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Generic Assessment of the Impacts of Cooling Options for the Candidate Nuclear Power Plant AP1000

UKP-GW-GL-034, Revision 1

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REVISION HISTORY

Revision	Description of Changes
0	Initial Submittal.
1	Incorporates new information on cooling water flow rate.

The attached "Generic Assessment of the Impacts of Cooling Options for the Candidate Nuclear Power Plant AP1000", RPS Planning and Development document number JER4078R080806TM, Revision: v. 4 FINAL provides information supporting the UK Generic Design Assessment of the Westinghouse Electric Company AP1000.

Generic Assessment of the Impacts of Cooling Options for the Candidate Nuclear Power Plant AP1000

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Revision: v. 4 FINAL
26th October 2009

Planning & Development

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Executive Summary

S.1 The core aim of the project is to develop a series of potential generic environmental impacts on the marine and coastal environment and undertake an assessment of these in relation to the AP1000 nuclear power station cooling water system. The impacts are developed from the generic site conditions defined by Aker Solutions (2008a and 2008b). The generic site conditions have been developed using typical characteristics of sites at which nuclear power stations currently exist around the UK coastline, comprising five coastal and/or estuarine nuclear power stations. These are, therefore, deemed to represent 'typical' environmental conditions for likely future sites.

S.2 The project has involved the establishment of baseline environmental conditions for the generic site, covering the following topics:

- Description of the conservation designations likely to be found within the vicinity of the generic site, (including an overview of the main habitats and species likely to be found);
- Description of the water abstraction and discharge process, together with issues relevant to the Water Framework Directive and potential mitigation measures;
- Description of the likely existing marine water quality at the generic site;
- Description of the likely existing marine biological environment at the generic site;
- Description of the likely environmental changes associated with the abstraction and discharge of cooling water, (including the biocide sodium hypochlorite) into the marine environment; and
- Summary of the potential environmental impacts of such changes on the existing marine biological environment.

S.3 The use of once through cooling systems, as proposed for the Westinghouse AP1000, is consistent with Best Available Techniques (BAT) for applications handling large amounts of low-level heat (10-25^{o}C). Cooling water will be discharged from the cooling water system approximately 13^{o}C warmer than the intake. This heat will be dissipated as rapidly as possible by suitable design and location of the discharge point.

S.4 The use of biocides during the warmer months of the year is essential to prevent biofouling that will, if unchecked, reduce the efficiency of the cooling system. Chlorine, in the form of sodium hypochorite, is widely used as a biocide in cooling water systems. The level of sodium hypochlorite dosing required to prevent biofouling can be minimised by using best practice design of the cooling water system. Good design of the dosing and monitoring systems will reduce the level of sodium hypochlorite dosing required still further. These two factors will minimise the discharge of both residual oxidant and chlorination byproducts to the receiving waters.

S.5 The proposed development has the potential to lead to a number of environmental changes within the marine environment, with such changes potentially having an impact on sensitive receptors. The following environmental changes were identified as:

- Impingement of marine organisms at the intake and subsequent entrainment;
- Increase in water flow rate at the abstraction and discharge points;
- Change in ambient temperature following the discharge of the cooling water; and
- Use and subsequent discharge of the biocide (sodium hypochlorite) into the environment via the cooling water discharge.

S.6 The sensitive ecological receptors include a number of different habitats and species that are likely to occur within the zone of impact and that may be vulnerable to these environmental changes. Therefore, the study investigated the possible significant effects that these environmental changes could have on the receptors and discussed the mitigation measures to counter these effects.

S.7 It is important to recognise the implications of any changes in the context of National and International legislation. The study therefore sets out the legislation relevant to this generic impact assessment with particular emphasis on the Water Framework Directive. The Water Framework Directive aims to protect ecosystems relating to water bodies and aims to achieve a status of good or better for all water bodies in Europe by 2015. It sets Environmental Quality Standards for pollutants that are potentially damaging to ecosystems.

Applicants for new nuclear installations need to demonstrate the absence of unacceptable impacts of their operations on the environment. To achieve this, modeling of the cooling water discharge is normally required to allow the size and location of the mixing zone to be identified and the impact on water quality and ecology to be assessed. Modeling work will need to be undertaken during the site-specific assessment, together with a range of other key studies including: ecological baseline, fish and fisheries, chlorination trials, water quality, sediment quality, bathymetry, currents and tides. Mitigation measures will then be reviewed against the design proposal on a site-specific basis and where possible demonstrate BAT.

S.8 Key mitigation measures can be summarised as follows:

- Design and location of the abstraction point to minimise impact on habitats and entrainment of fish;
- Modelling, design and location of the discharge point to minimise impacts on sensitive species and habitats;
- Minimising the need for conditioning of the cooling water by best practice design and choice of materials;
- Best practice design and monitoring of the cooling water treatment system;
- Blending of chlorinated and un-chlorinated streams to reduce residual oxidant to a minimum.

S.9 In summary, the proposed scheme would incorporate a combination of Best Available Techniques and mitigation measures into the design and operation of the site to minimise environmental impact. Such an approach would be designed to ensure that the concentration of the biocide and the increase in temperature compared to ambient would be anticipated to meet the required standards outside the mixing zone. The required level of biocide is likely to be met more quickly and within a shorter distance than the temperature standards. What is not possible at a generic level is to determine the geographic extent of the mixing zone, which will depend on site specifics and as such require site-specific studies, including modeling. Within the mixing zone, it is likely that habitats and species most likely to be affected will be those found on or in the benthos and the planktonic assemblages.

1 Introduction

1.1 Background

1.1.1 The UK Nuclear Regulators, the Health and Safety Executive (HSE) and the Environment Agency (EA) have developed a Generic Design Assessment (GDA) process. The process is designed to enable different designs for the new generation of UK built nuclear power stations to be evaluated. Westinghouse Electric Company (hereafter referred to as Westinghouse) has submitted an application for its AP1000 nuclear power plant design, for consideration under the GDA process.

1.1.2 The purpose of the GDA is to enable companies to submit information on reactor design to the regulators, without the information being attached to a particular site or project. Such an approach enables early examination of the safety, security and environmental aspects of the design. To facilitate the process, the UK Nuclear Regulators requested a generic site to be established, against which the design could be assessed. Such a generic site is intended, as far as practicable, to cover typical characteristics of a potential UK nuclear power station site. The generic site, from which our assessment has been developed for this current project, was developed by Aker Solutions (2008b).

1.1.3 During the GDA process, Westinghouse has been requested by the Environment Agency to provide a greater level of environmental information regarding the potential environmental impacts of the abstraction and discharge of cooling water from and to the marine environment. Specifically, *reference 3.1 within Table 1* of the EA's guidance document 'Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Design' refers to 'an analysis of the environmental impact of a range of cooling options relevant to the generic site characteristics'.

1.1.4 This report therefore presents a generic Environmental Impact Assessment of the AP1000 nuclear power plant design, with the assessment being restricted to the potential impact on the marine environment at the generic site from the cooling water abstraction and discharge during the operational phase.

1.1.5 The generic site developed by Aker Solutions (2008 a and b) is based on a combination of the environmental habitats, species and degree of environmental protection found at five existing nuclear power station sites in the UK.

1.2 Legislation and Policy Applicable to the Marine Environment

1.2.1 A number of articles of legislation and policy are applicable to applications for development within or adjacent to the marine environment, together with a number that are specifically focused towards power generation and nuclear power in particular. In addition to these, there may also be site specific or regional policies and byelaws that would need to be identified by a site-specific study. A summary of the legislation that may apply is provided in *Table 1.1* below.

Table 1.1 International and National Legislation

Legislation	Description
EC Directive on the Assessment of effects of certain public and private projects on the environment (85/337/EEC)	This directive is transcribed into UK legislation through the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999. The regulations require certain developments to prepare an Environmental Statement as part of the planning approval process.
EC Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora (Habitats Directive).	The principle aim of this directive is to sustain biodiversity through the conservation of natural habitats and wild fauna and flora in the territory of the European Member States. These targets are principally being met through the establishment of Special Areas of Conservation. The EC EIA Directive states that EIA is mandatory for Schedule 1 projects, and discretionary for Schedule 2 projects. Schedule 1- Thermal power stations and other combustion installations with a heat output of 300 megawatts or more Schedule 2- Industrial installations for the production of electricity, steam and hot water.
Conservation (Natural Habitats etc.) Regulations 1994	These regulations transpose Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive) into national law. They introduce licensing requirements (from DEFRA) for development that may affect European species and amend planning legislation in conjunction with PPG9 by introducing review procedures (with Local Authorities) for development in close proximity to European Sites (SAC, SPA) to determine whether they will have a significant effect. A species disturbance licence may also be required if species protected under the Regulations 1994 (as amended) are present
EC Council Directive 79/409/EEC on the conservation of wild birds (Birds Directive)	To protect birds, their eggs, nests and habitats in the EU. This is to be achieved by the protection of the birds' potential habitats, through the preservation, maintenance or restoration of a sufficient diversity and area of habitats essential to the conservation of all species of birds. These targets are principally being met through

Legislation	Description
	the establishment of Special Protection Areas (SPAs).
1981 Wildlife and Countryside Act	The Wildlife and Countryside Act 1981(WCA 1981) consolidates and amends existing national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and Council Directive 79/409/EEC on the Conservation of Wild Birds (Birds Directive) in Great Britain. Amendments to the Act have occurred, the most recent being the Countryside and Rights of Way (CROW) Act 2000 (in England and Wales) and the Nature Conservation (Scotland) Act 2004 (in Scotland). Consent from Natural England may be required under the Act if a development is within a SSSI
EC Directive (96/82/EC) Control of Major Accident Hazards	The EC Directive is transposed into UK legislation through the Control of Major Accident Hazards (COMAH) Regulations 1999 (SI 1999/743) and the Planning (Control of Major Accident Hazards) Regulations 1999(SI 1999/981). COMAH Regulations require operators to implement certain management practices and report to competent authorities. The Planning regulations require a licence for the storage of listed hazardous substances.
Food and Environment Protection Act 1985	The UK is signatory to the London Convention 1972 (prevention of marine pollution) and the OSPAR Convention (1998) for the Protection of the Marine Environment of the Northeast Atlantic. The UK meets its requirements under these conventions by licensing certain activities in the marine environment including construction activities, extraction and disposal of materials. Under part II of the Food and Environment Act (FEPA) 1985 the Secretary of State for Environment, Food and Rural Affairs, as the licensing authority, has a statutory duty to control the deposit of articles or materials in the sea/tidal waters. This includes sea outfall pipes. A FEPA Licence is required for all construction below MHWS from the Marine Consents and Environment Unit.
The Coast Protection Act 1949	This act sets out the legislative framework for the protection of the coastline against erosion from the sea consent is required by the Secretary of State for the construction alteration or improvement of any works on under or over any part of the sea shore lying below MHWS or the deposit or removal of any object or materials below the level of MHWS. Under Section 34 of the Coast Protection Act 1949 (as amended principally by Section 36 of the Merchant Shipping Act 1988) the consent of the Secretary of State for Environment, Food & Rural Affairs is required for the following operations: • The construction, alteration or improvement of any works on, under or over any part of the seashore lying below the level of mean high water springs; • The deposit of any object or materials below the level of mean high water springs; • The removal of any object or materials from the seashore below the level of mean low water springs (e.g. dredging). A dual application can be used if the proposal requires both FEPA and Coast Protection Act consent
Water Resources Act 1991	The Water Resources Act sets out the responsibilities of the Environment Agency in relation to water pollution, resource management, flood defence, fisheries, and in some areas, navigation. The Act regulates discharges to controlled waters, which includes rivers, estuaries, coastal waters, lakes and groundwaters. To obtain a permit to discharge to controlled waters, consent is required from the Environment Agency.
Electricity Act 1989	This Act provides the core legislation for planning consents for the construction and operation of generating stations within England

Legislation	Description
	and Wales. Under Section 36 of the Act, any energy installations greater than 50 megawatts onshore and 1 megawatt offshore are referred to the Secretary of State for Business, Enterprise and Regulatory Reform.
EC Directive 96/61/EC concerning integrated pollution prevention and control (the IPPC Directive)	The IPPC Directive is about minimising pollution from various industrial sources throughout the European Union. Operators of industrial installations covered by Annex I of the IPPC Directive are required to obtain an authorisation (environmental permit) from the authorities in the EU countries. New installations, and existing installations which are subject to "substantial changes", have been required to meet the requirements of the IPPC Directive since 30 October 1999. Other existing installations must be brought into compliance by 30th October 2007. The IPPC Directive is based on several principles, namely (1) an integrated approach, (2) best available techniques, (3) flexibility and (4) public participation. A licence would be required from the Environment Agency.
The Water Framework Directive (2000/60/EC)	The Water Framework Directive aims at maintaining high status of waters where it exists, preventing any deterioration in the existing status of waters and achieving at least "good status" in relation to all waters by 2015.
EC Shellfish Waters Directive (79/923/EEC)	The EC Shellfish Waters Directive, adopted on 30 October 1979, aims to protect or improve shellfish waters in order to support shellfish life and growth, therefore contributing to the high quality of shellfish products directly edible to man. The Directive sets physical, chemical and microbiological water quality requirements that designated shellfish waters must either comply with ('mandatory') or endeavour to meet ('guideline standards'). The Shellfish Waters Directive is designed to protect the aquatic habitat of bivalve and gastropod molluscs, including oysters, mussels, cockles, scallops and clams. The Directive does not cover shellfish crustaceans such as crabs, crayfish and lobsters. The Directive was transposed into national legislation in England and Wales through The Surface Waters (Shellfish) (Classification) Regulations 1997.
Water Act 2003	The Water Act 2003 will significantly change how water abstraction and impoundment is regulated. It aims to improve protection of the environment and to provide a more flexible process of regulation. The Act is in three parts, relating to water resources, regulation of the water industry and other provisions: Part 1 (Abstraction and impounding – water resources) Part 2 (New Regulatory Arrangements) These clauses reflect a number of objectives that put the consumer at the heart of regulation and to make it mire open. Accountable and predictable. This part also contains provisions about competition in supply of water services. Part 3 (Miscellaneous) This part contains clauses that amend the Water Industry Act 1991, Environment Act 1995, Water Resources Act 1991, Reservoirs Act 1975 and Environmental Protection Act 1990.
Salmon and Freshwater Fisheries Act 1975 (amended by the Environment Act 1995)	Recognises the hazards of water intake and outfall structures. Section 14 of the Act deals with the obligation of the owner to fit and maintain approved gratings, whilst section 15 affords powers to the regulating authority to fit and maintain gratings at its own expense. Changes to the SFFA arise from the 1995 Environment Act that defined fish farm intakes and outfalls as regulated structures, placing the onus of proof of effectiveness on the owner or occupier. It also became a regulation to provide a continuous by-wash in any situation where screens are sited within a conduit

Legislation	Description
	or channel. The SFFA applies only to the migratory salmonids Atlantic salmon *Salmo salar* and Sea trout *Salmo trutta*, and technically to the waters that host self-supporting populations of these species. Locations where there is a policy of reinstatement of migratory stocks are also covered.

1.2.2 Depending on the site specifics, additional consents may be required from the landowner (e.g. the Crown Estate) and any Port or Harbour Authority.

1.2.3 The primary European legislation governing abstraction from and discharges to water bodies is the Water Framework Directive, WFD. The WFD requires member states to classify waters in a different way, using new and revised environmental standards to assess whether the environmental conditions are good enough to support biological activity. It requires member states to look at the water environment as a whole, integrating water quality, quantity, and physical habitat with ecological indicators. One of the main objectives of the WFD is to achieve good ecological and chemical status. Water bodies of good ecological status should deviate only slightly from the biological, structural and chemical characteristics that would be expected under undisturbed conditions.

1.2.4 The ecological classification system has five classes: high, good, moderate, poor and bad. It uses biological, physico-chemical, hydromorphological and chemical assessments of status, which can be defined as follows:

- Biological assessment using numeric measures of plants and animals;
- Physico-chemical assessment looking at elements such as temperature and the level of nutrients which support biology
- Hydromorphological assessment looking at water flow and physical habitat.
- Chemical assessment within the ecological assessment, which refers to polluting substances that could adversely affect ecology.

The chemical assessment within the ecological classification refers to polluting substances that could adversely affect the ecology. These pollutant standards will be set by the UK according to the procedure outlined in Annex V of the WFD.

These substances are considered less harmful than the 'priority' polluting substances referred to in the chemical classification.

The chemical classification system for surface waters, used for most polluting substances, has only two classes: good, or failing to achieve good. Checking whether water quality meets Environmental Quality Standards (EQS) for substances listed in Annex IX (Dangerous Substances Directive and associated daughter directives) and Annex X (WFD Priority List Substances) assesses this. These standards are being set on a Europe-wide basis and are considered a priority because of their high potential for adverse effect on the receiving environment.

1.2.5 Depending on the site specifics, additional consents may be required from the landowner (e.g. the Crown Estate) and any Port or Harbour Authority.

Planning

1.2.6 The Marine Bill, published in draft in April 2008, has the potential to affect the application and licensing process for marine proposals. There are two main purposes given for the draft Marine Bill, these being tackling climate change and a need for better regulation. The current complicated nature of marine licensing is noted in some instances as being a laborious and complex process.

