RPS

The Potential for Interaction between Wave and Tidal Stream Devices with Military Interests in Welsh Waters

On Behalf of

The Welsh Assembly Government

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Executive Summary

S.1 RPS was commissioned by the Welsh Assembly Government (WAG) to undertake work towards the development of a 'Marine Renewable Energy Strategic Framework' for Wales (MRESF); a three stage project being undertaken in Welsh waters. The project forms part of the WAG's commitment to strong economic development combined with sustainable growth and prosperity.

S.2 Stage 1 of the MRESF project was completed in 2008. The key tasks undertaken in Stage 1 included a review of existing knowledge on the baseline environment of Welsh waters, including the ecological, social and economic aspects, together with a review of the known and potential impacts associated with wind, wave and tidal stream developments. The work enabled the identification of potential constraints on the development of such technologies in Welsh waters.

S.3 The aim of Stage 2 was essentially to investigate a core number of the key constraints identified in Stage 1 in more detail. It should be noted that where an issue was identified as a key constraint, this does not translate as a significant impact; in fact, many of the constraints identified related to a lack of data or understanding upon which to assess significance and it is the lack of such information itself that represents the 'constraint'. Of the constraints identified, six work areas, including military interests, were taken forward into Stage 2 of the project. This report represents the main deliverable for one of the Stage 2 work areas.

S.4 Military interests within Wales pose a potentially significant level of constraint on the development of wave and tidal stream energy devices in Welsh waters, with additional uncertainty around the potential significance that such constraints may have. In order to gain a greater understanding of where the constraints occur, and what the potential implications may be for a proposed development, a discussion document was distributed to relevant departments within the Ministry of Defence (MoD) that have activities within Welsh waters.

S.5 This document summarises the responses from the relevant departments within the MoD to the discussion document and seeks to:

- Identify the historic and existing MoD activities within Welsh waters to highlight where these activities may be compatible/incompatible with the development of wave and tidal devices;

- Identify the aspects of wave and tidal devices that may cause constraint/conflict with the MoD activities within Welsh waters;
- Identify a process by which communication between developers and the MoD can avoid any unnecessary delays to device development and deployment within Welsh waters;
- Identify the information that developers can provide to the MoD to allow an informed judgement of the potential constraints/conflicts for device deployment; and
- Identify where there are gaps in the knowledge base, and where additional information is required which would progress the process of device deployment.

S.6 This document is not intended to grade the various military activities according to the level of constraint they present to development. Such constraint rankings were drafted during Stage 1 of the MRESF (RPS, 2008) to inform GIS mapping of potential constraints on development and will be taken forward in Stage 3.

S.7 Feedback from the Royal Air Force (RAF) suggested that their activities within Welsh waters associated with the aerodromes on Anglesey and the range of low flying corridors would not constrain or be constrained by the development of wave and tidal devices in their areas. The use of the Pembrey firing range for RAF training is managed by the Defence Training Estates (DTE) and is not considered a suitable area for the deployment of wave and tidal devices. Helicopter search and rescue training conducted over the sea around Anglesey may introduce localised siting considerations for wave and tidal devices.

S.8 General naval operations within Welsh waters are not considered to limit or be limited by the deployment of wave and tidal devices. Deployment of devices would however need to be planned in cooperation with naval representatives to ensure that undisclosed naval transit routes are not compromised.

S.9 There are concerns with regards to danger areas associated with both Test and Evaluation activities (Aberporth and Pendine) and Defence Training Estate ranges (Castlemartin, Manorbier, Penally, Pembrey and Rogiet Moor marine danger areas). Discussions with managers of these facilities suggested that there would be considerable risk of damage to devices deployed within these danger areas and that site work including pre-deployment surveys, installation, maintenance and decommissioning works are likely to cause significant disruption to the existing activities within these areas. However, it was suggested that some devices (e.g. nearshore wave energy converters) could be deployed within danger areas, with a low risk of damage due to the location of the resource to be accessed. It was therefore suggested that discussions between the MoD and developers are initiated at an early stage in the process of a proposed deployment, to ensure the best chance of a successful siting of a device in relation to MoD activities.

S.10 It was highlighted in all discussions that the existence of Unexploded Ordnance (UXO) poses a significant risk to any proposed deployment of devices and associated infrastructure (including cabling/piping) within existing and historic danger areas. Although the identified danger areas are likely to have the highest concentration of UXO, the movement of these materials due to physical processes in the marine environment, along with the poor records associated with marine dumping and failed detonation of ordnance, introduces uncertainty in terms of risk.

S.11 The Aberporth danger area overlaps with a limited area of identified tidal energy resource and as such the deployment of devices on the majority of the tidal resource would present limited constraint/conflict with MoD activities. However, discussions with the MoD early in the process of proposed deployment would be necessary to determine the potential for access to the resource extending into the danger area. In contrast, the danger areas associated with Castlemartin and Manorbier overlap with large areas of identified wave energy resource creating significant potential constraint to the development of this resource. In addition, these two danger areas limit the access of connection with land from identified resources seaward of the danger areas.

S.12 The aspects of wave and tidal stream developments that have the potential to impact on military activities in Welsh waters have been identified and discussed with the MoD during the consultation process, and are summarised as follows:

- Physical presence (geographic overlap) including vessel access, devices and cabling;
- Potential impact of devices on radar equipment;
- Noise and vibration;
- Electro Magnetic Fields (EMF);
- Collision risk from fixed structures;
- Collision risk from loose devices; and
- Cumulative effects.

S.13 There is limited geographic overlap between MoD interests and tidal stream resource, whereas considerable overlap is apparent between wave energy resource and MoD interests, primarily to the south of Pembrokeshire. Wave and tidal stream devices are considered unlikely to present a significant risk for aviation radar (military or civil), although there is potential for constraint/conflict with shipboard, shorebased and airborne marine radar. The nature of MoD activities in Welsh waters mean that noise, vibration and EMF are not anticipated to be a significant issue, although there may be additional MoD activities sensitive to EMF that have yet to be established (e.g. communication or monitoring equipment). The potential risk from fixed structures, or structures should they become loose, are considered to be localised and site specific, and best addressed through consultation and the development of appropriate navigation and safety protocols. For the MoD, cumulative effects are likely to be associated with an increased likelihood of conflict with their activities due to increased activity in adjacent waters; specifically in areas identified as having a potential wave and tidal energy resource adjacent to defence areas.

S.14 Although there are a number of MoD areas that present a significant constraint on development, beyond these areas a number of uncertainties remain regarding the potential for military interests to present a constraint on development. To assist the decision making process, a consultation proforma has been developed, with the cooperation of the MoD. The intention is to enable potential constraints to be identified early, preferably during site selection. Such information will assist in enabling informed advice to be provided and decisions to be made about the appropriateness of the device(s) to be deployed in the location proposed.

S.15 It is recognised that the relative infancy of the wave and tidal energy industry means that there is often limited information associated with the construction, operation (including maintenance) and decommissioning of the devices on account of confidentiality issues and the limited extent of testing that has been conducted on some of the devices. As such, it may not be possible to provide all the information highlighted at the initial stages. Continued communication between developers and the MoD in such instances will ensure that additional information is provided as and when it is available. Essentially, the more complete the information provision, the less uncertainty there will be about the project.

S.16 In a similar way there are likely to be new technologies developed within the MoD, in addition to a change in the requirements for areas used for defence activities, which may increase or decrease constraints/conflicts with the deployment of wave and tidal devices in the future and will require continued communication between the sectors.

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1 Introduction

1.1 Background

1.1.1 The Welsh Assembly Government (WAG) is aiming to develop '*the strongest economic development policies to underpin sustainable growth and prosperity in Wales*'. Part of this aim is to use an evidence based evaluation of clean energy developments and to achieve economic drive through sustainable development and internal competitiveness. This aim is being achieved in part by the development of the Marine Renewable Energy Strategic Framework (MRESF); a three stage project being undertaken by RPS in Welsh waters on behalf of the WAG.

1.1.2 Stage 1 of the MRESF development focused primarily on the identification of information relevant to the marine renewable energy sector (wind, wave and tidal stream) and the potential constraints on development in Welsh waters. It should be noted that where an issue was identified as a key constraint, this does not translate as a significant impact; in fact, many of the constraints identified related to a lack of data or understanding upon which to assess significance and it is the lack of such information itself that represents the 'constraint'.

1.1.3 As part of Stage 1, a number of potential research projects were identified, each aimed at increasing the knowledge base for a particular issue considered to have the potential to present a significant constraint on development of wave or tidal stream in Welsh waters. The draft list was then prioritised by the project Steering Group to provide a focus for the studies undertaken as part of Stage 2, with the aim of decreasing the level of uncertainty for a number of key topics, and to better inform the decisions to be made during Stage 3 in the development of a strategic and sustainable approach to marine renewable energy.

1.1.4 The potential for military interests in Wales to constrain/conflict with the development of wave and tidal stream technologies was identified during Stage 1 by the project Steering Group as one of six work areas where further information would benefit the process. As such, the issue was taken forward in Stage 2, through the completion of additional research including a desk based study and consultation with representatives from each defence sector with interests in Welsh waters. This report is the final output for that work area.

1.1.5 By identifying issues that may constrain/conflict with the deployment of wave and tidal devices, the WAG, along with developers, can establish a process by which new technologies can be reviewed for their compatibility with Ministry of Defence (MoD) activities as they are developed, and developers can follow a process aimed at limiting the introduction of additional deployment constraints. Gaining an understanding of the concerns of the MoD based on the information that is presently available for device technologies, will highlight these concerns to the MoD and developers, while enabling a process to be established for further discussion as new technologies are proposed.

1.1.6 During Stage 1 each potential constraint was 'graded', in consultation with the project Steering Group (which includes a representative from the MoD), according to the degree of potential constraint it represented. Essentially, at the strategic level some existing activities represent a greater barrier to development than others, although site specifics will always have an influence. For Stage 1, potential constraints were graded from 1 (no likely constraint) through to 5 (likely to preclude development), with such grading or ranking undertaken separately for different renewable device groups. The degree of constraint assigned to military interests varied from 1 to 5 depending on the type of military activity and device group, however in a number of cases it was viewed to be a significant issue (grade 4) or likely to preclude development (grade 5).

1.1.7 It would not be possible for the potential constraint represented by military interests to be removed or downgraded for all sites, and it is likely that some sites will remain grade 5, i.e. 'likely to preclude development'. However, given the known concerns about wind farms and military interests, and the current uncertainties around the potential for certain aspects of wave and tidal stream devices to be viewed as incompatible with military interests, there is considerable value in increasing the level of understanding of the potential for interaction between wave and tidal stream devices and MoD interests. The intention is to reduce the risk of constraint through increasing the knowledge base.

1.1.8 Following on from the Stage 2 projects, the MRESF will move into Stage 3, part of which will involve progressing the constraint mapping initiated in Stage 1.

1.2 Potential for Constraint

1.2.1 Wave and tidal devices represent a vast array of proven and unproven technologies to capture the potential energy of the marine environment. At present the European Marine Energy Centre (EMEC) has recorded 104 wave energy concepts and 53 tidal energy concepts worldwide (www.emec.org.uk extracted 8 Sept 2009). The various individual devices were reviewed during Stage 1, with a number of groupings of 'device types' identified based on the manner in which the device operates and the anticipated deployment location (e.g. onshore or offshore), to enable the Framework to be device blind (RPS, 2008 and updated in RPS, in prep). Although the potential for constraint and/or conflict between these different technologies and MoD activities is likely to vary, with a need for device specific constraints to be discussed as the technologies are developed, there are a number of generic areas of potential constraint and/or conflict that can be addressed.

1.2.2 When determining the potential areas of constraint/conflict between MoD activities and the deployment of wave and tidal devices, it is important to be aware that the development of a site for the deployment of a device involves pre-deployment surveys, the deployment of the device and associated infrastructure (cabling, piping etc), device operation, maintenance and decommissioning. Each aspect would require access to the proposed deployment location for a period of time. In some instances the constraint may arise not from the deployed device *in situ* but from the installation and maintenance of the device. Given that both device deployment and defence activities are often targeted at short windows of good weather, the time available for deployment of a device without causing constraint/conflict with military activities may be further constrained.

1.2.3 In order to increase our understanding of the concerns that the MoD may have with respect to wave and tidal stream devices in Welsh waters, and which aspects of devices may cause such concern, both in terms of device type/operation and likely geographic locations, consultation with the MoD was initiated. This document provides a summary of the consultation undertaken with the MoD, including meetings, discussions and correspondence, which were aimed at discussing the potential effects of wave and tidal stream devices on military interests by addressing a number of key areas as follows:

- Identify the historic and existing MoD activities within Welsh waters to highlight where these activities may be compatible/incompatible with the development of wave and tidal devices;
- Identify the aspects of wave and tidal devices that may cause constraint/conflict with the MoD activities within Welsh waters;
- Identify a process by which communication between developers and the MoD can avoid any unnecessary delays to device development and deployment within Welsh waters;
- Identify the information that developers can provide to the MoD to allow an informed judgement of the potential constraints/conflicts for device deployment; and
- Identify where there are gaps in the knowledge base, where additional information is required which would progress the process of device deployment.

1.2.4 This document takes into account the historic use and existing activities of the MoD (Drawing 1) and, where possible, discusses the potential future changes in use and technology associated with the defence activities. As new technologies are developed within both the MoD and the renewable energy sector, new issues may arise and require discussion to identify and mitigate additional constraint/conflict. Through identification of the likely areas of constraint/conflict, communication can be encouraged between the wave and tidal stream developers and the MoD, to ensure early discussion of potential limitations on device deployment, in addition to a process of notification of changes in technologies within the marine renewable industries.

1.2.5 It should be noted that there are likely to be some sites that would be considered by the MoD as unsuitable for marine renewable development. In such cases, it may not be possible to reconcile military interests with marine renewable energy developments.

1.3 Potential Areas of Wave and Tidal Stream Resource in Welsh Waters

1.3.1 Part of the overall MRESF project has been to understand the site specific deployment requirements of different wave and tidal stream devices, primarily based on commercial requirements such as minimum energy levels, together with anticipated requirements for water depth and distance from shore. Broad scale data on the wave and tidal stream resource in Welsh waters is available in the Renewables Atlas (see www.renewables-atlas.info/), however given the limited inshore data held within the Atlas, RPS have supplemented the data with internally held data on tidal stream (where available).

1.3.2 The areas of potential resource for different device types have been mapped during the MRESF project using the supplemented data from the Atlas and the known device requirements sourced (see RPS, 2008 and updated in RPS, in prep), to generate a series of maps depicting areas of potential commercial resource for wave and tidal stream technologies, based on device specific requirements such as minimum energy and deployment position information such as water depth and distance from shore. Additional information on the methods used to map areas of resource are provided in RPS (2008) and RPS (in prep), with the areas of resource that meet current commercial requirements for energy depicted here in Drawings 2 and 3.

1.3.3 A key aim of Stage 3 of the MRESF is to compare the areas with commercial levels of wave and tidal stream resource with existing activities in Welsh waters, including MoD, to enables the determination of potential spatial conflict (see RPS, in prep). Mapping of the potential marine energy resource in Welsh waters has shown that for wave energy devices the southwest Pembrokeshire area holds the greatest potential (Drawing 2) while a commercial tidal stream energy resource can be found around Pembrokeshire, the Lleyn Peninsula, the outer Severn Estuary and Anglesey (Drawing 3). Existing, planned or proposed device deployment sites in Welsh waters are depicted in Drawing 4.

1.3.4 The potential for geographic overlap between areas of wave and tidal stream resource and military interests is described in Section 2, with a number of the MoD areas presenting a significant level of constraint on potential development. It does not automatically follow, however, that all military areas will prevent deployment of wave or tidal stream devices, as each of the military areas serves a different purpose, with a final decision on the potential for deployment of devices and routing of cables being a site specific issue. For example, in Canada a gas pipeline has been deployed 3 m beneath the seafloor in a military danger to enable access to the shore without compromising the military activities (pers. comm. J Wilson). The cabling for the transport of power generated by marine renewable devices would be less volatile and there may be suitable depths/armouring that enable routing through danger areas. This issue would need to be addressed on a case specific basis with the MoD.

1.4 Consultation with the Ministry of Defence

1.4.1 Consultation with the MoD was designed to investigate the extent to which the site surveys, deployment, operation, maintenance and decommissioning of wave and tidal stream devices and associated infrastructure may conflict with the activities of the MoD within Wales. Although there has been input into Stage 1 of the process through representation of the MoD on the Steering Group, it was considered that discussion with a range of defence sectors with specialist experience would be beneficial, to highlight any areas of potential constraint from particular MoD activities.

1.4.2 A consultation document was developed to summarise the process being undertaken by the WAG and to highlight potential areas of defence activities which may constrain the deployment of wave and tidal devices (see Appendix A). The purpose of the document was to seek a response from specialists within the different sectors of the MoD on the potential for conflict between existing military activities (and any proposed future activities) and the potential deployment of wave and tidal stream devices in Welsh waters.

1.4.3 Consultation documents were distributed through the Defence Estates Statutory and Offshore Safeguarding to five sectors of the MoD including:

- Defence Estates Statutory and Offshore Safeguarding (DESOS), which represents the interests of the MoD on the project Steering Group and provided assistance both in disseminating the discussion document and obtaining feedback from the relevant groups. This department is also identified as the point of contact for developers of wave and tidal devices in their communication with the MoD;

- Defence Equipment and Support (DE&S), as the MoD authority managing the requirement for test and evaluation range activities;
- Defence Training Estate (DTE), in their capacity for providing ranges and training facilities for the Army (including the Army Air Corp) and the RAF;
- Navy Command, in their capacity for coordination of all naval activities and strategic maritime defence interests; and
- RAF Air Command, in their capacity as the operator of air weapon ranges and general low flying activities.

1.4.4 Consultation meetings were held with a number of sectors of the MoD while correspondence was continued with the RAF and Navy through the DESOS as detailed in Table 1-1. Please note that meeting notes were taken and held by the MoD.

Table 1-1 MoD divisions contacted, their area of authority and interests in Welsh Waters and form of contact made (meeting, correspondence etc) for this project

MoD Contact	Area of authority	Sites of particular interest in Welsh Waters	Contact
Defence Estate Statutory and Offshore Safeguarding (DESOS)	Responsible for safeguarding operational defence assets on land in the UK and defence assets and interests in the UKCS area.	Ensuring continued access to defence estates. Liaison with the Welsh Assembly Government. Point of contact for developers in relation to MoD communication.	Point of contact for all correspondence during development of the document and for developers in regard to proposed developments. Meetings held 21st July and 30th July.
Defence Equipment and Support (DE&S)	As the MoD authority managing the requirement for test and evaluation range facilities.	Aberporth range in Cardigan Bay and Pendine range in Carmarthen Bay.	Meeting 21st July 2010 and correspondence through the DESOS.
Defence Training Estate (DTE)	In their capacity for providing ranges and training facilities for the Army and RAF.	Castlemartin and Manorbier, Penally, Pembrey ranges in Pembrokeshire and Rogiet Moor range on the Severn Estuary.	Meeting 30th July 2010 and correspondence through DESOS.
Navy Command	In their capacity of managing activities within Welsh waters.	Naval Activities within Welsh waters.	Correspondence through DESOS.
Royal Air Force (RAF) Air Command	In their capacity as the operator of Air Weapon ranges and general low flying activities.	Aerodromes, low flying and other RAF activities within Welsh waters.	Correspondence through DESOS.

2 Military Uses in Welsh Waters

2.1 Military Areas/Estates in Welsh Waters

2.1.1 There are a range of MoD interests that exist in Welsh waters, from historic association of military heritage sites and historic dumping sites, to existing areas of military use across all the defence sectors. Some of the areas are protected by military byelaws which regulate access for commercial and recreational sea users to specific range areas when firing activities are being carried out (see www.mod.uk/DefenceInternet/MicroSite/DE/OurPublications/Byelaws/Wales/).

2.1.2 The locations of military areas and estates in Welsh waters are summarised in Table 2-1 and depicted in Drawing 1.

Table 2-1 Military area/estates utilised for military activities in Welsh Waters.

Area/Site Reference	Area Name	Dept	Location in Wales	Purpose
D201	Aberporth range	DE&S	Cardigan Bay	Test and evaluation Range
D201A	Aberporth range	DE&S	Cardigan Bay	Test and evaluation Range
D201B	Aberporth range	DE&S	Cardigan Bay	Test and evaluation Range
D117	Pendine range	DE&S	Carmarthen Bay	Test and evaluation range Weapons Firing Underwater Explosion - Trials
D202	Llanbedr	DE&S	Cardigan Bay	Air space supports access to D201
D113A	Castlemartin	DTE	Pembrokeshire	Training range - land and air to surface firing
D113B	Castlemartin	DTE	Pembrokeshire	Training range - land and air to surface firing
D115A	Manorbier range	DTE	Pembrokeshire	Land to Air Firing range Training range overlap - land and air to surface firing
D115B	Manorbier range	DTE	Pembrokeshire	Land to Air Firing range Training range overlap - land and air to surface firing
D118	Pembrey	DTE	Carmarthen Bay	Air Weapon range
X5104	Penally range	DTE	Pembrokeshire	Rifle Firing range
X5108	Rogiet Moor	DTE	Severn Estuary	Rifle Firing range
	Valley and Mona Airfields	RAF	Anglesey	Military Aircraft training facilities
	Military Low Flying	RAF	Wales on and offshore	Military Aircraft exercise flight routes
	Milford Haven Explosive Dumping Grounds	MoD	Pembrokeshire	OME Disposal sites
	HM Submarine H5	MoD	North Cardigan Bay	Military Heritage Submarine Wreck site and 300m exclusion zone

2.2 Defence Equipment and Support (DE&S)

Aberporth and Pendine Ranges

2.2.1 The department of Defence Equipment and Support (DE&S) manage the Aberporth and Pendine Test and Evaluation Estates. Each of these ranges include components of marine danger areas of varying sizes within Welsh territorial waters which provide a marine safety zone for firing of ordnance into the marine areas.

2.2.2 The Aberporth range occupies a large proportion of Cardigan Bay while the Pendine range occupies a large proportion of Carmarthen Bay. Both the Aberporth and Pendine ranges are managed by the DE&S to provide test and evaluation range facilities within the MoD, and are specifically used for testing and evaluation of military ordnance, munitions and explosives (OME). The normal use of the range includes the firing of live OME into the danger areas, both to test the response of the munitions and to test new means of projecting the OME. As a result, the entire area of each range is considered a danger area during live firing of OME.

2.2.3 The Pendine danger area is also used as an underwater explosion area for the testing of explosive devices. Explosive devices are generally deployed during low tide conditions and detonated during high tide conditions. Although the risk of damage to cabling routed through the area could be reduced through trenching and armouring, this would need to be discussed on a case by case basis.

2.2.4 Given the use of the ranges, there is likely to be a concentration of Unexploded Ordnance (UXO) within the Aberporth and Pendine danger areas which may extend outside the boundaries of the danger areas due to potential movement of such UXO materials by natural processes. The concentration of UXO is likely to reduce with increasing distance from the danger areas themselves. Specific requirements relating to UXO are discussed in Section 2.6.

2.2.5 The principal risk for the deployment of marine renewable devices within these areas relates to the potential for damage to project vessels, the devices and associated infrastructure from ordnance fired into the danger area, explosive devices detonated or from shrapnel resulting from exploding munitions. The risk of damage to cabling is likely to be lower due to a lack of moving parts and increased protection from burying or armouring of the cable, however there is still a potential risk of damage which would need to be dealt with on a case specific basis.

2.2.6 For the existing range of technologies within the marine renewables sector, no wave resource has been identified within either the Aberporth or Pendine ranges (Drawing 2 and Table 2-2). Within the Aberporth range there is a small area that has been identified as suitable for tidal stream, while there is no identified resource associated with the Pendine range (Drawing 3 and Table 2-2).

2.2.7 The Aberporth range extends seaward beyond the limits of the Welsh Territorial waters into the European Economic Zone. There are currently no mapped marine renewable resources seawards of the marine danger area at Aberporth and as such there is currently no anticipated demand for the routing of cabling through this site. Although the area covered by the Pendine range has not been identified as a suitable resource for energy generation there are areas of identified resource (wave) seaward from the range (Drawing 2, Table 2.2). The activities of the range are likely to preclude the routing of cable through the range to potential shore facilities.

2.2.8 As the technology for wave and tidal energy generation is in its relative infancy and new technologies are being developed and proved at an ever increasing rate, it is possible that new technologies will be able to extend the resource areas through increasing efficiency of energy generation, to include many of those areas presently not considered viable. As a result it is important to be aware of the constraints that MoD activities may pose on additional areas although the focus remains on the existing identified resources of potential wave and tidal energy.

Conclusion from Consultation: **Wave and tidal stream device deployment unlikely to be considered possible by MoD in Aberporth and Pendine Ranges**

Llanbedr – Inactive Test and Evaluation Danger Area

2.2.9 Area D202 at Llanbedr is no longer used for firing activities, however the area was used for many years and may therefore be characterised by a high concentration of UXO both within the area and in close proximity should movement of existing UXO be facilitated by natural physical processes. Currently, the air space is managed as a danger area to facilitate military flying activities associated with the Aberporth ranges.

2.2.10 There are no tidal stream or wave energy resources identified at present for Llanbedr (Drawings 2 and 3, Table 2-2 Potential geographic overlaps of existing military activities with wave and tidal resource areas.). Should technologies be developed that could exploit the resources in the area (and offshore of this area) an understanding of the risk of UXO would need to be developed based on the procedures outlined in Section 2.6.

Conclusion from Consultation: **Wave and tidal stream device deployment may be considered possible by the MoD in Llanbedr Danger Area**

2.3 Defence Training Estate (DTE)

2.3.1 The department of Defence and Training Estates (DTE) manage five training areas in Wales including Castlemartin, Manorbier, Pembrey, Penally and Rogiet Moor ranges (Drawing 1). Each of these ranges include marine danger areas of varying sizes within Welsh territorial waters, providing a marine safety zone for overfire of ordnance or the passage of shrapnel resulting from an impact on land based targets.

Castlemartin

2.3.2 The range at Castlemartin supports the training of military personnel (Army) in the firing of a range of munitions at land based targets. The seaward danger area currently provides a safety zone for overfire and shrapnel which may result from the striking of targets.

2.3.3 A large portion of the Castlemartin range and the territorial waters seaward of the range have been identified as a potential resource for wave energy conversion devices (Drawing 2, Table 2-2). The Castlemartin range does not overlap with any of the resources identified for the existing tidal stream energy conversion devices (Drawing 3, Table 2-2).

2.3.4 The principal risk for the deployment of marine renewable devices within the Castlemartin range relates to the potential for damage to project vessels, the devices and associated infrastructure from ordnance fired into the danger area or from shrapnel resulting from exploding munitions. The risk of damage to cabling, including cabling required for devices sited seawards of the range, is likely to be lower due to a lack of moving parts and increased protection from burying or armouring of the cable, however there is still a potential risk of damage which would need to be dealt with on a case specific basis.

2.3.5 Although it is considered that there would be a lower potential for impact to the cable/pipelines once deployed, the pre-deployment surveys, deployment, maintenance and decommissioning of the cabling/pipelines is likely to be constrained by the activities of the range. None of these activities could be conducted while the range is in use. At present, the Castlemartin range is used every day of the week and on some weekends, which would significantly limit the amount of time available for the activities required for the deployment of a device or cable.

Conclusion from Consultation: **Available time for survey would be limited, device deployment is unlikely to be considered possible but cabling/pipeline deployment may be considered possible by the MoD in the Castlemartin Range**

Manorbier

2.3.6 The range at Manorbier supports the training of ground to air defence weapons utilising unmanned aerial targets over the range. The Manorbier range also serves as an additional safety area for the firing of munitions and ordnance at the Castlemartin training area when firing in an east-south easterly direction. Ordnance that miss the unmanned aerial targets is brought down into the marine danger area along with freefalling shrapnel from successful strikes.

2.3.7 A large portion of the Manorbier range in addition to the territorial waters seaward of the range have been identified as a potential resource for wave energy conversion devices (Drawing 2, Table 2-2). The Manorbier range does not overlap with any of the resources identified for the existing tidal energy conversion devices (Drawing 3, Table 2-2).

2.3.8 The principal risk for the deployment of marine renewable devices within the Manorbier range relates to the potential for damage to project vessels, the devices and associated infrastructure from ordnance overfire from the Castlemartin range, in addition to missiles brought down and shrapnel from the ground to air training at the Manorbier range. The risk of damage to cabling, including cabling required for devices sited seawards of the range, is likely to be lower due to a lack of moving parts and increased protection from burying or armouring of the cable, however there is still a potential risk of damage which would need to be dealt with on a case specific basis.

2.3.9 Although the use of the Manorbier range is relatively infrequent at present in comparison with the Castlemartin range, the MoD reserve the right to alter the type of munitions being tested and frequency with which the site is used in the future.

2.3.10 There is potential for shoreline and nearshore devices to be deployed on or adjacent to the shoreline within the Manorbier range with minimal potential risk to the device as the overfire or ditching of ground to air missiles and shrapnel are unlikely to land close to shore. The greatest constraint for the deployment of these devices however would be associated with the limited access for construction, maintenance and decommissioning of the devices due to the frequency of live fire training activities.

2.3.11 It may be possible to route cabling/pipelines from devices deployed outside the danger areas, through the danger areas to shore sites within military estates for connection to the grid, should negotiation with the MoD allow the use of the estates for this purpose. Again, access to the site for the range of surveys, deployment and maintenance activities required would be a limiting factor.

