



Appendix 23.1

Adaptive Environmental Monitoring Plan



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1.0 Adaptive Environmental Monitoring Plan

1.1 Introduction

1.1.0.1 Tidal Lagoon Swansea Bay Plc (TLSB) is proposing the development of a Tidal Lagoon (the Project) in Swansea Bay, South Wales for the purpose of generating electricity. This Adaptive Environmental Monitoring Plan (AEMP) accompanies TLSB's application for a Development Consent Order (DCO) for the Project (for more details on the consents required for the Project see section 2.2). This AEMP provides a framework for the monitoring of the Project. It discusses:

- i. the baseline monitoring already completed and reported upon in the Environmental Statement (ES) (TLSB, 2014) (this has also been produced as part of the Development Consent application); and
- ii. the monitoring planned as the project progresses through the pre-construction, construction and operational phases.

1.1.0.2 Due to the long lifespan of the Project (120 years), monitoring or surveys that are required during the decommissioning and post-decommissioning phases will be developed prior to the commencement of that process. This is secured by requirements attached to the draft DCO.

1.1.0.3 Any monitoring or surveys that are programmed to take place pre-construction or during construction that will not be continued through to the operation phase are covered within the Construction Environmental Management Plan. Therefore, such surveys and monitoring are not covered within the AEMP, e.g. marine and terrestrial archaeology, land quality and hydrogeology (onshore site investigations).

1.1.0.4 This document has been prepared in order to guide the monitoring of the effects of the Project at each stage of its progress. In the same way that results of the baseline surveys and monitoring carried out for the Environmental Impact Assessment (EIA) process have informed this document, the results of pre-construction and construction-phase monitoring will provide up-to-date baseline data for operational-phase monitoring. As the project evolves over its long lifespan, the AEMP will be updated and it is for this reason that it is an *adaptive* plan. The document will continue to be updated and refined to give the best possible understanding of the Project's environmental effects such that mitigation can be adjusted.

1.1.0.5 The document describes mechanism by which the plan will be implemented is outlined and a framework for dissemination of the findings of the studies is provided. It then describes the monitoring and surveys required for particular environmental topics following the ES chapter structure as follows:

- i. Coastal processes
- ii. Water quality
- iii. Subtidal and intertidal benthic ecology
- iv. Fish
- v. Marine mammals
- vi. Coastal birds



vii. Terrestrial ecology

viii. Marine noise

1.1.0.6 For each of these environmental topic areas, an overview of the baseline surveys and monitoring undertaken as part of the EIA process is presented (additional information can be found in the relevant ES chapter). Subsequently, outline methodologies for any surveys or monitoring required during the pre-construction, construction or operation phases are given. The final methodologies will require approval prior to the relevant phase of the Project.

1.1.0.7 As with any project, in order for monitoring to be effective the use of longer term data sets which can demonstrate natural trends is advantageous. Within the Swansea Bay area there is existing monitoring programmes that are already in place and replicating these would not necessarily provide additional benefit, whereas complimenting them could provide additional synergies. As such it is proposed that the AEMP builds on existing monitoring programmes, where appropriate, and reviews the relevant routine monitoring data sets which informed the various baseline assessments within the ES.

1.1.0.8 Areas where this would be relevant include the Swansea and Carmarthen Bay Coastal Engineering Group annual beach profile data; existing monitoring regimes which are in place to monitor siltation in the approach channels to the various ports, and routine monitoring of fish returns within rivers. These are discussed where relevant under the various subject areas in this AEMP.

Guidance for monitoring

1.1.0.9 Guidance in respect of monitoring for construction and operation of offshore renewable energy projects is contained in the following document:

Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects. Cefas contract report: ME5403 – Module 15. May 2012.

1.1.0.10 These guidelines consider a variety of environmental topics, including those identified above. The guidance states that monitoring must be hypothesis driven with measureable outputs. As such the findings of the ES have been used to develop this document.

Collaboration with SEACAMS

1.1.0.11 In order to inform the AEMP, such that the monitoring identified within this ES can be developed for the construction and operational phase of the Project, TLSB is working in conjunction with the SEACAMS (Sustainable Expansion of the Applied Coastal and Marine Sectors in Wales) project at Swansea University.

2.0 The Project

2.1 Introduction

- 2.1.0.1 This section of the AEMP describes the Project to provide context for the monitoring proposals that are described below. The Project is described more fully in the ES and is constrained by the DCO, which imposes limitations upon it as well as requirements that operate in the same way as planning conditions. The final AEMP will be developed under the terms of the DCO.
- 2.1.0.2 TLSB is proposing to construct and operate a tidal energy lagoon, located in Swansea Bay, South Wales (Figure 2.1). The tidal lagoon will generate renewable energy in the form of electricity using the large tidal range (the difference between high and low water) which is a distinguishing feature of the Bay. The lagoon will have a rated capacity of 240 Megawatts (MW), generating 400GWh net annual output. This is enough electricity for approximately 121,000 homes: more than Swansea's annual domestic electricity use (109k households); c.70% of Swansea Bay's annual domestic electricity use (Swansea, Neath & Port Talbot, 173k households); or c.9% of Wales' annual domestic electricity use (based on 1,369k households).

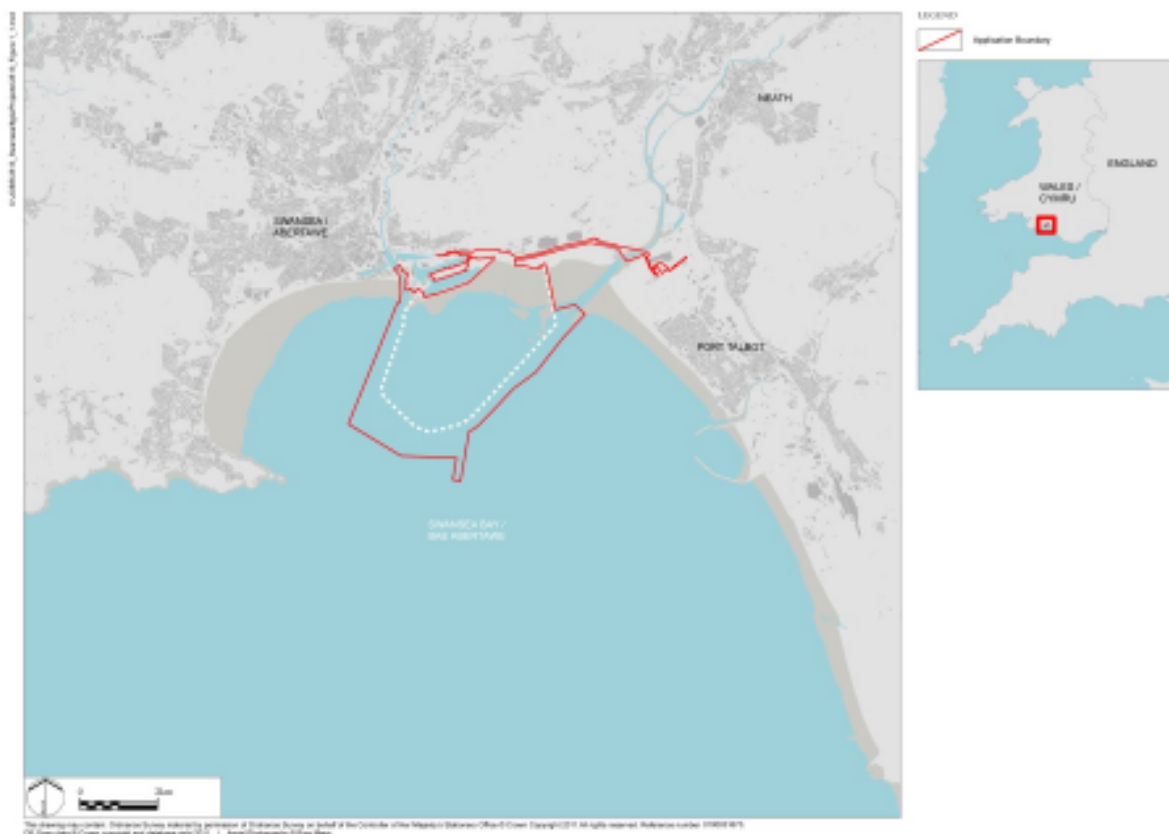


Figure 2.1 Location of the Project

- 2.1.0.3 In addition to generating electricity, the Project also aims to provide visitor facilities and other amenities including art, education, mariculture and sporting/recreational facilities. The seawall is expected to be open to the public during daylight hours for walking, running, cycling etc, though access will be controlled in extreme weather.



2.2 Consenting Process

- 2.2.1.1 As the Project is an offshore electricity generating station of more than 100MW, it is a Nationally Significant Infrastructure Project (NSIP) under the Planning Act 2008 (PA 2008). Construction of such a project requires that a DCO is first granted by the Secretary of State for Energy and Climate under the PA 2008.
- 2.2.1.2 The DCO for the Project will embrace a number of separate consents formerly required for a project of this type. Section 33 of the PA 2008 dispenses with the need for separate planning permission or deemed planning permission under the Town and Country Planning Act 1990 (TCPA 1990) and consents under Section 36 of the Electricity Act 1989. Any permissions required under TCPA 1990 will be sought after the grant of DCO, as these elements will not be integral to the construction or operation of the elements of the Project as defined by the DCO.
- 2.2.1.3 The DCO will authorise construction and operation of the generating station itself, and its component parts. These include both offshore and onshore elements of the project, including the integral electrical grid connection works.
- 2.2.1.4 As the Project lies within Welsh waters, an application for a Marine Licence will be made to the Marine Licensing Team within Natural Resources Wales (NRW). The process for granting a Marine Licence is regulated by the Marine and Coastal Access Act 2009 which gives the appropriate licensing authority (NRW in this case) powers to grant or not grant a marine licence to an applicant who wishes to carry out licensable activities in territorial waters.
- 2.2.1.5 An application for a Marine Licence will be submitted concurrently with the application for the DCO. The requirement for a Marine Licence (ML) is broadly defined by works taking place in the offshore environment that affect the seabed or the movement of materials related to it. In this sense, elements of the offshore Project that are subject to the DCO application are also subject to a separate ML application.

2.3 Overview of the Project

- 2.3.1.1 The Project is situated in Swansea Bay, near to the Port of Swansea, approximately 2.2 km southeast of Swansea City Centre. The Project contains elements within the administrative areas of the City and County of Swansea Council (CCSC) and Neath Port Talbot County Borough Council (NPTCBC). The main onshore development lies within the Port of Swansea, immediately south of Fabian Way (A483) which is the main trunk road from Junction 42 of the M4 into Swansea.
- 2.3.1.2 Figure 2.2 provides an indication of the Project and the wider extent to the mouth of the River Neath related to the national grid connection at Baglan.

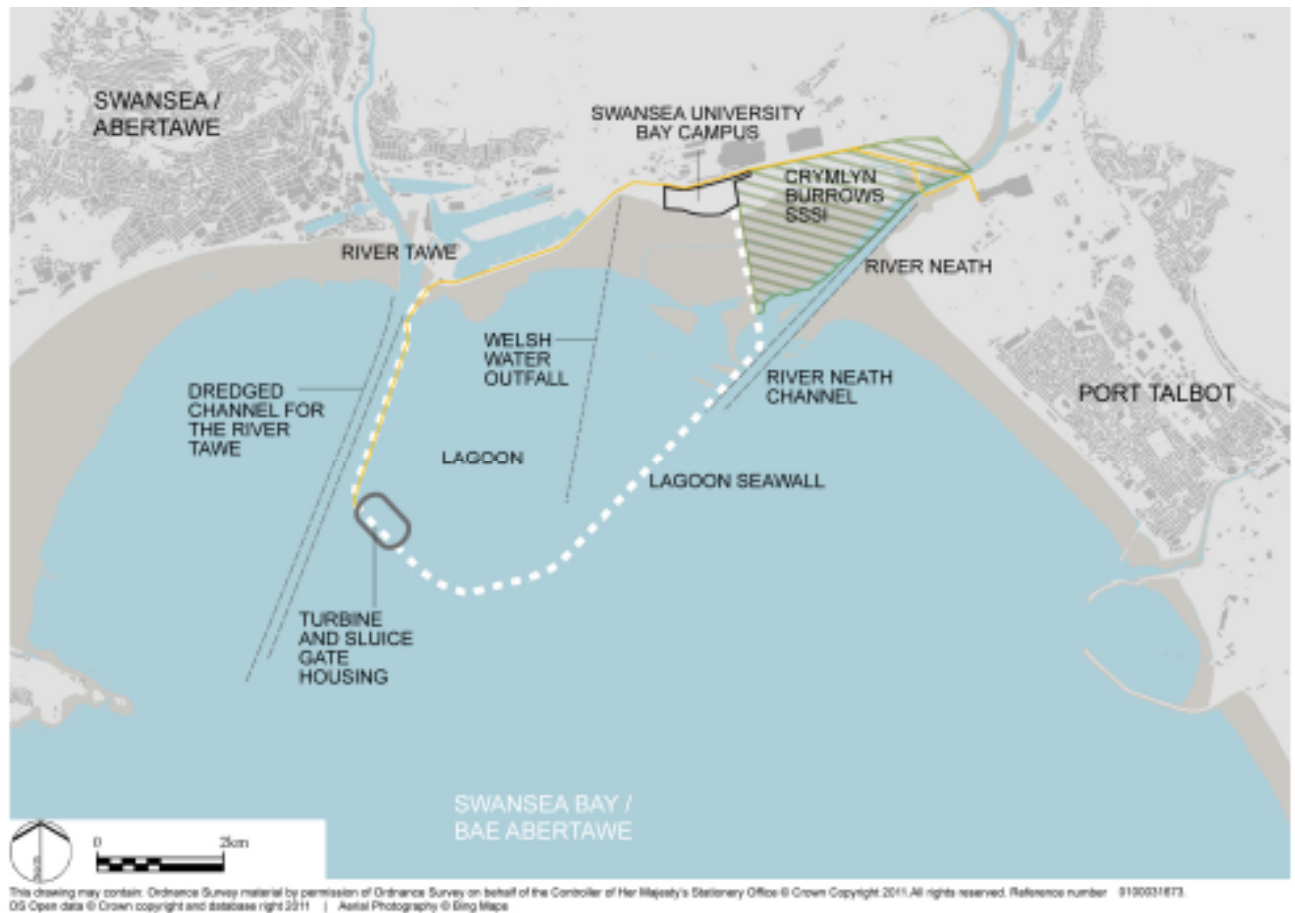


Figure 2.2: The Project

- 2.3.1.3 The lagoon will enclose part of Swansea Bay, from the eastern side of the River Tawe (western landfall) to the eastern edge of the new Swansea University Bay Campus (SUBC) (eastern landfall). The new seawalls that impound the lagoon will extend approximately 1.5km directly offshore from the campus, adjacent to Crymlyn Burrows SSSI. The seawalls will then extend in a southwest direction along the western boundary of the training wall of the River Neath Channel. The turbine and sluice gate housing will be located in the south west of the lagoon, at an angle to the dredged channel of the river Tawe. The seawall will then extend north towards Swansea Port, close to the mouth of the River Tawe parallel but off set by 100m to the dredged channel for the River Tawe. In total, this will form an approximately 9.5km-long, U-shaped, seawall which will encompass approximately 11.5km² of the seabed, foreshore and intertidal area of Swansea Bay.
- 2.3.1.4 The seawall will have a sediment core either held in place by a casing of sediment-filled geotextile tubes, known as Geotubes® or by a conventional sea wall construction method. The outside of the structure will be covered in rock armour of various sizes, depending on its level of exposure (Figure 2.3). The sand used to form the seawalls will be taken from within the Lagoon footprint. Rock armour will then be brought in by sea to provide protection. The top of the seawall will have an access road which will be used for operation and maintenance of the lagoon as well as for visitors.

