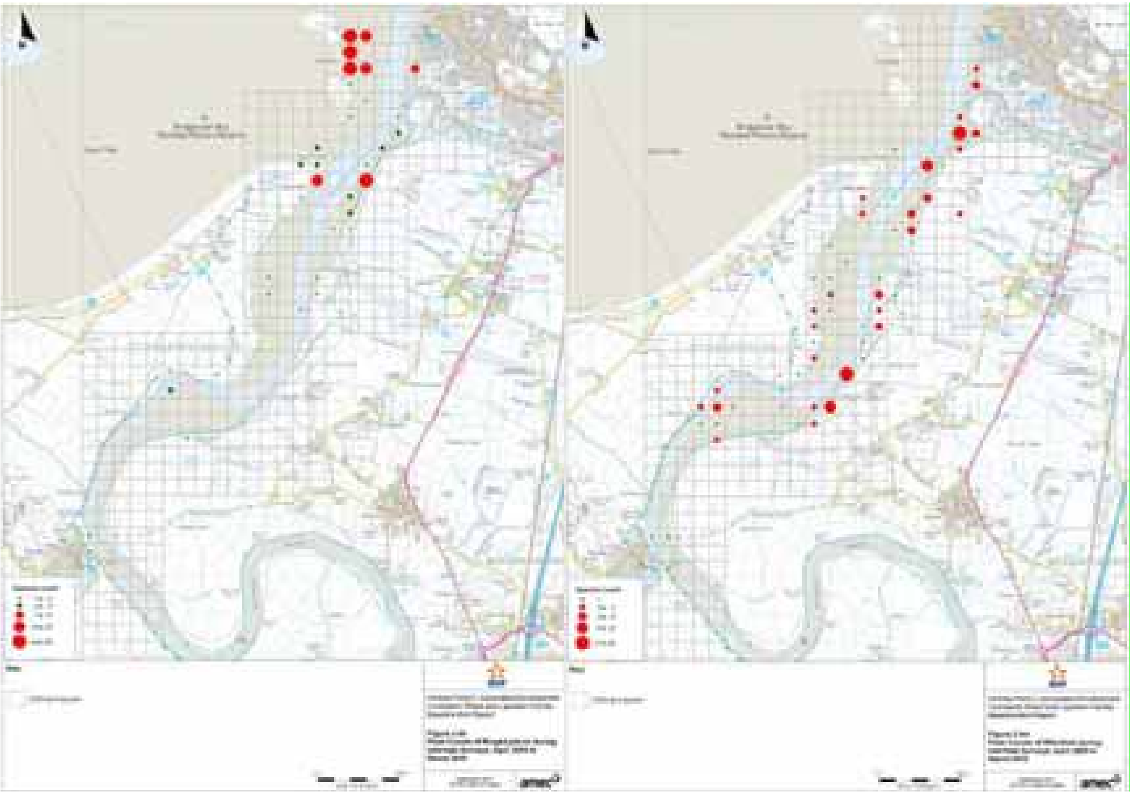
It is more likely there is potential for an in combination effect on birds as a result of disturbance from the breach works and Combwich wharf refurbishment. These works are approximately 2km apart and so spatial overlaps may occur if birds disturbed due to the Combwich refurbishment works are displaced downstream to the mudflats in the vicinity of the breach. It is however proposed that the Environment Agency project breach will be carried out in 2012, in advance of the reconstruction of Combwich wharf and the works will be carried out in the spring and summer months to avoid an impact on wintering birds (Halcrow 2011)[752]. The

[751] Natural England (2011). Principles for an adaptive shelduck monitoring strategy
[752] Halcrow (2011) Steart Coastal Management Project, Environmental Statement

designated summer passage species, ringed plover and whimbrel, are unlikely to be adversely affected by the in combination effects of the 2 projects because the survey data did not record either species to be present at Combwhich wharf [753](Amec 2011). The survey data for passage ringed plover and whimbrel is graphically represented in figure 6.11.8S3 below. We therefore do not consider that temporal or spatial in combination impacts will arise between the two projects.

The inland works at Steart would not impact on the Severn Estuary SPA/Ramsar birds as the fields are agricultural and so are not a critical resource for birds. The key areas are the intertidal habitat surrounding Steart.

Figure 6.11.8S3 - Mapped data for Passage ringed plover and whimbrel (Amec 2011b):



Bristol port Steart development

There is also potential for an in combination disturbance effect if the jetty and seawall were built at the same time as the Bristol Port Company's proposed Steart intertidal habitat creation scheme. The potential effects will be temporal rather than spatial because the works are 8km apart and displacement from the seawall and jetty are unlikely to occur beyond the immediate area of the works. If works do occur at the same time, as previously discussed, there is plenty of available habitat beyond the disturbance zone of the works for birds to utilise if they are displaced. The timescale for the Bristol Port Company project is currently uncertain. However, like the EA habitat compensatory project, the breach will be constructed in the spring and summer months (ABPMer, 2011)[754] to avoid an impact on wintering birds, so cumulative effects with the EDF project are not anticipated.

[753] Amec. (Amec 2011b). Combwich Wharf and Laydown Facility Baseline Bird Report. Report produced for EDF Development Company Ltd. 2011.

[754] ABPMer, 2011. (ABPMer, 2011). Steart Compensatory Habitat Project, Environmental Statement

Bridgewater to Seabank – construction of national grid station (Seabank 400kV transmission infrastructure connection)
The construction of the national grid station is proposed to start in 2014 and be completed by 2017. There will therefore be an overlap of construction times between this development and the construction of the seawall and the main site. Disturbance impacts from the construction of the national grid station at Hinkley Point will be land based and a considerable distance from the cliff edge and the seawall construction works. Like the main site construction works, works will also not be visible by birds using the intertidal area and would not result in unpredictable loud noises (70dB predicted noise level). Therefore disturbance impacts would be negligible and birds would habituate to general construction activity within the main site.

The proposed routeing of the new electricity transmission infrastructure between Bridgwater and Seabank passes to the west of the Somerset Levels and Moors SPA. Concerns have been raised that there could be impacts to frequented flight-lines and birds passing between the Severn Estuary SPA/Ramsar and the Somerset Levels and Moors SPA (Halcrow 2011). The national grid route included a collision risk assessment and it was found that the route did not result in any likely significant impacts on the integrity of the designations[755].

The potential for impacts to birds that are common to both the Severn Estuary SPA/Ramsar and the Somerset Levels and Moors SPA can only arise as a result of the Combwich wharf refurbishment works (ie similar species present). Therefore if birds are displaced during the Combwich wharf refurbishment works, it is likely they will not go to a location where they could be further impacted by the national grid works because there is suitable habitat close to Combwich outside of the 250m disturbance zone that they would move to. This would mean that if there are movements between the two SPAs, any displacement at Combwich would not effect these movements.

On the basis of the above, it is therefore concluded that there would be no in-combination disturbance effect between these two projects..

Bait collection
Bait digging was assessed in the Severn Estuary SAC/SPA Review of Environment Agency Consents[756]. It found that Bridgwater Bay is one of the frequented sites for this activity however it is limited to personal use only with bait being hand gathered using spades, forks, rakes and occasionally specialist bait pumps. Bird disturbance is one of the most serious impacts of bait digging in British estuaries in winter[757]. The presence of numerous bait diggers on the shore frequently has the effect of driving off feeding or roosting birds[758]. 1990s research found that activity was of a low intensity nature in the Severn Estuary and no major impacts were identified. Bait digging is therefore not considered to impact on the Severn Estuary features. This level of activity is also not likely to impact in combination with the Hinkley Point C foreshore works due to the level of impact and distance between the works and the Bridgwater bay mud flats further to the east.

755 National Grid's Hinkley Point C Connection Ornithological Assessment (October 2011) (Ref: 1979.097 r04)
756 Environment Agency, 2009. Severn Estuary SPA & cSAC Habitats directive Review of Consents Proforma for Stage 3 Appropriate Assessment, Part 2: Multifunctional in combination assessment – Final, October 2009
757 Townshend, D.J. and O'Connor, D.A. 1993. Some effects of disturbance to waterfowl from bait digging and wildfowling at Lindisfarne National Nature Reserve, north-east England. In: Davidson, N. and Rothwell, P. Disturbance to waterfowl on estuaries. Wader Study Group Bulletin, 68:47-52.
758 Evans, J. and Clark, N.A. 1993. Disturbance studies on Swansea Bay and the Burry Inlet in relation to bird populations. BTO Research Report No. 107.

Plan, permission, project (PPP)	Conservation objectives compromised?
Sea wall construction FDC	No
Combwich Wharf development FDC	No
HPC Construction of the main site	No
Jetty construction	No
Construction of cooling water infrastructure	No
Construction of Combwich freight laydown facility	No
Vessel movements	No
Bristol deep sea container terminal	No
EA Steart development	No
Bristol Ports compensatory habitat at Steart	No
Construction of the National Grid station	No
Bait Collection	No
Overall in combination effects	**No adverse effect upon the integrity of Birds within Severn Estuary SAC**

Overall conclusion of combined impacts in relation to birds
The above assessment has identified that there is potential for disturbance and some displacement of the designated bird species as a result of the construction works relating to Hinkley Point C. This is also likely to be the case for the various other competent authority projects. In combination, the likelihood of either spatial or temporal impacts is very limited and therefore we conclude that there will be no adverse effect on birds as a result of the HPC development in combination with other plans or projects.

Hazard assessed	Adverse effect on migratory bird and bird assemblage features?
Toxic contamination	No
Non-toxic contamination	No
Changes to thermal regime	No
Salinity	No
Siltation turbidity and suspended sediment	No
Habitat loss & physical damage	No
Entrainment	No
Overall conclusion	**No adverse effect upon site integrity**

6.12 Summary

6.12.1 Sum of all influences

Table 6.12.1 S1 shows a summary of all the possible effects from the proposed HPC. The following information summarises our findings from this appropriate assessment on each of the interest features. It considers the in combination effects from the different construction and operational aspects of the HPC nuclear power station application and in combination with other plans, projects and permissions.

Table 6.12.1 S1 – The sum of the influences acting on a feature from all PPP.

Potential effects	Atlantic salt meadows	Estuaries (including Rocky shore)	Inter-tidal mudflats and sandflats (including associated benthic communities)	Sub-tidal sandbanks	Reefs	Migratory fish (river lamprey, sea lamprey, twaite shad, allis shad, eel, atlantic salmon, sea trout) and general fish assemblage)	European white fronted goose, Dunlin, Red Shank, Shelduck, Gadwall, Curlew, Pintail, Ringed Plover, Whimbrel and Internationally important assemblage of waterfowl.
Alone - Toxic contamination	No	Mixing zone in SAC with levels of hydrazine above EQS over 0.21% surface and 0.1% at bed, The removal of hydrazine prior to discharge will be conditioned within an appropriate environmental permit Ammonia less than 1% of background. Negligible.	No	No	0.1% of SAC above EQS at seabed TRO. No adverse effect. Treatment of hydrazine will be conditioned within an appropriate environmental permit	Potential effect on eggs by hydrazine. Treatment of hydrazine will be conditioned within an appropriate environmental permit .	Elevated temperature of up to 3^0C above ambient. Potential effect on food source for some species on intertidal mudflats and sandflats. No likely Significant effect.
Alone – non-toxic contamination	No	No	No	No	Feature not sensitive to hazard	No	No
Alone - Changes in thermal regime	No	Mixing zone for ΔT of 2ºC is less than 1% of the Estuaries, but at or just greater than 1% for the SAC. No adverse effect for site integrity for sub features with in estuaries.	No	No	No	Some small changes to fish fauna in footprint of plume may be possible, no large scale changes in fish assemblage.	Some potential changes in growth rate for *Macoma benthica* but observation that macoma within HPB plume are no smaller than elsewhere in Bridgwater Bay. Therefore, No adverse effect expected.
Alone – Changes in salinity	No	No	No	No	No	No	No
Alone - Siltation and turbidity	No	No	No adverse effect. Advice to competent authority to control excessive speed wash from vessels to avoid any erosion (Combwich Wharfe)	No	No	Small scale changes in turbidity and siltation around outfall. No effect anticipated.	No
Alone - Habitat loss and physical damage	No	0.17% Rocky shore loss from sea wall construction. No adverse effect on overall site integrity.	No adverse effect. Advice to competent authority to control excessive speed wash from vessels to avoid any erosion (Combwich Wharfe)	No	Natural increase in mortality from 9% to 9.33% of *Sabellaria alveolata*. Considered negligible. No adverse effect.	Complex and multi-factoral interactions. Intake design, low velocity intake, acoustic fish deterrent system and fish recovery and return system will provide impingement losses similar or less to those of the existing Hinkley Point B station.	Some temporary displacement during seawall construction and Combwich wharfe operation and construction of but no adverse affect to site integrity.
Alone - entrainment	No	No – see more info on sub features.	No	No	Phytoplankton, copepod, decapod, zooplankton not affected. Negligible increase in mysid mortaility (state figures).	Complex and multi-factoral interactions. Intake design, low velocity intake, acoustic fish deterrent system and fish recovery and return system will provide impingement losses similar or less to those of the existing Hinkley Point B station.	No
Alone- Disturbance	No	No	No	No	No	No	Some temporary displacement during seawall construction and Combwich wharfe operation and