2.3.12 The marine danger area is likely to have UXO in addition to shrapnel from OME fired at craft above the area. Any deployment of devices or routing of cables/pipelines would require a UXO desk based risk assessment and potentially surveys for UXO; as discussed in Section 3.6. It is worth noting that surveys for UXO are presently conducted at turbine deployment locations and cabling routes for offshore wind farms.

Conclusion from Consultation: **MoD may consider deployment of cabling/ pipelines and/or inshore devices only in the Manorbier Range**

Pembrey

2.3.13 The range at Pembrey is predominantly a land based target site for aircraft firing blank rounds and dropping practice bombs at land based targets. The marine danger area associated with the site is a safety zone in the event of OME falling short or overfiring the land based targets or the passage of shrapnel following the striking of a target. As a result there remains a risk to any device deployed within this area. Due to the nature of the projectiles (blanks) there would be less risk associated with the laying of cabling/pipelines through the area, particularly where such cables are buried or armoured. The use of such blank projectiles in the area also means that there is a low potential of UXO being present within the site. It is, however, possible that future use of the site may result in an increased risk of UXO or possibly firing activities that could present a greater risk of direct damage to devices and infrastructure deployed in the area.

2.3.14 There are currently no wave or tidal resources identified for this area or in the waters directly seaward of the range (Drawings 02 and 03, Table 2-2). However, as the technology for wave and tidal stream energy generation is in its relative infancy and new technologies are being developed and proved at an ever increasing rate, it is possible that new technologies will be able to extend the resource areas through increasing efficiency of energy generation, to include many of those areas presently not considered viable. As a result it is important to be aware of the constraints that MoD activities may pose on additional areas although the focus remains on the existing identified resources of potential wave and tidal energy.

2.3.15 Completion of any surveys and requirements of deployment and maintenance of any device and/or cabling/pipelines within the area would be limited by the use of the site for defence training activities. The department of DTE manages the site and reserves the right to utilise the site as required.

Conclusion from Consultation: MoD may consider deployment of cabling/ pipelines only in Pembrey Range

Penally

2.3.16 The Penally range is a rifle firing range within close proximity to the Manorbier danger area, with a separate marine danger area that extends into the sea. The existing activities for the danger area are unlikely to pose a major UXO risk at the site however the proximity to the Manorbier and Castlemartin ranges would increase the possibility of UXO having been deposited at this site. Although the direct impact from ordnance overfiring and shrapnel impact would be relatively minimal, the activities at the range would conflict with the deployment, maintenance and decommissioning of any device deployed within the area. It is considered unlikely that there would be an issue with the routing of cabling/pipelines through the area.

2.3.17 There is no identified wave or tidal resource associated with this area at present (Drawings 2 and 3, Table 2-2). However, as the technology for wave and tidal stream energy generation is in its relative infancy and new technologies are being developed and proved at an ever increasing rate, it is possible that new technologies will be able to extend the resource areas through increasing efficiency of energy generation, to include many of those areas presently not considered viable. As a result it is important to be aware of the constraints that MoD activities may pose on additional areas although the focus remains on the existing identified resources of potential wave and tidal energy.

Conclusion from Consultation: MoD may consider deployment of cabling/ pipelines only in Penally Range

Rogiet Moor

2.3.18 The Rogiet Moor firing range is situated adjacent to the Severn Estuary and includes a marine danger area that extends into the Severn Estuary.

2.3.19 In addition to the area of potential tidal stream energy resource in the outer Severn Estuary (Drawing 3), the Severn Estuary has been identified as a potential major source of tidal range energy. The realisation of this source of energy is the subject of an independent investigation by the UK government of the most appropriate tidal energy generation methods. The generation of tidal energy from the Severn Estuary is therefore not considered further in this document. The Rogiet Moor danger area would have similar issues of constraint/conflict to that of the Penally range.

Conclusion from Consultation: MoD may consider deployment of cabling/ pipelines only in Rogiet Moor Range

2.4 Navy Command

2.4.1 There are no significant naval establishments in Wales and as a result there is limited activity within Welsh waters.

2.4.2 The MoD does, however, retain highly surveyed marine routes that include Welsh waters which would be used by vessels in times of conflict. Details of these routes are not available in the public domain. This defence interest can be considered a localised siting and design consideration and from discussions with the MoD is not expected to be a major constraint on wave and tidal development. However, the MoD would advise of appropriate mitigation to prevent conflict between the siting of wave and tidal devices and these interests.

2.4.3 Any constraint/conflict between wave and tidal devices and naval operations would include the obstruction of surface and submarine vessels by the siting of wave and tidal devices in areas of known vessel use. These constraints/conflicts may include the activities of vessels used for pre-deployment surveys, device deployment, maintenance and decommissioning. The Marine and Coastguard Agency (MCA) provide advice to mariners (including the MoD) regarding the appropriate protocol for marine operations associated with offshore renewable energy installations (Marine Guidance Note (MGN) 72-2). In addition, MGN 371-2 provides advice to developers on the issues that need to be considered when siting wave and tidal devices. Included in this advice are the requirements for navigational markers appropriate to the type and extent of the devices to be deployed. The issue of navigational requirements is discussed further in Section 3.5.

2.4.4 The potential for surface and midwater floating devices to break free from their moorings creating an uncharted collision risk also poses a threat to naval operations. The marking of devices managed through the MGN identifies the appropriate navigational markings required to allow a vessel to identify a device at the surface. However the management of devices in the event of the detachment may require the constant monitoring of the units by developers to ensure rapid response to any occurrence and minimisation of risk for other vessel operations. The issue of device detachment is discussed further in Section 3.6.

Conclusion from Consultation: **MoD would consider deployment of all device types possible, including cabling/pipelines**

2.5 Royal Air Force (RAF) Air Command

2.5.1 The RAF operate two aerodromes on Anglesey, RAF Valley and RAF Mona, supporting fast jet training and helicopter search and rescue training (Drawing 5). It is not considered that tidal devices deployed within the waters covered by the areas associated with these aerodromes will impact on these facilities. However, it is possible that surface devices in certain locations near the coast of Anglesey may affect search and rescue training involving motion detection equipment used to locate people in the sea. It would be appropriate to identify this as a local siting consideration.

2.5.2 The RAF also conducts general low flying activities over Welsh land and waters. It is unlikely that there would be any influence of the wave and tidal devices on the low flying operations of the RAF through either surface piercing or floating devices given the general device heights of <20m.

2.5.3 The RAF training activities associated with Pembrey Air Weapons range are managed by the Department of DTE and are discussed in Section 2.3.13-2.3.15 above.

Conclusion from Consultation: **MoD may consider deployment of all device types possible, including cabling/pipelines**

2.6 Unexploded Ordnance (UXO)

2.6.1 Unexploded ordnance (UXO) existing in Welsh waters may be derived from a range of sources including known explosive dumping grounds and military wrecks, ordnance fired from test and training facilities and ordnance fired during war time. In addition, the lack of monitoring of UXO within the marine environment further complicates the understanding of this threat.

2.6.2 Unlike on-shore sites, marine sites are likely to contain a far more extensive range of ordnance which may include Anti Aircraft Artillery Shells, Air Delivered Ordnance, Naval Mines and Torpedoes, amongst others. Historical dumping of obsolete and excess munitions into UK coastal waters was not an uncommon practice, particularly immediately post World War 2, further contaminating coastal waters surrounding Wales. The majority of these dumping areas are known however there may be additional sites that were never marked or reported.

2.6.3 The extensive historic use of the Welsh waters for testing and training contributes to the unpredictable nature of the UXO presence in these waters. Figure 2.1 provides some indication of the potential extent of UXO dispersion associated with the historic use of armament training areas. Many of these are contained within existing danger areas (see Drawing 1) while others are no longer in use and may have the potential for the existence of UXO.

2.6.4 The unknown quantity of UXO, in addition to the potential movement of this material through the natural physical action of wave and tide, as well as the human activities (e.g. trawling, dredging), makes understanding the exact locations of UXO outside of existing danger areas and dumping sites highly unpredictable (Beddington and Kinloch, 2005).

2.6.5 In their literature review of dumped munitions at sea, Beddington and Kinloch (2005), identified two main concerns which relate to the deployment of marine renewable devices. Firstly the potential for contact with UXO which may result in an explosion and secondly the spontaneous explosion of submerged UXO that may damage a device directly and may result in the further dispersion of the UXO.

2.6.6 Although known dumping sites and training/testing ranges are likely to be characterised by a higher concentration of UXO, the lack of monitoring of known dumping sites and the danger areas means that knowledge of the concentration and spread of the UXO at any location is limited. Any sector planning activities which may disturb UXO needs to be aware of the potential risks.

2.6.7 The deployment of marine renewable devices including the laying of cabling/pipelines has the potential to disturb UXO within the vicinity of the chosen site and as such, an assessment of the potential for UXO at the site and along any cable/pipeline route is highly advisable, particularly where a selected site or cable/pipeline route is within close proximity to known concentrations of UXO. The extent of the study would be directly related to the proximity to known sources of material. However, consideration must be given to the likelihood of other sources of UXO and unpredictability of the movement of the known and unknown sources on the seabed due to physical processes.

2.6.8 An outcome of the present discussions with the MoD has been the identification of a knowledge gap associated with the distribution of UXO in Welsh waters. A broad understanding of the potential concentration of UXO within Welsh waters would be useful in providing developers with a greater confidence in the site selection and an understanding of the potential for issues associated with UXO. In addition, monitoring of known sites of concentration would provide further information, to reduce the concern associated with this constraint on device deployment. As part of the Strategic Environmental Assessment (SEA) for marine renewables in Scottish waters, the Scottish Executive commissioned a desk study into the potential distribution of UXO within

Scottish waters (Martin, 2007). The study was designed to provide potential developers with an indication of the potential UXO concentration at potential development sites within Scottish waters early in the process.

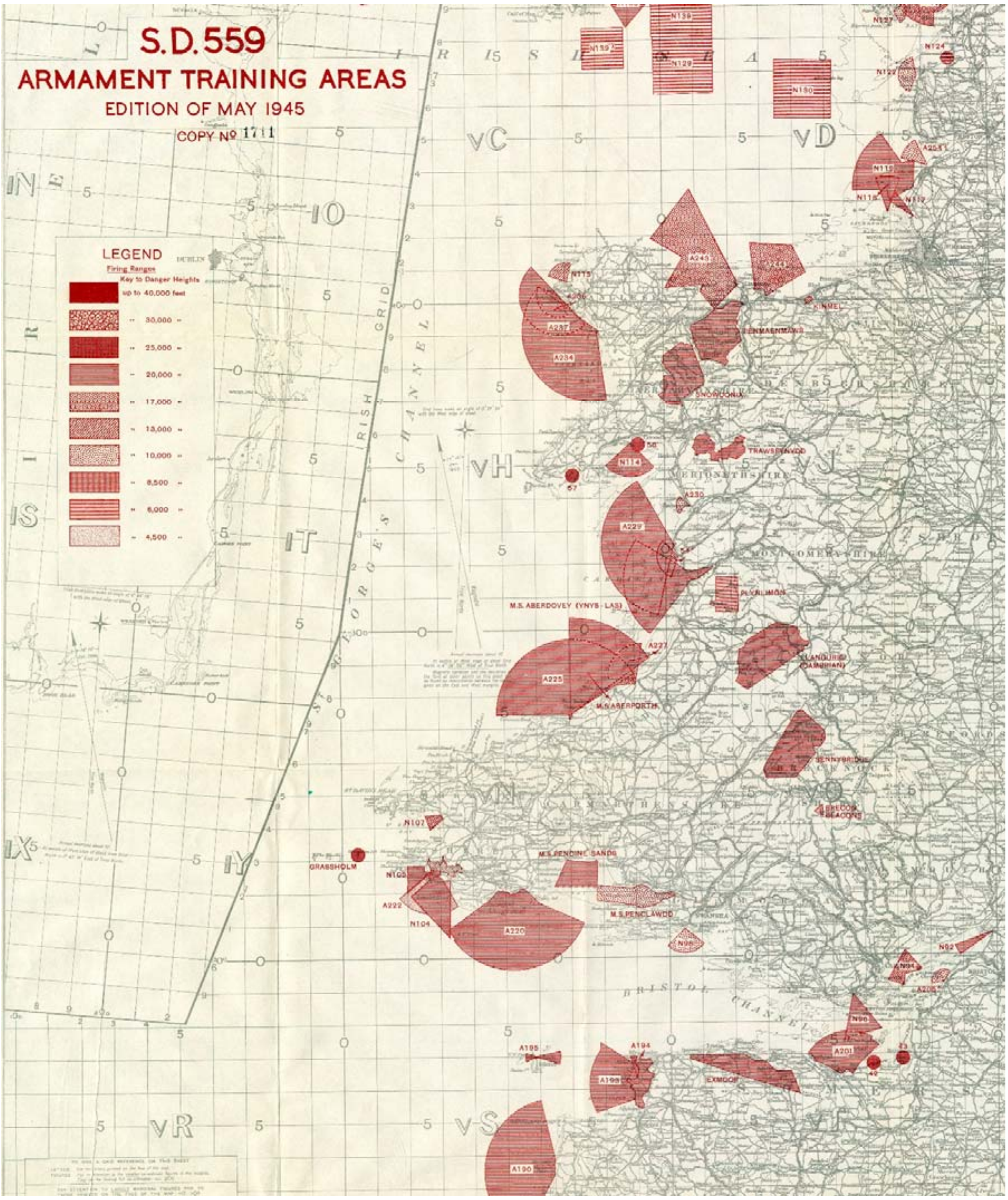

Figure 2.1 Chart of Welsh Armament training areas existing in 1945 highlighting the potential extent of UXO in Welsh waters Source: The National Archive.

2.6.9 Planning and mitigation of UXO in the marine environment requires a more specialist and technical approach in comparison to on-shore projects. It is strongly advised that prior to any works taking place in marine environments, where there is the potential for an UXO risk to remain, that an in depth risk assessment be carried out, which may have specific impacts on factors and limitations that need to be taken into account, should mitigation be required.

2.6.10 Due to the nature of these projects meticulous planning and technical design has to be implemented in order to devise appropriate mitigation strategies. The procedure required would depend on a range of factors including the proximity to the sources of UXO, the likely material to be found, the physical conditions characterising the site and the seabed composition etc. This information would be acquired through an initial desk top study to identify all available information (both historic and contemporary) relating to a site and its potential for UXO risk.

2.6.11 The results of the desktop study would inform the process for conducting the most appropriate mitigation techniques from a suite of methods used in marine environments which may include:

- Magnetometer Surveying (including Gradiometry and Electro-Magnetic);
- Sub Bottom Profiling and Side Scan Sonar;
- Submersible Remote Operated Vehicle (ROV) Reconnaissance and Identification Surveys;
- UXO/EOD Diver Support for Visual Searching and Identification/Investigation of Anomalies; and
- Explosives Safety Engineer Supervision and Support on vessels undertaking intrusive works.

Conclusion from Consultation: **MoD may consider deployment of all device types possible, including cabling/pipelines, with due consideration to UXO**

2.7 Explosive Dumping Grounds

2.7.1 Explosive dumpling grounds are areas of known dumping of military ordnance, which generally took place during and after the First and Second World Wars. There are three recorded dumping grounds for OME within Welsh waters. Each of these three dumping sites is associated with areas of identified wave energy resource (Drawing 2).

2.7.2 Although there is a possibility that the munitions may have dispersed from the original dumping site through natural physical processes characterising the marine environment, it is likely that the greatest concentration of munitions remains at or close to the original site with decreased chance of finding munitions with increased distance from the dumping sites. For deployment of devices within close proximity to the dumping sites, particular consideration should be given to employing at least some of the range of survey methodologies listed in Section 2.6.

2.7.3 It is important to note that UXO is not limited to recorded dumping sites as there may be other explosive devices present as a result of firing and bombing during periods of conflict.

Conclusion from Consultation: **MoD may consider deployment of all device types possible, including cabling/pipelines outside of known dump sites**

2.8 Military Wrecks

2.8.1 Military wrecks are protected by the Protected Military Remains Act 1986 to prevent damage to the wreck (which can be aircraft as well as ships) and to other parties due to the danger associated with the wreck (including UXO). The act also covers issues relating to war graves. Within Welsh waters there is only one identified wreck satisfying the criteria of a military wreck, a submarine off the south coast of Anglesey (see www.mcga.gov.uk/c4mca/mcga07-home/emergencyresponse/mcga-receiverofwreck/mcga-protectedwrecks/mcga-protectedwrecks-military.htm). A 300 m buffer zone around the wreck serves to prevent damage to the wreck and to prevent the disturbance of any UXO. Similarly to the explosive dumping grounds, wreck sites are not monitored, and without further specific investigation (desk based and/or survey), it is not known how far material from these wreck sites may have spread since the wrecking of the vessel occurred.

2.8.2 Deployment of a device or laying of a cable/pipelines within close proximity to a wreck site would require a survey of the site to ensure that there is no likelihood of damage to the wreck from the infrastructure being deployed and that there is no likelihood of disturbance and subsequent damage from UXO existing within or adjacent to the site of the wreck.

Conclusion from Consultation: **MoD may consider deployment of all device types possible, including cabling/pipelines outside of exclusion zones**

2.9 Marine Danger Areas

2.9.1 Marine danger areas denote marine areas which are associated with the test and evaluation of OME and training of the armed forces in the use of OME. These areas are detailed for the specific ranges in Sections 2.2 - 2.3.

2.9.2 Outside the boundaries of these Danger Areas the deployment of physical structures may occur in discussion with MoD (e.g. oil platforms, wave and tidal stream devices). For example access to the Eskmeals firing range in Cumbria has been granted for oil exploration vessels with plans to establish an operational drilling rig on the boundary of the firing range utilising horizontal drilling techniques to access resources beneath the range (pers. comm. J Wilson). In Wales, the initial application for the deployment of the 'Wave Dragon' wave energy converter within the Castlemartin marine danger area was denied due to safety concerns. However, permission was subsequently given for the deployment of the device outside the boundary of the danger area where safety concerns were alleviated (pers. comm. J Wilson).

2.10 Summary of Potential Interaction

2.10.1 The areas of potential wave and tidal stream resource which were identified in Stage 1 (see Drawings 2 and 3), have been compared to the areas of military activity in Sections 2.2-2.9, to determine areas of potential geographic overlap. The assessment has considered both direct geographic overlap as well as the potential for a constraint on the routing of cabling/pipelines to onshore infrastructure. The feedback received during consultation with the MoD has enabled a fuller picture to be formed of the actual use of each MoD area, thus enabling a more accurate determination of the potential degree of constraint which that military activity may have on the exploitation of wave and tidal stream resources.

2.10.2 The information described in Sections 2.2-2.9 has been summarised in Table 2-2 and 2.3 below. Table 2.2 summarises where geographic overlap occurs between current wave and tidal stream resource and existing military activities in Welsh waters.

Table 2-2 Potential geographic overlaps of existing military activities with wave and tidal resource areas.

Responsible Authority	Area of authority	Wave and tidal stream resources identified
Defence Equipment and Support	Aberporth range	Small area of tidal stream resource off Lleyn Head (Drawing 3)
Defence Equipment and Support	Pendine range	None (Drawings 2 & 3)
Defence Equipment and Support	Llanbedr Danger Area	None (Drawings 2 & 3)
Defence Training Estate	Castlemartin range	Wave (Drawing 2)
Defence Training Estate	Manorbier range	Wave (Drawing 2)
Defence Training Estate	Pembrey range	None (Drawings 2 & 3)
Defence Training Estate	Penally range	None (Drawings 2 & 3)
Defence Training Estate	Rogiet Moor range	Severn Estuary tidal
Royal Air Force Air Command	Aerodromes	Tidal Stream
Royal Air Force Air Command	Low flying aircraft routes	Wave and tidal (Drawing 2 & 3)
Ministry of Defence	Milford Haven Explosive Dumping Grounds	Wave and some tidal (Drawings 2 & 3)
Naval Command	HM Submarine H5	None (Drawings 2 & 3)

2.10.3 The potential constraint that the different military areas represent for wave and tidal stream devices varies depending on the proposed activity (e.g. site survey, cable laying etc) and device type (e.g. seabed mounted or surface piercing), with the information summarised in Table 2.3. Although not all military areas have geographic overlap with areas of potential wave and tidal stream resource, the assessment has been made for all sites, given the potential for areas of potential resource to expand as device technology develops.

2.10.4 Following the completion of Stage 2, including the current report, the constraint mapping undertaken in Stage 1 will be refined in Stage 3. The additional information on the potential degree of constraint posed by individual MoD areas in Welsh waters for the different device types will be used to further develop the MRESF (see RPS, in prep).

Table 2-3 Areas of constraint for different device types on military activity areas (Y-possible within the area N–not possible within the area).

Area of Authority	Use of vessels (Site Survey, Device Deployment and cable laying, maintenance and decommissioning)	Surface or near surface devices	Seabed or near seabed devices	Inshore devices	Offshore devices	Cabling/ Pipelines
Aberporth range	Dependent on military use schedule	N	N	N	N	N
Pendine	Dependent on military use schedule	N	N	N	N	N
Llanbedr	No limitation	Y	Y	Y	Y	Y
Castlemartin	Limited time is available for vessels activity within the danger area due to regularity of existing activities	N	N	Y	N	Y
Manorbier	Dependent on military use schedule	N	N	Y	N	Y
Pembrey	Dependent on military use schedule	N	N	N	N/A	Y
Penally	Dependent on military use schedule	N	N	N	N/A	Y
Rogiet Moor	Dependent on military use schedule	N	N	N	N/A	Y
Aerodromes	Search and rescue training activities need consideration	Possible	Y	Y	N/A	Y
Low flying corridors	No limitation	Y	Y	Y	Y	Y
Milford Haven Explosive Dumping Grounds	Buffer zone for vessel operations	Y	Y	N/A	Y	Y
HM Submarine H5	Buffer zone for vessel operations	Y	Y	N/A	Y	Y

3 Potential for Interaction between Military Activities and Wave and Tidal Stream Development in Welsh waters

3.1 Potential for Interaction

3.1.1 Section 2 primarily focused on the constraint that existing MoD activities may have on proposed wave and tidal stream devices. These are mainly linked to issues around MoD activities such as firing ranges and unexploded ordnance. In addition, there are concerns that should wave and tidal stream devices be deployed within areas used by the MoD, then the devices may act as a constraint on the activities of the MoD. The aspects of wave and tidal stream developments that have the potential to impact on military activities in Welsh waters were identified and discussed with the MoD during the consultation process. It is these concerns that can act as an additional constraint on wave and tidal stream development – i.e. should the MoD have concerns that its activities would be affected by a development, there is a risk that an objection to that development may be raised. The main areas of potential concern to the MoD are summarised below and discussed further in Sections 3.2-3.7:

- Impact of physical presence on radar equipment (Section 3.2);
- Noise and vibration (Section 3.3);
- Electromagnetic fields (Section 3.4);
- Collision risk from fixed structures (Section 3.5);
- Collision risk from devices floating loose (Section 3.6); and
- Cumulative effects (Section 3.7).

3.2 Impact of Physical Presence on Radar Equipment

3.2.1 The MoD utilises radar extensively in association with many of the activities conducted in Welsh waters (Table 3-1) to ensure the safety of its activities and the activities of other industries with overlapping ranges of use. The concern for the MoD as regards wave and tidal stream developments exists should the function of the radar operation be compromised by the introduction of devices within the range of the required radar operation (Brenner, 2008).

3.2.2 The establishment of 'The aviation working group' in 2001 by the Department of Trade and Industry (now the Department of Energy and Climate Change (DECC)) served to represent the interests of the wind energy sector and the defence and civil aviation interests in reviewing issues surrounding wind energy development and civil and military aviation zones. Through a review of practices in other European countries (Jago, 2002), the working group developed a set of interim guidelines for developers to follow (BWEA, 2002). The guidelines provide a clear source of information for wind farm developers on the potential impact of wind farms on both civil and military aviation. Included in the guidelines are the impact of wind turbines on military low flying areas and radar functioning.

3.2.3 The ongoing role of the aviation working group is to review the guidelines as they are implemented by developers in addition to the investigation of mitigation measures that can be put in place to reduce the impact of wind farms on the aviation industry and improve the development of wind farms throughout the UK. A Memorandum of Understanding was subsequently signed in 2008 to demonstrate a shared commitment to removing aviation and radar barriers to wind farm development (www.bwea.com/pdf/membersarea/0806_Aviation%20MOU%20Final.pdf).

3.2.4 As a result of such concerns, extensive research has been undertaken on the extent of the impact and mitigation measures that are available to ensure that future wind turbine installations will not cause conflicts. For example, the development of ‘stealth turbines’ has been investigated, which are designed to reduce the size of the radar signature made by individual turbines (e.g. BAE, 2007), together with technology such as tracker (BAE, 2008) or deploying a new radar to ‘infill’ areas lost to wind turbine interference (Bannister, 2007). For areas in the south and west of Scotland aviation officials are drawing up a map of radar impact areas which is expected to identify no go zones for onshore wind farms where the problems are considered all but insurmountable (ReNews 177, 8th Oct 2009).

3.2.5 The potential significance of radar for offshore wind has resulted in a degree of uncertainty regarding wave and tidal stream devices, essentially related to:

- Is radar interference a concern for wave and tidal stream devices; and
- If yes, how much of a concern is it.

3.2.6 Offshore wind farms have the potential to interfere with radar primarily due to their height above sea level and the movement of the blades. Wave and tidal stream devices differ considerable from wind turbines, notably having a relatively limited height above sea level (generally <20m) and as such it is not considered that these devices will pose a significant risk for the radar utilised in the aviation industry (military or civil), particularly due to the lack of moving parts (i.e. rotors) above the surface of the water, which are a major source of conflict between wind farms and radar signatures. (pers. comm. J Wilson).

3.2.7 It is likely, however, that there will be constraint/conflict associated with the deployment of wave and tidal devices and the use of shipboard, shore-based and airborne marine radar. Marine radar is used to monitor objects on the waters surface for the management of safety in marine danger areas, through monitoring the movement of recreational and commercial vessels that may encroach within the area of the ranges during live firing activities. The presence of wave and tidal devices, outside the boundaries of the danger areas, at/piercing the surface, has the potential to compromise the management of safety in the training and test and evaluation areas, due to their appearance on marine radar, particularly where multiple device deployments may occur.

3.2.8 Although the devices would be known stationary devices and could be accounted for by marine radar operators, an increasing number of devices clutter the radar signal. Discerning moving vessels amongst an array of stationary devices may increase the difficulty of safety management. In addition, vessels being used for activities such as deployment and maintenance would be hard to differentiate from those encroaching on marine danger areas and could also potentially compromise safety management. This is a potential conflict which will need to be dealt with on a case by case basis as the industry develops.

Table 3-1 Radar used to monitor military activity areas

Area ID	Range	Location	Radar used for monitoring of activities and safety
D202	Llanbedr	Cardigan Bay	No longer monitored
D201	Aberporth Range	Cardigan Bay	Marine Radar/Air Traffic Radar
D201A	Aberporth Range	Cardigan Bay	Marine Radar/ Air Traffic Radar
D201B	Aberporth range	Cardigan Bay	Marine Radar/ Air Traffic Radar
D117	Pendine range	Carmarthen Bay	No radar surveillance
D113A	Castlemartin range	Pembrokeshire	Air traffic radar/Marine Radar
D113B	Castlemartin range	Pembrokeshire	Air traffic radar/Marine Radar
D115A	Manorbier range	Pembrokeshire	Air traffic radar/Marine Radar
D115B	Manorbier range	Pembrokeshire	Air traffic radar/Marine Radar
X5104	Penally range	Carmarthen Bay	No radar surveillance
D118	Pembrey range	Carmarthen Bay	No radar surveillance
X5108	Rogiet Moor range	Severn Estuary	No radar surveillance
	Milford Haven Explosive Dumping Grounds	Pembrokeshire	Not monitored
	HM Submarine H5	North Cardigan Bay	Not monitored
	Valley and Mona Airfields	Anglesey	Air traffic radars
	Low flying	Wales	Air traffic radars

3.2.9 Mitigation measures under investigation within the offshore wind industry to reduce constraints/conflicts with radar effectiveness, such as infill radar and the re-siting of radar stations (e.g. BAE, 2007; BAE, 2008; Bannister, 2007), may also be incorporated into the wave and tidal industry if appropriate.

3.2.10 At present the development of wave and tidal devices is not considered an issue in relation to the operation of air traffic radar used in the military or civil aviation industry. There is potential for constraint/conflict between the use of marine radar and the deployment of wave and tidal energy devices particularly where arrays are being considered, which needs to be investigated further to ensure the mitigation of any conflict as the industry develops. The deployment of devices within close proximity to danger areas poses the greatest conflict with the use of marine radar for safety management and this would need to be dealt with on a case by case basis.

3.3 Constraint/Conflict from Noise and Vibration

3.3.1 The potential impact of noise and vibration from offshore wind farms has been investigated by a number of authors, including noise during construction, particularly from piling, and noise and/or vibration during operation (e.g. Betke, 2006, Nedwell and Howell, 2003 and 2004). The issue has since been raised for wave and tidal stream devices, with some of the work undertaken for offshore wind likely to be relevant (mainly the work completed on construction noise). There is potential for conflict with MoD interests, although it is not anticipated to be a major factor in Welsh waters due to the nature of the defence activities undertaken here.

3.3.2 The key sources of noise related to site preparation and device installation for wave and tidal stream devices are broadly similar to those investigated for offshore wind farm construction and include the following:

- Seismic (and other geophysical) surveys;
- Shipping and machinery;
- Potential requirement for cable burial e.g. trenching or jetting (soft sediment), rock cutting machinery or armouring with rock or concrete. This may be particularly relevant if cables/pipelines are routed through danger areas requiring additional protection through the depth of a trench or the armouring of the cable/pipelines; and
- Depending on the method chosen to restrain the device additional noise may be generated by pile driving or drilling.

