



Environmental Statement Chapter 4. Project Description

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4.0 Project Description

4.1 Introduction

- 4.1.0.1 This Chapter outlines the main elements of the Project for the purposes of EIA; how these will be constructed, maintained and operated, and decommissioned. Where more than one option remains under consideration or flexibility is needed (e.g. cable grid route, temporary cofferdam choice) the options are each assessed or the parameters of the flexibility are described. In the following sections of this Chapter, further information is provided on the main Project elements, parameters within which engineering design will be finalised and alternative options remaining under consideration.
- 4.1.0.2 As discussed in Chapter 1: Introduction, “the ‘Rochdale Envelope’ is an acknowledged way of dealing with an application comprising EIA development where details of a project have not been resolved at the time when the application is submitted” (Planning Inspectorate, Advice Note 9, 2012). This allows flexibility in the final design of a project, whilst giving certainty as to the parameters applying to the EIA process.
- 4.1.0.3 In line with the Planning Inspectorate’s Advice Note 9 (2012), the EIA process undertaken for this Project has ensured that all the realistic and likely worst case variations of the Project have been properly considered, and the findings presented in this ES. Thus, the likely significant impacts have been adequately assessed. In particular, where “*details have not been resolved*” and flexibility is allowed in the draft DCO, including by means of a power of deviation, this has been considered by the relevant chapter authors in their assessments.
- 4.1.0.4 As such, where an alternative exists, the option with the likely worst case effect has been assessed in the following EIA Chapters. Where there is more than one route choice or construction method (e.g. cable route or temporary cofferdam), and where the potential effects of the options are noticeably different, such that a single worst case cannot be determined, or the characteristics of such effects are different, then all variations have been considered in the assessment reported in this ES.
- 4.1.0.5 The following chapter sets out the main parameters of the Project for the purpose of EIA, along with those elements where further design iteration will take place within those parameters. For ease of reference these elements are summarised in Table 4.1 at the end of this chapter. Within this table reference is made to relevant Chapters, where the effects of such design advancements are considered further.

4.2 Overview of Project

- 4.2.0.1 The Project, is a generating station, which will have a nominal rated capacity of 240MW is to be located adjacent to Swansea Port at the eastern gateway to the City of Swansea. The rated power is assessed based upon a normal operating head (i.e. the amount of water available to turn the turbines). The operating head is described in Section 4.8 of this chapter.
- 4.2.0.2 The lagoon created as part of the Project will enclose part of the seabed and the foreshore of Swansea Bay, from the eastern side of the River Tawe to the eastern edge of the new Swansea University Bay Campus (SUBC, formerly known as the Science and Innovation Campus). The new seawalls of the lagoon will extend approximately 1.5km

directly offshore from the eastern landfall at SUBC (the eastern landfall), adjacent to Crymlyn Burrows SSSI. The seawalls will then extend in a south-westerly direction along the western boundary of the training wall of the River Neath Channel. A turbine and sluice gate housing structure will be located in the south west of the lagoon, at an oblique angle to the dredged channel of the River Tawe. The seawall will then extend towards Swansea Port, close to the mouth of the River Tawe parallel to the dredged channel for the River Tawe to rejoin the land (the western landfall).

- 4.2.0.3 An existing long sea outfall, owned and operated by Dwr Cymru Welsh Water (DCWW) extends into the lagoon area, and measures allowing use of the lagoon for water contact sports will be incorporated within the Project to accommodate this. The consideration of options for the outfall relating to lagoon use is discussed further in Chapter 3, Site Selection and Option Appraisal and proposals that TLSB are making available are further described in section 4.3.9 of this Chapter. The location and main elements of the lagoon comprised in the Project (including the zone for micro-siting the turbine and sluice gate housing) are shown in Figure 4.1. Other elements are described elsewhere in this chapter.



Figure 4.1 Location of the Project

- 4.2.0.4 The seawalls will enclose an area of some 11.5km² or more of seabed and foreshore to create the lagoon. The water within the lagoon provides the head - or build-up of water - needed to store kinetic energy that can be turned into electric power. Electricity will be generated as water flows through bi-directional turbines, located in the turbine and sluice gate housing, when the lagoon fills and empties after a holding period to create the head required. The electricity generated will be fed into the National Electricity Transmission System (NETS) via National Grid's substation in Baglan by way of an underground cable connection from the generating station. It is anticipated that the

Project will produce some 400 GWh net of electricity on an annual basis, which is enough to power around 121,000 homes.

- 4.2.0.5 Alongside the generation of electricity, the Project will offer additional benefits to the Swansea Bay area and the wider population, promoting educational, sport, recreational art and cultural activities for public use.
- 4.2.0.6 As set out in Chapter 1, the DCO will authorise construction and operation of the Project, including the integral electrical grid connection works, as well as their decommissioning.
- 4.2.0.7 The Project comprises on and offshore elements that are identified below under the main Project element titles. The Project comprises three phases: a construction phase, an operational phase and a decommissioning phase. An overview of the Project elements as a whole is initially provided. Subsequent to this, the construction, the operation and decommissioning phases are described. Certain elements are defined as parameters to permit appropriate levels of flexibility for future design development including consideration of options (turbines, construction methods and micro-siting) as well as construction phase planning. These options are discussed throughout this Chapter and the likely worst case option is assessed within the relevant chapters of this ES. Figure 4.2 illustrates the masterplan for the Project. The main elements of this masterplan are fixed and are not sensitive to changes from other elements of the Project.

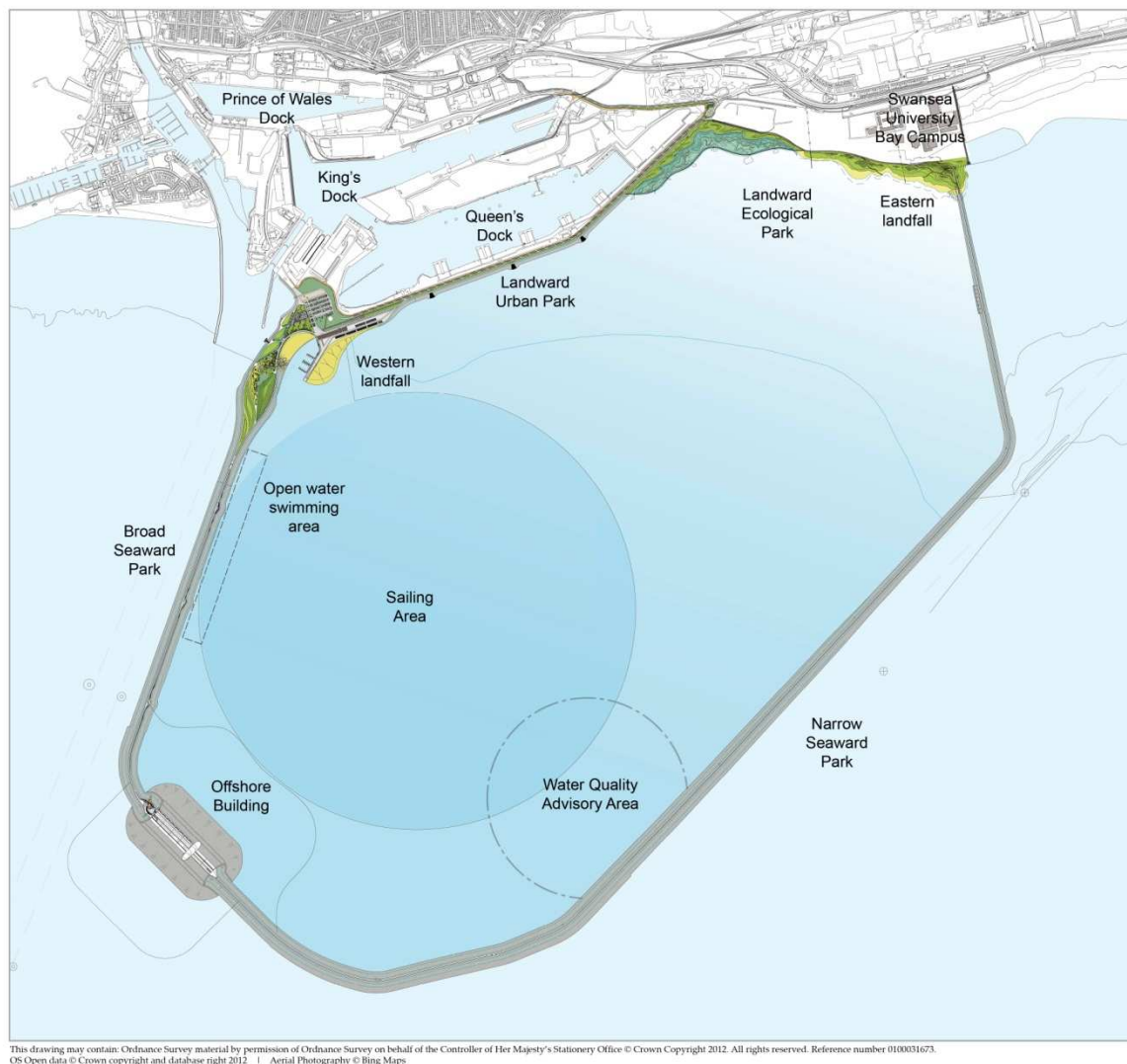


Figure 4.2 Masterplan

- 4.2.0.8 Offshore works:** The offshore works during the construction and operation phases comprise the following (and their construction): turbines and sluice gates, their housing structure, gantry crane and other facilities, such as generators and switchgear; temporary cofferdam to facilitate the construction of the turbine and sluice gate housing structure; temporary rock storage areas; seawalls and associated dredging works; dredging to create boating area; access road on the seawalls including public realm works, lighting structures and shelters; Offshore Building incorporating operation and maintenance (O&M) facilities, with integral visitor centre, leisure facilities and public realm; emergency facilities; works to Swansea Port Channel; demolition of existing eastern breakwater wall at the entrance to the Port of Swansea; works to Neath Harbour Channel including the widening of the entrance to the channel and replacement of its training wall; water quality enhancement works (if required or implemented); navigation facilities including lighting; reef habitat creation works, provision of oyster spatting ponds, herring mitigation and Sabellaria habitat works; and necessary services.
- 4.2.0.9 Onshore works:** Provision of construction support sites including access routes for construction traffic and permanent access routes to the Project, decontamination/land remediation works, installation of drainage and services, material handling facilities for deliveries by sea or rail, land creation works, including lay-down areas and temporary

rock stockpile areas; Western Landfall Building incorporating O&M facilities including visitor orientation, recreational boating facilities, laboratory/hatchery building at the western landfall with slipways; vehicle parking; manoeuvring areas, public realm and lagoon side public open space; Site of Special Scientific Interest (SSSI) information facility at the eastern landfall; water quality enhancement works (so far as required and implemented); habitat creation works/mitigation, including beach/dune and saltmarsh creation within the lagoon; access works to the lagoon, including new highway access via the controlled junction on Fabian Way with associated alterations to the Swansea Port road network; necessary services; improvements and additions to River Tawe water shuttle pontoon; and pedestrian and cycle routes.

4.2.0.10 Grid connection works: The cable connecting the turbines to the NETS will run along the western seawall to the western landfall. The cable will then follow a route through Swansea Port, past the SUBC, extending through the Crymlyn Burrows SSSI, and across the River Neath by use of existing ducts or by constructing new ducts using directional drilling techniques.

4.2.0.11 The following sections of this Chapter provide a description of the key components of the Project. Information on the construction works and their sequence is then provided, along with a description of the operational phase of the Project, including the lagoon, offshore works and onshore works. Where more than one option is being considered for certain components, information on the different options is provided. Finally the options for decommissioning are given.

4.2.0.12 The Project components are described under the following headings:

- i. the lagoon and seawalls;
- ii. the turbines and sluice gates including housing structure;
- iii. cable connection to the NETS;
- iv. masterplan, proposed buildings and public realm;
- v. ecological facilities and mariculture opportunities;
- vi. access infrastructure;
- vii. water shuttle and associated access;
- viii. water quality enhancement works; and
- ix. other works to support the Project.

4.3 Overview of Project elements

4.3.1 The Lagoon and seawalls

4.3.1.1 The proposed lagoon layout, J3 overlaid on the Admiralty Chart, is shown below in Figure 4.3 (details on previous lagoon layout options considered can be found in Chapter 3).¹ The lagoon has a total enclosed area of approximately 11.5km². The seawalls are around 9.5km in length and extends in a distorted U-shape between the Neath and Swansea (Tawe) channels.

¹ This drawing shows one way in which the seawalls and turbine and sluice gate housing may be configured. Others are discussed below.

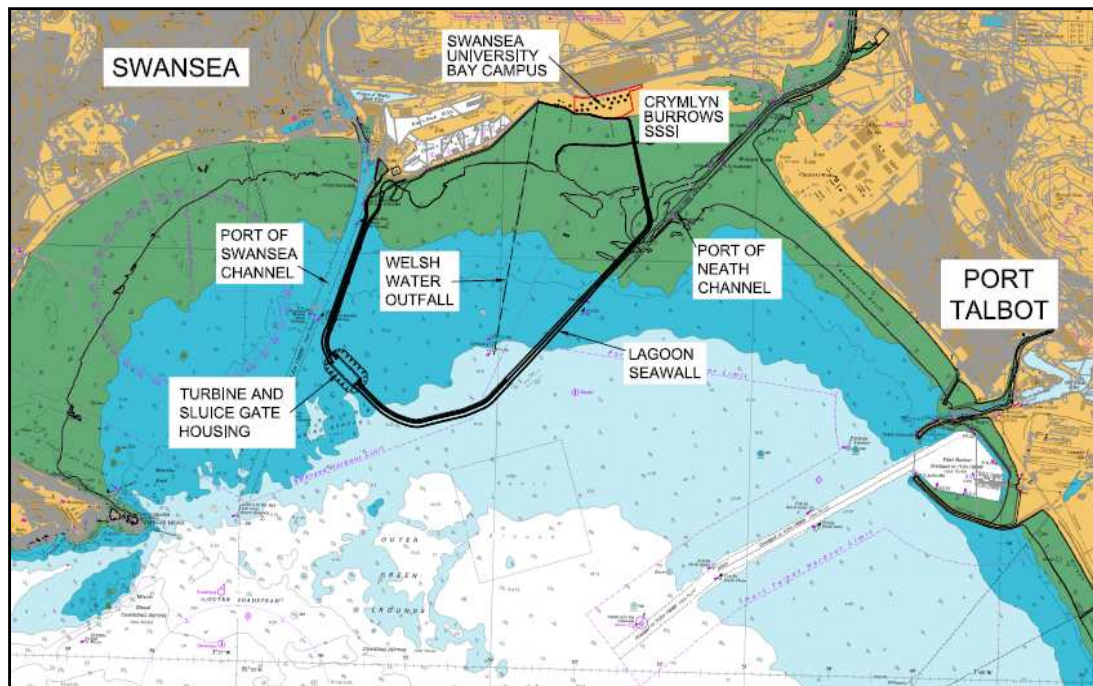


Figure 4.3 Lagoon layout Option J3 on Admiralty Chart background

- 4.3.1.2 The water frontage of the lagoon between the western and eastern landfall comprises the existing port rock armouring topped by a 2m high concrete wall, which will be removed except for 3m sections either side of where pill boxes exist. Further to the east, leading to the eastern landfall and SUBC, an access track will be created past the proposed saltmarsh and dune areas. This will have a similar construction to the seawalls, including rock armour. Additional details about the layout and design of public realm, including these areas, can be found in section 4.3.5. The DCWW outfall is discussed below in section 4.3.9.
- 4.3.1.3 The seawalls will form the enclosure of the lagoon, controlling the water to allow a difference in water level to be created between the lagoon and the sea outside. The seawalls will be constructed with a sediment core held in position with either sediment-filled geotextile tubes, known as Geotubes® or by more conventional methods, where the sediment core is encased in gravel/quarry run. Both these construction techniques are discussed further below. However, where the seawall crosses the beach on the eastern landfall approach, the seawall will be constructed purely of suitable sediment (sand and gravel). Layers of rock and rock armour will then be placed on the outside of the structure for protection; the thickness and quantity of these layers will vary depending on location.
- 4.3.1.4 At the most exposed locations, typically furthest offshore, adjacent to the turbine and sluice gate housing structure, the construction of the seawall will be as illustrated in Figure 4.4. The Geotubes® on the more exposed seaward side of the seawall will be covered with a 1 to 1.5m thick layer of under-layer rock, with each rock typically 0.1 to 0.5t in weight. A 2 to 2.5m thick layer of armour rock, varying in weight between 3 and 10t, will be placed over the top to create a slope of approximately 1 in 2.5. The lagoon side of the seawall is subject to smaller, locally-generated waves, and therefore less protection is required. This will be in the form of a 0.5 to 1m layer of rear face armour, consisting of 0.1 to 0.3t rocks. A 10m-wide level berm is required on the Lagoon side to

provide geotechnical stability to the seawall due to the steeper 1 in 1.5 and 1 in 1.75 slopes.

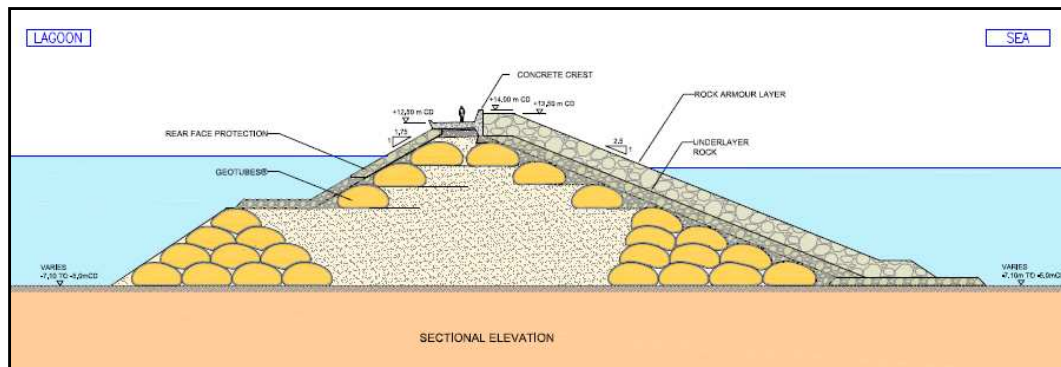


Figure 4.4 Section of the Lagoon seawall at exposed locations

- 4.3.1.5 In less exposed locations, closer to the existing shore, the structure required to achieve the necessary stability, has a less complex construction, as shown in Figure 4.5. The Geotubes®/sediment will be covered, on both the sea and Lagoon side of the seawall, in a layer of 0.1 to 0.3t rocks up to 1.5m thick. Both sides will have a finished slope angle of 1 in 2 or 1 in 2.5 depending on the position of the wall within the overall lagoon.

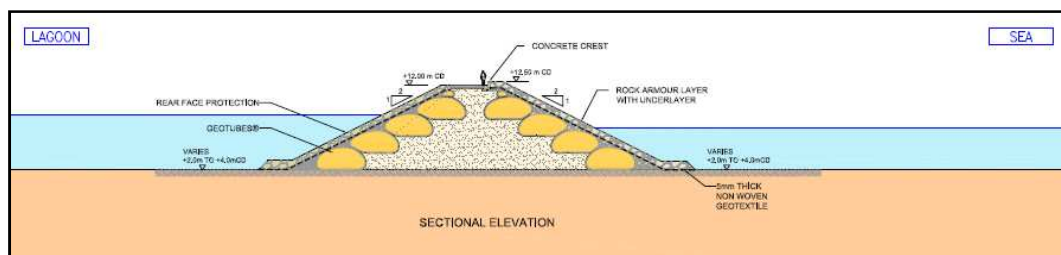


Figure 4.5 Section of the Lagoon seawall at more sheltered locations

- 4.3.1.6 An alternative more conventional construction design of the seawall is also being considered. This method does not incorporate Geotubes® and is shown in Figure 4.6. As for the Geotubes® technique, the seawall has a sediment core, but in this case it would be held in position by large piles of gravel. This gravel would either comprise dredged material from within the Lagoon footprint or quarry run imported by sea. Quarry run is stone material typically between 0 to 0.5t in weight which is left over after the blasting for rock armour. The footprint and angle of the slopes would remain largely unchanged from the design incorporating Geotubes®.

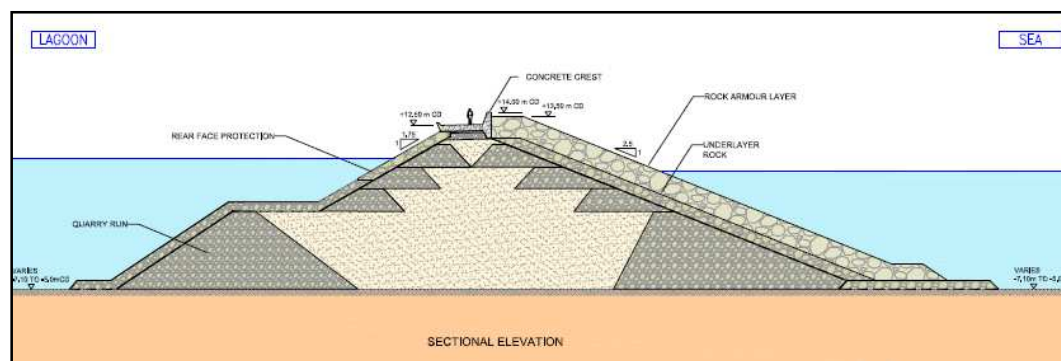


Figure 4.6 Section of the Lagoon seawall using conventional construction

- 4.3.1.7 The angle of the rock armour that forms the slope of seawalls gives stability to the structure and also reduces reflection of waves. The rock armour used has been incorporated into the design as it has natural low reflection levels through not being a smooth surface, and thereby absorbs at least 60% of the incident wave energy. This is important as it reduces the size of waves being reflected off the structure back to the surrounding environment. This is commonly measured as a ratio where 1 would be 100% reflection of waves (ie no absorption of wave energy) and 0.5 would be 50% reflection. The walls of the lagoon will be designed with a reflection coefficient in the region of 0.3 reflection for the exposed western arm of the seawall (absorbing 70% of the wave energy), running out to the turbine and sluice gate house, and 0.4 for the eastern seawall, running from the turbine and sluice gate house along the Neath channel.
- 4.3.1.8 The engineered toe at the base of the rock armour supports the main rock armour, as well as preventing erosion and scour at the base of the Geotubes®(or gravel/quarry run)/sediment core. This will ensure the long-term stability of the seawall structures.
- 4.3.1.9 The seawall will be a maximum of 107m wide at the base of the deepest section, adjacent to the turbine and sluice gate housing. The seawall will narrow as it extends towards the landfalls. At the eastern landfall the seawall extends to join the sand dunes. The crest of the seawall will generally be 13m across, with the exception of the location of the Offshore Building, for which it provides a foundation, and the section adjacent to the western landfall. For the Offshore Building, the seawall is widened to accommodate the building and/or create additional recreational space; this is further described in section 4.3.5. The seawall will also have local widened sections to accommodate sculptural elements. At the western landfall, the seawall crest extends to approximately 152m in width and accommodates recreational areas including a beach and spectators areas.
- 4.3.1.10 The visible height of the seawalls above the water level measured at the highest point will be approximately 4m at high tide (MHWS) and 12.5m at low tide (MLWS).
- 4.3.1.11 The permanent level of the top of the rock armour along the most exposed sections is +13.5mCD (Chart Datum²), as shown on Figure 4.4, falling to +13mCD for a section adjacent to the Neath Channel and will be +12.5mCD for the sections of the seawall approaching landfall on both sides, shown on Figure 4.5. During construction, material will be placed to a greater height to allow for settlement. The levels of the top of the rock armour include an allowance for sea level rise of 0.315m over a 50 year period. This is the 95% confidence level for a median scenario.
- 4.3.1.12 In order to allow access along the seawall, a road is to be constructed along its entire length. The road will be constructed of different materials, subject to its location and likely access requirements along it. The road will be at +12mCD, 0.5 to 1.5m below the crest of the outer rock armour, which provides protection for the road and those using it. The road will generally be 4.5m wide. The western seawall will have an additional 3.1m wide cycle track/passing place. The road will form the access route along the seawall to the turbine and sluice gate housing structure for operational staff, emergency access and the public. The public will be permitted to access the road on foot and by bicycle, which

² Chart Datum (CD) is the height measurement normally used offshore with 0m CD being the Lowest Astronomical Tide (LAT). Ordnance Datum (OD) is the height measurement normally used onshore and is 5m lower than CD. Therefore 0m CD is equivalent to -5m OD.

forms part of a circular route around the perimeter of the Lagoon, but it will be closed in extreme weather conditions and during hours of darkness, except for key O&M access. Its use and access may be regulated by application of byelaws, the making of which will be authorised under the DCO.

- 4.3.1.13 The sediment used within the core of the seawall and the Geotubes® will be taken from the seabed within the footprint of the lagoon. It has been calculated that approximately 8.1 million cubic metres (Mm^3) of sediment will be dredged for the Project as a whole, which includes about 7.3 Mm^3 of material to be used for the Project and an estimated 0.8 Mm^3 of unsuitable material. A licence to dredge and for the disposal of unsuitable dredged material is being sought from Natural Resources Wales (NRW), Marine Licensing Team (MLT).
- 4.3.1.14 To inform the EIA, further information on ground conditions and the quality of sediments within the lagoon footprint was obtained through Ground Investigations (GI) undertaken in June and July 2013. In addition, this data has been used to develop the design and specification of the sediment for the filling of the Geotubes®, as well as to refine the micro-siting for the turbine and sluice gate housing. The data will be subject to further assessment and refinement as the Project moves forward into the final design and construction phase.
- 4.3.1.15 The sampling locations for the GI are shown in Figure 4.7a overlaid on the proposed dredging plan, discussed in detail below, and comprise boreholes at seven sites (blue squares), vibro cores at 10 sites (green triangles) and cone penetration testing (orange circles) at 12 sites.



Figure 4.7a Location of ground investigation sample sites³

- 4.3.1.16 In terms of quality of sediments, metal analysis was targeted at those areas where dredging or excavation was likely to be undertaken (namely 9 vibro cores and 6 boreholes). Note additional vibrocore and boreholes were taken elsewhere (e.g. under the proposed seawalls) and these were processed for engineering properties.
- 4.3.1.17 A total of 67 sediment sub-samples were analysed from the various sites, at representative depths for dredging/disposal. The samples were processed for the CEFAS suite of determinants by a CEFAS accredited laboratory. An additional approximately 16 samples will be required to cover the 8.1Mm³ of sediment required for the Project in order to comply with CEFAS guidance. This additional sampling will take place during further Ground Investigations prior to the start of construction.
- 4.3.1.18 The results of the analysis were compared to the CEFAS Action Levels for individual metals. CEFAS guidance states “In general, contaminant levels in dredged material below Action Level 1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above Action Level 2 is generally considered unsuitable for sea disposal. The latter situation most often applies only to a part of a proposed dredging area and so that area can be excluded from disposal at sea and disposed of by other routes e.g. landfill. Dredged material with contaminant levels

³ This drawing shows one way in which the seawalls and turbine housing may be configured. Others are discussed within this chapter.

between Action Levels 1 and 2 requires further consideration and testing before a decision can be made”⁴.

- 4.3.1.19 The results of the chemical analysis are summarised in Table 4.2 at the end of this chapter. A simple colour coding scheme has been applied for ease of reference with those samples which have concentrations of the specific determinand below Level 1 as green; those with concentrations between Level 1 and Level 2 as yellow; and those with concentrations above Level 2 as red. A summary of the results is presented in Table 4.3 utilising the same colour scheme.

Table 4.3 Summary of sediment analysis compared to CEFAS action levels

Site reference	Number of samples analysed	Total No. analyses	Results below Level 1	Results above Level 1	Above Level 2	Determinand which was above relevant level
VC 202	5	55	53	2	0	Nickel, Chromium
VC 204	6	66	58	8	0	Nickel, Chromium
VC 206	5	55	44	11	0	Arsenic, Copper, Lead, Cadmium, Chromium, Nickel, Zinc, Mercury
VC 208	2	22	22	0	0	
VC 209	2	22	22	0	0	
VC 212	5	55	54	1	0	Copper
VC 213	6	66	66	0	0	
VC 214	5	55	55	0	0	
VC 216	1	11	11	0	0	
VC 208B	5	55	51	4	0	Copper, Lead, Nickel, Zinc,
VC 209B	3	33	27	6	0	Copper, Lead, Cadmium, Chromium, Nickel, Zinc
VC 216B	5	55	54	1	0	Cadmium
BH 101	2	22	20	2	0	Chromium, Nickel
BH 102	4	44	44	0	0	
BH 103	1	11	9	2	0	Chromium, Nickel
BH 104	3	33	33	0	0	
BH 105	4	44	43	1	0	Nickel
BH 107	3	33	25	8	0	Cadmium, Chromium, Nickel
Total	67	737	691	46	0	

- 4.3.1.20 Overall of the 67 sub-samples collected, the majority (approximately 73.5%) had determinands all below Action Level 1. The remaining samples had slightly elevated levels of a few determinands, above Action Level 1 but below Action Level 2 (approximately 26.5%) and none (0%) had values above Action Level 2 for any specific determinand. In terms of overall analyses, of the 737 determinands analysed 93.5% were below Action Level 1 and the remainder (6.5%) were above Action Level 1, but below Action Level 2. The results of the analysis are graphically presented in Figure 4.7b, Volume 2. Sediment quality is discussed further in Chapter 6, Section 6.4.4.
- 4.3.1.21 To obtain the sediment that is required for the Project, material will be taken from areas which need to be deepened for functional purposes (e.g. boating area and turbine and

⁴ <http://www.cefes.defra.gov.uk/media/562541/cefes%20action%20levels.pdf>

sluice gate housing) and from within the lagoon footprint as a whole. For that purpose, two main approaches are being considered and have been assessed in the relevant EIA chapters. The two approaches are:

- i. a large area at a relatively shallow depth, which results in impacts over a wider area (Figure 4.8); and
- ii. smaller areas of dredging at deeper depths (Figure 4.9), which allows the impact to be more localised.

- 4.3.1.22 The actual dredging campaign adopted is anticipated to lie somewhere between these two approaches, but consideration of these approaches allows a range of outcomes to be embraced by the assessments reported in this ES.
- 4.3.1.23 Figure 4.8 below shows how the first proposed dredging approach could look, with the primary dredging area in dark purple and potential secondary dredging areas shown in pink. The pink areas would be used if insufficient suitable material could be sourced in the dark purple areas. Likewise Figure 4.9 shows the primary dredging areas in dark purple for the second approach.
- 4.3.1.24 In terms of volumes from specific areas, as discussed above, dredging will be undertaken to facilitate the creation of the boating area. This would be to provide a permanent water depth of 2m below lowest tide level, as shown by the light purple area on Figures 4.8 and 4.9. This would generate approximately 2.5Mm^3 of material, of which, approximately 2.2Mm^3 will be used in the seawall construction and up to 0.3Mm^3 could be unsuitable and therefore require disposal. However this is an estimate which is dependent on both the suitability of material dredged and resultant characteristics.
- 4.3.1.25 At the turbine and sluice gate housing location, the seabed will be lowered to the required depth for the operation of the turbines, namely -14.35mCD, approximately 9 to 10m below existing bed level at this location. However, not all of the material at this location can be assumed to be suitable for use within the seawall and, as such, it is estimated that 0.5Mm^3 material will be available for re-use and some 0.5Mm^3 material would be disposed of. Micro-siting the turbine and sluice gate housing structure would reduce this need for disposal to approximately 0.36Mm^3 . Likewise the use of more “conventional” construction methods such as using gravel/quarry run instead of Geotubes® could also reduce dredging and disposal needs. The potential overall volumes of sediment/quarry run for each option are summarised in Table 4.1 at the end of this chapter.
- 4.3.1.26 The remaining approximate 4.6Mm^3 is anticipated to be taken from the dark purple area at a depth of between 0m and 5m below the seabed within a cutting 500m wide (dredging option A, Figure 4.8). The dredger would remove the material in a series of steps, until the required depth is reached. The sediment will then naturally form a slope over time, which is expected to have a gradient between 1:8 and 1:10.

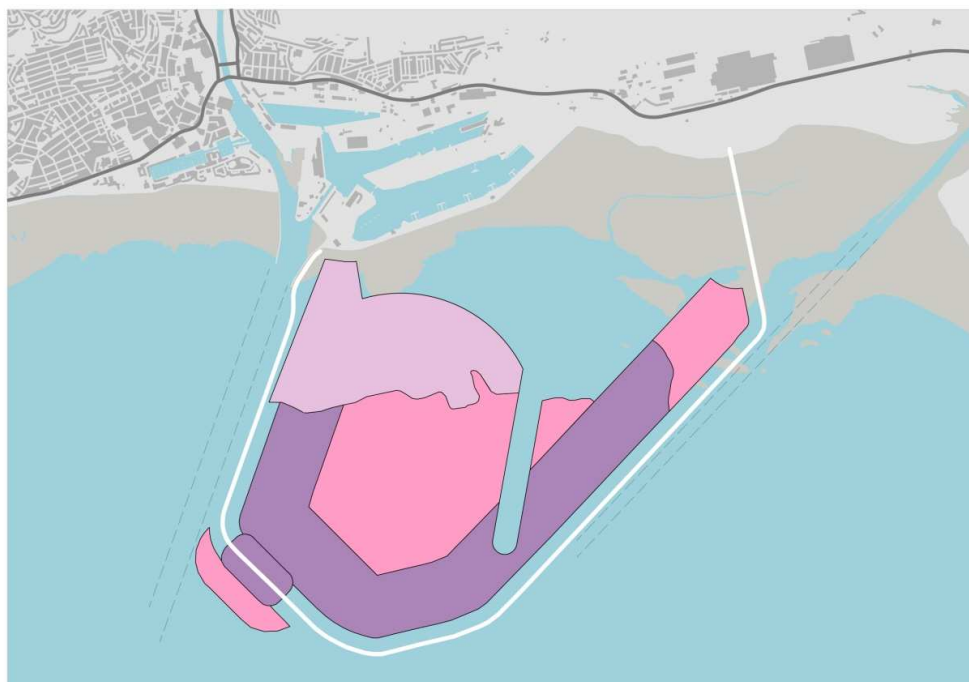


Figure 4.8 Dredging option A extensive, shallow option for dredging

- 4.3.1.27 The second dredging option (B, Figure 4.9) would be to create smaller, deeper dredging areas where the most suitable material has been identified during the ground investigations and is useful for construction. The approximate extents of the deeper areas are shown in dark purple in Figure 4.9 below, being approximately 450m diameter taken down to approximately 15m below the seabed. The final location of the dredged areas will be dictated by the location of the most suitable material from an engineering property and quality perspective.