1.2.7 In addition to the licensing aspects of the draft Marine Bill, the draft Bill also investigated the issue of planning in the marine environment. The overall aim of the draft Bill as regards planning was given as follows:

> *'To create a strategic planning system that will clarify our marine objectives and priorities for the future, and direct decision-makers and users towards more efficient, sustainable use and protection of our marine resources'*

1.2.8 The UK Government published a White Paper titled 'Planning for a Sustainable Future' in May 2007, followed by the Planning Bill in November 2007. The accompanying explanatory notes summarise the first 8 sections of the Bill as creating

> *'a new system of development consent for nationally significant infrastructure projects'. Key to the new planning system is the*

establishment of an Independent Planning Commission (IPC), which will decide on major infrastructure proposals from April 2009, subject to the Bill securing Royal Assent in summer 2008'

1.2.9 As part of the drive towards improved marine planning, a Marine Spatial Planning Pilot has been undertaken in the Irish Sea (www.abpmer.net/mspp/). The aim of the Pilot was to obtain a better understanding of the current situation and information on marine planning, and to develop a pilot project to test the feasibility and practicality of applying a marine spatial plan. A number of benefits were identified as being associated with a Marine Spatial Plan, in particular for the achievement of sustainable development.

1.2.10 On 10 January 2008, the UK Government announced its response to the public consultation 'The Future of Nuclear Power', which essentially considered whether it is in the public interest to allow energy companies to invest in new nuclear power stations. The announcement included the publication of the White Paper 'Meeting the Energy Challenge: A White Paper on Nuclear Power'. The Secretary of State (SoS) confirmed that, as part of the double challenge of addressing climate change and ensuring security of supply, that nuclear power should 'play a role in providing Britain with clean, secure and affordable energy'. Energy companies were invited to bring forward plans to build and operate new nuclear power stations.

1.3 Generic Conservation Designations

Statutory designations

1.3.1 Typically there is a number of International and nationally designated sites within close proximity to the generic site. These are highlighted below.

Special Protection Area (nearest site 300m)

1.3.2 All of the five existing nuclear power stations, upon which the generic site conditions were described, (Aker Solutions 2008a and 2008b) had an SPA within 2km of the proposed development site, the nearest being 300m from the boundary.

1.3.3 Special Protection Areas (SPAs) are sites protected under the EC Directive on the conservation of wild birds (79/409/EEC), more commonly referred to as the Birds Directive. Sites can be designated for a number of reasons, primarily for the following:

- Sufficient percentage of the overall population of a species making regular use of the area within a season (e.g. breeding, overwintering, on migration);
- The area is regularly used by over 20,000 waterfowl or seabirds in any season; and
- Less specific criteria such as population size and density, species range, breeding success, history of occupancy, multi-species area, naturalness and severe weather refuges.

1.3.4 As at December 2007, there were 253 SPAs designated within the UK, with a further 11 proposed. Of the designated sites, 72 have a marine component, with these primarily located in the following types of area:

- Marine areas and Sea inlets;
- Tidal rivers, Estuaries, Mud flats, Sand flats and Lagoons (including saltwork basins); and
- Salt marshes, Salt pastures and Salt steppes.

1.3.5 It should be noted that work is currently underway to identify extensions to existing coastal SPAs, together with wholly new SPAs, the latter being fully marine.

1.3.6 Bird species within an SPA that make direct use of the marine environment can therefore include groups such as waders, waterfowl and seabirds. In particular, ducks, seabird nesting colonies, waders and wildfowl areas have been highlighted as typically being present at or within 10km of the generic site. The differing habitats and ecology of these groups mean that different issues are likely to arise, however the key points will relate to sources of food, roosting and breeding sites.

1.3.7 In the coastal and marine generic site, the water birds will utilise food sources both intertidally (e.g. infaunal and epifaunal invertebrates or algae on mudflats, sandflats, rock platforms or saltmarsh), and subtidally, feeding primarily on epibenthic invertebrates on the seabed or pelagic fish species. High tide roosting areas and potential breeding sites for water birds within the generic site are likely to occur within the sand dune, dune grassland and saltmarsh habitat. Habitats and communities that are likely to be important features of the generic SPA site are discussed in more detail in *Section 3.3*, with potential impacts on the constituent habitats and species discussed in *Section 4*.

1.3.8 As mentioned above all of the five existing nuclear power stations, upon which the generic site conditions were described, (Aker Solutions 2008a and 2008b) had an SPA within 2km of the proposed development site. Of the sites on which the generic site was based, Site E had two SPAs within 2km. There are no specific identified species within the generic site conditions technical report (Aker Solutions 2008b). It will be assumed for this assessment that the SPA within the vicinity of the generic site will regularly support internationally important numbers of waterbirds that feed, roost and breed in the area since the habitats present at the generic site would support all of these activities. A search of the SPA sites within 2km of the five existing nuclear sites revealed the citation species likely to occur near the generic proposed development site (*Table 1.2*).

Table 1.2 Citation species for SPAs within 2km of the five existing nuclear power stations.

A	B	C	D	E
Annex 1 species (site qualifies under Article 4.1 of the Birds Directive				
During the breeding season:				
Common tern Little tern Mediterranean gull	Little tern	Common tern Ruff		Avocet Bittern Little tern Marsh harrier Nightjar Woodlark
On passage :				
Aquatic warbler	Sandwich tern			
Over winter:				
Bewick's swan		Bar-tailed godwit Bewick's swan Golden plover Whooper swan	Bewick's swan	Avocet Bittern Hen harrier

Migratory species (site qualifies under Article 4.2 of the Birds Directive)				
During the breeding season:				
		Lesser black-backed gull		
On passage:				
	Ringed plover	Ringed plover Sanderling	Ringed plover	
Over winter:				
Shoveler	Knot Redshank	Black-tailed godwit Dunlin Grey plover Knot Oystercatcher Pinkfooted goose Pintail Redshank Sanderling Shelduck Teal Widgeon	Curlew Dunlin Pintail Redshank Shelduck	
Assemblage qualification: A wetland of international importance (under Article 4.2 of the Birds Directive)				
	Over winter the area regularly supports 21,406 individuals	Over winter the area regularly supports 301,449 individuals	Over winter the area regularly supports 20,000 waterfowl	
Assemblage qualification: A seabird assemblage of international importance (under Article 4.2 of the Birds Directive)				
		During the breeding season the area regularly supports 29,236 individual seabirds		

* Site E incorporates the two SPAs that occur within 2km of the site.

1.3.9 The generic site condition report assessed that within 1km of the generic site there would be one SPA, within 2 to 10km of the generic site there would be two SPAs and within 10 to 20km there would be three SPAs (Aker Solutions 2008b).

Ramsar Site (nearest site 290m)

1.3.10 Ramsar sites are areas designated under the Ramsar Convention 1971 and consist of wetlands of international importance. In general, but not always, Ramsar sites are geographically associated with SPAs. As at December

2007, there were 146 Ramsar sites designated within the UK, with a further 7 proposed.

1.3.11 The Ramsar Convention defines wetlands as being:

> *'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.'*

1.3.12 Further, it notes that such sites:

> *'may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.'*

1.3.13 Sites can be designated as Ramsar sites based on their habitat and/or the species or communities therein. A site that meets any of the nine criteria specified under the Ramsar Convention could be designated as a Wetland of International Importance (*Table 1.3*)

Table 1.3 Ramsar criteria for designation of a site as a Wetland of International Importance (as on 29 March 2006).

	Group	Basis of Criterion	Criterion
1	A: Sites containing representative, rare or unique wetland types.	N/A	Contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.
2	B. Sties of international importance.	Criterion based on species and ecological communities.	Supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
3			Supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
4			Supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
5		Specific criteria based on waterbirds.	Regularly supports 20,000 or more waterbirds.
6			Regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

	Group	Basis of Criterion	Criterion
7		Specific criteria based on fish.	Supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
8			An important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
9		Specific criteria based on other taxa.	Regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

1.3.14 The types of marine and coastal wetland habitat anticipated to typically occur within a Ramsar site within the UK include a variety of intertidal habitats, as summarised below. Those that have been highlighted from the technical assessment to occur within the vicinity of the generic site are marked with '*' (Aker Solutions, 2008b):

- **Permanent shallow marine waters***; in most cases less than six metres deep at low tide; includes sea bays and straits.
- **Marine subtidal aquatic beds**; includes kelp beds, sea-grass beds*, tropical marine meadows.
- **Rocky marine shores***; includes rocky offshore islands, sea cliffs.
- **Sand, shingle or pebble shores***; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.
- **Estuarine waters***; permanent water of estuaries and estuarine systems of deltas.
- **Intertidal mud, sand or salt flats***.
- **Intertidal marshes***; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.
- **Coastal brackish/saline lagoons***; brackish to saline lagoons, with at least one relatively narrow connection to the sea.
- **Coastal freshwater lagoons**; includes freshwater delta lagoons.

1.3.15 Four of the five existing nuclear power stations on which the generic site was based had a Wetland of International Importance within 2km of the proposed development site, the nearest being 290m from the boundary. Based on these five sites it is assumed that the generic site will have one Ramsar site within 2km, one site within 2 to 10km and two sites within 10 to 20km. Habitats and communities that are likely to be important features of the generic Ramsar site are discussed in more detail in *Section 3.3*, with potential impacts on the constituent habitats and species discussed in *Section 4*.

Special Area of Conservation (nearest site 330m)

1.3.16 Special Areas of Conservation (SACs) are sites designated under the EC Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora), as transposed into UK legislation. The Directive includes a requirement to set up a European wide network of sites, referred to as 'Natura 2000', to protect certain habitats and species listed under Annex I and II of the Directive respectively. As of December 2007, there were 614 designated SACs, SCIs or cSACs (the various stages in the designation process) within the UK, with a further 8 sites highlighted as possible SACs and 1 at draft stage.

1.3.17 Within the habitats and species highlighted across Europe by the Directive, a more limited set of Annex I habitats are associated within UK marine and coastal waters. These habitats can be found from the fully marine subtidal zone (e.g. reefs) through to the coastal terrestrial zone (e.g. fixed dunes with herbaceous vegetation). Annex I habitats that occur within the SACs within 2km of the site are listed in *Table 1.4*. Broad descriptions of all habitats likely to occur up to 20km from the generic site can be found in *Section 3.3.*

1.3.18 Annex II species found within UK marine coastal waters are listed below. The generic site condition assessment has not specifically highlighted any of these species, however, based on the citation features of the SACs within 2km, it is assumed that Sea lamprey and Twaite shad will occur near the site (*Table 1.4*).

- Bottlenose dolphin (*Tursiops truncatus*);
- Harbour porpoise (*Phocoena Phocoena*);
- Grey seal (*Halichoerus grypus*);

- Common seal (*Phoca vitulina*);
- Sea lamprey (*Petromyzon marinus*);
- Allis shad (*Alosa alosa*);
- Twaite shad (*Alosa fallax*);
- Otter (*Lutra lutra*); and
- Atlantic salmon (*Salmo salar*).

1.3.19 Furthermore, there are two non-marine Annex II species that must be considered as potential receptors in the generic site, based on the citation features of the SACs within 2km of the site boundary. These are the Great crested newt and River lamprey. The Great crested newt preferentially occurs in freshwater, although it can occur in coastal dunes and shingle. The River lamprey is found in coastal waters and estuaries as well as rivers.

1.3.20 In light of the generic nature of this investigation, it is important to stress that whilst many of these Annex II species are not being specifically assessed, this does not preclude them from the possibility of occurrence at the proposed location for the power plant. Indeed, particular importance would need to be placed on the occurrence of all migratory species for a site specific study, including Atlantic salmon and Allis shad, (not considered specifically in this assessment), due to the potential negative impacts that may arise from any development. For example, the warm discharge water has the potential to cause a thermal barrier to migration, and the cooling water intake has the potential to cause impingement and/or entrainment.

1.3.21 Annex I habitats listed in the citation details of the SACs within 2km of each of the five sites on which the generic site has been based are summarised in *Table 1.4.*

Table 1.4 Citation features for SACs within 2km of the five short-listed locations

A	B	C	D	E*
Annex 1 habitats that are a primary reason for designation				
Annual vegetation of drift lines Perennial vegetation of stony banks	-	Estuaries Mudflats and sandflats not covered by seawater at low tide	Estuaries Mudflats and sandflats not covered by seawater at low tide	Estuaries

A	B	C	D	E*
		Large shallow inlets and bays Perennial vegetation of stony banks *Salicornia* and other annuals colonising mud and sand Atlantic salt meadows Shifting dunes along the shoreline with *Ammophila arenaria* Fixed dunes with herbaceous vegetation Humid dune slacks	Atlantic salt meadows	
Annex 1 habitats present as a qualifying feature, but not a primary reason for designation				
-	-	Sandbanks which are slightly covered by sea water all the time Coastal lagoons Reefs Embryonic shifting dunes Atlantic decalcified fixed dunes Dunes with *Salix repens* spp. *argentea*	Sandbanks which are slightly covered by sea water all the time Reefs	Mudflats and sandflats not covered by seawater at low tide Atlantic salt meadows
Annex II species that are a primary reason for designation				
Great crested newt	-	Great crested newt	Sea lamprey River lamprey Twaite shad	-
Annex II species present as a qualifying feature, but not a primary reason for designation				
-	-	-	-	-

1.3.22 The list in Table 1.4 is not exhaustive, as it does not include the interest features of SAC further afield. The generic site is assumed to have two SACs within 2 to 10km of the site boundary and three SACs within 10 to 20km of the site boundary.

Sites of Special Scientific Interest (nearest site 180m)

1.3.23 Sites of Special Scientific Interest are areas that are designated under the Wildlife and Countryside Act 1981 for the protection of the best examples of features of biological (flora and fauna), geological or physiological importance. The designation is further strengthened by the Countryside and Rights of Way (CROW) Act 2000, which improves protection for SSSIs in England and Wales. For example, the Act allows for powers of prosecution of wildlife crimes; enables conservation agencies to refuse consent for potentially damaging activities; increases penalties for deliberate damage; and places a duty on public bodies to preserve and enhance the integrity of SSSIs.

1.3.24 The generic site is assumed to have at least two SSSIs within 2km of the boundary, six SSSIs within 2 to 10km and 25 SSSIs within 10 to 20km (Aker Solutions 2008b). The features listed are not repeated here due to the extensive nature; however, key habitats and species would be included on the SAC and SPA citations highlighted above.

National Parks (nearest site 13,000m)

1.3.25 National Parks were created in the UK in 1949 to conserve the natural beauty of the British countryside. For each of the fourteen National Parks across the country there is a National Parks Authority, which by law have a duty to:

- Conserve and enhance the natural beauty, wildlife and cultural heritage;
- Promote opportunities for the understanding and enjoyment of the special qualities of National Parks by the public; and
- Seek to foster the economic and social well-being of local communities.

1.3.26 The generic site is assumed to have one National Park within 10 to 20km of the boundary (Aker Solutions 2008b). The terrestrial nature of National Parks is such that habitats and species associated have not been included here.

Important Bird Areas (nearest site 250m)

1.3.27 Important Bird Areas (IBAs) are key areas that are recognised as conservation priorities under one or more of the following three criteria:

- Hold significant numbers of one or more globally threatened species;

- Are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species; and
- Have exceptionally large numbers of migratory or congregating species.

1.3.28 The IBA Programme to designate a network of protected areas for birds across the globe was established and run by Birdlife International. The aim of the programme is to identify and designate new IBAs, monitor their status, carry out conservation actions on the ground and advocate policy changes at local, national and international levels. Birdlife International aims to achieve legal protection for all IBAs in order to ensure their safeguard. The level of protection depends on the country within which the IBA is designated.

1.3.29 For the generic site it is assumed that there is one IBA within 2km of the site boundary, two IBAs within 2 to 10km of the boundary, and 3 IBAs within 10 to 20km of the boundary. These designations may be terrestrial or coastal in nature; as yet there are no fully marine IBAs, but these are in the process of being identified. Significant bird species and assemblages are included in the generic site assessment through those listed under the SPA and Ramsar citation information.

Local designations

Local Nature Reserves (nearest site 850m)

1.3.30 Local Nature Reserves are areas of natural habitat that are recognised locally, (within a county or district), as having a value to both wildlife and people. Representing a diversity of habitats, both terrestrial and marine, they provide opportunities for education and research and allow enjoyment of the landscape by local communities.

1.3.31 Local Nature Reserves are not protected by statutory legislation, but rather by local authorities, which have the power to designate land as far as the low water mark, and make byelaws to protect the area from damage by the public. The power to provide and secure LNRs in Great Britain is provided by the National Parks and Access to the Countryside Act 1949. Through agreement with local landowners and occupiers of the land, the local authority, in consultation with statutory authorities, may then undertake management of the land, often through voluntary conservation organisations.

1.3.32 The generic site is assumed to have one LNR within 2km of the boundary, four LNRs within 2 to 10km of the boundary, and nine within 10 to 20km of the boundary. Significant habitats and species associated with the LNRs are included in the generic site assessment via those listed in the SAC, SPA and Ramsar citations.

RSPB Reserves (nearest site 1042m)

1.3.33 The Royal Society for the Protection of Birds (RSPB) is a UK charity organisation that works for the conservation of wild birds. One of the ways in which it achieves this is through the establishment and management of nature reserves. The reserves are established to protect key habitats for birds, particularly threatened or rare species.

1.3.34 To date, there have been approximately 170 RSPB nature reserves established across the country, and whilst these have no legal protection themselves, they are more often than not protected through the coincidence with other national or international designations, such as SSSIs or SPAs.

1.3.35 The generic site is assumed to have one RSPB designation within 2km, two reserves within 2 to 10km and 2 reserves within 10 to 20km. Significant bird species and assemblages are included in the generic site assessment, through those listed under the SPA and Ramsar citation information.