3.3.3 There may be a requirement for seismic survey as there is for other offshore energy developments, where it is used to provide vital information on site specific characteristics such as depth and seabed geology. Potential for interaction with MoD are related to vessel access and the noise associated with such surveys. Consultation with the MoD would highlight potential conflicts, which are likely to be temporally limited, with the recommended approach for consultation outlined in Sections 4 and 5.

3.3.4 Potential for conflict between MoD activities and shipping/machinery noise is considered unlikely, with the issue here most likely to relate to site access requirement (see Section 2). Should cabling connecting offshore devices to shore require protection, either burial or armouring, some additional temporary noise impacts would be expected, the significance of which would be directly linked to the cable protection method chosen. Although this has not generally been an issue for offshore wind farms, consultation with the MoD would be the best route to avoid or mitigate potential conflict between such temporary activities and MoD activities (see Sections 4 and 5).

3.3.5 There are a number of potential methods for fixing wave and tidal stream devices to the seabed, including anchors, gravity foundations and piling. Of all the sources of noise, the noise emitted during pile driving possibly has the greatest potential for noise related environmental effect (e.g. Nedwell and Howell, 2004). This is due to the fact that pile driving generates very high sound pressure levels over a relatively broad frequency range (20Hz - >20 kHz) (Scottish Executive, 2007b). Although this has not generally been an issue for offshore wind farms, consultation with the MoD would be the best route to avoiding or mitigating potential conflict between such temporary activities and MoD activities (see Sections 4 and 5).

3.3.6 To date, there is limited information available on noise and vibration associated with wave and tidal stream devices. However, in the Scottish Marine Renewables SEA, it was suggested that there maybe an effect as a result of the acoustic output from renewable devices on military sonar, although no additional information was available from the MoD (Scottish Executive, 2007a). This highlights the lack of knowledge in relation to the wave and tidal industry and the need for research into the potential impacts as the industry develops.

3.3.7 The potential sources of noise during operation of marine renewable energy devices include:

- Rotating machinery;
- Flexing joints;
- Structural noise;

- Moving air;
- Moving water;
- Moorings;
- Electrical noise; and
- Instrumentation noise.

3.3.8 The noise generated by these elements of the devices can be transferred into the water column via a variety of paths dependent on the position of the device in the water column and the method of attachment to the substratum. While the deployment of the device offers the potential for short term production of noise/vibration, it is the ongoing operation and maintenance of a device that has the potential for long term impacts on the existing activities of the MoD.

3.3.9 There is limited data in the public domain on noise associated with operational wave and tidal stream devices, a reflection of the infancy of the industry, although as more developers gain consent to deploy devices at sea the knowledge base is likely to increase. However, as an overview, noise generated by wave or tidal stream devices will be a combination of the environmental conditions (e.g. sea state) and device specifics, e.g. turbines, generators, air movement, cavitations etc (Patricio *et al*., in prep in ABPmer, 2010). A summary of the main sources of noise from wave and tidal stream devices, together with their frequency, is shown in Table 3-2 below (Richards *et al.,* 2007, in ABPmer, 2010).

Table 3-2 Summary of the main noise sources associated with different types of wave and tidal stream device types (based on Richards et al., 2007, in ABPmer, 2010).

		Noise Source						**Frequency Band (Hz)**				
		R	**F**	**S**	**A**	**W**	**M(1)**	**0-100**	**100-500**	**500-5k**	**5k-20k**	**>20k**
Wave Device	Oscillating water column			✓	✓	✓						
	Overtopping	✓		✓		✓	✓					
	Point absorber/ attenuator	✓	✓	✓		✓	✓					
Tidal Stream Device	Horizontal turbines	✓		✓		✓	✓					
	Vertical turbines	✓		✓		✓						
	Venturi units			✓	✓	✓						
	Oscillating hydrovanes	✓	✓	✓								

		Noise Source						Frequency Band (Hz)				
		R	F	S	A	W	M(1)	0-100	100-500	500-5k	5k-20k	>20k
Generic Noise	Electrical											
	Instrumentation											

The grey scale indicates the relative noise in each part of the spectrum, with black indicating the highest level and white indicating no or negligible noise.

R = Rotating Machinery noise; F = Flexing joint noise; S = Structural noise; A = Moving air noise; W = Moving water noise; M = Mooring noise (1) mooring noise applicable only to moored turbines, not piled turbines.

3.3.10 Depending on size, OSPAR (2009), reporting work from Parvin *et al.,* (2005), suggested that tidal current turbines will produce broadband source levels of between 165 and 175 dB re 1μ Pa. The investigations however are limited to reporting from individual devices due to the lack of array deployment at present, with the cumulative effect of multiple devices currently being largely uncertain.

3.3.11 The establishment of the Wave Energy Acoustics Monitoring (WEAM) project based at the Wave Energy Centre in Portugal has sought to capitalise on the momentum in the wave energy development sector to offer support for the development and promotion of ocean wave energy. The WEAM project aims to develop an underwater noise monitoring plan in order to assess and potentially prevent any impacts of underwater noise created by wave energy converters specifically on marine fauna.

3.3.12 As wave energy parks are developed the potential for assessing noise production within these parks will be enabled. The ultimate aim of the WEAM project is to monitor the noise produced by a number of wave energy parks utilising different technologies as they are developed.

3.3.13 Noise is not currently considered a major constraint/conflict between wave and tidal device deployment and the MoD in Wales, due to the type of activities carried out within Welsh waters, however the noise levels emitted by devices would need to be dealt with on a case by case basis as information becomes available. This is particularly the case for the deployment of arrays of devices which could have a cumulative effect on noise emission.

3.4 Potential Effects of Electro Magnetic Field (EMF)

3.4.1 The requirement to use cabling to transport power generated at sea to shore is common to the majority of marine renewable technologies, with the exception of some device types such as shoreline wave energy devices and devices that use hydraulics. Specific concerns were raised at an early stage of the development of offshore wind regarding the potential for such cables to generate an electromagnetic field (EMF) and the impact this may have to surrounding activities. The concerns lead to a number of studies investigating the effect of EMF associated with offshore wind farm cables (notably those commissioned by COWRIE e.g. Gill *et al.,* 2009).

3.4.2 Research on the effect of EMF has primarily focused on electrosensitive organisms (i.e. elasmobranchs, teleost fishes and agnathans) (CMACS, 2003, Gill *et al.,* 2005). The initial findings of investigations have shown that there is a response from some electrosensitive fish species to EM emissions from sub-sea, electricity cables of the type used by the offshore renewable energy industry (particularly offshore wind industry) (Gill *et al.,* 2009). The study was however limited to adult individuals of a few species and it did not determine if the response was positive or negative.

3.4.3 The impact of EMF generated by cabling from marine renewable devices is unlikely to have any impact on the MoD activities existing in Welsh waters as the majority of these activities are either in the airspace over the territorial waters or involve firing of ordnance into or over the territorial waters. There may be additional activities that are sensitive to the frequencies emanated by the cabling, such as communication or monitoring equipment, although this has yet to be established.

3.5 Potential Collision Risk from Fixed Structures

3.5.1 For any deployment of Offshore Renewable Energy Installations (OREI's) (including offshore wind, wave and tidal devices) a navigational risk assessment is advised in accordance with MGN 371-2 as published by the MCA (MGN 371-2, undated). This guidance note provides developers with an understanding of the potential conflicts that siting of OREI's may pose particularly to activities that presently exist in the area. The process described highlights issues that need to be taken into consideration when assessing the impact on navigational safety from OREI's proposed within UK territorial waters, or in the UK Renewable Energy Zone (when established) beyond the territorial sea. MoD activities would be included here, thus identifying existing MoD activities within Welsh waters to developers which may constrain/conflict with a particular site selection, promoting early communication with the MoD.

3.5.2 The MCA also provides advice to mariners regarding the correct procedures associated with navigating vessels around offshore renewable energy projects through MGN 372-2 (MGN 372-2, undated). This provides mariners with information on the most appropriate operation of vessels conducting all manner of marine activities in association with OREI's.

3.5.3 In addition, offshore wave or tidal stream energy devices would have to comply with International Association of Lighthouse Authorities (IALA) regulations for lighting, shapes and markings in order to ensure the correct identification of the device by passing vessels. Due to the wide ranging nature of wave and tidal stream devices there may be additional navigational marks required to ensure clear direction of vessels away from a site or suitable passage across a site where submerged devices are deployed.

3.5.4 Section 2.4 found that there are no significant navy establishments in Wales and that, as a result, there is limited navy activity in Welsh waters. However, the MoD maintain highly surveyed routes within Welsh waters, which would be used by vessels in times of conflict. The potential for navy activities to represent a constraint in Welsh waters is therefore likely to be localised and for these areas it may be possible that MoD operations could preclude the deployment of devices or markers. Such issues would be assessed on a site specific basis, with the MoD advising of appropriate mitigation to prevent conflict between the siting of wave and tidal devices and these interests.

3.6 Potential Collision Risk Should Devices Become Loose

3.6.1 Wave and tidal stream devices are typically deployed within a high energy environment characterised by physically demanding conditions. The infrastructure required to secure the devices to the substrate, whether deployed on the surface, in the water column or on the seabed, needs to be very robust to protect the device in extremes of weather. For the range of wave and tidal stream devices available there are several methods employed to secure devices into position, covering both tried and tested methods together with research and commercial development of new technologies for this purpose. Given the high energy conditions, there is always a risk, however minor, that a device or part of a device may become detached. This may happen for a variety of reasons including:

- Physical failure;
- Adverse or extreme weather;
- Vessel-to-device collisions;
- Failure of anchors or moorings;
- Cable interaction from other anchor or fishing gear; and
- Corrosion or fatigue.

3.6.2 Detached devices may ground soon after detachment, limiting damage to the device itself or damaging onshore infrastructure, or remain adrift posing a risk to recreational and commercial maritime traffic. For example in Sept 2009 the trident demonstration wave generator overturned as it was being taken out to sea to begin its year-long offshore trial (ReNews 177, 8 Oct 2009). Although not drifting, the overturned 80 tonne device became a navigational hazard and was grounded on a beach to keep the device secure while arrangements were made to shift the device to a location for damage assessment and repair (taken from www.tridentenergy.co.uk 30 Oct 2009). In March 2009 the 200MW prototype of the waveplane ran aground on a local beach causing an estimated £500k damage to the device and setting back testing of the device for several months (ReNews Issue 165 2 April 2009). Had the 100 tonne device remained free floating it would have created a greater risk to maritime traffic.

3.6.3 Although not specified in the MGN's for wave and tidal energy devices the MCA provides advice to mariners on the risk of collision with free floating objects. Due to the requirement for lights and markings on wave and tidal devices the likelihood of the device being noticed either through radar or visually is increased. Due to the nature of the environment and the potential risk of damage resulting from a detached wave and tidal devices, those at risk of detachment from the seabed, should be equipped with a monitoring system recording any movement outside a defined positional area to allow notification of movement and the ability to track the present position, particularly in the event of weather prohibiting the immediate salvage of a device.

3.6.4 Although the risk associated with detachment of devices from moorings is a generic issue for the maritime industry, the MoD could raise site specific concerns which may require access to monitoring equipment to ensure early/rapid response to free floating devices/components.

3.6.5 The development of a strategy for dealing with drifting devices/components may be appropriate in order to provide developers with standard operating procedures in the event of equipment loss. A protocol would incorporate procedures for the rapid response to the incidence of drifting devices/components.

3.7 Cumulative effects

3.7.1 Issues related to the potential for cumulative effects can be considered as either multiple devices within an energy farm development or multiple developments of devices within a similar area exploiting an identified wave or tidal stream resource. Most of the issues of cumulative effect tend to be addressed in Environmental Impact Assessment (EIA) and SEA documents, and hence to date are primarily restricted to wind. At present, the majority of wave and tidal device deployments are associated with the installation of a single device in test or evaluation stages. As such the assessment of cumulative effects from an array of devices can only be considered through modelling of the data that currently exists until monitoring of installed arrays can be reviewed. Modelling can provide an indication of the potential carrying capacity of devices in an area prior to deployment in order to avoid conflict with existing activities.

3.7.2 The issues associated with cumulative effects extend to each of the areas of potential conflict addressed in this document and are generally addressed individually. For example the increase in the number of surface deployed devices adjacent to a marine danger area has the potential to constrain the ability to use marine radar to identify objects.

3.7.3 Numerous research and management agencies are exploring the impacts of devices when deployed in energy farm arrays. For example, the WEAM project investigating noise production associated with wave energy converters will assess the cumulative effect of multiple devices in wave energy farms, as farms are developed. In addition, the Maritime and Coastguard Agency are actively engaged in the development of information relevant to marine renewables, in particular as the industry moves from the deployment of individual test devices to the deployment of energy farm arrays. As such there will be continued development of guidance associated with the cumulative effects of the deployment of individual devices and energy farms as the number of deployments increases.

3.7.4 For the MoD the impacts associated with cumulative effects are likely to be associated with an increase likelihood of conflict with their activities due to increased activity in adjacent waters. This is likely to be greatest in areas identified as a potential wave and tidal energy resource adjacent to defence areas. A general increase in the deployment of wave and tidal devices in areas associated with defence areas, including operations that are less site attached, such as vessel movements, would increase the potential for conflict with MoD activities. As the intensity of deployment of devices and farms increases the impact on military activities will need to be monitored.

4 Developer engagement with the MoD

4.1 Introduction

4.1.1 This section is designed to provide guidelines for developers involved in the wave and tidal stream energy sector for consultation with the MoD. This document aims to facilitate that process by encouraging effective liaison between the two parties via the establishment of a proforma for consultation and information exchange. As part of the process, it is important to note the existing views of the MoD on the potential for deployment of wave and tidal stream devices within MoD activity areas (see Section 2). During the consultation process undertaken for the current project, it was clear that the MoD would object to development in some areas. There is, however, potential for development in other areas. Sections 4 and 5 are aimed at facilitating consultation on potential deployment in these areas, in areas near or adjacent to all MoD areas and to check that unpublished MoD interests across Welsh waters would not be compromised by the proposal. Despite the consultation process it does not automatically follow that development would be acceptable to the MoD.

4.2 Purpose

4.2.1 The purpose of this section of the document is to provide clear guidance for the liaison with the MoD through the establishment of a consultation template. The main aim is to identify the information required by the MoD to make an informed assessment of the potential for conflict from a proposed wave or tidal stream development on MoD interests. Through this process, the intention is to expedite the progression of appropriate developments without compromising the activities of the MoD in Welsh waters.

4.2.2 The consultation template is designed to assist with the progression of proposed developments where appropriate through:

- Instigating an early engagement process between the developers and MoD (preferably during site selection);
- Early identification of areas of concern from the MoD relating to the development of devices;
- Provision of information to the MoD to enable an informed response to a proposed development;
- Ensure consistent units of measurement for all of the device parameters identified and provided to the MoD; and

- Develop a standard framework for engagement to expedite the process of identifying areas of constraint/conflict.

4.3 Establishing Contact

4.3.1 In order to highlight potential areas of constraint/conflict early in the development process it is recommended that contact between the developer and the MoD is established at the earliest possible time in the planning phase, ideally at the site selection phase. In England, Scotland and Wales the primary MoD contact for wave and tidal renewable energy developments is:

The Defence Estates Safeguarding Team
Jon Wilson – Safeguarding Officer (Statutory and Offshore)
DE Ops – North
T: 0121 311 3818
F: 0121 311 2218
E: Jonathan.Wilson@de.mod.uk
Enquiries can also be sent to the Defence Estates – Offshore Safeguarding inbox:
offshoresafeguardinggroup@de.mod.uk

4.3.2 The initial contact enables the establishment of lines of communication and, where possible, the developers can provide the required information about their device (see Section 5) to enable the MoD to make informed judgments about potential constraints/conflicts. From the establishment of the initial contact to highlight the proposed site location, the MoD may either conclude that the proposal holds no interest to their activities or that additional information is required in order to assess potential conflict.

4.3.3 The establishment of contact with the MoD is likely to coincide with establishing contact with a number of Government agencies, both local and national, such as the WAG, the MCA, the Marine Management Organisation (MMO), Port Authorities and the UK Hydrographic Office (UKHO). The information required by each of these organisations is likely to be consistent with that required to enable the MoD to make an informed judgment about any potential constraints/conflicts associated with the proposed development.

4.4 Managing contact

4.4.1 Should ongoing contact be required between the MoD and a developer, for such contact to proceed smoothly, it is important to be clear about the appropriate person to call.

Developers should therefore aim to identify an individual within their company (for example a Developer Liaison Officer) to be a single point of contact for the MoD. The degree of continued contact required will be a function of both the proximity to areas of MoD activity and the type of activity. Early engagement with the MoD can determine the extent and regularity to which this contact will be required, and it is of particular importance to establish early contact with the MoD, as there are some areas/types of activity within Welsh waters that are not specified for security reasons.

4.4.2 Potential examples of ongoing liaison may relate to information regarding the progress of a development including the program of activities and urgent bulletins in the event of any marine hazards (e.g. deployment of monitoring equipment, unmarked piles, loss of plant onto the seabed etc). Depending on the presence and type of military interests, there may be a requirement to negotiate access to specific sites, for example for pre-deployment surveys. Other contact may be more immediate, for example contact between vessel skippers and firing range managers.

Information needed by liaison officer

4.4.3 To ensure effective communication between the liaison officer and the MoD, the liaison officer should be informed on a timely basis of the following:

- All works and proposed works that may impede MoD activities including (but not limited to);
    - pre-development surveys (including hydrographic and geological surveys);
    - pre-submarine cable laying surveys;
    - changes to traffic routes;
    - restrictions to vessel movements;
    - changes or additions to navigation aids;
    - creation of prohibited/restricted areas;
    - exclusion/safety zones;
    - submarine cable laying;
    - installation activities;
    - cable routes and cable installations;
    - anchor patterns of installation vessels; and
    - any additional work required in association with the development of the site;

- Planned schedule for these works; and
- Details of vessels involved (call signs, Inmarsat numbers, comms links etc), their home ports, planned routes, work times and movements to and from the installation sites.

MoD Contact

4.4.4 It is important for the wave and tidal stream device developer to have a single contact point within the MoD who represents all of the interests of the MoD, particularly related to activities within Welsh waters. That person should also be able to disseminate information from the developer to the relevant departments of the MoD, in a timely manner.

4.4.5 The principal roles of the MoD contact may include, but not be limited to, the following:

- Form the principal link between the MoD and the wave and tidal stream device developer;
- Provide the developer with guidance on the MoD activities in the area and draw attention to particular MoD activity sensitivities;
- Liase with relevant MoD department managers and specific activity managers with the objective of relaying accurately their concerns and actual problems back to the developers liaison officer;
- Disseminate updated project information to department managers and activity managers and communicate any changes that occur;
- Promote methods of work which minimise disturbance to the MoD activities (and where there are problems seek to remedy these);
- Monitor the MoD activities in the development area; and
- Liase with the MoD department managers and activity managers with a view to informing the developer’s liaison officer of any particularly sensitive sites/issues that the MoD needs to be addressed in any proposals.

4.5 Construction and Maintenance

4.5.1 Where external contractors are required to assist in the completion of tasks in relation to the project it is expected that the liaison officer for the developer would brief the contractor of any MoD constraints/conflicts associated with the development site. If highlighted by the MoD, the MoD contact may be required to brief the contractor on specific issues.

4.5.2 For sites where ongoing liaison with MoD is required during construction, operation and maintenance of a project, the Site or Project Manager would be responsible for providing relevant information to the liaison officer and/or the MoD contact as appropriate. Where operations are within close proximity to sensitive defence activities a timeline of activities is likely to be required and in some instances there may be a requirement for daily updates of activity progress. Details provided to the MoD contact should include:

- Details on the vessel/s completing the works;
- Location of works;
- Port of embarkation and voyage path;
- Expected duration of those works and daily operations;
- Delays to works; and
- Type of works.

(These details may also be required as a notice to mariners)

4.5.3 Prior to the commencement of work, the Project Manager must established contact with the liaison officer, the MoD contact and if necessary the manager of any defence activities within close proximity that may require regular communication of daily activities. Securite (Safety) transmissions can be made from VHF channel 16 for general coverage while local defence stations can provide working channels.

4.6 Information dissemination

4.6.1 Information dissemination is central to avoiding problems between developers and the MoD, particularly for developments within close proximity to defence activities. It is therefore important that a communication plan be developed to ensure that timely information on activities being completed is disseminated to the appropriate people prior to the commencement of the development program.

4.6.2 During both the development and construction stages of a wave or tidal stream development, information on vessel movements associated with the projects and any other marine activities should be sent to the MoD contact in a standard format for dissemination to the relevant parties. This may include the vessel name, call sign, duration in the field and contacts for personnel onboard connected to the project.

5 General Information Requirements

5.1 Introduction

5.1.1 Provision of details of the proposed development in a standard format with standard units of measurement will enable the MoD to make an informed assessment of the potential constraint/conflict of development activities on their activities. The type of information that is likely to be required has been summarised below under a list of topic headings. The list is designed to cover most activities and it is to be expected that the amount and type of information required will vary depending on the specific project and the proximity to and type of MoD interests. Starting consultation early will enable key concerns to be highlighted, the detail required, and in particular to identify any sites where the MoD is unlikely to take a positive view on consent. As an aid to consultation, the information has also been summarised in a proforma and presented in Appendix B. Use of a proforma will help ensure the required information is provided to the MoD in a timely fashion, in a standardised format.

5.1.2 The detail potentially required from developers has been listed in two stages, to enable proposals where the MoD has either little or no interest or where the MoD is likely to raise an objection due to the location of the proposal to be highlighted at an early stage, and therefore potentially removing the need to provide more detailed information. The additional points are likely to be required from developers where the MoD requires more detail on which to make a decision and/or provide advice. It is recognised, however, that the level of detail available at the start of a proposal may be insufficient to provide full information on all points summarised here (and listed in the proforma in Appendix B), with the additional information to be provided as it becomes available. Information that should be provided at the start of the consultation process is highlighted in **bold**, with the additional information requirements in *italics* (additional detail on each point is presented 5.2-5.13):

- **The Developer(s);**
- **The proposed device location and cable/piping route (in WGS84 degrees, minutes and seconds);**
- **The Device type and details of its operation (including information on appearance and shape of the device/s);**
- **The proposed duration of device deployment;**

- **The positioning of the device in the water column, water depth and distance from shore;**
- The markings, colour, lighting of the device/s;
- The construction materials to be used in the device;
- The method of deployment and fixing in position;
- Marine cable/pipeline type and connections to the grid;
- Noise and Vibration;
- Operation in extreme weather conditions and emergency response protocols; and
- Pre-deployment and deployment operations including;
- Pre-deployment surveys; and
- Deployment. Maintenance and decommissioning.

5.2 Developers

5.2.1 In order to develop a working relationship with developers the MoD will require details of the company(s) that are proposing the development. At this stage the nomination of a liaison officer by the developer and MoD contact will initiate the lines of communication, as described in Section 4.

5.3 Proposed Device Location(s) and Cable/Piping Route

5.3.1 Within Welsh waters there is significant overlap between potential wave resources (there is minimal overlap for tidal stream resources) and military activities (see Section 2.10). As a result it is likely that proposed wave developments and, to a lesser extent, tidal stream developments, will be within close proximity to if not overlapping areas of military activity. This potential for conflict highlights the importance for the communication of the proposed deployment location(s) to the MoD at the earliest possible stage in the development process, ideally during site identification as several sites are often reviewed at this point. Details of the preferred site deployment locations, in WGS84 degrees minutes seconds format, should be provided as:

- A single site location with a proposed safety boundary area for the deployment of a single device; or
- A series of points identifying the boundaries of a proposed area of deployment for multiple devices in an array.

5.3.2 For either of the deployment scenarios the proposed cable route or route options would also be required in addition to the identified shore facilities. There are several coastal locations managed for defence interests that may be selected for the landfall of cabling and connection to the grid.

5.3.3 Where there is an intention to develop an array of devices in stages it is important that the full extent of the proposed development area is provided to ensure that there are no objections to the potential increase in area of development. Where possible the likely extent of any pre-deployment surveys should also be included to enable some assessment of the possible constraints/conflicts to the completion of these activities.

5.4 Device Type and Operation

5.4.1 Technical details of the type of device to be deployed and the operation of the device will be essential particularly where there is limited information about some of the parameters associated with the device such as noise and vibration. This will also detail the resource that is being exploited and how that resource will be harnessed.

5.4.2 Information on the size, appearance and shape of a proposed device provides valuable insight into the potential of a device or array of devices to conflict with MoD activities. Given the variability in device design, visual aids will be particularly useful (photos and/or drawings) including an indication of the scale of the device to be deployed.

5.5 Proposed Duration of Device Deployment

5.5.1 Proposed deployments in Welsh waters may range from short term device testing of scaled prototypes through full scale devices to the long term deployment of commercial projects involving either individual devices or arrays of devices. An understanding of the proposed duration of a proposed deployment will enable a determination of the potential constraint/conflict that this may have on MoD activities in the proposed area.

5.6 Positioning of Device, Water Depth and Distance from Shore

5.6.1 Information on the position of the device in the water column (e.g.: surface, mid column or seabed) is essential in assessing the suitability of a deployment at a proposed location in relation to the MoD activities that may be within close proximity. Included in this would be the low water clearance for submerged devices. There may be circumstances in which surface deployment would create constraints to a MoD activity while devices attached to the substrate may allow for the continuation of those activities.

5.6.2 Although a proposed location of deployment is provided, the provision of additional information on the ranges of depth and distance from shore suitable for the device will provide parameters within which suggestions for relocation can be discussed.

5.7 Markings, colour, visibility and lighting of devices

5.7.1 The MCA provides information on the suitable markings, colouring and lighting of devices to ensure consistency between structures in the ocean that can pose a threat to the operation of vessels. This type of information can be disseminated amongst departments to ensure that the specifications used will not cause conflict with MoD operations in the proposed location.

5.8 Construction Materials

5.8.1 Details of the construction materials include those used for the construction of the device itself, any infrastructure necessary to maintain the device in position (anchors/fixings and marker buoys), cabling/piping requirements to shore and any other fixed structures on site. The materials used may need to be considered in combination with the other characteristics of the device in assessing the potential for constraint/conflict with MoD activities. In the first instance these can be provided as generic materials and further details will be requested by the MoD in instances where this is relevant.

5.9 Method of Deployment and Fixing to Seabed

5.9.1 There are a vast array of methods for fixing a device to the seabed either directly or through the attachment to anchors and cabling etc. In combination with the position of the device in the water column and the size and operation of the device, the attachment method may be crucial in terms of the potential for constraint/conflict with MoD activities. In addition, the method of fixing a device to the seabed will also indicate the potential for movement of the device within a controlled area at a location and the fate of a device should it break free from the mooring/fixing points.

5.10 Marine Cable/Piping Type and Connections to the Shore

5.10.1 Information on the type of cabling to be employed or the piping for pressurised fluid including the method of deploying, anchoring and armouring the cable/pipeline.

5.11 Noise and Vibration

5.11.1 Information on noise and vibration produced by the devices may be important for an assessment of the potential constraints/conflicts with MoD activities conducted in the proposed deployment area. However, for many developers the information available on noise and vibration is limited and there may be a requirement for monitoring of these aspects of the device(s) deployed in order to provide information as it becomes available. Where possible any available information about the potential noise of the device should be provided as a range of potential frequencies (Hz) and the intensity of the potential noise in Decibels (dB).

5.12 Operation in Extreme Weather Conditions and Emergency Response Protocols

5.12.1 Due to the extreme conditions in which wave and tidal devices are deployed there is a possibility that devices will become detached from their deployed location. To combat this possibility some device manufacturers have developed an extreme weather mode that allows the device to stop operating in extremes of weather to prevent damage to the operational components in addition to limiting the potential for detachment of the device from its mooring/fixings. There is however the potential for devices to become detached due to the failure of a mooring system or collision with another object resulting in a mobile device that can cause further damage if not contained (see Section 3.6). As a result, details of operation of devices in extreme weather conditions and protocols for emergency response are required from developers prior to the deployment of the devices. This is more crucial where devices are to be deployed within close proximity to MoD infrastructure that has the potential to be damaged by devices that are not fixed in position.

5.13 Pre-deployment and Deployment Operations

5.13.1 For any deployment of a wave and tidal energy device there are a range of activities required for the site assessment and preparation, device deployment, monitoring, maintenance and decommissioning.

Pre-deployment Surveys

5.13.2 Following the selection of a site for the deployment of a device there are a number of pre-deployment survey requirements that are likely to include, but not limited to, the following:

- Resource Assessment;
- Geophysical and Geotechnical Surveys;
- Marine Traffic Surveys;
- Environmental Surveys; and
- Unexploded Ordinance (UXO) surveys.

5.13.3 It is likely that pre-deployment surveys will be required over a larger area than the site of device deployment itself in order to understand the environment into which the device(s) is being deployed. Due to the nature of defence activities the deployment of a device at a selected location may be suitable while the survey requirements within and adjacent to a site may result in a constraint/conflict on the defence activities. Through early communication of the requirements there may be an ability to coordinate activities in and around the requirements for the MoD over an agreed timeframe to enable both activities to be conducted with minimal disruption.

Device Deployment, Maintenance and Decommissioning

5.13.4 Due to the nature of the environment in which wave and tidal devices are deployed, developers employ device specific methods for deployment, maintenance and decommissioning. These device specific requirements are dependant on the type of device, position in the water column and the method of anchoring to be used among other criteria. Unlike pre-deployment surveys these tasks are limited to the deployment location, however, it is likely that these tasks will require an extended period of vessel time on site. Details of the technical requirements for each device would be necessary in order to assess the likely constraints/conflicts that may result.