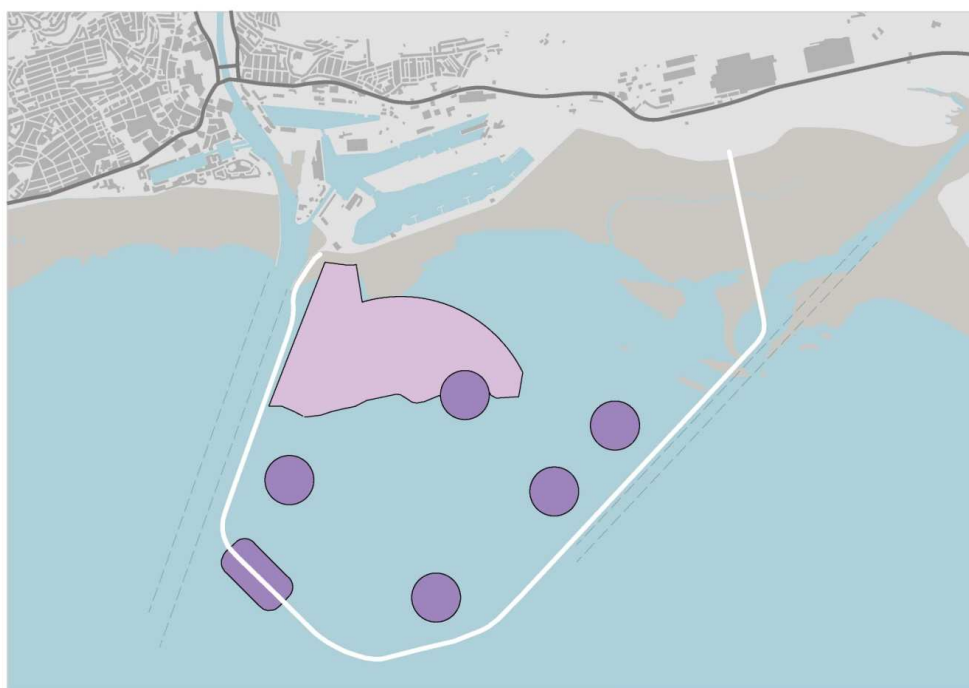


Figure 4.9 Dredging option B less extensive, deeper option for dredging

- 4.3.1.28 For dredging option B, the areas are shown to be circular, but the shape will again be dictated by the location of the suitable material. The dredging profile created by the dredger will be stepped, and then allowed to resume a natural slope over time.
- 4.3.1.29 The lip of any dredged area, including any predicted natural slope formation over time, will not be any closer than 100m to the toe of the seawalls or the existing DCWW outfall. This is to ensure that the stability and integrity of the seawalls and the outfall are not affected.

4.3.2 The turbines and sluice gates including housing structure

Turbines

- 4.3.2.1 The purpose of the turbines is to capture energy from tidal flows and for the generation of electricity. It is proposed to install between 13 and 16 bi-directional turbines of 7m (+/- 200mm) diameter in the turbine and sluice gate housing structure. An indicative diagram of a 7m bi-directional bulb fixed speed turbine is shown below in Figure 4.10. A bulb turbine derives its name from the shape of the upstream bulb-shaped watertight casing (although in this case the turbines are bi-directional with the bulb will facing into the lagoon, as most efficiency is gained from the ebb tide⁵).

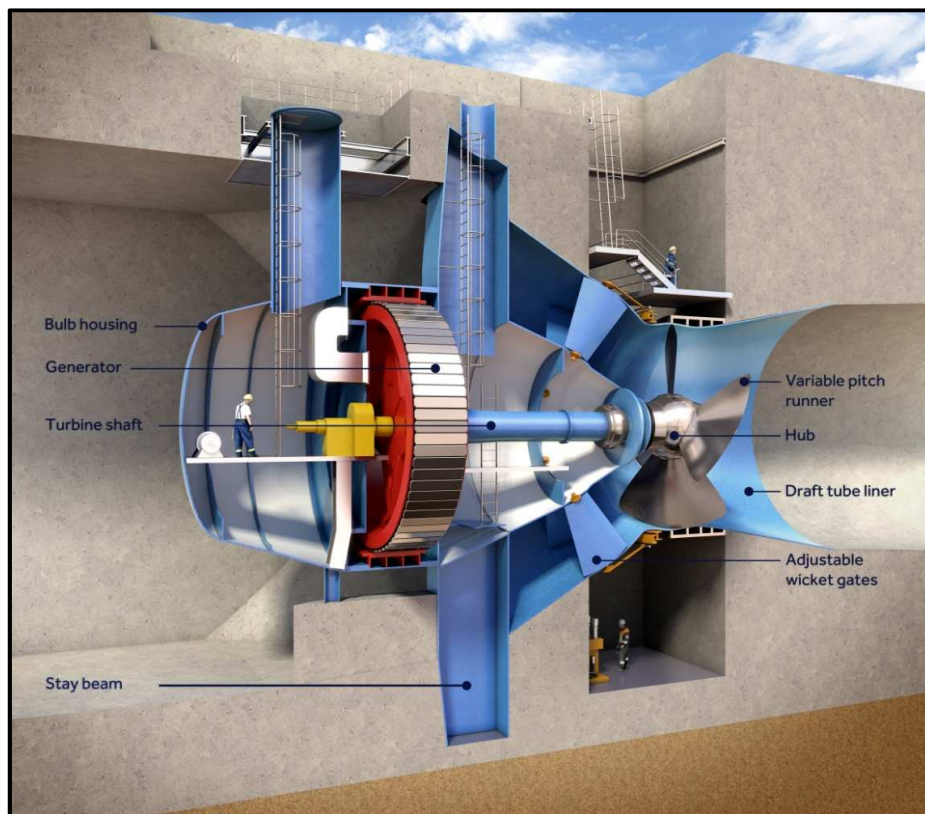


Figure 4.10 Illustrative cross section of a bi-directional bulb fixed speed turbine

⁵ Ebb tide occurs as the water level fall and the water leaves the Lagoon, the Flood tide is the opposite, as the water level rise and enters the Lagoon.

- 4.3.2.2 Two bi-directional turbines types are being considered:
- i. 7m (+/- 200mm) fixed speed or 'synchronous' turbines approx 60rpm (+/- 2.5rpm); and
 - ii. 7m (+/- 200mm) variable speed turbines (30 – 67rpm, average 50rpm).
- 4.3.2.3 Because the turbines are bi-directional, they are able to generate power with water flow entering the lagoon on the flood tide and leaving the lagoon on the ebb tide.
- 4.3.2.4 A double-regulated synchronous bulb turbine uses mechanical means, i.e. the moveable wicket gates and variable pitch runners, to adjust the water flow to maintain a constant speed of the generator with varying head/flow conditions. This ensures that the frequency of the electrical output is always 50Hz, which can be synchronised with the 50Hz frequency of the NETS - hence, 'synchronous'.
- 4.3.2.5 A variable speed bulb turbine uses power electronics to control the rotational speed of the turbine at the optimum efficiency point for a particular head and flow. Therefore, the output frequency from the generator is variable and uses power conversion electronics to convert the frequency of the power output to 50Hz to match the frequency of the NETS.
- 4.3.2.6 Variable speed turbines have the ability to be used in a pumping mode. As such, if variable speed turbines are chosen, this would be utilised at the end of each tidal cycle to equalise the water levels inside and outside the lagoon before the turn of the tide. The ability to pump at the end of a tide increases the total volume of water that can pass through the turbine on each tidal cycle. It would also have the benefit of enabling the extent of exposure of intertidal areas to be managed for ecological purposes (see section 4.8).
- 4.3.2.7 The preferred turbine design will be selected prior to implementation and following a tender process. Further details on the turbines can be found in section 4.8 – Operation and Maintenance. For the purpose of the EIA, an assessment of 16 fixed speed turbines with a rotational speed of 67rpm has been used, as this is the likely worst case from the point of view of a number of environmental factors (see Table 4.1) and where relevant, the different effects are assessed within this ES.

Sluice gates

- 4.3.2.8 Between six and ten vertical lift metal sluice gates will be located in the turbine and sluice gate housing structure. The sluice gates are an additional mechanism (as well as the turbines) to control the water entering and leaving the lagoon. The sluice gates will be opened and lowered by mechanical means and controlled remotely from the control centre. The gates remain closed until towards the end of each cycle when they are then opened to allow the water levels in and outside the lagoon to be equalised as much and as quickly as possible. Further detail of the operation of the turbine and sluice gate housing structure is given in Section 4.8. An illustration of a sluice gate is shown below in Figure 4.11. The clear opening of each sluice gate at the narrowest part is 13.5m wide and 14.5m high. However, the final dimensions will be refined as the turbine design is finalised, although the environmental effects will not be greater than those assessed within the ES.

- 4.3.2.9 Overall, to optimise the operation of the lagoon, a balance between the number of turbines and the number of sluice gates is required. For instance if 16 turbines were used up to 8 sluice gates would be needed; whereas if 13 turbines were used 10 sluice gates would be required. The total number of sluice gates and turbines would be accommodated within a housing structure which would not exceed the maximum envelope described in this ES. For the purpose of the EIA reported in this ES, a maximum of 16 turbines and 8 sluice gates has been illustrated and assessed. This is because the larger number of turbines means the greatest likelihood of encounters in relation to fish and other marine species and hence a worst case for assessment purposes.

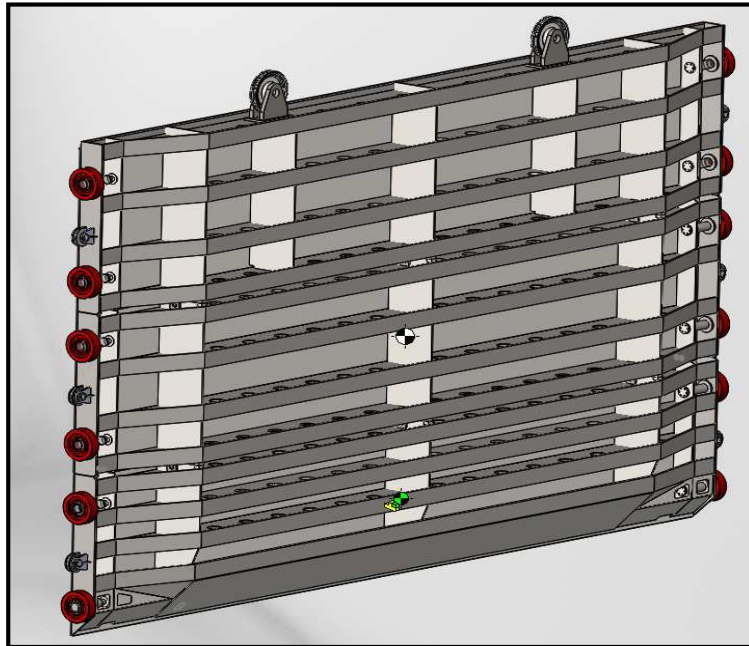


Figure 4.11 Illustrative elevation of sluice gate

4.3.3 Turbine and sluice gate housing structure

- 4.3.3.1 The turbine and sluice gate structure is a large, reinforced concrete structure comprising individual turbine and sluice gate housings (Figure 4.12). It will be located at the south west of the lagoon, as shown on Figure 4.1.

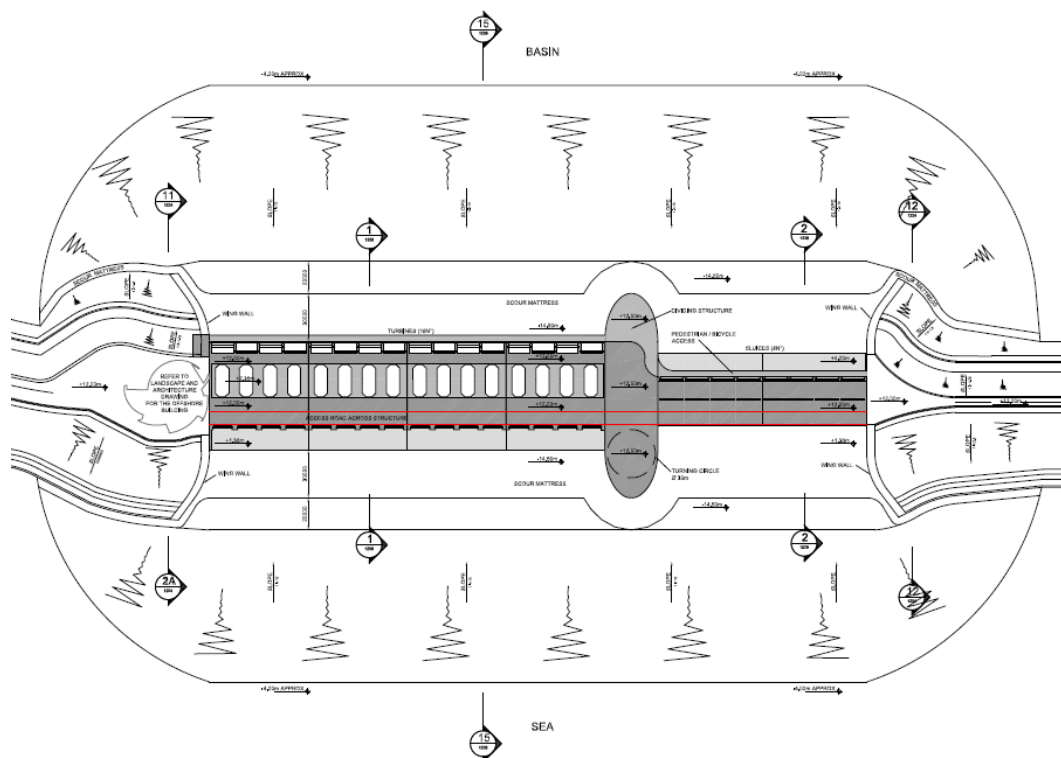


Figure 4.12 Turbine and sluice gate structure with deepening in seabed

- 4.3.3.2 A decision on the precise location of the turbine and sluice gate housing structure will be undertaken as the engineering design progresses. This will be undertaken, prior to construction, in order to select the most appropriate ground conditions for the structure, thereby minimising the need for disposal of unsuitable (fine) sediments and optimising geophysical conditions for its construction. The final siting of the turbine and sluice gate housing structure is predicted to be capable of influencing impacts assessed in this ES, for instance water quality, fish and navigation. Table 4.1 identifies where this is considered relevant to the topic area and provides an outline of the predicted effect.
- 4.3.3.3 Figure 4.13 below illustrates the two main alternative locations within the Order limits that are considered most likely to be chosen for the turbine housing structure as part of the Project. Option A involves construction on an area of mixed sediment which contains a component that is potentially unlikely to be suitable for reuse in construction of the Project. As discussed previously this would result in an increased requirement for disposal. Option B is better located in terms of seabed conditions, but increases the length of seawall to be constructed in the first year of the Project. As seawall construction is affected by weather conditions, this enhances project risk.
- 4.3.3.4 Both of these options are capable of being accommodated in the Order limits contained in the DCO and shown on the formal application plans which also accompany the application. However, for the purposes of this ES, and to simplify illustrations, Option A is shown on the plans that are used, except where necessary for the purposes of explanation or assessment.

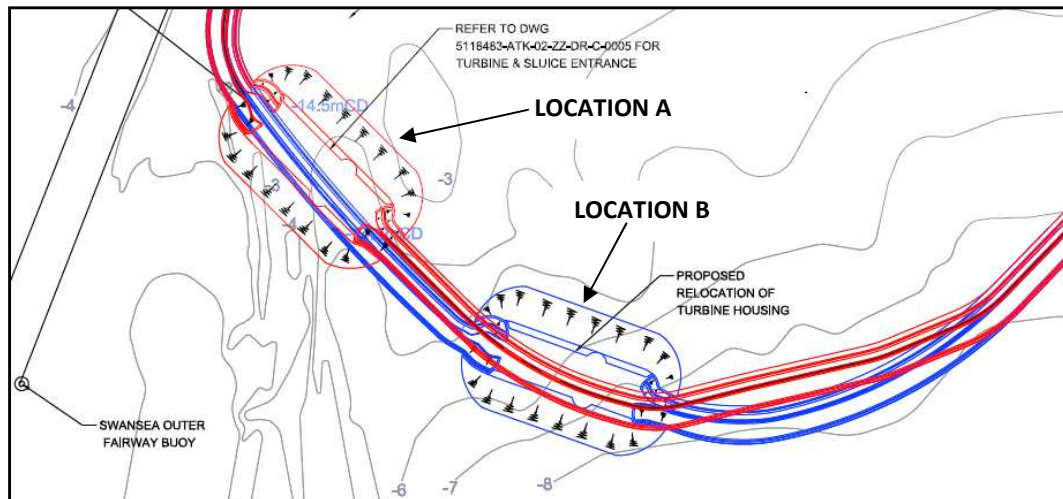


Figure 4.13 Two main alternative turbine and sluice gate housing locations

- 4.3.3.5 The exact configuration of the sluice gates and turbines is also yet to be determined, but will be arranged to minimise scour as the water enters and leaves the lagoon.
- 4.3.3.6 The layout on Figure 4.12 includes 16 turbines, 7m in diameter, 8 sluice gates and a dividing structure incorporating a maintenance area, giving an overall structure of approximately 410m in length. The structure is 67.5m wide in the vicinity of the turbines, 45.5m wide in the vicinity of the sluice gates and 137m wide at the widest point of the dividing structure. At seabed level, -14.35m CD, a scour protection mattress will be constructed, which will extend in the order of 50m on either side of the housing structure. A potential scour protection mattress could comprise a double layer of geotextile fabric placed in position and filled with a concrete/grout mixture.
- 4.3.3.7 As part of the turbine and sluice gate housing structure there will be a range of O&M rooms situated below the road level (concrete apron) and further O&M accommodation above ground within the Offshore Building. This accommodation will contain all ancillary electrical and access infrastructure required to operate the turbines on a 24 hour, manned basis.
- 4.3.3.8 The dividing structure will be a large concrete structure which assures efficient hydraulic flows into the turbines and sluice gates and will extend to the depth of the housing structure. It will be a platform from which large items can be accessed using the gantry crane for maintenance or repair.
- 4.3.3.9 In order to function efficiently, the turbines and sluice gates have to be submerged at all states of the tide. To achieve this, the seabed will be gradually deepened, at a 1 in 10 slope on either side of the turbine and sluice gate structure, to create a gently-sloping bowl up to 165m wide across the base where it meets the scour protection mattress (50m either side of the turbine housings). The angle of the slope will ensure that it remains stable and will minimise scour and erosion.
- 4.3.3.10 A sheet pile wall will be constructed around the base of the perimeter of the turbine and sluice gate structure. The sheet piles will be approximately 10-20mm thick and will extend into the seabed below the turbine and sluice structure to create an impenetrable barrier. The sheet pile wall will not act in a load-bearing capacity, but will be designed to

prevent seawater flow and therefore erosion underneath the structure. An example of a sheet pile wall is shown below in Figure 4.14.



Figure 4.14 Sheet pile wall

- 4.3.3.11 To protect the turbine and sluice gate structure, both during construction and operation, and to ensure a more visible demarcation, a number of dolphin piles will be installed. These will be placed approximately 500m from the turbine and sluice gate housing on the seaward side of the Lagoon. An indicative arrangement of these is shown below in Figure 4.15. The dolphin piles will be approximately 2m diameter hollow steel piles set 50 to 100m apart. There will be floating booms between the piles and they will be appropriately painted and lit.

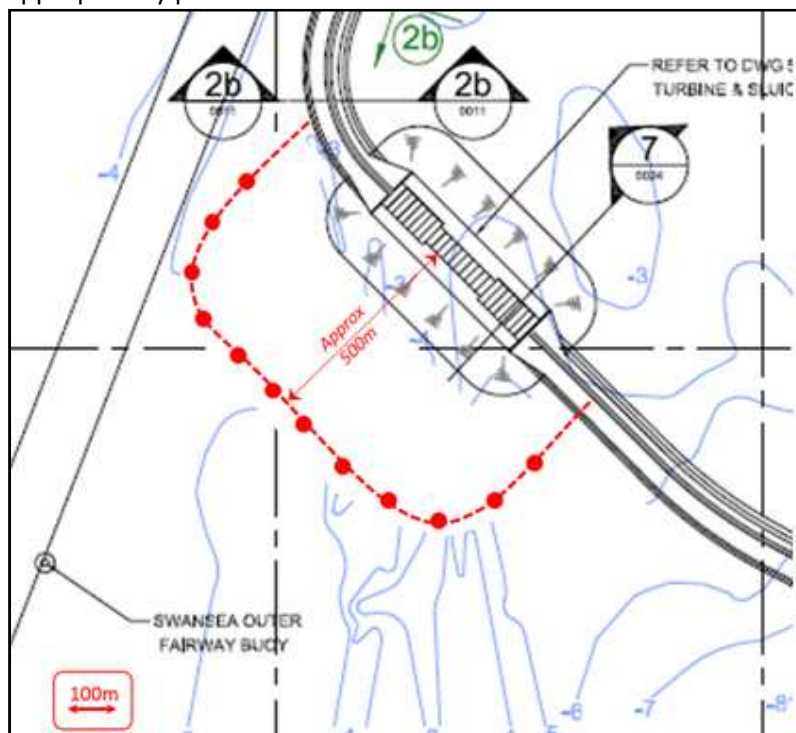


Figure 4.15 Indicative layout of dolphin piles

- 4.3.3.12 On the lagoon side of the turbines and sluice gate structure there will be a floating boom to demarcate a similar safety zone and an example of these are shown below in Figure 4.16.



Figure 4.16 Example of safety boom proposed

Turbine Housings

- 4.3.3.13 The housing unit for each 7m-diameter fixed speed turbine will be approximately 15m wide, 67.5m long and will be a total of 26.5m in height from deepened seabed level to the apron level. A small wave wall, 1.5m in height, will sit on top of the apron. The concrete apron across its length will lie at +12m CD, which is above the maximum tide and wave height and will permit O&M traffic to cross the structure.
- 4.3.3.14 An indicative cross-section of a 7m diameter, fixed speed turbine housing unit with turbine is shown in Figure 4.17.

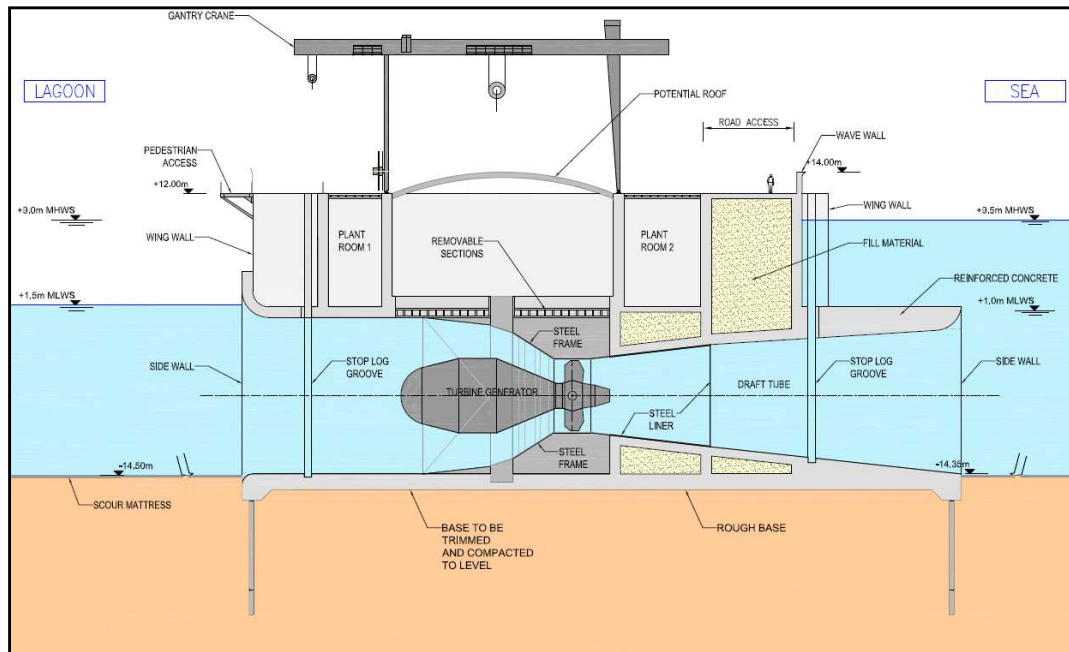


Figure 4.17 Cross-section of turbine housing unit with turbine

- 4.3.3.15 Figure 4.17 shows an external gantry crane above the turbine housing structure. However, it is anticipated that the design will be developed to raise the roof and have an internal crane with much reduced height.
- 4.3.3.16 The turbine housing unit will be constructed from reinforced concrete, with large voids created, some of which will be in-filled with sediment to increase the self weight of the structure. One turbine will be installed in each housing unit, with up to 16 turbine housings units within the complete turbine and sluice gate structure as described above.
- 4.3.3.17 A 'stop log' recess is located at either end of the housing structure to allow modular stop logs (barriers) to be installed with a crane, to create two temporary walls. This enables the turbine to be temporarily sealed off and the water between the two stop log barrier walls to be pumped out. A dry area is thus created permitting access to the outside of the turbine for cleaning/maintenance, or to allow parts of the turbine to be removed through the removable steel hatch above.

Sluice Gate Housings

- 4.3.3.18 Each individual sluice gate housing unit will be approximately 16m wide, 45.5m long and will be a total of 26.5m in height from the deepened seabed to the top of the concrete apron. There will be a maximum of 10 sluice gates. A cross-section of an individual sluice gate housing unit is shown below in Figure 4.18.

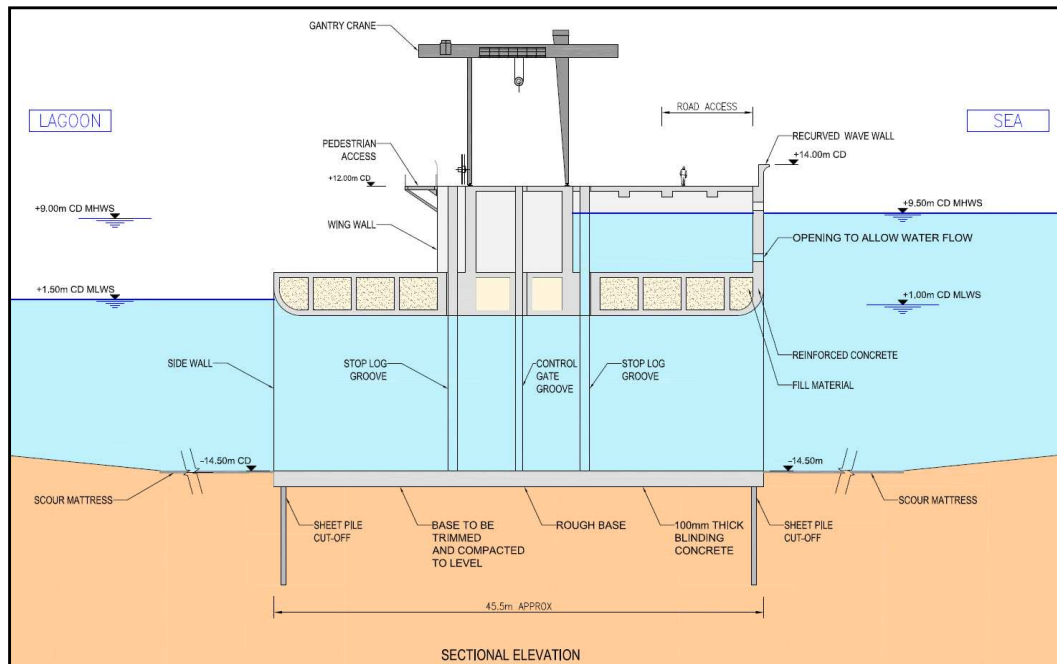


Figure 4.18 Cross section of sluice gate housing unit

- 4.3.3.19 As mentioned before, the gantry crane design is to be reviewed with the intention of providing an internal crane with much reduced height.
- 4.3.3.20 The sluice gate housing will be constructed from reinforced concrete, with large voids created, some of which will be in-filled with sediment. The sluice gates will be made of steel, and one sluice gate will be installed per housing structure.
- 4.3.3.21 The sluice gate is a submerged mechanical gate that can be raised and lowered. The gates are opened by raising them during the latter stages of generation on each tidal cycle to equalise (or as close as possible equalise), the water levels inside and outside the Lagoon before the next generation sequence is commenced. In this way, a maximum head is achieved to optimise electricity generation (see Section 4.8, Operation and Maintenance).
- 4.3.3.22 The 'stop log' recesses either side of the sluice gate allow modular stop log barriers to be installed. As with the turbines, this allows the water between the two barriers to be pumped out and a dry area temporarily created to gain access to the sluice gate for maintenance work.
- 4.3.4 Cable connection to the NETS**
- 4.3.4.1 Each of the turbines will be capable of generating up to 20MW of electricity at 9kV. This electricity will be stepped up to 33kV by a transformer which will be adjacent to, and linked to, pairs of turbines. The electricity will be stepped up again to 275kV by a larger transformer at the power house, located in, or adjacent to, the turbine and sluice gate structure.
- 4.3.4.2 The combined electrical output from all turbines will then be transferred to the nearest National Grid substation. This has been identified as Baglan Bay substation to the east of the River Neath. No additional onshore sub-station will need to be constructed.

- 4.3.4.3 The electricity will be transferred via three single phase cables, with an associated communication cable. These cables will be laid underground, commencing at the turbine and sluice gate housing structure and then extending within the western seawall. They will then be laid in a single trench from the Lagoon and onwards, after crossing the River Neath, to the Baglan Bay substation as described below. Sections of the cable route may need to be ducted prior to installation of the cables.
- 4.3.4.4 The route for the grid connection from the turbines to Baglan Bay substation to the substation is shown in Figure 4.19 below and has been divided into six sections;
- i. Section 1 - Turbines to western landfall;
 - ii. Section 2 – western landfall to Fabian way;
 - iii. Section 3 – Fabian Way across the front of the SUBC with the following options;
 - i. Through the SUBC; or
 - ii. Southern verge of Fabian Way.
 - iv. Section 4 – Fabian Way to West of River Neath with the following options;
 - i. Through the SSSI; or
 - ii. Southern verge of Fabian Way.
 - v. Section 5 – under River Neath with the following options;
 - i. Through existing disused pipe infrastructure; or
 - ii. New directional drill under the River Neath.
 - vi. Section 6 – west of River Neath to Baglan Bay substation

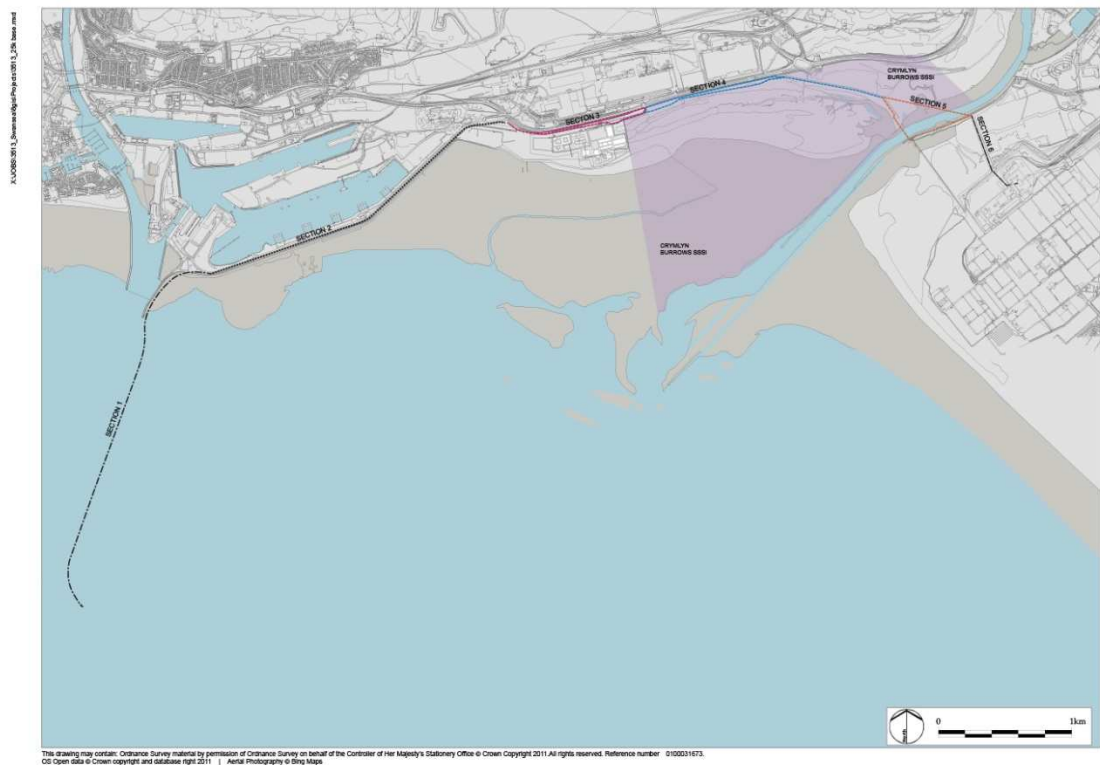


Figure 4.19 Overview of grid connection route from Swansea Port

Section 1 - Turbines to western landfall

- 4.3.4.5 The cables will be laid beneath the cycle track/passing place along the western seawall of the Lagoon above the high water mark. The cables will be laid in three 150mm diameter ducts approximately 0.3m beneath the surface of the cycle track/passing place. Cable joints with access chambers will be approximately every 1000m. A cross-section is shown below in Figure 4.20.

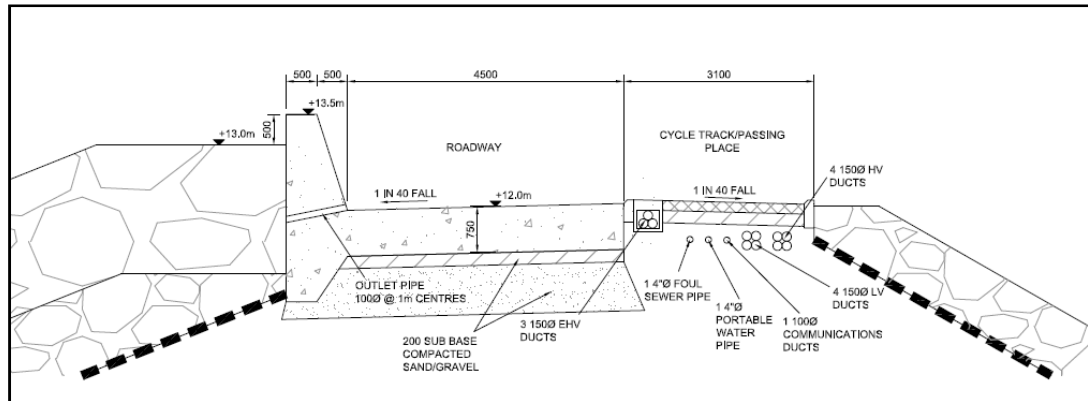


Figure 4.20 Crest detail

Section 2 - western landfall to Fabian way

- 4.3.4.6 Once onshore at the western landfall, the cables will be buried under the proposed combined footpath and cycle path which runs south of the proposed Project access road to the south of Queen's Dock. A plan of the proposed layout of the strip of land between Queen's Dock and the Lagoon foreshore is shown in Figure 4.21 below. The cables will be laid in a touching trefoil arrangement in a 1m wide trench, with 1m cover to ground level from the top cable. Widening will be required for cable joints and interfaces with other infrastructure, for example.