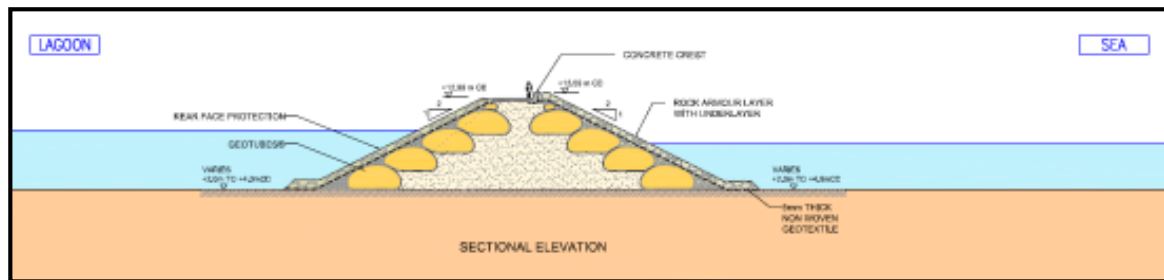


Figure 2.3: Example cross-section through lagoon seawall

- 2.3.1.5 An alternative design of the seawall may be used which does not incorporate Geotubes® and uses a more conventional construction for a seawall structure. An illustration of what this is shown below in Figure 2.4. The seawall would still have a sediment core which would be held in position by large piles of gravel dredged from within the Lagoon or quarry run material. The quarry run material would be material remaining after the blasting for the larger grade rock used for rock armour. The footprint and angle of the slopes would remain largely unchanged from the design incorporating Geotubes®.

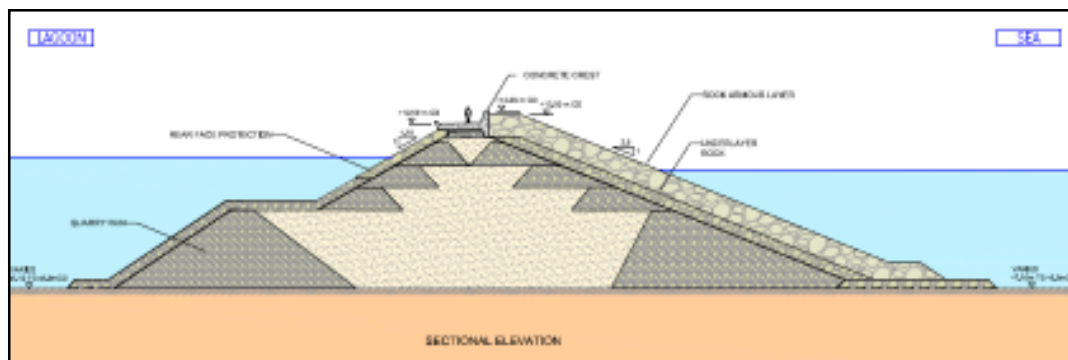


Figure 2.4 Section of the Lagoon seawall using conventional construction

- 2.3.1.6 The hydro (water) turbines (between 13 and 16), located within the turbine and sluice gate housing, will be bi-directional, i.e. able to generate power with flows of water in both directions (i.e. on both incoming and outgoing tides). The turbines, which will be up to 7m in diameter, will be permanently underwater (Figure 2.5). There will also be between 6 and 10 sluice gates – these are large gates which will be underwater and able to let seawater in and out of the lagoon without going through the turbines, as required.

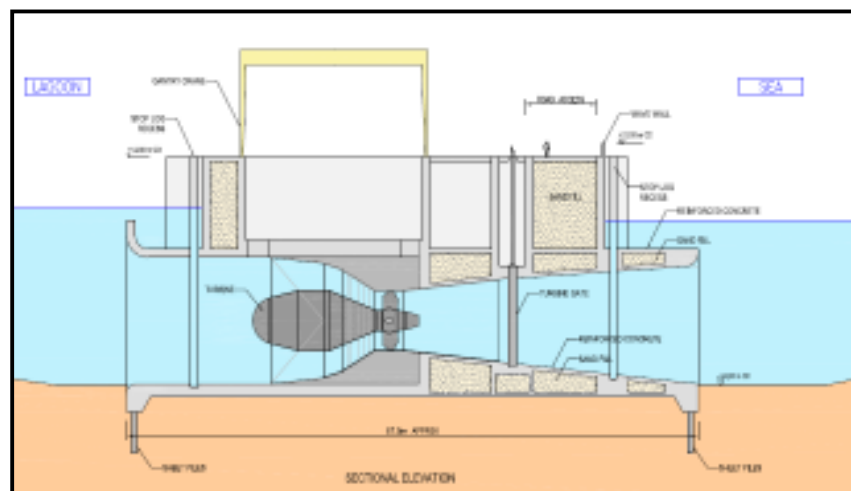


Figure 2.5: Cross-section of turbine housing structure

- 2.3.1.7 To generate electricity, as the sea starts to rise (flood tide) from low tide level, water is prevented from entering the lagoon for an average of 2.5 hours, and this creates a difference in water levels known as ‘head’. Once sufficient head has been reached, the water is allowed to flow into the lagoon through the turbines, turning the runner (like a propeller) and generating electricity. This process is repeated on the ebb tide, where the water is prevented from leaving the lagoon until there is sufficient head to start the process again (Figure 2.6).

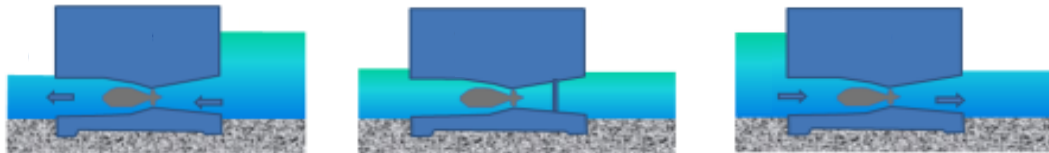


Figure 2.6: Illustration of water flow between the sea and the lagoon

- 2.3.1.8 Towards the end of the ebb or flood tide the sluice gates will be opened. This is to empty or fill the lagoon as quickly as possible before low or high tide level. By doing this, it ensures that the lagoon water level is as close to the outside sea level as possible, before the tide starts to rise or fall again. This is to maximise electricity generation and to keep the intertidal area as close as possible to that occurring naturally outside the lagoon. An option to pump the seawater at the end of the tide is also being examined, which would further equalise seawater levels. This generation sequence will happen on both the flood and ebb tides, four times a day in total. Figure 2.67 illustrates this generating cycle.

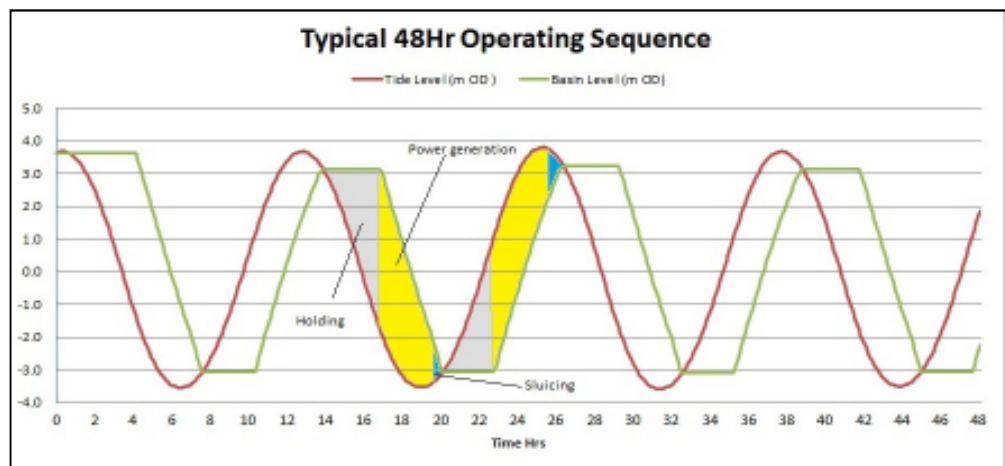


Figure 2.7: Indicative 48-hour operating cycle for the lagoon

- 2.3.1.9 The electricity generated from the lagoon will be transported to the nearest National Grid substation at Baglan Bay by underground cables. The cable landfall is located at the Western Landfall and runs eastwards along the coastline before either running alongside the A483 Fabian Way and through the Crymlyn Burrows Site of Scientific Interest (SSSI). The route then turns southeast, crossing the River Neath either by directional drill or within existing ducts, before continuing across Baglan Burrows to connect with a substation at Baglan Power Station.
- 2.3.1.10 In 120 years' time there are two potential options for decommissioning: namely to replace equipment, to upgrade and extend the life of the power generating station; or to remove the turbines and sluice gates so as to allow continued leisure use of the impounded Lagoon area.



3.0 Plan Implementation and Dissemination of Findings

3.1 Introduction

- 3.1.0.1 This AEMP has been produced as a stand-alone document. However, it will interact with the Construction Environmental Management Plan (CEMP) and the Operational Environmental Management Plan (OEMP). All of these plans will be imposed upon the relevant phases of the Project, being delivered *via* the construction contract or *via* the day-to-day running of the operational Lagoon, including generation. The requirement to produce final versions of these documents is secured by requirements attached to the DCO. Individual proposals will be developed for survey methodologies and agreed as appropriate with the relevant statutory organisations.

3.2 Pre-construction Plan Implementation

- 3.2.1.1 A number of pre-construction studies are already taking place, such as quarterly fish baseline surveys and marine mammal monitoring. Any other surveys required (as detailed in Sections 4 – 11) will be commissioned, undertaken and reported prior to construction commencing. The results of the studies will be reported prior to construction and disseminated to statutory and non-statutory consultees as appropriate and used to progress the detailed design phase where appropriate.

3.3 Construction - Plan Implementation

- 3.3.1.1 An Environmental Liaison Officer (ELO) will be identified for the construction phase of the Project. The ELO will be responsible for working with statutory and non-statutory organisations and managing the environmental aspects of the construction phase of the Project. Further details of the roles and responsibilities of the ELO are detailed within the CEMP produced for the Project.
- 3.3.1.2 Where appropriate, survey or monitoring methodologies will be agreed with statutory and non-statutory consultees. The findings from the surveys and monitoring will be reported annually and the documents disseminated to relevant statutory bodies and other stakeholders. The results of the studies will be used to inform mitigation, construction methods or strategies as appropriate.

3.4 Operation – Plan Implementation

- 3.4.1.1 The operation phase monitoring will take place following completion of construction and will be reported annually to Natural Resources Wales (NRW), City and County of Swansea (CCS) and Neath Port Talbot County Borough Council (NPTCBC). The period over which monitoring will take place will be established prior to operation will be reviewed in each annual report, along with the anticipated duration of monitoring in the light of the results of the report.
- 3.4.1.2 A warden will be employed for the operational phase of the Project. The warden will be responsible for working with statutory and non-statutory stakeholder organisations and managing the environmental aspects of the Project. The roles and responsibilities of the warden are detailed within the OEMP, which will be prepared for the Project.



- 3.4.1.3 As for the construction phase, methodologies will be agreed/reviewed with statutory organisations and the results reported annually and disseminated as appropriate. The findings will be used to inform mitigation and operation strategies as appropriate.

3.5 AEMP Reporting

- 3.5.1.1 An annual report will be prepared presenting the findings of the surveys completed in that year. The report will be structured under the environmental subject headings identified in this AEMP. Where specialist surveys have been undertaken by consultant or survey specialists, the main body of the AEMP Annual Report will provide an overview and discussion of the findings of the survey, whilst the specialist report will be provided as an Appendix or as a supporting document.
- 3.5.1.2 As the project progresses the main body of the AEMP Annual Report will be updated and the data gathered evaluated against the previous years' data sets. Where necessary the annual report will make recommendations for modification to the monitoring proposals. The AEMP annual report will be provided to NRW, CCSC and NPTCBC and feedback on the report and modification to the AEMP, if appropriate, will be requested within 6 weeks, thereby allowing the monitoring programmes to be updated.



4.0 Coastal Processes

4.1 Introduction

- 4.1.0.1 Chapter 6 Coastal Processes, Sediment Transport and Contamination of the ES provides full details of the data review and site-specific survey work carried out to collect baseline information to develop the conceptual understanding of Swansea Bay and to input into the coastal processes model.
- 4.1.0.2 EIA studies, which are informed by modelling, are able to demonstrate a high level of confidence in relation to baseline conditions as these can be validated against suitable baseline evidence. In contrast, the description of equivalent conditions with the introduction of a scheme can only be proven in a similar way once the scheme has been constructed. The EIA helps to manage the issue of confidence levels, in part, by opting for a conservative consideration of issues through the application of a realistic worst case with a premise that any scale of affects is described as an upper value. What might actually be built thereafter will be similar to what was assessed in the EIA but will be more likely to have a lesser affect. As such, monitoring can validate the assumptions made in the EIA, taking consideration the difference between the assessment of a realistic worst case and the actual case.
- 4.1.0.3 This section outlines the further monitoring and surveys which are proposed during the pre-construction, construction and operational phases of the Project, in order to review and confirm the findings of the EIA.
- 4.1.0.4 Additional data will be collected to support the validation of the coastal process assessment of impacts, noting the key differences between the predicted realistic worst case and the actual case following implementation. This is a validation of method and outcomes, and it will help add confidence to the approach used. As such, it has direct value to developers and regulators, especially if a similar approach is required on future projects.
- 4.1.0.5 Topics for validation proposed for this Project include:
- i. wave reflection off marine structures;
 - ii. jetting flows through the turbines and sluice gates and potential for effects on navigation;
 - iii. levels of siltation within the lagoon resulting from operation of the Project causing changes in changes in bathymetry affecting maintenance dredging frequency;
 - iv. levels of siltation in approach channels at Port Talbot, Port of Swansea and Port of Neath potentially affecting navigation; and
 - v. beach profiles to ascertain any potential changes in erosion and accretion patterns particularly examining Blackpill SSSI and Crymlyn Burrows SSSI.

4.2 Baseline

- 4.2.1.1 The baseline is the reference point for determining changes to the physical environment which may be brought about by the Project. The baseline is defined here as the environmental conditions that are likely to occur over the same period as the Project lifecycle but without any development in place. Necessarily, long-term variability of the



baseline over periods of up to 120 years, or more, draws on climate change related effects. The baseline includes the measured data for the current environmental conditions and the modelled future development of those conditions.