1.4 Water Abstraction and Discharge

Overview of the Cooling Water System

1.4.1 To achieve a high overall energy efficiency when handling large amounts of low level heat it is generally considered that the best available technique (BAT) (IPPC BREF 2001) is to cool by once through cooling systems. The AP1000 will be cooled by a once through cooling water system (CWS) and for this analysis it is assumed that there will be no cooling towers. 7,540 million BTU per hour of heat will be transferred by a flow of 600,000 US gallons per minute (3,270,596 Cubic Metres per day) of seawater with an increase in temperature of approximately 13^{o}C between the inlet and outlet (based on an inlet temperature range of 19 to 25 ^{o}C. Seawater will be extracted from the sea by three pumps, passed through the heat exchangers, and returned to the sea. For the generic site it is assumed that the discharge point will 150 meters off shore at a depth of 5 metres below low water level. The mean tidal range for the generic site ranges from 8.3 metres for spring tides to 7.08 meters for neap tides, with a coastal current of 0.1 metres per second. During the warmer months of the year the cooling water will be dosed with a biocide, sodium hypochlorite, to prevent biofouling. See para 1.4.16.

Cooling water abstraction and discharge –mitigation measures

1.4.2 The abstraction and subsequent discharge of the cooling water have the potential to have a significant impact on the receiving waters and the local ecology. These impacts are typically minimised by application of Best Available Techniques, drawing on the IPPC BREF 2001 document. The following measures are typically incorporated into the cooling water system at the design stage.

1.4.3 The cooling water abstraction location is situated so as to minimise any potential impact on habitats. It is designed to avoid disturbing sediments and thereby avoids adverse impacts on the cooling system and the mobilisation of pollutants.

1.4.4 A lesser thermal impact on the receiving waters, as well as overall energy savings, may be achieved if alternative uses for some of the waste heat can be found. Proximity to a potential heat customer can only be assessed on a site-by-site basis. In view of the relatively low-grade heat available, and the likely remoteness of the site, beneficial use of the waste heat may not be practicable.

1.4.5 The discharge location and design is normally based on extensive modelling taking into account the location of sensitive habitats and fish migration pathways etc. Careful design is undertaken to ensure the maximum dispersion of the thermal load whilst minimising the impact on ecology. There are two broad engineering approaches. One is to aim for rapid initial mixing and dilution, typically using diffusers to create a large volume of slightly warmed water. The other is to allow the plume, which in most cases will be buoyant, due to the lower density of the warm water, to rise virtually unmixed to the surface and spread horizontally where it will lose heat to the atmosphere and slowly mix downwards. In practice, subject to site-specific design, both of these techniques are typically used to maximise the dissipation of heat.

1.4.6 It is considered BAT to reduce the need for cooling water conditioning by reducing the occurrence of fouling and corrosion through proper design. A number of physical methods are available to reduce biofouling, thereby reducing the quantities of antifouling chemicals used. These minimise the hypochlorite dosing required and reduce the concentrations of both the residual oxidant and byproducts being discharged to the receiving waters.

- Intake design should minimise the entrainment of fish, debris, organic and inorganic material including suspended solids.
- Stagnant zones and turbulence should be avoided and flow velocities maintained at a high enough level to avoid fixation of organic organisms (velocities higher than 2m/sec). Critical velocities depend on the type of material.
- By using smooth surfaces and non-toxic coatings and paints which reduce the fixation of the organisms, reinforce the velocity effect and facilitating cleaning.
- On-line or off-line cleaning.

1.4.7 Best practice design of the biofouling treatment system will also minimise the required dosing of hypochlorite. The strategy is to prevent biofouling from occurring, as once it does larger doses for long periods are required to remove it once established. Best practice design will include;

- Targeted dosing at locations with a high fouling risk such as the heat exchanger inlet and outlet boxes.
- Optimisation of chemical monitoring and controlled (automatic) dosing to ensure the minimum required dose. Since the applied hypochlorite concentration will decrease through the CWS, chemical monitors are needed to ensure effective concentrations at critical points in the system.
- Pulse alternating chlorination© which takes account of the variation in residence times in different parts of the process. At different times and different points the required levels of chlorine are dosed following the patterns of the cooling water stream in the different process stages. At the end of the process and before discharge of the cooling water, stream dilution occurs by mixing the different process streams. Where

only one stream is chlorinated and the other is not the total residual oxidant in the former will be reduced by the chlorine demand of the latter. TRO levels in final discharge waters of <0.1 mg/l are stated to be achievable through use of this system.

- Monitoring of biofouling to ensure efficacy of the system.

Impingement and entrainment of marine organisms

1.4.8 Mitigation measures to reduce the potential for impingement and entrainment are also typically employed during operation. Impingement refers to the unintentional capture of organisms on the fine travelling (drum or band) screens, whilst entrainment is the uptake of organisms into the system and subsequent movement through the system.

1.4.9 The risk of impingement and entrainment is related to the swimming ability of a marine organism. Since swimming ability tends to be related to length, the species most at risk are small mobile species or juveniles of larger species that are unable to escape the intake currents. A review of fish entrainment studies showed that 90% of the entrained fish were less than 200mm in length (Stone and Webster 1992). In particular, smolts of diadramous fish species are at risk as their migration route between fresh and seawater may oblige them to move past the intake pipe.

1.4.10 Physical screening technologies are designed to provide a static barrier to prevent entrainment of individuals through the system. The most commonly used are traditional passive mesh screens for large fish and salmonids and passive wedge wire cylinders for small fish and juveniles. The traditional practice used at older power station is to backwash organisms off the screens and put these to waste. However, modern plants have systems in place to first prevent organisms from entering the CW inlet and second, to enable organisms to be return to the sea via the CW discharge or a dedicated return pipe. The Environment Agency's Best Practice Guidelines for preventing ingress of marine organisms for direct-cooled coastal and estuarine power stations involves the use of acoustic fish deterrent (AFD) systems placed at the CW inlet coupled with fish recovery (FRR) and return systems (Turnpenny & O'Keefe 2005).

1.4.11 AFDs can be used to prevent the ingress of many of the hearing-sensitive fish species, including herring and shad with a greater than 90% success rate.

The majority of fish have an intermediate hearing sensitivity, and AFD systems have a 50-80% success with these species. For those fish species with no hearing sensitivity (e.g. elasmobranches, lampreys, and epibenthic teleosts), the AFD system may have a less than 30% success rate as a deterrent. FRR systems are therefore used to complement AFD systems by intercepting and returning to the wild any fish that get past the AFD system. The pairing of technologies works well because the fish that have less sensitive hearing are generally robust and can survive handling on traveling screens. FRR systems are not an adequate fish protection measure by themselves because survival rates of delicate pelagic species are generally close to zero and it is these species that often make up the bulk of the catch at coastal stations.

Water Quality Impacts

Temperature

1.4.12 Once discharged, the cooling water will start to mix with the ambient water body. Based on a temperature in the discharge water at 14^{o}C above ambient, the following dilution factors would be required to achieve lower rises in temperature:

7 x dilution $\longrightarrow$ for a 2 ^{o}C difference

10 x dilution $\longrightarrow$ for a 1.4 ^{o}C difference

14 x dilution $\longrightarrow$ for a 1 ^{o}C difference

1.4.13 The UKTAG (UK Technical Advisory Group) has not yet recommended an EQS under the Water Framework Directive (WFD) for temperature, deferring this until the review of the first cycle of river basin plans. The UKTAG has confirmed that the standards from the Freshwater Fish Directive (FFD) should be protective of salmonid and cyprinid fish in rivers lakes and estuaries. The validity of the “uplift” values of 1.5^{o}C and 3^{o}C in the FFD was less clear. These aim to ensure that a step rise or a sharp gradient in temperature is not a thermal barrier to fish. The UKTAG was unable to find good evidence of the reality of such thermal barriers in rivers and estuaries, except when temperature rises of more than 3^{o}C or near the lethal limit occur. Member states are required to designate areas of coastal waters needing protection or improvement in order to support shellfish. The Shellfish Waters Directive’s

$2^{o}C$ limit for a rise in temperature has sometimes been adopted as a standard for marine waters generally, although it is a guideline only, for shellfish waters designated under the Directive. The Directive sets no Imperative value for temperature but environment agencies are under an obligation to endeavour to observe the guideline value, as well as a principle of no increased pollution. The 98th percentile temperature standard suggested in guidance relating to thermal discharges into European Marine Sites is $21.5^{o}C$.

Dissolved Oxygen

1.4.14 The solubility of oxygen in water reduces with temperature. For seawater at 35 parts per thousand salinity, the solubility of oxygen at $15^{o}C$ is 8.1 mg/litre. At $30^{o}C$ this reduces to 6.1 mg/litre. This may be further reduced by the Biological Oxygen Demand (BOD) that increases with increased temperature depending on the nutrient levels and microbial activity present in receiving waters. The UKTAG has set standards for dissolved oxygen for marine waters with 4.0 – 5.7 mg/l described as good, and greater than 5.7mg/l described as high.

Cooling Water Biocide

1.4.15 In order to maintain efficient operation of the CWS, abstracted water is dosed with a biocide to inhibit the settlement of biological organisms to the internal surfaces within the system (biofouling)'. Biofouling is generally of two main types: macrofouling (e.g. mussels) and microfouling (e.g. bacteria, fungi, algae). The main effect of biofouling is reduction of heat transfer capacity and increased energy losses due to increased frictional resistance. Where exposed metal becomes biofouled, microbial induced corrosion can also occur.

1.4.16 Biofouling normally only occurs with water temperatures above $10^{o}C$, generally from March to November. When water temperatures are above $10^{o}C$, biofouling of the CWS will be prevented by dosing the cooling water with a biocide. Current industry practice is to use chlorine, in the form of sodium hypochlorite, which has the advantage over other biocides that residues in the discharge will be reduced by the chlorine demand of the receiving water. The use of chlorine gas has been rejected on safety grounds. Chlorine generation by the electrolysis of seawater is suggested as an alternative to sodium hypochlorite in the IPPC BREF 2001. Seawater contains small quantities of bromide, which will react with the hypochlorite to form hypobromite and chloride. Both hypochlorite and hypobromite are extremely effective in preventing and or removing micro and macrofouling. They react actively with the nitrogen on compounds like proteins making them very active against protein-based organisms. However, in order to ensure the heat exchangers are kept clean it is inevitable that some excess hypochlorite will be discharged to the receiving waters.

1.4.17 The primary reaction of hypochlorite/hypobromite is oxidative. Certain inorganic and organic species are readily oxidised. This “chlorine demand” must be satisfied before a residual will be available as a biocide. Although the vast majority of the reactions are oxidative, around 2% of the hypochlorite/hypobromite will react with naturally occurring organic compounds to form certain halogenated byproducts, particularly trihalomethanes and halogenated acetic acids. These will also be discharged to the receiving waters.

Suspended Solids

1.4.18 Poor location of the site or design of the cooling water discharge point could cause scouring of the sea bottom and resuspension of sediments. This can remobilise historic contamination and cause the blanketing of habitats as the sediment settles out elsewhere. The increased turbidity reduces light penetration and hence photosynthesis.

Other potential pollutants’

1.4.19 Additional impacts on water quality may be caused by other water treatment chemicals, corrosion, and leakage from other parts of the system and possibly by discharges from other parts of the plant. As the need for additional treatment chemicals will be site specific these are not considered in this assessment. It is assumed that through best practice design and selection of materials, corrosion and leakages will be kept to an absolute minimum so that their impacts are unlikely to be significant. Discharges from other parts of the plant will be monitored prior to discharge and will be subject to separate consent and will therefore be assessed on a site-specific basis.

2 Impact Assessment Method

2.1 Water Quality

2.1.1 The potential impacts on water quality are assessed by identifying the pollutants that are likely to be present in the cooling water discharge, and the likely maximum concentrations of those pollutants. The pollutant concentrations are then compared against the relevant Environmental Quality Standards (EQS) to assess their potential impact on the ecology. The EQS indicate the quantity of a pollutant that can be present in the water environment without causing immediate harm to the ecology.

2.2 Ecology

2.2.1 The assessment of potential impact is restricted to the marine elements of the operational phase of the potential development and specifically the CW system and as such does not include reference to issues that relate to the terrestrial ecology, or to issues that would be restricted to the construction or subsequent decommissioning of the site. Such assessments would be required to be undertaken in any subsequent site-specific environmental impact assessment. In particular, it should be noted that although terrestrial habitats may lie within proximity to the power station, the restriction of the assessment to the abstraction and discharge of cooling water means that no communities or habitats above mean high water spring would be affected.

2.2.2 The approach to assessing the potential for impact from the discharge of cooling water on the marine environment of the generic site, as described in *Section 3*, follows the source-pathway-receptor method. This approach essentially requires the identification of the ‘source’ i.e. the cause of environmental change, together with the ‘receptor’, which for the marine environmental aspect of the current project relates to the habitats and species identified in *Section 3*. The ‘pathway’ refers to a linkage between the environmental change and the receptor, without which no impact can occur on that particular receptor.

2.2.3 The assessment of impact then takes into consideration issues such as the geographic extent and magnitude of that change, and the sensitivity of the receptor to that change. However, it should be noted that given the generic nature of the project, the quantification of effect, is most appropriately dealt with in generic terms, particularly since site specifics such as geographic extent cannot be determined with any great certainty for a generic study. As such, a worst case scenario has been assumed, with the result essentially being that all sensitive receptors identified in the baseline as being present at the generic site are potentially linked by a pathway to the environmental change, although some consideration is given to the limited potential for a pathway to link the environmental change to transitional habitats (e.g. sand dunes).

2.2.4 The steps taken in the assessment of potential impact are as follows:

- Identification of environmental changes associated with the discharge of cooling water;
- Consideration of the environmental receptors listed in *Section 3*;
- Brief assessment of the potential effect of the direct and indirect impacts associated with the environmental change on the receptors; and
- Summary of mitigation measures and best practice that are available (if applicable).

3 Generic Baseline

3.1 Water Quality

3.1.1 The generic site is assumed to be a coastal site with the quality of the seawater unaffected by either nearby rivers or major sewage treatment works discharges. The temperature range is assumed to be normal for UK waters and the salinity approximately 35 parts per thousand. Background water quality is assumed to be good since the EQS is not exceeded.

3.2 General Biological Environment

3.2.1 The generic site being considered is coastal in nature, with one of the five existing nuclear sites upon which the generic site is based being estuarine. Coastal and estuarine sites typically incorporate a variety of habitats, progressing from the subtidal, through the intertidal zone and progressively through transition habitats into fully terrestrial habitats. In practice, natural features, such as hard rock or cliffs, or anthropogenic structures, such as harbours, farmland or roads, may disrupt such progression. A general description of the types of habitat that may be found at the generic site is provided here, with these discussed in more detail in *Section 3.3*.

3.2.2 Near shore subtidal habitats, which are anticipated at the generic site, are likely to be shallow (i.e. less than 50m deep). The type of habitats present will primarily be a reflection of the physical conditions and potentially include a variety of substrates, ranging from hard rock, through coarse gravels and boulders to the finer sands and muds. The finer sediments would be expected to occur in the more sheltered areas.

3.2.3 The habitats present are key in determining the species that occur on or in the habitat, together with the more mobile species that are dependant on that habitat, for example for food or spawning sites. Species likely to be present in the generic site are considered further in *Section 3.4*.

3.2.4 With progression from the subtidal into the intertidal zone at the generic site, although the type of habitats may be similar, (i.e. a range in substrate types from hard rock through coarse sediments to the fines), the species assemblages found (together with the more mobile species dependant on the benthos) will reflect the additional challenges presented by the periodic exposure/inundation regime characterising intertidal zones.

3.2.5 It should be noted from the generic site condition information provided (Aker Solutions 2008a and b), that there are a number of intertidal substrates highlighted that may occur within the vicinity of a proposed site. Although all the habitats identified are anticipated to occur in the intertidal zone at the generic site, those that are marked with an '*' relate to substrates identified for the foreshore only and not the backshore. Intertidal substrates that are anticipated to occur at the generic site include the following:

- Sand;
- Gravel;
- Sand and gravel*;
- Rock;
- Mud;
- Sand and mud;
- Mud and gravel*; and
- Made ground.

3.2.6 With progressive distance from the water, habitats at the generic site are likely to change further, becoming transitional and potentially including typical coastal or estuarine features, such as salt marsh and sand dunes. Such habitats are characterised by salt-tolerant vascular plants and host different groups of fauna, compared with intertidal habitats *(see para 3.4.42).*

3.3 Habitats

3.3.1 A brief description of the typical ecology associated with the habitats listed in the generic site condition report (Aker Solutions 2008b) is given below, drawing on literature sources such as the Marine Life Information Network (www.marlin.ac.uk), the JNCC website descriptions of Annex I habitats (www.jncc.gov.uk) and the UK BAP Atlas (www.ukbap.org.uk).

Subtidal habitats

3.3.2 Limited information is available as regards the potential subtidal habitats that would be anticipated to occur at the generic site. The best indication is from the Annex I habitats that are listed in the SAC citation details for each of the five existing nuclear sites, including both primary reasons for designation and qualifying features *(see Table 1.4),* as the details given in the citation include an overview of the subtidal habitats found at each site, (although it should be noted that this is only for features listed as reasons for designation and hence does not cover the entire subtidal of the site). The subtidal Annex I habitats listed at the five existing nuclear sites, together with the habitats and substrates typically associated with them, are summarised in *Table 3.1.*

Table 3.1 Description of the Annex I habitats likely to occur in the subtidal zone of the generic site.