Potential effects	**Atlantic salt meadows**	**Estuaries (including Rocky shore)**	**Inter-tidal mudflats and sandflats (including associated benthic communities)**	**Sub-tidal sandbanks**	**Reefs**	**Migratory fish (river lamprey, sea lamprey, twaite shad, allis shad, eel, atlantic salmon, sea trout) and general fish assemblage)**	**European white fronted goose, Dunlin, Red Shank, Shelduck, Gadwall, Curlew, Pintail, Ringed Plover, Whimbrel and Internationally important assemblage of waterfowl.**
							construction of but no adverse affect to site integrity.
In-combination - Toxic contamination	No	Mixing zone of TRO during construction : 0.09% at sea bed and 0.13% at surface of estuary featre. Hydrazine 0.18 % at bed, 0.34% at surface of estuary feature.	TRO mixing zone of HPB and HPC 0.18% of feature at surface and 0.16% . Lethal concentrations 0.193 to 0.36. TRO mixing zone of HPB and HPC 0.18% at surface and 0.16% at bed. Lethal concentrations 0.193 to 0.36. Consiodered not to have an adverse effect	0.42% of feature at surface and 0.2% at bed. No adverse effect.	No	Mixing zone of TRO during construction : 0.09% at sea bed and 0.13% at surface of estuary featre. Hydrazine 0.18 % at bed, 0.34% at surface of estuary feature.	Mixing zone of TRO during construction : 0.09% at sea bed and 0.13% at surface of estuary featre. Hydrazine 0.18 % at bed, 0.34% at surface of estuary feature.
In-combination – non-toxic contamination	Negligible quantities in combination. No adverse effect.	Commisisioning: total combined loads in kg/d of BOD, ammonia, total inorganic nitrogen, and total inorganic phosphorus for these 3 discharges equate to 0.05%, 0.10%, 0.031%, and 0.19% respectively of the total loads to the Severn Estuary SAC. Operational phase, total combined loads in kg/d of BOD, ammonia, total inorganic nitrogen, and total inorganic phosphorus for these 3 discharges equate to 0.05%, 0.14%, 0.041%, and 0.28% respectively of the total loads to the Severn Estuary SAC	No	No	TRO exceedence of EQS extends over 0.2% at sea bed, 0.3% at surface. Feature has good tolerance of poor water quality conditions. No adverse effect concluded.	Dissolved Oxygen reduced by 5ug/l No indication of effect	No
In-combination - Changes in thermal regime	No	Main feature potentially affected *Macoma Balthica.* Potential temperature at mixing zones of HPB and HPC of 21.5ºC with temp differential of 2ºC. Also potential of 23ºC with a differential of 3ºC. Overlap of approx 2 years No adverse effect	Ny potential effect is from in combination of HPB and HPC. Potential temperature at mixing zones of HPB and HPC of 21.5ºC with temp differential of 2ºC. Also potential of 23ºC with a differential of 3ºC. Overlap of approx 2 years No advers effect	Sabillaria tolerant of increase in thermal regime. No advers effect. Recovery within 5-8 years after cessation of HPB.Sabillaria tolerant of increase in thermal regime. No advers effect. Recovery within 5-8 years after cessation of HPB. No adverse	Feature not sensitive to increased nutrients. Reduced DO by below 5mg/l No adverse effect concluded.	The standard requires that estuaries should not be subjected to temperature increases of >2°C across >25% of a cross section for >5% of the time	No

Potential effects	Atlantic salt meadows	Estuaries (including Rocky shore)	Inter-tidal mudflats and sandflats (including associated benthic communities)	Sub-tidal sandbanks	Reefs	Migratory fish (river lamprey, sea lamprey, twaite shad, allis shad, eel, atlantic salmon, sea trout) and general fish assemblage)	European white fronted goose, Dunlin, Red Shank, Shelduck, Gadwall, Curlew, Pintail, Ringed Plover, Whimbrel and Internationally important assemblage of waterfowl.
				effect			
In-combination – Changes in salinity	No	No	No	No	No	No	No
In-combination - Siltation and turbidity	No	The only potentially significant localised effect is the increased suspended sediments from Bristol Deep Sea Container terminal dredging. However not significant given natural variation in background levels. No adverse effect on site integrity.	No	No	Localised increases within Estuary and Bristol Channel but negligible impacts.	Negligable – conclusion of no adverse effect	Negligable – conclusion of no adverse effect
In-combination - Habitat loss and physical damage	Commercial shipping at Combwich Wharfe at construction and operation. Approx 14-15 vessels max per month. Advice and conditions for vessel movement. No adverse effect?	Actual areas of long-term habitat loss are: 0.6 ha of upper intertidal barren shingle and boulders which will be lost due to the construction of the seawall, and 0.18 ha of the subtidal area due to the intake and outfall structures	No	No	No	No	Negligable – conclusion of no adverse effect
In-combination - Disturbance	No	No	No	No	No	Negligable – conclusion of no adverse effect	Substantial detail in Section 6.11.8
In combination - Entrainment and impingement	No	Cumulative entrainment assuming HPC, HPB, Aberthaw and Oldbury combined. % per day phytoplankton =0.09% Mysid = 0.143% Copepods = 0.03% Decapods = 4% loss of annual production. *Crangon* biomass has increased over past 25 years despite existing potential effects. Conclusion of no adverse effect.	No	No	Increase of natural mortality from 9% to 9.95% of *Sabellaria alveolata* larvae. Considered negligible and therefore no adverse effect.	Substantial detail in Section 6.10.9	No

6.12.2 Environment Agency conclusion

The conclusions below reflect our findings for the Severn Estuary Natura 2000 sites and also cover any potential impacts on associated sites: River Usk/Afon Wysg SAC; River Wye/Afon Gwy SAC; River Tywi/Afon Tywi SAC. We concluded that there was no adverse effect on the integrity of the Exmoor Quantock Oakwoods SAC.

Toxic contamination

Total residual oxidant (TRO) and hydrazine in the operational discharges were above the relevant standard within the cooling water. We did not consider the resultant mixing zone for TRO to be significant, as it was restricted to small areas around the outfall diffusers. However, the maximum load for hydrazine and the potential mixing zone for this maximum load were potentially significant. For this reason, we could not rule out the potential for an adverse effect on the integrity of the Severn Estuary SAC due to the discharge of hydrazine. Therefore, the environmental permit for the operational discharges will require that hydrazine is removed from the relevant waste streams before discharge.

We concluded that the levels of all other toxic contaminants in the operational discharges from HPC would not have an adverse effect on site integrity of the SAC.

Thermal impacts

The main effect of the thermal plume from HPC on the features of the Severn Estuary SAC is the potential impact of increased water temperatures on the subtidal and intertidal benthic species, and, in particular, the bivalve *Macoma balthica*. This bivalve provides the greatest source of food in the subtidal and intertidal areas. It is also considered to be the species most at risk from increases in the temperature of seawater.

However, evidence on *Macoma balthica* and other benthic invertebrates within the mudflat area of Stert flats that are affected by the existing thermal plume from Hinkley Point B (HPB) show they are no different from those found outside the thermal plume.

This evidence supports the view that the thermal plume from HPC would have no significant effect on intertidal benthic invertebrate species. The subtidal benthic invertebrate species tends to be very limited, and is only affected by water temperatures higher than those on the intertidal area immediately near the outfall diffusers. These factors, together with the lack of any significant effect from the increased water temperatures on the intertidal mudflat area, indicate that any effect on the subtidal benthic invertebrate community will also not be significant.

We have, therefore, concluded that temperature changes due to the operational discharges from HPC would not have an adverse effect on site integrity.

Entrainment and impingement of fish and planktonic organisms

The preventative measures proposed for HPC included a low velocity intake design, acoustic fish deterrent (AFD) system and a fish recovery and return (FRR) system. We took these measures into account when calculating impingement losses from HPC. These were predicted to be similar to or less than those of the existing HPB station.

Based on the information provided in EDF's report to support the HRA, supporting technical documents and our assessments, we conclude that the predicted rates of fish impingement and entrainment at HPC should not adversely affect either the protected species, estuarine assemblage or integrity of the site.

However, given the many different factors influencing impingement and entrainment within the Severn Estuary/Bristol Channel and the reliance on the proposed preventative measures, there is still scope for potential improvements to systems to improve the predicted rates and, in turn, protect more fish.

We, therefore, consider it extremely important that the final designs of both the FRR and AFD are tested well in advance of the operation of HPC, preferably at the commissioning stage, to give enough time to reach maximum performance before operation begins.

We have advised the competent authorities (Infrastructure Planning Committee (IPC) and Marine Management Organisation (MMO)) that a comprehensive ecological monitoring and contingency plan should be developed before any water is abstracted. This would identify the measures needed to detect early and prevent any changes that may lead to environmental or ecological harm.

Disturbance to birds

The main disturbance issues are predicted to be caused by the construction of Combwich Wharf as part of the flood defence consent activity. We concluded that the Parrett Estuary next to Combwich Wharf, which is part of the Severn Estuary SAC/SPA/Ramsar, remains an important site for birds.

The data indicated that there are large numbers of birds within 250m of the wharf construction area, including three SPA qualifying species (gadwall, redshank and curlew) and three SPA listed species (wigeon, mallard and lapwing). There are also significant numbers of SPA birds in Combwich Brickpits County Wildlife Site next to Combwich Wharf, which were not included within the counts. This meant that the bird counts did not represent total counts for the whole river area. On the basis of the information provided, we were unable to conclude that there would be no adverse effect on the integrity of the site without taking preventative measures.

As it was not appropriate to implement these measures via the flood defence consenting process, we have strongly advised the competent authorities (local planning authority (LPA) and Marine Management Organisation (MMO) to make sure that further preventative measures are incorporated into the project to protect migratory birds and bird assemblage. These measures include:

- *confining piling work between April and September to avoid the winter months when birds are feeding on exposed mudflats;*
- *stopping construction in the event of severe winter weather leading to voluntary wildfowling restraint by the British Association for Shooting and Conservation (BASC) (after seven days of freezing conditions); developing a scheme for piling works before construction.*

In combination effects

The main concerns from both the combined effects of all the activities within the HPC project and also those combined with all other current activities and planned future projects in the area (in-combination assessment) were the combined HPC construction activities and the effects of the overlap period between HPC and HPB. As with the assessment of the impacts of the activities within our permissions in isolation (‘alone’ assessment), the main areas of potential concern we focused on were toxic contamination, thermal impacts, entrainment and impingement of fish and planktonic organisms. The main impacts to birds were considered to be from impact of water temperature increases on their food source within the intertidal and subtidal mudflats.

A major factor in assessing the in combination effects for the thermal discharges was the close proximity of the HPB discharge to the proposed cooling water discharge from HPC. As discussed in the alone assessment, the species most likely to be affected by the potential rise in water temperature from the combined thermal plumes from HPB and HPC is the Baltic tellin, *Macoma balthica*. However, using desk-based studies, together with comparative studies from the Gironde Estuary in France and historical data from Hinkley Point A, we have concluded that the combined thermal plume from HPB and HPC that will exist until 2023 will not compromise the conservation objectives and, therefore, will not have an adverse effect on site integrity.

We also considered the thermal effects of fish in combination in relation to direct effects and effects of thermal occlusion. Neither were considered to significantly impact on the migratory fish or fish assemblage features of the Severn Estuary SAC and Ramsar.

The in combination effects of the chemical discharges focused on the discharge of TRO from HPB and HPC, together with the discharge of hydrazine just from HPC, as HPB does not have a permit to discharge hydrazine.. As with the assessment of HPC on its own, it was not possible from the information available to conclude that the discharge of hydrazine does not have an adverse effect on the integrity of the site.

We assessed the cumulative effects of impingement and entrainment together with the in combination effects of HPB and HPC. The species that required detailed investigation included the brown shrimp, *Crangon crangon*, whiting, *Merlangius merlangus*, sprat, *Sprattus sprattus* and cod, *Gadus morhua*. Extensive desk-based studies, compared with the International Council for the Exploration of the Sea (ICES) sector allocations for this area of the Severn Estuary have shown the impacts of HPC and HPB will not have a significant effect on the species during the timeframe considered. Although, it should be noted that if the operation of HPB has to be extended further beyond 2023, then another Habitats Regulations Assessment will be needed.

There were minor in combination effects for both the Bristol Port and Environment Agency Steart Peninsula Projects and the combined construction activities.

Conclusion

This assessment has considered all relevant factors and undergone an internal peer review, as well as consultation with Natural England and Countryside Commission for Wales. As the competent authority for permits associated with this proposed site, we have concluded that:

- The maximum load for hydrazine and the potential mixing zone could potentially have a significant impact on the features of the site. Removing hydrazine from the relevant waste streams before discharge will eliminate this risk.

- Temperature increases from the discharge of cooling water create a plume of water with an increase in temperature, particularly when HPB and HPC are run at the same time. The Baltic clam, *Macoma balthica* in particular, and other benthic invertebrates found in the mudflat areas of Stert flats are the most vulnerable species. Evidence based on modelling, research into similar sites and the response of the species in the existing plume from HPB alone indicates that there would be no significant effect on these intertidal invertebrate species.

- With the site operating alone with the preventative measures of a fish recovery and return system, and an acoustic deterrent system in the design of the intake for the proposed HPC site in place, we believe that there will be no adverse effect on fish. However, given the complex nature of the estuary and the reliance on these proposed measures, the final designs should be tested at the commissioning stage of the set up, well in advance of the full operation of HPC to allow maximum performance.

- We were unable to conclude there would be no adverse effect on the birds listed in the European site designation due to disturbance (noise and visual) at the construction stage of the Combwich Wharf. To ensure migratory birds are protected, we have strongly advised the competent authorities to implement measures related to the timing of piling work and to stop work if there is severe winter weather.

The technical sections of the appropriate assessment include detailed evidence and our reasons for the conclusions above.

The table below (6.12.3) lists the conditions that the Environment Agency are able to apply within environmental permits associated with the site and avice that has been given to other relevant competent authorities.

6.12.3 Mitigation and advice table

The following summary only includes those features which required mitigation in some form.