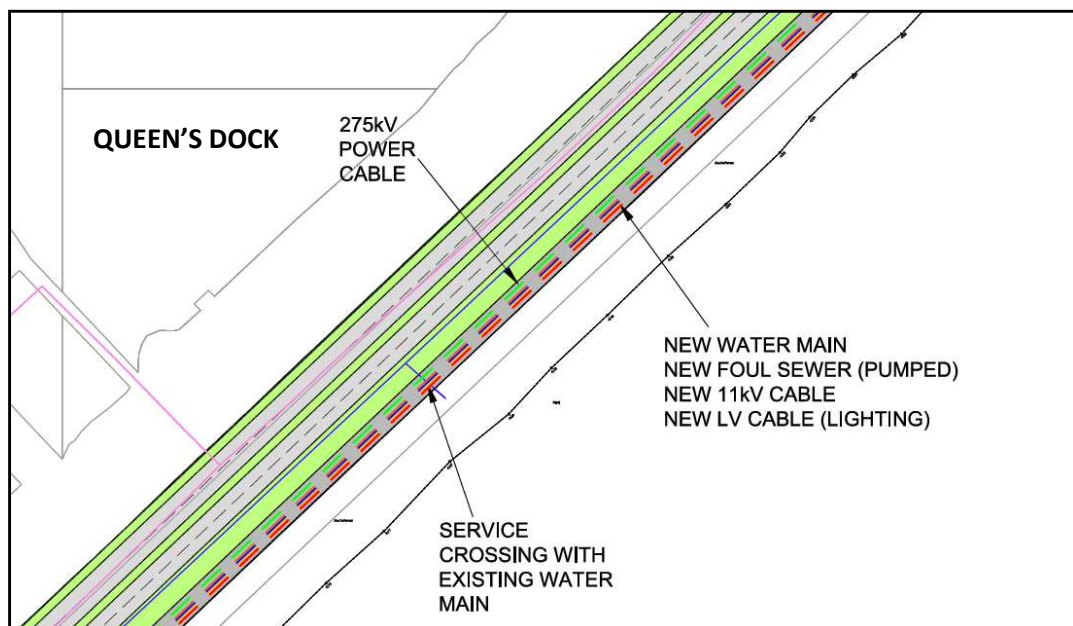


Figure 4.21 Plan of access road between Queen's Dock and the Lagoon

4.3.4.7 At the eastern end of Queen's Dock there is a small bridge, thought to be a redundant pipe bridge. Here it is proposed that the cables should continue along the proposed combined footpath and cycle route adjacent to the structure, with the possibility of the redundant bridge being removed and the area in-filled.

4.3.4.8 The proposed route for the cables then continues south of Baldwin's Crescent, extending east. It continues along an existing track that runs parallel and to the south of (but not on) Fabian Way, as far as SUBC.

Section 3 - Fabian Way across the front of the SUBC

4.3.4.9 At this point, the two options referred to below and shown on Figure 4.19 apply across the front of the SUBC.

Section 3 – Option a

4.3.4.10 If a route across the northern boundary of SUBC land can be agreed (see Figure 4.19), as a minimum, a duct for each cable will be laid under the main access road and other infrastructure. Alternatively, the entire length of the SUBC area will utilise cable ducts installed. The laying of the ducts will allow the cables to be pulled through the various sections, thereby avoiding the need to disturb the new roads to SUBC.

Section 3 – Option b

4.3.4.11 If a route through the main portion of the SUBC is not possible, the cables would cross from the track described in section 4.3.4.8 to the southern verge/cycle-path of Fabian Way at the western end of the SUBC.

Section 4 - Fabian Way to West of River Neath

4.3.4.12 From the eastern point of SUBC there are two potential routes.

Section 4a

4.3.4.13 The first option would be to follow the southern verge/cycle-path along Fabian Way.

Section 4b

4.3.4.14 The second option would be to follow a track through Crymlyn Burrows SSSI.

4.3.4.15 At approximately 150m before the Ffordd Amazon roundabout, the cable route options converge and extend south east through the SSSI immediately adjacent to the existing tarmac track.

Section 5 - west of River Neath to Baglan Bay substation

4.3.4.16 The cables will then have to cross the River Neath.

Section 5a

4.3.4.17 This will either be by using existing disused pipe infrastructure, which passes approximately 2m beneath the estuary and then following the coastal road north east.

Section 5b

4.3.4.18 The alternative would be to cross the River Neath by the installation of a single large diameter or 3 smaller diameter ducts by directional drill, approximately 650m in length.

The duct(s) will be installed with approximately 10m clearance from the top of the duct to the river bed above.

Section 6 - west of River Neath to Baglan Bay substation

- 4.3.4.19 The final section of the cable will then head south (at the point where the directional drill option would cross the Neath Estuary) and will run adjacent to an existing tarmac road or access track, to connect to the Baglan Bay substation. National Grid will be extending the substation to enable the new connection from the Project. Such an extension will be promoted separately by National Grid.

4.3.5 Masterplan, proposed buildings and public realm

- 4.3.5.1 The principal function of the Project is as an electricity generating station. However, it provides enhanced recreation facilities that will benefit the local and wider community. This benefit is important given that the land areas that will be occupied by the Project's infrastructure are either inaccessible or not of high quality. This is also relevant since the seawater area of the lagoon will no-longer be directly accessible from the open sea for water based pursuits. Therefore, public use of the lagoon will be encouraged.
- 4.3.5.2 The proposed facilities reflect the dual functions of clean energy generation and public recreation, and provide supporting recreational facilities integrated with necessary O&M facilities. All facilities are being designed to high standards of sustainability (e.g. energy efficiency, materials use and source, ease of access, etc), reflecting the Project's ambitions to support sustainable development as a whole, and to set an exemplary standard for subsequent projects.
- 4.3.5.3 In common with many generating stations, it is also appropriate for the Project to provide educational and visitor facilities. Here, as in other projects, such facilities are integrated as part of the generating station (offshore turbine and sluice gate structure).
- 4.3.5.4 It is anticipated that the Project will attract some 70,000-100,000 visitors a year (see Chapter 22, Economy, Tourism and Recreation), visiting the lagoon for both educational and recreational purposes. In terms of sporting events, these are anticipated to range from sailing competitions and training for a variety of classes of boat, to triathlon, swimming or running events once or twice a year, with between 2,000 and 8,000 visitors attending individual events. The design of the public realm and buildings provides for this anticipated demand and flexibility of layout to cater for peak demand for any activities at the lagoon.
- 4.3.5.5 Three focal areas are proposed to support the operation of the Project in this sense, which are illustrated on Figure 4.22. The function and general content of each area and the facilities provided for each are described below. The facilities comprise:
- i. Offshore Building;
 - ii. Western landfall; and
 - iii. Eastern landfall.



Figure 4.22 Location of three focal areas

- 4.3.5.6 The masterplan aims to link these three focal areas and the seawalls of the Lagoon to the land while capturing the existing waterside environments associated with Swansea Port, the SUBC and existing brownfield land. As such the public realm of the Project has been designed as a “marine park” with four offshore and onshore character areas, namely, the Broad Seaward Park, Narrow Seaward Park, Landward Urban Park and Landward Ecological Park. Overall the masterplan encompasses O&M requirements associated with the operation of the energy generation facility and related recreational opportunities, as illustrated in Figure 4.23.

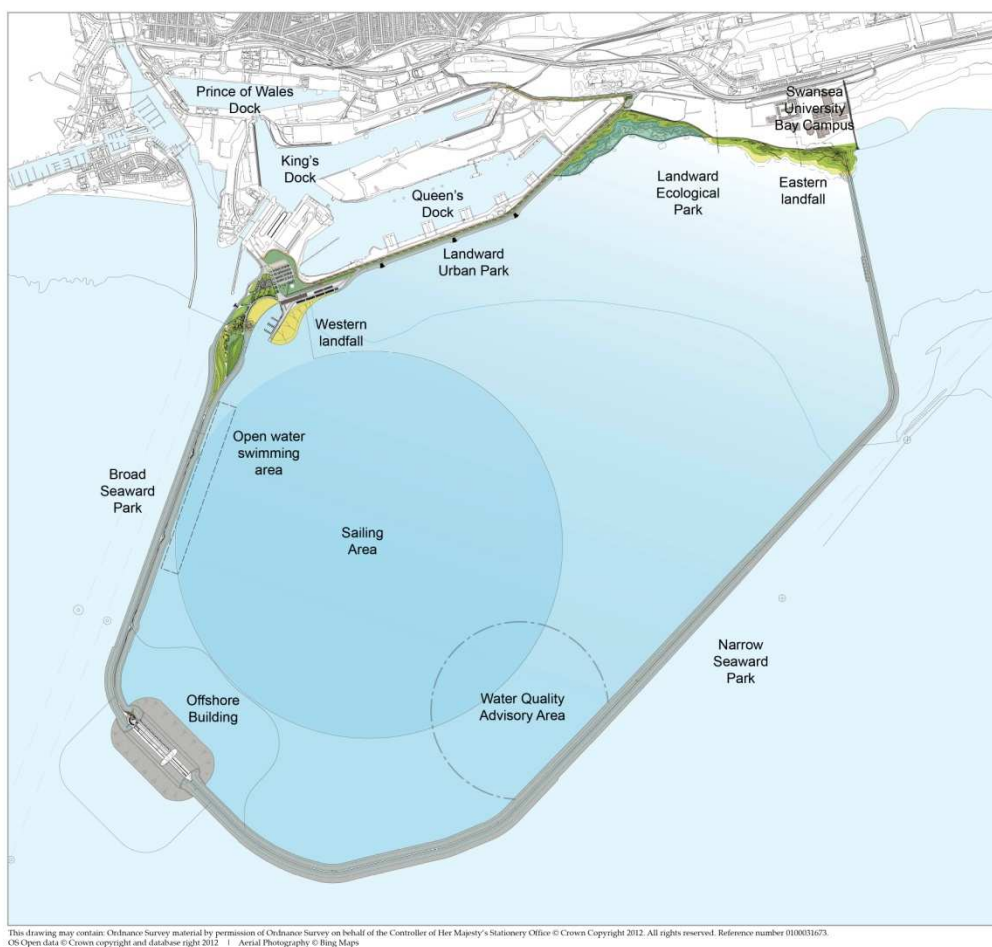


Figure 4.23 Lagoon public realm

- 4.3.5.7 Initially the key focal areas are discussed below and subsequently, information as to how the character areas are interlinked is provided. Finally the ecological enhancements which will be integrated into the masterplan are described.

Offshore Building

- 4.3.5.8 The Offshore Building is located on the North West side of the turbine and sluice gate housing structure (Figure 4.24).

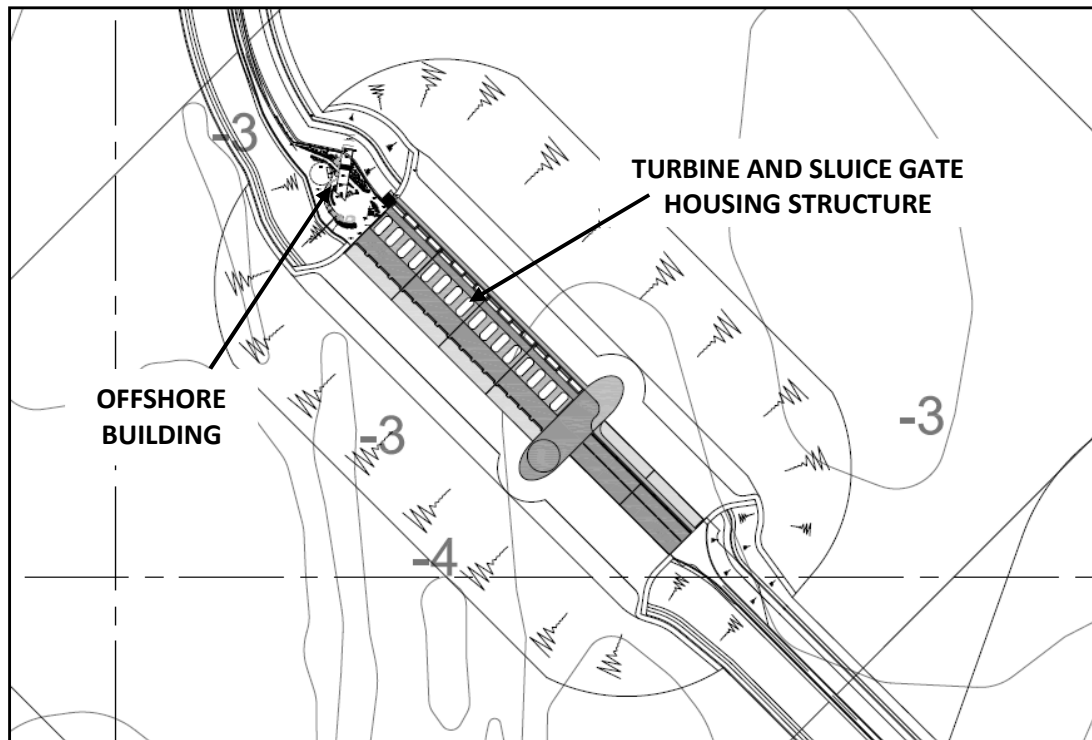


Figure 4.24 Location of Offshore Building

4.3.5.9 The Offshore Building will comprise a three-storey structure, with a maximum envelope of 57m by 51m by 25.5m high, and with a ground floor area of approximately 35m by 47m. The design of the building is shown in Figure 4.25a, with an illustrated cross-section is shown in Figure 4.25b.



Figure 4.25a Illustration of Offshore Building

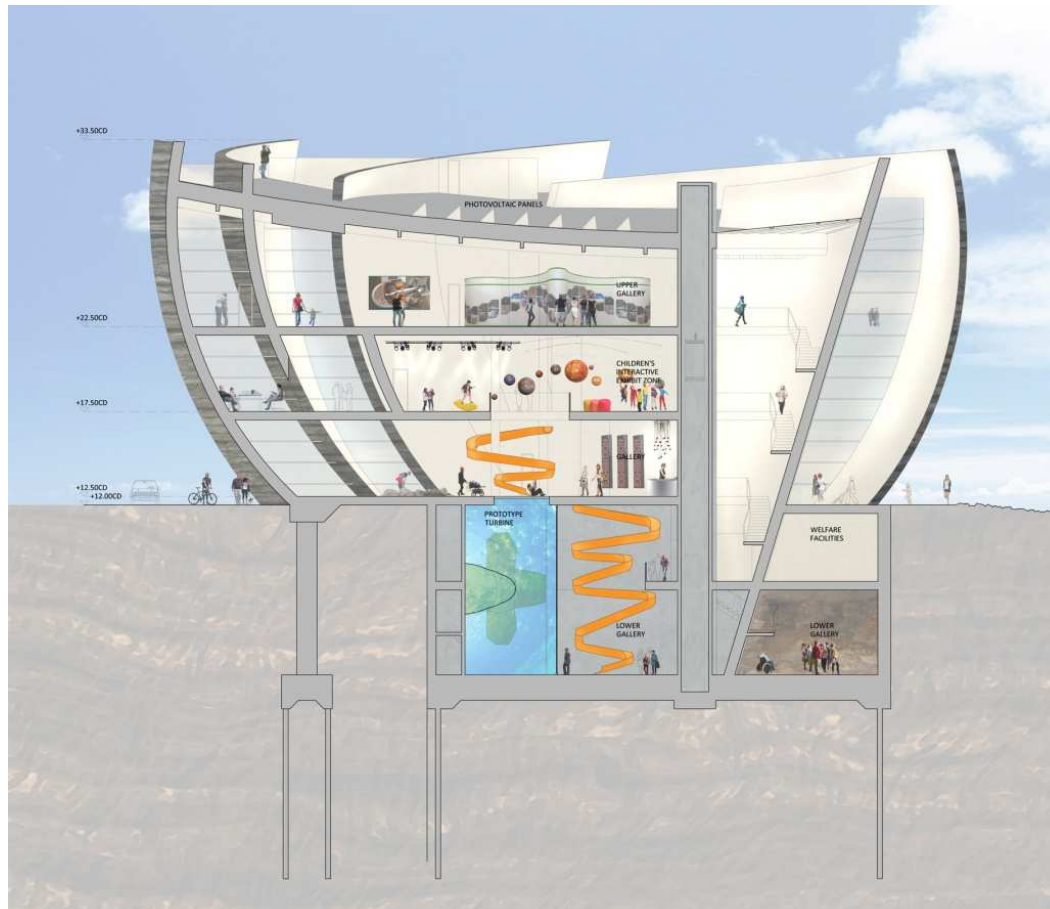


Figure 4.25b Illustrated cross-section of Offshore Building

4.3.5.10 The building would be up-lit and lighting of the immediate external area will be provided. Amenity lighting of the public realm would extend along the western seawall to the western landfall and at a lower intensity towards the eastern landfall. The Offshore Building will provide O&M facilities associated with the turbines and sluices, and recreational facilities for visitors. Certain O&M facilities are required to be sited close to the turbines below the concrete apron of the turbine housing and are also accessed via the building.

4.3.5.11 The Offshore Building O&M facilities include:

- i. stores space;
- ii. welfare facilities;
- iii. office accommodation;
- iv. control room;
- v. emergency room/treatment space; and
- vi. an area for emergency boat storage.

4.3.5.12 The following integral visitor facilities are also incorporated into the Offshore Building:

- I. reception and visitor facilities, including composting toilets.
- II. galleries and multi-functional exhibition space;

- III. turbine viewing gallery and viewing terraces;
- IV. education facilities;
- V. restaurant/café/ kitchens; and
- VI. staircases and lifts for access to all throughout the facility.

4.3.5.13 The building design allows for the use of composting toilets and water-less urinals. Additional waste and waste water will be discharged into a pumping station next to the building and then pumped via a sewer along the seawall. At the western landfall the sewer will then be combined with the sewer from the western landfall building in another pumping station. From there the waste and waste water will be pumped along a new sewer installed within the proposed footpath and cycleway south of Queen's Dock and be connected into the sewer close to the entrance of the WWTW.

4.3.5.14 External facilities include:

- i. access control to turbine housing to permit key maintenance operations to occur;
- ii. operational hardstanding areas on the turbine housing apron;
- iii. 25 car parking spaces for staff and maintenance vehicles predominantly located on the turbine and sluice gate housing structure, rather than adjacent to the offshore building;
- iv. bus and heavy vehicle turning facilities;
- v. public realm associated with the visitor experience;
- vi. lighting of external areas for key circulation routes and way-finding lighting to the public realm. The area will be up-lit with feature lighting on the edges of the building walls with internal lights visible through glazed panels/walls; and
- vii. access and boat platform outside turbine safety zone, with a jetty/floating pontoon and steps inside the lagoon wall.

4.3.5.15 The Offshore Building is designed to be sustainable and (as far as possible) self-sufficient, incorporating the following passive design features:

- 1) orientation: the building is orientated to manage solar influences offering shade to reduce solar gain during summer midday and afternoon but capture solar gain during winter early mornings.
- 2) natural light: glazing is incorporated to provide higher levels of natural light than traditional galleries reducing the energy demand for artificial lighting. A large roof light over the main circulation area will bring reflected light deep into the building.
- 3) stack effect: the design incorporates an open vertical circulation zone where hot air from the galleries will disperse to provide more comfortable ambient temperatures reducing the cooling load of the building.
- 4) insulation: the building will be insulated to a high level to reduce heat loss reducing energy demand on the building.
- 5) sealed building: high level of sealing to the building to reduce air leakage and energy loss.

- 6) thermal mass: the building design incorporates exposed concrete soffits to act as thermal absorbing and releasing energy over a cycle to assist in managing temperature fluctuations.

4.3.5.16 The Offshore Building incorporates the following technical design features, further contributing to its self-sufficiency:

- i. mixed-mode ventilation: reducing energy load by incorporation of managed natural ventilation and mechanical air distribution;
- ii. ground plenums: temper air through either sea water or ground cooled plenums to reduce energy load when heating or cooling intake air;
- iii. displacement ventilation: utilising low pressure mechanical ventilation to percolate conditioned air through the gallery spaces;
- iv. heat recovery system: capture heat loss and recycle to reduce energy load maintaining ambient temperature;
- v. rainwater harvesting: collection of rainwater and treatment to use as grey water;
- vi. water saving fittings: use water saving fittings to reduce water consumption;
- vii. light fittings: use low energy light fittings to reduce energy load;
- viii. photo voltaics: location of PV panels on roof to capture solar energy. Approximately 150 panels will provide conservatively 31,200kWh;
- ix. human waste: the building design includes composting toilets and water-less urinals;
- x. timber FSC: use of timber from Certified Sources; and
- xi. technical specification of concrete shells: inclusion of blast furnace slag from Port Talbot and other additives will reduce the carbon content of the concrete shells and it is proposed to pre-cast panels locally to reduce waste and make a more efficient construction profile. Bubble-Desk construction details will also reduce the concrete content for the floor slabs.

4.3.5.17 Finally, TLSB is investigating energy capture through the recovery of heat generated from the turbine action offshore. This could provide a major contributing element to the energy management of the Offshore Building.

Western Landfall

4.3.5.18 The western landfall area forms a destination location and the gateway to the western seawall, which extends as an attractive public realm towards the Offshore Building adjoining the turbine and sluice gate housing (Figure 4.24). It is anticipated that there will be an electric bus that can transport those visitors not wishing or able to walk between the western landfall and the Offshore Building.

4.3.5.19 The western landfall also includes access control measures that permit the seawall to be closed during the hours of darkness and during extreme weather conditions.



Figure 4.26 Western landfall layout

- 4.3.5.20 The water of the lagoon provides opportunities for a water sports venue capable of providing a permanent body of water for local, regional and national events, with spectator areas along the lagoon seawall. The development of the concepts behind the lagoon's use has been subject to consultation with a number of organisations and feedback through the consultation process has informed the design proposal.
- 4.3.5.21 Figure 4.27, illustrates the location of the sailing area on the open water of the lagoon.

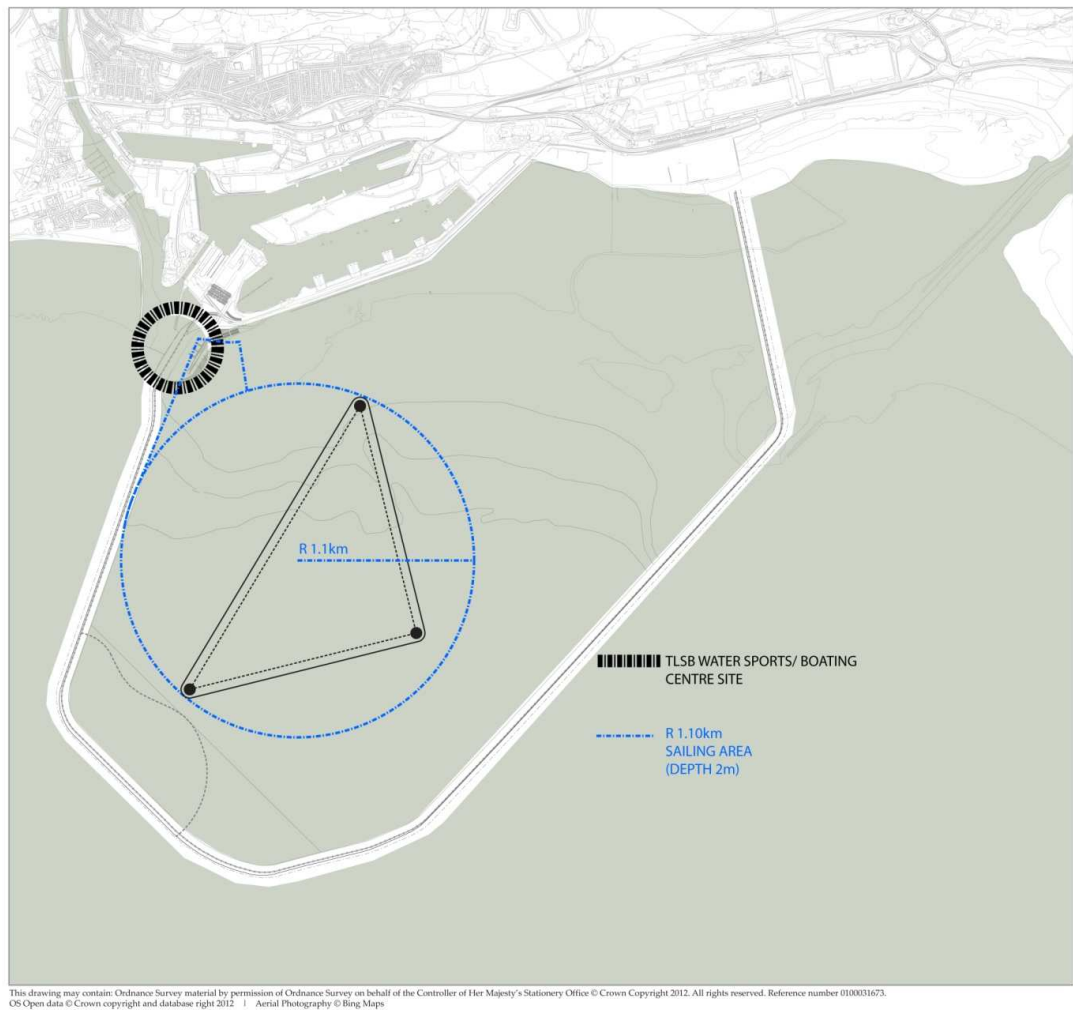


Figure 4.27 Sailing area within the Lagoon

- 4.3.5.22 The Western Landfall Building will comprise a three-storey structure with a ground floor area approximately 120m by 18m with a total height of 13.5m. The design of the building, which would be up-lit during hours of darkness, is illustrated in Figure 4.28, whilst the setting of the building within the Western Landfall is shown in Figure 4.26.
- 4.3.5.23 The building includes external spaces associated with its operation, key areas of which would also be lit during the hours of darkness. The building will provide functional space associated with the O&M requirements of the Project, including controlled access to the western end of the lagoon seawall and provision of space for recreational uses described below.



Figure 4.28 Illustration of Western Landfall Building

4.3.5.24 The Western Landfall Building O&M facilities include:

- i. stores/workshop space;
- ii. welfare facilities;
- iii. office accommodation;
- iv. control room;
- v. emergency room/treatment space; and
- vi. an area for emergency boat storage.

4.3.5.25 Operational access to the seawall and the turbine and sluice gate housing will require controlled access 24-hours a day and 7-days a week for staff and emergency vehicles. Controlled public access will be provided to the seawall and lagoon, ensuring that access is prevented or managed during extreme weather conditions and that access is limited by duration and location during the hours of darkness.

4.3.5.26 The following integral enhancement facilities are also included in the Western Landfall Building:

- I. gateway facilities including visitor orientation, exhibition space, visitor shop and offices;
- II. boating/water sports centre including entrance area, changing facilities, dry training/wet briefing areas, workshops/storage, cafe/bar/social space and viewing terrace, classrooms and staff facilities and medical room;
- III. public toilet facilities;
- IV. staircases, ramps and lifts for access to all throughout the facility; and
- V. laboratory and hatchery, including office space.

4.3.5.27 External facilities include:

- 1) access control to lagoon seawall;

- 2) up to 300 car parking spaces and associated overspill space;
- 3) six coach parking spaces;
- 4) bus and heavy vehicle turning facilities;
- 5) electric bus turning and set down area
- 6) slipway access to the lagoon, having a gradient of 1:10 with a vertical sheet pile wall to the west to create a sheltered harbour with pontoons;
- 7) boat storage area;
- 8) hard standing areas, soft landscaping, public realm and recreational space; and
- 9) lighting of external areas will be provided for key circulation routes and amenity way-finding lighting to the public realm.

4.3.5.28 Like the Offshore Building, the Western Landfall Building is designed to be sustainable. The Western Landfall Building (O&M, including boating/ watersports centre and hatchery facility) reflects a holistic approach to sustainable design. The simplicity of its shed-like massing and envelope has been designed to respond bio-climatically to its location, maximising solar opportunities from the south, consistent north light for natural day-lighting to the interior, whilst also maximising natural ventilation opportunities from the wind. The architectural design principles supporting this philosophy can be described as follows:

- i. continuous strip skylights at the apex redirect daylight into the depths of the upper level accommodation, creating optimised light distribution to reduce artificial lighting loads in administration/workshop/restaurant and lab spaces. Exhaust air outlets for natural ventilation are integrated into the skylights utilising the prevailing winds to induce accelerated natural suction ventilation principles;
- ii. the natural ventilation system has been supported by façade openings positioned relative to each cellular or open-plan space for single-sided window ventilation and uninhibited airflow through adjacent rooms at high level openings to ensure efficient cross-ventilation;
- iii. the cross-ventilation of workspaces/laboratories/administration at the upper floor is supported by the central circulation spine, acting like a mini-atrium along the building's entire length, connecting it like a road. The raised glass ceiling generates an enhanced stack effect. The warm return air from the cellular spaces provides this central zone with conditioned air in the winter;
- iv. the 40 degree slope of the roof helps enhance stack effect without the need for additional extract fan coils and promotes the passive cross-ventilation strategy;
- v. south-facing roof profile such that solar radiation can be harvested along the building's linear roof profile via photo voltaic panels. These will supplement the energy loading requirements to meet domestic hot water requirements for the changing areas and welfare/ kitchen areas;
- vi. rainwater utilisation: rainwater harvester from the roofs will be collected and redistributed for the building's non-potable water requirements reducing demand on incoming treated potable/ consumable water;
- vii. water-saving fittings are employed throughout the building to reduce water consumption;

- viii. Glulam timber frame building structure with prefabrication of the envelope and structure to eliminate site generated waste through construction;
- ix. prefabricated Structural Insulation Panels (SIPs): SIPs are most commonly made of Oriented Strand Board (OSB) panels sandwiched around a foam core made of expanded polystyrene (EPS), extruded polystyrene (XPS) or rigid polyurethane foam, but other materials can be used, such as Hemp or even wool. The panels can be used as floor, wall, and roof, with the use of the panels as floors being of particular benefit when used above an uninsulated space below. A building constructed using SIPs will have a tighter building envelope system and the walls will usually have higher insulating properties, which leads to reduced air leakage rates and a decrease in operating costs; and
- x. external timber cladding/ rainscreen: adopting a kebony, or natural Siberian larch, timber rain-screen will allow good durability and long life spans in the harsh and exposed marine climate. This type of timber product means that there is no need for paint products etc. to retain product properties. Required maintenance is limited to normal cleaning reducing life-cycle costs and potential chemical based stains or preservatives.

Eastern Landfall

- 4.3.5.29 The design of the eastern landfall facility comprises an information wall and viewing platform (shown in Figure 4.29 below) stepped into the proposed dune and coastal grassland area. The facility will abut the eastern landfall access track (discussed below). The final design is anticipated to be coordinated with SUBC as a combined facility providing information on the Project as well as Crymlyn Burrows SSSI, encouraging responsible behaviour for both lagoon access and habitat protection and conservation. The facility will not be lit.

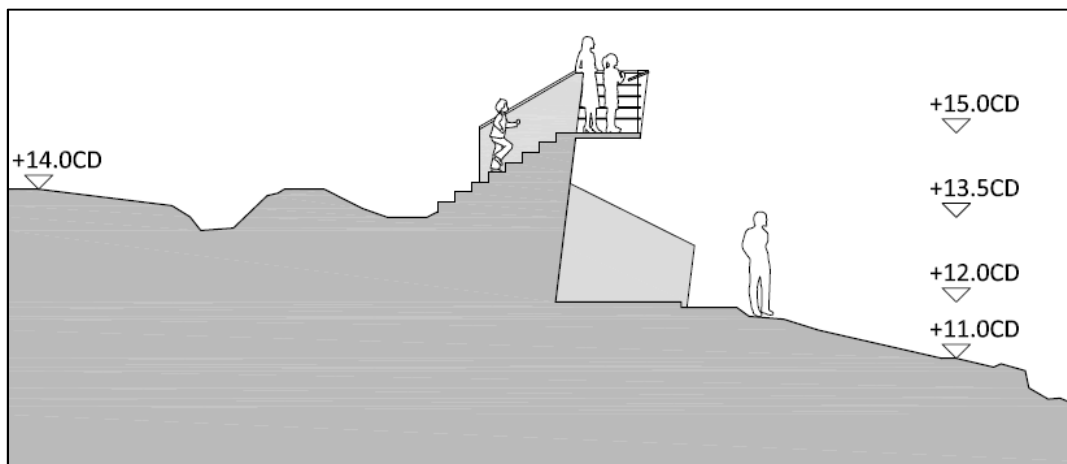


Figure 4.29 Eastern landfall and viewing platform

- 4.3.5.30 The eastern landfall area including the adjacent Landward Ecological Park, will be accessed via a track that will extend south of the SUBC. It will be secured with a locked gate thereby limiting unauthorised vehicular access at all times. Only O&M, emergency and possibly SUBC vehicles will be given access. Students and staff at the SUBC will access the eastern landfall via the Campus. Further details of the access infrastructure are given in Section 4.3.7.

- 4.3.5.31 The gate, which will also allow pedestrian and cycle access, will be manually opened and closed every day by staff based at the western landfall offices. It will secure the seawall from access during hours of darkness and extreme weather.

Character areas and public realm

- 4.3.5.32 As shown on the Masterplan the three focal areas are interconnected with four character areas or Parks; the Broad Seaward Park, Narrow Seaward Park, Landward Urban Park and Landward Ecological Park. All character areas will be lit in accordance with their context, role and with regard to operational, navigational and ecological demands, using low-energy equipment.

Broad Seaward Park

- 4.3.5.33 Starting at the Western Landfall, the Broad Seaward Park will invite visitors offshore to the Offshore Building. At its landward and widest extent it comprises a beach area with recreational space overlooking the Western Landfall Building and associated facilities. An intertwining network of paths will then lead visitors across a wide sweeping walkway offshore and onto the main lagoon wall. Positioned along this section will be stopping off places such as viewing areas and sculptures.
- 4.3.5.34 The new rock armour of the lagoon seawall, which will extend some distance offshore, will provide good opportunities for habitat creation at and below water level. In addition, opportunities will be available for both able-bodied and disabled recreational fishermen, with the provision of safe and formal fishing locations, as well as informal opportunities for walkers, runners and cyclists.
- 4.3.5.35 As discussed above a shuttle bus is proposed linking the existing Park & Ride facility on Fabian Way, the western landfall, and the Offshore Building, subject to investigation of its viability. Facilities are also proposed on the western seawall to support a potential 'lagoon water shuttle' service linking the existing pontoon on the west bank of the Tawe to the Lagoon facilities. These proposals support access to the Project from Fabian Way and Swansea Maritime Quarter respectively.

Narrow Seaward Park

- 4.3.5.36 Beyond the Offshore Building the Narrow Marine Park will lead visitors back onshore to the Eastern Landfall. As with the further offshore section of the Broad Seaward Park stopping off places, fishing platforms and sculptures will be dotted along the route.