Annex I Habitat	Typical Habitats/Substrates Associated
Estuaries	The subtidal habitats found within estuaries are a function of several factors, including sediment and salinity gradients, the geographic location of the estuary and the strength of tidal streams. There is a tendency for the upper reaches to be dominated by fine sediments (fine sands and muddy sands) and a greater proportion of freshwater, with species present being tolerant of the low or fluctuating salinity (e.g. oligochaetes). In areas of hard substrate, species are typically restricted to green algae, some fucoids, barnacles and hydroids. As the estuary becomes more marine (and hence more saline) in nature with progression seawards, sediments tend to become sandier with a more marine community, for example polychaetes and bivalves.
Large shallow inlets and bays	Such habitats are typically created by the physical structure of the coastline, which provides a greater amount of protection than a more open coastline. Although habitat types may be superficially similar to estuaries, the influence of freshwater is generally less. The habitats present are highly dependant on the adjacent geology, i.e. whether the coastline is formed from soft or hard substrate. For example, rocky coasts, or those that are more exposed, may support kelp forests, with other areas having ephemeral algal/maerl communities or seagrass. In more sheltered sites, substrates are more likely to be dominated by sands and muds, with the communities present reflecting these sediments.
Reefs	In essence, there are two main types of reef considered under Annex I, namely those where communities develop on rock or stable boulders and cobbles, and those where the reef is created by animals, i.e. biogenic reefs. Rocky reefs are very variable in structure and community composition, with the effect of waves and tide being particularly prevalent in coastal areas. Biogenic reefs are perhaps less variable, with the main species responsible for their formation in the UK being mussels (*Mytilus edulis*), horse mussels (*Modiolus modiolus*), ross worm (*Sabellaria spp*.), the serpulid worm (*Serpula vermicularis*) and cold-water corals (e.g. *Lophelia pertusa*). Perhaps the most important factor behind the majority of all Annex I reefs is the generally high level of diversity.
Sandbanks which are slightly covered by seawater all the time	Subtidal sandbanks included in this category in the inshore environment are generally found in water less than 20m deep, with the sediment type and prevailing physical conditions dictating the communities found. Within the UK, there are four main types; gravelly and clean sands, muddy sands, eelgrass (*Zostera marina*) beds and maerl beds (composed of free-living Corallinaceae).

3.3.3 In summary, there is potential for a wide variety of habitats to be found in the subtidal environment immediately offshore from the generic site option under consideration. When considering these, it should be noted that the generic site is coastal in nature, with an estuary located some distance from the proposed site. The habitats highlighted can be summarised into the following main groups:

- Estuarine fine sediments (i.e. reduced salinity muds and sands);
- Fully marine fine sediments (i.e. muds and sands);
- Fully marine sands and gravels;
- Estuarine (reduced salinity) hard substrates;
- Fully marine hard substrates;
- Reef structures (i.e. highly diverse communities);
- Eelgrass beds; and
- Maerl beds.

Intertidal habitats

3.3.4 The intertidal habitats considered here draw on the habitat types highlighted in the generic site report, (*Table 4.21 and 4.22* of Aker Solutions 2008b) and referenced under *paragraph 3.2.5* of the current report. A brief overview of such substrate types is provided.

3.3.5 Intertidal sandy substrates often tend to occur in areas with a degree of tidal or wave activity. In general, the degree of mobility of the sand combined with the sediment grain size (i.e. fine/coarse sand or the addition of muds/gravels), and parameters such as salinity and exposure, has a strong influence on the species that are likely to occur. Although some sandy shores are barren, primarily those where the sediment is particularly mobile, others host species such as burrowing amphipods or isopods, together with polychaetes. Where sediments become finer, bivalves may be present.

3.3.6 Intertidal gravels often occur adjacent to hard features such as sea defences or in areas where wave or tidal action results in the sorting of sediment. Species present generally relate to the driving process behind the habitat, for example where gravels and algae accumulate in the lee of structures there maybe an associated amphipod fauna. On more stable coarse sediments, particularly those on the sublittoral fringe or subtidal, a more diverse community may be present, for example macroalgae, echinoderms and hydroids.

3.3.7 Where the intertidal sediments are a mixture of sands and gravels, the species present will tend to reflect the sand and gravel communities already described, with the relative sand:gravel percentage, combined with the physical environment conditions such as wave/tidal processes and the salinity, influencing the community present.

3.3.8 Intertidal rock communities are influenced strongly by the degree of exposure to air, for example those found lower on the shoreline or in rock pools tend to be covered more frequently by the tide than those found further towards the strandline. The reduced exposure to air tends to result in a more diverse community structure. A wide variety of community types can be found on rocky shores, as evidenced by the classic rocky shore zonation patterns. Species such as barnacles and fucoids tend to predominate towards the upper shore, with increasing numbers of species including red and green algae, gastropods, crustaceans and anemones towards the low water mark. Within rock pools and under overhangs, species such as *Corallina*, hydroids or sponges may be found.

3.3.9 Intertidal muds are typically found in sheltered, often estuarine conditions. The benthic community present tends to include numerous polychaete and oligochaete species, together with bivalves and gastropods. The habitat often has a greater percentage of organic matter, sometimes supporting surface vegetation, which on the lower shore may be green algae or on the upper shore tending towards a more vascular plant community, such as salt marsh.

3.3.10 Intertidal habitats with a mixture of sands and muds would be expected to hold a benthic community somewhere between those typical of sands and muds.

3.3.11 Made ground refers to substrates formed by man made structures and as such typically include features such as sea defences, slipways and harbour walls. These tend to be hard structures, often vertical or at least steeply sloping. Depending on the purpose of the structure, the surface may be relatively smooth (e.g. concrete harbour walls) or pitted (e.g. rip rap sea defence). The species present are in general similar to those found on natural rocky intertidal surfaces, often tending to the more robust and opportunistic species, although issues such as the degree of tidal exposure and the complexity of the structure will also be important.

Coastal saltmarsh

3.3.12 Saltmarshes are intertidal, sediment-based habitats, which as saline-influence environments are dominated by halophytic vegetation. Saltmarshes develop above the mean high water level (MHWL) where there is little movement in tidal waters so allowing settlement of sediment and subsequent colonisation by saltmarsh plants.

3.3.13 In UK estuaries, saltmarsh habitats commonly form in association with other coastal habitats, such as mudflats, which in combination offer a diverse range of niches for exploitation by coastal and marine fauna. Consequently saltmarshes are viewed as important habitats, both in their own right but also to provide a refuge for birds at high tide, as fish nursery sites and, more recently, as a form of coastal defence (www.ukbap.org.uk/). As such large areas of saltmarsh habitat are protected by national and international legislation *(see Section 1.3*). Species found in coastal saltmarsh habitats are discussed further under 'Vascular Plants' in *Section 3.4*.

Vegetated shingle

3.3.14 Vegetated shingle is restricted in distribution, forming on substrates with a particle size range of 2-200mm (www.ukbap.org.uk/UKPlans.aspx?ID=29) where the stability of the substrate is sufficient to enable the plants to establish. Species found are typically tolerant of a degree of salt spray and abrasion, including plants such as sea kale *Crambe maritima* and sea campion *Silene uniflora*. The habitat is associated with diverse invertebrate communities and may provide habitat for breeding birds. Vegetated shingle is highlighted further in *Section 1.3* under nature conservation.

Sand dunes

3.3.15 Sand dunes are found at the upper end of the coastal environment, being typically formed in areas where sufficient sand is available from the intertidal zone, combined with an onshore wind. The term sand dune covers a variety of features that can form under slightly different conditions, for example spit dunes at estuary mouths or hindshore dunes, the latter occurring in exposed conditions, where the wind drives the sand inland (www.ukbap.org.uk/UKPlans.aspx?ID=28). A wide variety of sand dune types are protected through national and international legislation, as highlighted in *Section 1.3* under nature conservation. Plant species found in sand dune habitats are discussed further under 'Vascular Plants' in *Section 3.4.*

Wetlands

3.3.16 Coastal wetland habitats include both freshwater and saline waterbodies, the latter typically referred to as coastal lagoons. Such habitats include natural and artificial water bodies, ranging from small ponds of less than 1hectare to water masses (or groups of waterbodies) extending over 100's of hectares.

3.3.17 Freshwater habitats found along the coastline are fully separate from the marine environment and may be associated with habitats such as marshland, reedbeds and woodland. Saline lagoons are connected to the sea through a variety of routes to enable the saline intrusion (e.g. percolation, sluice gates or overtopping). The communities present will be strongly influenced by the degree of salinity within the water body, which can range from fresh through brackish, fully saline to hypersaline. Saline lagoons in particular are noted for unusual species that are rarely found elsewhere.

3.3.18 The communities present within such waterbodies can be divided into three main groups:

- Species that are essentially freshwater in origin;
- Species that are marine or brackish in origin;
- Species that are classified as specialist lagoonal species.

3.3.19 In addition to the vegetation and invertebrate ecology, both freshwater and saline waterbodies provide important habitats for waterfowl, marshfowl and seabirds.

3.4 Species

3.4.1 The generic site condition report highlighted a number of potential ecological receptors as being present in the vicinity of the generic site (Aker Solutions Ltd 2008b). The receptors most likely to be affected by the impacts from cooling water abstraction and discharge that were highlighted in this report are listed below, together with additional receptors that have been identified during the course of this study, (i.e. by looking at likely conservation designations and habitats present). The following list therefore includes all the identified receptors, categorised according to their general biology:

- **Avifauna:** (wading) bird (duck);
- **Mammals**; marine and coastal mammals, including otter;
- **Fish:** Benthic fish (flat fish), pelagic fish and migratory species of conservation interest;
- **Intertidal benthic communities**: bivalve molluscs, polychaete worms, sea anemones/true corals, and crustaceans;
- **Subtidal benthic communities** (not mentioned in the generic site condition report but is considered in this assessment e.g. invertebrate faunal communities, maerl);
- **Macroalgae**; includes the brown, green and red seaweeds.
- **Plankton**: Phytoplankton and zooplankton;
- **Vascular plants**; seagrass, dune grass and salt marsh plants
- **Amphibians** (terrestrial).

Avifauna

3.4.2 The generic site description provided in Aker Solutions (2008b) highlights the potential presence of wading birds and ducks, with these groups considered here. Seabirds are not highlighted in the Aker Solutions report, however it should be noted that some nature conservation sites (notably SPA and Ramsar) do include seabirds, (as highlighted in *Section 1.3* on nature conservation), and as such seabirds have been considered here.

3.4.3 Wading birds and ducks, which cover a number of species, can be found in large numbers on the intertidal and shallow subtidal around the UK coastline. Waders, such as dunlin, godwits and curlew, tend to be typified by relatively long legs and often a long slender beak, to enable the birds to find the benthic species on which they feed within the muddy sediments along the intertidal areas. Ducks, which together with geese and swans constitute the wider term 'wildfowl', are typically larger birds than the waders. Ducks can be broadly separated into surface feeders, which rarely dive and are more typically freshwater, and diving ducks (e.g. the common scoter and eider, both of which are subject to nature conservation interest), which as the name suggests dive under the water for food and dominate the coastal duck species. Diving ducks feed on species such as small fish and benthic invertebrates, often grouping into 'rafts' on the water surface. Shelducks can be considered intermediate between the two groups, (/www.rspb.org.uk/wildlife/birdguide/families/swans.asp).

3.4.4 Seabirds are of interest due to their listing in the designated sites on which the generic site is based. In particular, the following types or groups of seabirds are noted in the SPA and Ramsar citations referenced in *Section 1.3*:

- Seabirds during the breeding season (with the assemblage being in excess of 20,000);
- Seabirds on passage; and
- Migratory seabirds during the breeding season.

3.4.5 The JNCC monitor seabirds at sea and when breeding around the UK, with reports published on the findings (e.g. Mavor *et al*, 2008). The breeding season tends to fall between mid to late spring and early to mid summer, although Mavor *et al* (2008) noted a later than average breeding season in 2006 for several species, with laying in some cases extending into July. Low breeding success is generally attributed to food availability (notably sand eels). Nest sites and hence habitat requirements vary with species, with some nesting in large colonies e.g. on rocky cliff faces or within burrows, whilst others nest on the ground amongst the shingle.

3.4.6 Seabirds on passage or migration may use particular sites as a 'stop over' during migration between breeding and overwintering sites, using the site as an opportunity to feed and rest. The numbers of individuals in a given year, together with the sites used, are not always predictable *(www.jncc.gov.uk/default.aspx?page=2820).* At times of peak migration or passage, bird numbers at a particular site can rise considerably, due to the continuous nature of the arrival and departure of such species, (although individuals may only be present for short periods).

Mammals

3.4.7 Marine mammals include both cetaceans and seals, with the former being wholly marine and the latter coming ashore to established sites at intervals during the year e.g. for pupping and moulting. Marine mammals are covered by a variety of articles of conservation legislation, with designated sites highlighted in *Section 1.3*. Additional legislation protects individuals. The generic site description undertaken by Aker Solutions (2008b), which draws on the information from the five existing nuclear sites, does not highlight the potential presence of marine mammals within 10km of each site.

3.4.8 Although not technically a marine mammal, as it inhabits freshwater habitats also, the European otter (*Lutra lutra*) does occur within the near shore marine environment within the UK, particularly in Scotland. Where the species occurs in the marine environment, it tends to feed in shallow, inshore areas, however there remains a requirement for freshwater for bathing together with terrestrial sites for resting and breeding holts. Suitable coastal habitats range from sheltered inlets surrounded by woodland to more open areas of low-lying coast. There is a general assumption that a high water quality is required combined with an abundance of food sources (JNCC 2008).

Fish

3.4.9 Benthic species that live on or near the sea bottom will include flat fish such as plaice, dab, flounder and sole, which feed on polychaetes, bivalves and crustaceans. Flat fish spawn in coastal and offshore waters between March and September. Juvenile flatfish may spend up to two years in inshore nursery areas before gradually moving to deeper waters, as they mature. Benthic elasmobranch species may include skates and rays, which are usually found in waters down to 60m. The diet of rays in UK waters consists of a wide range of crustacea, nereids and fish, though rays are indiscriminate feeders, the selection of food items being limited by the availability of potential prey species. Although rays generally remain faithful to an area and do not migrate over large distances they often move offshore during the winter returning to inshore and estuarine environments in spring to spawn, laying their eggs between March and August, before moving back to deeper waters in the summer.

3.4.10 Pelagic species are typically mobile and migratory species that are not closely associated with permanent areas or structures. These species may be found over a wide range of substrates including mud, sand, gravel and rock. Mackerel and herring are the two main pelagic species landed by UK vessels into the UK. Herring are often found in vast near-surface shoals covering an area of several square kilometres offshore, and move to discreet localised near-shore spawning areas. Atlantic mackerel make extensive migrations, and consequently there are a variety of hydrographic features (including temperature), which together with the abundance and composition of zooplankton and other prey, likely to affect its distribution. Mackerel can be extremely common and found in huge shoals feeding on small fish and prawns.

3.4.11 Other pelagic species typical of UK coastal waters include gadoid species such as cod, whiting and pollock. These species typically spawn in offshore waters between January and June. Larvae are then carried by currents for up to two months before settling on the seabed in both coastal and offshore nursery areas. Young gadoids feed mainly on copepods but become increasingly dependant on fish as they age, eating species such as herring, capelin, haddock and cod. Bass in British waters are migratory, approaching inshore waters in spring and summer where they spawn between February and July. Young larvae then drift from the open sea inshore towards the coast, and eventually into creeks, backwaters, and estuaries. These sheltered habitats are used by juvenile sea bass for the next 4-5 years, before they mature and adopt the migratory movements of adults and move offshore in the autumn. Whilst bass are themselves not a protected species their nursery areas may be designated through the application of byelaws. The European sea bass is a predatory species feeding on mainly small pelagic fish such as sardines, sprats, and sand smelts. They also feed on sandeels and other bottom-living species, crustaceans, and squids.

3.4.12 Protected species of fish within the coastal waters associated with the generic site include twaite shad, river lamprey and sea lamprey. Salmon are also protected by a variety of conservation legislation, however its presence has not been highlighted at any of the 5 sites on which the generic site has been based. Allis shad is an Annex II species, which is recorded from many areas around the British Isles. This species must return to freshwater to spawn above gravel substrates and discreet spawning areas are known within some estuarine environments. Twaite shad are a schooling migratory species that spend most of their life offshore, this species, however, must also return to freshwater to spawn. Spawning locations are known within the southwest and the Bristol Channel. River lampreys occur close to the coast throughout the UK and Ireland, migrating upstream along many British and Irish rivers in August to spawn. Sea Lampreys occur offshore throughout the UK and Ireland, migrating upstream in many British and Irish rivers in August to spawn.

3.4.13 Temperature provides an important cue for the initiation and location of spawning, for example sea bass eggs are rarely found where the water is colder than 8.5-9.0 Celsius, or in water warmer than 15 Celsius.

3.4.14 Many of the fish species found around shallow coastal waters are of commercial importance. By weight, both demersal and pelagic species each account for approximately 34 percent of total landings, whilst commercially important shellfish species account for the remaining 32 percent of landings (MFA 2006). Any future detailed impact assessment will therefore need to consider the impacts on the commercial fish and shellfish fisheries near the proposed development site.

Intertidal benthic communities

3.4.15 Species found in the intertidal zone are general tolerant to changes in environmental conditions such as temperature, salinity, and exposure, brought about by the natural dynamic nature of the intertidal zone. The species considered here are the receptors highlighted in the generic site condition assessment and provide suitable indicators for possible impacts that may arise from the abstraction of cooling water and subsequent discharge.

3.4.16 One of the most common bivalve molluscs recorded in the intertidal is the common mussel *Mytilis edulis*. Mussels occur from the high intertidal to the shallow subtidal and are attached by fibrous byssus threads to suitable hard substrata. Mussels can tolerate a wide range of environmental conditions; inhabiting rocky shores on open coasts where they are attached to the rock surface, and on rocks and piers in sheltered harbours and estuaries, where they often occur as dense masses. Other common species, such as the cockle *Cerastoderma edule* are found on soft substrate, inhabiting the surface of muddy or sandy sediments, and burrowing to a depth of no more than 5 cm. This species is often abundant in estuaries and sheltered bays, where population densities of 10,000 per m^2 have been recorded.