4.2.1.2 To provide the basis to enhance the initial conceptual understanding of the baseline the following surveys were undertaken as part of the EIA process:

- i. A metocean survey (Titan, 2012b) to measure currents, waves and turbidity at two locations within the bay over a period of 3 months between February and May, 2012;
- ii. A geophysical survey (Titan, 2012a) to collect detailed swathe bathymetry, side scan sonar, sub-bottom profiler and magnetometer data within the immediate vicinity of the Project;
- iii. A geotechnical survey (Atkins, 2013) to investigate sediment characteristics at depth for specific locations within the Lagoon footprint where capital dredging is expected to occur; and
- iv. A subtidal benthic survey (Titan, 2013) to collect sediment samples for Particle Size Analysis (PSA) and sediment contamination analysis from both within the Lagoon footprint and across the bay.

4.2.1.3 The methodologies and results of the surveys are discussed in detail in Chapter 6 and also within the survey reports as referenced above.

4.3 Pre-construction

4.3.1 Bathymetric survey for objects

4.3.1.1 Multi-beam bathymetric and side scan sonar surveys are proposed within the proposed area of works of the footprint of the lagoon and a 250m wide corridor around the outside of the lagoon boundary to identify any objects and potentially, any unexploded ordnance that may be present. The proposed line spacing is 40m with multi-beam echo sounders used to infill at 10-20m line spacing for shallower areas.

4.4 Construction

4.4.1 Photographic record

4.4.1.1 Photographic records will be taken of the outside of the eastern seawall adjacent to Crymlyn Burrows and along the western seawall as they are formed. This will provide a simple visual recorded of potential sediment deposition or erosion patterns along the new seawalls. Photographs will be taken from a fixed point on a monthly basis at Low Water Springs. The need for specific profiles or recording at these locations during operation will be determined based on review of the photographic records.

4.4.1.2 The photographic record will be analysed and reported to NRW, CCSC and NPTCBC on an annual basis. The annual report will recommend whether specific profiles or recording should be undertaken. Where such profiles or recording is undertaken it will be contained in the annual report.

4.4.1.3 The construction monitoring will take place until a date six months following completion of construction and will be followed by the issue of a final report, which will be issued not more than one year following the completion of construction.



4.4.2 Post construction bathymetric survey for objects

- 4.4.2.1 Multi-beam bathymetric and side scan sonar surveys are proposed within the Lagoon footprint and a 250m wide corridor around the outside of the marine works to identify any objects that may have been left on the seabed during the construction phase of the Project. The proposed line spacing is 40m with multi-beam echo sounders used to infill at 10-20m line spacing for shallower areas. It is proposed that this survey will take place as soon as is feasible following completion of construction.

4.5 Operation

4.5.1 Bathymetric surveys and data review

Siltation within the lagoon and within navigation channels

- 4.5.1.1 It is proposed to undertake bathymetry surveys to assess the levels of siltation within the lagoon footprint. The surveys will comprise a single beam bathymetric at 50m line spacing within the lagoon boundary to inform any bed level changes. It is proposed to carry out the surveys annually for three years after completion of the works and then the frequency of surveys will be reviewed after the third year. The first such single beam bathymetric survey would coincide with the “objects on the seabed” survey and it would form the revised baseline for the operation phase surveys.
- 4.5.1.2 Where the results of bathymetry survey indicates that additional surveys to calculate volumetric variations within the lagoon are appropriate to assist dredge work, surveys with a tighter line spacing (10-20m) within the lagoon would be proposed. This information will be used to develop and refine the maintenance dredging strategy.
- 4.5.1.3 It is proposed that in relation to Swansea, Port Talbot and Neath navigational channels, data collected by the Port authorities will be reviewed.

4.5.2 Beach Profiles

- 4.5.2.1 Beach profiles within Swansea Bay are currently monitored annually by Swansea and Carmarthen Bay Coastal Engineering Group (SCBCEG) (see Figure 4.1). A high level overview of existing data gathered by SCBCEG for the sites within Swansea Bay between Mumbles and Kenfig Burrows was undertaken for the EIA. More detailed analysis will be carried out of beach profile data recorded at Kenfig Burrows (profile 228), Aberavon Sands (profile 220), Crymlyn Burrows SSSI (profiles 214 and 215), Swansea Beach (profile 208 or 209), Blackpill SSSI (West Cross profile 205 and Lower Sketty profile 206) (see Figure 4.1). It is proposed that beach profile data collected by SCBCEG is analysed at these sites after each recording event to assess any changes to beach profiles outside of natural variation. The analysis will be contained in the annual report.
- 4.5.2.2 The need for TLSB to carry out its own monitoring at any of these sites will be identified if ongoing monitoring by SCBCEG is not undertaken or if the reported results indicate that additional assessment is required. Particular attention will be paid to any accretion at Crymlyn Burrows SSSI and potential erosion at Blackpill SSSI (see Chapter 6 Coastal Processes, Sediment Transport and Contamination). The need for beach replenishment at Blackpill SSSI will be considered based on this analysis.
- 4.5.2.3 In addition to the above, photographic records will be taken of the outside of the eastern seawall adjacent to Crymlyn Burrows and along the western seawall. Photographs will

be taken from a fixed point on a monthly basis in the first year at Low Water Springs and reported in the annual report. These locations would be the same as the photographic surveys undertaken for the pre-construction phase (see section 4.4.1). The need for ongoing specific profiles or recording at these locations will be determined based on review of the photographic records and discussed in the annual report.

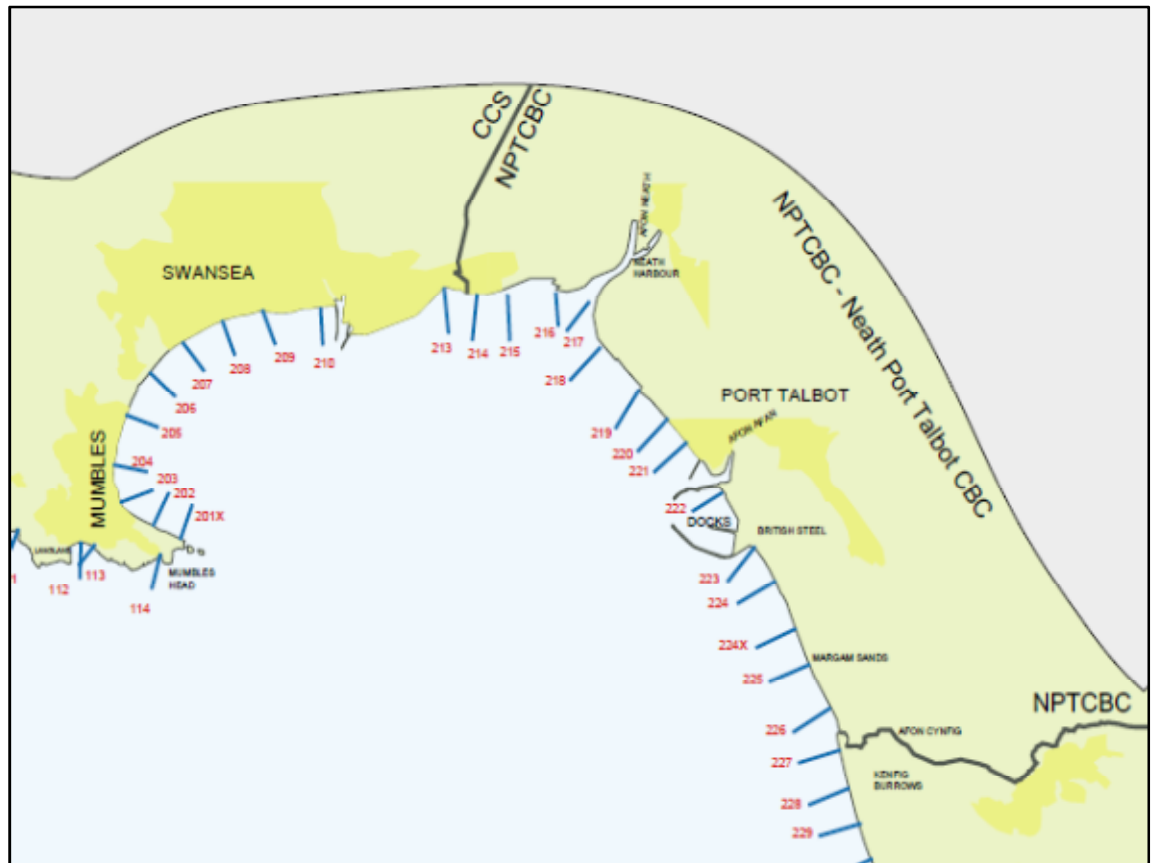


Figure 4.1 Locations of SCBCEG Beach Profiles within Swansea Bay

4.5.3 Wave reflection and currents

- 4.5.3.1 It is proposed that Nortek Acoustic Wave and Current (AWAC) devices will be deployed over continuous tidal periods to collect data on waves, water levels, current profiles and suspended sediment (acoustic backscatter), combined with Optical Back Scatter (OBS) for suspended sediment (turbidity). The devices will be deployed to obtain three months of oceanographic field data at two locations in the first year of operation. One location, site 2 (Proposed Geodetic (WGS84) Location $51^{\circ}35.2178'N$, $003^{\circ}54.4776'W$; Proposed Grid (OS Nat Grid (OSTN02) E 267915.04; N 189292.35) will be that used for the baseline monitoring (Titan, 2012b) as shown on Figure 4.2. Site 2 is located within the lagoon footprint.



Figure 4.2 Location of AWAC device deployment (February to May 2012)

- 4.5.3.2 It is proposed to locate a further AWAC device at a new site, Site 3, at a point outside the lagoon footprint. The location of Site 3 will be determined in consultation with NRW subsequent to micro-siting of the turbine and sluice gate housing structure and it will be positioned in order to collect flow data resulting from the physical presence and operation of the Lagoon, together with data that can be used to assess wave reflection. Current navigational movements around the bay will also be taken into account when selecting Site 3. Depending on the final position, the need for additional data collection of flows through the turbines will be determined. However, an outline survey concept is provided in Section 4.5.4.
- 4.5.3.3 The following presents the outline work scope of works:
- i. Deployment of two Nortek Acoustic Wave and Current Profiler (AWAC) instruments in seabed frames, marked with an International Association of Lighthouse Authorities (IALA) compliant surface marker buoy at two sites (one within the lagoon footprint - Site 2 and one outside the lagoon footprint – Site 3).
 - ii. Measurement of Current Speed and Direction throughout the water column at 0.5m intervals, together with directional wave data including: significant wave height (H_s), mean wave direction (M_{dir}) and the peak wave period (T_p). Depending on the final position of Site 3 and 2 in relation to the turbine and sluice gate structure, this will be used to assess jetting flows through the turbines inside and outside the lagoon.
 - iii. Measurement of water levels (m above CD) using the AWAC pressure sensors.
 - iv. Deployment of Optical Backscatter Sensors (OBS) to measure near bed turbidity in Formazine Turbidity Units (FTU).
 - v. Collection of water samples at the time of initial deployment and final recovery to assist calibration of recorded turbidity data into Suspended Particulate Material (SPM) in mg/l. It is proposed that up to forty two suspended sediment samples (as per baseline survey) will be taken at the time of initial deployment for calibration purposes, while three samples will be collected per site at bottom, mid-depth and surface. The samples collected would be used for suspended sediment concentration of acoustic backscatter and calibration of the turbidity sensors.
 - vi. Grab sampling on initial deployment and final recovery using a hand operated $0.045m^2$ stainless steel mini Van-Veen grab, for Particle Size Analysis (PSA).

4.5.3.4 The results of the AWAC surveys will be set out and analysed in the annual report.

4.5.4 Currents from turbines and sluice gates and suspended sediments

4.5.4.1 An alternative method to collect data on flows through turbines and sluices could be undertaken by using a vessel mounted Acoustic Doppler Current Profiler (ADCP). This would provide spatial current data as opposed to fixed point temporal data which is collected by the AWAC deployments. The spatial ADCP survey could also be used to provide more detailed information on flow patterns within the lagoon as a whole, as well as to measure backscatter intensity, which would provide an indication of turbidity in the water column.

4.5.4.2 Three survey types are illustrated below in Figure 4.3:

- i. Inside Lagoon Survey focussed on inlet (red)
- ii. Inside Lagoon General Flow Pattern Survey (green)
- iii. Outside Lagoon flows (purple)

4.5.4.3 The Moving Vessel ADCP surveys would be undertaken across several transects over the flood and ebb phase of a spring and a neap tide. This would provide current profile data through the water column over the transect lines. This would be carried out on a single occasion on each of a spring and neap tide.

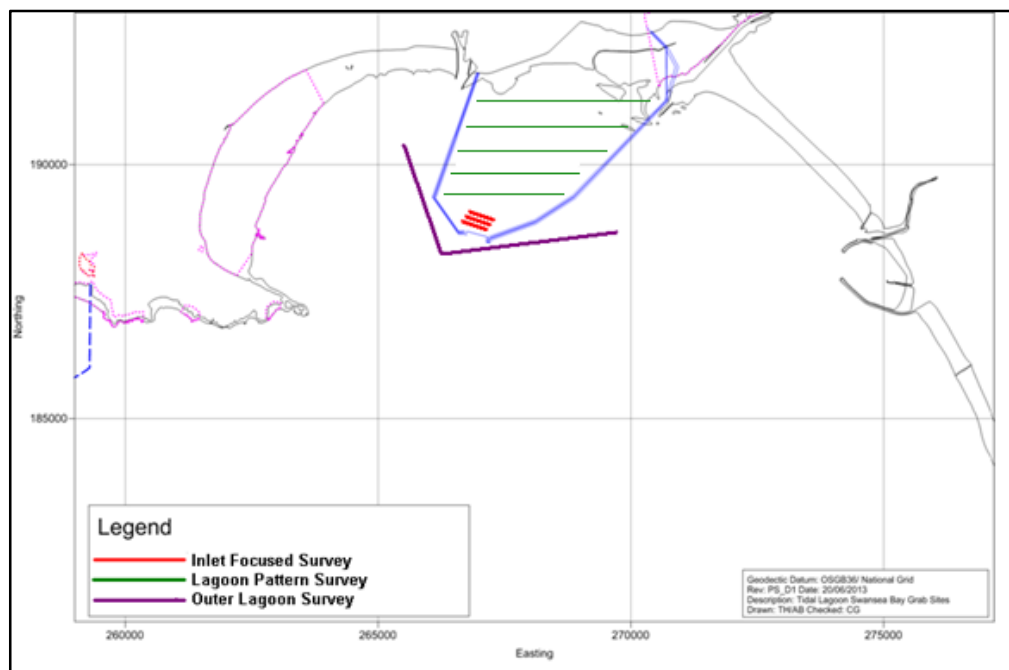


Figure 4.3 Potential ADCP survey areas

4.5.4.4 The transect surveys above would also provide information on suspended sediment within the water column. Additional data on bed level turbidity values could also be obtained during operation (as completed in the baseline ADCP survey by Titan). An Argus Silt Meter, which measures deposition/turbidity profiles near-bed (approx. 1m high) could be deployed in a suitable intertidal location. The location of the deployment would be dependent on the modelling output and the bathymetric surveys discussed above.