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
Estuaries feature including Rocky Shore: 1. The extent, variety and spatial distribution of estuarine habitat communities is maintained; 2. The extent, variety, spatial distribution and community composition of notable communities is maintained; 3. The abundance of the notable estuarine species assemblages is maintained or Increased.	Water discharge permits operational: Changes to water chemistry turbidity and physical damage.	Cannot conclude no adverse effect.	EA CONDITION Prior to the commencement of any operational discharges from the waste streams B, C, and D, treatment to remove hydrazine prior to discharge shall be in place. This treatment will be a requirement of the environmental permit for the HPC operational discharges.	Environment Agency via Environmental permit
		No adverse effect.	EA CONDITION As part of post-scheme appraisal, monitoring of the thermal plume will be required within 5 years of commissioning to validate (or not) the model predictions.	Environment Agency via Environmental permit
		No adverse effect.	EA CONDITION To ensure chlorine dosing is controlled should it be required, we will ensure that a dosing regime is written up and agreed with the Environment Agency as part of a requirement under the environment permit.	Environment Agency via Environmental permit
	Water discharge permits Construction Changes to water chemistry turbidity and physical damage.	No adverse effect	EA CONDITION: Surface water drainage At least 3 months prior to commencement of Activities A-C specified in schedule 1 table S1.1, the operator shall submit to the Environment Agency a Surface Water Drainage System report following completion of detailed contractor design. The report shall include: (a) an overview of the final proposals for the surface water drainage system serving the development site; (b) output from a suitable drainage model which reflects the attenuation provided by the WMZ's and the overall hydraulic performance of the pipe network; (c) the minimum design criteria in respect of environmental protection that the contractors used in producing their detailed design, highlighting elements of the design that will ensure that the limits within table S3.1 are achieved; and (d) details of your proposals for high level overflows on the WMZ's, both within the Built Development Area (BDA) and the Southern Construction Phase Area (SCPA). The operator shall re-assess the maximum estimated flow rate through the new foreshore outfall for the 1 in 30 year return period rainfall event based on the detailed design presented.	Environment Agency via Environmental permit

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
		No adverse effect	EA CONDITION **Concrete Wash Water** At least 2 months prior to commencement of Activity F specified in schedule 1 table S1.1, the operator shall submit to the Environment Agency a Concrete Wash Water Characterisation report, which will include the following information: (a) the nature and composition of the concrete(s) used on site, including additives; (b) the characteristics of the resultant wash water, for both concrete from the off-site supplier and from the on-site batching plant(s); and (c) performance data on the proposed treatment system(s) for all relevant substances identified within the wash water. The report should (i) take into consideration those substances listed in the Environment Agency's H1 Guidance on Environmental Risk Assessment, Annex D, (ii) make clear how the information has been derived and (iii) describe any assumptions or limitations associated with preparation of the report. The Concrete Wash Water Characterisation report shall be audited by the Environment Agency and used to establish operational compliance (numeric) limits for any contaminants present in the wash water at environmentally significant levels.	Environment Agency via Environmental permit
	Sea Wall flood defence consent: (sub feature rocky shore)	Whilst it is likely that discharges would be small and diluted with the tide, we have advised the competent authorities at the Development Consent Order stage to implement the following conditions:		
	Changes to water chemistry, changes in turbidity and physical damage (smothering)	No adverse effect	ADVICE for CONDITION: No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.	National Infrastructure Directorate (Planning Inspectorate) via Development Consent Order Local Planning Authority (Environment Agency)

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
		No adverse effect	ADVICE for CONDITION No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to the Marine Management Organisation for approval.	National Infrastructure Directorate (Planning Inspectorate) Marine Management Organisation (Environment Agency)
	Combwich Wharfe re-furbishment Changes to water chemistry	No adverse effect	ADVICE for CONDITION (1) The development shall not commence until written details of the surface and foul water drainage system (including means of pollution control, culverts and future responsibility of maintenance arrangements) have, after consultation with the Environment Agency, the sewerage authority and drainage authority (Parrett Internal Drainage Board), been submitted to and approved by Sedgemoor District Council. (2) The surface and foul water drainage system shall be constructed in accordance with the approved details.	National Infrastructure Directorate (Planning Inspectorate) via Development Consent Order Local Planning Authority (Environment Agency)
		No adverse effect	ADVICE for CONDITION (1) The development shall not commence until a scheme to treat and remove suspended solids from surface water run-off during construction works has, following consultation with the Environment Agency, been submitted to and approved by Sedgemoor District Council. (2) The scheme referred to in paragraph (1) above shall be implemented as approved.	National Infrastructure Directorate (Planning Inspectorate) via Development Consent Order Marine Management Organisation (Environment Agency)
Subtidal sandbanks and Intertidal mudflats and sandflats 1. the total extent of the mudflats and sandflats feature is maintained; 2. the variety and extent of individual mudflats and sandflats communities within the site is maintained; 3. the distribution of individual mudflats and sandflats communities within the site is maintained; 4. the community composition of the	Water Discharge permits Changes to water chemistry turbidity and physical damage.	No adverse effect.	EA CONDITION: As part of post-scheme appraisal, monitoring of the Benthic communities in the sub tidal and intertidal areas of Bridgwater Bay will be required to validate (or not) the expected outcomes.	Environment Agency via environmental permit
		No adverse effect	EA CONDITION A monitoring regime for scour/erosion will be required to ensure that there is no adverse impact on the subtidal sandbanks	Environment Agency via environmental permit
		Cannot conclude no adverse effect	EA CONDITION: Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges	Environment Agency via environmental permit

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
mudflats and sandflats feature within the site is maintained.	Flood Defence Consent for Combwich Wharfe	No Adverse effect	ADVICE for CONDITION Whilst it can be agreed that the vessel wash will not cause an adverse effect on the SAC habitat we have advised the competent authority at the Development Consent Order stage to implement the following for Combwich Wharf:	National Infractructure Directorate (Planning Inspectorate) via Development Consent order
			1. Work no 8A shall not commence until a marine monitoring and contingency plan has, after consultation with the Environment Agency, Countryside Council for Wales and Natural England, been submitted to and approved by the Marine Monitoring Organisation. The monitoring and contingency plan shall include: a) A plan identifying the geographical extent of monitoring of the topography of the intertidal shore and the associated flood defences. b) Provision for the monitoring of (i) sediment type and character and (ii) changes to intertidal habitats (including changes in the type and extent of vegetation associated with those habitats) c)The identification environmental baseline information that will be collected prior to the commencement of Work no 8A d) Frequency and format of monitoring reports e) Appropriate contingency measures that will be implemented should monitoring indicate that erosion of the inter tidal and / or damage to flood defences has occurred or is likely to occur and may be attributed to NNB GenCo activities at Combwich. 2. In the preparation of the monitoring and contingency plan, the undertaker shall establish a marine technical review group to review the draft Combwich monitoring and contingency plan. 3. The Combwich marine monitoring plan shall be implemented as approved. * Work 8A = development of Combwich Wharf – HPC associated development	Marine Management Organisation via Marine Licence (Environment Agency & Natural England)
			CONDITION The Combwich marine monitoring and contingency plan shall be implemented as approved	National Infractructure Directorate (Planning Inspectorate) via Development Consent Order.

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
Atlantic Salt meadows/Saltmarsh 1. The topography of the intertidal flats and the morphology (dynamic processes sediment movement and channel migration across the flats) are maintained. 2. The zonation of Atlantic salt meadow vegetation communities and their associated transitions to other estuary habitats is maintained. 3. The total extent of Atlantic salt meadow and associated transitional vegetation communities within the site is maintained; 4.The extent and distribution of the individual Atlantic salt meadow and associated transitional vegetation communities within the site is maintained; 5 The zonation of Atlantic salt meadow vegetation communities and their associated transitions to other estuary habitats is maintained; 6.The relative abundance of the typical species of the Atlantic salt meadow and associated transitional vegetation communities is maintained; 7.The abundance of the notable species of the Atlantic salt meadow and associated transitional vegetation communities is maintained; 8. The characteristic stepped morphology of the salt marshes and associated creeks, pills, drainage ditches and pans, and the estuarine processes that enable their development, is maintained.	Flood Defence Consent for refurbishment of Combwich Wharf. 1. Changes to flow and velocity regime and changes to physical regime. 2. Physical damage/loss .	No adverse effect	ADVICE for CONDITION No development shall commence until an estuarine monitoring and contingency strategy has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation.	National Infrastructure Directorate (Planning Inspectorate)) via Development Consent order Marine Management Organisation (Environment Agency)
		. No adverse effect.	ADVICE for CONDITION No development shall commence until an estuarine monitoring and contingency strategy has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.	National Infrastructure Directorate (Planning Inspectorate)) via Development Consent order Local Planning Authority (Environment Agency)
		No adverse effect	ADVICE for CONDITION 1. Work no 8A shall not commence until a marine monitoring and contingency plan has, after consultation with the Environment Agency, Countryside Council for Wales and Natural England, been submitted to and approved by the Marine Monitoring Organisation. The monitoring and contingency plan shall include: a) A plan identifying the geographical extent of monitoring of the topography of the intertidal shore and the associated flood defences. b) Provision for the monitoring of (i) sediment type and character and (ii) changes to intertidal habitats (including changes in the type and extent of vegetation associated with those habitats) c)The identification environmental baseline information that will be collected prior to the commencement of Work no 8A d) Frequency and format of monitoring reports e) Appropriate contingency measures that will be implemented should monitoring indicate that erosion of the inter tidal and / or damage to flood defences has occurred or is likely to occur and may be attributed to NNB GenCo activities at Combwich. 2. In the preparation of the monitoring and contingency plan, the undertaker shall establish a marine technical review group to review the draft	National Infrastructure Directorate (Planning Inspectorate)) via Development Consent order Marine Management Organisation via Marine Licence (Environment Agency & Natural England)

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
			Combwich monitoring and contingency plan. 3. The Combwich marine monitoring plan shall be implemented as approved. * Work 8A = development of Combwich Wharf – HPC associated development	

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
Reefs: *Sabellaria alveolata* 1. The total extent and distribution of *Sabellaria* reef is maintained; 2. The community composition of the *Sabellaria* reef is maintained; 3. The full range of different age structures of *Sabellaria* reef are present; 4. The physical and ecological processes necessary to support *Sabellaria* reef are maintained.	Flood defence consent for Sea Wall construction . Changes to water chemistry turbidity and physical damage.	No adverse effect.	EA CONDITION As part of post-scheme appraisal, monitoring of gravel transport and gravel distribution will be required following the construction of the seawall to validate (or not) the expected outcome that gravel supply to the east of Hinkley is not affected.	Environment Agency via Environmental permit
		Whilst it is likely that discharges would be small and diluted with the tide we have advised the competent authorities that a surface/tunnel water management scheme that will manage the contaminants associated with these construction activities is required. We have advised the competent authority at the Development Consent order stage to implement the following conditions.		
		No Adverse effect	ADVICE for CONDITION: No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.	National Infrastructure Directorate (Planning Inspectorate) via Development Consent Order Local Planning Authority (Environment Agency)
		No adverse effect	ADVICE for CONDITION No development shall commence until such time as a scheme to dispose of drainage associated with the construction of the sea wall and the cooling water intake and outfall tunnels has, after consultation with the Environment Agency, been submitted to the Marine Management Organisation for approval.	National Infrastructure Directorate (Planning Inspectorate) Development Consent Order Marine Management Organisation (Environment Agency)

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
Migratory fish and fish assemblage The size of the migratory fish populations in the Severn Estuary and the rivers which drain into it, is at least maintained and is at a level that is sustainable in the long term.	Flood defence consent for refurbishment of Combwich Wharf Physical damage and disturbance	No adverse effect.	ADVICE for CONDITION No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.	National Infrastructure Directorate (Planning Inspectorate) Development Consent Order Local Planning Authority (Environment Agency)
		No adverse effect	ADVICE for CONDITION No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation. Advice includes (also applies to condition above) a) Restriction of piling techniques to daylight hours only (defined as sunrise and sunset), to ensure the migrating fish have an appropriate window of opportunity to migrate without being impacted by piling noise. b) Where possible, silent' or 'vibrational' piling methods should be used. c) Main site piling shall be carried out using soft start up techniques.	National Infrastructure Directorate (Planning Inspectorate) Development Consent Order Marine Management Organisation (Environment Agency)
	Water Discharge Permit Toxic Contamination	Cannot conclude no adverse effect for Hydrazine	EA CONDITION: Hydrazine will need to be removed prior to discharge. Treatment to remove hydrazine prior to discharge will therefore be a requirement of the environmental permit for the HPC operational discharges.	Environment Agency via environmental permit
		No adverse effect for TRO	EA CONDITION: To ensure chlorine dosing is controlled should it be required, we will ensure that a dosing regime is written up and agreed with the Environment Agency as part of a requirement under the Environmental Permit.	Environment Agency via Environmental permit

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
	Entrainment and Impingement. Operation of Hinkley C	No Adverse effect	The Environment Agency has strongly advised the following conditions for the competent authorities to implement:	
			ADVICE for CONDITION: No water abstraction should take place until a marine monitoring and contingency plan has, after consultation with the Environment Agency been submitted to and approved by the Local Planning Authority and implemented as agreed.	National Infrastructure Directorate (Planning Inspectorate) via DCO Local Planning Authority (Environment Agency
			ADVICE for CONDITION: No water abstraction should take place until a marine monitoring and contingency plan has, after consultation with the Environment Agency been submitted to and approved by the Marine Management Organisation and implemented as agreed.	National Infrastructure Directorate (Planning Inspectorate) via DCO Marine Management Organisation via Marine licence.
			ADVICE for CONDITION: No water abstraction shall occur for operational or safety purposes until the abstraction mitigation systems including the Fish Return System and Acoustic Fish deterrent system have been fully commissioned.	National Infrastructure Directorate (Planning Inspectorate) via Development Consent Order Local Planning Authority and Marine Management Organisation
			ADVICE for CONDITION: The Acoustic Fish Deterrent system is to remain in operation whenever water is being abstracted.	National Infrastructure Directorate (Planning Inspectorate) via Development Consent Order Local Planning Authority and Marine Management Organisation

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
			EA CONDITION Pre-operational measure. Prior to the commencement of commissioning (Hot Functional Testing) the Operator shall submit to the Environment Agency for approval a Commissioning Plan for AFD and FRR Systems. The Plan shall include, but not be restricted to the following: – a description of how the Operator intends to optimise the AFD and FRR systems to minimise impacts upon fish; – details of the monitoring proposed to facilitate optimisation and meet the above objective; – confirmation of the timetable associated with the AFD and FRR system commissioning; – proposals for demonstrating the effectiveness of the optimisation process to the Environment Agency prior to the start of Active Commissioning of Unit 1 (fuel loading).	Environment Agency via environmental permit Operator