6 Conclusions and Recommendations

6.1.1 In this document we have discussed the potential constraints/conflicts between the development of wave and tidal energy devices and the activities of the MoD within Welsh waters based on the existing uses and technologies, giving some consideration to the potential changes in activity and technology within both the defence and the wave and tidal stream industries.

6.1.2 Due to the relative early stage of the wave and tidal stream industry, there are a number of areas in which the understanding of potential constraints/conflict between the industry and the MoD are currently unknown. Through the development of the offshore wind industry there has been progress in many of the areas of potential constraint/conflict, some of which will be relevant to wave and tidal devices, such as that associated with noise production, EMF, physical presence and cumulative effect. It is anticipated that there may be a similar requirement for research into potential constraints relevant to the wave and tidal industry as it develops, in which the MoD will remain an active partner.

6.1.3 One area of accepted constraint/conflict existing between the two industries is associated with the overlap between the MoD danger areas and the identified wave and tidal stream resources. Given the nature of some of the MoD activities conducted within offshore practice and exercise areas, e.g. firing ranges, the degree of risk involved in survey, device deployment and operation in such areas may exclude development in some such areas. In addition there may be further limitations associated with the routing of cabling/pipelines from devices deployed seaward of the Defence Estates to shore-based infrastructure through the estates. In some instances the existence of the cabling/pipelines within the area is considered possible given the types of existing activities; however the requirement for vessel access to the estates for pre-deployment surveys, deployment, maintenance and decommissioning of the devices has the potential to significantly constrain the activities of the MoD. In addition, there is a possibility that the MoD may choose to change the activities conducted in any of the areas, which may then render the positioning of devices or cabling unsuitable. Through regular contact between the marine renewables sector and the MoD an open line of communication can be established to ensure that changes occurring can be raised and the consequences discussed.

6.1.4 Another area of wide ranging potential constraint/conflict between MoD activities, both historic and current, and the development of the wave and tidal renewable sector is the issue of UXO. The existing knowledge of UXO distribution in Welsh waters is based on known dumping sites and the historic and present day use of armament testing and training areas. Although these areas are likely to represent the highest concentration of UXO, there is the potential that natural physical processes and a range of anthropogenic activities (dredging, trawling, coastal developments etc) may have resulted in the further dispersion of these deposits. The lack of monitoring of the UXO distribution makes it difficult to predict the possible area over which UXO has been dispersed. The issue of the UXO distribution is further complicated by alteration of armament training areas with time resulting in an increased legacy of UXO beyond the existing defence estates.

6.1.5 As part of the SEA for marine renewables in Scottish waters, the Scottish Executive commissioned a desk study into the explosives and other munitions contamination of Scottish waters (Martin, 2007). In order to provide a greater understanding of the potential dispersion and concentration of UXO within Welsh waters it may be suitable to conduct a similar review of the potential UXO concentration in Welsh waters taking into account both the historic and existing military training and testing areas, munitions dumping sites, wrecks, UXO discoveries (by fishing vessels and on beaches etc) and areas that may have been involved in potential conflict situations. This would provide a greater understanding of the areas which are most at risk of presenting issues associated with UXO, providing a basic understanding of the likely distribution of UXO from known sources. It would also enable more effective planning of strategic resource development while providing developers with greater certainty associated with the areas chosen for development.

6.1.6 The aspects of wave and tidal stream developments that have the potential to impact on military activities in Welsh waters were identified and discussed with the MoD during the consultation process, and include physical presence, potential interaction with radar, noise and vibration, electro magnetic fields, collision risk from fixed or loose devices and cumulative impact. Of these, the main risk of constraint in Welsh waters is due to the geographic overlap between potential wave resource and MoD interests to the south of Pembrokeshire, potential for constraint/conflict with shipboard, shorebased and airborne marine radar and cumulative effects. Issues such as noise, vibration, EMF and collision risk (from fixed and loose devices) are best addressed through site specific consultation and assessment.

6.1.7 Due to the infancy of the industry there is limited information available on a number of these points, including noise and vibration, radar interference, EMF production and navigational risk, although knowledge gained from the offshore wind industry is directly applicable in some instances. As more devices are deployed at sea, the knowledge base specific to wave and tidal stream devices will expand. Continued consultation with the MoD will ensure an open line of communication regarding new information and potential concerns from both industries.

6.1.8 The DESOS is responsible for management of MoD interests in relation to wave and tidal energy projects throughout the UK. As such it maintains regular communication with the major contributors to the progression of wave and tidal energy development, including the Crown Estate, the Department of Energy and Climate Change (DECC), WAG and a number of non government agencies. In its capacity as the manager of MoD interests in relation to Wave and Tidal energy, the DESOS also participates on a number of working groups relating to the wave and tidal industry, including the WAG steering group for the development of the MRESF, to provide advice on MoD issues that may relate to the progression of this industry. The DESOS will continue to assist WAG in the development and implementation of the MRESF through the provision of information as required and participation on working groups as necessary. In addition, the DESOS is the point of contact for developers to engage the MoD on issues of potential constraint/conflict between wave and tidal device development and defence activities in Welsh waters. Section 4 of this document summarises a consultation route between developers and MoD, providing clear guidelines for communication. Section 5 subsequently provides a detailed list of information that would assist the MoD in assessing the suitability of a proposed development in relation to MoD activities. The information is summarised as a proforma in Appendix B, to prompt for information and to assist in standardising the format (e.g. units) of data provided to the MoD.

6.1.9 It is recommended that developers instigate communication with the MoD as early as possible in the process of a proposed development (ideally during site selection phase) in order to develop a working relationship with the MoD. It is likely that developers will not have all the information required by the MoD to make a complete assessment of a proposed development. However, it is recommended that initial communications are established as early as possible in the process of a proposed development and a plan be developed for provision of additional information as it becomes available. This is particularly important for the MoD as the actual use of MoD sites is not always public and there is potential for some MoD activities to preclude marine renewable energy developments.

6.1.10 In addition to communication between individual developers and the MoD, the coordination of all of the uses of the Welsh waters for the benefit of all industries will need to maintain an up to date understanding of the use of MoD estates to determine the suitability of overlapping activities. It may even be suitable in future for the MoD to work with developers to coordinate/manage their exploitation of identified marine renewable resources within defence estates.

6.1.11 Although this document provides a summary of the constraints/conflicts between the MoD and potential wave and tidal stream device developers in Welsh waters, it is limited to the existing knowledge and technologies in each of these industries. As the industry develops, the information on potential constraints/conflicts will also develop, alongside potential mitigation measures. With increasing information, the constraints/conflicts as they are currently perceived may be resolved, for example if the data proves them to be unfounded, or from developments in design/deployment and mitigation methods.

6.1.12 It is recommended that developers should be encouraged to engage with the MoD at an early stage of the development process, armed with the knowledge of the potential constraints/conflicts discussed in addition to detailed information of their own proposals to enable discussion of issues that may inhibit a development going forward. This early engagement would involve the establishment of the developer and MoD contacts and the proposal of a communication plan which will be followed for the life of the project. Early engagement will prevent any loss of time and finance associated with a development and will provide the most likely case for a successful outcome where possible.

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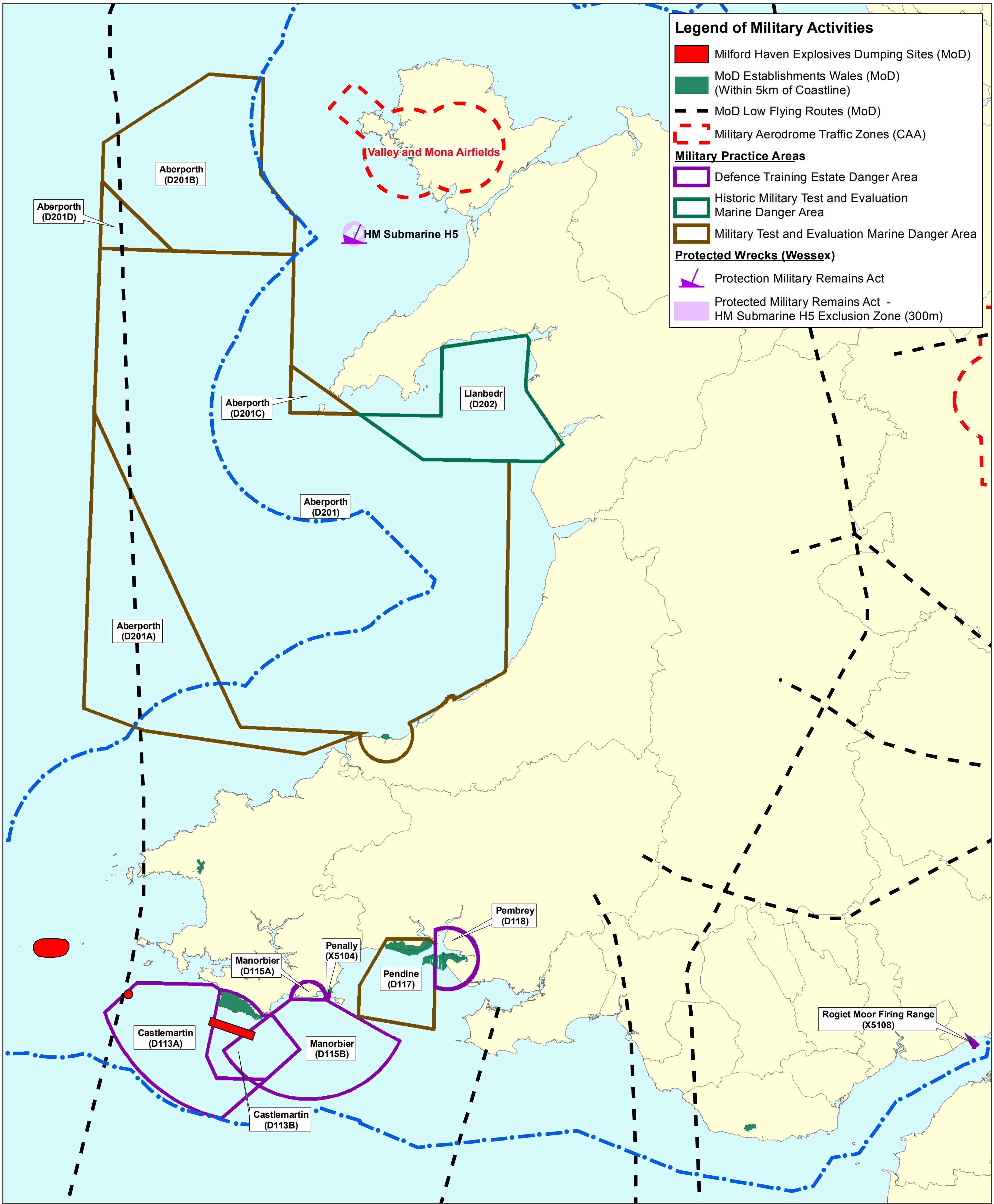
Drawings



Legend

12nm Territorial Waters Limit

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Project Ref: J:\Drawings\JER3688\

Rev:	Date:	Amendment:	Name:	Checked:

Data Source: RPS 2009
Status: FINAL
Client: Welsh Assembly Government
Project: MRESF

Title: **Military Activities in Wales**

Scale: A4 @ Not to Scale
Scale Bar: 0 25 50 km
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Date: 30/09/2010 Datum: WGS84 Projection: UTM30N
Drawn: S Morgan Checked: N Simpson Job Ref: JER3688
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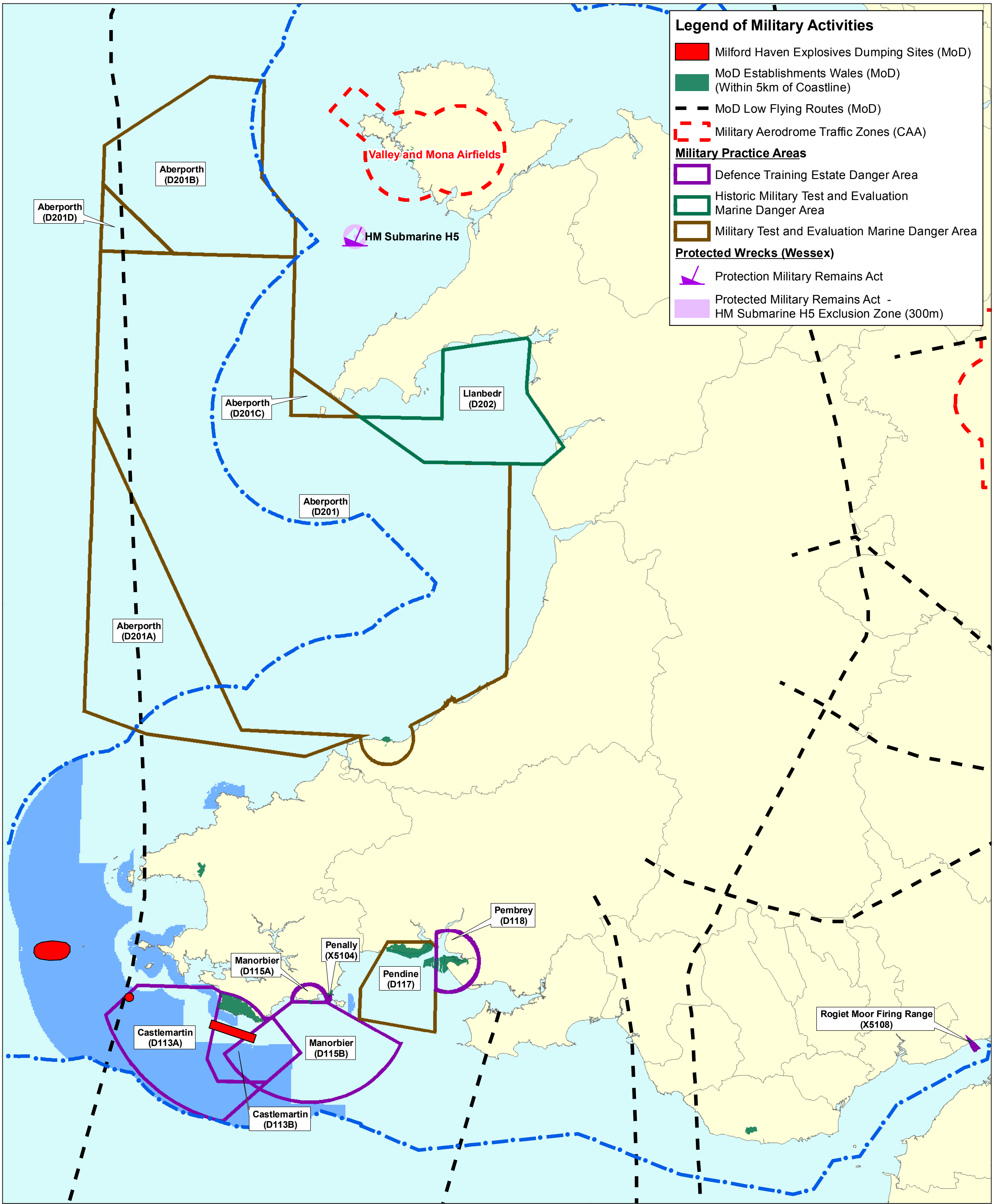

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Legend

- 12nm Territorial Waters Limit
- Wave Resource Area

Rev:	Date:	Amendment:	Name:	Checked:

Title: **Total Wave Device Types Resource Area & Military Activities in Wales**

Scale: A4 @ Not to Scale

Scale Bar: 0 25 50 km

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Data Source: RPS 2009

Status: FINAL

Client: Welsh Assembly Government

Project: MRESF

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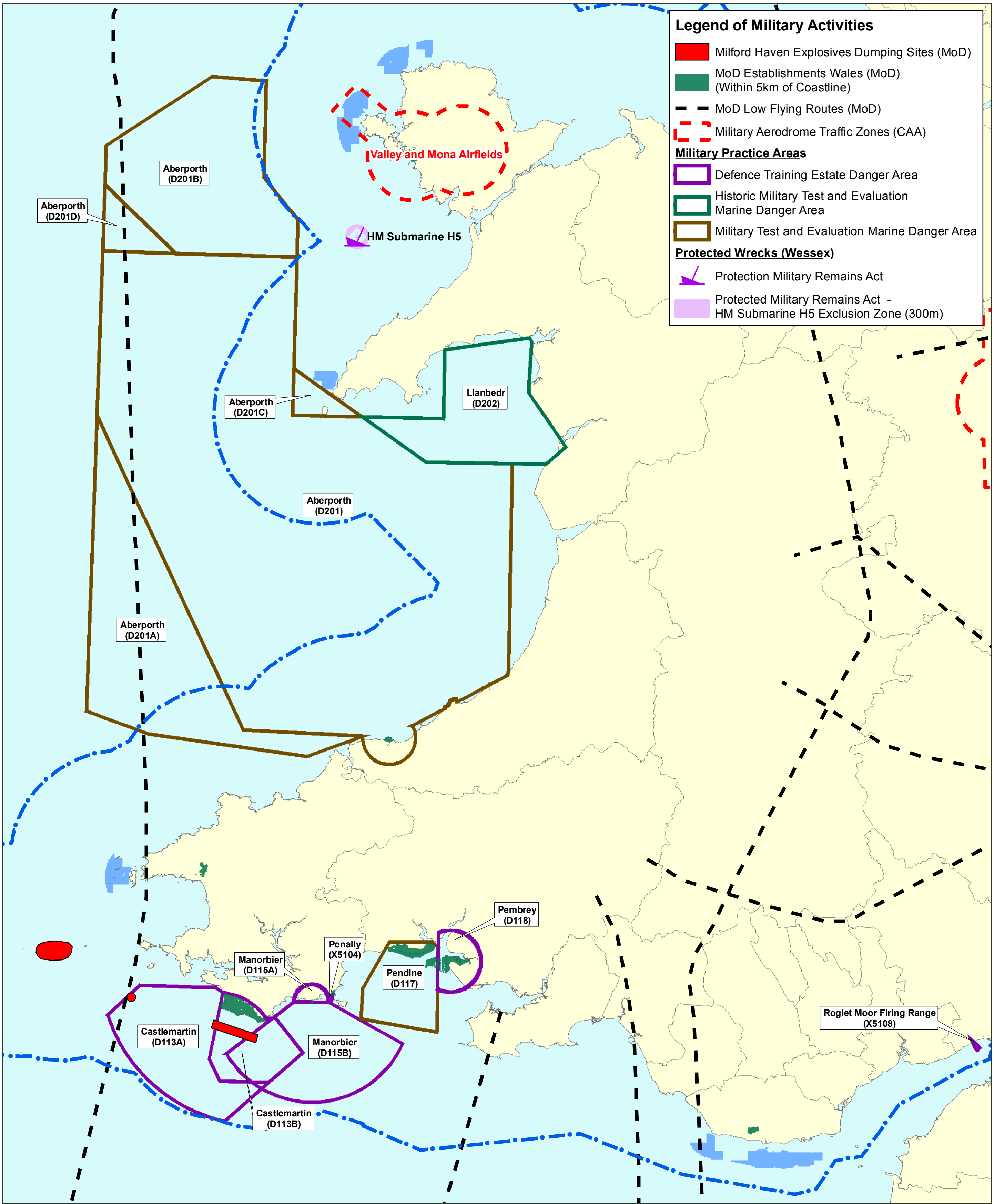

Legend

- 12nm Territorial Waters Limit
- Tidal Resource Area

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Rev:	Date:	Amendment:	Name:	Checked:

Title: **Total Tidal Device Types Resource Area & Military Activities in Wales**

Scale: A4 @ Not to Scale
Scale Bar: 0 25 50 km
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Data Source: RPS 2009
Status: FINAL
Client: Welsh Assembly Government
Project: MRESF

Date: 30/09/2010 Datum: WGS84 Projection: UTM30N
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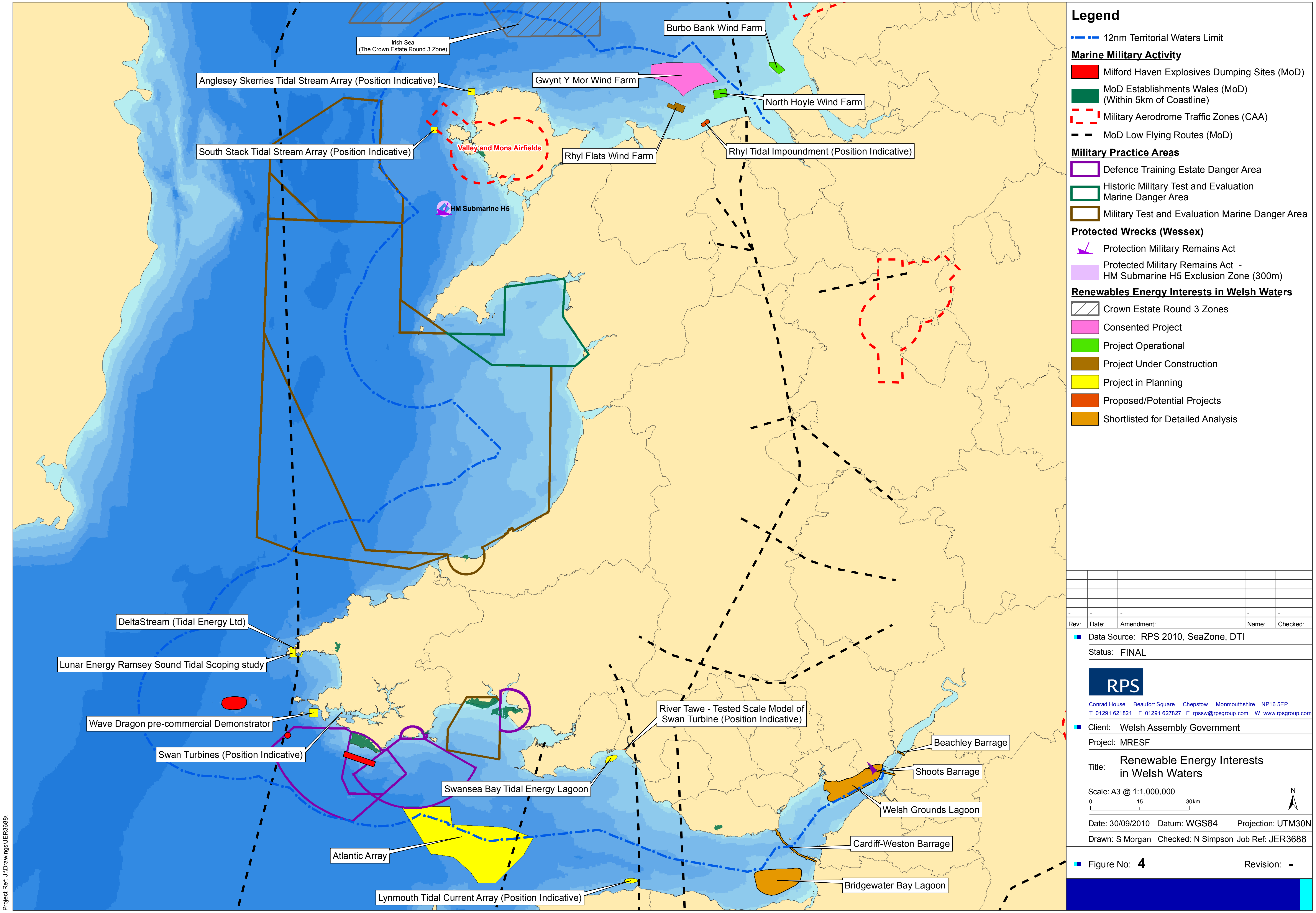
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12nm Territorial Waters Limit
Marine Military Activity
Milford Haven Explosives Dumping Sites (MoD)
MoD Establishments Wales (MoD) (Within 5km of Coastline)
Military Aerodrome Traffic Zones (CAA)
MoD Low Flying Routes (MoD)
Military Practice Areas
Defence Training Estate Danger Area
Historic Military Test and Evaluation Marine Danger Area
Military Test and Evaluation Marine Danger Area
Protected Wrecks (Wessex)
Protection Military Remains Act
Protected Military Remains Act - HM Submarine H5 Exclusion Zone (300m)
Renewables Energy Interests in Welsh Waters
Crown Estate Round 3 Zones
Consented Project
Project Operational
Project Under Construction
Project in Planning
Proposed/Potential Projects
Shortlisted for Detailed Analysis
Irish Sea (The Crown Estate Round 3 Zone)
Burbo Bank Wind Farm
Anglesey Skerries Tidal Stream Array (Position Indicative)
Gwynt Y Mor Wind Farm
North Hoyle Wind Farm
South Stack Tidal Stream Array (Position Indicative)
Valley and Mona Airfields
Rhyl Flats Wind Farm
Rhyl Tidal Impoundment (Position Indicative)
HM Submarine H5
DeltaStream (Tidal Energy Ltd)
Lunar Energy Ramsey Sound Tidal Scoping study
Wave Dragon pre-commercial Demonstrator
Swan Turbines (Position Indicative)
River Tawe - Tested Scale Model of Swan Turbine (Position Indicative)
Beachley Barrage
Shoots Barrage
Swansea Bay Tidal Energy Lagoon
Welsh Grounds Lagoon
Atlantic Array
Cardiff-Weston Barrage
Bridgewater Bay Lagoon
Lynmouth Tidal Current Array (Position Indicative)
Rev: Date: Amendment: Name: Checked:
Data Source: RPS 2010, SeaZone, DTI
Status: FINAL
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Client: Welsh Assembly Government
Project: MRESF
Title: Renewable Energy Interests in Welsh Waters
Scale: A3 @ 1:1,000,000
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Date: 30/09/2010 Datum: WGS84 Projection: UTM30N
Drawn: S Morgan Checked: N Simpson Job Ref: JER3688
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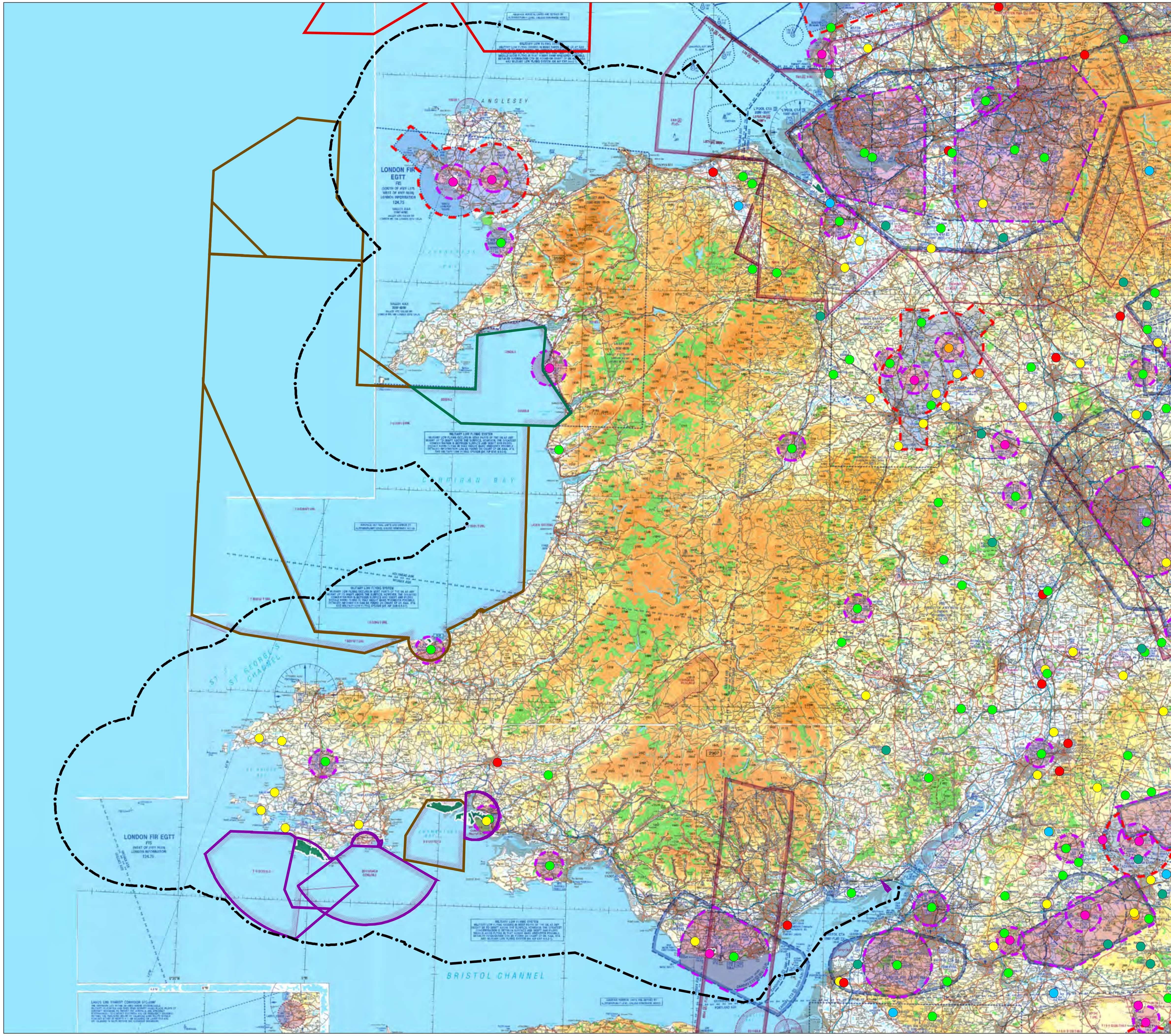
Project Ref. J:\Drawings\JER3688\



Legend

- 12nm Territorial Waters Limit (SeaZone)
- Crown Estate Round 3 Zones
- MoD Establishments Wales (MoD) (Within 5km of Coastline)
- Aerodrome Traffic Zones
- Military Aerodrome Traffic Zones

Aerodromes

- Civil
- Disused/Abandoned
- Glider Launch Site
- Government
- Heliport - Civil
- Heliport - Government
- Microlight Flying Site

Military Practice Areas

- Defence Training Estate Danger Area
- Historic Military Test and Evaluation Marine Danger Area
- Military Test and Evaluation Marine Danger Area

Rev:	Date:	Amendment:	Name:	Checked:

Data Source: RPS 2008, BWEA - Aviation & Wind Energy

Status: DRAFT

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Client: Welsh Assembly Government

Project: MRESF

Title: Aviation interests in Wales

Scale: A3 @ 1:1,000,000

0 25 50km N

Date: 01/10/2010 Datum: WGS84 Projection: UTM30N

Drawn: S Morgan Checked: N Simpson Job Ref: JER3688

Figure No: 5 Revision: -

Project Ref: J:\Drawings\JER3688A_MarineRenewables\-- DRAWINGS --\16_Aviation\JER3688-Figure_16_Aviation.mxd

Appendices

Appendix A

The Potential Effects of Wave and Tidal Devices on Military Interests – Consultation Document

The Potential Effects of Wave and Tidal Devices on Military Interests – Consultation Document

Welsh Assembly Government

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1 Summary

1.1.1 RPS was commissioned by the Welsh Assembly Government (WAG) to undertake work towards the development of a 'Marine Renewable Energy Strategic Framework' (MRESF) for Wales. The project forms part of WAG's commitment to strong economic development combined with sustainable growth and prosperity. The work programme is broadly divided into three stages. Stage 1 of the MRESF focused primarily on the identification of information relevant to the marine renewable energy sector and the identification of data gaps apparent from the exercise. Some of the data gaps identified in Stage 1 are the focus for gathering of additional information in Stage 2; to allow informed decisions to be made in the development of the strategic approach to the deployment of marine renewable energy technologies in a sustainable manner in Stage 3. One of the data gaps identified was that Military interests within Wales pose a potentially important conflict with the development of a range of wave and tidal stream energy devices due to military activities presently existing, and that further understanding of these conflicts is required.