5.0 Water Quality

5.1 Introduction

- 5.1.0.1 Chapter 7 Marine Water Quality of the ES provides full details of the data review carried out to collect baseline information for Swansea Bay.
- 5.1.0.2 This section outlines the further monitoring and surveys which are proposed for the pre-construction, construction and operational phases.
- 5.1.0.3 The key issues to be understood through a programme of monitoring are suspended solids (operational phase as discussed above), bacteria monitoring within lagoon and Bathing Water data outside the lagoon (through analysis of data collected by others).

5.2 Baseline

- 5.2.1.1 Data collected by Natural Resources Wales (NRW) under the Water Framework Directive (EC 2000/60/EC) (WFD), the Bathing Water Directive (EC 76/160/EEC) (BWD), and the Shellfish Water Directive (EC 2006/113/EC) (SWD), which are the principal legislative drivers for water quality assessments in coastal waters around the UK were reviewed. In addition, data gathered under the European Commission (EC) regulations pertaining to bacterial sampling of shellfish flesh, which is a key water quality indicator, were also reviewed.

5.3 Pre-construction

- 5.3.1.1 No surveys proposed.

5.4 Construction

- 5.4.1.1 No surveys proposed.

5.5 Operation

- 5.5.1.1 The use of the Lagoon for water sports, particularly swimming and bathing, will be dependent upon water quality within the Lagoon. It is important that such use of the Lagoon does not present undue risk to bathers from gastrointestinal infection from pathogens present in the Swansea Waste Water Treatment Works (WWTW) discharge and/or other sources outside the Lagoon.
- 5.5.1.2 To provide an assessment of the water quality impacts in the Lagoon, water quality modelling was undertaken as part of the EIA process and the results were assessed against standards set out in the Bathing Water Directive (EC 76/160/EEC) (BWD). This work has identified those areas of the Lagoon that are potentially suitable for water based activities, subject to a suitable management regime. A range of options to optimise water quality within the Lagoon impoundment have also been considered. Two optimisation options have been identified as feasible: UV disinfection of storm water loads from the Swansea Bay WWTW to improve water quality during wet weather periods and extension of the existing WWTW outfall to 1.5km from its current location to outside the Lagoon. Outfall extension provides the greatest improvement in Lagoon water quality and would allow maximum use of the Lagoon area for water activities. UV disinfection would allow greater use of the Lagoon during and after storm events, but

would not affect water quality during dry weather conditions. Parts of the Lagoon would therefore remain unsuitable for water activities.

- 5.5.1.3 As the UV disinfection option would not completely remove the effects of the WWTW discharge on the Lagoon, a 500m advisory area would be applied around the outfall. In addition, bathing and swimming areas would be established as illustrated in Figure 5.1.

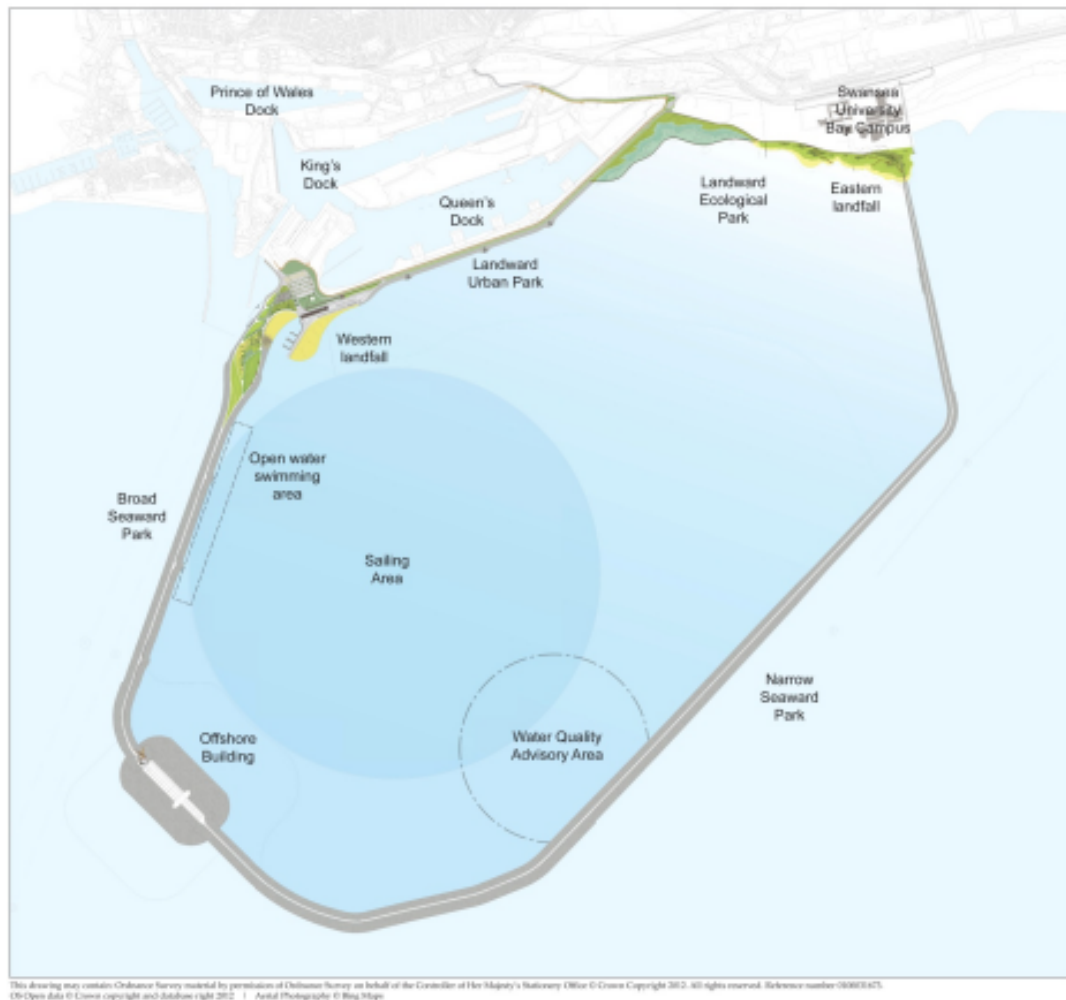


Figure 5.1 Water quality advisory area and open water swimming area

- 5.5.1.4 A Water Quality Strategy will also be implemented for the operational Lagoon and will be detailed within the OEMP. This strategy would require a means to assess Lagoon water quality continually, and advise the public of water quality, in a similar manner to requirements on local authorities under the Revised Bathing Water Directive. The Strategy would also provide a means by which DCWW can advise the operators of the lagoon of any potential issues at the WWTW that may affect water quality. The Strategy would also include a plan for extreme events, e.g. an emergency at the WWTW or failure of the UV disinfection system. To inform the development and operation of the Water Quality Strategy it is proposed to undertake a monitoring programme of water quality within the Lagoon.
- 5.5.1.5 Once the Project commences operation, it is proposed that Faecal Indicator Organism (FIO) bacteria samples would be taken at a number of locations within the impoundment over a grid of points for a full tidal cycle (13 or more hours). The survey would be



repeated for dry weather and storm conditions and over spring and neap tides. Concurrent sampling of the WWTW treated and storm discharges would also be undertaken, to determine input loads. Samples would be collected and analysed using current industry methods and best practise.

- 5.5.1.6 The primary aim of this sampling would be to provide a comprehensive picture of temporal and spatial variations in FIO concentrations in the Lagoon. This information would be used to confirm the results of current model predictions, and aid in confirming the location of designated water activity areas and the outfall advisory zone. The data would be further used to construct and validate a Lagoon Water Quality Model. By providing real time prediction of Lagoon water quality, the model will allow regular notices to be posted advising the public of water quality within the Lagoon. Sample results will also be used to identify locations to establish long term monitoring locations.
- 5.5.1.7 A programme for long term monitoring of Lagoon water quality, similar to that undertaken for Bathing Water sampling at Designated Sampling Points is also proposed. Following the standard designated bathing water sample regime, samples would be taken randomly 20 times during the bathing season at key locations. The location of sites will be determined from the more detailed survey outlined above, but would be expected to include a point on the main beach bathing area, a point within the open water swimming area and an appropriate location near the (non commercial) Oyster enhancement ponds. The routine sampling could be extended beyond the bathing season where bathing or swimming activity is anticipated in sufficient numbers.
- 5.5.1.8 The enclosed nature of the lagoon and the presence of a measurable waste water discharge provides a significant opportunity for research. Potential areas of research could include investigations of FIO and pathogen decay rates and the study of shellfish quality under the effects of waste water discharges. It is proposed to offer Universities the opportunity to use the Lagoon as a living laboratory.
- 5.5.1.9 The recording and reporting of water quality monitoring, and the programme for doing so, would be resolved prior to commencement of operation of the Project.



6.0 Intertidal and Subtidal Benthic Ecology

6.1 Introduction

- 6.1.1.1 Chapter 8 Intertidal and Subtidal Benthic Ecology of the ES provides full details of the data review and site specific survey work carried out to collect baseline information for Swansea Bay. This section outlines the further monitoring and surveys which will be undertaken during the pre-construction, construction and operational phases, in order to review and confirm the findings of the EIA.
- 6.1.1.2 The monitoring programme in intertidal and subtidal ecology aims to assess, among other things, the colonisation rate of the Lagoon seawall and its potential to develop into an artificial reef. Monitoring will therefore assess the biodiversity of the seawall and the presence/absence of non-native marine species.
- 6.1.1.3 At a wider level, benthic sampling and substrate sampling carried out from baseline through to operation will allow for a better understanding of the marine ecology of the Bay and the potential changes as a result of the Project.
- 6.1.1.4 The results of mitigation and enhancement implemented as part of the Project will also be investigated, including the *Sabellaria* translocation, colonisation of the seawalls and the re-introduction of the native oyster.

6.2 Baseline

6.2.1 Intertidal

- 6.2.1.1 An intertidal phase 1 walkover survey was undertaken for the area between the River Tawe and River Neath. In particular, the survey looked to confirm the presence, distribution and condition of *Sabellaria* reefs adjacent to the existing eastern Port breakwater, and confirm the presence and distribution of any nationally important biotopes or rare species. In addition, the area west of the River Tawe extending to Mumbles Head was surveyed specifically for protected habitats and species. The landward boundary of the survey was Mean High Water Springs (MHWS) with the seaward boundary following Mean Low Water Springs (MLWS) (or as near as possible depending on surf and surge conditions). The surveys were undertaken on 14-15 January 2013 and 28-29 May 2013, at low water during spring tides.

6.2.2 Benthic and sediment sampling

- 6.2.2.1 A benthic survey consisting of sediment sampling, epifaunal trawls and CTD profiling within Swansea Bay as part of the subtidal benthic characterisation for the Project was undertaken on 4th – 8th May and 18th June 2013. The survey comprised:
 - i. 59 sites for sediment sampling;
 - ii. 49 sites for benthic samples;
 - iii. 10 CTD (Conductor, Temperature and Depth) salinity profiles; and
 - iv. 7 epifaunal trawls.
- 6.2.2.2 The 59 sediment sampling sites were located both in the Lagoon and in the surrounding area. The sites comprised 49 sites for benthic analysis (27 samples from within Project



footprint and 22 samples from the surrounding area), 59 sites for particle size analysis (PSA) and 17 sites for metal analysis. In terms of the benthic 3 replicates were collected from each of the 49 sites, but only one was processed to “characterise” the benthic ecology in the area. The remaining two samples from each site have been stored for selective further analysis (see Section 6.3.2). Details of survey findings are presented in Chapter 8 Intertidal and Subtidal Benthic Ecology and also contained within the Swansea Bay Tidal Lagoon Benthic Data Report (Titan, 2013).

6.3 Pre-construction

6.3.1 Intertidal Survey at Mumbles Pier

6.3.1.1 The area around Mumbles Pier inside Swansea Bay is recognised as particularly species-rich. Oakley (2011) recorded 91 species in the intertidal area since 2004. The area is generally rocky with much artificial hard substrate and it appears that the habitat properties in the area are suitable for many invertebrate, algae and fish species.

6.3.1.2 The intertidal area around Mumbles Pier is more sheltered than other parts of Swansea Bay since Mumbles Head provides protection from south-westerly winds, currents and exposure to waves. Habitats include boulder fields, shallow pools and mixed sands, but also man-made structures such as overflow pipes, and legs and joists of the pier and lifeboat station. It appears that the man-made artificial substrates are particularly valuable for biodiversity, and naturalists and scientists emphasise that these structures should not be removed from the area, even if they are not used any longer (Oakley, 2011).

6.3.1.3 The Mumbles Pier area is generally rocky with good biodiversity of species as such some of the habitat features from here could be replicated within the design of the Lagoon seawalls, particularly on the outside of the seawalls. Within the Lagoon it may be feasible to replicate the natural mixture of rocky and soft shore habitat elements.

6.3.1.4 It is proposed to carry out a detailed analysis of the Mumbles Pier area, separate the different habitat features and determine their individual contribution to the biodiversity of the area. A field survey of the intertidal areas will be carried out and the topography and substrata between the Knab Rock slipway and Mumbles Head will be recorded. The flora and fauna of the intertidal area will be identified in the field; rarer species may need closer inspection in the laboratory. Further, the design of the Project will be examined to establish which area of the seawall would provide the most similar conditions to the Mumbles Pier area.

6.3.2 Benthic Survey

6.3.2.1 As identified above in the description of the baseline surveys, 3 replicate samples were collected at each benthic sampling site and one replicate was analysed to “characterise” the study area for the EIA. In order to further clarify the baseline subtidal environment prior to construction, the remaining two replicates from 20 of the sites will be analysed for infauna (PSA and metal analysis have already been carried out). The sites have been selected based on a number of factors, as identified below, and they represent a good coverage of where potential change may occur, as well as control sites.

6.3.2.2 In selecting sites, the following factors were considered:

- i. faunal classification during Characterisation Survey (see Figure 6.1 and Appendix A).
- ii. extent of effect of the Project
- iii. sites of a similar substrate outside the tidal influence of the lagoon.
- iv. sites within the lagoon footprint.
- v. sites outside of the lagoon but within its zone of tidal influence.
- vi. geographic distribution.

6.3.2.3 Figure 6.1 shows the location of all the characterisation sites undertaken for the EIA. Figure 6.2 the predicted difference in mean spring tidal flow (relative change) from the Coastal Processes assessment. This figure illustrates the extent of potential effect as a result of the Project.