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
Migratory birds and bird assemblage. 1. Aggregations of wintering European white-fronted goose, wintering dunlin, wintering redshank, wintering shelduck, gadwall, wintering ringed plover, wintering curlew, wintering pintail, wintering teal and breeding Lesser Black-backed Gull at feeding or roosting sites are not subject to significant disturbance. Internationally important assemblage of waterfowl 2. Waterfowl aggregations at feeding or roosting sites are not subject to significant disturbance.	Flood defence consent for Sea Wall construction Disturbance	We conclude that the construction of the sea wall will not cause an adverse effect on the integrity of the migratory bird and bird assemblage features designated under the Severn Estuary SPA and Ramsar as a result of disturbance. Nonetheless, we strongly advise that the competent authorities, in this case the Local Planning Authority (LPA) and Marine Management Organisation (MMO) ensure that further mitigation is incorporated in the project to ensure protection of the migratory birds and bird assemblage. These mitigation measures are:		
		No adverse effect.	ADVICE for CONDITION: Construction of the sea wall should cease in the event of severe winter weather leading to a wildfowling ban by the Secretary of State.	National Infrastructure Directorate (Planning Inspectorate) Local Planning Authority
		No adverse effect.	ADVICE for CONDITION Mitigation should be adopted to further safeguard shelduck from the barges delivering the rock for the sea wall.	National Infrastructure Directorate (Planning Inspectorate) Marine Management Organisation
	Flood defence consent for Combwich Wharf Disturbance	Unable to conclude no adverse effect on the integrity of the site without mitigation.	ADVICE for CONDITION Piling be confined to between April and September to avoid the winter months when birds are feeding on exposed mudflats; Construction should cease in the event of severe winter weather leading to voluntary wildfowling restraint by BASC (i.e. after seven days of freezing conditions).	National Infrastructure Directorate (Planning Inspectorate) Local Planning Authority
			ADVICE for CONDITION No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Local Planning Authority.	National Infrastructure Directorate (Planning Inspectorate) Local Planning Authority (Environment Agency)

Conservation Objective/Feature	Hazard and activity/permit	Conclusion in Appropriate Assessment	Advice and conditions for competent authorities	Competent Authority and mechanism
			ADVICE for CONDITION No development shall commence until a scheme for piling has, after consultation with the Environment Agency, been submitted to and approved by the Marine Management Organisation	National Infrastructure Directorate (Planning Inspectorate) Marine Management Organisation (Environment Agency)
			ADVICE for CONDITION Adaptive monitoring strategy to ensure that moulting shelduck will not be negatively affected by vessel movements to and from the temporary jetty and the refurbishment of Combwich wharf when judged in combination.	National Infrastructure Directorate (Planning Inspectorate) Marine Management Organisation
			ADVICE for CONDITION Proposed that a speed limit (relative to the water) of 4 knots (7.4km/hour) be enforced during the months June to October for vessels entering Bridgwater Bay, the Parrett Estuary or within 1 km of the temporary jetty. This will enable moulted shelduck to take avoidance action if approached by a vessel. Protocol and passage plans should be developed.,for navigation of large vessels to Combwich to formalise good practice operations.	National Infrastructure Directorate (Planning Inspectorate) Harbourmaster of Bridgwater Port

Environment Agency conclusion		
Can it be decided that the PPP will not adversely effect the integrity of the european site(s)? Yes/No (Please provide summary and explanation for answer given)		
Yes. The Environment Agency has assessed the implications for the site in view of the Conservation Obejctives and ascertained that alone and in-combination there will be no adverse effect on site integrity of the Severn Estuary SPA and SAC as long as the identified mitigation measures are put in place. Some of these mitigation requirements we are proposing to include within our draft Water Discharge Environmental Permits. For the remaining required mitigation measures that are outside our remit we have strongly advised the relevant Competent Authorities to set conditions / requirements within any permissions that they may issue to ensure that the required mitigation is put in place. This appropriate assessment was sent for consultation to Natural England and the Countryside Council for Wales. A summary of their responses and how they have been taken into consideration within this Appropriate Assessment has been included in Annex D to this document.		
Name of officer undertaking appropriate assessment:		
Signed:	Date	
Endorsed by: (team leader, if appropriate)		
Signed:	Date	

Natural England comments on appropriate assessment		
Is there agreement with the conclusion? Yes/No (Please provide summary and explanation for answer given)		
Name of: (Natural England local team manager)		

Signed:	Date	

CCW comments on appropriate assessment

Is there agreement with the conclusion? Yes/No (Please provide summary and explanation for answer given)
Name of: (CCW local team manager)

Signed:	Date	

Final appropriate assessment record

Part B: Final appropriate assessment record

Hinkley Point C Power Station Environmental Permit (Water Discharge)
Grid reference: ST 19200 47500
Date of appropriate assessment: 27 july 2012

"This is a record of the appropriate assessment required by Regulation 61 of the Conservation of Habitats and Species Regulations 2010 (SI No. 2010/490), undertaken by the Environment Agency in respect of the above plan/project/permission (PPP), in accordance with the Habitats Directive (Council Directive 92/43/EEC) Having considered that the PPP would be likely to have a significant effect on the Severn Estuary/ Môr Hafren SPA, SAC and Ramsar and that the PPP was not directly connected with or necessary to the management of the site for nature conservation, an appropriate assessment has been undertaken of the implications of the proposal in view of the site's conservation objectives.

Natural England/CCW were consulted under Regulation 61(3) on [date] and their representations, to which the Environment Agency has had regard, are attached in Annex 1. The conclusions of this appropriate assessment **are** in accordance with the advice and recommendations of Natural England/CCW.

The applicant was required to submit further information reasonably necessary for this assessment on a number of occasions details of this can be found on our public register

The site's nature conservation objectives have been taken into account, including consideration of the information supplied by CCW and Natural England. The likely effects of the proposal on the international nature conservation interests for which the site was classified or designated are summarised within this appropriate assessment

The assessment has concluded that:

The plan or project as proposed **can** be shown to have no adverse effect on the integrity of the site with the imposition of conditions within environmental permits issued by the environment agency or via other comptent authorities. These conditions/restrictions are listed in the table above.

-

Name of relevant Environment Agency manager:		
Signed:	Date	

Annex A

Habitats Directive: Form for recording likely significant effect (Stage 2)	Environment Agency

For ~~information /~~ consultation

Environment Agency Record of Assessment of Likely Significant Effect On A European Site (Stage 2). The new application for an Environmental Permit detailed below is within the Stage 1 criteria of Severn Estuary / Môr Hafren SAC, SPA and RAMSAR, and in order to progress the application a Stage 2 assessment and consultation with Natural England and Countryside Council for Wales is required.

Part A

Permitting officer to complete this section in consultation with Conservation/Ecology section and Natural England/Countryside Council for Wales (CCW)

Type of permission/activity:	Environmental permit (Water Discharge Activity)
Environment Agency reference no:	EPR/HP3228XT/A001
National grid reference:	ST 19200 47500
Site description:	Hinkley Point C new nuclear power station, Nr. Bridgwater, Somerset
Brief description of proposal:	This proposal relates to discharges during operation of Hinkley Point C (HPC) power station, which will consist of two UK-EPR reactors of the pressurised water design. The operation of HPC requires the continuous abstraction of seawater from the Severn Estuary, to provide cooling, before being discharged back to source. The abstraction will be via two tunnels with the intake heads located approximately 3km offshore. The resultant discharge of cooling water will be made approximately 1.8km offshore, via a single outfall tunnel. The non-radioactive, aqueous discharges considered in this proposal are as follows: (i) cooling water (ii) process effluent from the nuclear island*, including steam generator blowdown, and from the turbine hall drains (iii) oily water from areas where oils are used, e.g. workshops, diesel generators, transformers (iv) effluent from the production of demineralised water and (v) domestic sewage from staff welfare facilities. * The area of the power station referred to as the 'nuclear island' contains the reinforced concrete containment building, within which the primary circuit and nuclear steam supply system is located - this is the central part of the pressurised water reactor (PWR). The reactor core is housed within the reactor pressure vessel, which is connected to one of two, three or four heat transfer loops, each with its own separate steam generator and coolant pump. The UK EPR has four heat transfer loops. The main component of the discharge will be cooling water. HPC will use a direct cooling system, whereby water is abstracted from the sea,* passed once through the condensers, and discharged back to source at an elevated temperature (12.5°C above ambient under normal operating conditions). The cooling water may be

Brief description of proposal (continued)	dosed with sodium hypochlorite to control biofouling and consequently could contain total residual oxidant (TRO) and chlorinated by-products (CBPs). The maximum discharge rate of cooling water for HPC will be 134m3/s, equivalent to a maximum daily volume of 11.6 million cubic metres. Process effluents (ii) to (v) will all be diluted within the main cooling water flow prior to discharge. Their combined volume is relatively small and represents <0.1% of the total cooling water flow. Potential contaminants include substances used to control reactivity, e.g. boric acid, and to condition the various circuits by optimising pH and minimising corrosion, e.g. lithium hydroxide, ammonia, and hydrazine. Corrosion products, i.e. metals, although minimised by appropriate circuit conditioning will nonetheless be present in the discharge. A range of treatment techniques will be employed within the plant to reduce the concentration of potentially harmful substances. These techniques include filtration, demineralisation using ion exchange, degassing, evaporation and oil / water separation. The type of treatment is specific to both the origin and nature of the effluent and the required treatment objectives. Although some substances proposed for discharge under this permit application arise within the primary reactor circuit, on the 'nuclear island', radioactivity itself will be dealt with under a separate Radioactive Substances Activity permit application under EPR 2010. Discharges via the main outfall arising during commissioning (hot functional testing) and during power changes, shutdowns, outages, etc, are also considered within the application. Outages, for example, to facilitate refuelling tend to occur every 18-22 months.
European site name(s) and status:	**Severn Estuary/ Môr Hafren SAC** **Severn Estuary/ Môr Hafren SPA (or proposed SPA)** **Severn Estuary/ Môr Hafren Ramsar** **River Usk/ Afon Wysg SAC*** **River Wye/ Afon Gwy SAC*** **River Towy/ Afon Tywi SAC*** * The River Usk/ Afon Wysg SAC, River Wye/ Afon Gwy SAC and River Towy/ Afon Tywi SAC are intrinsically linked to the Severn Estuary/ Môr Hafren SAC in relation to migratory fish. It has been agreed[1] by both Natural England (NE) and the Countryside Council for Wales (CCW) that potential effects to the Rivers Usk, Wye and Towy SACs will not be directly considered as part of the assessment, but will be considered if effects arise in relation to the Severn Estuary/ Môr Hafren migratory fish feature, specifically in relation to Atlantic salmon, shad and sea lamprey.

[1] Meeting of 24 October 2011 between EA / NE/ CCW

List of interest features (relevant to this type of permission):	**Severn Estuary/ Môr Hafren Ramsar** 1.12 Estuarine & intertidal habitats (Atlantic salt meadows, estuaries, rocky shore, mudflats and sandflats not covered by seawater at low tide. 1.13 Submerged marine habitats (Sandbanks that are slightly covered by sea water all the time. 2.5 Migratory fish (river lamprey, sea lamprey, twaite shad, allis shad, eel, Atlantic salmon and sea trout). 3.6 Birds of lowland freshwaters and their margins (Gadwall (3.6), Lesser black-backed gull (3.6), Pintail (3.6), Ringed plover (3.6), Teal (3.6), Waterfowl(>20, 000) (3.6), White-fronted goose (3.6) 3.8 Birds of coastal habitats (Bewick's Swan (3.8), Waterfowl(>20, 000) (3.8) 3.9 Birds of estuarine habitats (Dunlin (3.9), Lesser black-backed gull (3.6), Redshank (3.9), Shelduck (3.9), Waterfowl(>20, 000) (3.9)) **Severn Estuary/ Môr Hafren SPA** 3.6 Birds of lowland freshwaters and their margins (Bewick's swan (3.6), Gadwall (3.6), Pochard (3.6), Shelduck (3.6), Teal (3.6), Tufted duck (3.6), Wigeon (3.6) 3.8 Birds of coastal habitats (Bewick's Swan (3.8), Curlew (3.8), Dunlin (3.8), Grey plover (3.8), Pintail (3.8), Pochard (3.8), Redshank (3.8), Ringed plover (3.8), Shelduck (3.8), Teal (3.8), Waterfowl(>20, 000) (3.8), White-fronted goose (3.8), Wigeon (3.8) 3.9 Birds of estuarine habitats (Curlew (3.9), Dunlin (3.9), Grey plover (3.9), Pintail (3.9), Pochard (3.9), Redshank (3.9), Ringed plover (3.9), Shelduck (3.9), Teal (3.9), Waterfowl(>20, 000) (3.9), Whimbrel (3.9), White-fronted goose (3.9), Wigeon (3.9)) **Severn Estuary/ Môr Hafren SAC** 1.12 Estuarine & inter-tidal habitats (Atlantic salt meadows, estuaries, rocky shore, mudflats and sandflats not covered by seawater at low tide). 1.13 Submerged marine habitats (reefs, sandbanks that are slightly covered by sea water all the time. 2.5 Migratory fish (river lamprey, sea lamprey, twaite shad)
Is this application necessary to manage the site for nature conservation?	No

What potential hazards are likely to affect the interest features (relevant to this type of permission?)

The permit application contains design and operational information and an impact assessment relating to the abstraction of sea water for direct cooling. We consider the seawater abstraction to be an inherent part of the cooling water system and therefore we have included potential hazards associated with the abstraction in the assessment below.