1.1.2 Through consultation with representatives from the Ministry of Defence (MoD) the areas in which these conflicts arise will be determined in order to develop a strategy for working with the interests of both the MoD and wave and tidal power device developers.

1.1.3 This document provides information sourced from a desktop study on a range of wave and tidal stream devices in varying stages of commercial development in order to prompt discussion and feedback from the MoD in terms of the areas in which the devices may conflict with existing and potential future activities of the MoD in Wales.

2 Introduction

2.1 Project Background

2.1.1 The Welsh Assembly Government (WAG) is aiming to develop 'the strongest economic development policies to underpin sustainable growth and prosperity in Wales.' Part of this aim is to use an evidence based evaluation of clean energy developments, to achieve economic drive through sustainable development and internal competitiveness.

2.1.2 This aim is being achieved in part by the development of the Marine Renewable Energy Strategic Framework (MRESF). Stage 1 of the MRESF development focused primarily on the identification of information relevant to the marine renewable energy sector and the identification of data gaps apparent from the exercise.

2.1.3 Some of the data gaps identified in Stage 1 are the focus for gathering of additional information in Stage 2; to allow informed decisions to be made in the development of the strategic approach to the deployment of marine renewable energy technologies in a sustainable manner in Stage 3.

2.2 Effects of Wave and Tidal Devices on Military Interests

2.2.1 The potential for military interests in Wales to constrain the development of wave and tidal stream renewable energy technologies was identified as an area where further information is needed, requiring additional research through a desk based study and consultation.

2.2.2 By identifying issues that may constrain the development of wave and tidal stream devices WAG can establish a process by which new technologies can be reviewed for their compatibility with MoD activities as they are developed and developers can work within guidelines to limit the introduction of additional development constraints. Gaining an understanding of the concerns of the MoD with the information that is presently available will highlight potential areas of concern for the MoD and a process can be established for further discussion as new technologies are proposed.

2.2.3 The marine renewable energy industry, particularly the wave and tidal energy components are in a state of relative infancy and as such the devices being developed and technologies used are very dynamic. In Stage 1 of the development of MRESF a number of issues were raised regarding knowledge gaps associated with the range of wave and tidal devices identified. These data gaps result from issues associated with confidentiality of device development, uncertainty of device requirements as models are scaled up to commercial size and the ability of some devices to be tailored to a variety of conditions. As a result, the information available on the range of devices described is highly variable.

2.2.4 Consultation with the MoD is designed to determine the extent to which the site investigation, construction, operation and maintenance of the devices identified, may raise issues with the operations of the MoD within Wales. In addition, the development of a process by which new developments in the marine renewables industry can be sensitive to the concerns of the MoD activities, is sought.

2.3 Aims and Objectives

2.3.1 The overall aim of the project is to develop a MRESF for Wales. The Framework is aimed at combining renewable energy extraction from the Welsh marine environment (wind, wave and tidal stream) and carbon capture and storage (CCS), with the intention being to minimise impacts on environmental resources and socio-economic activities while maximising the potential for sustainable energy production to be gained from Welsh waters. It should be noted that tidal range technologies, i.e. lagoons and barrages, are outside the remit of the current project and are thus not considered in any of the data collection or assessment work comprising this initiative.

2.3.2 The focus of Stage 2 of the project is the collection of information to fill the critical data gaps identified in Stage 1. For each of the identified areas a combination of primary research, and desk based studies will be used to fill these critical data gaps.

2.3.3 The focus of this document is to determine if the development of wave and tidal devices represent a particular concern for the MoD with the aim of assessing the potential for MoD interests to represent a constraint on development, and the degree of constraint that it may represent.

2.3.4 The outcomes of this document will be used to inform the development of the MRESF in Stage 3, using the information gathered in the earlier stages in the development of scenarios for sustainable renewable energy developments within Welsh waters.

3 Consultation

3.1 Background

3.1.1 Initial consultation with the MoD was begun during Stage 1 of the MRESF through the MoD's participation in the project Steering Group.

3.1.2 To increase the level of understanding of the nature and scale of interactions of wave and tidal stream developments with MoD activities and spatial/geographic interests, direct consultation with the representatives of the MoD has been identified as the logical step in achieving this. It is anticipated that this detailed engagement will provide an understanding of where existing wave and tidal devices may conflict with existing or planned future activities or technologies managed or operated by the MoD.

3.2 Proposed Consultation

3.2.1 A summary of existing wave and tidal devices is presented in this document in order to generate feedback from the MoD. The summary includes information which is considered necessary for the MoD to make an initial assessment on the potential and type of conflict which may arise from siting such devices within proximity of military use zones. The summary includes information such as:

- Proposed location areas for device deployment;
- Device operation;
- Size and number of devices including array density;
- Appearance and shape of devices;
- Construction materials;
- Positioning of device (e.g.: surface or surface piercing, mid column or seabed);
- Method of deployment and fixing to seabed;
- Locations of devices (e.g.: water depth and distance from shore);
- Marine cable connections to the grid;

- Markings, colour, visibility and lighting of devices; and
- Underwater noise levels and frequencies associated with the devices.

3.2.2 Due to the sensitivities of military activities, consultation with the representatives of the MoD will primarily attempt to fill knowledge gaps by seeking comment on information presented on the suite of known device types that may be considered as part of the future renewable energy strategy for Wales.

3.2.3 Through provision of technical information on devices, it is envisaged that discussions undertaken with appointed MoD representatives will enable the determination of which aspects of wave and tidal devices, either deployed singly or in arrays, are likely to be of concern to the activities of the MoD and in some instances where measures could be taken to mitigate those concerns.

3.2.4 Given the dynamism of the marine renewable industry and the continuing development of new technologies, coupled with (potentially) the development of sensitive new technologies associated with military activities, it will be important to develop an appropriate protocol for seeking comment on the application of new technologies as they arise in the future.

3.2.5 It is also envisaged that consultation with MoD representatives may provide important additional information about the activities of the MoD which may impact on the deployment of wave and tidal devices, acknowledging the potential for confidentiality and/or sensitivities of information precluding provision of such information.

4 Wave and Tidal Stream Devices

4.1 Introduction

4.1.1 The development of energy from wave and tidal stream devices requires the deployment of devices in areas providing a viable resource. As a product of the high density usage of much of our coastal water area, inevitably this means that such development often coincides with existing uses and pressures. In some circumstances conflict with existing activities in an area may arise from the physical deployment, operation or the maintenance of these devices.

4.1.2 In this regard Military presence and activity within an area can represent a significant potential constraint on the development of wave and tidal devices. In some circumstances this constraint involves an obvious conflict with the presence of the device with existing activities. Therefore, the presence or absence of a military interest in an area is important to determine, with potential for impact often being very site specific. However, there may also be potential conflicts arising from less apparent military activities, devices or spatial requirements and which are thus requiring discussion.

4.1.3 Given the wide range of military activities, there may be situations where renewable energy devices do not conflict with the identified activities and may in fact work in synergy with the existing uses. For example military activities such as low fly zones may limit the development of devices that protrude from the water surface while allowing those that are fully submerged.

4.1.4 Where information can be obtained on the military operation areas from, for example PEXA charts, it is important to determine which aspects of the activities may constrain the development of technologies in order to achieve the required level of understanding and to identify possible practical solutions if conflict occurs.

4.1.5 There is a wide range of military uses of the marine environment for which data is available for spatial mapping (for map see Figure 1) including

- Explosives dumping sites;
- Military aerodrome traffic zones;

- Military establishments on the coast;
- MoD low flying routes;
- Firing danger areas;
- Underwater explosion trial areas; and
- Ordnance demolition areas.

4.1.6 In addition to areas of known military presence and activity there are likely to be additional areas of military activity for which information is not available due to the sensitivity of the activities. By providing information to the MoD, rather than requesting details from them, it is intended that discussion may provide an idea of constraint level where specific information cannot be provided as a result of such sensitivities.

4.1.7 In addition to defined military areas there may also be concerns with devices that could interfere with military operations or hardware such as sonar, radar, sub-sea navigation systems or military listening devices; either existing or in development.

4.1.8 As much of the information on implications of device development on military operations is likely to be confidential, this document seeks to provide information on aspects of the device deployment, operation and maintenance so that areas of concern can be identified through consultation with MoD representatives. Through the consultation process discussion of potential mitigation measures can be introduced at an early stage in the development of wave and tidal stream developments in Wales.

4.2 Device and Development Specific Information

4.2.1 In Stage 1 a review of existing marine renewable energy devices where information was available was completed and a number of wave and tidal stream energy devices were identified. This included wave and tidal stream technologies at various stages of development, ranging from initial concept plans through to technologies being employed in consented and operational commercial projects. The type and quantity of information available for each device or development is a function of the relevant stage of development and the commercial sensitivities. The information presented here is an amalgamation of currently known information - i.e. it includes data on device requirements as they exist at present, supplemented, where available, with data on likely future requirements.

4.2.2 The type of information sourced includes the following:

- Computer modelling to test device feasibility;
- Tank testing of scale models;
- Performance feedback on demonstrator devices deployed at sea, in estuaries or rivers;
- Environmental Impact Assessments (EIAs) and associated reports for commercial scale deployment;
- Monitoring of the construction and operation of developments; and
- Consultee feedback.

4.2.3 Such reports contain information of relevance to the project, potentially including issues such as:

- Commercial siting constraints – e.g. energy requirements, distance offshore etc;
- Device scale, visibility, deployment position (seabed, mid column, surface, shoreline) and array density/structure;
- For proposals in Welsh waters, baseline data within a discrete area;
- Predicted/measured impacts – scale, extent, significance and duration; and
- Views of consultees regarding issues of concern, consenting restrictions and limitations of current data.

4.2.4 The wave and tidal stream energy industry encompasses device types, exhibiting a wide range of sizes, deployment strategies, and operational characteristics. These differences can be found between devices but also for the same device where site specifics can require structural differences.

4.2.5 In order to understand both where such devices could be located and the potential environmental impacts that may result, it is necessary to appreciate these differences and the siting constraints that are associated with them.

4.2.6 For wave and tidal stream devices, a list of the devices identified is given in Appendix A and B respectively. For simplicity and to ensure confidentiality, the wave and tidal devices identified have been grouped, based on the criteria summarised in Table 4-1. These are broadly consistent with groupings used in previous studies where appropriate with the addition of new groups reflecting the increasing array of technologies being developed.

Table 4-1: Categories and Criteria used for Device-Type Groupings (Tidal Stream and Wave)

Energy Type	Device Type Group	Device Type	Device Description
Wave	Installed on the shore or on harbour walls or other man made structure, with a general requirement for hard substrate	Oscillating water column	Wave energy causes water levels to rise and fall in a cylindrical shaft, powering an air-driven turbine.
		Hydraulic pressure	Uses shore fixed 'paddles' to absorb vertical wave motion and convert it to hydraulic pressure
		Overtopping	Incoming waves run up a slope, flowing back down into reservoirs. The water then powers a turbine.
	Nearshore, typically tens to few hundreds of metres from shore in water generally 15-40 m but potentially up to 100 m deep	Oscillating water column	Wave energy causes water levels to rise and fall in a cylindrical shaft, powering an air-driven turbine.
		Collector	Gathers wave energy over a given area, focusing the energy down to a central point
		Individual point/buoy	Individual point/buoy acting as a point absorber of wave motion.
		Orbital wave velocity	Rotor driven by circulating water resulting from surface waves within the water column
		Multiple buoy	Series of buoys linked together, operating on same principle as individual buoys
		Oscillating wave surge converter	Seabed mounted with oscillating arm to extract wave energy movement, primarily sub surface
	Offshore, typically in the range of kilometres, in water depths generally around 50 m, with a broad range between 30-100 m	Oscillating water column	Wave energy causes water levels to rise and fall in a cylindrical shaft, powering an air-driven turbine.
		Collector	Gathers wave energy over a given area, focusing the energy down to a central point
		Individual point/buoy	Individual point/buoy acting as a point absorber of wave motion.
		Attenuator	Generally float on or at the surface, using the movement induced by the waves to generate power
Tide	Individual device(s) situated within the tidal stream (i.e. tidal stream)	Rotating turbine	Device rotating horizontally or vertically in the tidal flow
		Hydroplanes, hydrofoils and sails	Use of hydroplanes, hydrofoils or sails moving in the vertical in response to tidal flow
		Single blade	Single blade aligned to the flow
		Venturi effect	The Venturi effect is used to accelerate water through the device, creating a pressure drop to drive a turbine
	Barrier across the tidal flow, using either tidal stream or tidal range	Lagoon	Enclosed impoundment, separate from land, using turbines to generate power from the difference in water level (head) on either side of the lagoon
		Pontoon	Vertical axis turbine within a fixed structure
		Barrage	Impoundment 'wall', typically across an estuary

4.2.7 It should be noted that tidal range developments (including barrages and lagoons) have been specifically excluded from this project.

4.2.8 In Stage 1 of the MRESF project the data sourced for particular device types were combined with data acquired during the Stage 1 consultation process to enable mapping of potential sites for economic development of each broad device type (Table 4-1) based on a range of physical constraints of each device (Table 4-2 and Table 4-3). Each physical constraint was inserted into a model in ArcGIS 9.2 to generate the suitable resource areas for each broad device type subgroup (Table 4-2) in Welsh waters, and then used to produce summary geographic plots for resource based on total for wave and tidal stream devices; Figures 2 and 3 respectively. The overlay of known military activity areas onto these areas of potential development highlights the extent to which conflict between the development of these device types and existing defence activities can occur (Figures 2 and 3).

Table 4-2: Development constraints for tidal stream powered energy generation devices

Type	Group	Device Type	Distance from Shore	Depth	Tidal Velocity
	Data Source:		**Renewables Atlas**	**Renewables Atlas**	**Renewables Atlas**
Tidal	**Tidal Stream**	Rotating Turbine	Rivers, Estuary, Narrow Straits	20-80 m	>2 m/s
		Hydroplanes, Hydrofoils and Sails, Venturi Effect A	500 m-1 km	10 – 120 m	>2 m/s
		Hydroplanes, Hydrofoils and Sails, Venturi Effect B	500 m-5 km	10 – 120 m	>2 m/s

Table 4-3: Development constraints for wave powered energy generation devices

Group	Device Type	Distance from Shore	Depth	Wave Energy	Wave Height	Wave Period	Tidal Range
	Data Source:	**Renewables Atlas**	**SeaZone Gridded Bathymetry**	**Renewables Atlas**	**Renewables Atlas**	**Renewables Atlas**	**Renewables Atlas**
Wave Shoreline	OWC, Hydraulic Pressure, Overtopping	0 m	5 – 15 m	15 kW/m – 30 kW/m	>1m	8 - 12 seconds	0 – 4 m
Wave Nearshore	Collector A		20 – 30 m	>16 kW/m			
	Collector B		20 – 80 m	>16 kW/m			
	Single Point/Buoy A	500 m – 5 km	30 – 50 m	>20 kW/m			
	Single Point/Buoy B	500 m – 5 km	30 – 100 m	>20 kW/m	0.5-7 m mean 4 m	6-8 seconds	
	Multi-Buoy		15 – 30 m		>2 m		

Group	Device Type	Distance from Shore	Depth	Wave Energy	Wave Height	Wave Period	Tidal Range
	Data Source:	**Renewables Atlas**	**SeaZone Gridded Bathymetry**	**Renewables Atlas**	**Renewables Atlas**	**Renewables Atlas**	**Renewables Atlas**
Wave Offshore	Single Point/Buoy	2 – 20 km	20 – 100 m	15 kW/m – 60 kW/m	2 – 4 m		
	Single Point/Buoy	2 – 20 km	50 – 100 m	15 kW/m – 60 kW/m	2 – 4 m		
	Attenuators	2 – 15 km	>50 m	15 kW/m – 50 kW/m	0.5 – 7 m		

4.2.9 The review of device types in Stage 1 also identified a number of projects incorporating wave and tidal device technologies that are being proposed/planned for Wales (Table 4-4). The locations proposed for each of these projects is described in Table 4-4 and mapped in Figure 4. Each of the proposed developments in Welsh waters are primarily in a research and development phases, although clearly some are at a more advanced stage than others, with demonstrator or 'pre-commercial' devices deployed.

Table 4-4: Identified Interest in Potential and Actual Marine Renewable Tide (Stream and Range) and Wave Energy Projects in Welsh Waters (includes all existing and proposed marine renewable energy projects as of March 2009)

ID	Site Name	Location	Energy Type	Status
1	Strategic Area	North Wales		
2	Burbo Bank windfarm (Dong Energy)	Burbo flats in Liverpool Bay	Wind	The Burbo Bank Wind Farm consists of 25 operational turbines (90MW). Opened 18 October 2007 (North of Welsh Terratorial waters) http://www.dongenergy.com/Burbo/index.htm
3	North Hoyle Wind Farm (RWE Npower renewables)	Liverpool Bay 4.7M off the North Wales coast	Wind	The North Hoyle wind farm consists of 30 operational turbines (60MW). Commenced operation in 2003 http://www.npower-renewables.com/northhoyle/
4	Rhyl Tidal Impoundment (Tidal Electric Ltd)	North Wales	Tidal Range	Proposed for the development of a Tidal impoundment (432MW) off Rhyl in N Wales (Ball 2002). Proposal in early stages www.tidalelectric.com
5	Rhyl Flats wind farm (RWE Npower renewable)	Rhyl flats in Liverpool bay	Wind	Construction of the first of 25 wind turbines to begin on 1 April 2009. The turbines are being mounted on top of the 25 foundation piles that were sunk in 2008. http://www.npower-renewables.com/northhoyle/
6	Gwent Y Mor Wind Farm (Npower renewable)	5M off N Wales in Liverpool Bay	Wind	Subject to remaining approvals, plus delivery of the appropriate consent conditions, offshore construction works could begin in 2011 with final commissioning expected in 2014. (750MW) http://www.npower-renewables.com/gwyntymor/
7	Crown Estate Round 3 Irish Sea	Offshore from the N Wales coast	Wind	Tenders have closed for development of offshore wind within the Irish Sea Round 3 Proposed area. http://www.thecrownestate.co.uk
8	Skerries Tidal Stream Array	Between the Skerries and Camel	Tidal Stream	Scoping Study submitted July 2006. Studies are underway through 2009, with a consent application likely to be submitted in mid 2009.

ID	Site Name	Location	Energy Type	Status
	(Marine Current Turbine Ltd)	Head on the Isle of Anglesey		Construction and commissioning subject to the length of the planning process, anticipated this could take place between 2011 and 2012. (10.5MW) http://www.marineturbines.com/18/projects/20/the_skerries/
9	South Stack Tidal Stream Array (Marine Current Turbines Ltd)	2-3km from the west Anglesey Coast	Tidal Stream	Scoping Study submitted July 2006. This is a secondary site to the Skerries site above. http://www.marineturbines.com/18/projects/20/the_skerries/
10	Ramsey Sound Tidal Energy (E.on and Lunar Energy)	Ramsey Sound, St. Davids, Pembrokeshire	Tidal Stream	Scoping study submitted end October 2007. A public consultation will begin 2009. It is proposed that a linked field of 8 1MW units will be operational by 2011. http://www.lunarenergy.co.uk/seaFarms.htm
11	TEL Delta Stream (Tidal Energy Ltd)	Ramsey Sound, St David's, Pembrokeshire	Tidal Stream	TEL have completed the scoping report in Nov 2008 and is now moving on to compiling the relevant environmental data to produce an environmental impact assessment. http://www.tidalenergyltd.com/index.htm
12	Wave Dragon (Wave Dragon Wales Ltd)	1.7km west of St. Ann's Head at Long Point, Pembrokeshire	Wave	EIA submitted April 2007. Proposed deployment in summer 2009 of a full-scale commercial demonstration unit with a capacity of 7 MW. Unit for 3-5 years only. http://www.wavedragon.co.uk/project.html
13	Swan Turbines tidal technology (Swan Turbines Ltd)	River Tawe, Swansea and Milford Haven	Tidal Stream	Scale Model tested in River Tawe. A 300kw demonstration device is being being built for installation at the European marine energy centre in Orkney. Deployment in Milford Haven is being investigated. http://www.swanturbines.co.uk/activity.htm
14	Crown Estate Round 3 Zone Bristol Channel	Bristol Channel	Wind	Tenders have closed for development of offshore wind within the Bristol Channel Round 3 Proposed area. http://www.thecrownestate.co.uk
15	Swansea Bay Tidal Impoundment (Tidal Electric Ltd)	Swansea Bay	Tidal Range	A 60 MW tidal impoundment project has been proposed for Swansea Bay. A feasibility study on the proposed project has been undertaken in (Atkins 2004).Early stages of interest – scoping undertaken in 2006. http://www.tidalelectric.com/Projects%20UK.htm
16	Tidal Current Turbine (Tidal Hydraulic Generators Ltd)	possibly between Severn Crossings and/or Ramsey Sound, Pembrokeshire	Tidal Stream	Previous trials undertaken in River Cleddau 2001, recent linkage with Peter Brotherhood Ltd to install a full scale system (location unknown). Trials in Milford Haven complete. http://www.dev.onlinemarketinguk.net/THG/company.html
17	Lynmouth Tidal Current Array (Marine Current Turbines Ltd.)	Lynmouth, North Devon	Tidal Stream	Prototype 300kw tidal stream generator was installed 1 km off Lynmouth, North Devon in May 2003. MCT is seeking consents to install an array of up to 10 twin-rotor generators at the same location in the future. http://www.regensw.co.uk/about-renewable-energy/tidal.php
18	Severn Barrage (numerous potential projects)	Severn Estuary	Tidal Range	A three month consultation on a short list of five possible Severn tidal power schemes has been launched in Jan 2009. This consultation concluding in April 2009 will be used to help the government decide whether or not to support tidal power development in the Severn Estuary. http://www.direct.gov.uk/en/Nl1/Newsroom/DG_174866 http://www.berr.gov.uk/files/file43809.pdf
19	Welsh Energy Research Centre (WERC)	Bristol Channel Exact location Unknown	Tidal Stream	It is understood that data is being acquired by the WERC for a potential tidal stream turbine site in the Bristol Channel (WERC is an independent all Wales collaborative body formed by energy research groups from the Universities of Cardiff, Swansea, Glamorgan and Bangor, and from the Institute of Grassland and Environmental Research) http://www.werh.org/research/groupings.php.en?catid=&subid=7171.

5 Potential Impacts

5.1.1 From the literature review conducted in Stage 1 of the project a number of reports were identified that provide information on the potential impacts of marine renewable energy developments relating specifically to military devices. The availability of information on the potential impacts arising from devices, both in terms of construction and operational phase effects, is largely dictated by the current status of the technology and industry, with significantly more information on offshore wind projects than for wave and tidal.

5.1.2 The status of the industry means that no monitoring data on decommissioning has been sourced, although the impacts likely to be associated are generally assumed to be similar to those during construction. It is also apparent that the majority of the literature relates to predicted rather than measured impacts, whether that is included in an EIA and its associated technical reports or held within a research report or paper. Such predictions may be based on expert judgment, computer modelling or by inference from experience gained in other offshore industries. A relatively small number of reports provide information measured directly from deployed devices. A greater quantity of information is available for offshore wind than for wave or tidal stream, with some of the offshore wind research directly applicable to wave and tide stream.

5.1.3 The literature review for data on potential impacts was sourced from plans and projects in Wales, the UK and from international studies, for the latter primarily from Europe, America and Canada. While projects based on the Welsh or UK environment, provide greater relevance to the project, there is considerable value in sourcing studies over a wider area. This is of particular significance for devices or research topics where little UK work has been completed to date. Although blanket application of the results from a particular project or study to a separate project should always be treated with caution, particularly when data has been gathered in a different country, this data does provide a useful background against which assessments of potential impact can be made.

5.1.4 The literature search conducted included issues that are currently considered unlikely to result in an impact as well as those that have the potential to lead to significant effects (both positive and negative).

5.2 Military Interests

5.2.1 The potential for impact on military interests is a key issue when considering siting of a proposed marine renewable development and hence military interests are considered in all EIA and SEA documents, where such interests occur. However, anecdotal information suggests that the potential degree of constraint offered by MoD interests may be considered to be so significant that proposals are altered prior to the consent application starting, effectively removing the issue and hence resulting in limited relevant literature. Indeed, during the consultation undertaken during Stage 1 of the project it was commented that problems had been encountered with identifying potential development sites in Welsh waters due to the degree of constraint posed by military interests (and nature conservation).

5.2.2 The recent Memorandum of Understanding reached between the Department for Business, Enterprise and Regulatory Reform (BERR), the MoD, the Department for Transport (DfT), the Civil Aviation Authority, National Air Traffic Services (NATS) and the British Wind Energy Association (BWEA) is aimed in part at addressing some of these concerns for wind devices, some of which may be applicable to wave and tidal devices. In particular, the MoD includes the following agreements:

- Explore innovative technological solutions to Air Defence and Air Traffic radar, as well as radar absorbent wind turbine technology;
- Shorten pre-planning times, by introducing a web-based screening tool for the early stage of planning;
- Establish a new Aviation Management Board which reports directly to Ministers; and
- Work with industry to establish financial and staffing resources dedicated to finding solutions.

5.2.3 As wave and tidal stream device technologies develop and conflicts are realised there may be a similar need to develop working groups to address the issues raised. This initial discussion with the MoD will identify some of the generic issues that may arise with a range of wave and tidal stream device developments.

5.2.4 There is some information available on the potential effects of marine renewable devices on military interests within existing EIA and SEA documents for sites within a reasonable distance of military interests. Hence, most of the information available is for offshore wind. Further, it is understood that MoD interest in wave and tidal stream devices is likely to be more site and device specific, and as such it is likely that the potential significance of MoD interests as a constraint may differ between wave and tidal stream developments.

5.2.5 The potential disturbances to military interests are likely to consider elements associated with deployment, operation and maintenance of devices including the following:

- Damage/disruption from device noise and vibration;
- Potential Effects of electro magnetic fields (EMF);
- Potential collision risk from fixed structures;
- Potential collision risk should devices become loose;
- Use of Danger Areas;
- Use of military exercise areas;
- Munitions;
- Disruption of Sonar and Radar;
- Low Fly zones; and
- Cumulative effects.

5.3 Disturbance/Damage from Noise and Vibration

Noise Sources

5.3.1 There is potential impact associated with noise and vibration disruption for sensitive acoustic devices employed for military activities. This potential impact would be primarily associated with construction, maintenance and decommissioning activities although noise and vibration generated from operation of devices also needs to be considered.

5.3.2 Studies that have investigated various aspects of underwater noise generation include reviews of baseline noise, both natural and noise from anthropogenic sources, together with an increasing number of studies reporting on measurements of noise taken during construction and operation of offshore wind farms (both above and below water), which may be applicable to activities associated with installation and operation of wave and tidal devices. Studies have also reviewed the success of noise reduction measures employed in a number of developments.

5.3.3 The key sources of noise related to site preparation and device installation are broadly similar to those investigated for offshore wind farm construction – namely:

- Seismic (geophysical) survey;
- Shipping and machinery;
- Dredging; and
- Pile driving or drilling.

5.3.4 Additionally, cable burial requires the use of trenching or jetting machinery in soft sediments, rock cutting machinery in hard sea-beds, or rock or concrete mattress laying may be used to protect cables in areas where they cannot be buried.