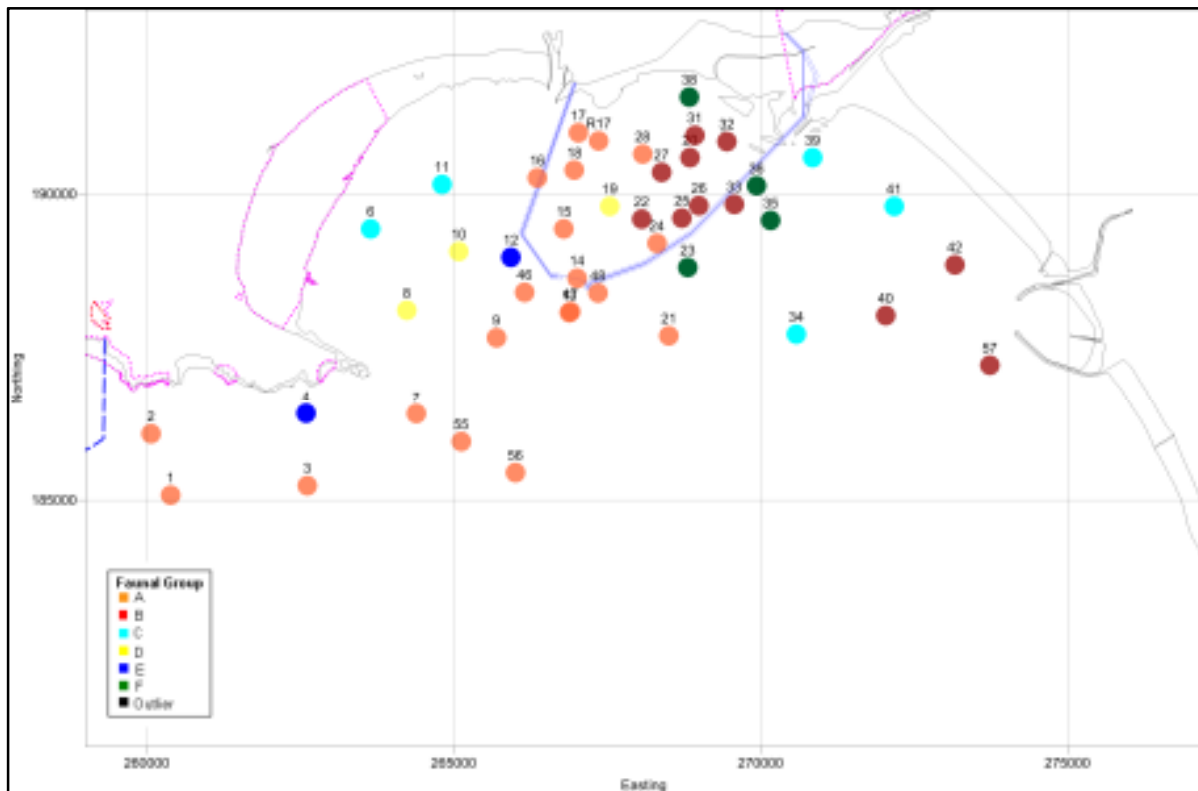


Figure 6.1 Location of all Benthic Sampling Sites and Faunal Groupings

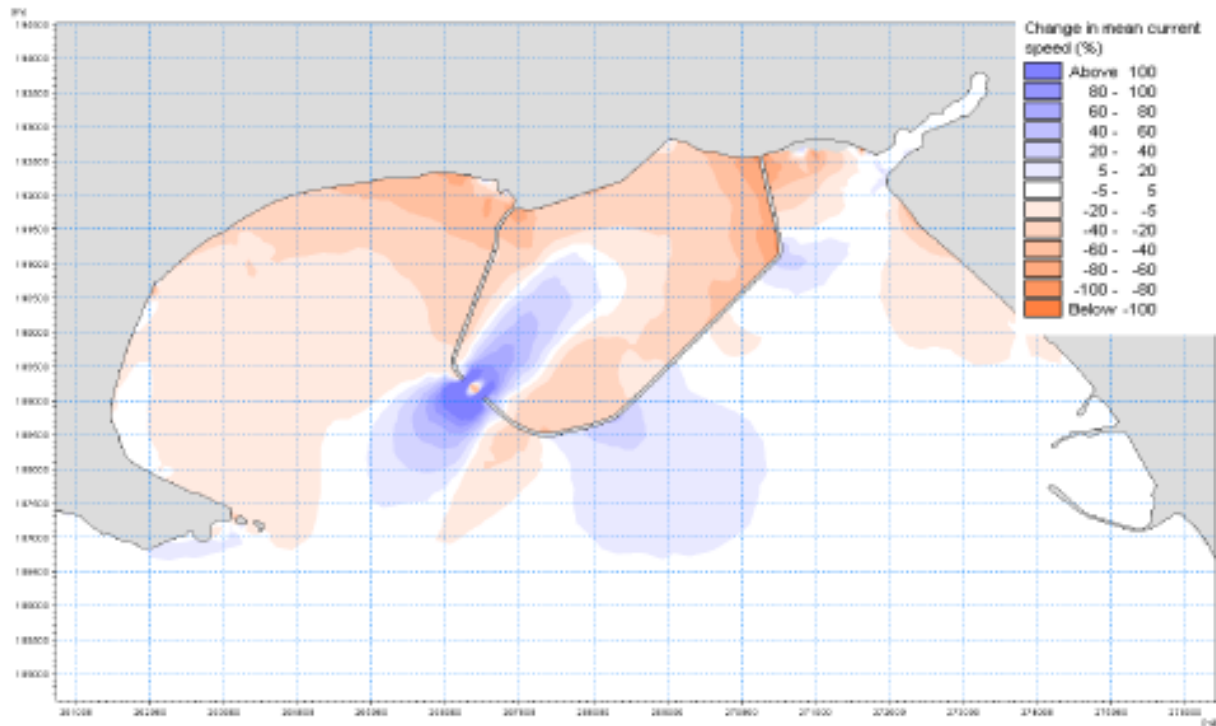


Figure 6.2 Predicted difference in mean spring tidal flow (relative change)

- 6.3.2.4 Based on the results of the EIA, twenty sites have been selected where replicate analysis will be undertaken and these are shown in Table 6.1. Site 1, 42 and 57 are proposed as a control sites and are located outside the influence of the Project. As such they will therefore fulfil the 'control' requirement in the Before After Control Impact (BACI) approach.
- 6.3.2.5 Ongoing monitoring during the subsequent phases of the Project will be undertaken at these sites following the survey methodology used for the survey identified in Section 6.2.2. Such surveys will be undertaken at regular intervals, which will be identified prior to the commencement of operation of the Project.

**Table 6.1: Proposed Benthic Sites for Replicate Analysis and Ongoing Monitoring**

Proposed Sites for Ongoing Monitoring						
Site	Selection	Sediment Type observed	Faunal Group (identified during Benthic Survey 2012)	Infauna	PSA	Metals
1	Outside Tidal Influence	Gravelly Sand	A	Y	Y	Y
4	Within Tidal Influence	Sand	B	Y	Y	Y
6	Within Tidal Influence				Y	
10	Within Tidal Influence	Sand	D	Y	Y	Y
11	Within Tidal Influence	Sand	C	Y	Y	Y
12	Within Tidal Influence	Sand and Gravel	E	Y	Y	Y
15	Inside Lagoon	Gravelly Sand	A	Y	Y	Y
16	Within Tidal Influence	Gravelly Sand	A	Y	Y	Y
18	Inside Lagoon	Gravelly Sand	A	Y	Y	Y
19	Inside Lagoon				Y	
21	Within Tidal Influence				Y	
22	Inside Lagoon				Y	
27	Inside Lagoon	Muddy Sand	B	Y	Y	Y
32	Inside Lagoon	Muddy Sand	B	Y	Y	Y
35	Within Tidal Influence	Sand	F	Y	Y	Y
38	Inside Lagoon				Y	
41	Within Tidal Influence				Y	
42	Outside Tidal Influence	Sand	B	Y	Y	Y
55	Within Tidal Influence				Y	
57	Outside Tidal Influence	Sand	B	Y	Y	Y

6.3.3 Sabellaria translocation

- 6.3.3.1 One of the key issues for the lagoon in terms of intertidal and subtidal ecology is the mitigation and enhancement of tube-worms in the genus, *Sabellaria*, which build habitats, termed biogenic reefs. Habitats such as these often support a wide range of species, and they are offered protection under UK law. The proposed Project will have a direct impact on this habitat and to this end a translocation programme has been designed.
- 6.3.3.2 Although, the effectiveness of translocation mitigation for *Sabellaria* is not proven, it will be implemented to optimise the potential for colonisation of the habitat created as a result of the Project, as well as for the benefit of enhancing scientific knowledge. Although factors will affect the effectiveness of the outcome and consequentially effect the confidence is placed in the mitigation it remains important to implement such measures.
- 6.3.3.3 Areas colonised by *Sabellaria alveolata* in Swansea Bay and in the vicinity of the Project were identified through intertidal mapping undertaken as part of the baseline for the EIA (see Section 6.2.1). Prior to the construction works the extent of these area will be reconfirmed and suitable temporary sites holding sites will be identified for sub sample of *Sabellaria* directly affected by the Project footprint.
- 6.3.3.4 In addition an assessment of reef vitality within the area that will be affected by the construction of the Project will be carried out by quantifying the number of tubes occupied by worms by analysing core samples. Blocks containing tube works will then be translocated to the area identified as potentially suitable. It is recognised that this approach is experimental and it is proposed that the SEACAMS project will assist with the translocation programme.



6.3.4 Oysters

- 6.3.4.1 Oyster dredge trawls of the lagoon footprint and areas to be disturbed during construction works will be undertaken. It is proposed that any oysters identified will be translocated to the Centre for Sustainable Aquatic Research (CSAR) at Swansea University whilst construction works are ongoing, where their spawning behaviour and spat development will be monitored.

6.4 Construction

6.4.1 Surveys of seawalls – intertidal colonisation and invasive species

- 6.4.1.1 A walkover survey will be carried out bi-annually extending to low water, if the construction work allows safe access, to assess the initial colonisation of rock armour in the intertidal area. Photographic records will be taken of hard substratum at fixed points and records of species present will be identified in the field. Where possible the photographic survey locations will form the operational monitoring sites (Section 6.5.1). The presence of invasive species will be monitored as part of the seawall survey. Any records of invasive species will be immediately reported to the statutory authorities.

6.4.2 Intertidal areas

- 6.4.2.1 No surveys proposed.

6.4.3 Monitoring of translocated Sabellaria during construction

- 6.4.3.1 Translocated reef blocks will be assessed for the survival of Sabellaria tube-worms by taking core samples from the reef blocks. The study will compare the vitality of the Sabellaria before and after translocation and also examine the vitality of the species in non-translocated reefs. Surveys will be carried out bi-annually during the construction phase.

6.5 Operation

6.5.1 Surveys of seawalls – intertidal and subtidal and invasive species

- 6.5.1.1 The intertidal section of the seawalls will be monitored. A number of representative transects of the wall will be fixed as permanent monitoring sites at various locations around the lagoon, with differing levels of exposure. The colonisation process will be monitored by photographic recording and mapping of a 0.5m corridor from the upper intertidal to lower intertidal area. Initially transects will be monitored twice per year in spring and autumn, and after two years the monitoring frequency will be reduced to once per year for the following 3 years.
- 6.5.1.2 Once the walls are completed divers will be used to carry out a survey of the submerged sections of the lagoon wall. The visibility in Swansea Bay is generally poor and diving will only be possible after several days of dry weather with little run-off from the catchment areas, and after periods of calm weather. Underwater cameras will be deployed either stationary or from a RIB to record motile fauna at the foot of the lagoon wall. Special attention will be paid to crustacea and fish. The results of this survey will be evaluated and if effective the survey will be repeated in Year 3 and Year 5 operation. Thereafter the need for further survey would be determined.



- 6.5.1.3 The intertidal and subtidal surveys discussed above will check for the presence of non-native marine species. Additionally there will be a general walk-over survey once per year paying particular attention to key species such as the Pacific oyster or invasive seaweeds, to reduce the risk that such species are missed in the transect surveys. Any records will be immediately reported to the statutory authorities. Swansea Bay is already colonised by invasive species such as the barnacle *Elminius modestus*, which is likely to colonise the rock armour. Special attention will be paid to invasive species not currently recorded in Swansea Bay. Appropriate measures will be established for any invasive species found to be present. These measures will depend on the nature of the species, and whether the species is exclusively found associated with the lagoon or in the wider coastal area.
- 6.5.2 Oysters**
- 6.5.2.1 Oysters stored in CSAR will be relocated to the spatting ponds constructed as part of the Project. The successful production of offspring from oysters in spatting ponds is affected by many variables, including site specific factors and the condition of the oysters. As such the oyster enhancement programme will be adapted.
- 6.5.2.2 The production of spat in hatcheries is a well-documented process. However, the physiological condition of oysters differs and the process has to be trialled and optimised. The preliminary aim is to stock 3-5 discrete areas inside the Lagoon with oysters from the spatting ponds and/or hatchery. The exact location depends on sediment and hydrodynamic conditions within the lagoon. It is anticipated that there will be suitable subtidal areas, but possibly also intertidal areas; in Swansea Bay native oysters are naturally found in lower intertidal areas, although in low numbers.
- 6.5.2.3 In order to create control areas, ideally it would be proposed to stock a similar number of sites outside the lagoon, but inside the application boundary area. However, if possible other sites with different environmental conditions could be considered within the wider Bay, although the feasibility of this will be discussed with the appropriate authorities at the time. The growth and survival of oysters inside and outside the lagoon will be monitored by boat sampling and underwater cameras. The extent to which the created oyster reefs support biodiversity compared with other habitats will be assessed.
- 6.5.2.4 TLSB seeks to undertake research in collaboration with SEACAMS and Swansea University to address current knowledge gaps. With regard to oysters this could be questions regarding their impact on water quality and algal composition, effects of harmful algal blooms (HABs) or climate change related issues such as ocean acidification (OA) and the calcification of shells. As with the water quality the Lagoon has the potential to be a “living laboratory”.
- 6.5.2.5 The development of a method that utilises a tidal lagoon for the creation of oyster reefs will depend on a series of experiments and optimisation stages. Each stage may have to be adapted to site specific conditions, technical feasibility and nature conservation requirements. However, the longevity of the tidal lagoon allows a step-by-step adaptive process and TLSB aspires to develop a procedure that can be transferred to other lagoons or similar structural developments. If successful the method could be rolled out to assist oyster restoration programs in other areas.



6.5.3 Intertidal benthic

- 6.5.3.1 Monitoring of intertidal habitats will be undertaken in year 1 following the completion of construction and again 5 years following completion, to validate the impact predictions made in the ES. Survey methodology will follow those undertaken during the baseline surveys for ease of comparison of results. Assessment of the results will be reported 6 months post survey. Particular focus will be made of the extent and quality of protected features, including Sabellaria extent both within Swansea Bay, within the lagoon and lagoon walls and at translocation sites.