Sensitive interest feature:	Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary Ramsar		
1.12 Estuarine & inter-tidal habitats (Atlantic salt meadows, estuaries, mudflats, rocky shore and sandflats not covered by seawater at low tide)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
	Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
	Physical damage	**Potential exposure** due to entrainment of planktonic organisms through the cooling water system
	Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
	Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
	Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
	Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
	Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.
1.13 Submerged marine habitats (Sandbanks that are slightly covered by sea water all the time.)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
	Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
	Physical damage	**Potential exposure** due to volume and rate of water discharge
	Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
	Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
	Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
	Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
	Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:	Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary Ramsar		
2.5 Migratory fish (River lamprey, Sea lamprey, Twaite shad, Allis shad, Eel, Atlantic salmon, Sea trout and assemblage of fish)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12°C above ambient
	Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
	Physical damage (Entrainment and impingement)	**Potential exposure** due to abstraction of water for direct cooling
	Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
	Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
	Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
	Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
	pH	**No potential exposure** as the discharge will be pH neutral
	Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:		Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary Ramsar			
3.6 Birds of lowland habitats, 3.8 Birds of coastal habitats and 3.9 Birds of estuarine habitats	Internationally important populations of wintering waterfowl (199 Ramsar Criterion 3c) Bewick's swan, European white-fronted goose, Dunlin, Redshank, Shelduck, Gadwall	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12°C above ambient
		Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
		Physical damage	**No potential exposure** as the discharge will be made via a diffuser system located 1.8km offshore
		Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
		Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
		Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
		Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
		pH	**No potential exposure** as the discharge will be pH neutral
		Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:		Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary Ramsar			
	Internationally important assemblage of waterfowl (1995 Ramsar Criterion 2c, 3a and 3c) Regularly supporting in winter over 20,000 waterfowl The above species plus Ringed plover, Whimbrel, Teal, Pintail, Wigeon, Pochard, Tufted duck, Grey plover, Curlew, Spotted redshank	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
		Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
		Physical damage	**No potential exposure** as the discharge will be made via a diffuser system located 1.8km offshore
		Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
		Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
		Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
		Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
		pH	**No potential exposure** as the discharge will be pH neutral
		Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:		Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary SPA			
3.6 Birds of lowland habitats, 3.8 Birds of coastal habitats and 3.9 Birds of estuarine habitats	4.1 Internationally important populations of regularly occurring Annex 1 species (under Article 4.1 of the EU Birds Directive) Bewick's Swan	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
		Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
		Physical damage	**No potential exposure** as the discharge will be made via a diffuser system located 1.8km offshore
		Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
		Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
		Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
		Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
		pH	**No potential exposure** as the discharge will be pH neutral
		Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:		Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary SPA			
	4.2 Internationally important populations of regularly occurring migratory species European white-fronted goose, Dunlin, Redshank, Shelduck, Gadwall, Ringed Plover* Curlew* Pintail* Internationally important assemblage of waterfowl (>20,000) (under Article 4.2 of EU Birds Directive). The above species plus Wigeon, Lapwing*, Teal, Mallard*, Shoveler*, Pochard, Tufted Duck, Grey Plover, Whimbrel, spotted redshank*, (*recommended additions under the SPA review)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
		Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
		Physical damage	**No potential exposure** as the discharge will be made via a diffuser system located 1.8km offshore
		Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
		Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
		Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
		Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
		pH	**No potential exposure** as the discharge will be pH neutral
		Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works

Sensitive interest feature:	Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary/ Môr Hafren SAC		
1.12 Estuarine & inter-tidal habitats (Atlantic salt meadows, estuaries, mudflats, rocky shore and sandflats not covered by seawater at low tide)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12°C above ambient
	Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
	Physical damage	**Potential exposure** due to entrainment of planktonic organisms through the cooling water system
	Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
	Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
	Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
	Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
	Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:	Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary/ Môr Hafren SAC		
1.13 Submerged marine habitats (reefs, sandbanks that are slightly covered by sea water all the time.)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
	Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from 'nuclear island processes and from the on-site sewage treatment works
	Physical damage	**Potential exposure** due to volume and rate of water discharge
	Salinity	**No potential exposure** as no changes to salinity of water discharges compared with ambient.
	Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
	Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
	Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
	Organic loading	**Potential exposure** due to releases from 'nuclear island' processes and the on-site sewage treatment works.

Sensitive interest feature:	Potential hazard:	Potential exposure to hazard and mechanism of effect/impact if known:
Severn Estuary/ Môr Hafren SAC		
2.5 Migratory fish (River lamprey, Sea lamprey, Twaite shad)	Changes in thermal regime	**Potential exposure** due to discharge of cooling water at up to +12^{o}C above ambient
	Nutrient enrichment	**Potential exposure** due to releases of nitrates and phosphates from ‘nuclear island processes and from the on-site sewage treatment works
	Physical damage (Entrainment and impingement)	**Potential exposure** due to abstraction of water for direct cooling
	Salinity	**No potential exposure** as no change to salinity of water discharges compared with ambient.
	Siltation	**No potential exposure** as no net change to sediment concentrations in discharge compared with ambient.
	Toxic contamination	**Potential exposure** due to presence of biocide and other contaminants, e.g. hydrazine, metals, within discharged water
	Turbidity	**No potential exposure** no net change to turbidity of discharge compared with ambient.
	pH	**No potential exposure** as the discharge will be pH neutral
	Organic loading	**Potential exposure** due to releases from ‘nuclear island’ processes and the on-site sewage treatment works.

Is the potential scale or magnitude of any effect likely to be significant?	
Alone?	Yes – particularly with respect to impacts resulting from (a) the thermal and chemical changes in the receiving water due to proposed discharges and (b) the impacts on fish assemblage due to the abstraction of water for direct cooling.
In combination with other Environment Agency permissions, plans or projects?	Yes – as above
In combination with permissions, plans or projects with competent authorities? **! Important** Use 202_04 Habitats Directive: Standard letter for consulting about new PPP for consulting about new PPP.	Yes – as above As a result of this risk assessment, the Environment Agency can conclude that this permit application could act either alone or in combination with permissions and/or plans/projects of other competent authorities to produce a Likely Significant Effect on the Severn Estuary Ramsar, SAC and SPA. Consultation is being undertaken and an appropriate assessment will be made in Stage 3.
Conclusion: **Is there likely to be a significant effect 'alone and/or in combination' on a European site?**	As a result of this risk assessment, the Environment Agency can conclude that this permit application could act either alone or in combination with permissions and/or plans/projects of other competent authorities to produce a Likely Significant Effect on the Severn Estuary Ramsar, SAC and SPA. Consultation is being undertaken and an appropriate assessment will be made in Stage 3.
EA Officer:	Senior Permitting Officer Nuclear New Build — Date: 23 January 2012
Natural England/CCW comment on assessment:	Based on the information provided within the assessment, Natural England agrees with the EA's conclusion that there is likely to be a significant effect from the proposal either alone or in combination with permissions and/or plans/projects of other competent authorities. An appropriate assessment is necessary.
Natural England/CCW Officer:	Glen Gillespie Senior Land Use Adviser — Date: 20th February 2012
If there is a likely significant effect, an appropriate assessment will be required (see part B for suggested scope).	

Part B Suggested scope of the EA appropriate assessment:		
Add details to following framework • Other competent authorities involved • Characterise the site in relation to the qualifying features and their conservation objectives; - existing information - additional surveys - management/unauthorised impacts • Detailed description of plan/project • Assess each likely impact on the interest features; - compare with historical data - predict impacts - compare with impact from management/unauthorised activities • Determine the extent to which each possible impact can be avoided.		
Natural England comment on scope of EA appropriate assessment: Natural England is currently involved in detailed discussions with the EA with regards to the scope of its appropriate assessment.		
Natural England Officer:	Glen Gillespie Senior Land Use Adviser	Date: 20th February 2012

Annex B

Annex B Predicted impacts of abstraction for HPB and HPC on migratory fish.

Species	HPC estimated annual impact with EAV, AFD/low velocity intake and FRR		HPB estimated annual impact numbers (EAV)	HPB plus HPC annual impact		Change over HPB (HPB plus HPC at 100%)	Change over HPB (HPC alone)	Comparable data on population estimates in the Severn Estuary / Bristol Channel (Spawning Stock Biomass (SSB) & local fishery (lf))		Percentage of population estimate HPB plus HPC		
	No. of fish	(t)	No. of fish	No. of fish	(t)	(%)	(%)	Local fishery (t)	SSB (t) or fish numbers	% tage of Local fishery (%)(t)	%tage of SSB (%)(t)	%tage of Populat i-on (%)
Sprat	405,702	3.16	936,386	1,342,088	7.3	43.3	-57.0	0.19	N/A	**2632**	**N/A**	
Whiting	64,818	11.50	79,253	144,071	14	81.8	-18.0	33.5	1,724	**41.8**	**0.8**	
Dover sole	5,448	1.24	8,559	14,007	1.95	63.7	-36.0	263	3,240	**0.74**	**0.06**	
Cod	527	2.30	638	1,165	5.1	82.6	-17.0	25.2	975	**20.2**	**0.52**	
Herring	2,240	0.28	12,570	14,810	1.57	17.8	-82.0	119.4		**1.3**	**N/A**	
Plaice	83	0.04	129	212	0.06	64.3	-36.0	84	952	**0.07**	**0.01**	
Blue whiting	36	0.01	46	82	0.01	78.3	-22.0	37,900	5,360,000	**0.00**	**0.00**	
Eel	261	0.08	351	612	0.1	74.4	-26.0	26	133.4	**0.39**	**0.08**	
Twaite shad	273	Not available	646	919		42.3	-58.0		100,000			**0.92**
Allis shad	8	Not available	22	30		36.4	-63.0		100,000			**0.03**
Sea lamprey	41	Not available	42	83		97.6	-3.0		15,269			**0.54**
River lamprey	16	Not available	18	34		88.9	-9.0		116,109			**0.03**
Salmon	0	Not available	0	0		0.0	0.0		0			**0.00**
Sea trout	0	Not available	0	0		0.0	0.0		0			**0.00**

Annex C

Table A1

Waste Stream A (Post Schedule 5)   Return of Abstracted Cooling Water

Flow m3/s	**Max Daily Flow (m3/s)**	**Average Daily Flow (m3/s)**	**Min Daily Flow (m3/s)**	**Min Flow used for dilution of other waste streams (taken to be as if one EPR running) (m3/s)**		**Max Volume (m3/day)**	**Maximum Annual Volume (m3/year)**
	134	125	116	60.4		11,700,000	4,270,500,000
Contaminants	**ΔT deg C based on Max Flow**	**ΔT deg C based on Mean Flow**	**ΔT deg C based on Min Flow**				
Temperature Differential (ΔT deg C)	10.7	11.6	12.5				
	Annual Load kg/yr	**Max Conc in Effluent µg/l**					
TRO (from chlorination if used)		200					

Table A2

Combined Streams B and C (Post Schedule 5) **Effluent from Primary Circuit and blowdown from the Secondary Circuit**

Flow m3/s	Average Daily Flow (m3/s)	Max Volume (m3//day)
	0.035	1500

Note: Max Volume is based on the discharge from 2 tanks, each of 750 m3

Note: Average Daily Flow is based on one tank of 750 m3/s being discharged over 6 hours

Contaminants	Annual Load (kg/yr)	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge over 12 hrs per day (µg/l)	Max Daily Load (kg/day)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge over 12 hrs per day (µg/l)
Boric Acid	14000.00	25570.78	3.83	7.65	5625.00	3750000.00	1077.88	2155.77
Boron	2448.00	4471.23	0.67	1.34	984.00	656000.00	188.56	377.12
Lithium hydroxide	8.73	15.95	0.00	0.00	4.40	2933.33	0.84	1.69
Hydrazine	3.00	5.48	0.00	0.00	1.00	666.67	0.19	0.38
Morpholine	210.00	383.56	0.06	0.11	75.00	50000.00	14.37	28.74
Ethanolamine	65.00	118.72	0.02	0.04	15.00	10000.00	2.87	5.75
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)	10.00	18.26	0.00	0.01	8.00	5333.33	1.53	3.07
Total Ammonia as N (assuming all nitrogen as N is ammonia)	10.00	18.26	0.00	0.01	8.00	5333.33	1.53	3.07
Nitrogen as N (total) based on total of N in all compounds containing N	61.34	112.03	0.02	0.03	24.39	16257.73	4.67	9.35
Phosphates (as P)	196.48	358.86	0.05	0.11	48.92	32610.00	9.37	18.75
Detergents	3200.00	5844.75	0.87	1.75	270.00	180000.00	51.74	103.48
Suspended Solids	134.96	246.50	0.04	0.07	20.24	13493.33	3.88	7.76
COD	600.95	1097.63	0.16	0.33	39.27	26180.00	7.53	15.05
Aluminium	0.41	0.75	0.00	0.00	0.09	60.00	0.02	0.03
Copper	0.03	0.05	0.00	0.00	0.01	6.67	0.00	0.00
Chromium	0.65	1.19	0.00	0.00	0.14	93.33	0.03	0.05
Iron	2.70	4.93	0.00	0.00	0.60	400.00	0.11	0.23
Manganese	0.26	0.47	0.00	0.00	0.06	40.00	0.01	0.02
Nickel	0.03	0.05	0.00	0.00	0.01	6.67	0.00	0.00
Lead	0.02	0.04	0.00	0.00	0.01	6.67	0.00	0.00
Zinc	0.46	0.84	0.00	0.00	0.10	66.67	0.02	0.04

Table A3

Waste Stream D (Post Schedule 5) **Effluent from the Turbine Hall and uncontrolled floor drains (but not blowdown from the secondary circuit)**

Flow m3/s	**Average Daily Flow (m3/s)**	**Max Volume (m3//day)**
	0.035	1500

Note: Max Volume is based on the discharge fron 2 tanks, each of 750 m3
Note: Average Daily Flow is based on one tank of 750 m3/s being discharged over 6 hours

Contaminants	**Annual Load (kg/yr)**	**Average Conc in Effluent (µg/l)**	**Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge continuous over 24 hrs (µg/l)**	**Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge over 12 hrs per day (µg/l)**	**Max Daily Load (kg/day)**	**Max Conc in Effluent (µg/l)**	**Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)**	**Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge over 12 hrs per day (µg/l)**
Boric Acid	0.00				0.00			
Boron	0.00				0.00			
Lithium hydroxide	0.00				0.00			
Hydrazine	24.30	88.77	0.01	0.01	3.00	2000.00	0.57	1.15
Morpholine	1464.00	5347.95	0.40	0.80	17.25	11500.00	3.31	6.61
Ethanolamine	854.00	3119.63	0.23	0.47	9.75	6500.00	1.87	3.74
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)	10120.00	36968.04	2.77	5.53	320.00	213333.33	61.32	122.64
Total Ammonia as N	10120.00	36968.04	2.77	5.53	55.46	36973.33	10.63	21.25
Nitrogen as N (total) based on total of N in all compounds containing N	10572.90	38622.47	2.89	5.78	327.64	218426.28	62.78	125.57
Phosphates (as P)	66.00	241.10	0.02	0.04	66.00	44000.00	12.65	25.29
Detergents	0.00				0.00			
Suspended Solids	2665.00	9735.16	0.73	1.46	399.80	266533.33	76.61	153.22
COD	4449.00	16252.05	1.22	2.43	290.70	193800.00	55.71	111.41
Aluminium	4.85	17.72	0.00	0.00	1.01	673.33	0.19	0.39
Copper	0.39	1.42	0.00	0.00	0.07	49.33	0.01	0.03
Chromium	7.72	28.20	0.00	0.00	1.56	1040.00	0.30	0.60
Iron	32.27	117.88	0.01	0.02	6.55	4366.67	1.26	2.51
Manganese	3.07	11.21	0.00	0.00	0.61	406.67	0.12	0.23
Nickel	0.41	1.50	0.00	0.00	0.08	55.33	0.02	0.03
Lead	0.28	1.02	0.00	0.00	0.06	36.67	0.01	0.02
Zinc	5.54	20.24	0.00	0.00	1.10	733.33	0.21	0.42