5.3.5 The potential sources of noise during operation of marine renewable energy devices are listed below.

- Rotating Machinery;
- Flexing Joints;
- Structural Noise;
- Moving air;
- Moving water;
- Moorings;
- Electrical Noise; and
- Instrumentation Noise.

5.3.6 The noise generated by these elements of the devices can be coupled into the sea via a variety of paths that are summarised below.

5.3.7 **Direct coupling** - This results when the noise generator is in direct contact with the sea, e.g. the flexing joints of a wave generator or the rotating blades of a tidal current turbine. This mechanism is generally the most efficient coupling mechanism.

5.3.8 **Mechanical coupling** - This mechanism requires a mechanical path between the noise source and the sea. An example would be the rotational noise of an air-driven turbine being coupled via the turbine mounts into a metal shell which is then in direct contact with the sea. The path will generally modify the content of the sound.

5.3.9 **Seabed coupling** - For units firmly secured to the seabed, noise may be coupled through the structure into the substrate and thence into the water column.

5.3.10 **Air coupling** - Sound can also be generated from the in-air part of a generation system and coupled through the air-water interface into the water column. This is generally a very inefficient coupling system because of the acoustic impedance mismatch between air and water.

5.3.11 Of all of the sources of noise noted above the noise emitted during pile driving is understood to have the greatest potential environmental effect. This is due to the fact that pile driving generates very high sound pressure levels over a relatively broad frequency range (20 Hz - > 20 kHz).

5.3.12 In order to assess the impact of noise on military equipment, it is necessary to understand the frequencies at which the equipment operate and those that may conflict with military technologies. Sensitivities to the release of this information from the MoD will necessitate the review of noise and vibration frequency and volume and feedback from the MoD regarding the likely impacts of these levels. This method will be limited by the information currently available and the technologies currently employed in both the devices and the military equipment used.

Tidal Current Device Noise

5.3.13 The majority of tidal stream devices utilise an underwater turbine to generate electricity. Turbines have slow moving rotors (much slower than ships' propellers), they are passive energy absorbers, and so will likely produce less underwater noise than ships of a similar power rating. In addition to the turbine noise there may also be noise from the generator electrical unit and gear noise, although some devices are direct drive.

5.3.14 Noise is generally measured for commercially deployed devices in order to assess the environmental impact relating to marine species. As the majority of devices are still in the prototype development stage there is little field measurement of noise data available.

5.3.15 Testing of the 350 kW ‘Marine Current Turbine’ prototype was conducted in Lynmouth, Devon by Subacoustic Ltd., in preparation for commercial deployment of the device in Strangford Lough.

5.3.16 Underwater sound measurements conducted during operation recorded overall Sound Pressure Level (SPL) variation from 123 to 140 dB re. 1 μPa. Extrapolation of the sound and range data indicates that the operational 350 kW turbine produces a source level noise of 166 dB re. 1 μPa at 1 m. Simple scaling predicts that a larger 1MW tidal turbine installation would generate underwater noise up to an overall sound SPL of 175 dB re. 1μPa at 1 m.

5.3.17 The underwater noise data indicates that a tidal turbine of the design installed at Lynmouth produces noise over the frequency range from 11 Hz to 100 Hz, and over a broadband frequency range from 150 Hz to 50 kHz. There are prominent noise peaks in the frequency spectrum indicative of mechanical systems. These dominate the noise spectrum at frequencies of 12 Hz, 350 Hz, 1500 Hz and 5000Hz.

5.3.18 In comparison, the overall source SPL for the Portaferry to Strangford ferry was measured at 164 dB re. 1 μPa at 1m, and compared with the estimated sound SPL of the 1 MW turbine of 175 dB re. 1μPa at 1 m. The underwater noise from a ferry transit could therefore be considered as broadly similar to that from a 1 MW tidal turbine operation.

5.4 Potential Effects of EMF

5.4.1 The requirement to use cabling to transport power generated at sea to shore is common to all marine renewable technologies, with the exception of onshore wave energy devices. Specific concerns have been raised regarding the potential for such cables to generate an electromagnetic field (EMF) and the impact this may have to surrounding activities.

5.4.2 Research on the effect of EMF has primarily focused on electrosensitive fish, and there is currently uncertainty about the significance of artificial electric fields for electrosensitive fish species and this is the subject of ongoing research sponsored by the offshore wind farm industry and the Crown Estate through the COWRIE programme.

5.4.3 The EIA for the Wave Dragon project off the coast of Wales stated that the expected magnetic field from the cable (up to a few µT) is very small especially when compared to the Earth's magnetic field (approximately 50 µT). Given both the small scale of the project and the low magnitude of the anticipated magnetic field it was not anticipated that there is any likelihood of a significant impact for magnetically sensitive fish species.

5.4.4 The effect of EMF on the activities of the MoD is unknown at this stage and requires further investigation to identify any areas of potential effect.

5.5 Potential collision risk from fixed structures

5.5.1 For any proposed deployment of wave and tidal devices, a navigational risk assessment would be a requirement in accordance with Marine Guidance Note MGN 371 (M) (Aug 2008) as published by the Maritime and Coastguard Agency. This guidance note highlights issues that need to be taken into consideration when assessing the impact on navigational safety from offshore renewable energy installations proposed within United Kingdom territorial waters, or in the UK Renewable Energy Zone (when established) beyond the territorial sea.

5.5.2 In addition, offshore wave or tidal energy structures would have to comply with the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) regulations for lighting, shapes and markings. There clearly may be navigational issues for the MoD in site specific areas. This is likely to be assessed on a site specific basis, though the MoD may have concerns in some of the broader military areas, such as those used for military exercise.

5.6 Potential collision risk should devices become loose

5.6.1 There is always a risk, however minor, that a device or part of a device may become detached particularly in the case of floating devices such as wave generating buoys. This may happen for a variety of reasons including:

- Physical failure;
- Adverse or extreme weather;
- Vessel-to-Device collisions;
- Failure of anchors or moorings;
- Cable interaction from other anchor or fishing gear; and
- Corrosion or fatigue.

5.6.2 It is presumed that offshore floating devices would likely have a monitoring system whereby an alarm is raised if the device moves outside a defined positional area. The risk of detachment may be of greater concern to the MoD in particular areas.

5.7 Use of Danger Areas

5.7.1 The potential constraint imposed by danger areas is likely to be device and site specific, related to issues such as the type of military activities undertaken and the exact location of offshore devices. During Stage 1 of the project, feedback from the Steering Group suggested that there has been an instance that involved a proposal to deploy a wave/tidal device within a MoD Danger Area in Welsh waters. It is understood that the proposal was considered to compromise MoD range safety, resulting in the proposal being relocated elsewhere.

5.8 Use of Military Exercise Areas

5.8.1 In a similar fashion to danger areas discussed above, the issue is likely to be device and site specific. No reference to a conflict between these interests has been sourced.

5.9 Munitions

5.9.1 The presence of live munitions in an area would represent a potential hazard to construction, operation and decommissioning of a marine renewable device. In addition the potential damage to devices deployed in waters adjacent to underwater explosions due to the subsequent shock wave may be an issue for developers. No reference to a proposed marine renewable development within such an area has been sourced.

5.9.2 Prior to the final selection of device specific sites the assessment of abandoned munitions will most likely be undertaken as an extension of the geophysical survey (and/or marine archaeology assessment). The interpretation of geophysical data from within and around the site will be analysed for signs of potential abandoned munitions. Should there be any suspicion about any particular remains, the developer will contact MoD, Receiver of Wreck, and English Heritage, prior to further development. In addition, an assessment of the likely impact of the development on abandoned munitions will be undertaken, together with a contingency procedure to be affected in the event of unforeseen munitions during the construction and operation phases of the development.

5.10 Disruption of Sonar and Radar

5.10.1 The potential for marine renewable devices to disrupt radar is primarily considered to be associated with wind powered devices and has received considerable attention. However there is potential for some wave and tidal stream devices that pierce surface waters to provide disruption to radar operations.

5.10.2 Studies of disturbances associated with wind farms have prompted investigations into the deployment of new radar to fill in the coverage anticipated to be lost following construction of the offshore wind farms. Given the greater potential for interruption from wind powered devices it can be assumed that ongoing investigations of mitigation measures for these devices can be incorporated into any mitigation required for wave and tidal stream devices, where applicable. To date reporting on findings has been limited by commercial confidentiality and non-disclosure agreements (with these documents therefore not available), however it is understood that a number of potential solutions have been identified.

5.10.3 Quantification of the minimum parameters of height and area for devices that may impact radar may assist in determining if wave and tidal stream devices pose a significant threat of impact to military radar interests.

5.10.4 Similarly for impacts on sonar an understanding of the parameters that may create an impact on sonar would enable an analysis of the potential impact of wave and tidal stream devices on military sonar requirements.

5.11 Use of Low Fly Zones

5.11.1 Wave and tidal stream devices are unlikely to impact on low flying due to the relatively low heights of devices, particularly in comparison with wind farm devices. The highest device in current development is the Marine Current Turbine device which has a height above sea level of 9 m to allow the turbine blades to be raised above sea level for maintenance. This does not rule out the development of devices with structures of a higher nature in the future. Determination of height restrictions for low flying areas is important to determine suitable parameters for devices to be deployed within these areas.

5.12 Cumulative Effects

5.12.1 Issues connected to the potential for cumulative effects tend to be addressed in EIA and SEA documents and hence to date are primarily restricted to wind. Assessing cumulative effects of wave and tidal stream devices can only be considered through modelling of the data that currently exists until monitoring of installed arrays can be reviewed.

6 Next Steps

6.1.1 Initial steps have been taken to instigate meetings with representatives from relevant departments within the MoD governing the broad range of military operations associated with the marine waters of Wales.

6.1.2 Discussion with MoD representatives will enable the presentation of information available in order to generate feedback regarding potential conflicts between military operations and the site investigation, construction, operation (including maintenance) and decommissioning of wave and tidal stream devices.

6.1.3 Feedback from discussions will be used in the development of the MRESF in Stage 3.

Appendix A Wave Devices

Device 1: Wave-Shoreline-OWC-Limpet

Energy Type	Wave
Device Type Group	Shoreline
Device Type subgroup	Oscillating Water Column -OWC
Definition	Installation 0-15m water depth
Technologies	LIMPET – Land Installed Marine Powered Energy Transformer
Developers	Wavegen – Inverness, Scotland, UK
Website and Contact details	www.wavegen.co.uk
Visibility	Primarily above the sea surface on the shoreline.
Existing Installations	Deployed on the Island of Islay, Scotland Proposed device at Island of Lewis, Scotland UK Proposed to supply devices in Spain
Device operation	Oscillating water column created by waves hitting the device built into the shore or seawall structure driving a turbine
Infrastructure required	A shoreline oscillating water column collector. A turbo generation unit Control and monitoring station
Size and number of devices including array density	10 -20m wide, height depth dependent Numbers depends on area or installation type. Layout in single line, e.g. connected to a breakwater or unconnected nearshore devices. Line can be as long as environmental/ physical/planning constraints allow given technical constraints.
Appearance and shape of devices	Square frontage
Construction materials	Concrete structure
Positioning of device (e.g. surface, mid column or seabed) and water depth	Device is positioned on the shoreline built into the shore geology partially submerged For bottom standing devices min 8m, max 15m depth, economic preference 10m
Method of deployment and fixing to seabed	The unit is built into stable rock structure in the shoreline or into breakwaters, and held in place by gravity (weight of unit) May use others attachments (piles or anchors) for extra stability and allowing gravity base to become smaller.
Locations of devices (e.g. water depth and distance from shore)	Fixed on shoreline either on existing cliff edge or on caisson breakwaters. Average 15m depth (shorter distances mean better cable use. Unlikely devices will be placed too far from the shore or on breakwaters)
Marine cable connections to the grid	Subsea cable covering short distance direct to shore grid.
Markings, colour, visibility and lighting of devices	Colour not defined, visible within shore geology or breakwater, no specific lighting required
Wave energy required and tidal range	Minimum 15kw/m annual wave climate Maximum 4m tidal range Optimum performance will be achieved when driven by a long ocean swell generated over a fetch of more than 400km.
Underwater noise levels and frequencies associated with the devices	Underwater noise and frequency unknown.

Device 2: Wave-Shoreline-OWC-SeWave

Energy Type	Wave
Device Type Group	Shoreline
	Oscillating Water Column -OWC
Definition	Installation 0-15m water depth
Technologies	SeWave – Torshaven, Faroe Islands
Developers	SeWave Ltd
Website and Contact details	www.sewave.fo
Visibility	Invisible due to construction tunnelling into natural bedrock from inland with intake below water surface.
Existing/Proposed Installations	Proposed site in the Faroe Islands. Model tests, site investigations and design issues completed in 2005
Device operation	Wave energy creating oscillating water column driving turbine.
Infrastructure required	A cliff face extending below the water in all tides with favourable geology for the purposes of tunnelling.
Size and number of devices including array density	Unknown at this stage
Appearance and shape of devices	Tunnel structure hidden from view 9see diagram below.
Construction materials	The device is tunnelled into the natural geological structure of the shoreline and a turbine fitted into the tunnel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Shoreline position with intake below the water. Requires rock-cliff with suitable geology for tunnelling Water depth unspecified, sufficient to allow intake below water level at all tides
Method of deployment and fixing to seabed	Tunnelling into natural shoreline geological structures
Locations of devices (e.g. water depth and distance from shore)	Shoreline location
Marine cable connections to the grid	Cable shore based
Markings, colour, visibility and lighting of devices	Invisible from the water.
Wave energy required and tidal range	Sites investigated have around or just under 30kW/m wave energy. 20m depth directly off cliffs.
Underwater noise levels and frequencies associated with the devices	Noise levels and frequencies unspecified.

Device 3: Wave-Shoreline-OWC-PICO

Energy Type	Wave
Device Type Group	Shoreline
	Oscillating Water Column -OWC
Definition	Installation 0-15m water depth
Technologies	PICO
Developers	Wave Energy Centre – Lisboa, Portugal
Website and Contact details	www.pico-owc.net
Visibility	shoreline
Existing/Proposed Installations	Installed Pico Island, Azores. Constructed in-situ in 1998, with repair works 2003-2005. No further installation proposals
Device operation	Wave energy creating oscillating water column driving turbine.
Infrastructure required	Fixed on shoreline
Size and number of devices including array density	The concrete structure has internal dimensions of 12m by 12m, with a rotor diameter of 2.3m 400kw device
Appearance and shape of devices	Square frontage
Construction materials	Concrete casing
Positioning of device (e.g. surface, mid column or seabed) and water depth	Onshore rock - gravity structure requires rock. Areas with compacted substrate that does not move may be suitable
Method of deployment and fixing to seabed	The unit is built into the shoreline and held in place by gravity (weight of unit) but may use others such as piles or anchors for extra stability. Piling allows the gravity base to become smaller
Locations of devices (e.g. water depth and distance from shore)	Fixed on shoreline on existing cliff edge. Average 15m depth (shorter distances mean better cable use.
Marine cable connections to the grid	cable direct to grid
Markings, colour, visibility and lighting of devices	onshore construction
Wave energy required and tidal range	Data was collected for a range of significant wave heights between 1.0 and 3.5 meters and energy periods between 8.0 and 12.0 sec
Underwater noise levels and frequencies associated with the devices	unknown

Device 4: Wave-Shoreline-OWC-WECA

Energy Type	Wave
Device Type Group	Shoreline
	Oscillating Water Column -OWC
Definition	Installation 0-15m water depth
Technologies	WECA - Wave Energy Conversion Activator
Developers	DaeDalus – Athens, Greece.
Website and Contact details	www.daedalus.gr
Visibility	Primarily above the sea surface on shoreline or attached to floating or rigid structure
Existing/Proposed Installations	Computer modelling undertaken, no existing or proposed installations
Device operation	Wave energy creating oscillating water column driving turbine.
Infrastructure required	Suitable attachment point, solid shoreline, breakwater or floating structure.
Size and number of devices including array density	Device concept 7m high by 6m wide working in combination with several devices.
Appearance and shape of devices	Square structure above the waters surface within intake below the surface.
Construction materials	Steel is proposed for ease of fixing to a range of shoreline and floating structures
Positioning of device (e.g. surface, mid column or seabed) and water depth	To be mounted on breakwaters or similar. Extends from surface below the water to capture wave energy.
Method of deployment and fixing to seabed	Fixed to the shoreline or offshore structure
Locations of devices (e.g. water depth and distance from shore)	Variable location from shoreline, offshore and floating structures
Marine cable connections to the grid	Cable connections dependent on location. On land overland cable connection.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 5: Wave-Shoreline-Hydraulic Pressure-SDE

Energy Type	Wave
Device Type Group	Shoreline
Device Type Sub group	Hydraulic pressure
Definition	Installation 0-15m water depth
Technologies	S.D.E – Tel Aviv, Israel
Developers	S.D.E
Website and Contact details	www.sde.co.il
Visibility	Shoreline structure with hydraulic rams raised and lowered by sea waves.
Existing/Proposed Installations	Testing completed on full scale device in Israel. Several proposed developments pending
Device operation	Floating rams driven by wave energy to produce hydraulic pressure which drives turbines.
Infrastructure required	Stable shoreline structure to mount rams with influence of shoreline waves
Size and number of devices including array density	Unspecified
Appearance and shape of devices	Steel Hydraulic rams, resembling paddles
Construction materials	4m is most effective depth
Positioning of device (e.g. surface, mid column or seabed) and water depth	Stable shoreline structure for mounting hydraulic rams
Method of deployment and fixing to seabed	Fixed to the stable shoreline structure
Locations of devices (e.g. water depth and distance from shore)	Fixed stable structures primarily onshore.
Marine cable connections to the grid	Shore attachment
Markings, colour, visibility and lighting of devices	Unspecified
Wave energy required and tidal range	A full-scale model was operated in Israel and produced 40ekW for almost one year required wave energy unspecified
Underwater noise levels and frequencies associated with the devices	unspecified

Device 6: Wave-Shoreline-Overtopping -Seawave slot cone generator

Energy Type	Wave
Device Type Group	Shoreline
Device Type Sub group	Overtopping
Definition	Installation 0-15m water depth
Technologies	SSG - Seawave Slot-cone Generator
Developers	WAVEenergy
Website and Contact details	www.wavessg.com
Visibility	Visible above water along shore line or breakwater structure
Existing/Proposed Installations	Have undertaken model testing on 1/15 scale plus 2D and 3D models. Prototype under construction in Norway in 2006
Device operation	Waves run up sloping structure directing water into stacked reservoirs that feed into multi stage water turbine for power generation. The higher
Infrastructure required	Fixed on the shore or as breakwater
Size and number of devices including array density	10m wide structure for prototype. Full scale shoreline plant anticipated to be 500m in length
Appearance and shape of devices	Solid concrete structure rising from water line sloping upward to encourage water overtopping into reservoirs
Construction materials	Concrete structure built into the shoreline
Positioning of device (e.g.: surface, mid column or seabed) and water depth	On shoreline Rock or can be integrated into a breakwater structure Foreshore water depth modelled at 6m and 15m
Method of deployment and fixing to seabed	Structure relies on weight to hold it in place.
Locations of devices (e.g.: water depth and distance from shore)	Shoreline or nearshore breakwater construction.
Marine cable connections to the grid	Directly to land connections
Markings, colour, visibility and lighting of devices	Fixed to shoreline or breakwater structure, visible above water
Wave energy required and tidal range	At prototype site average available wave energy resource is approx. 18 kW/m. Test significant wave height used were typical of the prototype area at 1-5m and 1-7m offshore Prototype pilot plant to have installed capacity of 150-200 kW, at 51% efficiency for offshore wave type. Full scale 500 m plant will be able to produce 10-20 GWh/year
Underwater noise levels and frequencies associated with the devices	From turbine unspecified

Device 7: Wave-Nearshore-OWC- Deniss-Auld Turbine

Energy Type	Wave
Device Type Group	Nearshore
	OWC – Oscillating Water Column
Definition	Installation 15-40m water depth
Technologies	Deniss-Auld Turbine
Developers	Ocean Linx Ltd (formerly Energetech)
Website and Contact details	www.oceanlinx.com
Visibility	Superstructure visible above water
Existing/Proposed Installations	Testing and sea trials completed at Port Kembla, Australia A signed Letter of Intent ("LOI") with SWRDA for a 5MW facility as part of the Cornwall Wave Hub. Other proposed developments at various stages of progress in Hawaii, Mexico, Namibia and Rhode Island.
Device operation	Oscillating Water Column created by movement of the oceans waves driving a turbine. Variable pitch blades with the slower rotational speed and higher torque of the turbine improve efficiency and reliability and reduces the need for maintenance.
Infrastructure required	Anchoring to seabed
Size and number of devices including array density	Scale model prototype was 485 tonnes, at 35m long and 18m tall Array of ,multiple units would require 60-90m centre line device spacing
Appearance and shape of devices	Floating superstructure with legs extending below the surface, rectangular shape.
Construction materials	Steel structure
Positioning of device (e.g. surface, mid column or seabed) and water depth	The guyed mooring arrangement is expected to be economic for water depths from 5m to 50m Range of water depths 8-16m preferable, 50m maximum.
Method of deployment and fixing to seabed	Asymmetric mooring arrangement with 6 forward mooring legs and 4 rear mooring legs. The structure is supported vertically on 4 mooring legs that are pinned to the structure and the seabed. . Variations within this concept may include the number and make-up of the mooring legs (e.g., use of wire or fiber moorings), the use of alternative anchor points (e.g., driven piles, suction anchors, drag anchors, gravity blocks etc) and the number & location of vertical supports. Alternative fully moored concepts also being developed and these will be suitable for water depths from 20m upwards.
Locations of devices (e.g. water depth and distance from shore)	Nearshore to offshore 50m maximum depth, 8-16m preferable.
Marine cable connections to the grid	Underwater cable leading to land based grid connection. Proposed alternative connection to a hub
Markings, colour, visibility and lighting of devices	
Wave energy required and tidal range	Efficiency of approximately 35% 9-26.5kw/m, wave height 7m and period 9-12s
Underwater noise levels and frequencies associated with the devices	

Device 8: Wave-Nearshore-OWC-Float Wave Electric Power Station

Energy Type	Wave
Device Type Group	Nearshore
	OWC - Oscillating Water Column
Definition	Installation 15-40m water depth
Technologies	Float Wave Electric Power Station (FWEPS)
Developers	Applied Technologies Company Ltd
Website and Contact details	www.atecom.ru/we/
Visibility	Floating with some structure above water level
Existing/Proposed Installations	Prototype has been tested (in a lab?) with further testing planned
Device operation	Mechanical wave energy converter within the unit, consisting of an oscillatory system and drive, and an electric generator and energy accumulator. Under the wave effect the capsule-float and inner oscillatory system of the mechanical converter are in continuous oscillatory motion, while the drive engaged with the system provides a continuous turn for the electric generator
Infrastructure required	
Size and number of devices including array density	Possible to develop both a single modular FWEPS for output power from units of watts up to 50 kW and multi-modular installation in a grid form
Appearance and shape of devices	The module of FWEPS is an oblong axisymmetrical capsule-float.
Construction materials	Steel construction
Positioning of device (e.g. surface, mid column or seabed) and water depth	Located on the sea surface.
Method of deployment and fixing to seabed	Individual floating units or array attached to the seabed via cables to an anchor or fixed point.
Locations of devices (e.g. water depth and distance from shore)	Nearshore operation
Marine cable connections to the grid	Underwater cabling from each unit to a landfall or marine hub
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 9: Wave-Nearshore-Collector-Wave Plane

Energy Type	Wave
Device Type Group	Nearshore
Device Type Sub group	Collector
Definition	Installation 15-40m water depth
Technologies	WavePlane - Denmark
Developers	Caley (technology developed by Danish inventors WavePlane International A/S)
Website and Contact details	http://www.asolutioninvent.com/wpp/index.htm
Visibility	Surface
Existing/Proposed Installations	Prototype deployed West coast of Jutland First full scale prototype ready for deployment.
Device operation	The device remains at the water surface directing wave energy past the reservoirs of the WavePlane and squeezed into the side of the fly-wheel-tube turning the flywheel turbine.
Infrastructure required	Floating structure anchored to the substrate
Size and number of devices including array density	25m wide
Appearance and shape of devices	V shaped steel structure floating at surface level with greater structure below the surface.
Construction materials	Steel construction
Positioning of device (e.g. surface, mid column or seabed) and water depth	Floating at surface level
Method of deployment and fixing to seabed	Anchored to the seabed
Locations of devices (e.g. water depth and distance from shore)	Nearshore operation
Marine cable connections to the grid	Cable laid along the substrate to the shore for connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified, standard lighting and marking for anchored structures
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 10: Wave-Nearshore-Collector-Floating Wave Power Vessel

Energy Type	Wave
Device Type Group	Nearshore
	Collector
Definition	Installation 15-40m water depth
Technologies	Floating Wave Power Vessel
Developers	Sea Power International AB - Sweden
Website and Contact details	www.seapower.se
Visibility	Visible at the surface
Existing/Proposed Installations	Tested in Sweden, also Shetlands
Device operation	Not specified
Infrastructure required	Anchored to the seabed
Size and number of devices including array density	Shetland plant weighed 1200 tonnes 1 device per location
Appearance and shape of devices	Not specified
Construction materials	Steel structure
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating
Method of deployment and fixing to seabed	moored at a single point
Locations of devices (e.g. water depth and distance from shore)	Preferred depth 50-80m
Marine cable connections to the grid	Cable running along the seabed to land connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Wave height up to 12m in Sweden Runs at full capacity 20% of the time, half capacity 40% and zero 40%.
Underwater noise levels and frequencies associated with the devices	Not specified

Device 11: Wave-Nearshore-Collector-Wave Dragon

Energy Type	Wave
Device Type Group	Nearshore
	Collector
Definition	Installation 15-40m water depth
Technologies	Wave Dragon
Developers	Wave Dragon ApS - Denmark
Website and Contact details	www.wavedragon.net
Visibility	Denmark and Pembrokeshire
Existing/Proposed Installations	Extensive testing has been conducted on a prototype deployed in Nissum Bredning, a fjord in the northern part of Denmark. Proposed deployment of a demonstrator device 2-3 miles off Milford Haven, Wales for 3-5 years to gain operational experience and knowledge on the energy transfer efficiencies.
Device operation	Surface
Infrastructure required	Open water site with substrate suitable for anchoring the device.
Size and number of devices including array density	Depends on the capacity of device. 24kw/m is >20m, 36kw/m is >25m and 48kw/m is >30m Scale variable depending on power output. 0.4kw/m is 58m wide by 33m long and 3.6m high. 24kw/m is 260m wide by 150m long by 16m high. 36kw/m is 300m wide by 170m long by 17.5m high. 48kw/m is 390m wide by 220m long by 19m high Density dependant on device size
Appearance and shape of devices	No constraint
Construction materials	Steel structure
Positioning of device (e.g. surface, mid column or seabed) and water depth	Nearshore mooring of device.
Method of deployment and fixing to seabed	Slack moorings on 2 anchors with gravity anchor blocks
Locations of devices (e.g. water depth and distance from shore)	
Marine cable connections to the grid	Cable connections along the sea floor to a landward connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified, prototype red
Wave energy required and tidal range	Minimum significant wave height of 1m, 10kW/m (demonstration) or minimum 16-24kW/m for commercial
Underwater noise levels and frequencies associated with the devices	Not specified

Device 12: Wave-Nearshore-Collector-Aqua Buoy

Energy Type	Wave
Device Type Group	Nearshore
	Buoy
Definition	Installation 15-40m water depth – single buoy acting as an absorber
Technologies	Aqua Buoy/IPS OWEC
Developers	IPS OWEC - British Columbia, Canada
Website and Contact details	www.finavera.com
Visibility	Approximately half the buoy is submerged
Existing/Proposed Installations	Makah Bay
Device operation	Energy generated from vertical movement of piston in the centre of a floating buoy
Infrastructure required	Open water with substrate suitable for anchoring devices
Size and number of devices including array density	Scale of device dependant on location, with an average size of 19.5 foot diameter float, with a 98 foot long, 15foot diameter acceleration tube. 10-500 units approximately 60 apart. Extent of 4 aquabuoys at Makah is approximately 60foot by 240 foot at the surface
Appearance and shape of devices	Floating unit with a central vertical mast
Construction materials	Not specified
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating units
Method of deployment and fixing to seabed	Moored using 4 concrete anchors with buoy being central. Buoy held by wires Each aquabuoy tethered by a tension cable to 4 surface floats approx 4 foot in diameter. Surface floats connected to a subsurface mooring system, just above the seafloor, by a cable fastened to a chain. The mooring system terminates with a chain running from the sub-surface buoy to a connection to the seabed placed approx in a square pattern on the seafloor with Aquabuoy central above.
Locations of devices (e.g. water depth and distance from shore)	Recommended at 500m from shore In 40m ideal up to maximum 80m depth
Marine cable connections to the grid	Cable runs along the seabed connecting to the shore power connection
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Pilot study had mean of 28kW/m Approx 30%
Underwater noise levels and frequencies associated with the devices	Not specified