Landward Ecological Park

- 4.3.5.37 Connecting the Eastern Landfall to the Western Landfall are the Landward Ecological Park and the Landward Urban Park. The landward Ecological, shown below in Figure 4.30, aims to provide a buffer between the Project users and the Crymlyn Burrows SSSI.



Figure 4.30 Landward Ecological Park

- 4.3.5.38 The Landward Ecological Park comprises areas of saltmarsh (5ha), coastal maritime grassland (3ha) and dunes (5.5ha). These areas will be formed part in mitigation for lost habitat but also as enhancement proposals thereby adding ecological connectivity and value to the area. Ecological enhancement is discussed further in Section 4.3.6.

Landward Urban Park

- 4.3.5.39 Finally the Landward Ecological Park leads into the Urban Park. This area extends along the existing Queen's Dock waterfront as an enhanced public realm and access road environment benefiting from the removal of the existing concrete seawall (where possible) opening up views across the lagoon. The proposal establishes a new waterfront road, lagoon-side public realm and attractive recreation areas at a level above the high tides with limited lagoon-side parking and pedestrian access to intertidal areas at low tide. Public realm, landscape and habitat creation proposals at either end of this route integrate the western and eastern landfall points of the seawall into its environment before extending into the Bay.
- 4.3.5.40 Overall this circular route around the lagoon is provided for O&M and recreational purposes which includes a publicly accessible cycle and footpath route.
- 4.3.5.41 The masterplan also includes and makes provision for sculptural elements of various heights, which form a trail around the length of the seawall as illustrated in Figure 4.31. This trail also includes large, lit pearls.

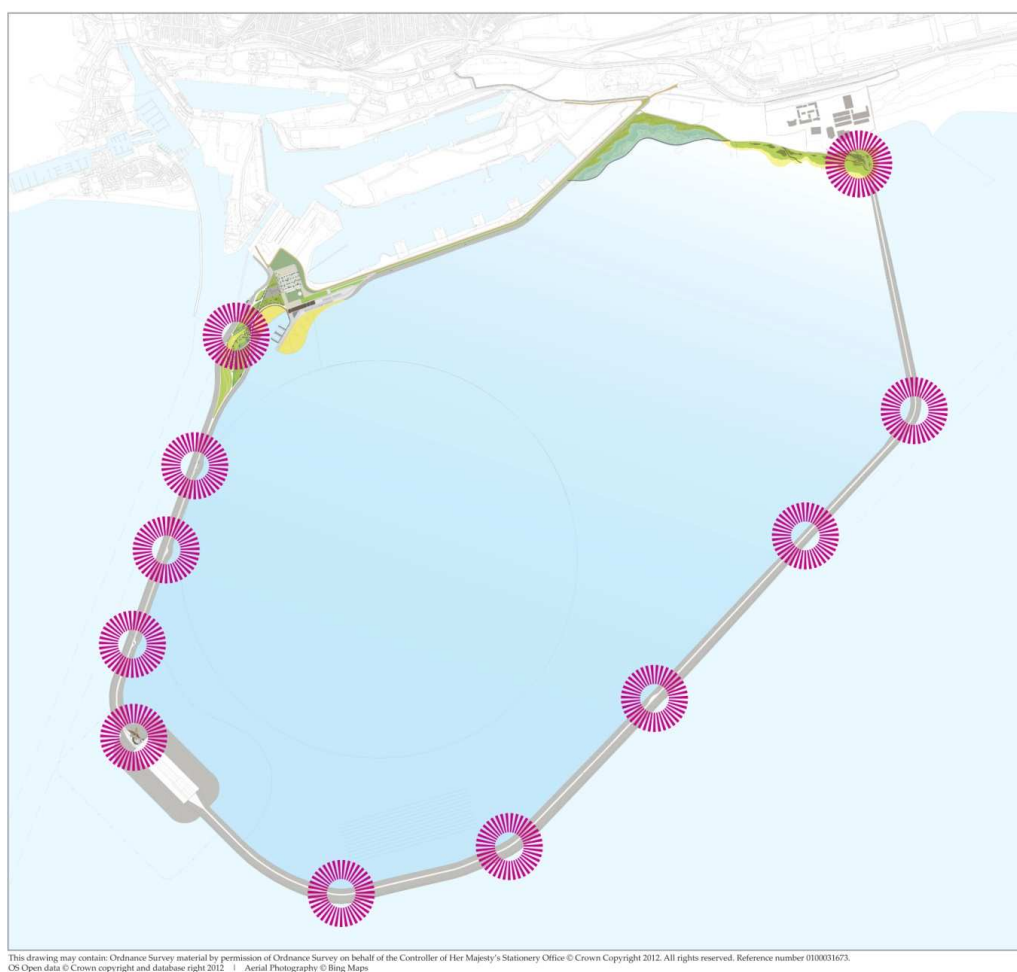


Figure 4.31 Location of sculptural elements

- 4.3.5.42 To mark the halfway point around the trail there will be the 'Halfway point pearl' as shown below in Figure 4.32

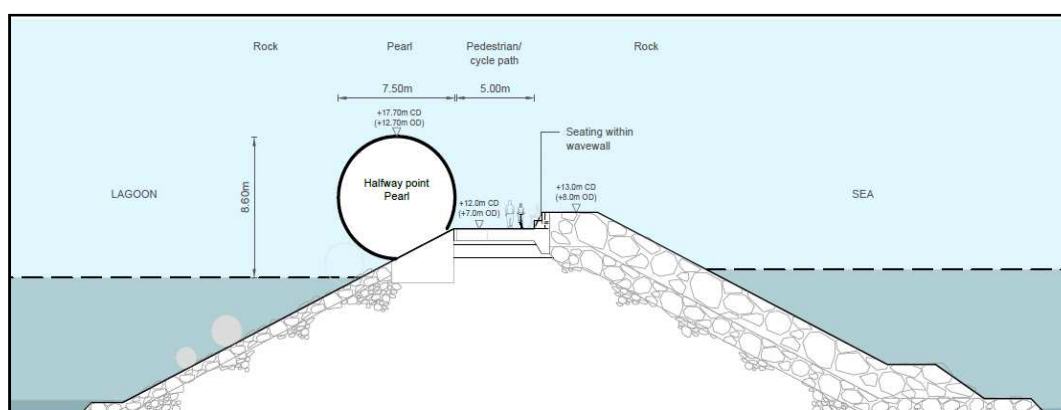


Figure 4.32 Halfway point pearl

- 4.3.5.43 As with the Offshore and Western Buildings, the design of the public realm has been developed as far as possible to be sustainable. The following principles and elements have been incorporated into the design:

- i. the new areas of public realm will utilise materials and resources found on site, where possible, or aim to procure material locally to help reduce the carbon footprint of the Project;
- ii. material sourced beyond the site will arrive by boat where possible;
- iii. where appropriate, concrete elements will be manufactured on site minimising transportation;
- iv. the use of timber from FSC certified sources will be used throughout;
- v. sustainable forms of access will be utilised for the Project, including provision of an electric bus, water shuttle and park and ride facilities, as well as continuous access along the length of the seawall for pedestrian and cycle users;
- vi. where appropriate creation of sand dune and salt marsh landscape will utilise material from the seabed within the lagoon;
- vii. planting designs have been inspired by local flora characteristics to minimise maintenance requirements and ensure they are suited to the prevailing conditions;
- viii. translocation of existing coastal grassland habitat will be incorporated into the design to improve establishment time and conserve flora/fauna, biodiversity and ecosystems;
- ix. the proposals will capitalise on local seed banks by brush combing grassland to recover seed sources;
- x. play areas will utilise natural play principles and materials;
- xi. low technology water play features will use minimal water resources;
- xii. lighting of the Project will be such that it will only be operational when needed, and lighting will be dimmed or switched off beyond the main visitor hours. The Institute of Lighting Engineers Guidance to Light Pollution will be adopted including reducing light pollution and minimising energy use;
- xiii. features/sculptural elements forming part of the 'string of pearls', where located away from electricity connections will be illuminated using power generated from photovoltaic cells; and
- xiv. swales will be incorporated into the design of the access road to allow for the provision of sustainable drainage.

4.3.6 Ecological considerations and opportunities

4.3.6.1 In order to ensure a comprehensive assessment within this Environmental Statement the extent of intertidal and subtidal habitat change as a result of the Project construction and operation has been determined. This evaluation is made straightforwardly by stating areas of intertidal or subtidal habitat change, as opposed to the nature of the habitat lost or gained e.g. sand, rock or gravel or the species present. Detailed assessment of the potential direct and indirect effects on habitats and species are presented in Chapter 8, Intertidal and subtidal benthic ecology, Chapter 9, Fish, including Commercial and Recreational Fisheries and Chapter 11 Coastal Birds. The changes in terrestrial habitat are discussed in Chapter 12, Terrestrial Ecology.

4.3.6.2 The tables presented below summarise the potential habitat change. For the construction phase Tables 4.4a and 4.4b summarise the estimated changes for each year of construction and presents this net change in terms of the local habitat of Swansea Bay

coastal water body as identified by the River Basin Management Plan (EA, 2009). For the subtidal habitat the calculation has been undertaken for both the worst case “shallow and wide” dredged area (Figure 4.8) as well as the “deep and narrow” dredged area (Figure 4.9).

Table 4.4a Construction – Intertidal losses and gains year 1 – year 3

Activity /area	Ha
Intertidal area within Swansea Bay	2424
Under lagoon walls Y1	-20.50
Habitat gain seawall Y1- Y3	38.00
Area for rock storage year 1 and 2	-22.25
Wall of cofferdam Y1 - Y2.5	1.90
Total change end Y1 (as % of Bay)	-2.85 (-0.12%)
Total change end Y2(as % of Bay)	-2.85 (-0.12%)
Total change end Y3 (as % of Bay)	17.50 (0.72%)

Table 4.4b Construction – Subtidal losses and gains year 1 – year 3

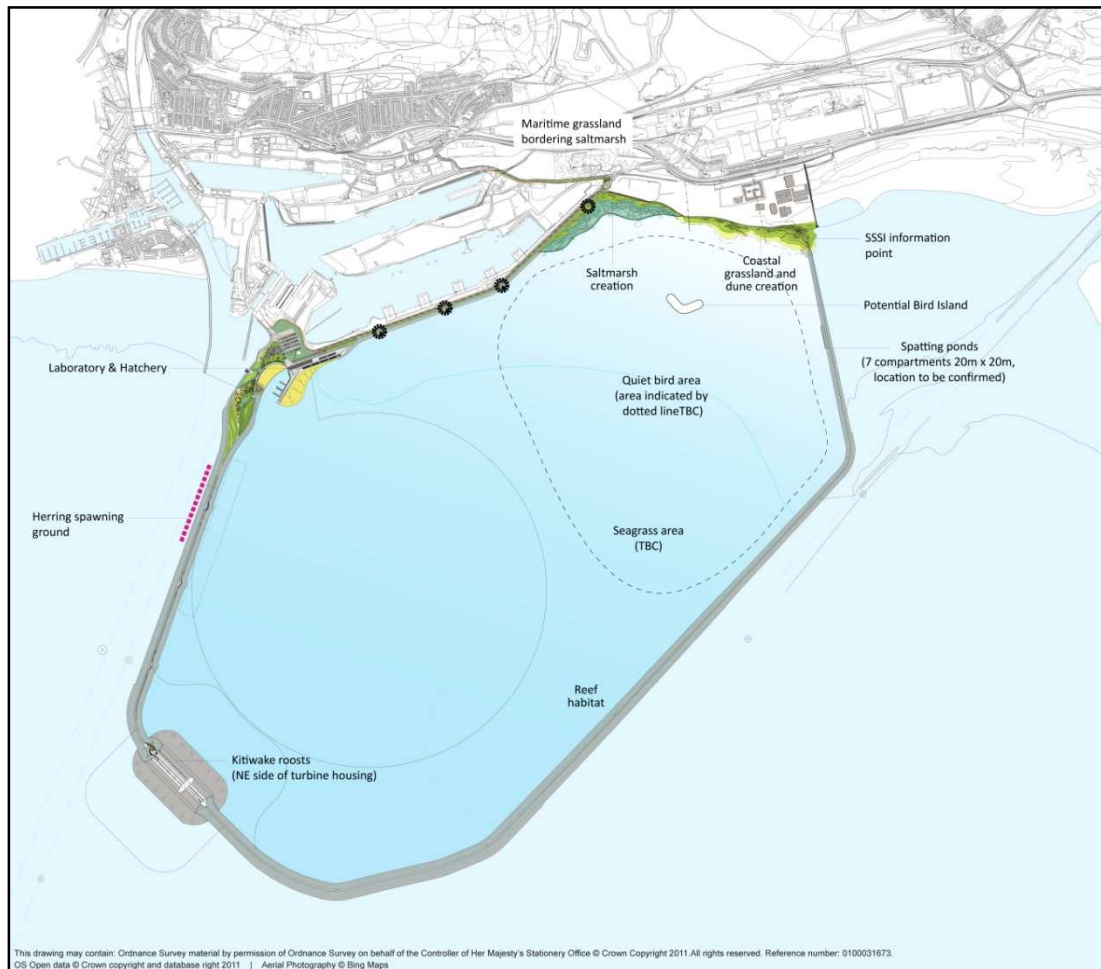
Activity /area	Ha (wide dredge)	Ha (deep dredge)
Subtidal area within Swansea Bay	10380	10380
Year 1 - subtidal lagoon wall	-21.7	-21.7
Gain on seawall Y1	7.67	7.67
Worst case dredge Y1	-200	-31.5
Temporary cofferdam Y1 - Y2.5	-20.30	-20.30
Gain on wall of cofferdam Y1 - Y2.5	9.00	9.00
Year 2 - subtidal lagoon wall	-27.2	-27.2
Gain on seawall Y2	9.58	9.58
Worst case dredge Y2	-133.33	-21.00
Year 3 - subtidal lagoon wall	-16.3	-16.3
Gain on seawall Y3	5.75	5.75
Worst case dredge Y3	-66.67	-10.50
Total change end Y1 (as % of Bay)	-225.37 (-2.17%)	-56.87 (-0.55%)
Total change end Y2 (as % of Bay)	-162.21(-1.56%)	-49.88 (-0.48%)
Total change end Y3 (as % of Bay)	-77.22 (-0.74%)	-21.05 (-0.20%)

4.3.6.3 For the operation phase the total habitat change has included losses as a result of water changes. This includes the losses within the local Swansea Bay area as well as that within the lagoon footprint based on the use of fixed speed turbines. In this instance the water levels within the lagoon will not attain the same levels as those outside the lagoon. This results in an intertidal loss, which becomes a subtidal gain. A further calculation has been undertaken for the use of variable speed turbines, where pumping at the end of the tidal cycle will return water levels inside the lagoon to that outside the lagoon.

Table 4.5 Operation – Intertidal and subtidal losses and gains

Activity /area	Fixed speed turbines		Variable speed turbines	
	Intertidal hectares	Subtidal hectares	Intertidal	subtidal
Under lagoon wall and turbine house	-20.5	-68.48	-20.5	-68.48
Sour protection	n/a	re-colonise	n/a	re-colonise
habitat gain - seawall/turbine house	38.7	24.15	38.7	24.15
loss/gain from changes in water levels within lagoon footprint	-62	62.00	0	0.00
1cm loss/gain in wider bay	-2.88	2.88	-2.88	2.88
Total habitat change (as % of habitat within Bay)	-46.68 (-1.93%)	20.55 (0.2%)	15.32 (0.63%)	-41.45 (-0.40%)

4.3.6.4 Ecological considerations have also been integral to the design of the Project's onshore and offshore environment, both in terms of mitigation and enhancement. Figure 4.33 presents the key ecological features which are allowed for in the Project design.

**Figure 4.33 Key ecological proposals**

4.3.6.5 Saltmarsh (5ha), coastal maritime grassland (3ha) and dunes (5.5ha) are proposed as part of the eastern landfall ecological park providing a buffer between the Project users and the Crymlyn Burrows SSSI. On the open water and in the shallower areas of water where

the greatest extent of intertidal area exists, a quiet zone will be established within the lagoon where water sports will be discouraged. Roosting areas will be provided at locations around the lagoon including provision of kittiwake ledges on the northeast side of the turbine house or at other locations around the seawall. Proposals will be further developed so that key bird species can be encouraged into the lagoon.

- 4.3.6.6 Enhancement to the foot of the seaward side of the seawall is proposed to encourage herring spawning. This will be through the provision of suitable coarse substrate. Where possible this material would be translocated from other areas of the lagoon which would be disturbed through construction works.
- 4.3.6.7 In addition ecological concepts for inclusion in the design of the lagoon have been developed with SEACAMS⁶. These include Oyster spatting ponds which will be placed in the intertidal zone. These would form part of a proposed 10-year programme to encourage the return of the native oyster to Swansea Bay.
- 4.3.6.8 The natural rock of the lagoon seawall itself will be designed to include rockpools, overhangs and crevices which will provide a diverse range of habitats for different marine species. The concept of 'BioBlocks'⁷ will be adapted for the specific context and opportunity the Project offers and will be integrated into the seawall design (Appendix 8.3, Volume 3).
- 4.3.6.9 The varied design of the natural rock will provide an extension to the artificial diversification of the lagoon wall and would provide an opportunity to actively involve several groups of society and to integrate many interests. For instance the shape and size of pits, ridges and crevices should primarily be diverse, and this could be exploited creatively. Artists would be given the opportunity to design modifications of the rock armour or to sculpture features that could be integrated into the wall. They could collaborate with ecologists in order to take colonisation patterns into account. The modifications would also be an opportunity for scientists to test specific features such as standardised rockpools in a controlled manner.
- 4.3.6.10 The use of concepts such as Bioreefs will also be considered for use within the lagoon design. These shell-filled gabions, which can be used to prevent erosion, will be positioned within the intertidal area primarily for their ecological enhancements. Studies at Swansea University in collaboration the bioengineering company Salix (who are developing this concept) showed that shell filled mesh bags attract a diverse coastal fauna within a short period of time, and they have the potential of enhancing local biodiversity.
- 4.3.6.11 A hatchery and laboratory facility will be integrated into the western landfall building and will include a seawater supply pipe from the lagoon into the facility. The concept and operational characteristics of the proposed facility have been developed with SEACAMS. The hatchery will facilitate the oyster enhancement programme but will also look at rearing lobster for placement on the Lagoon wall. Other opportunities to culture other species including fish will also be explored.

⁶ SEACAMS, a project part-funded by the European Regional Development Fund through the Welsh Government is a partnership between Bangor, Swansea and Aberystwyth Universities. SEACAMS aim is to integrate research and business opportunities in the marine sector in Wales.

⁷ The Bioblock is a cuboid construction with dimensions 1.5 x 1.5 x 1 m and modifications on 5 sides. The block includes pools of variable depths on the upper surface, multiple depth holes on 2 opposing vertical surfaces and horizontal grooves on the remaining surfaces

- 4.3.6.12 The laboratory will also form part of the monitoring facilities for the lagoon. This will be centred around an adaptive environmental monitoring plan (AEMP) (Appendix 23.1) which will not only monitor the effect of the lagoon and the integral ecological enhancement measures, but it will also inform further the understanding of the effect of tidal range projects for the future.

4.3.7 Access infrastructure

- 4.3.7.1 Access to the Project will be provided via a new access road with combined footpath and cycleway. This access road will start from Langdon Road, as shown on Figure 4.34 below, with vehicles leaving Fabian Way at the existing traffic signal controlled junction, turning left at the existing roundabout (which extends to link with the SA1 development) and then turning right to join the new road.



Figure 4.34 Access to Lagoon off Fabian Way

- 4.3.7.2 A new footpath/cycleway will be created south of Langdon Road to link the existing footpath from SA1 to the start of the Project access road.
- 4.3.7.3 The new access road will run along the north side of the existing Port Road, separated by a verge and swale (potentially lined), up to the boundary of the DCWW WWTW, as shown on Figure 4.35. Here the Port Road will be moved south and the proposed Project access road will continue past the entrance to the WWTW. At approximately 50m past the entrance of the WWTW, the proposed access road will turn, cross the Port Road, and extend west along the south of Queen's Dock. A new Port security entrance will be created with the existing security gatehouse relocated to the west of the proposed Lagoon access road. Access to the Port will remain from Baldwin's Bridge junction.

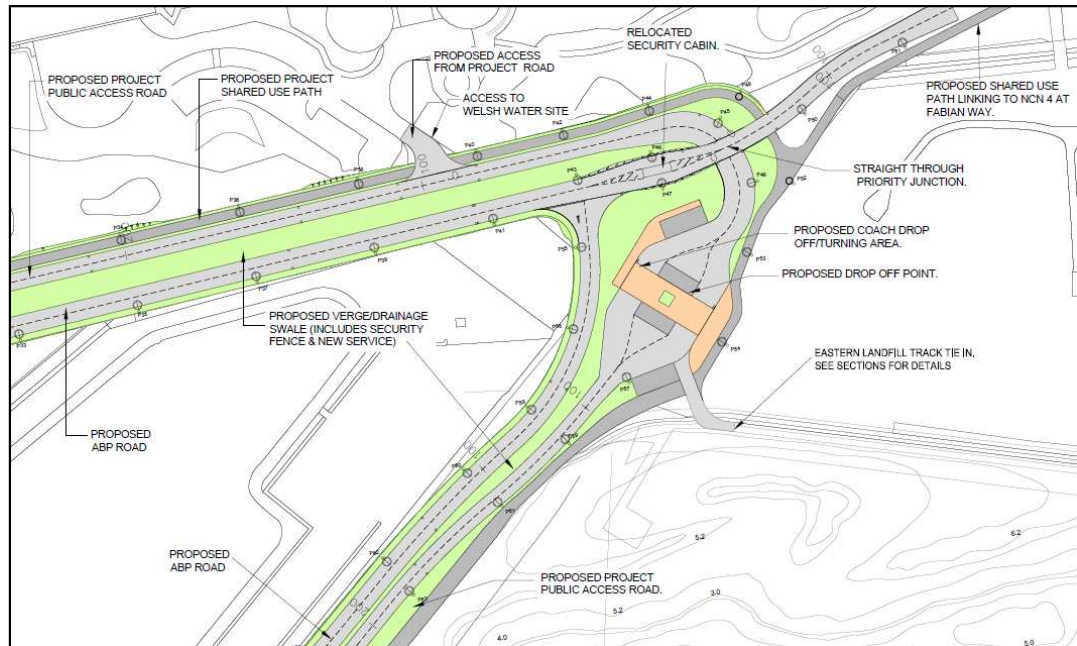


Figure 4.35 Proposed access road with Port security entrance relocated

- 4.3.7.4 There will be a new combined footpath/cycleway that will run along the length of the new access road, it will be 3m wide from Langdon Road to where the road turns to head west along in front of the WWTW. At this point the combined footpath/cycleway will join the route that runs around the perimeter of the Lagoon and widens to 5m as it follows the route to the western landfall.
- 4.3.7.5 Once the Project road has crossed the Port Road there will be a drop off point and turning area allowing pedestrians and cyclists to join the footpath and cycleway to the eastern landfall, this can be seen in Figure 4.35. A 3m wide access track for O&M vehicles will be provided, leading to the eastern landfall, which follows the line of the pedestrian/cycleway route discussed previously, this can be seen in Figure 4.36 below.

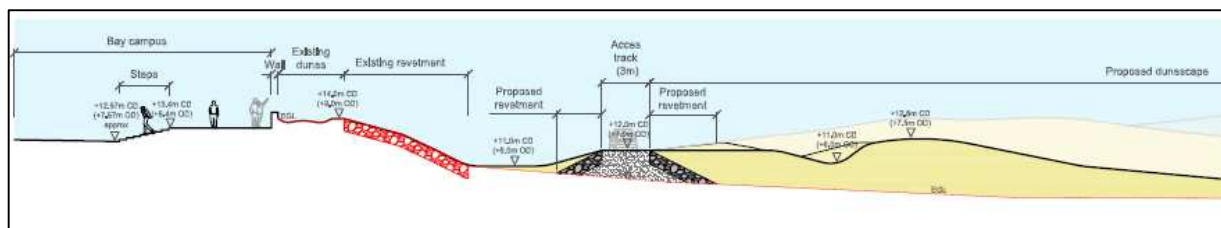


Figure 4.36 Access track to eastern landfall

- 4.3.7.6 The access track will be constructed in the same method as the seawall, including rock armour, and then the proposed dunescape built up either side. This will ensure the access track remains in place even if the dunes change level adjacent to the track. The track will join into the eastern seawall to create a seamless structure.
- 4.3.7.7 The Queen's Dock waterfront currently comprises an existing Port road with wide grass and stoned verges. On the seaward side is rock armour seawall protection surmounted by a 2m high concrete wall with some gaps. The area is currently privately controlled with access for Port operations only.

- 4.3.7.8 The proposed Project road will extend along the south side of the Queen's Dock and utilise the alignment of the existing Port road. The majority of the existing 2m high concrete flood wall will be removed to open up views to the Lagoon, this is shown in Figure 4.37 below. Where there are existing World War II features, such as pill boxes, these structures will be retained, along with a 3m section of wall either side, shown on Figure 4.38 below. More information on these features can be found in Chapter 21, Cultural Heritage: Terrestrial Archaeology and Historic Landscape.
- 4.3.7.9 A new Port road will be constructed immediately north of the Project road, separated by a secure fence line. In this way, existing Port operations will not be affected by the development. The Project road will be in the order of 5.5m wide with an adjacent 5m wide footpath and cycleway.

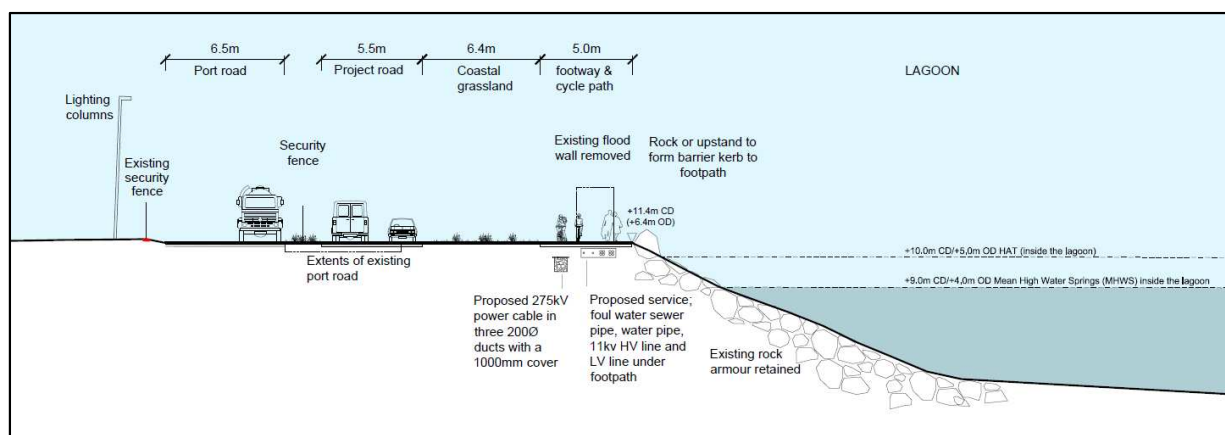


Figure 4.37 Cross-section of new access road

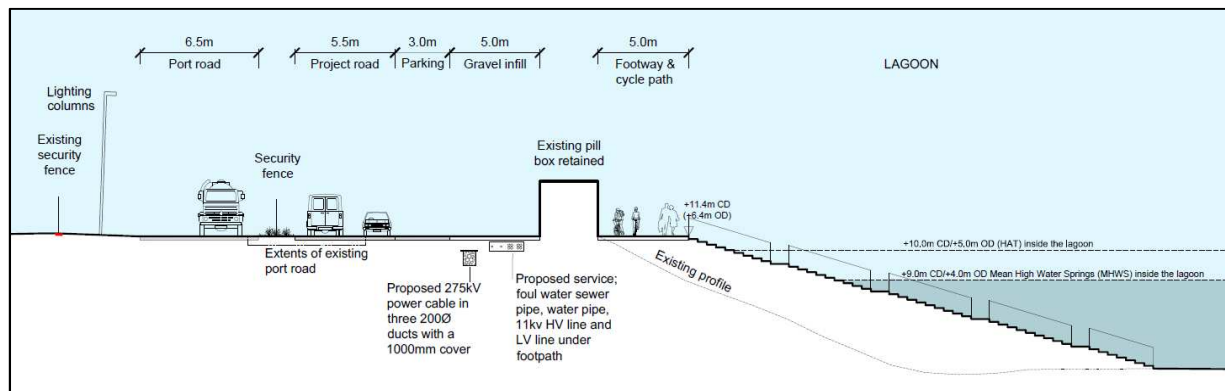


Figure 4.38 Cross-section of new access road with pill box retained

- 4.3.7.10 The layout of the roads and combined footpath and cycleway south of Queen's Dock is shown on Figure 4.39 below. The Figure also shows the arrangement around a retained pill box.

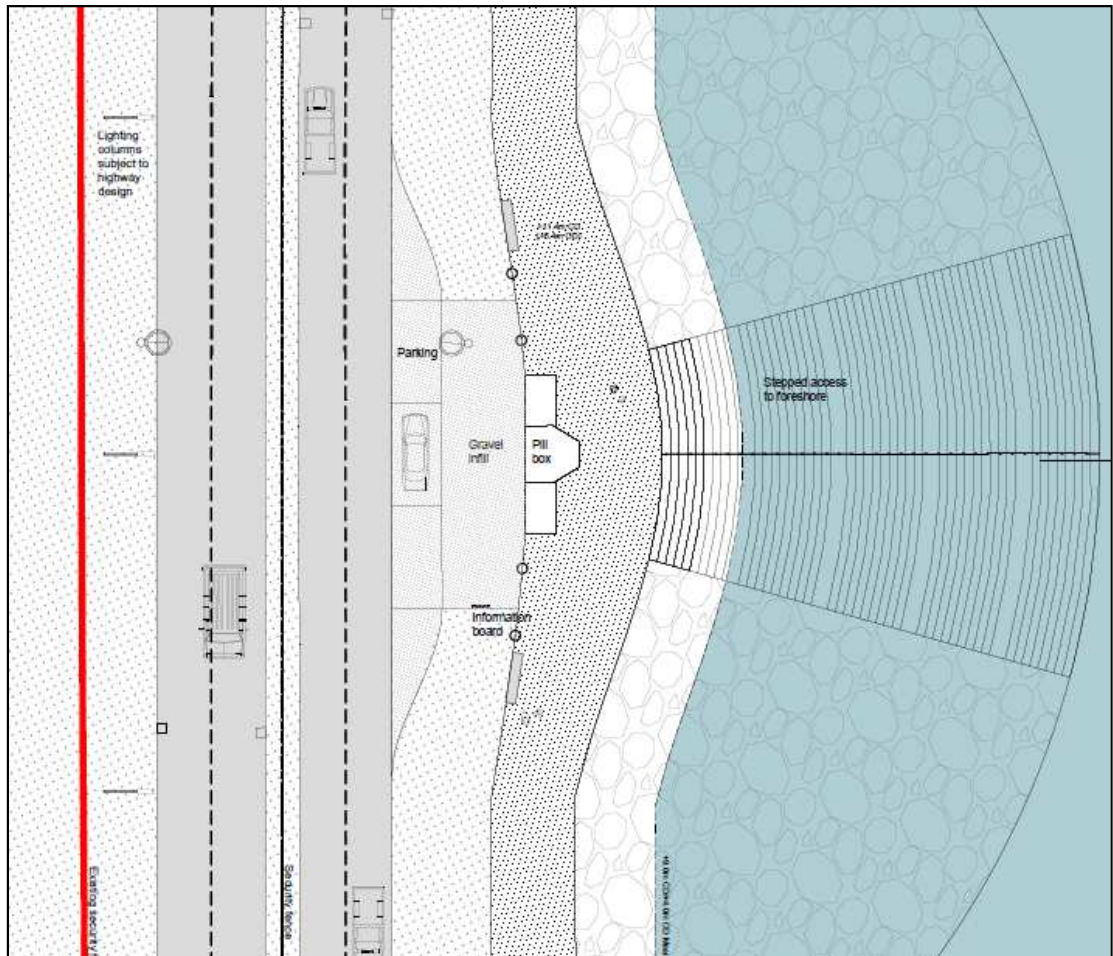


Figure 4.39 Layout south of Queen's Dock

- 4.3.7.11 The roads will be designed to suitable vehicle loading and swept path analysis and be lit to adoptable standards. Further details on transport for all stages of the Project can be found in Chapter 15, Onshore Transport Assessment.

4.3.8 Water shuttle and associated access

- 4.3.8.1 A potential link from the Project to the west bank of the River Tawe and central Swansea is to be facilitated by the provision of a new pontoon and landing point at the western landfall. This will support a water shuttle service that will run between the western landfall and the existing pontoon on the western bank of the River Tawe. The existing eastern breakwater of the Port of Swansea will be removed as part of the Project and this will create a suitable access point. If possible and practical, the Harbour Light which is located on the breakwater will be retained and relocated. If this is not practical recording of the light will be undertake prior to removal (Chapter 21, Cultural Heritage: Terrestrial Archaeology and Historic Landscape). A plan of the potential pontoon with double linkspan access at the lagoon seawall is shown below (Figure 4.40).

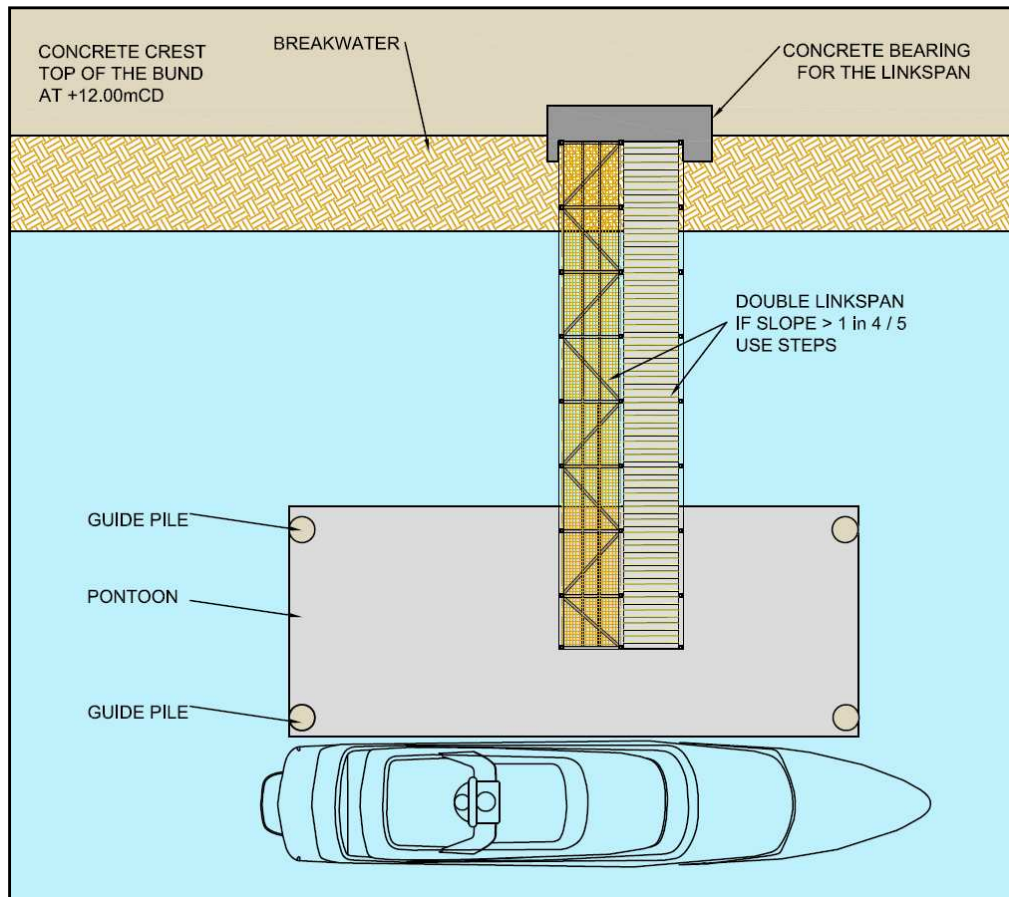


Figure 4.40 Plan of Water Shuttle Service

- 4.3.8.2 A concrete foundation will be constructed within the seawall that will support the double linkspan access. The floating pontoon will be supported with guide piles, likely to be hollow steel sections, which will move up and down with the tides.