Table A4

Combined Waste Streams B & C & D **Effluent from Primary Circuit and blowdown from the Secondary Circuit and the Turbine Hall**

Flow m3/s	Average Daily Flow (m3/s)	Max Volume (m3//day)
	0.035	1500

Note: Max Volume is based on the discharge fron 2 tanks, each of 750 m3
Note: Average Daily Flow is based on one tank of 750 m3/s being discharged over 6 hours

Contaminants	Annual Load (kg/yr)	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge over 12 hrs per day (µg/l)	Max Daily Load (kg/day)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge over 12 hrs per day (µg/l)
Boric Acid	14000.00	51141.55	3.83	7.65	5625.00	3750000.00	1077.88	2155.77
Boron	2448.00	8942.47	0.67	1.34	984.00	656000.00	188.56	377.12
Lithium hydroxide	8.73	31.89	0.00	0.00	4.40	2933.33	0.84	1.69
Hydrazine	27.30	99.73	0.01	0.01	4.00	2666.67	0.77	1.53
Morpholine	1674.00	6115.07	0.46	0.92	92.25	61500.00	17.68	35.35
Ethanolamine	919.00	3357.08	0.25	0.50	24.75	16500.00	4.74	9.49
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)	10130.00	37004.57	2.77	5.54	328.00	218666.67	62.85	125.71
Total Ammonia as N	10130.00	37004.57	2.77	5.54	63.46	42306.67	12.16	24.32
Nitrogen as N (total) based on total of N in all compounds containing N	10634.24	38846.54	2.91	5.81	352.03	234684.02	67.46	134.91
Phosphates (as P)	262.48	958.83	0.07	0.14	114.92	76610.00	22.02	44.04
Detergents	3200.00	11689.50	0.87	1.75	270.00	180000.00	51.74	103.48
Suspended Solids	2799.96	10228.16	0.77	1.53	420.04	280026.67	80.49	160.98
COD	5049.95	18447.31	1.38	2.76	329.97	219980.00	63.23	126.46
Aluminium	5.26	19.21	0.001	0.003	1.10	733.33	0.211	0.422
Copper	0.42	1.53	0.000	0.000	0.08	56.00	0.016	0.032
Chromium	8.37	30.58	0.002	0.005	1.70	1133.33	0.326	0.652
Iron	34.97	127.74	0.010	0.019	7.15	4766.67	1.370	2.740
Manganese	3.33	12.16	0.001	0.002	0.67	446.67	0.128	0.257
Nickel	0.44	1.61	0.000	0.000	0.09	62.00	0.018	0.036
Lead	0.30	1.10	0.000	0.000	0.07	46.67	0.013	0.027
Zinc	6.00	21.92	0.002	0.003	1.20	800.00	0.230	0.460
Cadmium	0.37	1.35	0.0001	0.0002	0.005	3.33	0.0010	0.0019
Mercury	0.099	0.36	0.0000	0.0001	0.0011	0.73	0.0002	0.0004

Table A5

Waste Stream E Effluent from areas potentially containing oils and hydrocarbons

Flow m3/s	Max Daily Flow (m3/s)	Max Volume (m3//day)
	0.0028	240

Note: Max Daily Flow is based on max volume being discharged over 24 hours

Contaminants	Annual Load kg/yr	Average Conc in Effluent µg/l		Max Daily Load kg/day	Max Conc in Effluent µg/l	Max Conc in Effluent following dilution of max conc in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)
Oils					5000	0.083

Table A6

Waste Stream F **Effluent from the production of demineralised water**

Flow m3/s	Max Daily Flow (m3/s)	Max Volume (m3//day)
	0.046	4000

Note: Max Daily Flow is based on max volume being discharged over 24 hours

Contaminants	Annual Load (kg/yr)	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	Max Daily Load (kg/day)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)
Detergents	624.00	854.79	0.17	nd	nd	
Sulphates	98400.00	134794.52	26.90	2000.00	500000.00	383.25
Sodium	52400.00	71780.82	14.32	855.00	213750.00	163.84
Amino tri-methylene phosphonic acid (ATMP)	9100.00	12465.75	2.49	45.00	11250.00	8.62
Hydroxy Ethylidene Diphosphonic Acid (HEDP)	890.00	1219.18	0.24	4.50	1125.00	0.86
Acetic Acid	14.00	19.18	0.00	0.10	25.00	0.02
Phosphoric Acid	12.00	16.44	0.00	0.10	25.00	0.02
Sodium Polyacrylate	8030.00	11000.00	2.20	40.00	10000.00	7.66
Acrylic acid	165.00	226.03	0.05	1.00	250.00	0.19
Iron	46000.00	63013.70	12.57	250.00	62500.00	47.91
Suspended solids	88000.00	120547.95	24.06	450.00	112500.00	86.23
Chloride	87100.00	119315.07	23.81	450.00	112500.00	86.23
Total P (as P) As a sum of all inputs, based on the proportion of P in the P-containing compounds	3559.84	4876.49	0.97	17.65	4411.49	3.38

Table A7

Waste Stream G **Effluent from Site STW**

Flow m3/s	Max Daily Flow (m3/s)	Max Volume (m3//day)
	0.002	175

Note: Max Daily Flow is based on max volume being discharged over 24 hours

Contaminants	Annual Load (kg/yr)	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution in CW flow of 116 m3/s (µg/l)	Max Daily Load (kg/day)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution in CW flow of 60.4 m3/s (µg/l)
Total Ammonia (as N)	1278.00	20007.83	0.35	3.50	20000.00	0.67
Suspended Solids	1916.00	29996.09	0.52	5.30	30267.03	1.01
BOD	1278.00	20007.83	0.35	3.50	20000.00	0.67
Nitrogen (as N) from permit application	1278.00	20007.83	0.35	4.00	22833.75	0.77
Assumed Total Inorganic Nitrogen (as N) based on a concentration in the discharge of 30 mg/l	1916.25	30000.00	0.52	5.25	30000.00	1.01
Phosphate (as P) based on per capita daily load of 0.6522 g	416.60	6522.11	0.11	1.14	6522.11	0.22

Table B1 Target Values for Potential Contaminants

Discharge	Potential contaminants	EQS	EQS	PNEC	PNEC	Other Targets WFD Good standard			Habitats Directive WQ TAG Guidelines		Operational Target
		AA µg/l	MAC µg/l	Chronic µg/l	Acute µg/l	AA µg/l	95%ile µg/l	5%ile mg/l	If different to other standards/targets		MAC µg/l
Waste Stream A	Excess Temperature					3 ºC uplift over background	23 ºC as 98%ile		2 ºC uplift over background	21.5 ºC as 98%ile for SAC, 28 ºC as 98%ile for SPA	
	Total Residual Oxidant						10				
	Chlorination by-products										
	Chloroform	2.5 T	N/A								
	Bromoform			9.6 T	70 T						
	Dibromoacetonitrile										
Waste Streams B, C, & D	Boron	7000 T		180	4000						
	Lithium										
	Phosphate										
	Detergents										
	COD							5.0 - (0.028*salinity) as DO conc	6.0 - (0.028*salinity) as DO conc		
	Hydrazine			0.0004	0.004						
	Morpholine			17	28						
	Ethanolamine			16	16						
	Copper					5 D					
	Chromium	15 D				0.6 D	32 D				
	Nickel	20 D	N/A								
	Iron					1000 D					
	Manganese										
	Aluminium								1000 T		1000 T
	Lead	7.2 D	N/A								
	Zinc					40 D					
	Ammonia					21 UIA			1100 Total as AA	8000 Total as MAC	
	Nitrate					Varies with turbidity for both coastal and transitional waters - see Annex 1 below					
	Phosphate										
	Acetates										
	Formates										
	Glycolates										
	Oxalates										
	Suspended Sediments										

Target Values for Potential Contaminants cont

Discharge	Potential contaminants					Other Targets					
		EQS	EQS	PNEC	PNEC	WFD Good standard			Habitats Directive WQ TAG Guidelines		Operational Target
		AA µg/l	MAC µg/l	Chronic µg/l	Acute µg/l	AA µg/l	95%ile µg/l	5%ile mg/l	If different to other standards/targets		MAC µg/l
Waste Stream E	Oils/hydrocarbons										
Waste Stream F	Cadmium	0.2 D	0.9 D								
	Mercury	0.05 D	0.07 D								
	Detergents										
	Sulphate	N/A	N/A								
	Sodium	N/A	N/A								
	Amino tri-methylene phosphonic acid (ATMP)										
	Hydroxy Ethylidene Diphosphonic Acid (HEDP)										
	Acetic Acid										
	Phosphoric Acid										
	Sodium Polyacrylate										
	Acrylic acid										
	Iron					1000 D					
	Suspended Solids										
	Chloride	N/A	N/A								
	Phosphate										
Waste Stream G	BOD							5.0 - (0.028*salinity) as DO conc	6.0 - (0.028*salinity) as DO conc		
	SS										
	Ammonia					21 UIA					
	Nitrate					Varies with turbidity for both coastal and transitional waters - see Annex1 below					
	Phosphate										

Annex `1

Dissolved Inorganic Nitrogen Concentrations (in µg/l) at a mean salinity of 32 for coastal waters and 25 for transitional waters for the period 1st Nov to 28th Feb.	Coastal waters	Mean	99%ile	Transitional waters	Mean	99%ile
	Clear	252		Clear	420	
	Intermediate turbidity		980	Intermediate turbidity		980
	Medium turbidity		2520	Medium turbidity		2520
	Very turbid		3780	Very turbid		3780

Note Turbidity types are related to the annual mean concentrations of suspended particulate matter in mg/l

Very turbid	> 300
Medium turbidity	100 to 300
Intermediate turbidity	10 to <100
Clear	< 10

Table C1

Waste Stream A (Post Schedule 5)   Return of Abstracted Cooling Water

Contaminants	**ΔT deg C based on Max Flow**	**ΔT deg C based on Mean Flow**	**ΔT deg C based on Min Flow**	**Habitats Directive WQ TAG Guidelines – SAC: Deviation from ambient**	**SAC: Maximum temperature**	**SPA: Deviation from ambient**	**SPA: Maximum temperature**	**Mean Background Concentrations in µg/l or Values**	**Max Background Concentrations in µg/l or Values**
Temperature Differential (ΔT deg C) over ambient temperature	10.7	11.6	12.5	2°C as a Maximum Allowable Concentration (MAC) at the edge of the mixing zone	21.5°C as a 98 percentile at the edge of the mixing zone	2°C as a MAC at the edge of the mixing zone	28°C as a 98 percentile at the edge of the mixing zone	12.6 deg C as mean of annual means (whole years data only)	20.4 deg C as 98%ile of monthly means from CEFAS Data (whole years only)

	Annual Load kg/yr	**Max Conc in Effluent µg/l**			**EQS or Target (µg/l)**	**Mean Background Concentrations in µg/l or Values**	**Max Background Concentrations in µg/l or Values**
TRO (from chlorination if used)		200			10 T as a 95%ile	No Data	No Data
Chlorination by-products							
Chloroform					2.5 T as AA	< 1	< 1
Bromoform					9.6 T as Chronic PNEC	< 1	< 1
Dibromoacetonitrile					??	< 1	< 1

Notes:
D is Dissolved
T is Total
AA is Annual Average
MAC is Maximum Allowable Concentration
PNEC is Probable No Effects Concentration

Table C2

Combined Streams B and C (Post Schedule 5) **Effluent from Primary Circuit and blowdown from the Secondary Circuit**

Contaminants	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge over 12 hrs per day (µg/l)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge over 12 hrs per day (µg/l)	EQS or Target (µg/l)		Mean Background Concentrations (µg/l)	Max Background Concentrations (µg/l)
Boric Acid	25570.78	7.65	3750000.00	2155.77				
Boron	4471.23	1.34	656000.00	377.12	7000 T		4059	7173
Lithium hydroxide	15.95	0.00	2933.33	1.69			114 D	184 D
Hydrazine	5.48	0.00	666.67	0.38	0.0004 as chronic PNEC	0.004 as acute PNEC	< 100	< 100
Morpholine	383.56	0.11	50000.00	28.74	17 as chronic PNEC	28 as acute PNEC	< 10	< 10
Ethanolamine	118.72	0.04	10000.00	5.75	16 as chronic PNEC	16 as acute PNEC	< 10	< 10
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)	18.26	0.01	5333.33	3.07			849	1556
Total Ammonia as N (assuming all nitrogen as N is ammonia)	18.26	0.01	5333.33	3.07	1100 T as AA	8000 T as MAC	160 T[a]	580 T[a]
Nitrogen as N (total) based on total of N in all compounds containing N	112.03	0.03	16257.73	9.35			849	1556
Phosphates (as P)	358.75	0.11	32610.00	18.75			30	140
Detergents	5844.75	1.75	180000.00	103.48			< 100	< 100
Suspended Solids	246.50	0.07	13493.33	7.76			264000	1795000
COD	1097.63	0.33	26180.00	15.05			14100	169000
Aluminium	0.75	0.00	60.00	0.03	1000 T as MAC		22.8 D	240 D
Copper	0.05	0.00	6.67	0.00	5 D as AA		3.95 D	14.1 D
Chromium	1.19	0.00	93.33	0.05	15 D as AA		0.02 D	1.20 D
Iron	4.93	0.00	400.00	0.23	1000 D as AA		13.5 D	80.0 D
Manganese	0.47	0.00	40.00	0.02			3.51 D	19.3 D
Nickel	0.05	0.00	6.67	0.00	20 D as AA		0.19 D	3.94 D
Lead	0.04	0.00	6.67	0.00	7.2 D as AA		0.02 D	1.46 D
Zinc	0.84	0.00	66.67	0.04	40 D as AA		39.3 T	54.0 T

Notes:
D is Dissolved
T is Total
AA is Annual Average
MAC is Maximum Allowable Concentration
PNEC is Probable No Effects Concentration
T[a] is Total Ammonia as NH3

Table C3

Waste Stream D (Post Schedule 5) **Effluent from the Turbine Hall and uncontrolled floor drains (but not blowdown from the secondary circuit)**