6.5.4 Benthic Surveys

- 6.5.4.1 Subtidal surveys will be repeated at the twenty sites identified above in order to assess change. The survey methodology used in the EIA will be repeated in year 1 following completion of construction and again 5 years following completion. The need for further surveys will be considered in the relevant annual report. Replicated samples will be collected analysed from the 20 sites for PSA and infauna. Metals (Aluminium, Arsenic, Barium, Cadmium, Chromium, Copper, Iron, Mercury, Nickel, Lead, Tin, Vanadium, Zinc, Total Petroleum Hydrocarbons, Tributyl Tin) will be analysed at 10 of the sites.



7.0 Fish, including Recreational and Commercial Fisheries

7.1 Introduction

- 7.1.0.1 Chapter 9 Fish, including Recreational and Commercial Fisheries in the ES provides details of the data review and site specific survey work carried out to collect baseline information for Swansea Bay. This section outlines the further monitoring and surveys proposed for the various phases of the Project.
- 7.1.0.2 Prior to construction commencing it is proposed to continue the characterisation surveys commenced in Winter 2012 and completed over 2013 for a further year, although the number of sites will be refined but the scope of these surveys is likely to be expanded to include aspects such as predation, target species etc. as discussed below. In addition, surveys are proposed to confirm locations of herring spawning in Swansea Bay prior to construction. Analysis of data recorded on rivers as part of the National Fish Monitoring Programme and at the River Afan fish counter is also proposed to further examine migratory fish populations within the area.
- 7.1.0.3 When the Project is operational, it is proposed to examine fish populations within and around the Lagoon by a variety of survey methods. Monitoring of herring spawning at the artificial habitat areas created as part of the Project is also proposed. Data analysis for the rivers entering Swansea Bay as described above would be continued. Surveys are also proposed to the potential for collision, through the operational turbines.
- 7.1.0.4 Mariculture proposals i.e. reintroduction of the native oyster is discussed in Section 6 Intertidal and Subtidal Benthic Ecology.

7.2 Baseline

7.2.1 Quarterly fish surveys – characterisation

- 7.2.1.1 For a detailed account of survey methodologies, please refer to Appendix 9.2 Quarterly survey reports of the Environmental Statement. A summary of the methods used in site-specific surveys is provided below.
- 7.2.1.2 Four surveys involving intertidal and subtidal techniques were conducted at 6 sites intertidal and 6 subtidal sites. Surveys were: Quarter one (winter 2012); Quarter two (spring 2013); Quarter three (summer 2013) and Quarter four (autumn 2013).
- i. Intertidal surveys involved two surveying methods: a beach seine net (43 m long by 4 m deep, with 6.5mm knotless mesh) set from a small rigid vessel; and a Riley push-net (1.5 m wide by 30 cm deep with 1 mm fry mesh) used from the shore.
 - ii. The subtidal surveys were carried out from a 12.1 m mono-hull trawler using both otter and beam trawls.
 - iii. For each survey the catch was identified to species level and measured to the nearest millimetre; fish were sub-sampled when > 50 specimens of the same species were captured.



7.3 Pre-construction

7.3.1 Fish surveys

7.3.1.1 In 2014, four surveys involving intertidal and subtidal techniques are proposed: Quarter one (spring 2014); Quarter two (summer 2014), Quarter three (autumn 2014) and Quarter four (winter 2014). The scope of the surveys would be developed in consultation with NRW based on the findings of the ES. These surveys would build upon the characterisation survey undertaken for the baseline in 2013 as described above, by utilising selected sampling sites and methods. In addition it is proposed that the surveys would also look into targeting particular species of interest (e.g. herring) whilst taking into consideration long term data sets and other routine and non-routine sampling undertaken in the Bay.

7.3.2 Herring spawning

7.3.2.1 In addition, surveys are proposed that will further identify herring spawning sites within Swansea Bay. Survey methods would be confirmed with NRW, but it is anticipated that herring spawning aggregations would be identified using hydroacoustic equipment. When a spawning aggregation is identified, a drop down camera could be used or alternatively a small dredge could be undertaken to collect egg samples. It is proposed to liaise with local fishermen who regularly fish the Bay to identify when herring are within the Bay so that surveys can be carried out at an appropriate time.

7.3.3 National Fisheries Monitoring Programme

7.3.3.1 NRW undertake routine monitoring of fish fauna in the freshwater catchments that feed into Swansea Bay. Local angling clubs have historically complemented this programme¹ by funding ad hoc monitoring. The survey methodologies employed typically bias the surveys towards determining the abundance of juvenile life stages. The data sets would be analysed and areas where further surveys at historic stations may be required to improve the resolution and statistical robustness of these programmes would be identified so that an assessment could be made of the potential effect of the Project.

7.3.3.2 If areas are identified where further surveys may be required, it is proposed that this would involve quantitative electric fishing surveys at historic stations within identified catchments (and a control site). Surveys located in known nursery habitat would record species, length and abundance of fish fauna.

7.3.3.3 It is proposed that data analysis and where required, further surveys would be continued through the construction phase and into the operational phase of the Project.

7.3.4. River Afan Fish Counter.

7.3.4.1 A compound super-active bottom baffle fish pass was installed in 2012 at the tidal limit of the River Afan at Green Park Weir, Port Talbot. A video camera was fitted in to the upstream exit of the pass to enable the effectiveness of the pass to be assessed. NRW have operated the camera since the pass was installed however the data has not been analysed to date. It is proposed that the data, both historical and ongoing, would be analysed to provide information on stocks of returning migratory fish.

¹ Afan Valley Angling Club



- 7.3.4.2 As for the data analysed as part of the National Fish Monitoring Programme, It is proposed that analysis of data from the River Afan fish counter would be continued through the construction phase and into the operational phase of the Project.

7.4 Construction

- 7.4.1.1 No construction surveys are proposed.

7.5 Operation

7.5.1 Fish surveys

- 7.5.1.1 Further fish surveys are proposed for the operational phase of the Project based on the methodologies and sampling locations used for the baseline and pre-construction surveys. The scope of the surveys would be further refined in consultation with NRW based on the findings of the ES and the surveys undertaken pre-construction as described above. The findings would be analysed taking into consideration long term data sets and other routine and non-routine sampling undertaken in the Bay.

- 7.5.1.2 The scope of these surveys would also consider that the construction of the lagoon seawalls will afford increased spawning, juvenile, foraging and refuge habitat to a variety of species of fish and invertebrates. It is proposed that the surveys would also be designed to assess the colonisation and development of the lagoon seawall (reef) and the diversity and abundance of associated fish fauna.

- 7.5.1.3 It is proposed to undertake a suite of surveys within the range of habitats created by the Project that include fine sediment environments of the inner lagoon, sub-tidal rocky habitats and intertidal rock pools. Intertidal and subtidal benthic ecology surveys are discussed in Section 6 and these surveys may be combined and/or the data used to assess the potential effects of the Project on fish and shellfish populations. Surveys may include:

- i. *Fine sediment environments*: potential use of beach seining, push nets, small beam trawls, drop trapping and fyke netting
- ii. *Subtidal Rocky Habitats*: potential use of fyke netting, trapping, diving transects and baited remote underwater video (depending on turbidity of water and spatial scale of surveys required).
- iii. *Intertidal rockpools*: sampling by anaesthetisation, hand netting and visual assessment.

7.5.2 Herring Spawning

- 7.5.2.1 Artificial spawning material for herring shoals that are currently known to spawn within the Bay will be provided at the base of the seawalls (see Chapters 9 and 23 of the ES). It is proposed to monitor the artificial spawning medium and a number of techniques are being considered including:

- i. Placement of artificial substrate that can be readily removed and assessed
- ii. Direct observation by diving and observers
- iii. Fixed transect monitoring by divers
- iv. Drop down cameras (depending on turbidity of the water)
- v. Sonar – fixed and vessel based.



7.5.3 Predation

- 7.5.3.1 The construction of the Lagoon seawall along the dredged navigation channels of the Neath and the Tawe is designed to increase fish fauna productivity of the near shore environments. However this may in turn result in the increased predation of emigrating juvenile salmonid fish.
- 7.5.3.2 Monitoring of birds before and after construction within the vicinity of the Project would assist in the assessment of the potential impacts of the Project upon fish stocks. Seasonal observation of the abundance and diversity of fish eating birds in the vicinity of the Project, recording foraging activity would provide information to assess this effect. Data has already been collected during coastal bird surveys undertaken as part of the baseline EIA and further surveys are proposed for the operational phase as described in Chapter 9.
- 7.5.3.3 Predatory species may be attracted to the reef environment of the lagoon walls as a result of the increased productivity of prey species resulting from the design of the complex and heterogeneous environment. Migratory juvenile fish may concentrate along these walls as they move out of the estuaries, running the length of the new reefs that will afford enhanced habitat and foraging grounds for cryptic or pursuit predators such as e.g. bass. The seasonal abundance and diversity of fish eating fish complimented with stomach analysis to determine diet would contribute to an understanding of the impact these predators may have on emigrating migratory fish.
- 7.5.3.4 It is proposed that data be collected from anglers using the seawall on both an *ad hoc* basis as well as during angling competitions. Data collected would include species, weight and length as well as stomach content if possible.
- 7.5.3.5 In addition to this, seasonal surveys to determine catch per unit effort of predatory fish species will be considered as a means of collecting further data. If progressed, stomach analysis from a sample of the predators encountered will be undertaken to determine prey items.
- 7.5.3.6 The frequency and need for ongoing data analysis and continued surveys would be proposed and reviewed based on a comprehensive, holistic review of the findings of studies undertaken for the Project and discussions with NRW.

7.5.4 National Fish Monitoring Programme

- 7.5.4.1 It is proposed that data analysis and where required, further surveys would be continued through the construction and operational phases of the Project. The frequency and need for ongoing data analysis and continued surveys would be reviewed based on a comprehensive, holistic review of the findings of studies undertaken for the Project and discussions with NRW.

7.5.5 River Afan fish counter

- 7.5.5.1 As for the data analysed as part of the National Fish Monitoring Programme, it is proposed that analysis of data from the River Afan fish counter would be continued through the construction and operational phases of the Project. The frequency and need for ongoing data analysis would be reviewed based on a comprehensive, holistic review of the findings of studies undertaken for the Project and discussions with NRW.



7.5.6 Angling

7.5.6.1 Angling opportunity and desirability to fish from the lagoon wall may be assessed both by angler surveys (creel census) or by multiple fixed CCTV. Time lapse images of the latter can be analysed to determine the density of anglers, tide or time of day preference, type of angling experience afforded i.e. static fishing on the bed, float fishing or spinning. Method of angling may often be used to determine target species.

7.5.6.2 Angler “surveys” would be encouraged in that anglers using the lagoon seawall are to be requested to record their catches. These “surveys” could be implemented as part of licence conditions for anglers using the seawall. In addition, it is proposed to hold angling competitions and for information about fishing effort and fish caught e.g. numbers, species, size, etc. to be recorded.

7.5.7 First Movements of Salmonid Smolts and Smolt Behaviour in the Bay.

7.5.7.1 It is proposed to consider survival of salmonid smolts in the lower reaches of the River Tawe and during their first forays into the marine environment. It is perceived that the Tawe Barrage has removed migratory cues within the lower river that delays passage into the marine environment. It is known that there is a limited window of opportunity for smolts to successfully make the transition from freshwater to marine environments and delays to their migration may significantly reduce the marine survival of these sub-adults making them more prone to predation. Further the dispersal and behaviour (i.e. swimming speeds) of smolts in to the Bay is not fully understood. Enhanced understanding of this component of their life history would enhance the power of models such as the IBM currently used to predict the behaviour and fate of fish both in Swansea and at future developments, as well as validating some of the rule sets applied to these species within these models. The patterns of migration of smolt from the River Neath and River Tawe are likely to be well captured in the IBM, because the currents are well defined and the smolts are relatively weak swimmers and thus at the mercy of currents to a high extent. It is evident, based on the coastal processes of the area that all the smolts exiting Swansea Bay and heading to the sea will pass closest to the coast just south of the Mumbles. Therefore there is an opportunity to reliably monitor their movements at some distance from their natal river mouths by placing acoustic transceivers in this area.

7.5.7.2 A potential survey method that could be employed and which will be investigated further comprises:

- i. capture of smolts at Tawe Barrage;
- ii. apply acoustic tracker,
- iii. release after habituation to marine water
- iv. deploy acoustic transceivers within Bay
- v. monitor movement within and external to lagoon.

7.5.7.3 The transceivers could potentially be placed at the exit to the river (to monitor leaving, waiting and returning smolts), at the entry to the turbines and sluice gates, inside and outside the lagoon, and off the south of the Mumbles. If implemented the survey would be undertaken once in the first three years of operation and the results reported within the annual report.



7.5.8 Turbine collision

- 7.5.8.1 Surveys are proposed to assess fish pass through the turbines. Methods are currently being refined due to the complexity of sampling in areas of high flow, but it is considered feasible to position a small fishing vessel with a bass trawl downstream of a turbine and collect a number of trawls over a defined period. Flow from one turbine would be monitored. The fishing boat could be repositioned to monitor fish pass through the different turbines.
- 7.5.8.2 An alternative method of survey would involve fixed position sonar. Devices such as Simrad SH80 omnidirectional fisheries sonar have been reliably used to detect and survey schools of fish such as herring up to about 400m in range in a circular pattern around a fixed point. These devices could be placed in a fixed position on the sea bed at 200 m outside the lagoon adjacent to the turbine array. They could be powered from the offshore O&M facility and set to continually store data back at this location. This survey method would have the benefit of continuous monitoring of fish and predator activity in relation to the turbines and would provide an unprecedented level of quality and continuity in monitoring fish populations, in a large area of the bay near the turbines.
- 7.5.8.3 A custom machine learning application would be an advantage with respect to analysis of the continuous streams of data that would be too large for a person to analyse by eye. This device could be used to categorically demonstrate avoidance behaviour and its effectiveness, and behaviour related to sound, or currents. These data would be invaluable to develop understanding and new science around the impact of the turbines and their effects on behaviour of marine animals. This device would also have the great advantage of storing the conditions and events leading to injury or death of marine mammals if this occurs and thus offers some potential for effective mitigation.
- 7.5.8.4 Devices similar to the fisheries sonar mentioned above have been installed near standalone tidal turbines to monitor the interaction of mammals up to around 60m away with the devices. Reference: Hastie, G.D. (2012). Tracking marine mammals around marine renewable energy devices using active sonar. SMRU Ltd report URN:12D/328 to the Department of Energy and Climate Change. September 2012 (unpublished). In this case it is assumed that the sonars are attached to the turbine structures themselves and monitor a wedge shaped area around 60 m in extent. Several devices would be required to cover the full array.
- 7.5.8.5 An alternative to above would be vessel based sonar. Similar devices to that mentioned above but vessel attached and thus intermittent surveys. These devices would be useful to monitor herring and other transitory fish populations. They give a reliable and independent estimate of presence and abundance, but are ephemeral and so would need to be carefully targeted in time.

7.5.9 Acoustic deterrents

- 7.5.9.1 Chapter 9 of the ES proposes the use of acoustic deterrents to reduce the potential turbine collision risk. The Chapter identifies that noise surveys should be undertaken prior to installation of the devices. Noise surveys are discussed in Section 11 of this Report.
- 7.5.9.2 The sonar surveys outlined above could also be used to determine the effectiveness of acoustic deterrents, as well as passage of fish through the sluice gates when the deterrents are turned off during sluicing.