Device 13: Wave-Nearshore-Buoy-OE Buoy

Energy Type	Wave
Device Type Group	Nearshore
	Buoy – Oscillating water column duct
Definition	Installation 15-40m water depth – single buoy acting as an absorber
Technologies	OE Buoy
Developers	Ocean Energy – Cork, Ireland
Website and Contact details	www.oceanenergy.ie
Visibility	The device rises approximately 10m above the water surface
Existing/Proposed Installations	1:50 and 1:15 lab testing Deployment of model in 2006 ocean testing at the Marine Institute test site at Galway
Device operation	The air contained in the main chamber(plenum) is pumped out and drawn in through the turbine duct by the movement of the water free surface within the device. Motions of the hull enhance the relative surface movement and increase the air flow.
Infrastructure required	Offshore floating device
Size and number of devices including array density	Deployed model weighs 28 tonnes, number in arrays unspecified
Appearance and shape of devices	Large square steel structure approximately 15 x 10m with superstructure extending 10m above the water surface when deployed
Construction materials	Steel construction
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface device
Method of deployment and fixing to seabed	Minimal mooring system, anchoring to bottom.
Locations of devices (e.g. water depth and distance from shore)	Deployment in 15-40m water depth at inshore locations
Marine cable connections to the grid	Cabling running along the sea surface to a suitable landing site for connection to the grid.
Markings, colour, visibility and lighting of devices	Unspecified
Wave energy required and tidal range	Unspecified
Underwater noise levels and frequencies associated with the devices	Unspecified

Device 14: Wave-Nearshore-Buoy-The Linear Generator

Energy Type	Wave
Device Type Group	Nearshore
	Buoy
Definition	Installation 15-40m water depth – single buoy acting as an absorber
Technologies	The Linear Generator
Developers	Trident Energy
Website and Contact details	www.tridentenergy.co.uk
Visibility	Floating sea platform containing the energy generating devices is visible above the waters surface.
Existing/Proposed Installations	Tested a 1/5 scale model at NaREC in 2005 Preparing for deployment of fully functional test rig in the North Sea in 2009
Device operation	The system works by using floats attached to a floating sea platform, placed in the sea which rise and lower with the passing waves, to drive the company's own design and patented linear generators, resulting in the immediate generation of electricity. No hydraulic equipment or air compression is required. Floats can be retracted in storm conditions to prevent damage.
Infrastructure required	Operates within a protective floating sea platform anchored to the seabed.
Size and number of devices including array density	Individual units can be as small as a domestic fridge and up to the size of a shipping container Farms may extend over 5ha and include 10s, 100s or potentially 1000s of devices
Appearance and shape of devices	The devices are floats which can range in size supported within the floating sea platform.
Construction materials	Predominantly steel structure
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface positioning
Method of deployment and fixing to seabed	Floating structure is anchored to the seabed
Locations of devices (e.g. water depth and distance from shore)	Devices are for nearshore deployment.
Marine cable connections to the grid	Cable connections are along the seabed to a suitable shoreline point of connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	A generating capacity per point absorber of approximately 100KW in good sea conditions. From this, a wave farm occupying just 5 hectares will be capable of supplying 100MW. Energy conversion in excess of 80%
Underwater noise levels and frequencies associated with the devices	Not specified

Device 15: Wave-Nearshore-Buoy-Aegir Dynamo

Energy Type	Wave
Device Type Group	Nearshore and offshore buoy
	Buoy
Definition	Installation 15-40m water depth for nearshore and 40-200m water depth for offshore– single buoy acting as an absorber
Technologies	Aegir Dynamo
Developers	Ocean Navitas – Lincolnshire UK.
Website and Contact details	www.oceannavitas.com
Visibility	Floating device with some elements above the water column.
Existing/Proposed Installations	Testing of a Working bench model complete Proposed deployment of a single 200kWh or 1.4MWh Aegir Dynamo Buoy into the EMEC facility for a period of 1 year. Proposed deployment of an array of 5 1.4MWh Aegir Dynamo Buoys into the Wave Hub project for 5 years
Device operation	The Aegir Dynamo functions by generating electrical current from the motion of the prime mover, mounted on a buoyancy vessel, in one phase via a direct mechanical conversion in response to wave motion.
Infrastructure required	Seasurface structure to support the power generation unit
Size and number of devices including array density	4.5m across accelerator flume
Appearance and shape of devices	Floating structure with a tower containing the Aegir Dynamo
Construction materials	Steel construction
Positioning of device (e.g. surface, mid column or seabed) and water depth	Deployment would be primarily sea surface floating however units could be incorporated into seawalls.
Method of deployment and fixing to seabed	Three point anchor to the seabed or incorporated into seawall structure
Locations of devices (e.g. water depth and distance from shore)	Floating units would be nearshore, seawall units would be onshore
Marine cable connections to the grid	Cabling would run along sea floor to suitable landing site for grid connection
Markings, colour, visibility and lighting of devices	Unspecified
Wave energy required and tidal range	300mm wave height minimum
Underwater noise levels and frequencies associated with the devices	Unspecified

Device 16: Wave-Nearshore-Buoy-OPT Power Buoy

Energy Type	Wave
Device Type Group	Nearshore
	Buoy
Definition	Installation 15-40m water depth – single buoy acting as an absorber
Technologies	OPT Powerbuoy
Developers	Ocean Power Technologies Inc
Website and Contact details	www.oceanpowertechnologies.com - New Jersey, USA
Visibility	Masts and navigational aids above water
Existing/Proposed Installations	Limestone in Hawaii, sand and rock in Spain
Device operation	The rising and falling of the waves off shore causes the buoy to move freely up and down. The resultant mechanical stroking is converted via a sophisticated power take-off to drive an electrical generator.
Infrastructure required	Floating unit anchored to the substrate
Size and number of devices including array density	Buoys can be deployed in arrays of any number of units. A 10mW unit would occupy 4acres
Appearance and shape of devices	Floating buoy with tower containing energy generating unit.
Construction materials	Primarily steel superstructure.
Positioning of device (e.g. surface, mid column or seabed) and water depth	Floating structure anchored to the seabed in depths of 30m minimum, prefer 50-100.
Method of deployment and fixing to seabed	Floating structure anchored to the seabed
Locations of devices (e.g. water depth and distance from shore)	Deployment of minimum 0.8km to a maximum 8km, typically 1-3 miles (3 miles is 5km)
Marine cable connections to the grid	Subsea cable connection to suitable shore connection to the grid
Markings, colour, visibility and lighting of devices	Unspecified, in accordance with deployment area regulations
Wave energy required and tidal range	Minimum energy density for commercial exploitation 20-25kW/m, significant wave height above 1.5m, wave period 5-15 seconds 300mm wave height minimum
Underwater noise levels and frequencies associated with the devices	Unspecified

Device 17: Wave-Nearshore-Orbital Wave Velocity Wave Rotor

Energy Type	Wave
Device Type Group	Nearshore
	Orbital wave velocity
Definition	Installation 15-40m depth. Rotor driven by circulating water caused by waves
Technologies	Wave Rotor
Developers	Ecofys
Website and Contact details	www.ecofys.com
Visibility	Wave device submerged but design includes wind turbine above water
Existing/Proposed Installations	1/10 scale testing undertaken at NaREC
Device operation	Monopile
Infrastructure required	Attachment of monopole to the substrate as for wind turbine provide structure for the wave turbine
Size and number of devices including array density	A 10mW unit would occupy 4acres
Appearance and shape of devices	Wave unit attached to a monopole for the wind turbine
Construction materials	Steel
Positioning of device (e.g.: surface, mid column or seabed) and water depth	Attached to monopole below surface
Method of deployment and fixing to seabed	Attached to monopole that is attached directly to the substrate
Locations of devices (e.g.: water depth and distance from shore)	Deployment in water depths of 30m minimum, prefer 50-100
Marine cable connections to the grid	Cable connections along the substrate to a suitable location on the shore to connect to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 18: Wave-Nearshore-Multi Buoy-Wave Star

Energy Type	Wave
Device Type Group	Nearshore
	Multi Buoy
Definition	Installation 15-40m depth
Technologies	Wave Star
Developers	Wave Star Energy
Website and Contact details	www.wavestarenergy.com
Visibility	The superstructure is visible above the surface with power generation buoys attached to the underside
Existing/Proposed Installations	1:10 model of the Wave Star machine has now been installed at Nissum Bredning, Denmark
Device operation	The movement of the buoys up and down with the passing waves is converted into energy.
Infrastructure required	The superstructure to which the power generating buoys are attached is attached to the substrate via legs.
Size and number of devices including array density	The 1:10 model at Nissum Bredning has 40 hemisphere-shaped floats, each with a diameter of one metre. The large-scale model will be equipped with floats of 10 metres in diameter. Full scale they will be 10-20m high.
Appearance and shape of devices	The superstructure is a platform attached to the substrate via legs with each of the power generation buoys attached to the underside of the superstructure
Construction materials	Predominantly steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	The energy generation buoys are at the surface of the water rising and falling with the passing waves
Method of deployment and fixing to seabed	Superstructure is attached directly to the substrate and an array of buoys is attached to the superstructure.
Locations of devices (e.g. water depth and distance from shore)	The larger the machine, the greater the depth it can stand at. The 1:10 model stands in water two metres deep. The large-scale model is designed to stand in water 20 metres deep.10-20 kilometres from shore
Marine cable connections to the grid	Dependent on the distance from the shore however cable would probably lay along the substrate from the device to a suitable location on the shoreline for connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	The 1:10 model at Nissum Bredning has a 5.5 kilowatt generator and the large-scale model a three megawatt generator.
Underwater noise levels and frequencies associated with the devices	Not specified

Device 19: Wave-Nearshore-Multi Buoy-Wave Berg

Energy Type	Wave
Device Type Group	Nearshore
	Multi Buoy
Definition	Installation 15-40m depth
Technologies	Waveberg
Developers	Waveberg Development Ltd
Website and Contact details	www.waveberg.com
Visibility	Device sits on the surface of the water
Existing/Proposed Installations	Scale model tested off Nova Scotia, with a potential project in Hawaii
Device operation	Each of the legs of the device rise and fall with the motion of the waves driving hydraulics that convert to energy generation.
Infrastructure required	The Device floats on the surface of the water and is anchored to the substrate.
Size and number of devices including array density	About 50m long series of connected floats Typically deployed in arrays, number not specified. For Hawaii, 12 are being considered
Appearance and shape of devices	Steel superstructure consisting of a number of arms off a central unit. Movement of the arms around the central unit generates energy
Construction materials	Predominantly steel.
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating device
Method of deployment and fixing to seabed	Surface floating device anchored in place.
Locations of devices (e.g. water depth and distance from shore)	The device is surface deployed in nearshore waters.
Marine cable connections to the grid	Cables laid along the substrate to a suitable landward connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	A typical full-scale Waveberg would generate more than 100 kW of power under normal conditions; output doubles during rough weather
Underwater noise levels and frequencies associated with the devices	Not specified

Device 20: Wave-Nearshore-Oscillating Wave Surge Converter-Oyster

Energy Type	Wave
Device Type Group	Nearshore
	Oscillating Wave Surge Converter
Definition	Installation 15-40m depth. Seabed mounted with oscillating arm to extract wave energy movement primarily sub surface
Technologies	Oyster
Developers	Aquamarine Power
Website and Contact details	www.aquamarinepower.com
Visibility	Some of the superstructure of the device may be visible above the surface of the water as it is driven back and forth by the wave energy.
Existing/Proposed Installations	Wave tank tests completed Queens University, Belfast. Further studies planned at EMEC
Device operation	The Device has a large paddle structure which opens and closes with the force of the wave and surge.
Infrastructure required	The device is a large steel structure that will be attached directly to the substrate.
Size and number of devices including array density	A commercial wave farm consisting of 10 Oyster™ modules deployed in arrays will generate up to 6MW of power.
Appearance and shape of devices	Large square flat paddle like structure which opens and closes with the motion of waves and surge.
Construction materials	Predominantly steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	The device would be attached directly to the sea bed and the paddle like structure would move with the force of wave and surge.
Method of deployment and fixing to seabed	The device is attached directly to the seabed.
Locations of devices (e.g. water depth and distance from shore)	The device would be deployed in depths of 12m at the mean water levels near to the shore.
Marine cable connections to the grid	Subsea cables would connect the device to the grid on the shore
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	The peak power generated by each Oyster™ unit is between 300 and 600kw, depending on location and configuration. Targeted load factor in excess of 40%
Underwater noise levels and frequencies associated with the devices	Not specified

Device 21: Wave-Nearshore-Oscillating Wave Surge Converter-CETO

Energy Type	Wave
Device Type Group	Nearshore
	Oscillating Wave Surge Converter
Definition	Installation 15-40m depth. Seabed mounted with oscillating arm to extract wave energy movement primarily sub surface
Technologies	CETO Wave Power Converter (delivers high pressure sea water and not electricity on shore)
Developers	Renewable Energy Holdings plc
Website and Contact details	www.ceto.com.au/home.php
Visibility	Fully submerged
Existing/Proposed Installations	Initial testing of scale models in tanks. 3d computer modelling. Sea trials of CETO II at Fremantle, Australia
Device operation	
Infrastructure required	
Size and number of devices including array density	Commercial device approx 6 times the size of the model Arrays of multiple units on a grid system (3 by 3)
Appearance and shape of devices	
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed mounted unit deployed in 15-40m of water.
Method of deployment and fixing to seabed	Fixed to the substrate.
Locations of devices (e.g. water depth and distance from shore)	CETO II in 7 m with CETO III in 25-50 m water depth
Marine cable connections to the grid	Subsea cables connect the device to the grid onshore.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	CETO III in 80m wave length. The standard design is intended to operate at 50 % capacity in a combined 2 m swell. With the standard setup the system will not be able to operate in swells less than 1 m. Under the standard design wave, SPPL has calculated that a single CETO unit will convert 20 % of the wave's total energy into pumped high-pressure water. Depending on distance from shore, up to 5 % capacity may be lost transferring the high-pressure water to shore. The Calder energy recovery turbines have a 90 % recovery rate through the turbine.
Underwater noise levels and frequencies associated with the devices	

Device 22: Wave-Nearshore-Oscillating Wave Surge EB Frond

Energy Type	Wave
Device Type Group	Nearshore
	Oscillating Wave Surge Converter
Definition	Installation 15-40m depth. Seabed mounted with oscillating arm to extract wave energy movement primarily sub surface
Technologies	Frond Wave Generator
Developers	The Engineering Business Ltd
Website and Contact details	www.engb.com
Visibility	Seen above the water
Existing/Proposed Installations	phase 1 physical testing has been undertaken at scales of 1/33rd and 1/25th in the Lancaster University test tank, the academic partners in the project. Proposed deployment of a larger model in more varied and extreme wave conditions for additional testing.
Device operation	The device is seabed mounted in 20-35m of water. A paddle-like collector on the end of a long lever is placed close to the sea surface and driven by the waves to produce hydraulic power.
Infrastructure required	
Size and number of devices including array density	In test phase only
Appearance and shape of devices	
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	The device is seabed mounted in 20-35m of water.
Method of deployment and fixing to seabed	
Locations of devices (e.g. water depth and distance from shore)	Nearshore wave energy device designed for installation in 20-35 metres of water.
Marine cable connections to the grid	Subsea cables connect the device to the grid via a suitable onshore connection point.
Markings, colour, visibility and lighting of devices	Not specified.
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 23: Wave-Nearshore-Oscillating Wave Surge-Neptune near shore wave energy converter

Energy Type	Wave
Device Type Group	Nearshore
	Oscillating Wave Surge Converter
Definition	Installation 15-40m depth. Seabed mounted with oscillating arm to extract wave energy movement primarily sub surface
Technologies	Neptune Near Shore Wave Energy Converter
Developers	Triton
Website and Contact details	www.neptunerenewableenergy.com
Visibility	Some structure above water level
Existing/Proposed Installations	Lab tests have been completed on1/100 and 1/10
Device operation	An axi-asymmetrical buoy is attached to an A-frame which would be piled into the sea bed. The buoy is designed to generate a counter phase upstream wave and a much reduced downstream wave; maximising the energy capture from the wave and improves overall efficiency. In order to tune the buoy to the incident wave regime, the mass can be controlled by pumping sea water into and out of the hollow cavity inside the buoy. Power take off is achieved via a piston and hydraulic arrangement.
Infrastructure required	Seabed mounted in a frame attached to the substrate with piles.
Size and number of devices including array density	400kW installed capacity generated from one device
Appearance and shape of devices	
Construction materials	Not specified
Positioning of device (e.g. surface, mid column or seabed) and water depth	Groups of 4 along a 100m length of shore in 10m water depths.
Method of deployment and fixing to seabed	A frame holding the device would be piled into the substrate.
Locations of devices (e.g. water depth and distance from shore)	The device operates in the nearshore within 100m of low water
Marine cable connections to the grid	Submarine cable connection to the grid via a suitable onshore location.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 24: Wave-Nearshore-Oscillating Wave Surge-Neptune near shore wave energy converter

Energy Type	Wave
Device Type Group	Nearshore
	Oscillating Wave Surge Converter
Definition	Installation 15-40m depth. Seabed mounted with oscillating arm to extract wave energy movement primarily sub surface
Technologies	BioWAVE
Developers	BioPower Systems – Sydney Australia
Website and Contact details	www.biopowersystems.com/biowave.html
Visibility	
Existing/Proposed Installations	A 250kW pilot project to deploy a 25m bioWAVE unit at King Island, Tasmania, Australia, a 25m unit. The pilot is scheduled to be operational during 2009. First commercial products due for release in 2010. Systems are being developed for 250kW, 500kW, 1000kW capacities to match conditions in various locations.
Device operation	The wave power system is based on the swaying motion of sea plants in the presence of ocean waves. The hydrodynamic interaction of the buoyant blades with the oscillating flow field is designed for maximum energy absorption. In extreme wave conditions the automatically ceases operating and assumes a safe position lying flat against the seabed. This eliminates exposure to extreme forces, allowing for lighter designs and substantial cost savings.
Infrastructure required	A suitable substrate is required for attachment of the devices.
Size and number of devices including array density	Not specified, still in development phase
Appearance and shape of devices	Buoyant blades extending above the substrate
Construction materials	Not specified
Positioning of device (e.g. surface, mid column or seabed) and water depth	Device will be attached directly to the substrate
Method of deployment and fixing to seabed	Each device will be fixed directly to the seabed.
Locations of devices (e.g. water depth and distance from shore)	Device lies flat on the seabed during extreme conditions
Marine cable connections to the grid	Subsea cables will connect devices with the grid onshore
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 25: Wave-Offshore-Oscillating Water Column-MRC1000

Energy Type	Wave
Device Type Group	Offshore
Device Type Sub-Group	Oscillating Water Column
Definition	Installation 40-200m water depth.
Technologies	MRC1000 - Multi resonant chambers wave energy device
Developers	Orecon – Cornwall UK
Website and Contact details	www.orecon.com
Visibility	A large part of the structure will be floating at the surface of the water.
Existing/Proposed Installations	Trialled at postgraduate project at the University of Plymouth which included sea trials of a 12th scale concept prototype in Plymouth, UK 13 tonne sea trial unit in development
Device operation	
Infrastructure required	
Size and number of devices including array density	A standard facility of 20 units would be deployed
Appearance and shape of devices	Large floating structure at surface level which would be attached to the seabed via anchor cables
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating structure attached to the substrate in 50m maximum depth.
Method of deployment and fixing to seabed	Floating structure with the power generation units attached to the substrate via cables
Locations of devices (e.g. water depth and distance from shore)	Devices would ideally be located10-16km
Marine cable connections to the grid	Subsea cables would connect the device with the grid on shore.
Markings, colour, visibility and lighting of devices	Not specified, although unit would be visible above water.
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 26: Wave-Offshore-Oscillating Water Column-The mighty Whale

Energy Type	Wave
Device Type Group	Offshore
	Oscillating Water Column
Definition	Installation 40-200m water depth.
Technologies	Mighty Whale
Developers	JAMSTEC - Japan
Website and Contact details	www.jamstec.go.jp/jamstec/MTD/Whale/
Visibility	A large proportion of the structure would be visible above the water.
Existing/Proposed Installations	Prototype tested in 1998 Gokasho Bay off Mie Prefecture, Japan
Device operation	
Infrastructure required	
Size and number of devices including array density	Prototype dimensions were chosen to be 50 m (Length) X 30 m (Breadth) X 12 m (Depth). The design called for it to float at even keel at a draft of 8 m. The overall rated power capacity was set at 110kW.
Appearance and shape of devices	Large floating structure with a sloping ramp facing the oncoming waves
Construction materials	Predominantly steel.
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface positioning.
Method of deployment and fixing to seabed	Maintained in place with moorings to fixed points on seabed
Locations of devices (e.g. water depth and distance from shore)	Prototype water deployed in a water depth of 40m
Marine cable connections to the grid	Dependant on operation. Deployment as breakwater/wave energy dissipater may allow surface cables while offshore deployment would require subsea cable connection to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 27: Wave-Offshore-Buoy-Grampus Wave Energy Converter

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	Grampus Wave Energy Converter
Developers	Offshore Wave Energy Ltd
Website and Contact details	www.owel.co.uk
Visibility	A large proportion of the structure can be seen above the water
Existing/Proposed Installations	Initial Tank Testing trials were conducted by QinetiQ followed by 1/10th Tank Tests conducted by NaREC. 1 in 10 scale demonstrator to be deployed at EMEC was 55 metres in length by 20 metres in width (tapering to 10 metres) and 12 metres deep Investigating deployment at EMEC Design, Construction and Testing of a near full-scale device, most likely in the EMEC facility off Orkney.
Device operation	The device traps and compresses air in successive wave troughs. The compressed air is accumulated in a reservoir and is then used to drive a turbine and thus generate power.
Infrastructure required	Floating structure anchored to seabed
Size and number of devices including array density	Commercial WEC to be 6 units placed side by side
Appearance and shape of devices	Flat fan shaped structure
Construction materials	Predominantly steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	The devices are inherently robust & are designed to be installed on floating platforms, moored offshore in sea areas where energetic wave spectra are found.
Method of deployment and fixing to seabed	Attached to fixed points on the seabed.
Locations of devices (e.g. water depth and distance from shore)	preference for >50m water depths but depends on energy to 100m maximum
Marine cable connections to the grid	Subsea cables connecting the device to the grid.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Little power from 0.2m waves. Design of device can be optimised to site wave conditions, therefore ideal wave energy varies. Intended to ensure performance is independent of tidal range
Underwater noise levels and frequencies associated with the devices	Not specified

Device 28: Wave-Offshore-Bouy-FO3 (Buldra)

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	FO3 (Buldra)
Developers	Fred Olsen
Website and Contact details	www.seewec.org
Visibility	Large part above water
Existing/Proposed Installations	1:3 laboratory rig at Buldra and the single system test station (SSTS) at Løkstadt Scale device measures 12m by 12m and 8m high. The hydraulic towers are 7m high. The full scale device will be 36m by 36m.
Device operation	
Infrastructure required	
Size and number of devices including array density	Scale prototype of device measures 12m by 12m and 8m high. The hydraulic towers are 7m high. The full scale device will be 36m by 36m.
Appearance and shape of devices	
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	The device is surface floating.
Method of deployment and fixing to seabed	Floating structure moored to seabed
Locations of devices (e.g. water depth and distance from shore)	Deployment water depth is min 50m (near term devices) max 100m (long term potential) economic preference 50m
Marine cable connections to the grid	Not specified
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Wave height of 6m is optimum. The full-scale model will produce 2.52 MW from 6-meter high waves with a period of 9 seconds
Underwater noise levels and frequencies associated with the devices	Not specified

Device 29: Wave-Offshore-Buoy-Brandl Motor

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	Brandl Motor
Developers	Brandl Motor
Website and Contact details	http://brandlmotor.de/brandlgenerator_eng.htm
Visibility	The floating pontoon and vertical tower can be seen above water.
Existing/Proposed Installations	Scale model tested in the North Sea
Device operation	A pendulum mass hanging beneath a spring moves anticyclically up and down. This mass drives the direct-connected magnets that are inducing an electrical current while moving through the inductance coils.
Infrastructure required	
Size and number of devices including array density	Buoy diameter of 15m
Appearance and shape of devices	The devices are composed of a floating disc type buoy with a vertical tower in the centre of the buoy.
Construction materials	Predominantly steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Devices are positioned on the surface of the water with extensions above and below.
Method of deployment and fixing to seabed	Floating buoy directly attached by cable to generator (no apparent mooring/anchorage system)
Locations of devices (e.g. water depth and distance from shore)	Not specified
Marine cable connections to the grid	Not specified
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Not specified
Underwater noise levels and frequencies associated with the devices	Not specified

Device 30: Wave-Offshore-Buoy-SyncWave Power Resonator

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	SyncWave Power Resonator
Developers	SyncWave BC Canada
Website and Contact details	www.syncwaveenergy.com
Visibility	Described as having a low visual profile with the majority of the device sitting below the water.
Existing/Proposed Installations	Company has undertaken prototype testing, Plans to move ahead with a three year demonstration wave power project off the West Coast of British Columbia
Device operation	Makes power by capturing the motion differential (phase lag) between two dissimilar float structures. The phase lag is continuously maximized under varying swell frequencies via a proprietary variable inertia tuning system located inside the large oscillator float Power is captured by an hydraulic power take-off, driving a permanent magnet DC generator Shuts down in extreme sea states
Infrastructure required	The floating unit
Size and number of devices including array density	
Appearance and shape of devices	
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	Device can be deployed in water depths greater than 20m
Method of deployment and fixing to seabed	Slack moorings anchored to the seabed
Locations of devices (e.g. water depth and distance from shore)	Open ocean, distance not specified
Marine cable connections to the grid	DC power from several SyncWave units in a wave farm will be collected and converted to AC power in a sea-bed mounted collector hub, then transmitted to shore by subsea cable for interconnection to a load.
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Each SyncWave unit will have a peak capacity of around 500 kilowatts, and will likely be designed to produce around 15-25 kw average power
Underwater noise levels and frequencies associated with the devices	Not specified

Device 31: Wave-Offshore-Buoy-Sperboy

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	Sperboy
Developers	Embley Energy
Website and Contact details	www.sperboy.com
Visibility	Surface piercing
Existing/Proposed Installations	Trialled at Plymouth, UK 1/5 sized pilot
Device operation	A floating buoy Oscillating Water Column (OWC) device consisting of a buoyant structure with a submerged & enclosed column. The plant, turbines, generators and associated system facilities are housed above the OWC on top of the buoy. The device is capable of deployment in deep water to maximize greatest energy source
Infrastructure required	
Size and number of devices including array density	Dimensions vary depending on sea conditions at deployment site. Max envisaged – Diameter: 30M. Overall Height: 50M, Draft: 35M Designed to be deployed in large arrays. Current work focused on 10 device farm. Spacing is around 350 meters, depending on water depth, with a full size farm of 1000 devices requiring up to 10 – 15 square kilometres
Appearance and shape of devices	Buoyant vertically oriented cylinder structure.
Construction materials	Floating buoy constructed using composite concrete materials
Positioning of device (e.g. surface, mid column or seabed) and water depth	Device is positioned on the waters surface.
Method of deployment and fixing to seabed	The mooring system composed of three or four diametric tethers to subsurface floats moored to suitable seabed fixings
Locations of devices (e.g. water depth and distance from shore)	Devices are located 8-12 miles offshore Water depth minimum of 30m, maximum of 100m. Greater than 50M, but less if located in less active seas using smaller device All conditions acceptable given suitable seabed fixings are attainable
Marine cable connections to the grid	
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Annual average wave energy 60kW/m
Underwater noise levels and frequencies associated with the devices	Not specified

Device 32: Wave-Offshore-Buoy-Archimede Wave Swing

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	Archimede Wave Swing
Developers	Teamwork Technology BV
Website and Contact details	www.waveswing.com
Visibility	Fully submerged, 6m below low water
Existing/Proposed Installations	Tested in Portugal, Pending development in Orkney
Device operation	This is a cylinder shaped buoy, moored to the seabed. Passing waves move an air-filled upper casing against a lower fixed cylinder, with up and down movement converted into electricity. As a wave crest approaches, the water pressure on the top of the cylinder increases and the upper part or 'floater' compresses the gas within the cylinder to balance the pressures. The reverse happens as the wave trough passes and the cylinder expands. The relative movement between the floater and the lower part or silo is converted to electricity by means of a hydraulic system and motor-generator set.
Infrastructure required	
Size and number of devices including array density	48 m by 28 m by 38 m30m Device spacing of 80m to cover an area up to 10km2. Arrays of several 10s of units. A 50MW farm will occupy an area around 3 nautical miles long by 2 cables wide.
Appearance and shape of devices	Each device consists of a cylinder tethered to the substrate.
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	The devices are held in mid water at least 6m below low water level.
Method of deployment and fixing to seabed	Mounted on a gravity base sitting on the substrate
Locations of devices (e.g. water depth and distance from shore)	minimum with 60m being ideal. 40-100m given on website
Marine cable connections to the grid	Not specified
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	2-4m significant wave height
Underwater noise levels and frequencies associated with the devices	Not specified

Device 33: Wave-Offshore-Buoy-WaveBob

Energy Type	Wave
Device Type Group	Offshore
	Buoy
Definition	Installation 40-200m water depth. Single buoy acting as an absorber
Technologies	WaveBob
Developers	Wavebob Ltd - Ireland
Website and Contact details	www.wavebob.com
Visibility	Primarily submerged, with some visible above water
Existing/Proposed Installations	Sea trials at Marine Institute/Sustainable Energy Ireland 's wave energy test site in the Atlantic Ocean off the coast of Spiddal in Co. Galway
Device operation	An axi-symmetric, self-reacting point absorber, primarily operating in the heave mode. It is specifically designed to recover useful power from ocean wave energy, and to be deployed in large arrays offshore.
Infrastructure required	
Size and number of devices including array density	15m diameter, 30-40m draught, weighing 440tons. (ABPmer). The outer torus has a diameter of the order of 20metres, and an overall height of 8 metres (website) Units can be deployed at 50m intervals. Designed to be large arrays offshore
Appearance and shape of devices	Long cylindrical shaped units
Construction materials	
Positioning of device (e.g. surface, mid column or seabed) and water depth	
Method of deployment and fixing to seabed	Axi-symmetric buoy structure on slack moorings
Locations of devices (e.g. water depth and distance from shore)	Website mentions deep water a few km from the shore ('North Atlantic energy 'hot spot' West of Ireland in minimum depths of 50m
Marine cable connections to the grid	Not specified
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	Wavebob's natural frequency may be set to match the typical ocean swell (Atlantic 10", or Pacific 15")
Underwater noise levels and frequencies associated with the devices	Not specified