3.4.17 In sheltered sandy and muddy intertidal coastal habitats such as mudflats and sandbanks there may be high concentrations of a number of polychaete species. The ragworm *Hediste diversicolor* is one of the most common intertidal polychaetes and is widespread along all British coasts where suitable muddy substrata exist, particularly in estuaries. Polychaetes can inhabit a range of sediment types from soft silt to gravel and rocks. The catworm *Nephtys hombergii* usually lives infaunally in muddy sand but may also be found amongst gravel, rocks and occasionally *Zostera* beds.

3.4.18 The Honeycomb worm *Sabellaria alveolata* may be found on hard substrata on exposed, open coasts with moderate to considerable water movement where sand is available for tube building. This species is found intertidally, typically on the bottom third of the shoreline, but also in the shallow sub-tidal. This worm may construct densely aggregated tubes, which may form a crust or a reef. Large reefs may reach several metres across and a metre deep. *Sabellaria alveolata* does not have its own Species Action Plan but is covered in its reef form by a Habitat Action Plan.

3.4.19 Hermit crabs such as *Pagurus bernhardus* and *Anapagurus hyndmanni* may be found on a wide variety of substrates from rocky shores to fine muds and sands. Masked crab *Corystes cassivelaunus* and Angular crab *Goneplax rhomboides* are typically found in burrows in soft muds and sand from the lower shore and shallow sublittoral to about 100m. Prawns and shrimps such as *Palaemon serratus, Crangon crangon* and *Palaemon elegans* are present around the coast usually in groups, and inhabit a range of habitats. They are typically found in crevices and under stones in intertidal pools, or subtidally (to a depth of 40m) on sandy and muddy ground. Crustaceans are likely to be tolerant to an increase in temperature, although increased temperatures may cause increased vulnerability to other stressors, such as low oxygen levels and the introduction of chemicals.

3.4.20 Sea anemones commonly encountered on hard and rocky substrata within the intertidal zone include snakelocks anemone *Anemonia viridis*, beadlet anemone *Actinia equine* and strawberry anemone *Actinia fragacea*. Sea anemones encountered in soft sediment habitats around the UK coast include tube anemone *Cerianthus lloydii* and daisy anemone *Cereus pedunculatus*. Sea anemones live in a wide range of temperatures and so small increases in temperature are unlikely to affect individuals or populations.

Subtidal benthic communities

3.4.21 Subtidal benthic communities typical of shallow inshore communities are characterised by a high abundance of infaunal and epifaunal invertebrate species. Annelids are usually the most numerically dominant and diverse of the taxa, followed by crustacea, mollusca, and echinodermata. Other typical groups found subtidally include porifera, cnidaria, bryozoans, tunicata, platyhelminthes, nemertea, nematoda, sipuncula, chelicerata, phoronida, hemichordate. Recent surveys conducted by RPS for sites along the south coast of the UK have revealed that typically a shallow marine environment may contain in the region of 500 different species of marine invertebrates, (RPS 2006 & 2007).

3.4.22 Polychaete worms inhabit a diversity of habitats from estuarine inshore habitats and hypersaline lagoons to deep offshore substrates. These species live mostly within the sediment as 'infauna' and provide the basis of the food chain for many higher marine species. They are also valuable biomonitors, quickly showing sensitivity to contaminants such as polyaromatic hydrocarbons (PAHs) and heavy metals through bioaccumulation. Environmental impacts can therefore be monitored through changes in the species richness, abundance and community composition of the polychaetes.

3.4.23 Whilst most species of polychaete are not recognised as being of conservation significance, the occurrence of high abundances of the tube-building polychaete *Sabellaria spinulosa* on mixed sediment may form an important habitat. This species forms a low-lying 'reef' on the seabed by consolidating the sediment, which is subsequently colonised by a diversity of infauna and epifauna, that may be absent from adjacent sandy-bottom habitats see *Section 1.3* on nature conservation, particularly SAC Annex 1 habitats.

3.4.24 Bivalve molluscs are highlighted above as tending to occur within the finer sediments in the intertidal and subtidal, although some species, notably the common mussel (*Mytilus edulis*), can be found fixed onto hard substrates while some occur on the surface of sediments, such as the native oyster (*Ostrea edulis*). Bivalve molluscs feed primarily by filter feeding and/or surface deposit feeding. The process of filter feeding in particular means that any contaminants within the water column have the potential to accumulate in bivalve flesh, presenting a potential issue for the individual bivalve but also for predator species and, for commercially exploited shellfish, human consumption.

3.4.25 Sea anemones and true corals are within the subclass Hexacorallia (class Anthozoa, Phylum Cnidaria). Hexacorals are attached organisms either as solitary individuals (as in the anemones), in the colonial form (as with many species of corals) or in aggregations. Sea anemones and true corals can inhabit the lower intertidal (see *para 3.4.20*) to the subtidal zone and may be most affected by changes in temperature, water flow and wave exposure (Jackson 2008). High temperatures can cause mortality of species or reproductive inhibition, with effects dependant on the geographic distribution of the particular species and the degree of change.

3.4.26 Crustaceans include species such as barnacles, shrimps, sand hoppers and isopods, together with the generally larger species such as crabs, lobsters and prawns. With the exception of barnacles, which filter feed from a fixed position on a hard substrate, the majority of crustaceans are mobile and generally feed on surface detritus or filter feeding or, in some cases, by removing organic matter from the surface of individual grains of sediment.

3.4.27 Maerl is a generic name for several species of calcified red seaweed, in the family Corallinacae, that grow unattached on the seabed. Maerl grows slowly, forming unattached nodules (thalli) on the seabed. Over long periods, and in favourable conditions, maerl can form dense beds of up to 22,000 nodules per square metre (Birkett, 1998).

3.4.28 Maerl beds in the UK are typically found in the sublittoral zone at depths of less than 20m, extending up to the low tide level on either sand, gravel or mud substrata. However, there are some records of live maerl at depths of up to 40m (Jackson, 2007; Hall-Spencer, 2005). The most significant environmental factors that influence maerl distribution are water movement (current and wave action) and the interactive effects of depth and water quality.

3.4.29 Other factors that influence the ecology of maerl beds include temperature, water chemistry and substratum. Whilst maerl has a wide geographic distribution, the temperature can influence the species of coralline algae that form the maerl bed and the composition of the associated flora and fauna (Adey, 1973). Low salinity was once thought to favour maerl however, this has since been disproved and maerl beds develop best in fully saline environments, and indeed may be impaired by salinities less than 24psu (King, 1982).

3.4.30 Maerl beds have considerable conservation value due to their importance as a habitat for a wide variety of plants and animals, which live amongst or are attached to its branches, or burrow through the top layer to inhabit the dead maerl gravel underneath. Studies of maerl beds throughout Europe have shown a disproportionately high diversity and abundance of species in comparison with the surrounding sublittoral habitats (Keegan, 1974; Hall-Spencer, 2005; Birkett, 1998). Maerl beds are also importance contributors to carbonate production (Barbera, 2003) and play a role in sustainable fisheries through provision of nursery areas for fish and invertebrate species of commercial importance, in particular queen scallops *Aequipecten opercularis* (Kamenos, 2004).

3.4.31 There are three main maerl bed-forming species in the UK: *Phymatolithon calcareum*, *Lithothamnion glaciale*, and *Lithothamnion corallioides*. *P. calcareum* is the most widely distributed, occurring throughout British waters. *L. glaciale* is a northern species, with its southern limits at Lundy Island in the Bristol Channel, whilst *L. coralloides* appears to be restricted to the south west. Problems with *in situ* identification of maerl bed forming species – particularly in the case of *L. coralloides* – mean that the full distribution of each species is uncertain (www.ukbap.org.uk). The most extensive maerl beds in the UK (and indeed in Europe) occur in Scotland, mainly around the western isles and Orkney, and in many sea-loch narrows. Smaller maerl beds are also found off the southern and western coasts of the British Isles.

3.4.32 Due to the value of maerl beds in the UK, and the threats faced from anthropogenic impacts, a number of candidate Special Areas of Conservation (SACs) are in the process of being designated to protect this habitat. Whilst maerl has not been specifically identified as a receptor in the generic site condition report (Aker Solutions 2008b), it is considered here due to the possible presence of suitable substrate in the subtidal zone (*para 3.3.3*) and the high conservation importance of this habitat.

Macroalgae

3.4.33 Plant species can be broadly divided into two main groups; the higher or vascular plants, which have differentiated cells for different purposes, and the lower or non-vascular plants, which include the bryophytes (e.g. moss and liverwort) and algae. In the marine environment, algae are found both as macroalgae (i.e. seaweed) and single cells (including phytoplankton). Phytoplankton is discussed separately below, under 'plankton'.

3.4.34 Seaweeds are the characteristic primary producers of rocky seashores. They are physiologically adapted to exposed environments as most species inhabit the intertidal zone and therefore are regularly exposed to air by the retreating tide. The degree of tolerance to desiccation varies across species, leading to distinct zonation laterally across the shore. The capacity of seaweeds to withstand such regular changes in environmental conditions means that these species are likely to be less vulnerable to changes in water temperature.

3.4.35 There are three Divisions within the macroalgae: Chlorophyta (green algae), Phaeophyta (brown algae), and Rhodophyta (red algae). This classification is based on the pigment within the tissues, giving the species their colour. Green algae are often tolerant of difficult conditions, such as pollution or reduced salinity, and are commonly found in the upper half of intertidal regions, in brackish water, on beaches subject to freshwater runoff or in splash zone rock pools. The brown algae comprise a diverse group and are typically represent the largest of the three Divisions. Many of the species live in distinct zones on rocky shores, but some species, such as kelp, flourish in the shallow subtidal environment. Species within the brown algae are less able to tolerate reduced salinities or higher temperatures. Red algae are usually relative small or moderately sized species, and can be fairly tolerant of reduced light conditions (living under the canopy of other seaweeds as epiphytes). The red seaweeds tend to be fairly intolerant to desiccation or reduced salinities and are therefore found in permanent rock pools or in the subtidal zone.

3.4.36 Due to their intolerance of changes in temperature compared to red and green algae, the brown algae are considered here as an ecological receptor most likely to be impacted by the cooling water discharge. The habitat in the generic site comprises rock platforms in the foreshore and backshore of the intertidal zone and therefore brown algae are likely to be present within the zone of potential impact, (*Tables 4.21 and 4.22* in Aker Solutions 2008b).

Plankton

3.4.37 Plankton may be divided into two major groups: zooplankton and phytoplankton. Both play an important role in the functioning of marine and freshwater ecosystems, as plankton form the basis of most food webs. Impacts on the plankton community can have a knock-on effect on organisms further up the food chain, including top predators such as sea birds and piscivorous fish. Any impacts on commercially important fish and shellfish through disruption of the plankton community will also have economic implications. Plankton can also have an important role in biogeochemical cycles such as carbon cycling.

3.4.38 Phytoplankton is autotrophic or eutrophic algae, which as the primary producers of the ocean provide the principal source of nutrition for organisms such as the zooplankton. As primary producers, phytoplankton requires light to photosynthesise and therefore phytoplankton abundance is highest in the photic zone, where light intensity is greatest in upper waters. Phytoplankton may be further subdivided with three orders of algae predominating; namely the diatoms, the dinoflagellates and the smaller flagellates.

3.4.39 Zooplankton is the ‘animal’ constituent of the plankton. Zooplankton may be categorised into two major groups, holoplankton and meroplankton. Holoplankton are organisms that are permanent members of the plankton where all developmental stages are retained in the plankton. Meroplanktonic organisms are characterised by a temporary planktonic phase followed by either a nekton or benthic phase and may include the larval stages of fish (Bamber & Seaby, 2004).

3.4.40 The UK is surrounded by continental shelf therefore the phytoplankton assemblage is generally dominated by diatoms and dinoflagellates and the zooplankton is dominated by crustaceans, mainly copepods.

3.4.41 The local abundance, distribution and population dynamics of plankton varies horizontally, vertically and seasonally. They are mainly influenced by light, nutrient concentrations, the physical state of the water column e.g. temperature stratification, depth, tidal mixing and salinity, and the abundance and taxon of other plankton. During winter the abundance of phytoplankton and zooplankton is very low. In spring the abundance of phytoplankton rises sharply and is followed by a corresponding bloom in zooplankton. By summer the abundance of both has peaked, after which numbers start to decline. During autumn, the abundance of phytoplankton continues to fall but the zooplankton show a second distinct peak in abundance, although it is smaller than the peak in spring (Batten *et al*., 1998). The seas around the UK all follow this seasonal pattern but it may occur later at higher latitudes, as there is less light available early in the year.

Vascular plants

3.4.42 In the marine and coastal environment, vascular plants are found along the upper shore, intertidally and subtidally. In the upper shore, the key examples include marram grass, with specialised species occurring in sand dune environments and salt marshes. In the intertidal and subtidal zone, vascular plants are restricted to the sea grasses, of the genus Zostera (eelgrass), which in the UK includes the dwarf eelgrass *Zostera noltii*, narrow-leaved eelgrass *Zostera angustifolia*, and common eelgrass *Zostera marina* (in order of zonation from upper shore to mid/lower shore, to the sublittoral zone).

3.4.43 Sand dune vegetation changes over time due to succession, with grazing being an important factor influencing community composition. Mobile sand dunes and semi-fixed sand dunes support very few species, the most characteristic being marram grass *Ammophila arenaria*. As the dune stabilised over time the community changes and species such as the heather

Calluna vulgaris and creeping willow *Salix repens argentea* characterise the habitat. These fixed dunes and heaths are considered threatened habitats.

3.4.44 Sand dune communities vary geographically. Lyme grass *Leymus arenarius* is increasingly common in northern Britain, growing alongside marram grass in mobile dunes; whilst wild thyme *Thymus polytrichus* is characteristic of south-west England; and common juniper *Juniperus communis* occurs on dunes only in two locations, both in Scotland. Most fixed dunes contain a wide variety of flowering plants particularly orchids and these plants in turn support many insects such as butterflies, moths, burrowing bees and wasps.

3.4.45 The lower edges of salt marsh communities are comparatively species-poor; often with only the common salt marsh-grass *Puccinellia maritima* present. However, further up the salt marsh a wide variety of species may occur including red fescue *Festuca rubra*, Sea rush *Juncus maritimus,* and in salt pans there may be salt marsh flat-sedge *Blysmus rufus* and slender spike-rush *Eleocharis uniglumis.* Turf fucoid *Fucus cottonii* is common on grazed land.

3.4.46 In east and south east England low to mid-marsh communities predominate, owing to extensive enclosure of the upper marsh. In contrast, the salt meadows of north west England and south west Scotland are dominated by extensive areas of grazed upper marsh communities characterised by Common salt marsh grass and Saltmarsh rush *Juncus gerardii*. Swamp communities are particularly common in the upper marsh in southwest England, while *Juncus maritimus* communities are characteristic of Welsh saltmarshes, and transitional common reed *Phragmites australis* communities are common in south-east Scotland. Some characteristic plant species of southern saltmarshes are absent from Scotland, while others such as sea-purslane *Atriplex portulacoides* have a restricted distribution in northern Britain. Saltmarshes are a valuable habitat for wildfowl and waders as well as a habitat for many Biodiversity Action Plan priority species such as ground beetles *Amara strenua,* saltmarsh shortspur *Anisodactylus poeciloides* and the narrow-mouth whorl snail *Vertigo angustior*.

3.4.47 Seagrass meadows are highly productive submerged or semi-submerged plant communities, inhabiting sheltered sandy or muddy substrata in tidal and subtidal marine and estuarine environments to a maximum depth of about

10m. In Britain there are three species of eelgrass in the genus *Zostera* the largest of which is common eelgrass *Zostera marina. Z.marina* typically occurs in the shallow sublittoral zone to a depth of approximately 4m – although with sufficient light penetration it can occur up to 10m deep – and is primarily found in fully marine environments. Mature *Zostera* plants have a high tolerance to salinity changes and occurrence of *Z.marina* in low salinity environments is thought to stimulate flowering shoot production (Davison and Hughes 1998).

3.4.48 Many factors interact to promote seagrass growth, but key to their productivity are temperature, underwater irradiance and nutrient availability. Seagrass growth exhibits distinct seasonality, with productivity increasing from spring through to summer as temperature increases, and then dropping back down from autumn through to winter (Taylor, 1995; Lee, 2007). Light levels underwater are directly linked to the growth and survival of seagrasses (Taylor, 1995; Lee, 2007), to the extent that decreases in light availability have been linked to extensive losses of seagrass beds worldwide (Taylor, 1995; Lee, 2007; Short, 1984; Short, 1996).

3.4.49 *Zostera* beds in the UK experienced an extensive decline in the 1920's due to an outbreak of 'wasting disease'. Historical evidence suggests that recovery did not start until the 1950's and in some areas, such as estuaries in the south and east of England, recolonisation has not occurred (Tubbs, 1995). This slow recovery may be linked to the increase in coastal development in the UK: as a shallow, near shore habitat, seagrass beds are particularly vulnerable to coastal activities such as dredging and excessive nutrient loading (Davison, 1998).