4.3.9 Water quality enhancement works

- 4.3.9.1 The long sea outfall from Swansea Bay Waste Water Treatment Works (WWTW), owned by DCWW, shown on Figure 4.3, terminates within the proposed lagoon area. The outfall discharges a high quality tertiary treated UV disinfected final effluent. This discharge should not preclude the use of the lagoon for water contact sports.
- 4.3.9.2 After heavy rainfall, the occasional discharge of screened storm water from the long sea outfall into the lagoon is capable of causing localised, temporary deterioration in water quality. In order to maintain an appropriate standard of water quality all year round for water contact sports within the lagoon in the case of heavy rainfall, additional treatment of the storm water has been considered. These are being promoted as "water quality enhancement works". If water contact sports were not proposed within the lagoon, no such measures would be required (See Chapter 7, Marine Water Quality Assessment).
- 4.3.9.3 Three options were initially reviewed, the details of which are presented in Chapter 3, Site Selection and Option Appraisal.
- 4.3.9.4 The options considered were:

- i. provision of additional storage capacity for storm water;
- ii. ultraviolet (UV) disinfection of the storm water; and
- iii. extension of the existing long sea outfall beyond the seawall of the lagoon.

4.3.9.5 As part of the Project, only options 2 and 3 are being promoted for the reasons given in Chapter 3 Site Selection and Option Appraisal. The assessment of the effects of the Project and the benefits of these enhancements on water quality within Swansea Bay can be found in Chapter 7, Marine Water Quality Assessment. A summary of these two options are given below.

UV disinfection of storm water

4.3.9.6 Option 2 comprises the provision of UV treatment facilities for the storm water from the WWTW. This methodology is used to treat storm water at other WWTW in South Wales, such as at Llanelli WWTW to the west of Swansea and Cogmoors WWTW in Cardiff. UV disinfection is already present on the final effluent at Swansea, which is currently discharged through the long sea outfall into Swansea Bay. The proposed UV disinfection plant would be used to treat all storm water flows which currently pass down the outfall, thereby reducing bacterial content to achieve the required water quality standard for year-round, water-contact recreational use as described in Chapter 7. The additional treatment plant is most likely to be best-located near the input to the outfall at Swansea WWTW.

4.3.9.7 The UV disinfection plant would either be accommodated underground like much of the existing WWTW or in a small additional building the dimensions of which would be unlikely to exceed 50m by 50m. The Order limits for the Project deliberately incorporate the whole of the WWTW to permit the construction of the UV plant and connection into the existing WWTW infrastructure. It is not intended to construct an extensive structure or to acquire land on a permanent basis from DCWW for this purpose. It is intended that DCWW will operate the UV disinfection facility.

Extension of the outfall

4.3.9.8 The main WWTW outfall is 3.5km long, internal diameter 1.3m made of 12mm steel with 150mm reinforced concrete wall coating (each section of outfall was approx 160m long – approx 22 in total). The outfall was buried to a depth 1-2m with the diffuser ports projecting 1m above the sea bed along its last section. Option 3 comprises the proposed extension of this existing long sea outfall from the WWTW by approximately 1.5km to allow discharge to take place outside the Lagoon.

4.3.9.9 These works would comprise the construction of a new pipe of similar dimensions to those already in situ, with an approximate internal diameter of 1.3m. The pipeline extension would be laid on the sea bed or buried in a trench below the level of the existing seabed at a depth as agreed with DCWW.

4.3.9.10 The outfall extension would be installed within a culvert to pass under the seawall, so as to maintain access to undertake maintenance if required. Within the culvert, an additional, spare pipe would be installed in case of failure of the original pipe. This culvert would be blocked off to stop flows of seawater through the culvert.

- 4.3.9.11 The diffuser section at the end of the existing pipe would be removed, lifted out and stored for re-use once the extension is complete. If this is not possible, a new diffuser section would be constructed at the new outfall limit.

4.3.10 Other works to support the Project

- 4.3.10.1 There are additional permanent works that need to be carried out to support the construction of the Project. These comprise the demolition of the Eastern Breakwater at the entrance to the River Tawe and the realignment of the eastern training wall at the entrance to the River Neath estuary.
- 4.3.10.2 To link the Lagoon to the public transport network, a bus stop will be installed adjacent to the western landfall.

4.4 Sequence of Construction

- 4.4.0.1 The construction of the Project will commence following the grant of development consent and the Marine Licence and discharge of any relevant requirements or conditions precedent to construction. This is expected to be in 2015. The construction period is split into four main phases. The phases and extent of work will be subject to review and alteration where necessary and as such is indicative only. However sufficient detail is provided to inform the assessment of effects in this ES. A brief summary of the main activities included in each phase, along with an illustration(s) (where appropriate), is set out below. There are also other works that sit outside the four main phases that continue throughout the duration of construction. The key elements of the four phases are described below.

Phase 1: Mobilisation, western seawall and start of eastern seawall

- 4.4.0.2 The landside set up of the construction support site.
- i. Construction access routes.
 - ii. Seawall – western arm.
 - iii. Temporary cofferdam around construction area for the turbine and sluice gate housing structure.
 - iv. Lagoon seawall – eastern arm phase 1 (see Figure 4.41 below for explanation of phasing).
 - v. Water quality enhancement works option 3 - outfall extension.
 - vi. Connection to power supply and utilities for construction phase.
 - vii. Demolition of structures within construction compound areas, removal of Swansea Port eastern breakwater and removal of existing wall along the length of Queens Dock.

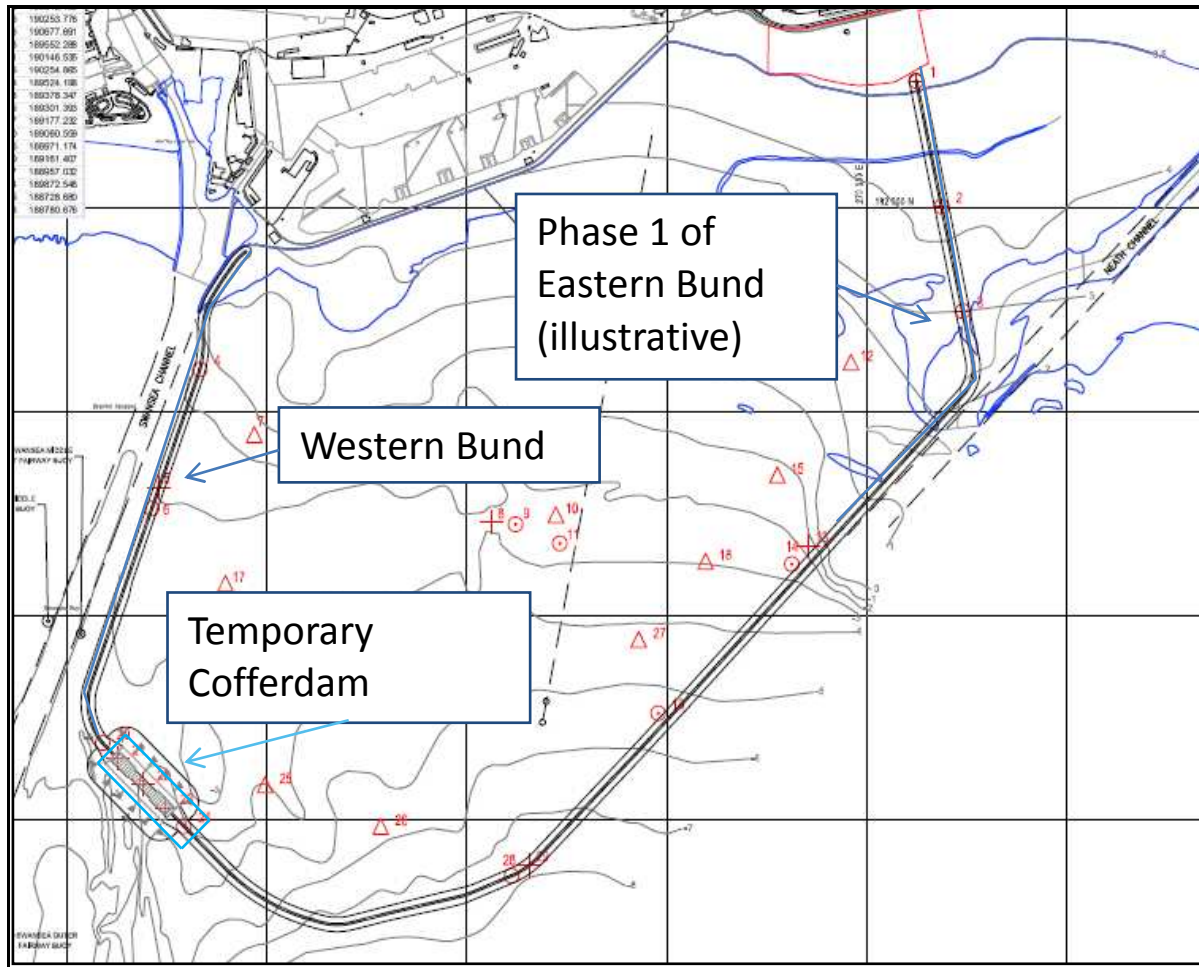


Figure 4.41 Key elements phase 1 construction

Phase 2: Turbine and sluice gate structure construction, continue eastern seawall

- i. Construction of the turbine and sluice gate housing structure.
- ii. Water quality enhancement works (option 2 - UV disinfection of storm water).
- iii. The installation of the turbines and sluice gates.
- iv. Dry commissioning of the turbines and sluice gates.
- v. Connection to NETS.
- vi. O&M facilities.
- vii. Seawall - eastern arm phase 2 (see Figure 4.42 below for explanation of phasing).

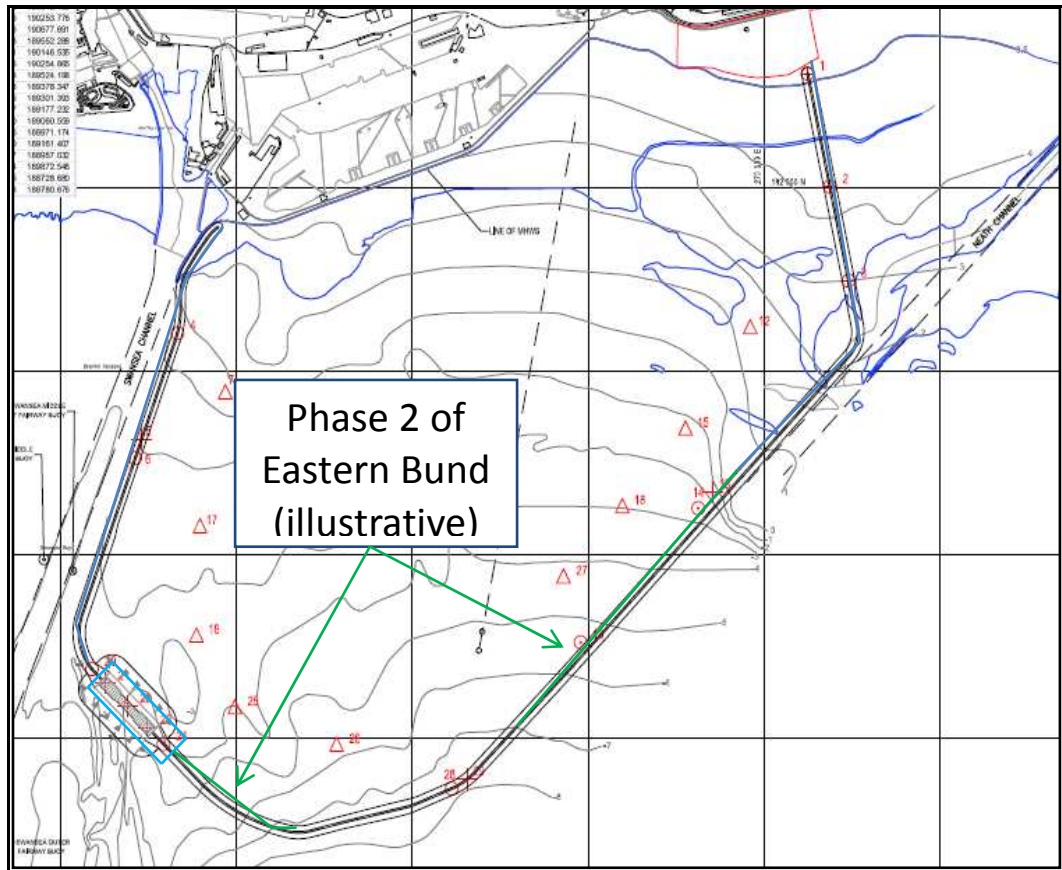


Figure 4.42 Key elements phase 2 construction

Phase 3: Lagoon Closure and Commissioning

- I. Removal of the temporary cofferdam wall.
- II. Seawall - eastern arm (closure) (see Figure 4.43 below for explanation of phasing).
- III. Wet commissioning of the turbines and sluice gates.
- IV. Commencement of finishings and offshore building works.

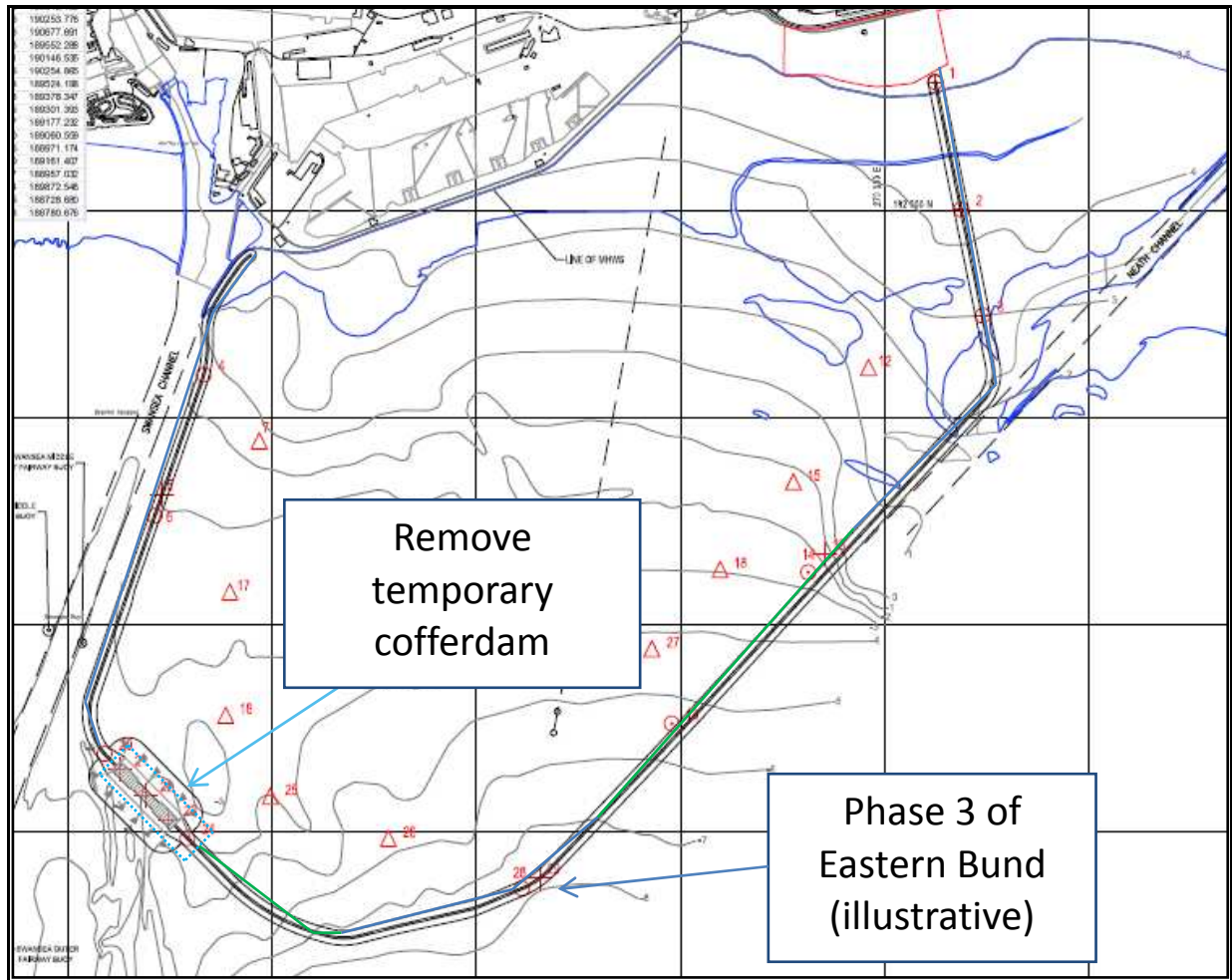


Figure 4.43 Key elements phase 3 construction

Phase 4: Finishings

- i. Seawall finishing.
- ii. Completion of construction of the Offshore Building.
- iii. Removal of the construction support sites.
- iv. Emergency facilities and slipways.

Other Works

- I. Construction of onshore building and sporting public realm.
- II. Road and pedestrian infrastructure.
- III. Visitor facilities, public realm including access and parking.
- IV. Pedestrian and cycle route links.

4.5 Construction Process

4.5.1 Construction Environmental Management Plan (CEMP)

- 4.5.1.1 As part of the Project, certain practices and mitigation is embedded in the manner in which the works are to be performed. A vital measure in achieving this is the CEMP,

which is designed to ensure that contractors and operatives implement good practice techniques in delivering the project and perform mitigation described in this ES.

- 4.5.1.2 The CEMP details the environmental control measures for the Project. Environmental briefings will be given to everyone involved with works that could have an impact on the environment. Any zones identified as environmentally sensitive will be demarcated and signs erected as a result of its terms. An environmental liaison officer will also be present where necessary. The CEMP will also detail which personnel will have the authority to suspend construction work in the event of an environmental incident.

4.5.2 Programme

- 4.5.2.1 The current target programme for the Project follows the phases outlined above as detailed in the following sections. An outline programme is shown in Figure 4.44 below. The construction phase of the Project is planned to commence in spring 2015 extend to the beginning of 2019, and the first power generated by the Project expected to be exported during the summer of 2018.⁸
- 4.5.2.2 Construction will start following the DCO coming into effect and securing other relevant licences and consents required for the Project. It is anticipated that this will be in early 2015. In general, dredging should usually take place in the period from April to October, such that there is less potential chance of delay as a result of bad weather and fewer/smaller environmental impacts. As such, it is intended that the seawalls will be constructed during the summers of 2015, 2016 and 2017, the closure of the eastern arm of the seawall will take place in early 2018. The temporary cofferdam for the turbine and sluice gate structure will be installed in 2015, with the construction of the turbine and sluice gate structure programmed for between Spring 2016 and Autumn 2017.
- 4.5.2.3 Following commencement of generation, the supporting infrastructure elements of the Project will be completed during 2018 and the beginning of 2019.

⁸ In this ES, the possibility of alternative construction and operation commencement has been considered by the experts who have carried out the topic-based assessments reported elsewhere. In each case, the sensitivity of the various assessments is considered and recorded in each chapter.

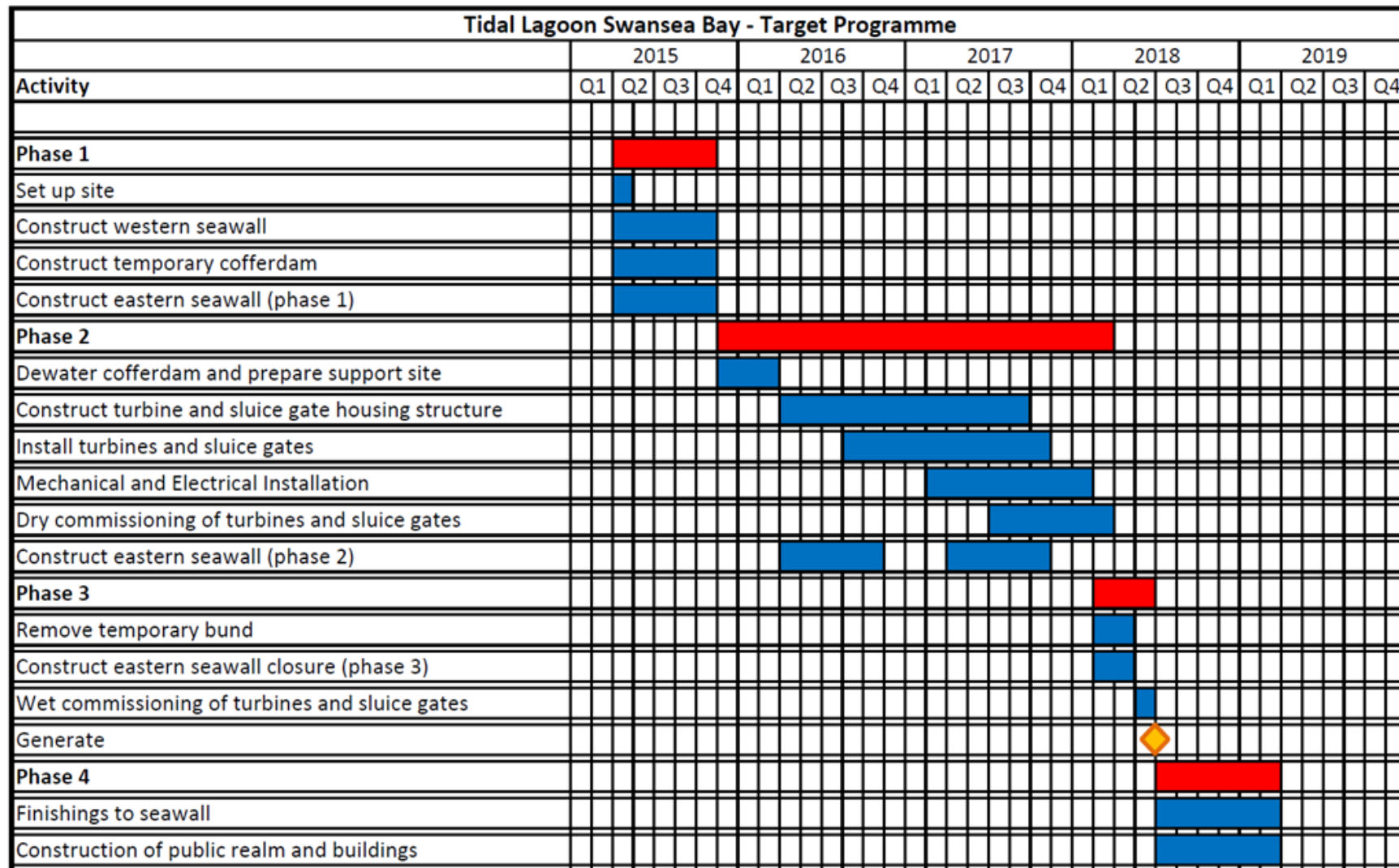


Figure 4.44 Target construction programme

4.5.2.4 The working hours for construction of the Project will vary through the construction phases, but will generally be 24-hours a day 7-days a week for the offshore works and any operations supporting the offshore works. This includes all of the seawall construction and supply of rock and concrete. This is due to the need to work around the tides and weather conditions for the marine work and also due to programme constraints in respect of the turbine and sluice gate housing structure.

4.5.3 Phase 1: Mobilisation, western seawall and start of eastern seawall

Landside Set up of Construction Support Site

4.5.3.1 The landside construction support site is assumed to include:

- i. offices, stores, car parking, site access control and plant yard;
- ii. construction of new Project road from Langdon Road through Swansea Port to connect with Queen's Dock and access road to eastern landfall;
- iii. marine access and plant yard;
- iv. concrete batching plant, stockpile area and pre-casting yard; and
- v. steelwork fabrication yard.

4.5.3.2 Once the location for each of the elements has been finalised, the area of each will be cleared and prepared for its intended use. This could involve the clearance of existing buildings, small trees and shrubs, stripping of topsoil and taking down fences. Any ecological constraints/mitigation measures, as detailed in Chapter 23, Mitigation and Monitoring will be implemented with regard to the planning, timing and execution of these works.

4.5.3.3 Services will be required for the construction support sites, including water supply, power supply and telecommunications, and these will be installed early in the process. Where possible these will utilise the infrastructure requirement for the permanent works, including water mains and the power cables.

4.5.3.4 Waste water from the construction support sites will either be collected in storage tanks and tankered offsite or pumped through pipework to join the sewerage network.

4.5.3.5 If concrete hardstandings are required then the ground will be prepared, a geotextile layer with sub-base layer laid and compacted on top and concrete placed with small retaining shutters at the edges. If the hardstandings are to be subject to heavy loads, then a design will be prepared, possibly deepening the slab and adding steel reinforcement. All surface water runoff from working areas will be monitored for silt levels and silt traps will be installed where required. Discharge and monitoring requirements will be agreed with the relevant organisations prior to starting on site.

4.5.3.6 Where temporary haul roads are across any areas that could be contaminated, then a separating membrane will be laid and covered with a sufficient layer of hardcore. The site traffic will initially use the Port roads to access the site, with the construction of the new Port Lagoon road and the access road to the eastern landfall undertaken early in the construction programme. This will allow the construction traffic to be separated from the Port operations. Route preparation will be undertaken and any remediation measures

implemented. The need and extent of remediation will be dependent on the road design and the review of existing or site specific GI data.

Lagoon seawall – western arm

- 4.5.3.7 This element of the works comprises the construction of the western arm of the seawall from its landfall at the Port of Swansea to the turbine and sluice gate structure location.
- 4.5.3.8 Translocation of Sabellaria will be undertaken prior to the start of construction works as detailed in the AEMP (Appendix 23.1). Areas of Sabellaria along the foreshore will be identified and demarcated. Where the works will affect the Sabellaria, the individual rocks that have been colonised will be lifted and moved to an appropriate identified area. The rest of the rock with broken or limited casts will be lifted by excavators and stored for use as herring spawning material on the sea side of the western seawall, as shown on Figure 4.33, once complete.
- 4.5.3.9 An exclusion zone will be established around the position of a known wreck located to the east of the eastern landfall as outlined in Chapter 20 prior to works on the eastern landfall.
- 4.5.3.10 A safety zone of 100m either side of the existing long sea outfall will be enforced for all vessels. Buoys will be installed to highlight the safety zone and vessels will be given the details of the location of the safety zone. The safety zone will then be displayed on the on-board navigation screens of the vessels where this facility exists. A risk assessment will be undertaken to assess the risk of vessels working in the proximity of the long sea outfall and suitable control measures will be imposed.
- 4.5.3.11 Prior to any sediment removal a side scan sonar survey will be performed that will create an image of the seabed to allow any obstructions to be identified. Any unexploded ordnance (UXO) will be removed when located, along with any rocks or any items that could cause damage to the Geotubes®. Any rocks that are suitable as herring spawning media will be retained for placement along the initial section of the western landfall once complete. Dredging with an Oyster Dredge and relocation of any native oysters to an agreed location will also be undertaken in advance of the main dredging works.
- 4.5.3.12 The construction of the western arm of the seawall will commence adjacent to the Port of Swansea and progress towards the site of the turbine and sluice gate structure.
- 4.5.3.13 For the seawall construction, sediment will be dredged from the seabed by a Cutter Suction Dredger (shown in Figure 4.45) or possibly a Trailing Suction Hopper Dredger (TSHD) within the lagoon footprint as discussed in Section 4.3.1. Environmental mitigation measures to be followed for vessels are detailed within the CEMP and include issues such as the control of Invasive Non Native Species (INNS), water quality arrangements and pollution prevention measures. Mitigation involving a watching brief for marine archaeology will be implemented for the dredging operations as outlined in Chapter 20.



Figure 4.45 Cutter Suction Dredger

- 4.5.3.14 Initial results of ground investigation works provide information on levels of contamination within the sediments (Chapter 6). The results show that the majority of sediments within the area of the lagoon and the offshore works are generally uncontaminated or have low levels of some metals. Notwithstanding this, if necessary, any material identified as unsuitable either from a contamination or engineering point of view can be excluded from the source locations. Any of these areas would be entered into the onboard computers of the dredger to ensure they are avoided.
- 4.5.3.15 Where it is not possible to avoid all unsuitable sediment areas, such as where dredging is required for deepening of the seabed either side of the turbine and sluice gate structure, some material may have to be disposed of. This would be carried out by using a TSHD. Final siting of the turbine and sluice gate structure will also be undertaken to minimise the need for disposal of unsuitable (fine) sediment. However, where materials cannot be avoided or reused within the construction of the seawalls, the sediments will be taken for disposal at the Swansea (Outer) licensed deposit ground. Permission to do so will be sought under the dredging licence from NRW (MLT). This ES also accompanies the application for the dredging licence.
- 4.5.3.16 The seawalls will be built sequentially starting with the geotextile casings known as Geotubes®. The method of placing and filling the Geotubes® is still being refined, but currently the sequence is anticipated to be as described below. Note as illustrated in Figure 4.6, gravel or quarry run mounds could be used instead of Geotubes®, but the general sequence of construction would remain, to all intent, the same.
- 4.5.3.17 The Geotubes® will be laid and hydraulically filled directly from a purpose-modified installation vessel (as shown below in Figure 4.46). The dredger will pump the sediment through floating pipes to the modified vessel.

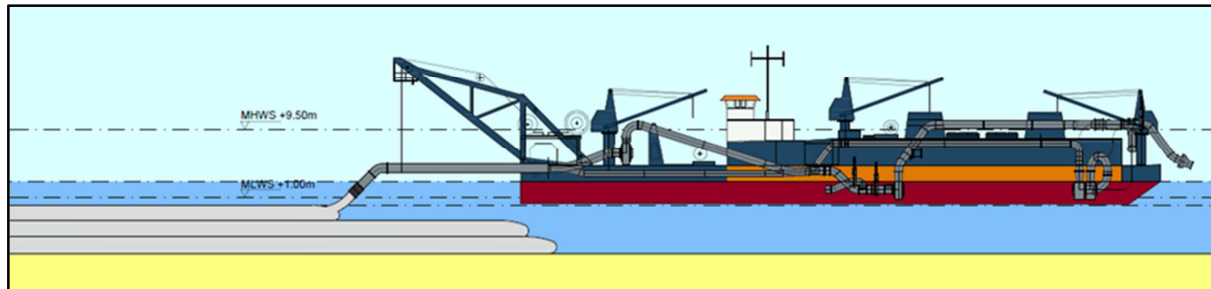


Figure 4.46 Geotube® filling (illustration of purpose-modified installation vessel)

- 4.5.3.18 The Geotubes® will be placed in layers on either side of the footprint of the seawall as shown in Figure 4.47 below. Each Geotube® will be between 150m and 200m in length and the largest will be 5m in diameter. It is anticipated that each large Geotube® will take approximately 1hr to fill at a continuous rate. Once a Geotube® has been filled it will be closed, the installation vessel will reposition and the next Geotube® will be loaded onto the installation vessel and then the process will start again.

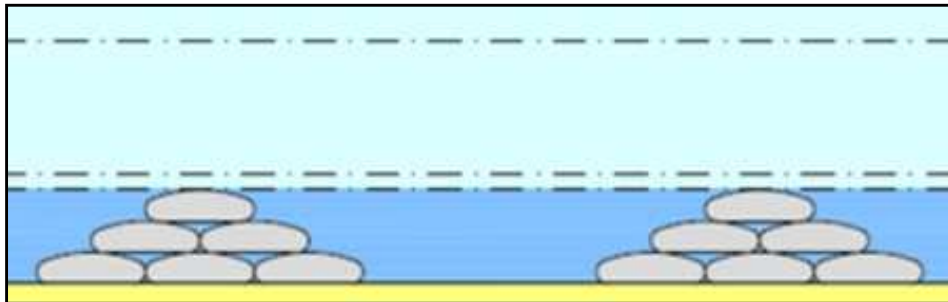


Figure 4.47 First stage of the seawall construction

- 4.5.3.19 The sediment for the infill area, shown in Figure 4.48 below, between the Geotubes® will again be pumped from the Cutter Suction Dredger and will travel along floating pipes from where it will be deposited in the correct location.

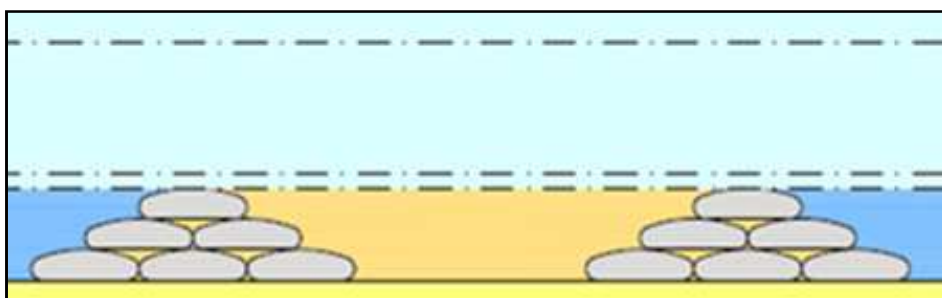


Figure 4.48 Second stage of the seawall construction

- 4.5.3.20 Subsequent layers of Geotubes® will be added to build up the seawall to the required height with the areas between, again, filled with sediment. To complete some sections of the seawall high (spring) tides will be required.
- 4.5.3.21 The installation of the Geotubes® or placement and shaping of the sediment, will be followed by stone and rock placing operations. The gap between the two operations will be kept to a minimum (taking vessel safety into consideration) to ensure that the extent

of unprotected sections of the seawall is minimised and to avoid remobilisation of placed sediments.