8.0 Marine Mammals and Turtles

8.1 Introduction

- 8.1.0.1 Chapter 10 Marine Mammals and Turtles of the ES provides details of the data review and site specific survey work carried out to collect baseline information for Swansea Bay. This section outlines the further monitoring and surveys which will be undertaken during the pre-construction, construction and operational phases, in order to review and confirm the findings of the EIA.
- 8.1.0.2 A European Protected Species (EPS) Licence will be obtained in respect of harbour porpoise prior to the construction of the Project commencing. Discussions will be held with NRW to obtain this licence and further monitoring may be required as part of this process. Any additional measures will be incorporated within the final, pre-commencement iteration of this AEMP.
- 8.1.0.3 Monitoring will be undertaken to collect further information on the usage of the Swansea Bay area by marine mammals. Data will be collected on the potential effects of construction noise, principally impact/percussive piling (if undertaken). Once operational, the potential noise effects of the operation of the turbines and the potential risk of collision will be examined.

8.2 Baseline

- 8.2.0.1 The scope of works for the assessment of the potential effects of the Project on marine mammals and turtles was presented in the Proposed Tidal Lagoon Development in Swansea Bay, South Wales, Environmental Impact Assessment Scoping Document (October 2012). Numerous sources of information were reviewed to inform the marine mammal baseline description, although it was determined that site specific surveys were not necessary. These include a number of national and regional studies to provide information on marine mammal distribution and ecology. This data was used to inform the understanding of the relative importance and functionality of the Bristol Channel and Swansea Bay in the context of the wider Celtic Sea area.

8.3 Pre-construction

8.2.1 Usage surveys

- 8.2.1.1 A long-term acoustic monitoring programme for harbour porpoises is being established in the proposed Lagoon footprint and the wider Swansea Bay area. These surveys are being undertaken in 2014 to examine the use of Swansea Bay by harbour porpoises, and to determine if there are any seasonal patterns to usage.
- 8.2.1.2 Two C-PODs were purchased by TLSB in 2013 and in conjunction with SEACAMS and they were deployed in November 2013 for an initial month of calibration. These C-PODs will be redeployed as part of this on-going study. The C-PODs will be positioned within the Lagoon footprint and outside the area to provide a control site. The survey will involve the use of in total four C-PODs, 2 at the lagoon site and 2 at a designated control site (off Mumbles), the exact locations will be dependent on mooring logistics and permit restrictions. Data will be collected on the presence and absence as well as foraging frequency and intensity for harbour porpoises. Monitoring will continue during



construction and operation. Data will be analysed to determine daily and seasonal patterns. The results of the surveys will inform the subsequent monitoring strategies.

- 8.2.1.3 The C-POD data collection will be supported by additional surveys for grey seal. The initial scope of surveys will be developed in conjunction with SEACAMS. These could include boat based work or site surveys at potential haul out sites along the Gower.

8.3 Construction

8.4.1 Usage surveys

- 8.4.1.0 The C-POD surveys commenced pre-construction as describe above will continue through the construction phase.

8.4.2 Marine noise monitoring

- 8.4.2.1 Mitigation proposals for impact piling are described fully in Chapter 23 of the ES. These include the use of the JNCC (2010) protocol for piling activities (soft start procedure) if impact piling is required, the presence of a Marine Mammal Observer and the use of passive acoustic monitoring.
- 8.4.2.2 Marine noise surveys at key receptor locations will be undertaken for impact piling as outlined in the noise section of this report (Section 11). If impact piling is required, and there is sufficient advance notice available, additional marine mammal observers would be based on survey vessels in the vicinity of the site, as well on strategic locations in the bay. This would allow the extent of behavioural change and relative abundance to be assessed before and during noise generating activities. JNCC protocols for observation will be followed.

8.5 Operation

8.5.1 Usage surveys

- 8.5.1.1 The C-POD surveys commenced in the pre-construction phase will continue into the operational period. The data collected will be regularly reviewed and will be used to refine the extent of on-going surveys.

8.5.2 Turbine collision risk

- 8.5.2.1 Monitoring of marine mammals will be undertaken following completion of construction of the Project. The results of the monitoring will be regularly reviewed and reported on an annual basis to ensure that the most appropriate collision risk mitigation package is in place. The content and duration of the monitoring programme will be agreed with NRW based on further discussion as part of the EPS licensing conditions. Monitoring may include detection of mammals using both surface detection (using a qualified Marine Mammal Observer) and an active sonar system. This combination was used successfully to monitor collision risk at Strangford Lough SAC (Royal Haskoning, 2011). For Strangford Lough active sonar relied on 24-hour a day manual monitoring. However, SMRU have recently been developing software for the detection and classification of marine mammals using active sonar which could be developed as part of an automated system (Hastie et al, 2012).



- 8.5.2.2 The use of an acoustic deterrent device is proposed as a mitigation measure for the potential turbine collision risk (see Chapter 10 Marine Mammals and Turtles and Chapter 23 Mitigation and Monitoring). Studies to assess the noise effects of the acoustic deterrents on fish are identified in Section 7 of this report and this would also be used for marine mammals. In addition, noise monitoring of the operational turbines prior to the installation of the acoustic deterrents will also be undertaken as outlined in Section 11 of this Report.
- 8.5.2.3 To assess the potential noise effects of the operational turbines and the effectiveness of acoustic deterrents to reduce the risk of turbine collision, marine mammal reaction to generated noise could be quantified using both acoustic dataloggers and visual observation from survey vessels in the vicinity of site, using established guidelines. This data will be used together with research previously undertaken (e.g. See for example: Dawson et al (2013), To ping or not to ping: the use of active acoustic devices in mitigating interactions between small cetaceans and gillnet fisheries, Endangered Species research Vol. 19: 201–221, 2013) to determine the suitability for using acoustic deterrent devices.
- 8.5.2.4 Any collision events or near misses will be recorded and an appropriate reporting mechanism will be set up to report such events to the appropriate authorities and to inform the mitigation and monitoring protocols, as well as being reported annually. A strategy will be developed to locate any collared (injured or dead) animals and appropriate measures will be taken to deal with carcasses. Further details of mitigation measures for marine mammals associated with turbine collision or if an animal becomes isolated within the lagoon are described in Chapter 23.

8.5.3 Carcass Surveillance

- 8.5.3.1 It is understood that at present any carcasses which are washed ashore tend to be reported and assessed. Within the monitoring programme identified above, the need for regular additional monitoring for carcasses, post mortem evaluation of carcass stranding and assessment of cause of death will be ascertained and linked into any existing programmes. Routine surveillance for carcasses will be undertaken and liaison with the UK Cetacean Strandings Investigation Programme (CSIP) concerning existing shoreline surveillance which covers key areas which are predicted to be hotspots for strandings, based on local advice and hydrodynamic modelling. Integration of the Lagoon programme would be developed and run in coordination with the CSIP.



9.0 Coastal Birds

9.1 Introduction

- 9.1.0.1 Swansea Bay is important for over-wintering birds with Blackpill SSSI in the west of the bay being notified for its importance as an over-wintering and passage site for waders, particularly Ringed Plover (*Charadrius hiaticula*) and Sanderling (*Caladris alba*). The site is considered of local importance for Oystercatcher (*Haematopus ostralegus*), Grey Plover (*Pluvialis squatarola*), Bar-tailed Godwit (*Limosa lapponica*), Knot (*Calidris canutus*) and Dunlin (*Calidris alpina*).
- 9.1.0.2 Chapter 11 Coastal Birds of the ES provides full details of the data review and site specific survey work carried out to collect baseline information for Swansea Bay. This section outlines the further monitoring and surveys which will be undertaken during the pre-construction, construction and operational phases, in order to review and confirm the findings of the EIA.
- 9.1.0.3 Matters of relevance to the Project include its impact on existing roosting and foraging habitat as well as future use of modified or created habitats. Particular issues include: potential impact on a high tide roost used by Sanderling and Ringed Plover near the Lagoons eastern landfall; the effect on wintering Great Crested Grebes that regularly raft in nationally significant numbers in the east of the bay; in addition to, potential disturbance of birds using Blackpill SSSI. Utilisation of new habitat including rocky shores of the lagoon wall, nesting ledges and intertidal habitat within the Project by birds will also be of interest.

9.2 Baseline

- 9.2.1.1 To inform the EIA and to supplement the more extensive longer term Wetland Bird Survey (WeBS) data. Coastal bird surveys were undertaken within a study area, divided into 23 sectors, that extended from just east of the River Neath to Mumbles Head.
- 9.2.1.2 Wintering bird surveys were completed on a monthly basis (October 2011- March 2012 and September 2012 – March 2013). Additional surveys were carried out in the east of the survey area (between the River Tawe and River Neath) in the summer of 2013 (April-August 2013).
- 9.2.1.3 Survey methodology was based on that used by the British Trust for Ornithology in their Wetland Bird Survey (WeBS), consisting of both Core Count and Low Tide Count methods (Gilbert *et al*, 1998). Generally, Low Tide Counts and are used to determine the spatial distribution of birds across a site whilst Core Counts (carried out at high tide) can give accurate counts of the number of birds using a site.
- 9.2.1.4 Data were also collected on bird movement around the bay and the presence of any water birds (sea-duck, grebe and diver species present). Full details of the survey areas and methodology can be found in Chapter 11 Coastal Birds of the ES and it's supporting Appendices.

9.3 Pre-construction

- 9.3.1.1 No pre-construction surveys or monitoring are proposed.



9.4 Construction

9.4.1 Core and Low Tide Counts

9.4.1.1 The Lagoon construction programme is due to commence when the main over-wintering bird interest of Blackpill will have declined. As such monthly surveys will first be targeted around the east side of the bay (as per the baseline summer surveys). These surveys will continue from commencement of construction year 1 to end of summer year 2.

9.4.1.2 The monthly surveys will be extended to the west side of the bay for the over-wintering period year 1 to year 2. This data will be used to provide a comparison between baseline data and birds using habitat during the construction phase. The results of the survey will be reviewed and the need for surveys in the following years will be ascertained.

9.4.2 Gull Assemblage

9.4.2.1 No specific surveys targeting the gull assemblage are proposed.

9.4.3 Wading and Waterfowl Assemblage

9.4.3.1 Integrated into the surveys identified above (section 9.4.1) specific observations will be undertaken to target the wading and waterfowl assemblage in order to investigate the impact of construction on birds. In particular those using habitat at Blackpill SSSI as well as the high tide roost at Crymlyn Burrows SSSI.

9.4.3.2 Details of the construction will be obtained and surveys would be targeted when particularly noisy construction activities are being carried out which coincide with the presence of birds.

9.4.4 Diver and Grebe Assemblage

9.4.4.1 Integrated into the surveys identified above (section 9.4.1) specific observations will be made of the diver and grebe assemblage in order to investigate the impact of construction on birds using the bay. Details of the construction will be obtained and surveys would be targeted when particularly noisy construction activities are being carried out which coincide with the presence of birds.

9.5 Operation

9.5.1 Core and Low Tide Counts

9.5.1.1 Monthly winter surveys will be undertaken in order to provide a comparison between baseline data and birds using habitat during the construction phase. Core and Low Tide Counts will be undertaken between October and March in years 1, 3, 5 and 10. These will be reported in the ensuing annual reports.

9.5.2 Gull Assemblage

9.5.2.1 Specific surveys and *ad hoc* monitoring will be focused on gull assemblages in years 1, 3, 5 and 10. The objective of the observations will be targeted towards how gulls use the lagoon walls as well as habitat within the lagoon.



- 9.5.2.2 Monitoring will also be undertaken in respect of uptake of the proposed kittiwake nesting ledges (on turbine housing) on an annual basis and will organise any remedial management required.

9.5.3 Wading and Waterfowl Assemblage

- 9.5.3.1 Specific surveys and adhoc monitoring in years 1, 3, 5 and 10 will target the wading and waterfowl assemblage in order to ascertain: the continued use of former high tide roosts; as well as effect of the tidal lag (inside/outside of the lagoon) on foraging behaviour.

9.5.4 Diver and Grebe Assemblage

- 9.5.4.1 Surveys and adhoc monitoring in years 1, 3, 5 and 10 will be targeted to investigate use of the bay by the diver and grebe group and in particular, continued use of the eastern bay or lagoon by Great Crested Grebe.

9.5.5 Features designed for birds

- 9.5.5.1 Monitoring will be undertaken in years 1, 3, 5 and 10 to investigate the efficacy of features designed into the Project. These will include investigation of the roosting features, quiet zones, nesting ledges as well as indirect impacts such as the tidal lag which potentially provides increased availability of foraging habitat for birds using the bay.



10.0 Terrestrial Ecology

10.1 Introduction

10.1.1.1 Chapter 12 Terrestrial Ecology of the ES provides full details of the data review and site specific survey work carried out to collect baseline information for Swansea Bay. This section outlines the further monitoring and surveys which will be undertaken during the pre-construction, construction and operational phases, in order to review and confirm the findings of the EIA.

10.1.1.2 Key issues associated with the Project include its impact on existing and created habitats as well as the presence of protected or otherwise notable species including invasive species.

10.2 Baseline

10.2.1.1 The following site specific surveys were undertaken between 2012 and 2013 to understand the terrestrial ecology baseline environment within the Project study area and along the cable route to Baglan power station:

- i. Phase 1 habitat survey;
- ii. Botanical survey;
- iii. Bat survey;
- iv. Breeding/overwintering bird survey (terrestrial birds);
- v. Otter survey;
- vi. Reptile survey; and
- vii. Invertebrate survey.

10.3 Pre-construction

10.3.1 Coastal Grassland

10.3.1.1 Baseline surveys identified the presence of coastal grassland habitat within areas likely to be disturbed during Project construction. Proposed mitigation measures included retention of habitat at specific locations as well as brush-harvesting of seed, translocation of grassland turves and reuse of topsoil.

10.3.1.2 Brush-harvesting of seed will be required a year in advance of construction.

10.3.1.3 A timetable for translocation and topsoil stripping will be established in order to reduce the amount of time that turves/topsoil are stored. Habitat identified for retention will be defined and protected at the pre-construction stage, in order to protect it from inadvertent disturbance. The identification of species-rich habitat suitable for turf translocation or topsoil stripping will also be required pre-construction at an appropriate time of year. In addition, areas that are to be used for turf/topsoil storage will be identified and demarcated.



10.3.2 Invasive species

- 10.3.2.1 Invasive plant species including Japanese Knotweed were identified during baseline surveys. The locations of these invasive species will require demarcation at pre-construction stage prior to in-situ treatment or controlled removal. A Japanese Knotweed Management Plan will be established to set out a programme of removal, where appropriate.

10.3.3 Notable plants

- 10.3.3.1 Baseline surveys identified the presence of notable plant species, including Golden-samphire, within construction impact zones. Mitigation measures including the translocation of robust species or substrates containing target species have been proposed within the ES. The location of target plants or substrates and areas suitable to act as temporary receptor sites will be demarcated during pre-construction and a timetable for translocation drawn up.