Contaminants	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge over 12 hrs per day (µg/l)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge over 12 hrs per day (µg/l)	EQS or Target (µg/l)		Mean Background Concentrations (µg/l)	Max Background Concentrations (µg/l)
Boric Acid								
Boron					7000 T		4059	7173
Lithium hydroxide							114 D	184 D
Hydrazine	88.77	0.01	2000.00	1.15	0.0004 as chronic PNEC	0.004 as acute PNEC	< 100	< 100
Morpholine	5347.95	0.80	11500.00	6.61	17 as chronic PNEC	28 as acute PNEC	< 10	< 10
Ethanolamine	3119.63	0.47	6500.00	3.74	16 as chronic PNEC	16 as acute PNEC	< 10	< 10
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)	36968.04	5.53	213333.33	122.64			849	1556
Total Ammonia as N	36968.04	5.53	36973.33	21.25	1100 T as AA	8000 T as MAC	160 T[a]	580 T[a]
Nitrogen as N (total) based on total of N in all compounds containing N	38622.47	5.78	218426.28	125.57			849	1556
Phosphates (as P)	241.10	0.04	44000.00	25.29			30	140
Detergents							< 100	< 100
Suspended Solids	9735.16	1.46	266533.33	153.22			264000	1795000
COD	16252.05	2.43	193800.00	111.41			14100	169000
Aluminium	17.72	0.00	673.33	0.39	1000 T as MAC		22.8 D	240 D
Copper	1.42	0.00	49.33	0.03	5 D as AA		3.95 D	14.1 D
Chromium	28.20	0.00	1040.00	0.60	15 D as AA		0.02 D	1.20 D
Iron	117.88	0.02	4366.67	2.51	1000 D as AA		13.5 D	80.0 D
Manganese	11.21	0.00	406.67	0.23			3.51 D	19.3 D
Nickel	1.50	0.00	55.33	0.03	20 D as AA		0.19 D	3.94 D
Lead	1.02	0.00	36.67	0.02	7.2 D as AA		0.02 D	1.46 D
Zinc	20.24	0.00	733.33	0.42	40 D as AA		39.3 T	54.0 T

Notes:
D is Dissolved
T is Total
AA is Annual Average
MAC is Maximum Allowable Concentration
PNEC is Probable No Effects Concentration
T[a] is Total Ammonia as NH3

Table C4

Combined Waste Streams B & C & D (Post Schedule 5)

Effluent from Primary Circuit and blowdown from the Secondary Circuit and the Turbine Hall

Contaminants	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge over 12 hrs per day (µg/l)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge over 12 hrs per day (µg/l)	EQS or Target (µg/l)		Mean Background Concentrations (µg/l)	Max Background Concentrations (µg/l)
Boric Acid	51141.55	7.65	3750000.00	2155.77				
Boron	8942.47	1.34	656000.00	377.12	7000 T		4059	7173
Lithium hydroxide	31.89	0.00	2933.33	1.69			114 D	184 D
Hydrazine	99.73	0.01	2666.67	1.53	0.0004 as chronic PNEC	0.004 as acute PNEC	< 100	< 100
Morpholine	6115.07	0.92	61500.00	35.35	17 as chronic PNEC	28 as acute PNEC	< 10	< 10
Ethanolamine	3357.08	0.50	16500.00	9.49	16 as chronic PNEC	16 as acute PNEC	< 10	< 10
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)	37004.57	5.54	218666.67	125.71			849	1556
Total Ammonia as N	37004.57	5.54	42306.67	24.32	1100 T as AA	8000 T as MAC	160 T[a]	580 T[a]
Nitrogen as N (total) based on total of N in all compounds containing N	38846.54	5.81	234684.02	134.91			849	1556
Phosphates (as P)	958.83	0.14	76610.00	44.04			30	140
Detergents	11689.50	1.75	180000.00	103.48			< 100	< 100
Suspended Solids	10228.16	1.53	280026.67	160.98			264000	1795000
COD	18447.31	2.76	219980.00	126.46			14100	169000
Aluminium	19.21	0.003	733.33	0.422	1000 T as MAC		22.8 D	240 D
Copper	1.53	0.000	56.00	0.032	5 D as AA		3.95 D	14.1 D
Chromium	30.58	0.005	1133.33	0.652	15 D as AA		0.02 D	1.20 D
Iron	127.74	0.019	4766.67	2.740	1000 D as AA		13.5 D	80.0 D
Manganese	12.16	0.002	446.67	0.257			3.51 D	19.3 D
Nickel	1.61	0.000	62.00	0.036	20 D as AA		0.19 D	3.94 D
Lead	1.10	0.000	46.67	0.027	7.2 D as AA		0.02 D	1.46 D
Zinc	21.92	0.003	800.00	0.460	40 D as AA		39.3 T	54.0 T
Cadmium	1.35	0.0002	3.33	0.0019	0.2 D as AA	0.9 D as MAC	< 1	< 1
Mercury	0.36	0.0001	0.73	0.0004	0.05 D as AA	0.07 D as MAC	0.02	1.94

Notes:
D is Dissolved
T is Total
AA is Annual Average
MAC is Maximum Allowable Concentration
PNEC is Probable No Effects Concentration
T[a] is Total Ammonia as NH3

Table C5

Waste Stream E **Effluent from areas potentially containing oils and hydrocarbons**

Contaminants	Average Conc in Effluent (µg/l)		Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max conc in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	EQS or Target (µg/l)	Mean Background Concentrations (µg/l)	Max Background Concentrations (µg/l)
Oils			5000	0.083		< 10	< 10

Table C6

Waste Stream F **Effluent from the production of demineralised water**

Contaminants	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution of annual load in CW flow of 116 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution of max daily load in CW flow of 60.4 m3/s. Effluent discharge continuous over 24 hrs (µg/l)	EQS or Target (µg/l)	Mean Background Concentrations (µg/l)	Max Background Concentrations (µg/l)
Detergents	854.79	0.17	nd			< 100	< 100
Sulphates	134794.52	26.90	500000.00	383.25		1924000.00	2960000.00
Sodium	71780.82	14.32	213750.00	163.84		8545000.00	16070000.00
Amino tri-methylene phosphonic acid (ATMP)	12465.75	2.49	11250.00	8.62			
Hydroxy Ethylidene Diphosphonic Acid (HEDP)	1219.18	0.24	1125.00	0.86			
Acetic Acid	19.18	0.00	25.00	0.02			
Phosphoric Acid	16.44	0.00	25.00	0.02			
Sodium Polyacrylate	11000.00	2.20	10000.00	7.66			
Acrylic acid	226.03	0.05	250.00	0.19			
Iron	63013.70	12.57	62500.00	47.91	1000 D as AA	13.5 D	80.0 D
Suspended solids	120547.95	24.05	112500.00	86.23		264000.00	1795000.00
Chloride	119315.07	23.81	112500.00	86.23		14275000.00	20251000.00
Total P (as P) As a sum of all inputs, based on the proportion of P in the P-containing compounds	4876.49	0.97	4411.49	3.38		30.00	140.00

Notes:
D is Dissolved
T is Total
AA is Annual Average
MAC is Maximum Allowable Concentration
PNEC is Probable No Effects Concentration

Table C7

Waste Stream G **Effluent from Site STW**

Contaminants	Average Conc in Effluent (µg/l)	Average Conc in Effluent following dilution in CW flow of 116 m3/s (µg/l)	Max Conc in Effluent (µg/l)	Max Conc in Effluent following dilution in CW flow of 60.4 m3/s (µg/l)	EQS or Target (µg/l)		Mean Background Concentrations (µg/l)	Max Background Concentrations (µg/l)
Total Ammonia (as N)	20007.83	0.35	20000.00	0.67	1100 T as AA	8000 T as MAC	160 T[a]	580 T[a]
Suspended Solids	29996.09	0.52	30267.03	1.01			264000	1795000
BOD	20007.83	0.35	20000.00	0.67			1200	14400
Nitrogen (as N) from permit application	20007.83	0.35	22833.75	0.77			849	1556
Assumed Total Inorganic Nitrogen (as N) based on a concentration in the discharge of 30 mg/l	30000.00	0.52	30000.00	1.01			849	1556
Phosphate (as P) based on per capita daily load of 0.6522 g	6522.11	0.11	6522.11	0.22			30	140

Notes:
D is Dissolved
T is Total
AA is Annual Average
MAC is Maximum Allowable Concentration
PNEC is Probable No Effects Concentration
T[a] is Total Ammonia as NH3

Table D1

Combined Streams B and C (Post Schedule 5) **Effluent from Primary Circuit and blowdown from the Secondary Circuit**

Contaminants	Average Conc in Effluent relative to EQS or Target as %age	Max Conc in Effluent relative to EQS or Target as %age	Average Conc in Effluent relative to Average Background as %age	Max Conc in Effluent relative to Max Background as %age	Average Conc in Effluent after dilution relative to EQS or Target as %age	Max Conc in Effluent after dilution relative to EQS or Target as %age	Average Conc in Effluent after dilution relative to Average Background as %age	Max Conc in Effluent after dilution relative to Max Background as %age
Boric Acid								
Boron	127.75	9371.43	220.31	9145.41	0.02	5.39	0.03	5.26
Lithium hydroxide			27.97	1594.20			0.00	0.92
Hydrazine	2739726.03	16666666.67	10.96	666.67	410.04	9581.19	0.00	0.38
Morpholine	4512.49	178571.43	7671.23	500000.00	0.68	102.66	1.15	287.44
Ethanolamine	1484.02	62500.00	2374.43	100000.00	0.22	35.93	0.36	57.49
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)			4.30	342.76			0.00	0.20
Total Ammonia as N (assuming all nitrogen as N is ammonia)	20.37	203.22	140.04	2803.06	0.00	0.12	0.02	0.53
Nitrogen as N (total) based on total of N in all compounds containing N			4.30	342.76			0.00	0.60
Phosphates (as P)			2392.39	23292.86			0.36	13.39
Detergents			11689.50	180000.00			1.75	103.48
Suspended Solids			0.19	0.75			0.00	0.00
COD			15.57	15.49			0.00	0.01
Aluminium	0.15	6.00	6.57	25.00	0.00	0.00	0.00	0.01
Copper	2.19	133.33	2.77	47.28	0.00	0.08	0.00	0.03
Chromium	15.83	622.22	11872.15	7777.78	0.00	0.36	1.78	4.47
Iron	0.99	40.00	73.06	500.00	0.00	0.02	0.01	0.29
Manganese			27.06	207.25			0.00	0.12
Nickel	0.55	33.33	57.68	169.20	0.00	0.02	0.01	0.10
Lead	1.01	92.59	365.30	456.62	0.00	0.05	0.05	0.26
Zinc	4.20	166.67	4.28	123.46	0.00	0.10	0.00	0.07

Table D2

Waste Stream D (Post Schedule 5) **Effluent from the Turbine Hall and uncontrolled floor drains (but not blowdown from the secondary circuit)**

Contaminants	Average Conc in Effluent relative to EQS or Target as %age	Max Conc in Effluent relative to EQS or Target as %age	Average Conc in Effluent relative to Average Background as %age	Max Conc in Effluent relative to Max Background as %age	Average Conc in Effluent after dilution relative to EQS or Target as %age	Max Conc in Effluent after dilution relative to EQS or Target as %age	Average Conc in Effluent after dilution relative to Average Background as %age	Max Conc in Effluent after dilution relative to Max Background as %age
Boric Acid								
Boron								
Lithium hydroxide								
Hydrazine	22191780.82	50000000.00	88.77	2000.00	3321.33	28743.56	0.01	1.15
Morpholine	31458.50	41071.43	53479.45	115000.00	4.71	23.61	8.00	66.11
Ethanolamine	19497.72	40625.00	31196.35	65000.00	2.92	23.35	4.67	37.37
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)			4354.30	13710.37			0.65	7.88
Total Ammonia as N	3511.13	2730.33	24139.04	37659.70	0.53	1.57	3.46	3.66
Nitrogen as N (total) based on total of N in all compounds containing N			4354.30	2376.18			0.68	8.07
Phosphates (as P)			803.65	31428.57			0.12	18.07
Detergents								
Suspended Solids			3.69	14.85			0.00	0.01
COD			115.26	114.67			0.02	0.07
Aluminium	1.77	67.33	77.71	280.56	0.00	0.04	0.01	0.16
Copper	28.49	986.67	36.07	349.88	0.00	0.57	0.01	0.20
Chromium	188.01	6933.33	141004.57	86666.67	0.03	3.99	21.10	49.82
Iron	11.79	436.67	873.19	5458.33	0.00	0.25	0.13	3.14
Manganese			319.50	2107.08			0.05	1.21
Nickel	7.49	276.67	788.27	1404.40	0.00	0.16	0.12	0.81
Lead	14.21	509.26	5114.16	2511.42	0.00	0.29	0.77	1.44
Zinc	50.59	1833.33	51.49	1358.02	0.01	1.05	0.01	0.78

Key		
	(red-orange)	>100%
	(orange)	50 to 100%
	(olive green)	10 to 50%
	(bright green)	5 to 10%
	(yellow)	< 5%

Table D3

Combined Waste Streams B & C & D — **Effluent from Primary Circuit and blowdown from the Secondary Circuit and the Turbine Hall**