3.4.50 The habitat in the generic site is likely to support all three communities of vascular plant. Sand dune habitat is assumed to be present all along the upper shore in front of the proposed development site and coastal saltmarsh is present near the wetland habitat between 10 and 20km from the site boundary (*Figure 3.4* in Aker Solutions 2008b). Whilst seagrass has not been specified, it is considered likely to occur in the intertidal zone given the presence of soft sand substrate (see 3.3.5). Similarly, it is also assumed likely to occur in the subtidal zone based on our assessment of possible subtidal habitats present (see 3.3.3).

Amphibians

3.4.51 The occurrence of wetland habitat within the generic site may attract several species of amphibian, most of which inhabit freshwater but some being tolerant of brackish water.

3.4.52 The review of statutory designations near the generic site revealed that for two of the five existing nuclear sites, great crested newt occurred within 2km of the site boundary. Due to its highly protected status (as an Annex II species under the Habitats Regulations 1994 and Schedule 5 species under the WCA 1981), this species was cited as one of the reasons for designation of a Special Area of Conservation.

3.4.53 Great crested newts inhabit a wide variety of habitats, including farmlands, ponds, dunes, hedges, woodlands and brownfield sites. The breeding season starts early in the year, when the newts move to suitable wetland habitat to begin their courtship. In February and March the eggs are laid on the fronds of aquatic plants, the leaf being folded over in order to protect the eggs. After hatching the newts spend the summer in their aquatic habitat feeding on a range of aquatic invertebrates, before finally leaving the water in August and September to move to their winter hibernacula on land. Protection of these great crested newt metapopulations should therefore encompass a network of connected suitable habitats, including the migration corridors between these habitats.

3.4.54 Suitable habitat for great crested newts occurs within 2 to 10km of the generic site (*Figure 3.4* of Aker Solutions 2008a).

4 Effects of Cooling Options

4.1 Possible Environmental Changes

4.1.1 The proposed development has the potential to lead to a number of environmental changes within the marine environment, with such changes potentially having an impact on sensitive receptors. The assessment presented here is limited to changes associated with the marine aspects of the operational phase of the proposed development i.e. the abstraction and subsequent discharge of cooling water, and as such does not include changes that would be anticipated to result from the construction stage. These would be appropriately dealt with at the site-specific assessment stage.

4.1.2 The potential environmental effects considered in this section are as follows:

- Impingement of marine organisms at the intake and subsequent entrainment;
- Increase in water flow rate at the abstraction and discharge points;
- Change in ambient temperature following the discharge of the cooling water; and
- Use and subsequent discharge of the biocide (sodium hypochlorite) into the environment via the cooling water discharge.

4.1.3 The process of abstracting cooling water at the intake point has the potential to lead to two direct effects, namely impingement and entrainment, (see *para 1.4.8*). The risk of impingement can be minimised through the use of screening and behavioural deterrents that prevent organisms from entering the system and the use of recovery and return systems to allow entrained organisms to be returned to the wild. These best practice procedures are discussed in more detail in *paragraphs 1.4.8* onwards. The residual impacts after application of these technologies will depend on the organisms present and location of the intake pipe.

4.1.4 The discharge of the cooling water is likely to lead to an increase in water flow rate, as a direct result of the water being discharged but potentially also indirectly from the thermal plume. The details of the effect on the hydrodynamics would depend on specifics such as the tidal conditions and bathymetry and as such would require site specific modelling to determine the extent and significance of the effect. However, there is the potential for the increased flow rate resulting from the cooling water discharge to re-suspend sediments, depending on its location, although as noted in *paragraph 1.4.18* such resuspension would most likely result should the discharge point be poorly sited or designed. Such re-suspension may result in remobilisation of historic contamination and, depending on the amount of sediment, lead to a reduction in light penetration and hence photosynthesis and cause smothering of habitats as the sediment settles out elsewhere. Re-suspended sediments may also exhibit a significant oxygen demand due to decomposition of organic matter. These effects would be minimised by optimising the location and design of the discharge.

4.1.5 In order to further inform the assessment of potential impact at the point of discharge, additional information on the anticipated change in temperature (including the change compared to ambient, the rate of decrease towards ambient and the potential extent of change) together with information on the biocide usage (seasonality of dosing, mixing of different cooling streams, concentration at discharge, rate of decrease in concentration and the potential extent of change) are required. It should be noted that any such changes would comply with best practice/ statutory requirements as appropriate. The information presented here draws on the information presented in *Section 1.4*.

4.1.6 The UK Marine SAC website (www.ukmarinesac.org.uk) lists the direct effects of thermal discharges as follows:

- Change to the temperature regime of the water column, and perhaps the sediment, of the receiving environment;
- Lethal and sub-lethal responses of marine organisms to the change in temperature regime;
- Stimulation in productivity in a range of organisms; and
- Reduction in the dissolved oxygen saturation.

4.1.7 Potential indirect effects of temperature are highlighted as follows:

- Changes in the distribution and composition of communities of marine organisms comprising European marine sites (particularly estuaries); and
- Localised changes in bird distributions usually in response to increased macroinvertebrate or fish food supplies close to thermal discharges.

4.1.8 Specific guidance, including regulatory limits, is available for UK waters on the temperature change permissible for certain types of designated waters. Such legislation stems from EC Directives, with water bodies covered including shellfish-designated waters and salmonid and cyprinid freshwaters. However, no statutory standards exist for estuarine and coastal waters in general. The most relevant interim guidance was developed for use by regulators when assessing thermal discharges to estuarine and coastal Natura 2000 sites. Of particular note is the guidance WQTAG160 (Habitats Directive Technical Advisory Group on Water Quality, 2006) which states that the thermal discharge must not cause the temperature to increase by more than 2°C, (Maximum Allowable), at the edge of the mixing zone. It also states, *inter alia*, that:

> *'While estuarine organisms survive at temperatures as high as the maximum daily annual temperature recorded, survival is likely to depend on the duration of the high temperature being short and followed by lower temperatures. Therefore the discharge should not prolong the duration of the natural temperature to a degree that would begin to have negative impacts on the biota."*

4.1.9 As a result, the WQTAG guidance sets a threshold level for assessing potential impact on an SAC of 21.5°C as a 98 percentile at the edge of the mixing zone. The guidance assumes that salmonids are the organism most sensitive to thermal impact and that the thresholds cited aim to protect these species. As such, it is likely that such a uniform standard is over-protective of some interest features or of aspects of the non-designated general ecology, particularly intertidal areas.

4.1.10 It is understood that the UK Technical Advisory Group (UKTAG on the Water Framework Directive (WFD) is currently working on UK environmental standards and conditions for marine and freshwaters. However, the Phase 1 report (UKTAG WFD, 2008a) highlights that temperature is to be considered in subsequent reports.

4.1.11 In addition to the direct effects of a change in temperature, it should be noted that the solubility of oxygen in water decreases with increasing temperature. Seawater that is saturated with oxygen will lose some of its dissolved oxygen as it warms. At the normal ambient temperatures of UK waters the reduction in oxygen solubility is around 0.2mg/litre per 1^{o}C increase in temperature. The saturation concentration of seawater at normal UK ambient temperatures is around 8 mg/l. Beyond the immediate mixing zone, the 2^{o}C change permitted under the WQTAG guidance would relate to a 0.4mg/litre drop, i.e. to 7.6mg/l. Such a change in dissolved oxygen is unlikely to have a significant impact on flora of fauna and as such is not considered further.

4.1.12 It should be noted that to accurately determine temperature changes both inside and outside the mixing zone (together with the extent of the mixing zone itself), site specific modelling would be required. The need for site-specific studies is discussed further in *Section 5*.

4.1.13 An increase in water temperature may also have the secondary effect of increasing the rate of oxygen consumption by bacteria and other microorganisms digesting organic matter. This is the equivalent of an increase in BOD. The effect is likely to be minor as BOD levels in clean seawater will be very low. As such, potential effects of BOD are not considered further at this stage.

4.1.14 The UK Technical Advisory Group (UKTAG) on the Water Framework Directive (WFD) published revised proposals for environmental quality standards for Annex VIII substances in June 2008 (UKTAG WFD, 2008b). Chlorine is one of the substances that have been evaluated to date. It should be noted that the report commented that 'aquatic organisms tend to be more sensitive to chlorine at higher temperatures', which implies that the heated cooling water could lead to in-combination effects. The proposed standard relates to short-term exposure only, with a compliance statistic of 95 percentile. The standard given is 10µg/litre (total residual oxidant).

4.1.15 The term 'total residual oxidant' refers to the sum of free and combined residual oxidant and hence includes both chlorine and bromine compounds. The standard was set as a result of the available literature on the sensitivity of early life stages of fish to chlorine. For example, the UKTAG report (2008) cited that for the larvae of both plaice (*Pleuronectes platessa*) and sole (*Solea solea*), an LC50 of 28µg/litre TRO has been reported. The combination of a relatively large dataset on the acute effects together with the relatively short persistence of free residual oxidant in marine water resulted in an EQS set at 10µg/litre TRO, as a maximum allowable concentration.

4.1.16 The UKTAG reviewed the EQS for chlorine according to WFD guidance taking account of predicted no effect concentrations (PNEC). The identified PNECs for chlorine and total residual oxidant in seawater were found to be much lower than the current EQS. However, they were based on limited ecological data and therefore gave rise to a considerable degree of uncertainty in the extrapolation of the data. In addition analytical methods are not currently capable of measuring to the required levels. For these two reasons the UKTAG recommended the existing EQSs should be adopted until these issues can be addressed. It should be noted that it is likely that the EQS level will be reduced in the future.

4.1.17 Assuming best practice, a remaining TRO concentration of 50µg/litre at discharge should be achievable (based on mixing of chlorinated and unchlorinated streams prior to discharge). This will rapidly be dissipated by the chlorine demand of the receiving water as well as dilution effects. The EQS for TRO will therefore be met very close to the discharge point, the exact distance being dependant on the chlorine demand of the receiving water. The TRO plume is likely to be very much smaller than the thermal one. Even without the effects of the chlorine demand of the receiving water, dilution is likely to take the TRO below the current EQS of 10µg/litre before the temperature difference falls to 2 ^{o}C.

4.1.18 A mixture of chlorinated and brominated compounds will be formed by the chlorination of the cooling water and the reaction of the chlorine with bromide. In chlorinated seawater brominated species normally predominate. Whilst brominated species are generally more toxic they also breakdown more rapidly in the environment. Trihalomethanes and halogenated acetic acids are the most common byproducts formed. Brominated phenols will also occur in the presence of phenol i.e. where other industrial discharges exist.

4.1.19 The quantities of by products formed will be related to the applied chlorine dose, not the residual concentration of oxidant. Key factors in by-product formation are the concentration of organic carbon (normally humic and fulvic acids), temperature, pH and contact time and hence will be site specific.

4.1.20 There are no EQSs for these chlorination byproducts. Compounds with significant halogen content often partition into organic matter and biota. Byproducts that have the potential to accumulate in sediments and biota can be identified by examining data on their log Kow and Bioaccumulation Factor (BF), where these are available. The log Kow is a measure of the relative solubility in octanol and water. A log Kow of greater than three indicates a potential to partition to organic matter. A BF of greater than 100 also implies that a chemical is likely to bioaccumulate. *Table 4.1* below lists the most common chlorination byproducts, together with their log Kow and bioaccumulation factors. Only tribromophenol demonstrates potential to bioaccumulate.

4.1.21 Based on the lowest reliable No Observed Adverse Effect Level for reproductive/developmental study in rats, and using conversion factors from the Appendix VII of the European Commission's Technical Guidance Document, an EAL/EQS for marine predators such as fish eating mammals has been derived. This gave an EQS for saltwater for secondary poisoning of 5.85 μg/l for tribromophenol. This level is unlikely to be exceeded even immediately at the outfall.

4.1.22 The UK Marine SAC website (www.ukmarinesac.org.uk) lists the potential effects of biocide use on European marine sites as follows:

- Toxicity to invertebrates at concentrations above the EQS; and
- Risk of bioaccumulation.

4.1.23 The WFD prohibits the discharge of List 1 substances, e.g. cadmium and mercury, and requires that discharges of List two substances be reduced to as low as practicable. Although there is currently no data on the potential for discharge of metals within the cooling water, it is assumed that the main source will be from corrosion or from discharges from other parts of the plant. Corrosion should be minimised through a combination of design and selection of materials and therefore discharges from this source should be minimal.

Discharges from other parts of the plant should be subject to separate consent.

Table 4.1 Common halogenated by-products of chlorination in seawater

Chemical	CAS No	Log Kow	BCF
Haloamines			
Monobromamine	14519-10-9	-	-
Dibromamine	14519-03-0	-	-
Tribromamine	-	-	-
Haloacetonitriles			
Bromochloroacetonitrile	83463-62-1	-	-
Bromoacetonitrile	590-17-0	-	-
Dibromoacetonitrile	3252-43-5	0.47	-
Haloacids			
Bromoacetic acid	79-08-3	0.41	-
Dibromoacetic acid	631-64-1	0.7	-
Tribromoacetic acid	75-96-7	1.71	-
Bromochloroacetic acid	5589-96-8	0.61	3.2 (estimated based on log Kow)
Bromodichloroacetic acid	71133-14-7	-	-
Chlorodibromoacetic acid	5278-95-5	-	-
Halogenated phenols			
2,4-Dibromophenol	615-58-7	3.22	24 (estimated based on log Kow)
3,5-Dibromophenol	626-41-5	3.29	27 (estimated based on log Kow)
2,4,6-Tribromophenol	118-79-6	4.13	83-513 (measured in Brachydanio rerio)
Haloketones			
Bromopropanone	867-54-9	-	-
3-Bromo-2-butanone	814-75-5	0.53	3.2 (estimated based on log Kow)
Trihalomethanes			
Bromodichloromethane	75-27-4	2	7 (estimated based on log Kow)

Chemical	CAS No	Log Kow	BCF
Bromoform	75-25-2	2.4	14 (estimated based on log Kow)
Chlorodibromomethane	124-48-1	2.16	9 (estimated based on log Kow)

4.2 Marine Environmental Receptors

4.2.1 *Sections 3.3 to 3.4* highlight the marine habitats and species that are predicted to occur at the generic site, with these habitats and species representing the potential 'receptors' for any environmental change resulting from the intake and discharge of the cooling water. The receptors identified draw on the generic site conditions defined by Aker Solutions (2008), together with the habitats and species for which the SAC, SPA and Ramsar sites in the five existing nuclear power stations, upon which the generic site conditions were described, were designated (as highlighted in *Section 1.3*). To enable a broad scale assessment of potential impact to be made, a summary of the broad marine environmental receptors identified through both routes is provided here, essentially drawing on the habitats and species which are listed as a primary reason for SAC, SPA and Ramsar site selection at the 5 sites on which the generic conditions are drawn, together with the habitats and species highlighted specifically for the generic site. The information is presented in *Table 4.2*. These are amalgamated to provide a final list for consideration in the impact assessment in *Table 4.3* in *Section 0*.

Table 4.2 Summary of the Habitats and Species Identified for the Generic Site.

SAC/SPA/Ramsar habitats and Species	Broad habitats and species	Amalgamated list
Breeding birds	Avifauna (wading birds and ducks)	Avifauna
Birds on passage		
Overwintering birds		
Migratory birds		
Assemblage of wetland birds		
Assemblage of seabirds		
Large shallow inlets and bays/permanent shallow marine waters	Subtidal habitats (including fully marine and reduced salinity muds and sands and hard substrates, fully marine sands	Subtidal habitats and species
Estuaries/Estuarine waters		

SAC/SPA/Ramsar habitats and Species	Broad habitats and species	Amalgamated list
Subtidal sandbanks	and gravels, reef structures, eelgrass beds and maerl beds) Together with Subtidal benthic communities (includes polychaetes, bivalves, sea anemones and true corals, crustaceans and maerl)	Seagrass beds
-	Plankton (includes zoo- and phytoplankton)	Plankton
-	Macroalgae (includes green, brown and red)	Macroalgae
Rocky marine shores	Intertidal habitats (including sand, gravels, hard rock, muds and made ground) Together with Intertidal benthic communities (includes bivalves, polychaetes, *Sabellaria alveolata*, crustaceans, sea anemones)	Intertidal habitats and species
Sand, shingle or pebble shores		
Mudflats and sandflats/intertidal mud, sand or salt flats		
Annual vegetation of drift lines	Vegetated shingle	Vegetated shingle
Perennial vegetation of stony banks		
Salicornia etc, Atlantic salt meadows/intertidal marshes	Coastal saltmarsh	Saltmarsh
Shifting dunes, fixed dunes, humid dune slacks	Sand dunes	Sand dunes
-	Vascular plants (includes seagrass, sand dune and saltmarsh plants)	Covered in separate sections on subtidal habitats and species (seagrass), sand dunes and saltmarsh
-	Wetlands	Wetlands
Great crested newt	Amphibians (great crested newt)	Great crested newt
Sea lamprey	Fish (including benthic species, elasmobranchs, pelagic species and migratory species)	Fish
River lamprey		
Twaite shad		
-	Mammals (otters)	Otters

4.3 Possible Impact of the Intake and Discharge of Cooling Water on the Marine Environment at the Generic Site

4.3.1 The possible impacts that may be associated from the effect of the environmental changes listed in *Section 4.2* on the environmental receptors listed in *Table 4.2* are summarised in *Table 4.3*. It should be noted that designated sites have not been assessed as stand alone sites; rather the assessment is based on habitats and species, which includes those that are listed as the reasons for site designation.

Table 4.3 Potential Effects on the Habitats and Species at the Generic Site as a result of the Abstraction and Discharge of Cooling Water.