10.3.4 Bats

- 10.3.4.1 No pre-construction monitoring is required.

10.3.5 Otters

- 10.3.5.1 No pre-construction monitoring is required.

10.3.6 Reptiles

- 11.2.1.1 No pre-construction monitoring is needed. However, a Reptile Mitigation Plan is required pre-construction in order to minimise the risk of injury or mortality to the small population of reptiles identified as present.

10.4 Construction

10.4.1 Coastal Grassland

- 10.4.1.1 Checking of any turves/topsoil (e.g. are they sufficiently watered/covered) will continue until the time that supervised translocation of species-rich grassland/movement of topsoil will take place. A monitoring programme will be drawn up throughout the construction phase to assess the success of the translocation/reuse of topsoil mitigation. This is likely to involve a period of visits which will gradually reduce in frequency in response to monitoring findings. Remediation measures will be put in place should monitoring reveal that the mitigation is not working, including weed control, watering and re-seeding with native species.

10.4.2 Invasive species

- 10.4.2.1 The control of Japanese Knotweed will be monitored throughout construction, primarily in line with the Japanese Knotweed Management Plan. Control of other invasive species identified during baseline surveys will also be monitored where required.



10.4.3 Notable plants

- 10.4.3.1 Checking of any translocated plants/substrate will continue until the time that they are moved to a permanent location. A monitoring programme will be drawn up throughout the construction phase to assess the success of both the temporary and permanent translocation. Remediation measures will be put in place should monitoring reveal that the mitigation is not working, including weed control, watering and re-seeding.

10.4.4 Bats

- 10.4.4.1 A construction lighting strategy avoiding light spill to foraging habitat used by bats has been proposed. Monitoring of the placement and illumination of construction lighting will be undertaken during the construction phase to ensure inappropriately placed illumination is repositioned. The monitoring strategy will be developed once final details of site set up have been determined.

10.4.5 Otters

- 10.4.5.1 Proposed mitigation measures to ensure potential impact to Otters is minimised include avoidance of light spill onto open water of the docks and exclusion of high risk construction areas whilst maintaining access for Otters between the docks estate and coastline. These proposals will require monitoring during the construction phase.

10.4.6 Reptiles

- 10.4.6.1 Monitoring will be carried out to ensure retained habitat is clearly demarcated and protected from accidental construction impact.

10.5 Operational Monitoring

10.5.1 Coastal Grassland

- 10.5.1.1 An operational monitoring programme will be drawn up in conjunction with the relevant stakeholders. This is likely to comprise monitoring at an appropriate time of year in years 1, 2, 3, 5, 7 and 10 post-construction. The monitoring may include fixed point quadrats and fixed point photography. Remediation such as weed control will be carried out where problems are identified.

10.5.2 Saltmarsh

- 10.5.2.1 The operational monitoring programme will also cover areas of habitat creation such as saltmarsh. This is likely to include visits at an appropriate time of year in years 1, 2, 3, 5, 7 and 10 post-construction. The monitoring may include fixed point quadrats and fixed point photography. Management may be required should monitoring reveal that habitat creation is not being effective, for example ineffective tidal flooding.

10.5.3 Sand dune

- 10.5.3.1 Sand dune habitat creation is currently proposed at the north-eastern end of the Lagoon. The operational monitoring programme of this habitat is likely to comprise monitoring at an appropriate time of year in years 1, 2, 3, 5, 7 and 10 post-construction. The monitoring may comprise fixed point quadrats and fixed point photography.



Management may be required should monitoring reveal that habitat creation is not being effective, for example removal or reduction of opportunistic 'weed' species.

10.5.3.2 Additional monitoring will be required to assess predicted changes fronting Crymlyn Burrows SSSI. Sand dune movement and accretion will be tied in with the coastal process monitoring as described in Section 4.

10.5.3.3 Further monitoring of habitat within the SSSI will be required to ensure recovery following temporary works associated with cable installation. The detail of any monitoring programme will need to be discussed and agreed with NRW.

10.5.4 Notable plants

10.5.4.1 The operational monitoring of notable plants species will include those of rocky shore vegetation (including Golden-samphire) but also the colonisation of habitat within the Project by others. Monitoring is likely to comprise visits at an appropriate season in years 1, 2, 3, 5, 7 and 10 post-construction. The monitoring may include fixed point photography.

10.5.5 Invasive species

10.5.5.1 The operational monitoring programme will include surveillance visits to those areas where invasive vegetation control has taken place, to ensure efficacy (particularly relevant for Japanese Knotweed) in years 1, 2 and 3 post-construction. Infestations will be dealt with promptly within land under Project control.

10.5.6 Bats

10.5.6.1 In order to confirm the continued use of foraging habitat by bats, it is proposed that remote bat detectors (anabats) are deployed for at least a week duration, bi-annually (between May and September), for three years post-construction. In addition, use of the lagoon wall by foraging bats could also be determined over the same time period using a hand-held bat detector.

10.5.7 Otters

10.5.7.1 Trail cameras (remote cameras triggered by movement or passive infra-red) will be employed in addition to searches for spraint, in the three years post-construction to confirm / identify the continued use of the area by otters.

10.5.8 Reptiles

10.5.8.1 The effectiveness of the reptile mitigation strategy will be monitored including subsequent colonisation of habitat associated with the Project. Given public access within areas likely to support reptiles, monitoring surveys may involve visual assessments rather than surveys, using techniques such as tinning, that are often disrupted by members of the public.

10.5.9 Invertebrates

10.5.9.1 A number of section 42 NERC 2006 invertebrate species were identified from the docks estate during baseline surveys. Additionally, Crymlyn Burrows is notified for invertebrate assemblages as well as presence of the strandline beetle (*Eurynebria complanata*).

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- 10.5.9.2 Post-construction survey of habitats within the Project will be undertaken by the Lagoon Warden on an ad hoc basis but specific surveys will also be commissioned to determine the colonisation of intertidal habitat as well as coastal grassland habitat in years 1, 2, 3, 5, 7 and 10.



11.0 Noise

11.1 Introduction

- 11.1.1.1 Chapter 19 Noise and Vibration of the ES provides full details of the data review and site specific survey work carried out to collect baseline information for the Project area. This section outlines the further monitoring and surveys which will be undertaken during the pre-construction, construction and operational phases, in order to review and confirm the findings of the EIA in relation to potential effects on marine mammals and fish. Chapters 8 and 9 of the ES provide an assessment of the potential effects of the Project on marine mammals and fish respectively.
- 11.1.1.2 Noise monitoring will be undertaken in the marine environment to gain a better understanding of marine noise levels during construction and operation in terms of verifying the findings of the ES in relation to potential impacts on fish and marine mammals.

11.2 Baseline

- 11.2.1.1 Baseline land noise surveys were undertaken at seven sites along Swansea seafront past the Swansea Bay University Campus and the adjacent Crymlyn Burrows Site of Special Scientific Interest (SSSI) along to southern end of Aberafan seafront in April 2013. Measurements were made following guidance from ISO 1996-2:2007 Acoustics – Description, measurement and assessment of environmental noise – Part 2: Determination of environmental noise levels.
- 11.2.1.2 In addition, underwater noise measurements were undertaken in April 2013 at five locations around the proposed Project area. The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) were consulted on the proposed underwater noise measurement methodology prior to the survey, and all measurements were undertaken in accordance with this methodology.

11.3 Pre-construction

- 11.3.1.1 It is proposed to undertake pre-construction noise surveys to examine ambient noise levels at the mouth of the River Tawe and upstream near to the existing barrage. These surveys are proposed to examine the baseline noise within the estuary and the findings will be used to assess the potential effects on fish migration. Survey methods as used for the baseline EIA will be employed.
- 11.3.1.2 Additional baseline noise surveys are proposed in the vicinity of the proposed turbine and sluice gate housing. Possible locations for monitoring sites comprise a site within approximately 500m from the turbine and sluice gate housing and a further site 1000m westwards towards Mumbles. Measurements will be undertaken with a hydrophone suspended from a buoy at a range of depths. Measurements will be recorded close to the surface, at mid-depth and close to the seabed (nominally at 1m, 4m and, where possible due to depth, 8m).

11.4 Construction

- 11.4.1.1 Marine noise monitoring will be undertaken to gain a better understanding of noise generated underwater from marine construction activities. The data collected can then



be used to further inform future assessment work of marine projects. Data would be collected of the various activities such as vibro piling, impact piling (if used), dredging works and rock armour placement.

- 11.4.1.2 With respect to impact piling the acoustic output of the impact piling equipment has been predicted as part of the EIA process. The results will be verified by recording noise levels using the Drifting Ears method. The recorders will capture the received soundscape at frequencies from 50Hz to 46kHz and, when combined with GPS locations relative to device location, will allow calculation of source level at frequencies up to 20 kHz. From this survey, the acoustic footprint of the impact piling device in-situ will be determined.

11.5 Operation

- 11.5.1.1 Monitoring of underwater noise is proposed at locations identified at pre-construction at the mouth of the River Tawe and in the vicinity of the turbine and sluice gate housing.
- 11.5.1.2 It is proposed that prior to the installation of acoustic deterrents, acoustic modelling of the proposed devices should be undertaken to ensure that the spread of noise is not excessive, which might interfere with the natural movements of for instance marine mammals. Sound projector source levels are typically 160 dB re 1μPa@1m, with frequencies covering a maximum range of 20-3000 Hertz. Normally effective ranges are limited to a few tens of metres. The actual acoustic field would be measured during the commissioning phase to allow adjustment of sound levels to the desired values.
- 11.5.1.3 In addition, noise monitoring of the operational turbines prior to installation of the acoustic deterrents will also be undertaken. These results will be used, together with the monitoring undertaken as described above, to verify the EIA findings for noise (Chapter 19), fish (Chapter 9) and marine mammals (Chapter 10). Surveys are proposed in the vicinity of the turbine house. Possible locations for monitoring sites comprise a site within approximately 500m from the turbine house and further sites 1000m westwards towards Mumbles, northeast towards the mouth of the River Tawe and south. Measurements will be undertaken with a hydrophone suspended from a buoy at a range of depths. Measurements will be recorded close to the surface, at mid-depth and close to the seabed (nominally at 1m, 4m and, where possible due to depth, 8m).



12.0 Summary

- 12.0.0.1 Monitoring has been proposed for coastal processes, water quality, intertidal and subtidal benthic ecology, fish, marine mammals, coastal birds, terrestrial ecology and noise. However, further details and individual proposals for monitoring will be developed within the framework of this Plan throughout the duration of the Project. Survey methodologies will be agreed as appropriate with the relevant statutory authorities. The findings of the surveys will be analysed and disseminated to relevant organisations.
- 12.0.0.2 It is proposed that the final AEMP will serve not only as a guide for this Project but also a template for future tidal energy schemes. Collaborations between TLSB and various consultancies and academic institutions may well lead to the publication of peer-reviewed, scientific articles, thereby increasing the collective knowledge of Swansea Bay's environment.



13.0 References

Atkins, 2013. Swansea Bay Tidal Lagoon: Factual Report on Ground Investigation. Atkins Limited, Report A3076-13.

Gilbert, G., Gibbons, D.W. & Evans, J. (1998). Bird monitoring methods: A manual of techniques for UK key species. The Royal Society for the Protection of Birds. Sandy, Bedfordshire.

Hastie, Sparling and Murray (2012) Sonar as a tool to monitor interactions between marine mammals and tidal turbines; pitfalls and possibilities. Environmental Interactions of Marine Renewable Energy Technologies. Report by SMRU, St. Andrew's University.

HM Government (March 2011), UK Marine Policy Statement

JNCC, 2010. Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise.

Oakley, J. (2011) Observations of intertidal life beneath Mumbles Pier. Gower, Vol. 62. Woolmer AP, Syvret M, FitzGerald A (2011b) Restoration of Native Oyster, *Ostrea edulis*, in South Wales: Options and Approaches. CCW Contract Science Report No: 960, 93pp

Royal Haskoning, 2011. SeaGen Environmental Monitoring Programme Final Report. Marine Current Turbines

Titan, 2012a. Swansea Tidal Lagoon Geophysical Investigation: Final Report. Titan Environmental Surveys Ltd, Report CS0330.

Titan, 2012b. Swansea Bay Tidal Lagoon – Current/Wave Monitoring: Final Overview Report. Titan Environmental Surveys Ltd, Report CS0343.

Titan, 2013. Swansea Lagoon Benthic Data Report: Draft Report V2. Titan Environmental Surveys Ltd, Report CS0399.

TLSB (2012) Proposed Tidal Lagoon Development in Swansea Bay, South Wales, Environmental Impact Assessment Scoping Document (http://infrastructure.planningportal.gov.uk/wp-content/ipc/uploads/projects/EN010049/1.%20Pre-Submission/EIA/Scoping/Scoping%20Request/EN010049_Tidal%20Power%20Swansea%20Bay%20Scoping%20Document%20Final%20reduced%20size.pdf)

TLSB (2014) Tidal Lagoon Swansea Bay Environmental Statement.



Appendix 1 Benthic Faunal Groupings

Faunal Group A (average group similarity of 28.89%) was the most commonly occurring and most diverse group identified from benthic samples collected across the area, occurring at 19 stations. Characterising fauna of this group included the polychaete worms *Pomatoceros lamarcki*, *Sabellaria spinulosa*, *Cirriformia tentaculata*, *Jasmineira elegans* the bivalve *Sphenia binghami* and the amphipod *Ampelisca diadema*.

Faunal Group B (average group similarity of 29.77%) comprised 11 stations across the Swansea Bay area and constituted 10 taxa (at the 90% cut-off for low species contribution). Characterising taxa for fauna of this group included the polychaete worms *Spiophanes bombyx*, *Owenia fusiformis*, *Nephtys hombergii*, the bivalve *Nucula nitidosa* and individuals belonging to the Phylum *Nemertea*.

Faunal Group C (average group similarity of 30.19%) comprised 5 stations across the study area and consisted of 6 taxa (at the 90% cut-off for low species contribution). The polychaete worms *Magelona johnstoni*, *Nephtys*, *Glycera tridactyla*, *Magelona filiformis*, *Magelona mirabilis* and the bivalve *Nucula nitidosa* were key characterising fauna of this group.

Faunal Group D (average group similarity of 25.14%) occurred at 3 stations across the study area. This group was characterised by the presence of one individual, the polychaete worm *Travisia forbesii*.

Faunal Group E (average group similarity of 29.29%) was the least commonly occurring group, being found at only two locations across the study area. This was not a diverse group with the amphipod *Urothoe brevicornis* accounting for 100% of this group's similarity.

Faunal Group F (average group similarity of 29.90%) comprised 4 stations across the Swansea Bay area. Characterising fauna of this group included the polychaete worms *Nephtys cirrosa*, *Nephtys (juv)*, *Chaetozone christiei* and *Owenia fusiformis*.

The geographical distribution of these faunal groups is likely to reflect differences in sediment composition across the survey area.