Device 34: Wave-Offshore-Attenuator-Pelamis

Energy Type	Wave
Device Type Group	Offshore
	Attenuators
Definition	Installation 40-200m water depth
Technologies	Pelamis
Developers	Ocean Power Delivery
Website and Contact details	www.oceanpd.com
Visibility	Much of the device is visible above the water
Existing/Proposed Installations	Multiple Pelamis units make up the Aguçadoura wave farm, Portugal and constitute both the world's first, multi-unit, wave farm and also the first commercial order for wave energy converters. A further 20 MW of Pelamis equipment ordered. Orcadian Wave Farm at EMEC in Scotland will consist of four Pelamis generators supplied by PWP to ScottishPower Renewables for installation at the EMEC wave site Ocean Prospect secured exclusive access to one of four Wave Hub berths in Cornwall for the connection of multiple Pelamis machines. The wave hub equipment is proposed for installation and commissioning in 2009.
Device operation	A semi-submerged, articulated structure composed of cylindrical sections linked by hinged joints. The wave-induced motion of these joints is resisted by hydraulic rams, which pump high-pressure fluid through hydraulic motors via smoothing accumulators. The hydraulic motors drive electrical generators to produce electricity. Power from all the joints is fed down a single umbilical cable to a junction on the sea bed.
Infrastructure required	
Size and number of devices including array density	Current production machines are 140m long and 3.5m in diameter with 3 power conversion modules per machine each machine is rated at 750kW. Several devices can be connected together and linked to shore through a single seabed cable.
Appearance and shape of devices	Long chain of cylindrical drums connected by hydraulic rams
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating
Method of deployment and fixing to seabed	Moored by a combination of floats and weights to prevent lines becoming taut. On a seabed free of obstacles
Locations of devices (e.g. water depth and distance from shore)	Ideal range 50-60m of water depth and 5 – 10km offshore
Marine cable connections to the grid	Not specified
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	70% at low power levels to over 80% at full capacity (ABPmer). at a typical site about 40% of the full rated output potential should be achievable (website)
Underwater noise levels and frequencies associated with the devices	No specified

Device 35: Wave-Offshore-Attenuator-C-Wave

Energy Type	Wave
Device Type Group	Offshore
	Attenuators
Definition	Installation 40-200m water depth
Technologies	C-Wave – Southampton, UK
Developers	Cwavepower - Southampton Uni
Website and Contact details	www.cwavepower.com
Visibility	The device is surface floating and visible
Existing/Proposed Installations	
Device operation	The device works at a broad band width around this half wave length spacing. However, the addition further walls can provide a higher annualised energy outputs.
Infrastructure required	Not specified
Size and number of devices including array density	Not specified
Appearance and shape of devices	Square shallow floating frame.
Construction materials	Concrete walls supported by steel frames
Positioning of device (e.g.: surface, mid column or seabed) and water depth	Device is positioned on the surface of the water
Method of deployment and fixing to seabed	The device floats on the surface of the water with slack moorings to seabed anchors.
Locations of devices (e.g. water depth and distance from shore)	Floating wave farms in deepwater between five and twenty kilometres offshore, >50m depth
Marine cable connections to the grid	Not specified
Markings, colour, visibility and lighting of devices	Not specified
Wave energy required and tidal range	The C-Wave device is very effective at extracting energy from the waves, and has a particularly high energy capture in the longer waves where the large majority of ocean wave energy exists
Underwater noise levels and frequencies associated with the devices	Not specified

Appendix B Tidal Stream Devices

Tidal Device 1: Tidal-Rotating Turbine-Marine Current Turbines

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Seagen and Seaflow
Developers	Marine Current Turbines (MCT)
Website and Contact details	www.marineturbines.com
Visibility	Pile 9m above average sea level
Existing Installations	Seaflow – Installed Lynmouth, Devon Seagen – Installed Strangford Lough, Northern Ireland
Device operation	Generates power from sea currents, using axial flow turbines driving generators through gearboxes using similar principles to wind generator technology.
Infrastructure required	Grid connection Control and monitoring station
Size and number of devices including array density	Seagen has twin underwater turbines of 15 to 20m diameter giving over 400 square meters of rotor area. Groups of 10-20 devices. Arrays set out in rows
Appearance and shape of devices	Round surface structure protruding 9m above the average sea level.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed to above sea surface, water depth (20-30m)
Method of deployment and fixing to seabed	Seabed monopile
Locations of devices (e.g. water depth and distance from shore)	Water depth (20-30m), distance from shore dependant on water depth
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	IALA colour, topmark and light
Tidal stream energy required and tidal range	Mean spring peak velocity exceeding about 2.25-2.5m/s. Generally quoted as 2-3m/s. Strangford Lough has current speeds up to 4m/s. Relatively limited tidal range is a benefit.
Underwater noise levels and frequencies associated with the devices	Detailed assessment undertaken for Seaflow at the Lynmouth site and predicted assessment of underwater noise for Seagen at Strangford Lough.

Tidal Device 2: Tidal-Rotating Turbine-Kinetic Energy Systems

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Hydrokinetic Generator, KESC Bowsprit Generator, KESC Tidal Generator
Developers	Kinetic Energy Systems
Website and Contact details	www.kineticenergysystems.com
Visibility	Fully submerged
Existing Installations	Not detailed
Device operation	Generates power from sea currents
Infrastructure required	Grid connection
Size and number of devices including array density	Hydrokinetic Generator – 15m diameter turbines Bowsprit Generator – 10m diameter turbine Tidal generator – 10m diameter turbine No details on array density
Appearance and shape of devices	All devices fully submerged on seabed: Hydrokinetic Generator – triangular flow director with turbine Bowsprit Generator – bow shaped structure on pedestal with turbine attached Tidal generator – bow shaped structure on pedestal with two turbines attached for ebb and flood flow
Construction materials	Presumed steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed
Method of deployment and fixing to seabed	Fixed to the bed or attached to structures. May be anchored
Locations of devices (e.g. water depth and distance from shore)	Seabed – Distance from shore: No details – connection to grid required
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	2m/s is ideal. A stationary 600 kW Bowsprit Generator with a 10 meter turbine diameter, 2 m/s (4 knots) current, at 45% efficiency will generate 2,332,800 kWh per year.
Underwater noise levels and frequencies associated with the devices	No details

Tidal Device 3: Tidal-Rotating Turbine-Clean Current Turbines

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Tidal turbine generator
Developers	Clean Current Power Systems Incorporated
Website and Contact details	www.cleancurrent.com
Visibility	Fully submerged
Existing Installations	Generator installed near Race Rocks Canada in 2006
Device operation	Generates power from sea currents through a ducted turbine
Infrastructure required	Grid connection
Size and number of devices including array density	Round turbine duct containing rotor 4 – 5 metres diameter. Clean Current envisage that the turbine generators will be deployed in farms of 20 to 500 units
Appearance and shape of devices	All devices fully submerged on seabed: The turbine generator is mounted on a post and is not visible from the surface. A minimum clearance of 15metres is provided to ensure that commercial navigation is not impeded.
Construction materials	Presumed steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed. A minimum clearance of 15metres above the device is provided to ensure that commercial navigation is not impeded.
Method of deployment and fixing to seabed	The tidal generator is supported on a single 32 inch diameter piled into the seabed or grouted into the bedrock.
Locations of devices (e.g. water depth and distance from shore)	Water depth likely to be 20m or greater
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	The unit has been designed to rotate only when the current velocities exceed 2 knts (1 m/s). Each unit will produce between 2,300 and 5000 MW/hrs of electricity annually depending on the diameter of the unit and the strength of the tidal currents.
Underwater noise levels and frequencies associated with the devices	Clean Current's tidal turbine generator has a direct drive variable speed permanent magnet generator. The generator can be configured to produce either alternating or direct current. The rotation speed of the turbine varies between 20 and 70 rpm depending on current speed and unit size. As a result a very low frequency noise (<100 Hz) will be produced.

Tidal Device 4: Tidal Turbine-Scotrenewables

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Scotrenewables Tidal Turbine (SRTT) – floating tidal energy converter.
Developers	Scotrenewables
Website and Contact details	www.scotrenewables.com
Visibility	Floating device – no details
Existing Installations	None at present – currently progressing a full scale prototype to be tested at the European Marine Energy Centre (EMEC) in Orkney.
Device operation	The concept in its present configuration involves dual counter-rotating horizontal-axis rotors driving generators within sub-surface nacelles, each suspended from separate keel and rotor arm sections attached to a single surface-piercing cylindrical buoyancy tube.
Infrastructure required	Grid connection
Size and number of devices including array density	No details – though would expect to be deployed in arrays.
Appearance and shape of devices	Cylindrical surface buoyancy tube buoy
Construction materials	No details
Positioning of device (e.g. surface, mid column or seabed) and water depth	Device suspended from surface buoy with anchors to seabed.
Method of deployment and fixing to seabed	The device can be towed to site and anchored to the seabed via a mooring attachment and compliant mooring system.
Locations of devices (e.g. water depth and distance from shore)	Test depths 20 – 50 metres. Distance from shore dependent on water depth
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	Presume cylindrical buoy will incorporate IALA colour, topmark and light
Tidal stream energy required and tidal range	No details. Full scale device 1.2 MW
Underwater noise levels and frequencies associated with the devices	No details

Tidal Device 5: Tidal-Rotating Turbine-Swanturbines

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Prototype tidal stream generator
Developers	Swanturbines
Website and Contact details	www.swanturbines.co.uk
Visibility	Fully submerged
Existing Installations	A 300KW demonstration device is being assembled for installation at the European Marine Energy Centre in Orkney.
Device operation	Seabed turbine generating power from seabed currents
Infrastructure required	Grid connection
Size and number of devices including array density	Presently a 1 metre diameter prototype device. Future commercial devices would be larger and deployed in arrays.
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of turbine mounted on triangular frame on seabed.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed. Designed for both shallow and deep water.
Method of deployment and fixing to seabed	Appears to sit on weighted triangular frame on seabed.
Locations of devices (e.g. water depth and distance from shore)	Seabed
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	The power developed by a 1m diameter rotor in 3-5.5knots would be approximately 0.7-4.5kW
Underwater noise levels and frequencies associated with the devices	No specific details. The gearless low speed generator is likely to produce low noise levels.

Tidal Device 6: Tidal-Rotating Turbine-Verdant Power

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Free Flow Kinetic Hydropower System
Developers	Verdant Power
Website and Contact details	www.verdantpower.com
Visibility	Fully submerged
Existing Installations	Verdant Power's Roosevelt Island Tidal Energy (RITE) Project is being operated in New York City's East River, along the eastern shore of Roosevelt Island. Subsequent CORE project being planned in Canada
Device operation	Seabed turbine generating power from seabed currents
Infrastructure required	Grid connection
Size and number of devices including array density	Free Flow Systems can be scaled in unit size and number. The RITE project is progressing from an initial demonstration array of six turbines to a full field of turbines that could generate up to 10 MW
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of turbine mounted on seabed monopile, 6 metres height above seabed
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed. Designed for both shallow and deep water.
Method of deployment and fixing to seabed	Turbine mounted on seabed monopile.
Locations of devices (e.g. water depth and distance from shore)	Seabed
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	35kW capacity per device. 100-300 turbines could generate up to 10MW.
Underwater noise levels and frequencies associated with the devices	No specific details. The gearless low speed generator is likely to produce low noise levels.

Tidal Device 7: Tidal-Rotating Turbine-Tidal Generation Limited

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Prototype tidal stream generator
Developers	Tidal Generation Limited
Website and Contact details	www.tidalgeneration.co.uk
Visibility	Fully submerged device
Existing Installations	Tidal Generation Limited are We are currently working on a 500kW prototype, to be installed at the European Marine Energy Centre in Orkney.
Device operation	Seabed turbine generating power from seabed currents
Infrastructure required	Grid connection
Size and number of devices including array density	No details. Future commercial devices would be deployed in arrays.
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of turbine mounted on triangular frame on seabed.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed
Method of deployment and fixing to seabed	Device sits on triangular frame on seabed. No details if fixing to seabed required.
Locations of devices (e.g. water depth and distance from shore)	Depths greater than 30 metres.
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	No details on tidal stream required - Each machine will produce sufficient electricity to power 650 homes.
Underwater noise levels and frequencies associated with the devices	Turbines have slow moving rotors (much slower than ship's propellers), they are passive energy absorbers, so will produce less underwater noise than ships of a similar power rating.

Tidal Device 8: Floating Paddle Wheel Turbine-Hydrogen

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Delta Stream
Developers	Tidal Energy Limited
Website and Contact details	www.tidalenergyltd.com
Visibility	Fully submerged device
Existing Installations	Proposed development of a prototype demonstrator tidal stream project in Ramsey Sound, off the Pembrokeshire coastline, West Wales. The project will comprise of a single DeltaStream device with a nominal installed capacity of 1MW, deployed for 12 months
Device operation	Seabed turbine generating power from seabed currents
Infrastructure required	Grid connection
Size and number of devices including array density	Each device will contain 3 turbines on each frame, array density unspecified
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of 3 turbines mounted on triangular frame on seabed with vertically mounted blades
Construction materials	Steel and carbon fibre
Positioning of device (e.g.: surface, mid column or seabed) and water depth	Seabed
Method of deployment and fixing to seabed	Device sits on triangular frame on seabed without a need for a positive anchoring system
Locations of devices (e.g.: water depth and distance from shore)	Not defined
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	No details on tidal stream required - Each machine unit will produce a nominal 1.2MW.
Underwater noise levels and frequencies associated with the devices	Not specified

Tidal Device 9: Floating Paddle Wheel Turbine-Hydrogen

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Prototype tidal stream generator
Developers	Hydrogen, France
Website and Contact details	www.hydro-gen.fr
Visibility	Rectangular floating device containing paddle turbine.
Existing Installations	Prototype deployed and being tested in France.
Device operation	Uses a large padle wheel on an anchored vessel to generate electricity from tidal currents.
Infrastructure required	Grid connection
Size and number of devices including array density	Prototype was 2.3m by 4.5m. Intending to start testing a 10m by 8m device. Future commercial devices could be deployed in arrays.
Appearance and shape of devices	Prototype is floating pontoon structure with round paddle wheel. Larger commercial model would also display IALA colour, topmark and light
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating device.
Method of deployment and fixing to seabed	Device can be towed to site and is anchored to the seabed.
Locations of devices (e.g. water depth and distance from shore)	Most likely deployed in estuaries with large tidal range.
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	IALA colour, topmark and light
Tidal stream energy required and tidal range	Prototype was 10kw. Larger model would be 50kw, aiming for 1MW. A device 16m long by 14m diameter in current velocity 0-4.6m/s expected to produce power from 0-800Kw
Underwater noise levels and frequencies associated with the devices	As the device is a slow moving paddle turbine noise levels would be considered low.

Tidal Device 10: Tidal Stream Turbine–Ocean Flow Energy Limited

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Evopod, a semi-submerged, floating, tethered tidal stream energy capture device.
Developers	Ocean Flow Energy Limited.
Website and Contact details	www.oceanflowenergy.com
Visibility	Semi-submerged with triangular fin structure visible above sea level.
Existing Installations	
Device operation	Uses a mooring system that allows the free floating device and attached turbine to maintain optimum heading into the tidal stream.
Infrastructure required	Grid connection
Size and number of devices including array density	A seabed region of one square kilometre can support 39 x E1500 units
Appearance and shape of devices	Three above sea level fins interconnected in a triangular shape.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Surface floating device.
Method of deployment and fixing to seabed	Device can be towed to site and is anchored to the seabed.
Locations of devices (e.g. water depth and distance from shore)	Designed to be deployed in water >40m, but smaller devices can be deployed in shallower areas.
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	IALA colour, topmark and light
Tidal stream energy required and tidal range	Looking to develop 500kw and eventually 1500kw devices. 39 x E1500 units can provide a total rated output of 58.5MW. An accumulated cross section area of about 1.6M m^2 at one site was assessed as being about 10% of the total flow cross section and would take out 3.3% of the energy from the stream. At a separate site, an accumulated cross section area of about 1.6M m^2 or about 4% of the total flow cross section would take out 1.5% of the energy from the stream
Underwater noise levels and frequencies associated with the devices	No detail – utilises gearbox between turbine and generator.

Tidal Device 11: Tidal-Rotating Turbine-OpenHydro

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Open centre subsea rotating turbine
Developers	OpenHydro
Website and Contact details	www.openhydro.com
Visibility	Fully submerged device
Existing Installations	Test unit presently deployed at the European Marine Energy Centre in Orkney.
Device operation	Seabed turbine generating power from seabed currents
Infrastructure required	Grid connection
Size and number of devices including array density	Test unit 6 metres diameter with larger units likely once fully developed. Future commercial devices would be deployed in arrays.
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of an open centred turbine mounted on triangular frame on seabed.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed
Method of deployment and fixing to seabed	Device sits on triangular frame on seabed. No details if fixing to seabed required.
Locations of devices (e.g. water depth and distance from shore)	They will be located at depths so as not to present a navigational hazard.
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	No details
Underwater noise levels and frequencies associated with the devices	Turbines have slow moving rotors with low noise levels expected.

Tidal Device 12: Tidal-Rotating Turbine-New Energy

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	EnCurrent cross-flow turbine
Developers	New Energy Corporation Inc
Website and Contact details	www.newenergycorp.ca
Visibility	Vertical single top structure with subsea turbine below or mounted below surface floating catamaran
Existing Installations	25KW unit installed in the St.Lawrence River, Canada 25KW unit installed at Marshall Falls, Nova Scotia TOR-5 turbine, 5KW system mounted below a standard 18 foot fibreglass boat hull.
Device operation	Generates power from sea currents, using cross-flow 'wisk' turbine based on the Darrieus wind turbine.
Infrastructure required	Grid connection
Size and number of devices including array density	At present only test units, if they reach commercial deployment will likely be scaled up and deployed in arrays.
Appearance and shape of devices	Round surface structure protruding above sea level or below catamaran shaped hull.
Construction materials	No detail
Positioning of device (e.g. surface, mid column or seabed) and water depth	Either seabed to above surface device or floating device.
Method of deployment and fixing to seabed	Seabed monopile or anchored catamaran.
Locations of devices (e.g. water depth and distance from shore)	No detail, though appears to be primarily a shallow water device.
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	Presumably IALA colour, topmark and light if commercially deployed.
Tidal stream energy required and tidal range	Tests on TOR-5 showed it generated 5KW of power output at 2.35 m/s.
Underwater noise levels and frequencies associated with the devices	No details, though likely low level noise.

Tidal Device 13: Tidal-Rotating Turbine-Lunar Energy

Energy Type	Tidal
Device Type Group	Rotating Turbine
Technologies	Rotech Tidal Turbine (RTT) – bi-directional horizontal axis turbine housed in a symmetrical venturi duct.
Developers	Lunar Energy
Website and Contact details	www.lunarenergy.co.uk
Visibility	Fully submerged
Existing Installations	None – initial design and costing of a 1MW prototype demonstration device for sea trials at the EMEC test site in Orkney. Plan for future development located off St.Davids Head, Wales for farm consisting of 8 linked 1MW turbines.
Device operation	Seabed turbine housed in a venturi duct, generating power from tidal streams.
Infrastructure required	Grid connection
Size and number of devices including array density	Sea trials at EMEC are for 1/3rd scale device. Plan for future development located off St.Davids Head, Wales for farm consisting of 8 linked 1MW turbines. Future turbine farm numbers likely to consist of 100 – 500 1MW linked units.
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of turbine mounted on triangular frame on seabed.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed. Can be deployed in water depth greater than 40 metres.
Method of deployment and fixing to seabed	Use of gravity foundation consisting of 3 ballast filled legs on which the main frame, duct and turbine are positioned.
Locations of devices (e.g. water depth and distance from shore)	Seabed
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	No details
Underwater noise levels and frequencies associated with the devices	No specific details. Enclosed turbines are likely to produce low noise levels.

Tidal Device 14: Hydroplane–IHC Engineering business Ltd

Energy Type	Tidal
Device Type Group	Hydroplane
Technologies	Stingray – Oscillating hydroplane
Developers	IHC Engineering Business Ltd
Website and Contact details	www.engb.com
Visibility	Fully submerged
Existing Installations	None – Full scale 150W demonstrator of Stingray tidal stream generator in Yell Sound, Shetland Islands 2002. Project presently on hold due to lack of funding.
Device operation	Hydroplane which has its attack angle relative to the approaching water stream varied by a simple mechanism. This causes the supporting arm to oscillate which in turn forces hydraulic cylinders to extend and retract. This produces high pressure oil which is used to drive a generator.
Infrastructure required	Grid connection
Size and number of devices including array density	Demonstrator model produced. If became commercially viable it is likely it would be deployed in arrays.
Appearance and shape of devices	All devices fully submerged on seabed: Device consists of hydroplane mounted on 4 leg base.
Construction materials	Steel and GRP
Positioning of device (e.g. surface, mid column or seabed) and water depth	Seabed.
Method of deployment and fixing to seabed	No details
Locations of devices (e.g. water depth and distance from shore)	Presume sufficient depth so as not to impede navigation.
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	150W demonstrator
Underwater noise levels and frequencies associated with the devices	No specific details. Movement of hydroplane likely to produce low noise levels.

Tidal Device 15: Tidal Sails–Tidalsails AS

Energy Type	Tidal
Device Type Group	Tidal Sails
Technologies	Underwater tidal sails deployed across the tidal stream.
Developers	Tidalsails AS
Website and Contact details	www.tidalsails.com
Visibility	Submerged with anchored buoys at each end
Existing Installations	Presently a pilot test facility. The next phase includes a large scale demonstration plant spanning a 200 metre wide tidal stream.
Device operation	The device is a series of underwater sails, affixed to wires strung across the tidal stream at an angle. The sails are driven back and forth by the tidal flow between two stations, at one of which the generator is installed.
Infrastructure required	Grid connection
Size and number of devices including array density	Possibly up to 1km in length with 10 strings across a tidal stream.
Appearance and shape of devices	Sails submerged in current. Anchored support buoys visible at each end.
Construction materials	No details
Positioning of device (e.g. surface, mid column or seabed) and water depth	Sails below surface
Method of deployment and fixing to seabed	Presume anchored
Locations of devices (e.g. water depth and distance from shore)	No details
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	Sails submerged, presume end buoys / float structure marked as per IALA regulations.
Tidal stream energy required and tidal range	A full commercial plant with 10 strings, each 1000m long, could yield 200 to 300 GWh annually.
Underwater noise levels and frequencies associated with the devices	No specific details. Movement of sails likely to produce low noise levels.

Tidal Device 16: Hydrofoils–Pulse Tidal

Energy Type	Tidal
Device Type Group	Oscillating Hydrofoils
Technologies	Pulse Tidal is a technology based on hydrofoils moving beneath the sea surface to generate electricity from tidal currents in shallow waters.
Developers	Tidalsails AS
Website and Contact details	www.pulsegeneration.co.uk
Visibility	Twin piled structure with element above sea surface.
Existing Installations	Device being developed for deployment in the Humber.
Device operation	Two horizontal opposite hydrofoils which move up and down in the water flow.
Infrastructure required	Grid connection
Size and number of devices including array density	The single Humber prototype consists of two, under water, vertically oscillating hydrofoils, 11m in length, each mounted on a pile-driven upright. A generator and access platform sits on the twin piles above the water surface. At high water the device will protrude 5m above the water and 12m at low water.
Appearance and shape of devices	Rectangular top of pile visible above sea surface.
Construction materials	Steel
Positioning of device (e.g. surface, mid column or seabed) and water depth	Mounted to a main structure of twin steel piles driven into the Seabed. Humber prototype to be constructed at 5 metre chart datum depth.
Method of deployment and fixing to seabed	Piled structure
Locations of devices (e.g. water depth and distance from shore)	No details
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	IALA colour, topmark and light
Tidal stream energy required and tidal range	Humber prototype requires Tidal flow (mean Spring peak) >2m s-1
Underwater noise levels and frequencies associated with the devices	During operation the noise propagation from the device is expected to be very low and in the case of the Humber deployment given the relatively high ambient noise generation from the nearby Immingham Oil Terminal and estuarine navigation, the additive effects of the noise generated is expected to be negligible in the context of the existing noise field.

Tidal Device 17: Single Blade–Bio Power Systems

Energy Type	Tidal
Device Type Group	Single Blade
Technologies	Single blade aligns to tidal flow
Developers	Bio Power systems
Website and Contact details	www.biopowersystems.com/
Visibility	Fully submerged
Existing Installations	BioSTREAM pilot, Flinders Island, Tasmania, Australia. A 250kW pilot project is being developed at Flinders Island, Tasmania. The 20m bioSTREAM unit will be connected to Hydro Tasmania's distribution grid on the Island. The pilot should be operating in 2009.
Device operation	Based on the propulsion of Thunniform mode swimming species, such as shark, tuna, and mackerel. The device mimics the shape and motion characteristics of these species but is a fixed device in a moving stream. In this configuration the propulsion mechanism is reversed and the energy in the passing flow is used to drive the device motion against the resisting torque of an electrical generator. Due to the single point of rotation, this device can align with the flow in any direction, and can assume a streamlined configuration to avoid excess loading in extreme conditions.
Infrastructure required	Grid connection
Size and number of devices including array density	Presently single prototype device. Could in the future be deployed in arrays.
Appearance and shape of devices	All devices fully submerged on seabed. Fin mounted on rotating arm.
Construction materials	No details
Positioning of device (e.g.: surface, mid column or seabed) and water depth	Seabed.
Method of deployment and fixing to seabed	No details
Locations of devices (e.g.: water depth and distance from shore)	No details
Marine cable connections to the grid	Subsea cable direct to grid
Markings, colour, visibility and lighting of devices	All devices fully submerged
Tidal stream energy required and tidal range	Systems are being developed for 250kW, 500kW, and 1000kW capacities to match conditions in various locations.
Underwater noise levels and frequencies associated with the devices	No details. Moving fin with generator. Noise levels expected to be low.

Appendix B

Proforma for Developer Engagement with the MoD - Details of the Proposed Development

Proforma of details to be supplied to the MoD from developers in relation to a proposed development (please provide as much detailed information as possible under the themes provided below including an 'x' where ☐ is used). Information to be provided at the first point of contact is listed in Table 1, with ancillary information to be provided is required by the MoD in Table 2.

Table 1 Essential Information to be Provided by Developers to the MoD

Theme	Details		Additional Information Required by MoD?
1. Developers	**Company Name**		**Yes** ☐ **No** ☐
	Contact Name		
	Telephone		
	Email		
	Address		
2. Location **(to be provided in WGS84 as degrees, minutes, seconds)**	**Maximum extent of area of interest**		**Yes** ☐ **No** ☐
	Cable route corridor		
	Landfall point		
	Name of MoD areas within or adjacent to the proposed site		
3. Device	**Name of device**		**Yes** ☐ **No** ☐
	Method of operation		
	Size/scale of device		

Theme	Details		Additional Information Required by MoD?
	Number of devices proposed		
	Device appearance	Please append drawings/photos	
4. Deployment duration	Indicative timescale of project		Yes ☐ No ☐
9. Position	Relative position	Shoreline ☐ Nearshore ☐ Offshore ☐	Yes ☐ No ☐
	Water depth (m)		
	Approx distance from shore (m or km as appropriate)		
	Position in water column (including clearance at low water if fully submerged)	Surface ☐ Mid column ☐ Seabed ☐ Clearance (m)………………………………	

Table 2 Potential Additional Information Requirements

1. Markings The device markings, colour, lighting of the device/s	Any MCA requirements?	Append if available	Yes ☐ No ☐
	Device colour		
	Planned lighting		
	Planned markings (e.g. buoys etc)		
2. Materials	Device (main construction material (s))		Yes ☐ No ☐
	Anchor/mooring/piling materials		
	Cabling/pipeline to shore		
	Shoreline structure		
	Any other?		
3. Deployment method	Piled	Yes ☐ No ☐	Yes ☐ No ☐
	Anchored	Yes ☐ No ☐	
	Moored	Yes ☐ No ☐	
	Other (please describe)		
4. Cabling/ Piping Marine cable/pipeline type and connections to the grid	Cable to shore required?	Yes ☐ No ☐	Yes ☐ No ☐
	Pipeline to shore required?	Yes ☐ No ☐	
	Method of deployment known? If yes, please specify	Yes ☐ No ☐ ………………………	

	Is armouring or similar anticipated to be required?	**Yes** ☐ **No** ☐	
5. Noise and Vibration	**Anticipated noise source(s) during construction and indicative Hz and dB where applicable (particularly piling)**		**Yes** ☐ **No** ☐
	Anticipated noise source(s) during operation and indicative Hz and dB		
6. Emergency Protocols	**Please append appropriate safety information**		**Yes** ☐ **No** ☐
7. Predeployment surveys	**Resource assessment**	**Yes** ☐ **No** ☐	**Yes** ☐ **No** ☐
	Geophysical and/or geotechnical	**Yes** ☐ **No** ☐	
	Marine traffic	**Yes** ☐ **No** ☐	
	Environmental	**Yes** ☐ **No** ☐	
	Unexploded ordnance	**Yes** ☐ **No** ☐	
	Others?		
8. Additional Information	**Details of additional information required by the MoD (please append additional sheets if required):**		