- 4.5.3.22 The Geotubes® or shaped sediment will be covered with an additional geotextile layer to protect them from damage during stone placing. The geotextile will then be covered by a small sized rock under-layer which will be shaped to give the correct profile. The depth of the layer will vary depending on location and exposure to the sea. The larger sized, rock armour, layer will be placed on the seaward side of the seawall, again varying in depth dependant on location.
- 4.5.3.23 It is proposed that the lower levels of rock armour will be placed straight from the vessel delivering the material, although this will depend on timings. There may be a need to transfer some of the material onto smaller barges before placing. The upper levels of rock armour will be placed by land based plant, large excavators being fed by dump trucks, working from the top of the Lagoon seawall.
- 4.5.3.24 There will be two stockpiles of rock sufficient to prevent work ceasing if a vessel was late as a result of adverse weather. The stockpiles would be located near the landfalls at both sides of the Lagoon. The stockpile adjacent to the western seawall would be approximately 400m by 400m and piled up to 3m high. The stockpile adjacent to the eastern seawall within the lagoon would be approximately 250m by 250m in area and piled up to 3m high.
- 4.5.3.25 The final rock armour towards the top of the seawall will not be placed at this stage, so as to allow the construction of a wide haul road along the top of the western arm of the seawall. This will extend from the shore at the western landfall to the construction area for the turbine and sluice gate structure. The road will be approximately 8m wide to allow for large construction and lifting machinery. The prefabricated sluice gates and turbines will also be brought along the haul road from the prefabrication yard to the structure.
- 4.5.3.26 Once the first section of the western seawall is complete, the existing Eastern Breakwater adjacent to the River Tawe can be removed and herring spawning material will be placed along the base of the new sea wall adjacent to, but not affecting, the Swansea navigation channel.
- 4.5.3.27 The harbour light at the end of the eastern breakwater was built in 1909 and is of low historic value, as detailed in Chapter 21, Cultural Heritage; Terrestrial Archaeology and Historic Landscape. Nevertheless, a level 2 building recording exercise will be undertaken and, if possible, the wooden framework tower which supports the light will be retained and placed in temporary storage for reuse as part of the proposed public realm scheme, prior to the breakwater being demolished. This is described further in Chapter 21.
- 4.5.3.28 The breakwater will be demolished by a combination of marine and land based plant. The structure will be dismantled using excavators with grabs and breakers. Where possible the material will then be reprocessed and, where possible, re-used for the permanent works.

Temporary Cofferdam for the Turbine and Sluice Gate Structure Construction

- 4.5.3.29 To construct the concrete turbine and sluice gate housing structure, a temporary cofferdam is required to create a dry construction area. There are two potential options for the temporary cofferdam:
- i. sediment cofferdam with Geotubes® and rock armour; or
 - ii. twin wall sheet pile cofferdam.
- 4.5.3.30 Both of these temporary cofferdams are described in detail below. The two options will be further developed to achieve the most appropriate solution to take forward to construction.
- 4.5.3.31 Prior to construction of the temporary cofferdam the dolphin piles necessary for the permanent safety zone for the Project will be installed to offer protection to the construction operation. These are described above in Section 4.3.3. The dolphin piles will be vibrated or driven into place from a jack-up barge by a piling rig.
- 4.5.3.32 The temporary cofferdam will be built at the same time as the western arm of the permanent seawall. It is anticipated that this will be between the end of March and the end of October 2015. Once started, the work on the temporary cofferdam and the western arm must carry on until complete. If left partially complete the seawall would be vulnerable to bad weather and it would prevent the de-watering of the cofferdam and the commencement of the construction of the turbine and sluice gate structure.
- 4.5.3.33 The construction period for both cofferdam options is in the region of 6 months, working 24-hours a day, 7-days a week. As these works are weather dependent the construction period may increase.
- 4.5.3.34 Seabed levels across the footprint of the turbine and sluice housing will need to be reduced to a general excavation level of -14.5m CD from the current bed level of between -3 and -4m CD. Survey results have indicated that there may be volumes of unsuitable material at the proposed location of the housing structure depending upon the final siting choice. If the location of the structure remained at Location A, (Figure 4.13, Section 4.3.3 and Table 4.1), then a proportion of the material, approximately 0.5Mm³ would be unsuitable. If the structure is moved further to the southeast at Location B (Figure 4.13, Section 4.3.3 and Table 4.1) the unsuitable material should be reduced to approximately 0.36Mm³. If possible the unsuitable material will be incorporated into the widened seawall at the western landfall, if not then it will need to be removed to the Swansea Bay offshore dumping ground. An additional smaller Cutter Suction Dredger or hopper dredger will be used to perform this to allow the seawall construction to continue. Any suitable leftover material that is not required for the temporary cofferdam construction will be used within the seawall.

Option 1: Sediment Bund with Geotubes® and Rock Armour

- 4.5.3.35 To construct option 1 of the temporary cofferdam, a large volume of imported rock will be placed along the outer and inner footprint of the temporary cofferdam (Figure 4.49) by a Side Stone Dumping Vessel. This replaces the initial lower double row of Geotubes® with a quicker method of construction. Sediment will then be pumped into position between the two bunds of rock.

- [illegible]

4.5.3.37 The Geotubes® will be installed above MLWN (+3.1m CD) to allow for later removal with land based plant.

4.5.3.38 Following the bund construction, a water cut-off wall will be installed to prevent water flowing under the sand bund and into the working area. The cut-off wall will probably be in the form of a deep slurry wall (possibly bentonite⁹), approx 600mm thick to achieve the 32m total depth required (Figure 4.49). Once the bund and the cut-off wall is complete, the internal space will be de-watered.

4.5.3.39 A cross section of the proposal for a twin wall sheet pile cofferdam is shown below in Figure 4.50. This comprises two rows of sheet piles installed and filled with sediment between to give a bund width in the region of 21m.

Tidal Lagoon Swansea Bay - Environmental Statement

Project Description

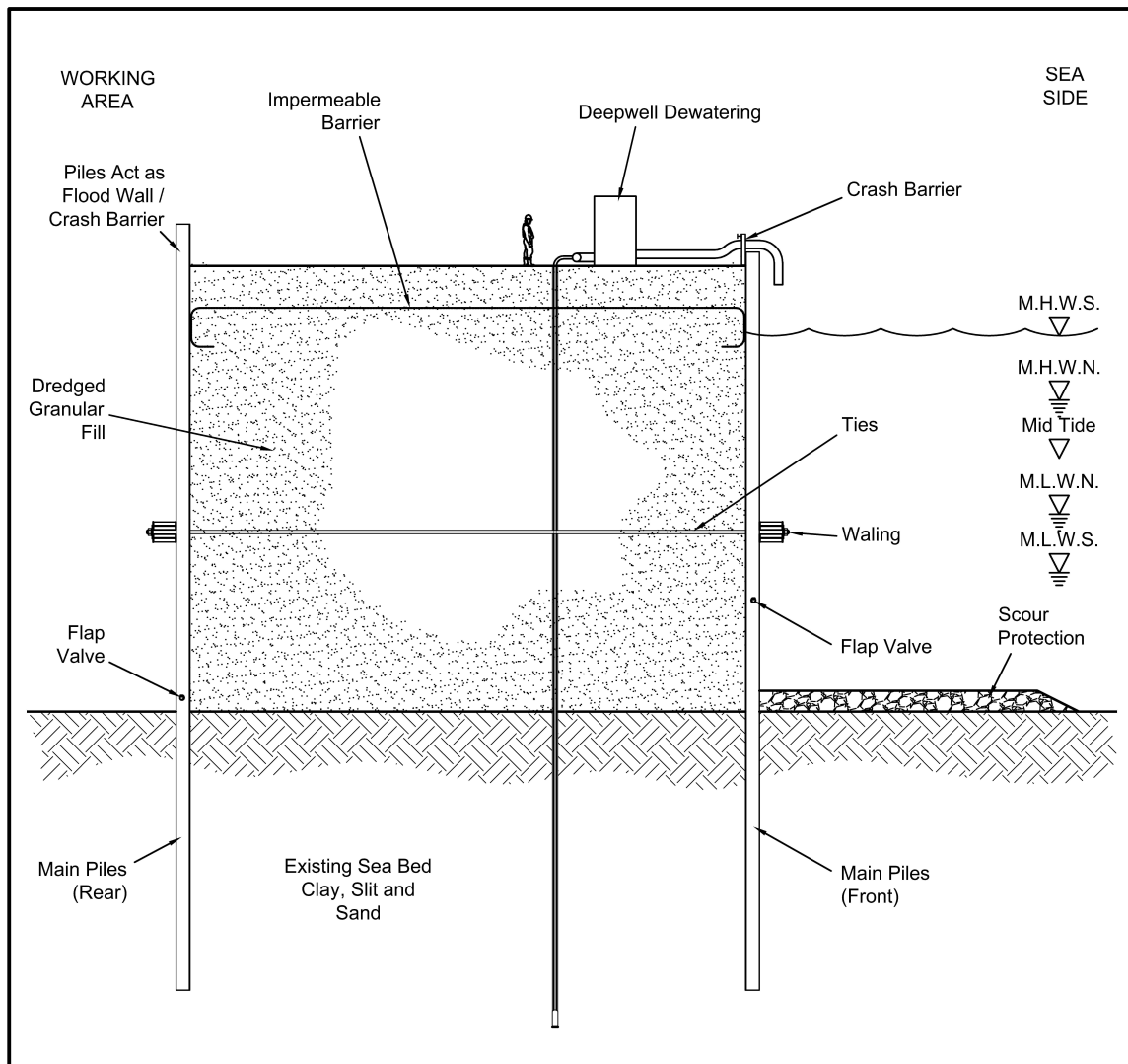


Figure 4.50 Cross section of twin wall sheet pile cofferdam

- 4.5.3.40 The method of installing the twin wall sheet pile cofferdam is still being developed. The current proposed method is described below; this method may change as the design is progressed, but this is not likely to result in material changes in environmental effects.
- 4.5.3.41 A jack-up barge, loaded with a crawler crane and pile driver attachment, will be used to drive the sheet piles into the seabed; this operation is illustrated in Figure 4.51 below.
- 4.5.3.42 The piles will be delivered to the Project by sea either into the Port of Swansea or offloaded onto parts of the bund already constructed. When required they will then be loaded onto a supply barge with spud legs, which will be transported to the working area by a tug. The spud legs are then lowered to the seabed to create a stable platform.

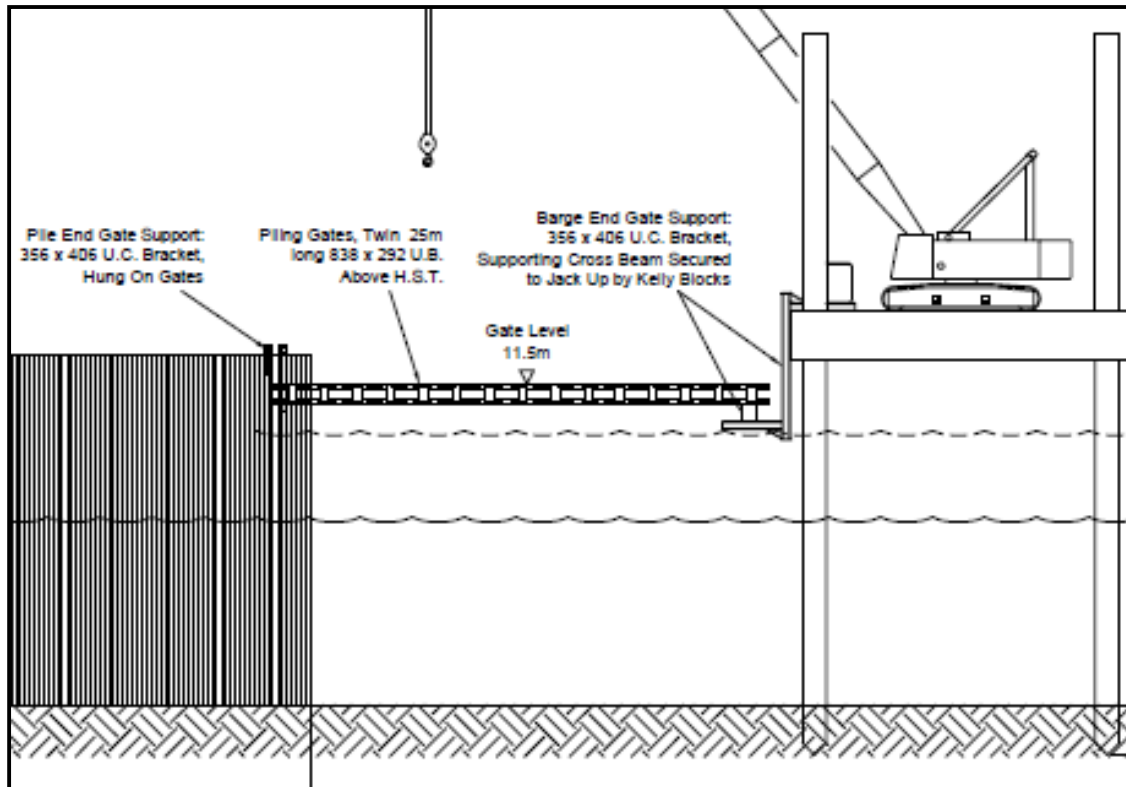


Figure 4.51 Illustration of installation of sheet piles

- 4.5.3.43 The initial ground investigation results suggest that the most appropriate piling method would be vibratory, but there may be times when harder material is encountered and in these circumstances, percussive methods may need to be adopted. A piling method statement prior to starting construction will be required under the Order, and this will ensure that the most appropriate methodology is adopted in the circumstances.
- 4.5.3.44 Once a section, approximately 42m in length, of the twin wall has been installed a cross wall of sheet piles will be driven between the rows. This allows for sediment filling to commence within the completed 'box'.
- 4.5.3.45 The first stage of sediment fill will be placed, from a Cutter Suction Dredger or TSHD, to the underside of the first level of tie rods (horizontal bars that connect the two rows of sheet piles).
- 4.5.3.46 At this point, a second jack-up barge, loaded with a crawler crane, will be positioned adjacent to the section. The crane will lift the dive boat into the section followed by the placing of the tie rods, with divers guiding the tie rods through holes in the sheet piles. A plan of how this proposed operation would look is shown in Figure 4.52 below.

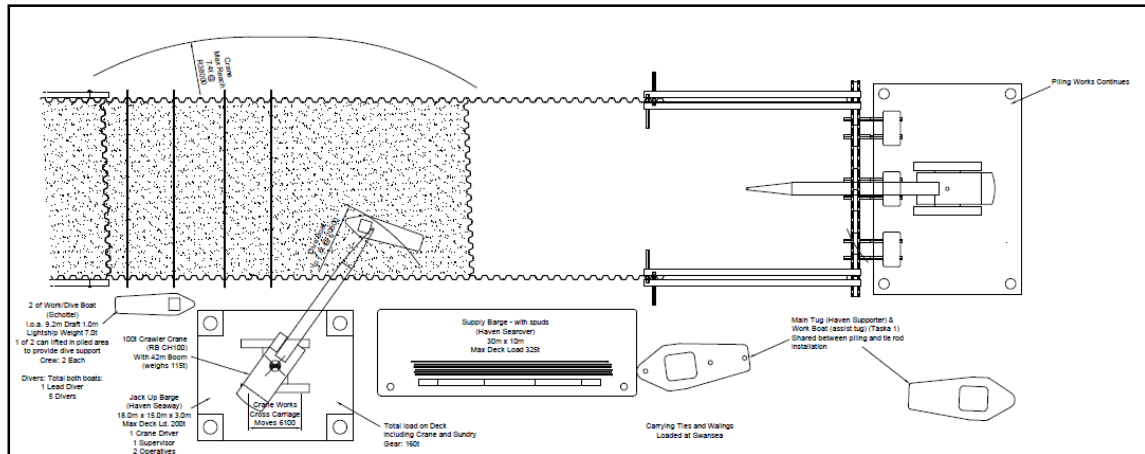


Figure 4.52 Plan of proposed operation of installing lower level tie rods

- 4.5.3.47 Once the lower level tie rods are in place then sediment filling can continue up to the underside of the higher level tie rods. At this point, the sediment will be to a level of approximately +7m CD. Therefore, the top ties can be installed by land based operatives and plant, as the area will only be wet a couple of hours either side of a high tide. As such, this element of work will only be undertaken during the periods when the area is dry.
- 4.5.3.48 Once the top level of ties is completed, the filling can be finished with land based working from the previous completed section. The work will progress so that adjoining sections have only, at maximum, one level of fill difference. This is shown below in Figure 4.53.

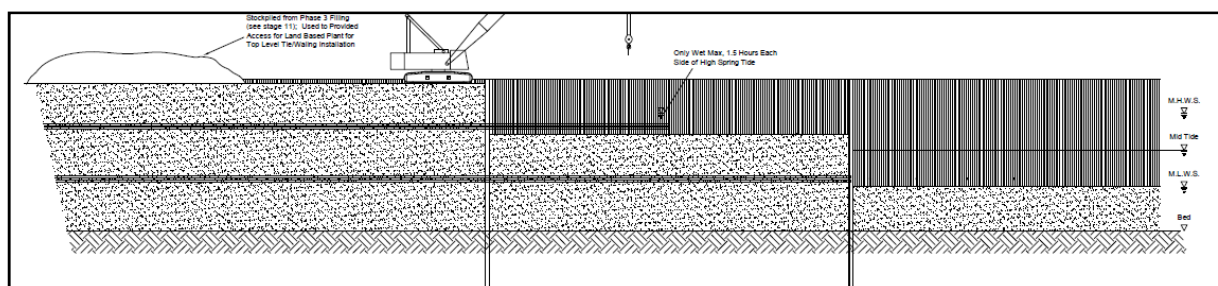


Figure 4.53 Sediment fill levels in sections during installation

Lagoon seawall – Eastern arm phase 1

- 4.5.3.49 Once the construction of the western seawall is completed either out to and including the temporary cofferdam (if option 1 sand cofferdam is pursued) or after the first section of seawall is complete out to the cofferdam (if option 2 sheet piled cofferdam is used), works will commence on the seawall adjacent to the SUBC. The first phase will be constructed from the eastern landfall out towards the Neath Channel.
- 4.5.3.50 Along the first section of the eastern seawall there are no Geotubes® (cross-section shown below in Figure 4.54) and, as such, the construction method will vary slightly from that described previously. Here, the dredged sediment material will be pumped into position using the Cutter Suction Dredger then shaped with land based excavators on top of the lagoon seawall. As the lagoon seawall at this point runs parallel to the boundary of the Crymlyn Burrows SSSI, a working corridor of 50m will be left between the toe of the

seawall and the SSSI. This will allow the seawall to be constructed without the need for construction vehicles to enter the SSSI. This will also ensure that an archaeological wreck, which is also located in the SSSI, is avoided. The SSSI boundary will be clearly marked during these main construction works.

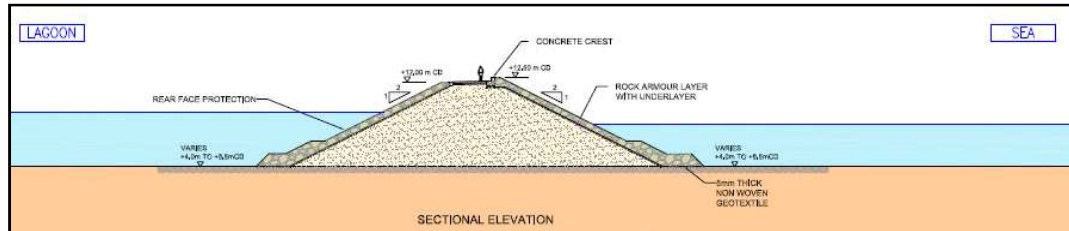


Figure 4.54 Illustrative cross-section of seawall without Geotubes®

- 4.5.3.51 As with the Geotubes® wall section, after the placement and shaping of the sediment will be the stone and rock placing operations. Initially, a geotextile membrane will be laid and this will then be covered by a small-sized rock under-layer which will be shaped to give the correct profile. Larger sized rock armour will then be placed on the sea side of the seawall, again with depth and size dependant on location.
- 4.5.3.52 This final element of work in year 1 would ensure that a full dredging season of work is achieved by the dredging equipment. After this the Cutter Suction Dredger and associated equipment would leave the site.

Water Quality Enhancement Works

- 4.5.3.53 The outfall extension (if implemented), would be expected to comprise a pipe approximately 1.5km in length. The pipe would be produced in lengths, possibly two, each being approximately 0.75km long, and would be towed to site by a vessel. The pipe would either be laid on the sea bed or a trench would be excavated by a dredger. The diffuser at the end of the existing pipe would be removed, lifted out and stored. The pipe extension would then be fitted with extra weight, usually in the form of concrete collars, and sunk into place. The diffuser would be reattached to the end of the pipe, if suitable, otherwise a new diffuser would be fitted. The trench, if applicable, would be backfilled with sediment and rock.
- 4.5.3.54 For the crossing underneath the seawall, access to this section of outfall would be maintained. As such, the outfall pipe would be placed inside a culvert under the wall. Provision to allow a second, spare section of pipe would also be made inside this culvert.
- 4.5.3.55 Ideally the work would be carried out in calm dry weather. However, the removal of the diffuser section will shorten the outfall temporarily and, as such, works outside the bathing season may have to be considered.

4.5.4 Phase 2: Turbine and sluice Gate Structure Construction, continue Eastern Seawall

Construction of the Turbine and Sluice Gate Structure

- 4.5.4.1 Whichever of the temporary cofferdam options is selected, the closure of the cofferdam would begin around low tide to leave the minimum amount of water trapped in the enclosure which would need to be pumped out. The volume of water anticipated to be pumped out of the enclosure is in the region of 1,000,000m³. The water will be pumped

into the sea, possibly through silt traps if the seabed is disturbed during the final stages of the closure-emptying operation.

- 4.5.4.2 Once all of the water has been pumped out of the temporary cofferdam, a de-watering system will be installed that will ensure the cofferdam remains dry for the duration of the construction works. This is envisaged to be in the form of a deep well system with pumps, discharging in the region of 0.5 l/sec/m run of bund wall directly into the sea from each well. It is envisaged that silt removal for the de-watering will not be required through the development of an appropriate method.
- 4.5.4.3 When de-watering is complete, access ramps will be created from the top of the temporary cofferdam into the construction area and a power supply brought to the area such that the main construction works can commence. Hardstanding areas will be created, crane rails will be installed and the welfare facilities and offices will be set up.
- 4.5.4.4 Excavation equipment will then be brought to site for final trim of the excavation area to formation level. The excavated material during this stage, which is predicted to be in the order of 60,000m³, will be included in the permanent works, minimising the length of haul. The locations where the material excavated can be used include temporary ramps, stockpiles for subsequent use to fill cells in the turbine sluice gate structures and, if suitable, for forming roads or hard standings.
- 4.5.4.5 Once the area is to formation level, a sheet pile cut-off wall will be installed around the perimeter of the turbine and sluice gate structure using cranes mounted with vibratory attachments. Figure 4.55 below demonstrates a similar method of installing the sheet pile wall to that proposed for this Project.



Figure 4.55 Installing sheet piles harbour side

- 4.5.4.6 The construction of the turbine and sluice gate structure will then commence. As the construction area will be dry, the structure will be built using reinforced concrete construction techniques. Each working front will be supported by conventional craneage. The sequence for the construction will be integrated with the sequence for installation of the turbines to optimise the construction duration.
- 4.5.4.7 It is anticipated that the concrete works will progress on multiple work fronts, possibly incorporating pre-cast elements, such as the draft tube liners. Elements of the steel reinforcement that will need to be incorporated within the concrete walls will be pre-fabricated, and then lifted into place wherever possible to reduce construction duration. Concrete will be delivered from the site batcher, along the western seawall to the turbine structure with a fleet of readymix trucks. The concrete will be placed, compacted and cured using conventional techniques.
- 4.5.4.8 Precasting of various elements may be carried out at the construction support site in the Port and then transported to the temporary cofferdam site on Self-Propelled Modular Transport (SPMT).
- 4.5.4.9 Once the main structure is complete the wave wall and O&M rooms will be constructed on top of the housing.

Water Quality Enhancement Works – UV Disinfection

- 4.5.4.10 If selected, the provision of treatment (high pressure UV disinfection) at the WWTW for the intermittent storm water prior to discharge would be implemented prior to the closure of the gap in the lagoon seawall, or during the final year of construction works. It would follow standard construction methodology for reinforced concrete, pipework and UV system. It would be constructed offline and, when complete, connected into the treatment works system, and finally commissioned.

Installation of Turbines and Sluice Gates

- 4.5.4.11 During the concrete works for the turbine and sluice gate structure, the internal parts of the turbines will be sub-assembled either onshore or remotely from the site. Elements of the turbines will be transported to site and taken to the assembly area where applicable. The main structural part of the turbine; the stay ring, will be cast into the concrete turbine housing and the main elements of the turbine erected in-situ around the stay ring.
- 4.5.4.12 The sluice gates will be installed on completion of the concrete sluice work for each sluice structure.

Dry commissioning of the turbines and sluice gates

- 4.5.4.13 Once the turbines have been installed they will be subject to a commissioning period. The first stage of commissioning will be performed in the dry (dry commissioning) whilst the temporary cofferdam wall is still in place. This is expected to last for 3 weeks.
- 4.5.4.14 Dry commissioning is the process of testing each element of the mechanical and electrical plant so that it can be shown that they work under test conditions. This includes turning each turbine, raising and lowering the sluice gates whilst not under load (in the dry), and testing cables and controls with simulated test signals and loads. This phase of the commissioning is done after each mechanical and electrical element is

installed, and before the temporary construction site for the turbine and sluice gate structure is flooded.

Cable Connection to the NETS

- 4.5.4.15 As described in Section 4.3.4, the connection to the NETS will be made by laying three cables, forming one circuit. All cable connection options assessed will generally follow alongside the existing road/footpath network, through Crymlyn Burrows SSSI and underneath the River Neath to connect to the existing Baglan Bay substation.
- 4.5.4.16 Prior to laying the cable, the timing of the works along with appropriate mitigation measures will be identified and implemented for the various sections of the proposed route. This could include working outside of bird nesting season where vegetation is present and working during autumn and winter where annual plants are present.
- 4.5.4.17 The three cables will be XPLE land cables, each approximately 110mm in diameter. On land the cables will be laid to provide approximately 1m cover to ground level in a trench in the region of 0.7m wide by means of standard open trench excavation. The trench will be backfilled with cement-bound sand to approximately 150mm above and below the cables once the cables have been installed. Ducts may be installed to facilitate pulling of the cables at a later date for all or part of the route.
- 4.5.4.18 For sections along Fabian Way, it is envisaged that the trench will be excavated from behind the footpath, although the exact location will depend on the presence of other services. Where the cables cross roads, or affect a road lane, traffic management/lane closure will be implemented in liaison with the local highway authority(ies). Further details can be found in Chapter 15, Onshore Transport Assessment.
- 4.5.4.19 Where the cables pass under the River Neath, this will be achieved either through existing cable ducts or a new drilled crossing. If using existing ducts, the cables would run in three separate small-diameter ducts, identified as being empty. A CCTV survey of these existing ducts will be performed to ascertain if they are suitable. If these ducts are not appropriate, a new crossing would be directionally drilled under the river.
- 4.5.4.20 Directional drilling is a trenchless technique that allows either a single larger diameter duct, in the order of 500mm or smaller to be installed underneath the River Neath with minimal impact on the surrounding area. A cutting head will be used to drill through the ground along the proposed path; a drilling fluid (often containing Bentonite) would be fed to the cutting head to facilitate the removal of the cuttings. Once the cutting head reaches its exit point, a back reamer is attached to the cutting head at the exit point and pulled back along the hole. This process is repeated until the hole is big enough to install the duct.
- 4.5.4.21 The construction plant required for the installation of the cables will be secured within a fenced off area at the end of each working day.
- 4.5.4.22 A compound in the order of 40m x 40m would be required at the drill site, along with access to it for equipment and vehicles carrying bentonite. At the exit site, a compound would be needed, approximately 15m x 15m, in addition to a laydown area to allow the plastic duct to be strung out and welded together before it is pulled into the drilled hole.

- 4.5.4.23 Where existing services are encountered they will be suitably protected and the necessary clearance maintained.

Operation and Maintenance Facilities

- 4.5.4.24 The initial offshore O&M facilities will also be constructed during phase 2. This will allow the required cables to be connected to the power room in preparation for commissioning.
- 4.5.4.25 The offshore O&M facilities will be constructed within the Offshore Building and the main turbine and sluice gate housing structure from reinforced concrete.

Lagoon Seawall – Eastern Arm phase 2

- 4.5.4.26 During the second phase of construction, works to the eastern arm of the seawall will continue from the end of the phase 1 works. In total, approximately 3.1km of seawall will be constructed during this phase, and a gap of approximately 1.5km will be left between the end of these works and the turbine structure to allow the tide to flow. These works will continue in the same manner as is described at paragraph 4.5.3.7 to 4.5.3.24 above.

4.5.5 Phase 3: Lagoon Closure and Commissioning

Removal of Temporary Cofferdam Wall

- 4.5.5.1 Once the turbine and sluice gate structure is complete, all turbines and sluice gates installed and the dry commissioning finished, the temporary cofferdam wall will be removed.
- 4.5.5.2 A controlled flooding of the cofferdam will be performed, possibly by pipes. Once flooded the temporary cofferdam will be removed. The removal method of the temporary cofferdam wall will depend on the option chosen (Geotubes® and rock or twin-wall sheet piled bund). The exact sequence of removal will be finalised during detailed design, but would follow the following principles.
- 4.5.5.3 **Option 1 (sediment/ Geotubes®/rock):** The sediment bund with Geotubes® and rock armour would initially require the stone and rock armour above water to be moved by land based plant to a position where it can be used for the completion of the eastern arm of the seawall. The Geotubes® would then be split and emptied. Once the enclosure is flooded the remaining sediment would again be removed by the Cutter Suction Dredger and placed either into the eastern seawall or elsewhere in the Lagoon area. The remaining rock at the bottom of the bund would be retrieved by a backhoe dredger and placed into the eastern seawall.
- 4.5.5.4 **Option 2 (sheet pile):** The twin wall sheet pile bund would be removed starting from one or two locations simply reversing the installation method. The sediment along one section would be removed to top tie level. The ties would be removed then sediment reduced to the next level of ties. Once the bottom ties are removed, the extraction of the sheet piles can begin from the crawler crane. This would be repeated until the structure is fully removed.

Lagoon seawall –eastern arm (closure)

- 4.5.5.5 The final phase of the construction of the lagoon seawall will see the completion of the eastern arm to the turbine and sluice gate structure. It would be proposed that any sediment, stone or rock armour removed from the temporary cofferdam would be used to complete the seawall.
- 4.5.5.6 The closure of the gap, which will be performed at low tide, will be further planned during detailed design.

Wet commissioning of turbines and sluice gates

- 4.5.5.7 To perform the second stage “wet” commissioning requires a head of water (level difference), which can only occur once the seawall is complete. During the “wet” commissioning, water flowing in and out the Lagoon will be through the sluice gates and turbines in order to commission them. Power will be generated from the start of wet commissioning and each unit will be fine-tuned.
- 4.5.5.8 Each element of the mechanical and electrical (M&E) plant will be tested individually to show that it works under load, and each element will be brought on-line sequentially. The interaction between elements of the scheme will also be tested. Finally, the operation of the entire Project can be tested to show that it meets the design requirements.

4.5.6 Phase 4: Finishings

Seawall finishings

- 4.5.6.1 On completion of the turbine and sluice gate structure, the permanent reinforced concrete crest along the lagoon seawall will be constructed, along with the placing of the final rock armour. This work will commence at the turbine and sluice gate structure and progress towards the shore along both the western and the eastern arms of the seawall.
- 4.5.6.2 Subject to securing suitable consents – likely to include planning permission - any sculptural elements will also be installed, mostly on concrete foundations constructed on the seawalls.

4.5.7 Other works

Completion of the western and eastern landfall infrastructure

- 4.5.7.1 The Western Landfall Building will be completed during Phases 3 and 4. As discussed in Section 4.3.5 this will be a Glulam timber frame building structure with prefabrication of the envelope and structure to eliminate site generated waste.
- 4.5.7.2 The completion of the vertical faced sheet pile wall and slipway at the western landfall will be completed at a stage in the programme so as not to interfere with the construction of the seawall.
- 4.5.7.3 The sheet piles will be either driven or vibrated into place, depending on ground conditions. Ground anchors will be installed near the top of the sheet pile wall to provide further stability. The wall will be finished with a concrete capping beam.

4.5.7.4 To create the slipway a temporary sand and rock or sheet pile cofferdam will need to be in place to allow the concrete works to take place.

4.5.7.5 Finally the facilities at the eastern landfall, will progress during Phases 3 and 4. Appropriate screening and consideration will be paid to the SUBC in terms of privacy and nuisance.

Access infrastructure

4.5.7.6 It is assumed that the construction phase access will complete the roads to base course only. The final wearing course will be installed towards the end of the works and will include completion of kerbs and or replacement, road widening, additional accesses and road markings.

4.5.7.7 Additional signage will be erected to guide visitors and event goers to the Project.

Offshore Building

4.5.7.8 The Offshore Building is to be located adjacent to the turbine and sluice gate housing structure. It is anticipated that the building will need driven-pile foundations for support with a concrete slab. Otherwise conventional construction methods will be used.

Public realm, pedestrian and cycle route links

4.5.7.9 The public realm proposals include earthworks, beach, dune and saltmarsh construction, retaining wall construction with filling and surfacing of areas in various materials. These works will be completed during phase 4. The seawall cycle and pedestrian route surfacing will be completed following the cessation of the construction phase traffic movements along the western arm.

Removal of the construction support site

4.5.7.10 With the offshore works complete, the offshore construction support site will be decommissioned and the onshore construction support site will be downscaled as necessary.

4.6 Bulk materials and logistics

4.6.1 Sediment

4.6.1.1 As discussed in Section 4.3.1, approximately 7.3Mm³ of sediment is required for the Project and this will be obtained from an area within the lagoon of 2.75km² at an average depth of less than 5m or from smaller, deeper areas. At the turbine and sluice gate structure location, the seabed would be taken down to 14.35m below CD. This will be the new seabed level to accommodate the turbines and sluice gates.

4.6.1.2 It is proposed that upon final siting of the turbine and sluice gate structure, the sediment from that location would be moved directly to its permanent position within the permanent works by the Cutter Suction Dredger directly or via floating pipes.

4.6.1.3 Use of locally-obtained sediment in Geotubes® is considered to be a more sustainable construction method than the traditional alternative for seawall construction, involving far greater quantities of rock armour, invariably sourced from external locations, with associated greater impacts of quarrying, transport, etc.

4.6.2 Rock and rock armour

- 4.6.2.1 It is proposed that all rock armour for the Project will come from Dean Quarry in Cornwall. The quarry was fully operational up to 5 years ago and its operational licence is still in place. As such rock extraction from the quarry can commence, when required, with the appropriate plant and operators. The quarry is located on the coast and has a jetty which needs some repair and upgrading work. This work includes lighting, bollards and replacing some sheetpiles etc. These works would be within the quarry's present approved operational conditions and no new approvals are necessary.
- 4.6.2.2 No significant or adverse impacts are anticipated at the quarry itself, as it will operate within its existing licence and licence conditions. As part of the operational licence the quarry would be inspected every year or so to check that it adheres to these operational conditions.
- 4.6.2.3 As the quarry is located on the coast, with a jetty and barge loading facility, materials from the quarry can be brought to the Project by sea transport. This will reduce the number of HGVs travelling to the site, as, in respect of the largest size of rock armour to be used, only two pieces could be delivered on a HGV, whereas considerably more could be transported on a barge.
- 4.6.2.4 The by-product of quarrying such large quantities of rock armour is the volume of smaller sized rock produced. This material would be used in the Project either for the smaller diameter under-layer rock for the seawall, or as aggregate for concrete. In total about 2.8 million tonnes of rock will be used for the Project.