Contaminants	Average Conc in Effluent relative to EQS or Target as %age	Max Conc in Effluent relative to EQS or Target as %age	Average Conc in Effluent relative to Average Background as %age	Max Conc in Effluent relative to Max Background as %age	Average Conc in Effluent after dilution relative to EQS or Target as %age	Max Conc in Effluent after dilution relative to EQS or Target as %age	Average Conc in Effluent after dilution relative to Average Background as %age	Max Conc in Effluent after dilution relative to Max Background as %age
Boric Acid								
Boron	127.75	9371.43	220.31	9145.41	0.02	5.39	0.03	5.26
Lithium hydroxide			27.97	1594.20			0.00	0.92
Hydrazine	24931506.85	66666666.67	99.73	2666.67	3731.37	38324.75	0.01	1.53
Morpholine	35970.99	219642.86	61150.68	615000.00	5.38	126.27	9.15	353.55
Ethanolamine	20981.74	103125.00	33570.78	165000.00	3.14	59.28	5.02	94.85
Nitrogen as N (excluding hydrazine, morpholine, and ethanolamine)(appears to consist of ammonium, nitrite, and nitrate, ie. inorganic N species)			4358.61	14053.13			0.65	8.08
Total Ammonia as N	3531.50	2933.55	24279.09	40462.76	0.53	1.69	3.46	4.19
Nitrogen as N (total) based on total of N in all compounds containing N			4358.61	2718.94			0.68	8.67
Phosphates (as P)			3196.10	54721.43			0.48	31.46
Detergents			11689.50	180000.00			1.75	103.48
Suspended Solids			3.87	15.60			0.00	0.01
COD			130.83	130.17			0.02	0.07
Aluminium	1.92	73.33	84.27	305.56	0.00	0.04	0.01	0.18
Copper	30.68	1120.00	38.84	397.16	0.00	0.64	0.01	0.23
Chromium	203.84	7555.56	152876.71	94444.44	0.03	4.34	22.88	54.29
Iron	12.77	476.67	946.25	5958.33	0.00	0.27	0.14	3.43
Manganese			346.56	2314.34			0.05	1.33
Nickel	8.04	310.00	845.95	1573.60	0.00	0.18	0.13	0.90
Lead	15.22	648.15	5479.45	3196.35	0.00	0.37	0.82	1.84
Zinc	54.79	2000.00	55.77	1481.48	0.01	1.15	0.01	0.85
Cadmium	675.80	370.37	135.16	333.33	0.10	0.21	0.02	0.19
Mercury	723.29	1047.62	1808.22	37.80	0.11	0.60	0.27	0.02

Key		
	(red-orange)	>100%
	(orange)	50 to 100%
	(olive green)	10 to 50%
	(green)	5 to 10%
	(yellow)	< 5%

Table D4

Waste Stream E **Effluent from areas potentially containing oils and hydrocarbons**

Contaminants	Average Conc in Effluent relative to Average Background as %age	Max Conc in Effluent relative to Max Background as %age		Average Conc in Effluent after dilution relative to Average Background as %age	Max Conc in Effluent after dilution relative to Max Background as %age
Oils	50000.00	50000.00		0.83	0.83

Key		
	(orange-red)	>100%
	(orange)	50 to 100%
	(yellow-green)	10 to 50%
	(green)	5 to 10%
	(yellow)	< 5%

Table D5

Waste Stream F **Effluent from the production of demineralised water**

Contaminants	Average Conc in Effluent relative to EQS or Target as %age	Max Conc in Effluent relative to EQS or Target as %age	Average Conc in Effluent relative to Average Background as %age	Max Conc in Effluent relative to Max Background as %age	Average Conc in Effluent after dilution relative to EQS or Target as %age	Max Conc in Effluent after dilution relative to EQS or Target as %age	Average Conc in Effluent after dilution relative to Average Background as %age	Max Conc in Effluent after dilution relative to Max Background as %age
Detergents			854.79	854.79			0.17	0.17
Sulphates			7.01	16.89			0.00	0.01
Sodium			0.84	1.33			0.00	0.00
Amino tri-methylene phosphonic acid (ATMP)								
Hydroxy Ethylidene Diphosphonic Acid (HEDP)								
Acetic Acid								
Phosphoric Acid								
Sodium Polyacrylate								
Acrylic acid								
Iron	6301.37	6250.00	466768.14	78125.00	1.26	4.79	93.15	59.88
Suspended solids			45.66	6.27			0.01	0.00
Chloride			0.84	0.56			0.00	0.00
Total P (as P) As a sum of all inputs, based on the proportion of P in the P-containing compounds			16254.98	3151.06			3.24	2.42

Key	
(red)	>100%
(orange)	50 to 100%
(olive green)	10 to 50%
(green)	5 to 10%
(yellow)	< 5%

Table D6

Waste Stream G **Effluent from Site STW**

Contaminants	Average Conc in Effluent relative to EQS or Target as %age	Max Conc in Effluent relative to EQS or Target as %age	Average Conc in Effluent relative to Average Background as %age	Max Conc in Effluent relative to Max Background as %age		Average Conc in Effluent after dilution relative to EQS or Target as %age	Max Conc in Effluent after dilution relative to EQS or Target as %age	Average Conc in Effluent after dilution relative to Average Background as %age	Max Conc in Effluent after dilution relative to Max Background as %age
Total Ammonia (as N)	1818.89	250.00	12504.89	3448.28		0.03	0.01	0.22	0.12
Suspended Solids			11.36	1.69				0.00	0.00
BOD			1667.32	138.89				0.03	0.00
Nitrogen (as N) from permit application			2356.63	1467.46				0.04	0.05
Assumed Total Inorganic Nitrogen (as N) based on a concentration in the discharge of 30 mg/l			3533.57	1928.02				0.06	0.06
Phosphate (as P) based on per capita daily load of 0.6522 g			21740.38	4658.65				0.38	0.16

Key		
	(orange-red)	>100%
	(orange)	50 to 100%
	(yellow-green)	10 to 50%
	(green)	5 to 10%
	(yellow)	< 5%

Annex D

Natural England Comments	Environment Agency response
The EA's HRA conclusion identifies the impacts to shad as being less than those identified in the information for the HRA (impacts to shad at a population level) supplied by EDF. Could the EA please clarify this.	The assessment for shad within the HRA was reviewed and further discussed with Natural England. Natural England have agreed that the approach used in the HRA is conservative and the differences in impact data made results in the conclusions of the HRA being based on 'worst case' scenario.
In combination assessment for fish for the combined impingement and entrainment does not include assessment of impacts to Annex II species. Have the residual mortalities from these impacts been considered 'in combination'?	No Annex II species are thought to be affected by entrainment (only impingement), therefore it is not possible to do a combined assessment of impingement and entrainment impacts. The HRA has been updated to make the assessment more clear in both the alone and in combination assessments.
Clarification of how Table 6.10.8 accounts for the mortality to sea lamprey as a consequence of HPB being operational for at least 2 years at 100% capacity in parallel with HPC (c.2020-2023). Mortality after mitigation results in an annual loss of 0.27% (80% survival with FRR) for HPC alone, but total mortality is identified as 0.28% for B & C together. Are these % figures an annual average loss calculated for the operational period of B & C together?	The figures for lamprey and shad were presented incorrectly and have now been amended. Total mortality of sea lamprey with HPC and B together now equated to 0.54%. This does not change the overall conclusions. The table in Annex B showed a more detailed representation of table 6.10.8. This table has now been put into the main body of the HRA for clarity. The % figures are predicted annual loss.
NE recommend acknowledging CCW issues regarding in combination within our HRA – i.e. the thermal plume not considered an issue alone but requires consideration in combination with residual mortality from the intake.	This has been assessed within the in-combination section of the HRA. Clearer cross-referencing between different sections of the HRA document has been done to link the 'alone' assessment to the subsequent 'in-combination' assessment.
The assessment states that Macoma is reported to only feed when the sea water temperature exceeds 15 degrees C. We have assumed this is a typo and should read that they only feed below 15 degrees C.	This was a 'typo' and the HRA has now been corrected to state that Macoma stop feeding when sea water temperature exceeds 15 degrees C.

CCW Comment	Environment Agency response
The following aspects should be monitored to ensure that they are within the range assessed within the HRA.	
Characteristics of each waste stream prior to discharge	Our draft permit requires NNB GenCo to monitor and report sample data to the Environment Agency
Monitoring of Habitat features: ➢ Population of phytoplankton to ensure potential changes are of the order predicted. Also require further clarification of conclusion of Mysid entrainment element, particularly the term 'there would not be a negligible increase'. ➢ Population of Macoma Balthica pre & post operation to ensure any unexpected change to their biology can be identified ➢ Subtidal Sandbanks – to ensure any scouring effects are as predicted ➢ Fish population in the event of chlorination occurring to ensure behaviour is as predicted. This is in combination with conditions on potential use of chlorination to ensure effective control ➢ Eel and salmon movements; if the thermal conditions described in the assessment occur during key migratory periods ➢ Fish Fauna – to ensure any changes are of the scale predicted, particularly under certain meteorological conditions. Monitoring should include direct impacts and those associated with changes to DO, increased toxicity and salinity ➢ DO – to ensure levels are maintained within the WFD threshold	Pre-operational condition PO11 within the draft Permit requires that a monitoring strategy is put in place with the agreement of the Environment Agency to monitor and mitigate any changes to the biology, chemistry and physical characteristics of the areas impacted by the water discharge and abstraction system. This monitoring strategy will need to include all the features listed within CCW's comments. This monitoring would enable early detection of potential impact on species whether it is as a result of the water discharge, abstraction or other aspects of the development.

CCW Comment	Environment Agency response
Clarification of why changes to water chemistry are not seen as a hazard to estuarine birds (if generic tables are not agreed with CCW/NE) Clarification that physical damage includes potential disturbance/displacement effects on mobile species such as fish and birds, either directly as a result of changes to physiochemical regime or hydrology, or as a result of changes to prey species distribution Recommendation that 'competition from non-native species' is included in this section and appropriately assessed, due to the potential for them to be found in warmer areas associated with the discharge	Tables to be updated to reflect potential indirect impact on birds of changes to water chemistry. Agreed with CCW within meeting of 28 June 2012 that the Environment Agency definition of physical damage is correct and that disturbance / displacement effects are considered under a separate heading of disturbance as opposed to under physical damage. HRA has been updated to consider this potential impact. This does not alter the overall conclusion of our HRA.
Clarification of why detergent is classified against toxic contamination in one table and organic enrichment in the other	Detergent can be toxic and also depending on the type of detergent can contribute to organic enrichment of the water. HRA updated to include both potential hazards in respect of detergents in all tables.
Physical damage – change in physiochemical conditions should be considered here	Agreed with CCW within meeting of 28 June 2012 that the Environment Agency definition of physical damage is correct and that changes in physio/chemical conditions need not be considered under physical damage.
Toxic contamination should be considered as a potential hazard from the production of demineralised water within Table 2.3.2.1	The HRA has been updated to reflect this. This does not alter the overall conclusion of our HRA.
pH should be included in list of hazards in Table 2.3.3.1 in respect of effluent from the primary circuit. Also other discrepancies between what is listed here and in the previous table	Table 2.3.3.1 updated to include pH as a potential hazard and to be consistent with Table 2.3.2.1
Bird features should be considered within Table 2.4.4.1 of the HRA as the abstraction and discharge of water may indirectly impact upon birds due to the potential displacement of prey species	The HRA has been updated to reflect this. This does not alter the overall conclusion of our HRA.

CCW Comment	Environment Agency response
Should also refer to Conservation Objectives within the section that discusses relevant environmental standards and targets.	HRA updated to reflect this.
Further clarification of the statement 'it is not expected that there will be a long term build-up of temperature in the waters off Hinkley', for both the commissioning and operation phases	HRA has been updated to give greater justification for this statement. This does not alter the overall conclusion of our HRA.
Note that ambient temperatures of sea water tend to be higher within Bridgwater Bay – could this be due to the impact of water discharge from Hinkley Point B. If pre-construction of Hinkley Point A and B temperature range data is available it should be used here for comparison of relative temperatures within the Severn Estuary SAC.	Analysis of data shows that the ambient temperatures in Bridgwater Bay are higher during the summer months but lower than some areas of the Severn Estuary at other times of the year. HRA has been updated to analyse this data. This does not alter the overall conclusion of our HRA.
The HRA has used arithmetic mean as per standard procedure but this can skew the data due to small number of high summer values, use of median values would be more realistic.	The arithmetic mean leads to a worst case scenario when assessing against lethal temperatures for Habitat species. Therefore, in using the arithmetic mean we have used a conservative approach. As no adverse impact is expected based on arithmetic means then the same conclusion would be reached if median values were used.
Lithium, hydroxide, suspended solids, COD, sodium, sulphates, & chloride, should be considered 'in combination', unless levels can be considered de-minimis, in which case this should be stated	HRA has been updated to include consideration of these contaminants both 'alone' and 'in-combination'. This does not alter the overall conclusion of our HRA.
Morpholine, Ethanolamine, and detergents. Further clarification required on conclusions of this element and the justification of 'no likely significant effect'. Also requires consideration of potential 'in combination' effects.	HRA has been updated to include consideration of these contaminants both 'alone' and 'in-combination'. This does not alter the overall conclusion of our HRA.
Chromium & Iron – potential in combination effects should be acknowledged & assessed	HRA has been updated to include consideration of these contaminants both 'alone' and 'in-combination'. This does not alter the overall conclusion of our HRA.

CCW Comment	Environment Agency response
Loadings of contaminants – while largely accept the argument that total loadings from Hinkley Point C on the Severn Estuary as a whole as being insignificant, recommend that further consideration is given to potential loadings within Bridgewater Bay sediment cell to ensure localised loading impacts are fully assessed	HRA has been updated to include consideration of these contaminants both 'alone' and 'in-combination'. This does not alter the overall conclusion of our HRA.
Confirmation that a 'worst case scenario' were used for assessment of discharges, in terms of volumes and composition	This is confirmed – worst case scenarios have been used in terms of volumes and composition. The limits set on the Permit reflect the levels used within the assessment.
The uncertainty within the report BEEMS TR186 over potential hydrazine concentrations is cause for concern. Does not appear to be a precautionary approach or demonstrate the worst case scenario. Therefore, CCW question the assertion that a relatively small percentage of the estuary feature would be affected, as this could be as high as 8%. The use of 'percentage area of feature affected' may need further justification/clarification as this does not necessarily relate directly to the potential significance of the impact.	This concern is noted. Pre-operational condition PO10 within the Permit requires that NNB GenCo agree a process for removal of hydrazine prior to discharge with the Environment Agency before operations start at the site. This will ensure that hydrazine is released and no impact results from the use of hydrazine on the site.
Whilst CCW don't necessarily disagree with conclusion of 'no likely significant effect' of by-products of chlorination, there is still a need to consider potential 'in combination effects' & whether the use of 'area of feature affected' is adequate justification for there being no adverse effects.	HRA has been reviewed. This does not alter the overall conclusion of our HRA. Pre-operational condition PO7 within the Permit requires NNB GenCo to assess in detail the requirement for chlorination and the potential impact of their chlorine dosing regime prior to operations starting at the site.
Entrainment – note that twaite shad also spawn in the River Tywi SAC	This is noted. We have concluded that HPC (alone and in combination) will not have an adverse effect on the twaite shad shad populations designated under the Severn Estuary SAC and Ramsar as a result of entrainment and can therefore conclude that populations within the River Tywi will not be adversely affected.

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