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
Impingement/ Entrainment of Marine Organisms	Avifauna	No direct effect on avifauna likely	The potential for indirect effect on avifauna would arise should prey items be affected directly or indirectly. The potential for impact on such prey items is considered separately under subtidal habitats and species, plankton and fish	See mitigation/best practice under plankton and fish
	Subtidal habitats and species	Limited potential for direct impact, with any such impacts occurring should sediments/benthos be disturbed	Potential for indirect impact exists for benthic species with a planktonic larval stage or, potentially, for benthic species that feed on plankton. Direct impacts on plankton are discussed separately.	None required
	Seagrass beds	No direct effect on seagrass beds likely	No indirect effect on seagrass beds likely	None required
	Plankton	Fish eggs, larvae and small juveniles stages within the plankton will be at risk from entrainment within the system, although entrainment does not necessarily preclude their survival within the system. In general, it is likely that whilst there may be some mortality of fish larvae, although the scale of the impacts may only be small. The potential to survive the entrainment will depend on the sensitivity of the species, for example species such as clupeids are more vulnerable to damage. In addition, survival will depend to the site-specific stressors such as the system design, temperature and biocide regime (Fawley 1995).	No indirect effect on plankton likely	If possible, careful timing of the application of the biocide to avoid key fish spawning times for sensitive species.

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Macroalgae	No direct effects on macroalgae likely	No indirect effects on macroalgae likely	None required
	Intertidal habitats and species	No direct effects on intertidal habitats and species likely	No indirect effects on intertidal habitats and species likely	None required
	Vegetated shingle	No direct effect on vegetated shingle likely	No indirect effect on vegetated shingle likely	None required
	Saltmarsh	No direct effect on saltmarsh likely	No indirect effect on saltmarsh likely	None required
	Sand dunes	No direct effect on sand dunes likely	No indirect effect on sand dunes likely	None required
	Wetlands	No direct effect on wetlands likely	No indirect effect on wetlands likely	None required
	Great crested newt	No direct effect on great crested newt likely	No indirect effect on great crested newt likely	None required

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Fish	Fish most at direct risk of impingement are smaller species or juveniles of larger species that are unable to escape the intake currents. In general, there is unlikely to be impingement to fish at velocities less than $0.35ms^{-1}$ (Turnpenny 1998). The species of mature fish entrained will largely be dependent on the mesh size (Turnpenny, 1981). Smolt of diadromous migratory fish, including Twaite shad and lampreys may also be particularly vulnerable if the intake pipe lies across their migratory path.	Indirect effects of impingement and entrainment will depend on the survival rate of ichthyplankton through the system and subsequently the overall change to plankton survival in the environment. The potential for such direct effects on plankton are discussed separately in the table.	Adherence to relevant standards. Use of fish screens. Acoustic fish deterrent (AFD) systems placed at the CW inlet can be used to prevent the ingress of many of the hearing-sensitive fish species, leaving mainly the more physically robust bottom-living fish to be returned via the travelling screen fish return route. Consideration of mitigation for impact on migratory species will need to be undertaken on a site-specific basis, since the potential for impact will depend on the degree of water quality change and/or the width of the migration channel affected.
	Otters	The potential for direct effect on otters relates to impingement on the intake screen. However, as otters can swim at speeds of at least 1m/s (Garcia de Leaniz et al, 2006), the potential for such direct effects is considered low, provided adequate screening is provided	The potential for indirect effect on otters would arise should prey items be affected directly or indirectly. The potential for impact on such prey items is considered separately under subtidal habitats and species and fish	Adherence to relevant standards. Provision of 50mm-spaced bar screens at the intake entrance

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
Increase in water flow rate	Avifauna	No direct effect on avifauna likely	The potential for indirect effects on avifauna would arise should prey items or food sources be affected, directly or indirectly. The potential impact on such prey items is discussed separately, primarily under subtidal habitats and species, intertidal habitats and species and fish.	None required
	Subtidal habitats and species	No direct effect on most subtidal habitats and species likely, however, Sabellaria spinulosa beds are sensitive to strong water flow, which may cause fragmentation of the reef and loss of associated communities.	No indirect effect on subtidal habitats and species likely	Avoidance of Sabellaria spinulosa beds.
	Seagrass beds	Seagrasses require sheltered environments with low currents and tidal flux. Increased water flow may therefore cause erosion of the seagrass bed.	No indirect effect on seagrass beds likely	Adherence to relevant standards. Careful site selection of the point of discharge, to avoid areas of seagrass beds
	Plankton	No direct effect on plankton likely	No indirect effect on plankton likely	None required
	Macroalgae	Direct effects may occur if the water flow rate is strong enough to dislodge the basal discs from the substrate. However, studies of Fucus species have shown that these are attached strongly to rocks in order to withstand wave action (Hill 2005) therefore they are considered to have only a low intolerance to increased water flow.	No indirect effect on macroalgae likely	None required

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Intertidal habitats and species	Some intertidal habitats and species (e.g. those characteristic of littoral mixed sediment) are associated with weak tidal stream and therefore may be vulnerable to increases in water flow rate leading to a change in sediment characteristics and therefore a shift in community composition. Epibenthic species are most vulnerable and possible effects may be removal of individuals by the outfall water to deeper, less suitable environments, or disruption to the feeding apparatus of suspension feeders leading to reduced food consumption. Overall these effects could lead to a decrease in species richness in the community and a possible shift a community that is permanently inundated with seawater.	Indirect effects may occur through changes in the fecundity of species that have a planktonic larval stage thereby affecting recruitment. This is discussed under direct impacts on plankton.	Adherence to relevant standards. Site-specific benthic survey would be required to determine the specific risk to the habitat. May be possible to incorporate modifications to the design/layout if a significant effect is anticipated.
	Vegetated shingle	No direct effect on vegetated shingle likely	No indirect effect on vegetated shingle likely	None required
	Saltmarsh	No direct effect on saltmarsh likely	No indirect effect on saltmarsh likely	None required
	Sand dunes	No direct effect on sand dunes likely	No indirect effect on sand dunes likely	None required
	Wetlands	No direct effect on wetlands likely	No indirect effect on wetlands likely	None required
	Great crested newt	No direct effect on great crested newt likely	No indirect effect on great crested newt likely	None required
	Fish	No direct effect on fish likely	No indirect effect on fish likely	None required
	Otters	No direct effect on otters likely	No indirect effect on otters likely	None required

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	**Indirect**	
Change in Ambient Temperature	Avifauna	The maximum allowable temperature change beyond the mixing zone is 2^{o}C. Although bird species are likely to physically feel the change in temperature, potentially prompting some to move from the site. Unless the site is particularly important for the species or the area affected to that extent is large, the direct effect is unlikely to be significant	The potential for direct effect on avifauna would arise should prey items be affected directly or indirectly. The potential for impact on such prey items is considered separately under subtidal habitats and species, plankton and fish.	Adherence to relevant standards. Careful site selection of the point of discharge, to avoid key areas used by birds
	Subtidal habitats and species	The maximum allowable temperature change beyond the mixing zone is 2^{o}C. As reflected in a wide geographic distribution, most habitats and species are tolerant of or have only a low or intermediate intolerance to temperature changes. Possible direct effects include reduced growth and fecundity of individuals, and early spawning leading to a reduced survival of larvae during their planktonic stage. The may also be potential for the establishment of species that require slightly warmer conditions, whether native or alien to the UK.	Indirect effects may occur from increased mortality of zooplankton or a shift in the community composition of plankton, which would consequently alter the abundance and species composition of subtidal benthos whose reproductive cycle involves a planktonic stage. In addition, temperature could affect the microbial activity in the sediment thereby altering the depth at which the anoxic layer occurs (Hill 2007). It should be noted that an increase in temperature may enhance the toxicity of the chlorinated cooling water. The effect of this would be greatest on species already at the limit of thermal tolerance (Capuzzo 1979). Impacts associated with the biocide are discussed separately.	Adherence to relevant standards. Site specific benthic survey would be required to determine the specific risk to the habitat. May be possible to incorporate modifications to the design/layout if a significant effect is anticipated.

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Seagrass beds	The maximum allowable temperature change beyond the mixing zone is 2°C. Seagrass species have a wide geographic distribution and therefore may be tolerant to a gradual rise in temperature. However, at rapid elevated temperatures there may be some thermal stresses on plants. The degree to which this will occur will depend on issues such as species and the local environmental conditions to which the plants have adapted.	Indirect effects may occur through a decrease in water clarity arising from plankton blooms. This could effect seagrass beds by reducing light availability for photosynthesis and consequently reduce seagrass growth {Lee et al. 2007). Increased temperature may also promote the growth of epiphytes and ephemeral algae, whilst decreasing abundance of important grazing mollusc species, thereby also reducing light availability through overgrowth by macroalgae. It should be noted that an increase in temperature may enhance the toxicity of the chlorinated cooling water. The effect of this would be greatest on species already at the limit of thermal tolerance (Capuzzo 1979). Impacts associated with the biocide are discussed separately.	Adherence to relevant standards. Careful site selection of the point of discharge, to avoid areas of seagrass beds

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Plankton	The maximum allowable temperature change beyond the mixing zone is $2^{o}C$. Since plankton has no mechanism for selective avoidance of unfavourable areas they are sensitive to effects of thermal plumes. Possible effects may be a shift in community composition to dominance by exotic species. Also, as water temperature raises the rate of photosynthesis and thereby phytoplankton biomass increases. This accelerated response can lead to a decrease in water clarity and increase in Biological Oxygen Demand as bacterial activity required to decompose the algae is accelerated. Changes in planktonic communities are particularly important as these effects could have consequences for species higher up the trophic web. Upper thermal limits for plankton will vary between and within species, i.e. geographically, with temperate species potentially more vulnerable to extremes of temperature.	Early spawning of fish and invertebrates induced by thermal plumes could lead to increased mortality of zooplankton as the environmental conditions for survival may be less than suitable. It should be noted that an increase in temperature might enhance the toxicity of the chlorinated cooling water. The effect of this would be greatest on species already at the limit of thermal tolerance (Capuzzo 1979). Impacts associated with the biocide are discussed separately.	Adherence to relevant standards
	Macroalgae	The maximum allowable temperature change beyond the mixing zone is $2^{o}C$. Sudden elevation of temperature may have an effect on brown algae causing reduced growth and fecundity, particularly those at the upper temperature limit of their geographic distribution. Species of green algae may be more tolerant to a chronic temperature increase ($2^{o}C$) (Budd 2004).	It should be noted that an increase in temperature may enhance the toxicity of the chlorinated cooling water. The effect of this would be greatest on species already at the limit of thermal tolerance (Capuzzo 1979). Impacts associated with the biocide are discussed separately.	Adherence to relevant standards

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Intertidal habitats and species	The maximum allowable temperature change beyond the mixing zone is $2^{o}C$. Habitats and species are generally tolerant to changes in temperature as experienced during the regular tidal cycle; however, acute rises in temperature may have negative effects. For example, a temperature rise of $>3^{o}C$ has reportedly caused early spawning in cirratulid worms causing high mortality of larvae (George 1964). In addition, at critical temperature levels the effects could be mass mortality. Lethal temperature limits vary interspecifically and geographically. Studies of Cerastoma edule show a range of $31\text{-}35^{o}C$, with an ability to acclimatize to an ambient change of $10^{o}C$ (reviewed in Marshall 2004).	Indirect effects may occur from increased mortality of zooplankton or a shift in the community composition of plankton, which would consequently alter the abundance and species composition of intertidal benthos whose reproductive cycle involves a planktonic stage. It should be noted that an increase in temperature may enhance the toxicity of the chlorinated cooling water. The effect of this would be greatest on species already at the limit of thermal tolerance (Capuzzo 1979). Impacts associated with the biocide are discussed separately.	Adherence to relevant standards
	Vegetated shingle	No direct effect on vegetated shingle likely	No indirect effect on vegetated shingle likely	None required
	Saltmarsh	The maximum allowable temperature change beyond the mixing zone is $2^{o}C$. Limited potential for a direct effect on saltmarsh, due to the position of saltmarsh on the shore, however it should be noted that temperature can affect seasonality of growth and as such should the footprint of change be sufficient the issue may require consideration	No indirect effect on saltmarsh likely. However, it should be noted that an increase in temperature may enhance the toxicity of the chlorinated cooling water. The effect of this would be greatest on species already at the limit of thermal tolerance (Capuzzo 1979). Impacts associated with the biocide are discussed separately.	Adherence to relevant standards
	Sand dunes	No direct effect on sand dunes likely	No indirect effect on sand dunes likely	None required
	Wetlands	No direct effect on wetlands likely	No indirect effect on wetlands likely	None required

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Great crested newt	The maximum allowable temperature change beyond the mixing zone is $2^{o}C$. Great crested newts are ectotherms and rely on external heat sources to raise their body temperature to a level that allows activity. However, extreme temperatures, below $18^{o}C$ and above $24^{o}C$, have been found to disrupt sex determination (Wallace & Wallace 2000). As the species typically does not occur in salinities greater than 12 mm (Wallace, 1991), being more commonly associated with freshwater environments, it is unlikely that they will be affected by coastal development.	No indirect effect on great crested newt likely	Adherence to relevant standards
	Fish	There are concerns that thermal plumes from cooling water could present a 'thermal barrier' to some species of fish and large crustaceans, notably salmon, although there is no compelling evidence of its occurrence. Local behavioural changes have been observed in some species, e.g. bass are attracted to the discharge at Fawley, with the area designated a bass nursery site (Pickett et al, 1995), however other species not suited to the temperature may avoid the area.	Early spawning of fish species due to an increase in ambient temperature could have knock on effects for next generation communities. Increased mortality of fish eggs in the plankton would reduce the abundance and diversity of fish species the following season. Indirect effects may occur through enhanced uptake of biocides, this is considered below.	Adherence to relevant standards. Consideration of mitigation for impact on migratory species will need to be undertaken on a site-specific basis, since the potential for impact will depend on the degree of water quality change and/or the width of the migration channel affected.
	Otters	No direct effect on otters likely	The potential for direct effect on otters would arise should prey items be affected directly or indirectly. The potential for impact on such prey items is considered separately under subtidal habitats and species and fish.	Adherence to relevant standards. Careful site selection of the point of discharge, to avoid key areas used by otters

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
Introduction of Biocide	Avifauna	No direct effect on avifauna likely	The potential for direct effect on avifauna would arise should prey items be affected directly or indirectly. The potential for impact on such prey items is considered separately under subtidal habitats and species, plankton and fish. However, it should be noted that the potential for bioaccumulation of breakdown products could not be ruled out at this high level.	Adherence to relevant standards. Careful site selection of the point of discharge, to avoid key areas used by birds
	Subtidal habitats and species	Most habitats and species show high or intermediate intolerance to biocides. Direct effects include loss of characterising species, decline in species richness, productivity and fecundity of organisms resulting in a shift towards a community dominated by more opportunistic species. The plume is likely to be buoyant and therefore may have limited impacts on subtidal benthic communities except in the localized area of the discharge.	Indirect effects of biocide may be through a decrease in abundance and diversity of prey species e.g. plankton. These changes are discussed separately.	Adherence to relevant standards.
	Seagrass beds	Seagrass plants may accumulate chemical contaminants in their tissues, with sublethal effects such as physiological decay of plants or inhibition of photosynthesis (Tyler-Walters 2006).	Indirect effects may occur if biocide contamination causes high mortality of important grazers, which help to keep macroalgal communities in check: effects may then occur through overgrowth of algae leading to reduced light availability and consequently reduced photosynthetic activity.	Adherence to relevant standards. Careful site selection of the point of discharge, to avoid areas of seagrass beds

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Plankton	Biocide may cause direct toxic effects on plankton with Lethal Dose (LD) levels varying interspecifically. Icthyplankton are considered to be particularly sensitive. Detailed analysis of LD levels for different species is beyond the scope of this report. The scale and significance of impacts will depend on the time of year the biocide is administered.	Indirect effects of biocide may be through a decrease in reproductive capacity of marine fauna and flora with a planktonic life stage.	Adherence to relevant standards.
	Macroalgae	Biocides used in cooling water by definition are toxic to marine algae, however limited information is available to assess the degree of potential impact in the wider environment	No indirect effect on macroaglae likely	Adherence to relevant standards.
	Intertidal habitats and species	Biocides used in cooling water by definition are toxic to marine invertebrates, with most habitats and species showing a high or intermediate intolerance. For invertebrates, the chronic toxicity of chlorine has been investigated only in molluscs and crustaceans. Direct effects include an effect on shell deposition in bivalves, loss of characterising species, decline in species richness, productivity and fecundity of organisms resulting in a shift towards a community dominated by more opportunistic species.	Indirect effects of biocide may be through a decrease in abundance and diversity of prey species e.g. plankton. These changes are discussed separately.	Adherence to relevant standards.
	Vegetated shingle	No direct effect on vegetated shingle likely	No indirect effect on vegetated shingle likely	None required

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	Indirect	
	Saltmarsh	Limited potential for a direct effect on saltmarsh, due to the position of saltmarsh on the shore, however it should be noted that temperature can affect seasonality of growth and as such should the footprint of change be sufficient the issue may require consideration	Limited potential for an indirect effect on saltmarsh, due to the position of saltmarsh on the shore, however it should be noted that saltmarsh species may be affected by the breakdown products of the biocide, should the dispersion extend to areas of saltmarsh	None required
	Sand dunes	No direct effect on sand dunes likely	No indirect effect on sand dunes likely	None required
	Wetlands	No direct effect on wetlands likely	No indirect effect on wetlands likely	None required
	Great crested newt	Direct contact with biocides is likely to incur toxic effects on individuals. Possible effects may be gill-damage, physiological damage and mortality.	Indirect effects may occur through deterioration of suitable habitats such as wetland areas.	None required
	Fish	Limited data is available to assess the effect of sodium hypochlorite on fish. Effects of direct uptake that have been recorded and to relate to gill damage and reduced oxygen consumption (Cappuzo 1979) and effects on fry and eggs. Studies have investigated the lethal effects levels for various species of fish that may be compared against No Probable Effects Levels. Detailed analysis of these levels is beyond the scope of this report.	Indirect effects of biocide may occur through impacts on the subtidal habitats and species. For example, a decline in species diversity and abundance of benthic invertebrates may reduce available prey resources for fish species. Similarly, deterioration of important habitats for fish, such as seagrass beds, may have an impact on fish nursery areas, causing reduced survival of juvenile fish.	Adherence to relevant standards.