4.6.3 Concrete

- 4.6.3.1 In the region of 220,000m³ of concrete is required for the development, dependent on the final lagoon layout and turbine and sluice gate numbers.
- 4.6.3.2 It is proposed that a batching plant will be built on site to provide all concrete required. The raw materials will be delivered to site by road, although the possibility of bringing them in by rail is being considered as the Port of Swansea has disused sidings that could potentially be brought back into use. Supply by vessel is also an option being investigated, but for the purpose of the worst case assessment in this ES, it is assumed that road delivery will be used.
- 4.6.3.3 Regarding the sand required for the concrete, instead of bringing it in by road, a supply directly from the Port of Swansea is being considered. In this way, impacts on the local road network would be reduced. There is also the possibility of the using sand reclaimed from within the footprint of the Lagoon for inclusion in the concrete if suitable. In this instance, it would have to be washed and processed before use.
- 4.6.3.4 A provisional summary of the bulk materials associated with the Project is given in Table 4.6 and a provisional summary of offshore vessels is given in Table 4.7.

Table 4.6 Summary of current bulk materials

Bulk Material	Option	Quantity (In the region of)	Source	Transportation Method	Storage Location	Handling Procedure	Movements per week
Sediment	-	7,300,000m ³	Swansea Bay within Lagoon	Floating pipes	-	Cutter Suction Dredger or Trailing Suction Hopper Dredger – Floating pipes	Reclaim 83,500m ³ per week
Rock Armour 6-10t 3-6t 0.3-1t	Virgin rock	1,920,000t	England – Dean Quarry	Rock barge	Adjacent to seawall landfall	Unloaded by excavator at storage location – loaded onto dump truck/barge by excavator – unloaded by excavator at seawall location	Approximately 3 barges per week based on 10,000t barge
Rock Underlayer	Virgin rock	870,000t	England – Dean Quarry	Rock barge	Adjacent to seawall landfall	Unloaded by excavator at storage location – loaded onto dump truck/barge by excavator – unloaded by excavator at seawall location	1 or 2 barges per week
Concrete – Cement	-	55,000t	Aberthaw	Rail/road	On site batching plant	Delivered by HGVs or self-discharging barge and stockpiled within batching plant. Batch into concrete truck then take to location	38 HGVs per week
			Ireland				
			Europe				
Concrete – Cement Replacement	GGBS	25,000t	Port Talbot	Barge/road	On site batching plant	Delivered by HGVs, and stockpiled within batching plant. Batch into concrete truck then take to location	24 HGVs per week
	PFA		Aberthaw/ Newport	Rail/road			
Concrete - Water	-	35,000,000l	Water Main	-	Drawn as required	Batch into concrete truck then take to location	
Concrete – Sand		165,000t			On Site Batching Plant	Delivered by HGVs, and stockpiled within batching plant. Batch into concrete truck then take to location	135 HGVs per week
	Marine Dredged		Swansea Bay within Lagoon				
	Marine Dredged		Via Swansea Docks				

Bulk Material	Option	Quantity (In the region of)	Source	Transportation Method	Storage Location	Handling Procedure	Movements per week
Concrete - Aggregate	Quarry	250,000t	Local Quarry			Delivered by HGVs, and stockpiled within batching plant. Batch into concrete truck then take to location	202 HGVs per week
Steel Reinforcement		38,000t					30 HGVs per week
Steel Sheet Piles		17,500t if twin wall used 1,100t for permanent	Europe	Barge	Seawall adjacent to structure		1 delivery
Turbines –Steel		9,000t	Various S. Wales & UK	Road	Fabrication Yard	Delivered by road and stockpiled within fabrication yard. Taken to location on special vehicles within site boundary.	5 HGVs per week (over 60 weeks)

Table 4.7 Summary of offshore plant and vessels

Stage/Element of Marine Work	Offshore Plant/Vessels		Originating Location	Anchor Location when not in use
	Type	Anticipated Quantity		
Construction Lagoon Seawalls and Temporary Sand Cofferdam Bund (if this option were chosen)	Cutter dredger or hopper dredger	1 or 2	Rotterdam	During bad weather conditions – Local Port in consultation with the Harbour Master During fine weather conditions – Anchor at sea
	Backhoe dredger	2		
	Split barge	4 to 6		
	Side stone dumping vessel	2		
	Rock barge	4		
	Tug	4 or 5		
	Multicat	1 or 2		
	Survey launch	1		
	Crew launch	1		
	Safety boat	1		
Construction of Temporary Twin Wall Sheet Pile Bund (if this option were chosen)	Jack-up barge	4	UK	Mooring created within the Lagoon
	Tug	4	UK	Stay in position
	Supply/Spud barge	4		Mooring created within or adjacent to the Lagoon
	Work/Dive boat	4		
	Safety boat	3		On jack-ups
	Crew launch	3		
	100t Crawler crane (on jack-ups)	4		On completed bund
	100t Crawler crane (on completed bund)	2		
	30t Excavator	2		In port
	Wheeled articulated dumpers	4		
	100t Crawler crane (landside in Port)	2		

4.7 Construction Health, Safety and Environment

4.7.1 Waste

- 4.7.1.1 Due to the nature of the construction of the Project, there will be a relatively small amount of waste created.
- 4.7.1.2 A site waste management plan will be required as detailed within the CEMP. The plan targets a sustainable approach to waste management, ensuring that materials are managed efficiently, waste is disposed of legally and material recycling, reuse and recovery is maximised. A summary of the construction waste management has been included within the CEMP.
- 4.7.1.3 Targets will be set for the scheme, year-on-year, to increase the amount of waste diverted from landfill and to increase recycling. Innovative solutions for waste minimisation will also be sought.
- 4.7.1.4 Waste segregation will be implemented wherever possible and skips provided: one for general waste, one for wood, one for metal.
- 4.7.1.5 In terms of concrete, large scale continuous concrete pours produce very little wastage, as, when a section has been completed, any concrete left on order can be put into the bottom of the next day's pour. The concrete wagons and pumps will 'wash out' their apparatus into polythene lined ponds. The water will be left to evaporate and the concrete will harden. The concrete will then be removed from the ponds by excavators, broken up and reused within the permanent works.
- 4.7.1.6 Any concrete that needs to be removed, including the concrete wall south of Queen's Dock, any concrete within the existing Eastern Breakwater and any temporary hardstandings will be crushed and re-used on site, where possible.
- 4.7.1.7 A summary of the main anticipated waste quantities has been provided in Table 4.8 below.

Table 4.8 Summary of waste

Type of waste	Quantity	Disposal method
General waste		Segregated Skips – General waste sorted at transfer facility – over 95 % recycled
Concrete	<1 % = 2400m ³	Re-use within permanent works
Steel reinforcement	<0.5 %	Recycled
Structural steel	<0.5 %	Recycled
Packaging		Waste transfer facility

4.7.2 Temporary Navigation

- 4.7.2.1 Temporary navigation will be discussed and agreed with the port authorities, Trinity House and the Marine Coastguard Agency (MCA). A series of buoys would be laid to mark channels and designated routes for the dredging plant, and safety zones.

- 4.7.2.2 The dolphin piles that mark the safety zone for the turbine housing will be installed at the beginning of the construction of the temporary cofferdam to act as a visible demarcation of the area.

4.7.3 Vessel Working Zones

- 4.7.3.1 Working zones are required around the dredging and placing operations. These will be implemented in association with ABP, in respect of Swansea Port, and with Neath Port Authority. It is anticipated that the working zones would be approximately 300m outside the lagoon and the entirety of its interior. This would be with the exception of the Port channels where access will be maintained at all times for vessels using the channels. When operations are carried out adjacent to the Port channel, contact would be made and maintained with the relevant Port Authorities.

4.7.4 Construction Safety Measures

- 4.7.4.1 This is detailed in a Construction Code of Conduct/Health, Safety and Environmental Management Plan (HASEMP)
- 4.7.4.2 Safety boats will be available during all marine works. Further details of safety and procedural measures to be put in place during the construction phase are provided in the Navigation Risk Assessment which accompanies the DCO application.

4.7.5 Environmental Measures

- 4.7.5.1 To minimise the transfer of invasive non-native marine species (INNS) from vessels travelling from other countries, appointed contractors would be required to develop a management plan to reduce risk of transfer in line with existing international regulations. Further information on INNS is provided in Chapter 8, Intertidal and Subtidal Benthic Ecology along with control measures within the CEMP (Appendix 4.1, Volume 3).
- 4.7.5.2 All vessels will undergo standard periodic inspections.

4.7.6 Offshore Working Restrictions

- 4.7.6.1 Generally the operation of marine plant is restricted by wave height, which means that this work will be programmed for the summer to minimise standby time.
- 4.7.6.2 During the construction and M&E installation of the turbine and sluice structure craneage will be essential, which can be restricted by high winds. This is a common restriction that would affect any construction site, but it would be slightly exaggerated by the exposed location of the site.
- 4.7.6.3 Generally noise and vibration will be controlled to the extent required, to ensure no adverse effect on the workforce, as the public will be sufficiently remote from the main works site at the turbine and sluice gate structure. Further information on predicted noise during construction can be found in Chapter 19, Noise and Vibration.

4.7.7 Temporary Elements Associated with Construction

- 4.7.7.1 The construction phase for the offshore works utilises locally won material for the Geotubes® and will include extensive use of marine transportation thereby limiting construction phase traffic onshore. Temporary areas of land will be required for the Project to support the construction activities (construction support sites). A number of potential construction site locations have been identified for possible use (Figure 4.56). In order to ensure sufficient land is available at the required time in the construction phase, it may be necessary to split the construction support between more than one site.
- 4.7.7.2 The areas provided to allow maximum appropriate flexibility for siting are shown below on Figure 4.56. The shaded areas state the sizes required, although only one of each type of area would be required. The areas are as follows:
- i. area A - offices, stores, car parking, site access control and plant yard;
 - ii. area B (two possible locations) - concrete batching plant, stockpiling area and pre-casting yard;
 - iii. area C (two possible locations) – steelwork fabrication yard; and
 - iv. area D (two possible locations) – storage yard.
- 4.7.7.3 Where possible, the footprint of the permanent Project elements, such as public realm areas, will be used to accommodate the construction support sites.



Figure 4.56 Potential locations for construction support sites

- 4.7.7.4 The potential elements that make up the construction support sites for the Project are detailed below.

Area A – Site access control, offices, stores, car parking and plant yard

- 4.7.7.5 This requires an area of approximately 26,000 m². An indicative layout is shown below in Figure 4.57 and will include temporary office accommodation up to 4 stories high. The entire area will be cleared and then capped with a suitable amount of fill material prior to set up. It will be fenced with appropriate secure fencing, and lit during the hours of darkness. This area will incorporate access control during the construction phase, controlling which vehicles and personnel have access onto the seawall and to the turbine and sluice gate housing structure during construction. The potential area is shown in Figure 4.56, with a possible mooring point at the western point of Area A. There will also be a marine access facility at the eastern landfall. Other construction phase moorings will comprise temporary facilities within the area for the lagoon.
- 4.7.7.6 The plant yard area will be used for storage of plant used in the construction phase. In particular, this will store the land-based earthmoving plant which will be used to construct the seawalls and place the rock armour. A schematic diagram for the plant yard area is shown on Figure 4.57.

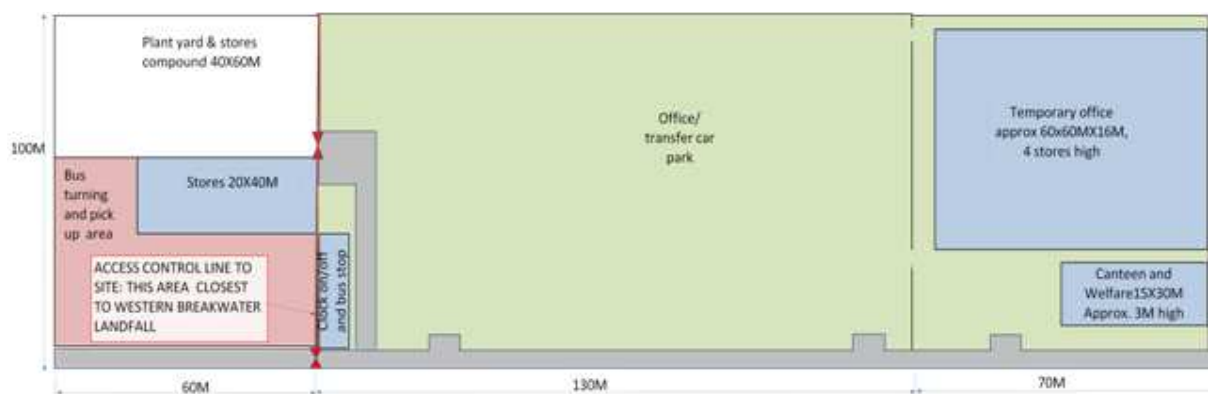


Figure 4.57 Schematic layout of offices, stores, car parking, site access control and plant yard

- 4.7.7.7 An area of 40m by 70m is required for an accommodation block approximately 30m by 30m up to two stories high.

Area B - Concrete batching plant, stockpiling area and pre-casting yard

- 4.7.7.8 The quantity of concrete required for the Project, and the anticipated offshore working hours, necessitates the provision of a Project-specific concrete batching facility. To avoid the need for concrete trucks to use the public highway, this is proposed to be located within the area of the existing Port of Swansea, from which the Project is accessible using the existing internal Port Road network. The batching facility requires an area of around 17,000m² and an indicative layout is illustrated in Figure 4.58. The batching plant will need to have the capacity to stockpile about 7000m³ of aggregate, piled up to 5m high in aggregate bins. There will also be silos to contain the powered material, such as cement and cement replacement.
- 4.7.7.9 The area would need to be lit during hours worked in darkness.

- 4.7.7.10 There may be a need to bring a mobile crushing plant on site at times, when reprocessing of temporary slabs and hardstandings is required along with the crushing of the concrete from the seawall and existing eastern breakwater. It is likely to be set up within the area identified for the batching facility.

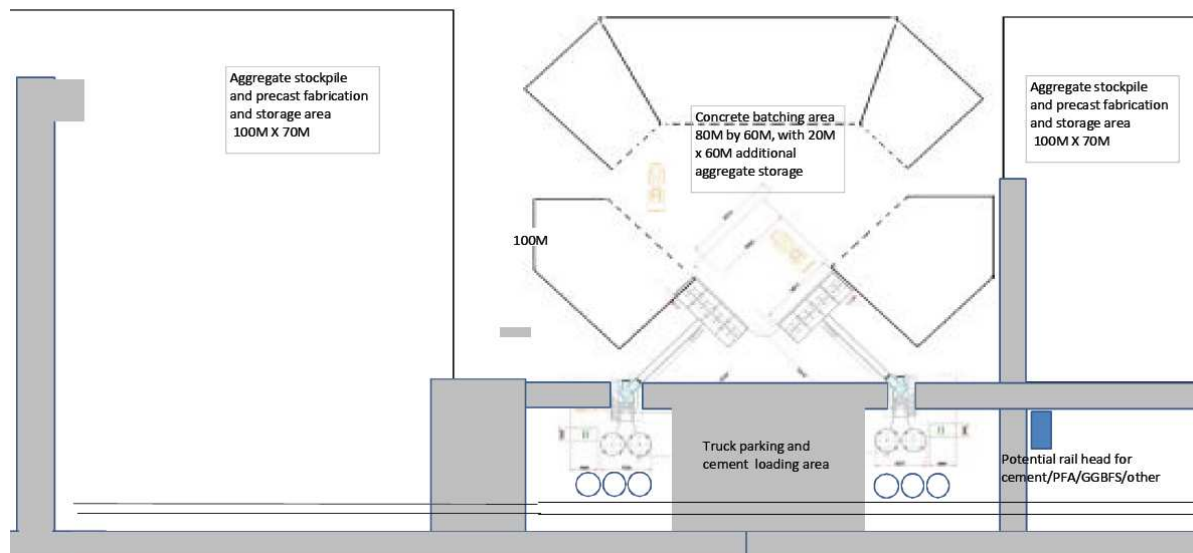


Figure 4.58 Indicative batching plant layout

Area C - Steelwork fabrication yard

- 4.7.7.11 An area will be required to receive, assemble and fabricate the turbines and sluice gate steelwork prior to installation¹⁰. This may require the construction of a facility on site. An indicative layout of the steel fabrication area is shown in Figure 4.59 and is anticipated to be in the region of 22,500m². The area includes a turbine assembly building 15m high and a floor area of 3000m² with overhead craneage.

¹⁰ This activity is comprised in the operations for the installation of the turbines, rather than their manufacture. The provisions of a factory or other facility for turbine manufacture is a possibility as a result of synergies created by the Project, but is not comprised in the Application and not subject to the EIA reported in this ES.

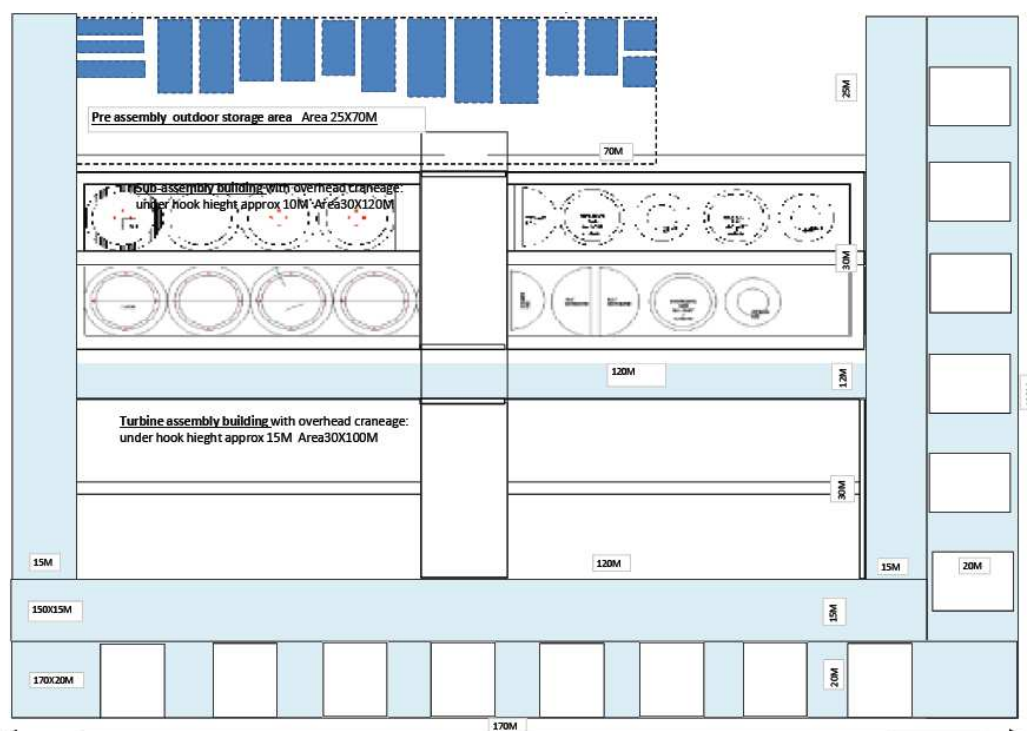


Figure 4.59 Indicative steel fabrication yard layout Area C

Area D – storage yard

- 4.7.7.12 Area D would be a storage yard approximately 625m x 100m for materials and vehicles involved in construction.

Rock storage

- 4.7.7.13 Rock required for the provision of rock armour is expected to be sourced from quarries remote from Swansea Bay. It is expected to be delivered to site by barges from the sea.
- 4.7.7.14 Some will be placed directly on the seawall immediately upon delivery. However, a storage area adjacent to the seawall near both landfalls will be required. This will allow flexibility in work programme, and to make allowance for varied weather conditions. The storage area would, therefore, need to be able to hold the quantity of rock required for approximately 3 weeks' worth of seawall construction in case of disruption of supplies by sea. In addition, some of the rock armour will be placed on the lagoon seawall by land-based earthmoving plant, including large dump trucks and tracked excavators.
- 4.7.7.15 Rock will be delivered by barge and would be transferred to a stockpile by land-based dump trucks where appropriate. The area of land required for 3 weeks storage equates to a requirement of approximately 400m by 400m at the western landfall and 250m by 250m with a storage height limit up to 3m at the eastern landfall.

4.7.8 Onshore construction access and routeing

- 4.7.8.1 A framework for the construction phase traffic management plan has been provided to the highway authorities during consultation and forms part of the construction phase

project description and basis for relevant assessment topics. The traffic management plan is found in Appendix 15.12, Volume 3.

- 4.7.8.2 Road access to the Project for construction traffic will be via Fabian Way from the traffic light controlled junction opposite the Park and Ride and then through the port. Exceptional loads, access at the start of the Project before the new access road is complete and possible routeing of traffic on a one-way system may require the use of the Baldwin's Bridge junction (which is used by the Port) for the off slip only. The access route will follow the permanent proposed Lagoon access road to the western landfall. The construction access routes are shown in Figure 4.60 below.

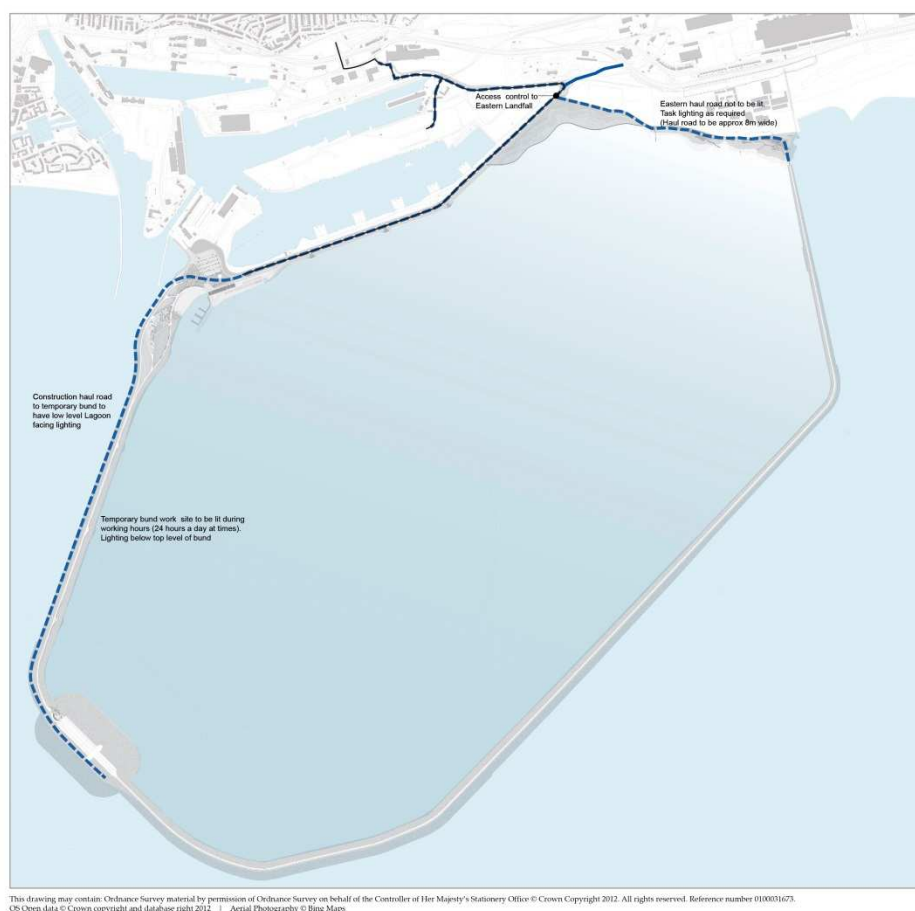


Figure 4.60 Construction access routes

- 4.7.8.3 The routing of construction access to the eastern landfall will again be via the main access route off Fabian Way and the Project access road. Once at the existing shoreline in the vicinity of the existing Swansea Port security gate, a temporary track will be constructed across brownfield land (a former BP tank farm), seaward of the existing sea wall, and across intertidal land to the south of SUBC. The route of this eastern construction access road will follow the alignment of the permanent combined footpath and cycleway and is shown on Figure 4.60.
- 4.7.8.4 This construction access to the eastern landfall will run along the southern strip of the old tank farm behind the existing rock armour and concrete retaining wall. At the eastern extent of this area the route would then cross the rock armour revetment and

run along the upper beach to the eastern landfall. Across the beach the road will be built up to a level to ensure it is above the highest tide and protected with rock armour. As the access route passes across the shore adjacent to SUBC, it will be at a lower level, with the existing rock armour acting as visual screening. If further screening is required this will be done by either temporarily raising the height of the existing rock armour or by another agreed method.

- 4.7.8.5 The construction access to the western landfall will initially be by the use of the Port Roads until the permanent access road, as described previously, from Langdon Road has been constructed.

4.7.9 Offshore turbine and sluice gate structure support site

- 4.7.9.1 As the turbine and sluice gate structure will be constructed approximately 3km from the landfall, a separate support site will be required at this offshore location within the temporary cofferdam. The facilities at this location will mainly comprise offices, welfare facilities and stores. A construction haul road will be built on top of the western seawall, before the turbine and sluice gate housing construction starts. This will connect this offshore construction support site with the land and will be used for access by construction plant, concrete deliveries and transportation vehicles for the workforce.

4.8 Operation and Maintenance

4.8.1 Overview

- 4.8.1.1 The Project is anticipated to have a nominal installed capacity of 240MW at a normal operating head, and will produce 400GWh of electricity on a net annual output basis.

- 4.8.1.2 The overall life expectancy of the Project is 120 years. Whilst it has a design life of 50 years, ongoing maintenance and repair work will be required to extend the lifespan of the Project beyond this. An Operation Environment Management Plan (OEMP) will be prepared for the Project and an outline framework is provided in Appendix 4.2, Volume 3. This plan will be developed and updated during the detailed design. As part of the Project an adaptive environmental monitoring plan (AEMP) is also being prepared which will be developed during the various stages of the project in consultation with Statutory Nature Conservation Bodies (SNCB). The draft AEMP is provided as Appendix 23.1, Volume 3. This AEMP outlines the monitoring in four distinct phases, namely:

- i. monitoring which has been undertaken to inform the development of the Project,
- ii. pre construction monitoring,
- iii. construction monitoring, and
- iv. operational monitoring.

- 4.8.1.3 In terms of the Lagoon seawalls will be designed for 1 in 100 year return wave conditions. The expected sea level rise for a period of 50 years will be used in the design of the seawall, and it is expected that maintenance work and/or raising of the crest level could be required after this period.

- 4.8.1.4 The raising of the crest (if required) would be performed by land based plant, namely a crane with a grab and dumpers. Wheeled dumpers would be used to transport

additional rock armour to the crane. The crane would then rearrange the top layers of rock armour and add additional rock to the new desired level.

- 4.8.1.5 For mechanical and electrical equipment, it is expected that this may need replacing and/or upgrading after 25 years. The turbine runners are expected to need major refurbishment or replacement after 50 years.

Structural integrity of lagoon seawall

- 4.8.1.6 A breakwater or bundwall type structure, is normally designed so as to allow some limited damage to take place during serious storm events. The rationale for this is that over the lifetime of the Project it is more cost effective to allow for a robust design so that when damage takes place, repair of this damage is anticipated as a form of maintenance, and provided for from the outset. This is a more efficient approach than to allow for design to accommodate extreme events without sustaining any damage.
- 4.8.1.7 It is common to allow for damage up to 5% of the structure during 1 in 100 year wave conditions, but in such a way that such wave conditions do not lead to “failure” of the structure. In other words, the damage that takes place will be repairable as a matter of course. Irrespective of the approach adopted, it remains possible that a more extreme storm event will occur, resulting in more serious damage to the structure.
- 4.8.1.8 In practical terms what this means is that (say) every 10 years, or after every serious storm, a monitoring assessment is undertaken of the seawall structure in order to determine whether damage has taken place that needs to be repaired. Such a monitoring study is normally undertaken by means of aerial photography (from a helicopter) during low tide conditions.
- 4.8.1.9 The damage that may normally be expected is that the front slope will be re-arranged during big storms, whereby the straight outer slope of 1 in 2.5 will be replaced by a “S” type slope. Rock would roll down from the top of the slope (where the most violent wave action is experienced) towards the bottom of the slope, and in the process some rock would break down or would even roll down onto the seabed.
- 4.8.1.10 Where extensive movement of rock armour has occurred, repair of those sections of the seawall that were most affected would be required. The repair work, would consist of bringing in a crane and then replacing some of the rock from the bottom slope back to the top of the slope again. Where necessary, additional rock may have to be brought in to replace broken or missing rock. Such work could be undertaken from a barge or from the top of the seawall.
- 4.8.1.11 Typically such repair work would be undertaken every 25 years or so. As such, during the operational life of the Project, a regular monitoring and repair programme is required to ensure that the structure remains fit for purpose. This will be detailed within the OEMP.
- 4.8.1.12 Where the Project is not required for electricity generation purposes, but still used for recreational and environmental purposes (artificial reefs), then it may well be necessary to continue with this monitoring and repair programme.

4.8.2 Turbines

4.8.2.1 As discussed previously there remain two types of bi-directional turbines which are being considered. These are:

- i. 7m (+/- 200mm) fixed speed or 'synchronous' turbines; and
- ii. 7m (+/- 200mm) variable speed turbines.

4.8.2.2 As mentioned previously, it is proposed that up to 16 bi-directional bulb turbines will be used. For the fixed speed turbines, they will have a rotational speed of approximately 67rpm, the variable speed turbines are expected to operate between 30 and 67rpm, with an average of 50rpm. The flow rate through the turbines varies according to the head from 100m³/s at 1m head to 400m³/s at 5m head. Based on 16 turbines, the total peak discharge, through the turbines and sluice gates at 1.4m head, will be approximately 10,000m³/s.

4.8.2.3 An illustrative cross section of a turbine is shown in Figure 4.10, Section 4.3.2.

4.8.2.4 For synchronous machines, in the region of 15.5GWh/year of heat will be produced by generator and transformer losses based on 400GWh energy and 3% electrical losses. The heat loss will be discharged by air heat exchangers on top of the turbine and sluice gate structure for the transformers. For the generators the heat loss will be discharged in to the water via a heat exchange jacket on the draft tube liner. This will be discharged into approximately 100,000,000m³ of water in each tidal cycle; at 1,410 tidal cycles per year gives a total of approximately 141,000,000,000m³. It is anticipated that this would result in a negligible rise in sea temperature (1 ten thousandth of a degree), see Chapter 7, Marine Water Quality.

4.8.2.5 In terms of noise, there is no specific data for this new type of turbine. However, they will be running at somewhere near 90% efficiency and, as such, vibration and associated noise is expected to be very low. Notwithstanding this, for the purpose of this EIA, the work of Anderson *et al* (1989) has been considered. This study undertook measurements of bulb head turbines at three different sites and a variety of locations. These measurements provide a range of source levels for similar turbine installations and this has been used in Chapter 19, Noise and Vibration.

4.8.2.6 It is not proposed to install trash screens on the turbine and sluice gate structure for a number of reasons. In terms of damage, smaller debris/objects are not a risk to the size of turbines proposed, as the openings in between the turbine blades and between the wicket gate blades are large. In addition, due to the anticipated flow velocities through the turbines it would be difficult for such objects to cause a blockage. In terms of large objects, like trees, these could in principle cause damage or blockage to the turbines. However, large objects such as these are rarely found in the sea and if present they would be on the surface, rather than be pulled down in the water column towards the intake. Therefore, such measures are not considered necessary for the purpose of this Project.

4.8.3 Operation

4.8.3.1 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 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 (Figure 4.61).

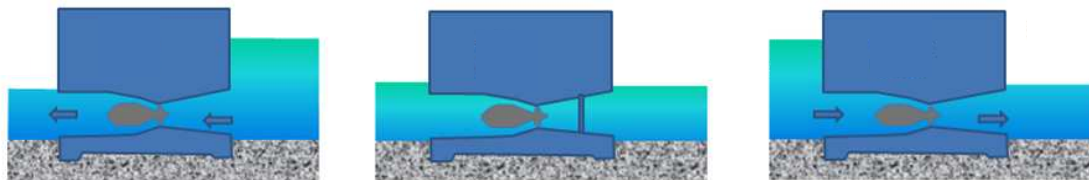


Figure 4.61 Illustration of water flow between the sea and the Lagoon

- 4.8.3.2 Towards the end of a generation sequence, in order to maximise head on the following tide, the sluice gates will be opened. This will empty or fill the lagoon so that the water levels inside and outside the lagoon are equalised as much and as quickly as possible prior to 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; thereby maximising electricity generation. This generation sequence will happen on the flood and ebb tide, four times a day in total.
- 4.8.3.3 Sluicing on the end of a generation sequence will help to equalise sea and lagoon levels, but there will still be a difference which will slightly reduce foreshore exposure. However, optimising the sluice gate opening (i.e. sluicing earlier in the sequence), sluicing in parallel with turbinning at the bottom of the generation sequence, increasing the sluice gate size and improving sluice gate design to improve the discharge capacity are all currently being investigated in detail, which will help to reduce any foreshore attenuation. Another operating sequence is also being explored to further reduce this potential effect and this is discussed further below.
- 4.8.3.4 At present, a detailed technical and commercial evaluation of both synchronous and variable speed turbines is being undertaken to identify the best option. If the variable speed option is chosen, it gives an opportunity to use the turbines for pumping, as the efficiency in 'pump mode' is far higher than the equivalent synchronous turbine. Pumping could therefore be used in order to improve overall power output and reduce any foreshore attenuation. Pumping would work as follows:
- i. On the flood tide, water flows into the lagoon, the turbines operate and power is generated;
 - ii. When the head becomes too small for effective generation, at about 1 to 1.5 m, then the sluices are opened, and water flows quickly into the lagoon through the sluices and also through the freely spinning turbines;
 - iii. When the water levels are almost balanced, then the sluices are closed and the turbines are used in reverse mode to pump additional water into the lagoon in order to raise the water levels; and
 - iv. This process is repeated on the ebb tide where pumping is used to lower the water levels within the lagoon.

- 4.8.3.5 The idea is to pump in water against a low head, on average 0.6m, and then to release it again later at a much bigger head, e.g. 4m. Potentially this could give an overall net power gain and by pumping down on the ebb tide it would match the natural tide levels more closely. It would also have the benefit of enabling the extent of exposure of intertidal areas to be managed for ecological purposes
- 4.8.3.6 The period where water is prevented from leaving or entering the lagoon is called the “hold” period and no electricity will be generated during this time. A summary of annual “hold” and generating phases is shown below in Table 4.9 below.