Potential Environmental Change	Marine Environmental Receptors within Generic Site	Potential Effect on Receptor of Environmental Change		Potential Mitigation Measures/Best Practice
		Direct	**Indirect**	
	Otters	Provided the requirements of any consent to discharge are met, it is anticipated that the discharge of biocide poses limited potential for direct effect on otters	The potential for direct effect on otters would arise should prey items be affected directly or indirectly. The potential for impact on such prey items is considered separately under subtidal habitats and species and fish. However, it should be noted that the potential for bioaccumulation of the breakdown products could not be ruled out at this high level.	Adherence to legislative requirements. Careful site selection of the point of discharge, to avoid key areas used by otters

5 Site Specific Study

5.1.1 The current project relates to the potential environmental impacts associated with the abstraction and discharge of cooling water from a nuclear power station at a generic site. The approach enables the potential environmental impacts of the cooling water aspects of the AP1000 nuclear power station design to be identified and assessed, highlighting where mitigation measures can be applied and where there may exist potential for direct and indirect effects.

5.1.2 As discussed in *Section 4.1*, the use of a generic site causes difficulties when considering issues such as the potential scale and magnitude of environmental change. In essence, it is difficult to assess both the possible size of the change and extent of the footprint of that change; both factors having a strong influence on the potential for impact and the degree of significance of that impact. For example, it has not been possible to determine whether the footprint of change is sufficiently large to extend to a key sensitive receptor, nor whether the size of the change would be sufficient to cause a measurable effect. The approach taken in the current project is a 'worst case scenario' and may therefore overstate the potential impact in some cases, primarily by assuming that the footprint of change is sufficient to reach all receptors, with the exception of some of the transitional habitats and species, (these are noted in *Table 4.3*).

5.1.3 On a site-specific basis, these issues are dealt with in a number of ways. In particular, a number of studies would be required in order to improve the understanding of the baseline environment, (and hence improve understanding of the sensitivity of the receiving environment), together with studies to more accurately determine the likely scale and magnitude of the environmental changes. The types of site-specific work that would be anticipated to be required are highlighted in *Table 5.1* below.

Table 5.1 Site specific work required

Site Specific Study	Purpose of Work
Ecological survey	To describe the existing baseline. The extent of the survey would be dictated by issues such as the anticipated footprint of the impact, together with some sites to provide a control and the presence of protected habitats and/or species. The extent of such a survey is therefore likely to include both subtidal and intertidal sampling, with a potential requirement for survey of transitional habitats
Fish survey	To describe the existing baseline. To provide data on the species present, including issues such as presence of juveniles, to inform the impact assessment and to assess how best to use mitigation measures
Water quality survey	To describe the existing baseline. Data would be required both to inform the subsequent impact assessment but also to enable modelling of the predicted change
Chlorination trials	To allow better modelling of the residual oxidant and by-product concentrations
Sediment quality survey	To describe the existing baseline. In particular, for areas where there is potential for sediments to be disturbed by the increase in water flow at the abstraction and discharge points.
Bathymetric survey	Data on the bathymetry of the site would be required to enable the dispersion and dilution of the resulting plume to be modelled, in particular the scale and extent of the mixing zone
Current meter profiling	Data such as current speed and direction would be required to enable the dispersion and dilution of the resulting plume to be modelled, in particular the scale and extent of the mixing zone
Tidal data	Data on the tidal profile of the site (e.g. range and excursion) would be required to enable the dispersion and dilution of the resulting plume to be modelled, in particular the scale and extent of the mixing zone
Modelling	The dilution and dispersion of the resulting discharge would require modelling, to enable the magnitude and extent of the mixing zone to be determined and to better inform the impact assessment process. Such modelling would need to take into consideration issues such as seasonal changes (e.g. in background temperature or storminess), spring/neap cycles together with the influence of the discharge pattern such as when biocide is applied and the influence of such measures as mixing the cooling streams
Detailed design of the cooling water system	To ensure the optimum design following BAT whilst taking account of specific site conditions

5.1.4 It should be noted that the information provided in Table 5.1 is indicative only and that site specifics, such as presence/absence of migratory species, proximity to designated sites etc would need to be taken into consideration. It is likely that any survey programme would need to be drawn up with input and discussion with the appropriate regulator and/or statutory advisor.

6 Conclusion

6.1.1 The baseline environmental assessment of the generic site has identified a number of habitats and species, including both those that are common to the UK together with a limited number that either occur less frequently or are subject to a greater degree of legislative protection. In particular, the baseline review highlighted the number of designated areas in the vicinity of the generic site, ranging from locally designated and non-statutory sites to a number of internationally protected sites, the latter including SAC, SAP and Ramsar sites. The presence of such sites brings with them the requirements of the Habitats Directive and the need to address the issues that this raises.

6.1.2 It should be noted that the generic site does not include all the habitats and species that may occur at a specific site, once one is selected, with any such future site requiring a site-specific assessment. The assessment of the generic site does, however, offer information on the type of habitats and species that are likely to be found, with much of the information applicable to other habitats and species. For example, the issues around potential impact on Twaite or Allis shad, both migratory fish, are very similar to those that would affect salmon, should salmon be present.

6.1.3 The Water Framework Directive (WFD) requires the classification of water bodies by examining ecological, chemical and physical elements. One of its main objectives is to achieve good ecological and chemical status. Water bodies of good ecological status should deviate only slightly from the biological, structural and chemical characteristics that would be expected in undisturbed conditions.

6.1.4 The WFD, either at European or member state level, sets Environmental Quality Standards for a range of pollutants including temperature. If these EQS are met the quantities of the pollutants should not be sufficient to cause harm to the local ecology.

6.1.5 The impact assessment considered the operational effects of the abstraction and discharge of cooling water, together with the associated requirement for biocide, with the environmental effects therefore restricted to the following:

- Impingement of marine organisms at the intake and subsequent entrainment;
- Increase in water flow rate;
- Change in ambient temperature following the discharge of the cooling water; and
- Use and subsequent discharge of the biocide (sodium hypochlorite) into the environment via the cooling water discharge.

6.1.6 Once the baseline environment and the type of environmental change predicted had been described, the potential effect of that change on the main environmental receptors could be assessed. As site specific factors such as the scale and magnitude of the change can not be predicted for a generic site, a worst case scenario was assumed that all potential receptors present were potentially linked by a pathway to the environmental change (although some consideration of potential pathway was made when considering transitional habitats).

6.1.7 While making the assessment of potential effect, the mitigation measures that are inherent in the design were taken into consideration. Key mitigation measures can be summarised as follows:

- Design and location of the abstraction point to minimise impact on habitats and entrainment of fish;
- Modelling, design and location of the discharge point to minimise impacts on sensitive species and habitats;
- Minimising the need for conditioning of the cooling water by best practice design and choice of materials;
- Best practice design and monitoring of the cooling water treatment system;
- Blending of chlorinated and un-chlorinated streams to reduce residual oxidant to a minimum.

6.1.8 The assessment of potential effect identified a limited number of habitats and species for which there is a greater potential for significant impact, although it should be noted that application of the mitigation measures described above should, in most cases, limit such impact outside the immediate mixing zone. The habitats and species highlighted are as follows:

- Depending on the importance of the site chosen for planktonic spawning fish species, there may be benefit in consideration of timing the biocide dosing intervals outside key spawning times, (if possible);
- Although best practice procedures will be followed to minimise the risk of impingement and entrainment, their effectiveness with depend on the species present and the location of the intake pipe. Residual impacts will therefore need to be assessed on a site-specific basis and mitigation determined at this stage, depending on what species is affected;
- Some habitats and species are more sensitive to an increase in flow rates resulting from the abstraction/discharge process, e.g. seagrass beds. Site specific surveys should be carried out to assess the presence of such habitats and species, to enable the final design to avoid such areas where feasible;
- The change in ambient temperature beyond the mixing zone will be within the 2°C limit and as such effects are likely to be limited. Where effects do occur, these are most likely on sessile species such as the intertidal and subtidal benthos and seagrass, or species that have limited opportunity to avoid less favourable areas such as the plankton. Such effects have the potential to have implications both for predators and species that are affected at early stages in their lifecycle. Potential impact on fish would require careful assessment. It should, however, be noted that this assessment does not involve modelling of the plume, and as such the geographic extent of the cooling water prior to reaching the 2°C above ambient, and hence the extent of any mixing zone, is broadly unknown; and
- In a similar manner to the potential effect of the increase in temperature, the effect of the discharge of the biocide outside the mixing zone is likely to be minimal, due to the adherence to the required standards. Within the mixing zone, the main potential risk is again for sessile species such as the intertidal and subtidal benthos and seagrass, or species that have limited opportunity to avoid less favourable areas such as the plankton. Such effects have the potential

to have implications both for predators and species that are affected at early stages in their lifecycle. Potential issues around the extent of the mixing zone are not considered to be as great for the biocide as for the temperature, due partly to the chemical processes involved but also the mixing of the cooling water streams to ensure a low concentration of biocide at the point of release.

6.1.9 In summary, the proposed scheme would incorporate a combination of best available techniques and mitigation measures into the design and operation of the site to minimize environmental impact. It is noted that the concentration of the biocide and the increase in temperature compared to ambient would be anticipated to meet the required standards outside the mixing zone. The required level of biocide is likely to be met within a shorter distance than the temperature. What is not possible at a generic level is to determine the geographic extent of the mixing zone, which will depend on site specifics. Within the mixing zone, it is likely that habitats and species most likely to be affected will be those found on or in the benthos and the planktonic assemblages.

References

Adey, W. H. and P. J. Adey (1973). *Studies of the biosystematics and ecology of the epilithic crustose Corallinaceae of the British Isles*. British Phycological Journal **8**: 343-407.

Aker Solutions (2008a). Assumed Data for Dose Assessment. Technical Report. Westinghouse. Revision A1. 13 June 2008.

Aker Soultions (2008b). Generic Site Conditions Draft. Technical Report for Westinghouse. Revision A1. 23 April 2008.

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

Barbera, C., C. Bordehore, et al. (2003). *Conservation and management of northeast Atlantic and Mediterranean maerl beds*. Aquatic Conservation-Marine and Freshwater Ecosystems **13**: S65-S76.

Batten, S.D. Allen, R.J.S. & Wotton, C.O.M. (1998). *The Effects of the Sea Empress Oil Spill on the Plankton of the Southern Irish Sea.* Marine Pollution Bulletin: **36** (10): 764-774.

Birkett, D. A., C. A. Maggs, et al. (1998). Maerl: an overview of dynamic and sensitivity characteristics for conservation management of marine SACs. A Natura 2000 Report prepared for the Scottish Association for Marine Science.

Budd, G,C. (2004) . *Ulva* spp. on freshwater-influenced or unstable upper eulittoral rock. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 13/09/2007]. Available from: <http://www.marlin.ac.uk>

Capuzzo, J.M. (1979). The effect of temperature on the toxicity of chlorinated cooling waters to marine animals – a preliminary review. Marine Pollution Bulletin **10**: 45-47.

Davison, D. M. and D. J. Hughes (1998). *Zostera* biotopes: An overview of dynamics and sensitivity characteristics for conservation management of marine SAC's. Dunstaffnage Marine Laboratory, Centre for Coastal and Marine Sciences: 1-95.

Fawley, (1995) *Fish communities at Pembroke Power Station: Impacts of impingement and entrainment*. Fawley Aquatic Research Laboratories Ltd, Marine and Freshwater Biology Unit, Southampton.

Garcia de Leaniz, C, Forman, DW, Davies, S and Thomson, A. (2006). Non-intrusive monitoring of otters (*Lutra lutra*) using infrared technology. J. Zool.,pp 1469-7998.

George, (1964). The life history of the cirratulid worm, *Cirriformia tentaculata*, on an intertidal mudflat. J. Exp. Mar. Biol. Ecol., 44: 47-65.

Habitats Directive Technical Advisory Group on Water Quality. (2006). Guidance on Assessing the Impact of Thermal Discharges on European Marine Sites. WQTAG160.

Hall-Spencer, J. (2005). *Ban on maerl extraction*. Marine Pollution Bulletin **50**(2): 121pp

Hill, J.M., (2005). *Fucus distichus* and *Fucus spiralis* on extremely exposed upper shore rock. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 13/09/2007]. Available from: http://www.marlin.ac.uk

Hill, J.M., (2007). *Echinocardium cordatum* and *Ensis* spp. in lower shore or shallow sublittoral muddy fine sand. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 13/09/2007]. Available from: http://www.marlin.ac.uk

Jackson, A. (2007). *Phymatolithon calcareum*. Maerl. *Marine Life Information Network*: Biology and Sensitivity Key Information Sub-programme [on-line]., Plymouth: Marine Biological Association of the United Kingdom. [cited 25/03/2008]. Available from: <http://www.marlin.ac.uk>

Jackson, A., (2008). *Amphianthus dohrnii*. Sea fan anemone. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 14/07/2008]. Available from: <http://www.marlin.ac.uk/species/Amphianthusdohrnii.htm>

JNCC (2008) [cited 14/07/08] Available from: <http://www.jncc.gov.uk/protectedsites/sacselection/ species.asp?FeatureIntCode= S1355>

Kamenos, N. A., P. G. Moore, et al. (2004). *Maerl grounds provide both refuge and high growth potential for juvenile queen scallops* (*Aequipecten opercularis* L.). **313**(2): 241-254.

Keegan, B. F. (1974). *The Macrofauna of Maerl Substrates on West Coast of Ireland*. Cahiers de Biologie Marine **15**(4): 513-&.

King, R. J. and W. Schramm (1982). *Calcification in the maerl coralline alga Phymatolithon calcareum, effects of salinity and temperature*. Marine Biology **70**: 197-204.

Lee, K. S., S. R. Park,& Kim, Y. K. (2007). *Effects of irradiance, temperature, and nutrients on growth dynamics of seagrasses: A review*. Journal of Experimental Marine Biology and Ecology **350**(1-2): 144-175.

Marshall, C.E., (2004). Cirratulids and *Cerastoderma edule* in littoral mixed sediment. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 13/09/2007]. Available from: http://www.marlin.ac.uk

Mavor, RA, Heubeck, M,Schmitt, S and Parsons, M, (2008). *Seabird numbers and breeding success, 2006.* UK Nature Conservation No 31.

MFA (2006). United Kingdom Sea Fisheries Statistics 2006:Overview of the Fishing Industry. Marine and Fisheries Agency, Whitehall Place, London.

Pickett, GD, Eaton, DR, Cunningham, S, Dunn, MR, Potten, SD and Whitmarsh, D. (1995). An appraisal of the UK bass fishery and its management. MAFF Laboratory Leaflet No. 75.

RPS (2006) Benthic fauna and sediment assessment: on behalf of Portland Storage Ltd. Ref JER3424 v.5 27/09/2006.

RPS (2007) Subtidal ecology for proposed Pembroke CCGT power station: on behalf of RWE npower. Ref JER3566 v.3 12/02/2007.

Short, F. and C. P. McRoy (1984). *Nitrogen uptake by leaves and roots of the seagrass* Zostera marina L. Botanica Marina **17**: 547-555.

Short, F. T. and S. Wyllie-Echeverria (1996). *Natural and human-induced disturbance of seagrasses*. Environmental Conservation **23**(1): 17-27.Stone and Webster Environmental Services, 1992. Fish Entrainment and Turbine Mortality Review and Guidelines. Prepared for the Electric Power Research Institute, Palo Alto, California.

Taylor, D. I., S. W. Nixon, *et al*. (1995). *Responses of coastal lagoon plant communities to different forms of nutrient enrichment - a mesocosm experiment*. Aquatic Botany **52**: 19-34.

Tubbs, C. R. (1995). The meadows in the sea. British Wildlife **6**: 351

Turnpenny, A.W.H (1981). *An analysis of mesh size required for screening fishes at water intakes*. Estuaries 4(4) 363-368.

Turnpenny, A.W.H. (1998) *Fish impingement at estuarine power stations and its significance to commercial fishing*. J. Fish Biol. **33** (Suppl. A).

Turnpenny, A.W,H. and O'Keefe, N. (1995). Screening for intake and outfalls: a best practice guide. Science Report SC030231. Environment Agency, Bristol.

Tyler-Walters, H. (2006). *Zostera marina*/*angustifolia* beds in lower shore or infralittoral clean or muddy sand. *Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme* [on-line]. Plymouth: Marine Biological Association of the United Kingdom. [cited 13/09/2007]. Available from: <http://www.marlin.ac.uk>

UKTAG WFD, (2008a). UK Environmental Standards and Conditions (Phase 1). Final April 2008.

UKTAG WFD, (2008b). Proposals for environmental quality standards for Annex VIII substances. Final January 2008 (revised June 2008).

Wallace, H (1991) *The development of Triturus cristatus under osmotic stress*. Rouxs archives of developmental biology Volume: 200 Issue: 1 Pages: 58-60

Wallace H, Wallace B.M.N (2000) *Sex reversal of the newt Triturus cristatus reared at extreme temperatures* International Journal of Developmental Biology Volume: 44 Issue: 7 Pages: 807-810