Table 4.9 Average annual generating time and holding periods

	Total Time (hrs)	No. of Tidal Cycles Annually	Average Time (hrs) per tidal cycle (4 cycles daily)
Hold	3558.75	1411	2.52
Sluice	945.35	1411	0.67
Generate	4252.25	1411	3.01

- 4.8.3.7 Figure 4.62 illustrates the 48hr operating cycle for the lagoon, with the holding (grey), generating (yellow) and sluicing (green) periods for one tidal cycle highlighted.

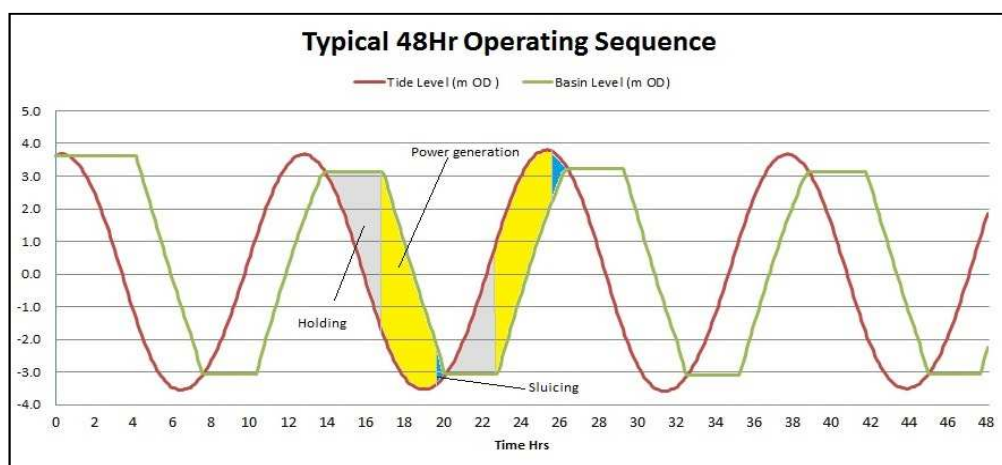


Figure 4.62 Lagoon operating cycle

- 4.8.3.8 The lagoon will have a maximum discharge of approximately 10,000m³/s, with a total volume in the lagoon at a high spring tide of approximately 100,000,000m³.

4.8.4 Assessment of current speeds near turbine and sluice gate structure

- 4.8.4.1 A review of the difference in maximum flow speed of water coming out of and going into the lagoon turbine housing structure has been undertaken. The flow data is based on the 16 x 7m turbine/10 sluice gate design at Location A (see Figure 4.13). To undertake the assessment depth average data had been extracted from the 2D coastal process model used for this EIA. Figure 4.63 below shows an image of the maximum flows in the area surrounding the turbine house on ebb tide generation. Figure 4.64 shows a similar figure for the flood tide generation sequence. The following flow datasets have been extracted every 50m along transect lines (dotted lines):

- dataset 1 – maximum ebb tide flows in front of turbine housing (outside lagoon);

- ii. dataset 2 - maximum ebb tide flows oblique to turbine housing (towards Swansea channel);
- iii. dataset 3 - maximum ebb tide flows drawn into the turbine house (inside lagoon);
- iv. dataset 4 – maximum flood tide flows in front of turbine housing (inside lagoon); and
- v. dataset 5 – maximum flood tide flows drawn into the turbine housing (outside lagoon).

4.8.4.2 The data is shown in Tables 4.5 and 4.6 for the ebb tide and flood tide respectively.

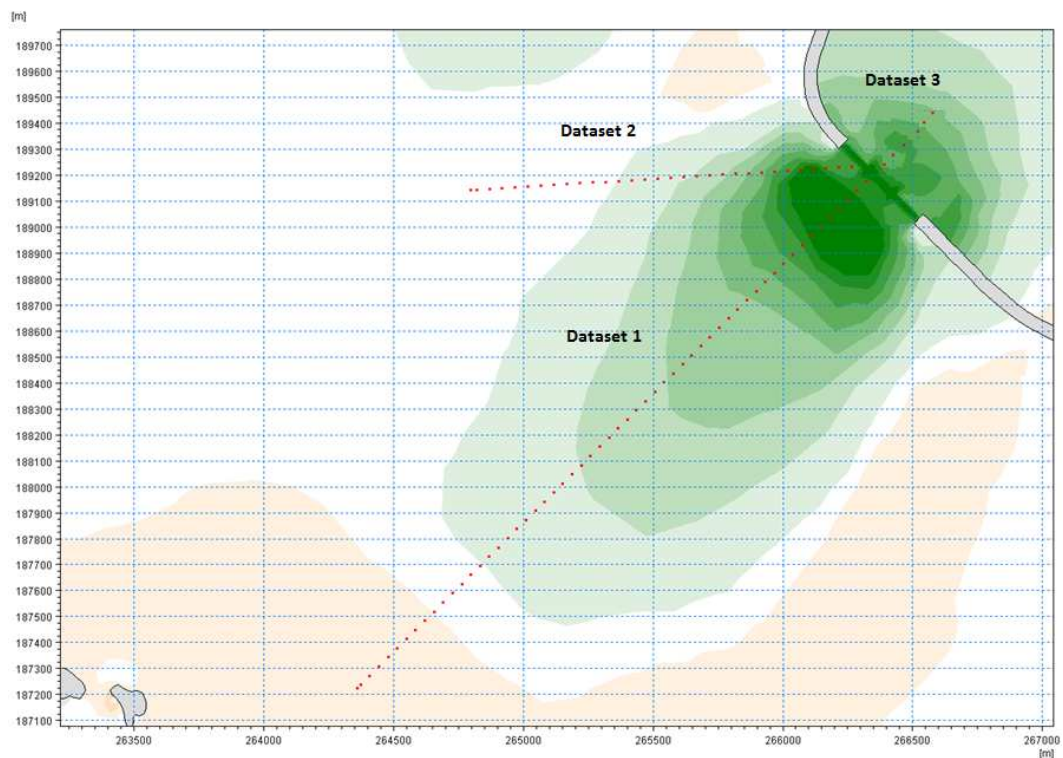


Figure 4.63 Maximum ebb tide current flow patterns (in front of and oblique to turbine house)

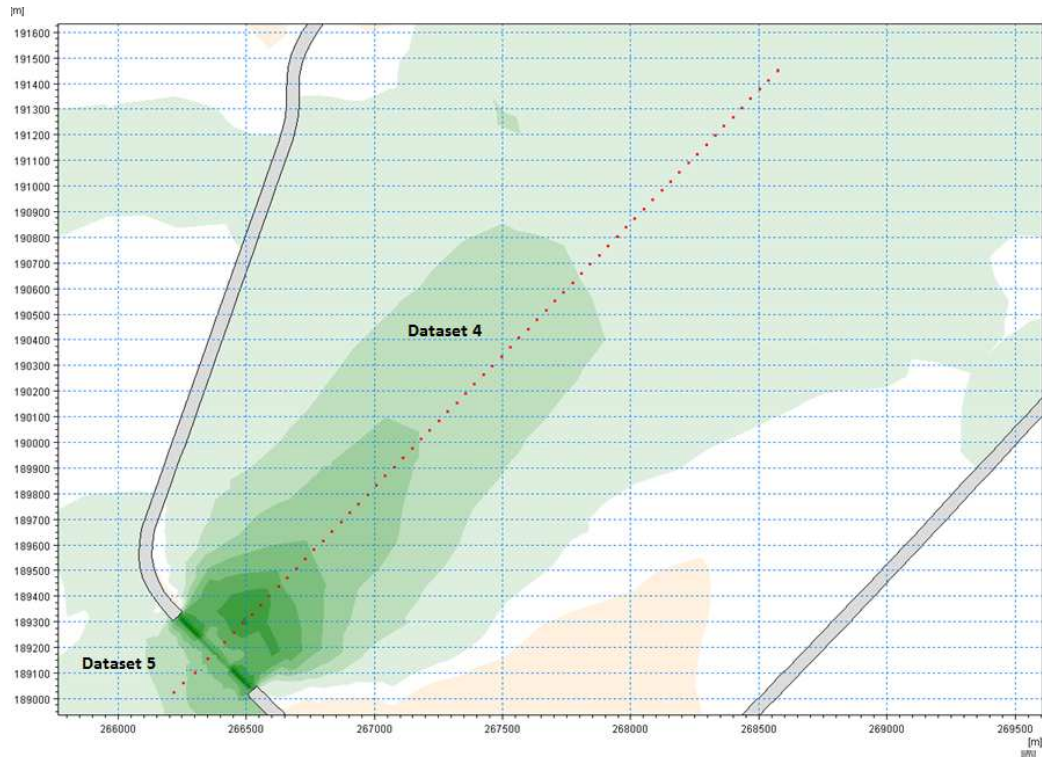


Figure 4.64 Maximum flood tide current flow patterns (in front of turbine house)

Table 4.10 Maximum flow data at 50m intervals - ebb current speed (m/s)

Chainage (m)	Dataset 1 Exit turbines (outside Lagoon)	Dataset 2 Exit Oblique to turbines (outside Lagoon)	Dataset 3 Into turbines (inside Lagoon)
50	1.87	1.57	1.31
100	1.93	1.60	1.36
150	2.33	1.57	1.50
200	2.37	2.60	1.47
250	2.51	2.00	1.47
300	2.51	1.71	1.08
350	2.13	1.67	1.08
400	1.74	1.51	0.89
450	1.49	1.20	0.77
500	1.36	1.20	0.77
550	1.36	1.10	0.75
600	1.26	0.74	0.65
650	1.26	0.74	0.65
700	1.12	0.75	0.67
750	1.18	0.75	0.67
800	1.18	0.76	0.59

4.8.4.3 As can be seen from Table 4.10, the maximum flow speed exiting the turbine house on the ebb tide generation along a transect line directly in front of the turbine/sluice gate structure (Dataset 1) is around 1.87m/s. The flows then increase to 2.51m/s at

approximately 250 to 300m away before reducing to 1.36m/s at a distance of 500m. The peak flow is associated with the start of the sluicing phase which occurs for a short period towards the end of each generation cycle (Figure 4.62).

- 4.8.4.4 Maximum flows oblique to the outside of the turbine house, towards the Swansea channel, show a similar picture (Dataset 2). Here the flows start at 1.57m/s and there is a similar increase pocket of flows up to 2.60m/s, but this time at approximately 200 to 250m away. At the 500m chainage the flows are lower, at around 1.2m/s. For the edge of the Swansea Channel, which is the approximately 375m distant from Location A, the maximum flows experienced would be in the order of between 1.67 to 1.51 m/s.
- 4.8.4.5 If the turbine sluice gate housing structure is sited at location B, further to the southeast (Figure 4.13). This would take the turbine house further away from the Swansea Channel and the alignment is such that the flows from the turbines and sluice gates would not affect the Channel.
- 4.8.4.6 Inside the Lagoon, the maximum flows being drawn into the turbine sluice gate housing are lower, starting at 1.31m/s at 50m chainage (Dataset 3). The same pattern of increased flows can be seen at 150m (1.5m/s) before the flows reduce again to 1.08 m/s at 300m and 0.77m/s at 500m. Once again these peak flows are associated with the start of the sluicing phase of operation.

Table 4.11 Maximum flow data at 50m intervals – Flood current speed (m/s)

Chainage (m)	Dataset 4 Exiting turbines	Dataset 5 Into turbines
50	1.26	1.05
100	1.42	0.89
150	1.65	0.92
200	1.73	0.84
250	1.73	0.69
300	1.47	0.69
350	1.47	0.66
400	1.19	0.58
450	1.12	0.57
500	1.12	0.56
550	1.06	0.56
600	1.00	0.54
650	1.00	0.54
700	0.97	0.53
750	0.97	0.55
800	0.97	0.55

- 4.8.4.7 On the flood generation the maximum flows entering the lagoon associated with the sluicing phase (Dataset 4) will be around 1.26m/s at 50m from the turbine and sluice gate house. These will increase slightly at a distance of 200m to 250m distance (1.73m/s) before reducing to 1.47m/s at 300m and 1.12m/s at 500m.

- 4.8.4.8 As with the ebb tide generation maximum flows being drawn into the lagoon are lower (Dataset 5). The peak flows at 50m will be around 1.05m/s and these consistently reduce to 0.69m/s at 300m and 0.56m/s at 500m.

4.8.5 Preliminary safety details and wave reflection

- 4.8.5.1 As identified above, the maximum currents outside the turbine and sluice gate housing are experienced at the end of the generation cycle when sluicing commences. In relative terms, these increases represent changes in mean flow speeds over spring tides of more than 100% in comparison to baseline flows in relatively close proximity to the turbine/ sluice gate structure (i.e. within approximately 225m). Although the currents would be only for a short period of time each tide (approximately 15min) and are within ranges that are normally experienced by sailing vessels/shipping, safety around the lagoon is paramount in case a vessel should get into difficulty. The dolphin piles and safety boom described above at Section 4.3.3 will prevent any vessels entering the safety zone and possibly coming into contact with the structure.
- 4.8.5.2 In addition to change in currents, the effect of the lagoon on the existing wave climate within the Bay has also been reviewed. This is of particular relevance with regard to vessels using the approaches to the Swansea and Neath approach Channels.
- 4.8.5.3 Design wave conditions have been assessed at various locations along the Lagoon seawall. Information with respect to climate change and resulting sea level rise has also been taken into account. The findings of these assessments have been fed into the design of the Project and further information can be found in Chapter 6, Coastal Processes, Chapter 14, Navigation and Chapter 17, Hydrology and Flood Risk.
- 4.8.5.4 Notwithstanding this, as discussed in Section 4.3.1, the sloping walls and rock armour of the lagoon seawalls will assist in absorbing wave energy, and reduce wave reflection when compared to vertical walls. The vertical walls of the turbine and sluice housing structure will produce some additional wave reflection. Further details on the wave action and the effects on the approaches to the Neath and Swansea channels are provided in Chapter 6, Coastal Processes and Chapter 14, Navigation.

4.8.6 Maintenance

- 4.8.6.1 The need for additional maintenance dredging in the Swansea, Neath and Port Talbot Port navigation channels has been determined through sand and mud coastal process modelling (Chapter 6, Coastal Processes, Sediment Transport and Contamination). In terms of the Neath Channel, no change has been predicted outside of natural variability. At Port Talbot approximately 1,154,000m³ is dredged each year from the channel and the Project would result in a small change (1.2-2%) to this. It is considered that this predicted change in sediment deposition will be generally indistinguishable from the natural variation in annual dredge volumes.
- 4.8.6.2 Currently lower volumes of sediment are annually dredged from the Swansea channel compared to the Port Talbot Channel (about 192,300m³). As such the slight increase in sedimentation as a result of the Project is proportionally greater (20 -34%). Liaison will be undertaken with Swansea Port and additional dredging of the Swansea Channel will be undertaken if necessary.

- 4.8.6.3 With respect to areas inside the lagoon, the currents formed through the operation of the turbines and sluice gates will result in a localised scour area both upstream and downstream of the turbine and sluice gate housing. Within the areas either side of this, currents will decrease and, therefore, there will be potential for sediments to deposit. Further information on the potential for siltation within these areas is provided in the coastal process assessment (Chapter 6, Coastal Processes, Sediment Transport and Contamination).
- 4.8.6.4 It is anticipated that maintenance dredging within the Lagoon will not need to start until 10 to 15 years after the completion of construction and then be performed approximately every two years. However, the need to do so will be monitored. Based on this monitoring, a dredging strategy will be developed and a licence for disposal will be discussed and agreed with MLT.
- 4.8.6.5 In terms of dredging it is assumed that dredging equipment will need to be brought to the lagoon by road and launched into the Lagoon to collect sediment deposits. The dredger will then place the material in front of the sluice gates prior to the Lagoon emptying to allow the sediment to be carried out of the lagoon with the flow of water. Alternatively materials from the lagoon are likely to be disposed of at the Swansea Outer Spoil Ground.
- 4.8.6.6 Once the lagoon is operational any maintenance to the turbines and sluice gates will involve installing the modular stop log walls either side of the turbine and pumping out the water between them. If any large sections of the turbines have to be removed, or large equipment is required for the maintenance work, then these will be lifted through the removable steel hatch covers over the turbine and transferred to the maintenance pit.
- 4.8.6.7 The stop logs will be installed using temporary mobile cranes that will only be required for short durations during maintenance or repairs to the turbines or sluice gates. The cranes will access the turbine and sluice gate housing structure along the western seawall.
- 4.8.6.8 There will be one main gantry crane located on top of the turbine and sluice gate structure at +12.00m CD, which will service both the turbines and sluice gates. As discussed previously, the aim is to install an internal crane with much reduced height. The details described here are the original design that has been assessed within Chapter 13 (Seascape & Landscape Visual Impact Assessment).
- 4.8.6.9 The gantry crane is intended to be semi-goliath type and will have an overall height of 18.65m above the top of the turbine housing which puts the top of the crane at approximately +31m CD. The crane will be used for heavy and intermediate lifting events and, as such, will be used during major maintenance events. It is likely that it will be used approximately 6-10 times per year. Figure 4.65 shows an arrangement for the proposed turbine crane.

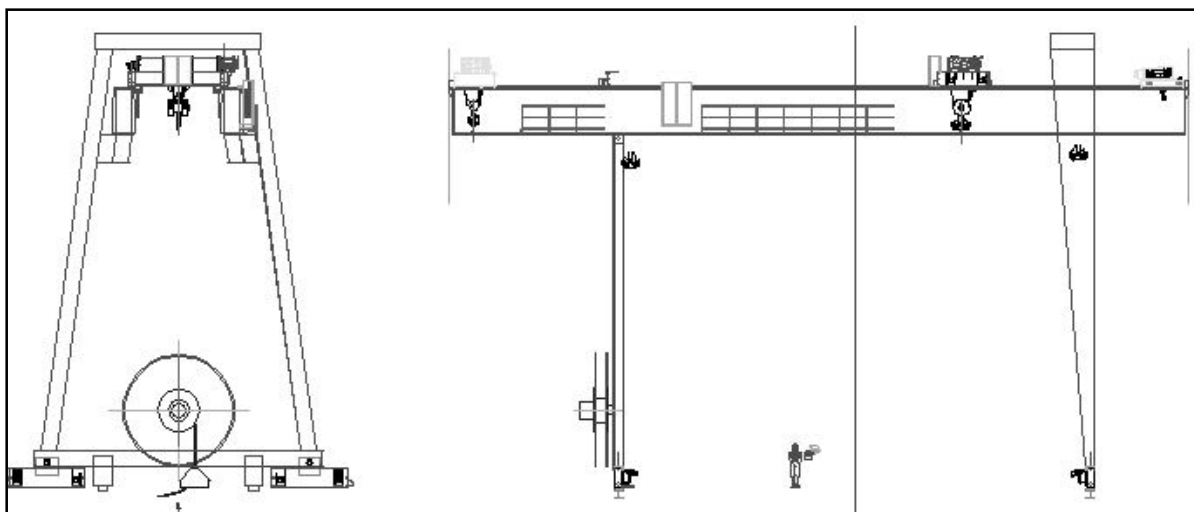


Figure 4.65 Turbine semi-goliath gantry crane

4.8.6.10 The gantry crane will be permanent feature on top of the turbine and sluice gate structure. It will traverse the structure as required and have a normal 'home' position where it will be placed when not in use. At this location the crane can be secured to the structure to protect it against the effects of high winds during storm events. The crane will be grey/black in colour to limit visual intrusion.

4.8.6.11 Routine inspections of the turbine and sluice gate housing structure concrete will be carried out. Repairs will be undertaken when required.

4.9 Decommissioning

4.9.0.1 Apart from the alternative discussed in Chapter 3 Site Selection and Option Appraisal, at this stage there are two potential options for decommissioning which are to:

- i. replace, upgrade and extend life of the generating station; and
- ii. remove turbines, sluice gates and M&E equipment and continue leisure use of the Lagoon water area.

4.9.0.2 Even though the lagoon and its power generating capabilities have a specified design life, if its components are maintained, and upgrading works are carried out, then its life can be extended. It is likely that at this point, power generation by tidal lagoons will have developed further, and the Project will be progressively updated so that the facility can be kept in use as an energy source, as well as continuing to fulfil its ongoing leisure use.

4.9.0.3 At the end of the working life of the Project, it is also possible that that the turbines and sluice gates could be removed, and the tide allowed to flow through the resultant gaps in the structure – still allowing the lagoon to fulfil its ongoing leisure uses.

4.9.0.4 Whilst only the second of these alternatives is "decommissioning", both are referred to as such in this ES.

4.10 Sustainability

- 4.10.0.1 Sustainability statements/assessments are not a strict legal requirement in relation to the DCO or Marine Licensing processes; nor are they required by local planning policy (City & County of Swansea, Neath Port Talbot County Borough). TLSB has not provided a separate sustainability statement among the suite of application documents, as sustainable development is inherent in the Project rather than a topic that is appropriate for being meaningfully reported or assessed separately in this particular case. TLSB further considers that sustainability is integral to every element of the Project, something that has been considered at all stages of development, and something that should be reported accordingly – i.e. throughout the suite of application documents, not as a stand-alone item.
- 4.10.0.2 A carbon life-cycle report is provided as an Appendix to this Chapter (Appendix 5.1, Volume 3), which sets out that the Project will be carbon-neutral after approximately four years of operation. Other areas of sustainability are addressed as follows:
- i. Compliance with planning policy for energy and climate change: summarised in Chapter 5 (Planning and Policy Context) and detailed in the accompanying Planning Statement.
 - ii. Designing for sustainability: considerations of the sustainability of the overall scheme design are addressed throughout the application documents. Design detail (e.g. building design, materials selection, resource use, energy/water efficiency, access and movement, sustainable drainage, use of native plant species, etc) is summarised in this Chapter and detailed in the accompanying Design & Access Statement. Chapter 23 (Mitigation and Monitoring) summarises initiatives to mitigate all impacts of the scheme, including design matters.
 - iii. Sustainable construction: sustainable construction methods have been adopted throughout (e.g. selection, sourcing and handling of materials, re-use and recycling of materials, use of sea transport, Considerate Contractor schemes) as summarised in this Chapter and assessed throughout ES Chapters 6 to 22. Further detail is provided in the accompanying CEMP and OEMP. Chapter 23 (Mitigation and Monitoring) summarises initiatives to mitigate all impacts of the scheme, including construction matters.
 - iv. Project provisions for social sustainability: for example, recreational space, sport, art, culture, visitor facilities and education initiatives; and for economic sustainability: for example, job creation, supply chain development, enhancement of the local tourism offer and establishment of a new tidal lagoon industry (as described elsewhere); are summarised in this Chapter and assessed in Chapter 22 (Economy, Tourism and Recreation), Chapter 20 (Cultural Heritage: Marine Archaeology) and Chapter 21 (Cultural Heritage: Terrestrial Archaeology). Chapter 23 (Mitigation and Monitoring) summarises initiatives to mitigate all impacts of the scheme, including impacts on social matters. Further detail is provided in the accompanying Design & Access Statement, and in the Consultation Report which have been produced as part of the application for the DCO.
 - v. Project provisions for environmental sustainability: for example, the generation of renewable energy in support of efforts to decarbonise UK power and combat climate change, habitat creation and biodiversity enhancement measures; summarised in this Chapter and assessed throughout ES Chapters 6 to 22. Chapter

23 (Mitigation and Monitoring) summarises initiatives to mitigate all impacts of the scheme, including impacts on environmental matters. Further detail is provided in the accompanying Design & Access Statement.

4.11 References

Anderson & Blake (1989). Measurement of Low Frequency Sound at Bonneville, McNary and Lower Granite Dams – 1988

Environment Agency (December 2009) River Basin Management Plan Western Wales River Basin District

Table 4.1 Design Options

Component	Optionality/Design Flexibility	Comments and relevant assessment in following EIA chapters
Turbines and Sluice Gates	Number of turbines: 16 no 7m diameter fixed speed working at 67rpm and 8 no sluice gates. Total structure footprint: Length = 410m, width (max) = 67.5m.	A total of 13 - 16 turbines and 6 - 10 sluice gates are assumed in arrangement to minimise scour. Overall peak flow and turbine /sluice gate structure size will not increase as when turbine number increases sluice gates will decrease. Likewise the overall size of the turbine and sluice gate housing structure size will not increase. This provides a worst case design for assessment purposes in terms of direct and indirect effects on wider environment. Sixteen turbines and eight sluice gates are assessed throughout EIA in all technical Chapters (6 – 22).
	An option for variable speed turbines (30 - 67rpm – average 50rpm)	Fixed speed turbines are assessed as a reasonable worst case. Use of variable speed turbines if available and appropriate, instead of fixed speed turbines would provide additional benefits in a number of areas, including reduced effects on fish; allow pumping at end of tidal cycle which would reduce intertidal losses and therefore potential beneficial effects on birds. Further consideration is given to variable speed turbines in Chapter 7 Marine Water Quality, Chapter 8 Intertidal and Subtidal Benthic Ecology, Chapter 9 Fish, including Recreational and Commercial Fisheries and Chapter 11 Coastal Birds.
Overall Turbine and Sluice Gate Structure and its position (see Figure 4.13)	Location A on southwest straight of lagoon seawalls – positioned at northeast extent of micro-siting area. Total footprint: Length = 410m, width (max) = 67.5m. Estimated volume of materials based position A Sediment for Geotubes® and sand core approximately 7.3Mm³ Sediment for disposal approximately 0.8Mm³ Rock underlayer approximately 0.87Mt Rock armour approximately 1.92Mt	The results of the GI show that the ground conditions in the vicinity of the turbine and sluice gate housing structure would require approximately 0.5Mm³ of material to be disposed of. Other locations are potentially available with ground conditions that are preferable thereby reducing the need for disposal of dredged arisings. Location A is the “worst case” design siting in terms of potential direct and indirect effects on wider environment. It is assessed throughout the EIA in all technical Chapters (6 – 22). This location is considered to be acceptable.
	Location B on southwest straight of lagoon seawalls – positioned at southeast extent of micro-siting area. Total footprint: Length = 410m, width (max) = 67.5m. Estimated volume of materials based on position B Sediment for Geotubes® and sand core approximately 7.3Mm³ Sediment for disposal approximately 0.66Mm³ Rock underlayer approximately 0.87Mt Rock armour approximately 1.92Mt	Siting of turbine housing in such location would have potential improvements in the following areas: construction water quality due to less material to be disposed of; operation water quality as turbines further offshore, navigation and fish as further from Swansea channel. Further consideration of this option is given Chapter 6, Coastal Processes, Sediment Transport and Contamination; Chapter 7 Marine Water Quality and Chapter 9 Fish, Recreational and Commercial Fisheries and Chapter 14 Navigation.

Component	Optionality/Design Flexibility	Comments and relevant assessment in following EIA chapters
Lagoon seawall design	The formation of the Lagoon seawalls using an initial outer structure of Geotubes® with a sand core infill, surrounded with rock armour protection. (Figure 4.4 and 4.5) Volume of materials based on turbine sluice housing gate position A Sediment for Geotubes® and sand core approximately 7.3Mm³ Sediment for disposal¹¹ approximately 0.8Mm³ Rock underlayer approximately 0.87Mt Rock armour approximately 1.92Mt	This option uses locally won sediments encased in Geotubes® to form the outer core seawall structure, with the central area comprised of further sediments sourced from within the Project footprint. This option would potentially have more temporary construction effects through increased need for dredging and disturbance of sediments. As such this option has been discussed throughout the EIA.
	An alternative option to form the Lagoon seawalls using an outer structure of rock with a sand core infill, surrounded with rock armour protection (Figure 4.6). Volume of materials based on turbine sluice housing gate position A Gravel dredged from lagoon footprint and sand core approximately 7.3Mm³. If imported quarry run used for outer sections this would reduce dredging to 5.42 Mm³ Sediment for disposal¹² approximately 0.8Mm³ Rock underlayer approximately 0.87Mt Rock armour approximately 1.92Mt	With this alternative construction technique the outer structure of the inner seawall is formed with gravel from the Lagoon footprint or imported quarry run instead of Geotubes® but the central core remains sediment taken from within the lagoon footprint. Overall this could maintain the same dredged volumes if gravel were used from the Lagoon footprint, or reduce the extent of dredging and disturbance of sediments if quarry run were used. However, this reduction in dredging would increase the quantity of material imported by sea. The short-term additional vessel movements are not anticipated to increase impacts on the area.

¹¹ if the turbine and sluice gate structure were located to position B the sediment for disposal would be reduced to 0.66 Mm³

¹² if the turbine and sluice gate structure were located to position B the sediment for disposal would be reduced to 0.66 Mm³

Table 4.2 Summary of sediment analysis compared to CEFAS thresholds (see footnote) all concentrations in mg/Kg

Type	No.	Depth (m)	Arsenic	Copper	Lead	Cadmium	Chromium	Nickel	Zinc	Dibutyltin	Monobutyltin	Tributyltin	Mercury	Material
CEFAS Action Level 1 threshold¹³			20	40	50	0.4	40	20	130	0.1	0.1	0.1	0.3	
CEFAS Action Level 2 threshold			100	400	500	5	400	200	800	1	1	1	3	
VC	202	0.2	16.2	17.7	29.4	0.1	19.9	13.6	94.8	0	0	0	0.03	Sand
VC	202	1.5	6.4	3.4	4.6	0	10.5	7.8	20.3	0	0	0	0	Sand
VC	202	2.5	6.7	3.8	5	0	11.9	9.4	23.5	0	0	0	0	Sand
VC	202	3.6	5.6	5.3	9.4	0	27.5	15.2	42.3	0	0	0	0.01	Sand
VC	202	4.7	6.8	10.8	15.2	0.3	52.2	27.8	70.4	0	0	0	0.01	Clay
VC	204	0.5	8.8	0	8.6	0	10.7	8.2	33.5	0	0	0	0.02	Sand
VC	204	1.5	4	0	3.9	0	6.3	5.6	12.9	0	0	0	0	Sand
VC	204	2.5	7	10.7	12.4	0.2	40.1	22.2	56.2	0	0	0	0.01	Clay
VC	204	3.5	6.5	9	12.3	0.2	40.1	22.3	58.9	0	0	0	0.01	Clay
VC	204	4.5	5.8	8.5	12.3	0.2	40.8	22.3	56	0	0	0	0.01	Clay
VC	204	5.5	5.5	12.1	13	0.1	42.9	23.2	59.2	0	0	0	0.01	Clay
VC	206	0.7	48.3	327.3	344.9	3.3	47.2	68	688.1	0	0	0	0.74	Silt
VC	206	1.5	7.7	28.7	23	0.5	21.7	12.7	69.8	0	0	0	0.09	Sand
VC	206	2.5	8	28	25	0.2	22	12.8	73.7	0	0	0	0.06	Sand
VC	206	3.6	7.7	18.9	30.9	0.3	17.7	9.4	66.6	0.14	0	0	0.13	Sand
VC	206	5.2	5.8	14.9	17.6	3.2	42.7	19.5	71.9	0.05	0	0	0.02	Clay
VC	208	0.5	10.6	31.7	43.9	0.2	12.4	13	101.8	0	0	0	0.04	Sand
VC	208	1.5	7.3	9.1	17.2	0	8.9	8.3	46.1	0	0	0	0.02	Sand

¹³“In general, contaminant levels in dredged material below Action Level 1 are of no concern and are unlikely to influence the licensing decision. However, dredged material with contaminant levels above Action Level 2 is generally considered unsuitable for sea disposal. The latter situation most often applies only to a part of a proposed dredging area and so that area can be excluded from disposal at sea and disposed of by other routes e.g. landfill. Dredged material with contaminant levels between Action Levels 1 and 2 requires further consideration and testing before a decision can be made”. Colour coding has been applied for ease of reference with those below Level 1 as green; those between Level 1 and Level 2 as yellow and those above Level 2 as red. The blue colour denotes the preferred substrate for use in the seawall construction.

Tidal Lagoon Swansea Bay plc



Type	No.	Depth (m)	Arsenic	Copper	Lead	Cadmium	Chromium	Nickel	Zinc	Dibutyltin	Monobutyltin	Tributyltin	Mercury	Material
VC	209	0.7	6.3	12.8	9.2	0.3	10.8	8.5	31.5	0	0	0	0.02	Sand
VC	209	1.5	5.2	11.8	6	0	6.1	6	20	0	0	0	0.01	Sand
VC	212	0.5	4.6	81.7	8.5	0.1	11.8	6.4	51.8	0.11	0	0	0	Sand
VC	212	1.5	4.1	8.3	6.1	0	8.9	5.9	24.9	0.14	0	0	0	Sand
VC	212	2.5	4.6	8.6	7.7	0	17.3	10.5	29.7	0.1	0	0	0	Sand
VC	212	3.5	4.4	6.9	6.8	0	12.9	5.8	25.7	0.07	0	0	0	Sand
VC	212	4.5	4.9	9.6	7	0	10.5	5.5	24.7	0.07	0	0	0.01	Sand
VC	213	0.5	5.8	9.5	6.1	0	6.5	6	20.6	0.11	0	0	0.01	Sand
VC	213	1.5	5.3	5.4	5.8	0	4.8	5.6	19.8	0.10	0	0	0.01	Sand
VC	213	2.5	6.9	10.6	6	0	7.6	6.9	23	0	0	0	0.01	Sand
VC	213	3.5	4.9	9.3	5.6	0	6.3	6	19.5	0.11	0	0	0.01	Sand
VC	213	4.5	5.3	14.1	6.4	0	9.3	7	21.6	0	0	0	0.02	Sand
VC	213	5.5	4.3	17.8	6.7	0	10.3	7	22.8	0	0	0	0.02	Sand
VC	214	0.5	10.5	9.8	12.2	0	7.4	6	57.4	0.14	0	0	0.01	Sand
VC	214	1.5	10.5	13.3	19.6	0	15.9	9.3	87.3	0.14	0	0	0.04	Sand
VC	214	2.5	6.4	7.7	6.2	0	8.5	5.2	25.3	0.09	0	0	0	Sand
VC	214	3.5	5.3	5.9	5.6	0	7.8	5.9	31.7	0.15	0	0	0.02	Sand
VC	214	4.5	6.4	7.2	8.5	0	12.5	7.1	26.8	0.29	0	0	0	Sand
VC	216	0.6	15	13.5	13.1	0	6.9	9.5	59.2	0	0	0	0.02	Sand
VC	208B	0.5	19.3	91.4	135.5	0.3	27.2	30.2	290.4	0	0	0	0.24	Clay
VC	208B	1	10.7	8.6	14.5	0	10.1	8.3	39.8	0	0	0	0.03	Sand
VC	208B	2.5	5.6	2.3	4.7	0	7.4	5.3	12.4	0	0	0	0.01	Sand
VC	208B	3.5	4.6	5.2	4.1	0	6.1	5.1	13.5	0	0	0	0	Sand
VC	208B	4.5	6.8	7	11.4	0	33.3	18.4	50.1	0	0	0	0.01	Clay
VC	209B	0.2	17.2	49.9	76.2	3.5	42	32	159.5	0	0	0	0.26	Silt
VC	209B	2.5	9.2	11.4	6.5	0	8.4	6.2	19.2	0	0	0	0	Sand

Tidal Lagoon Swansea Bay plc



Type	No.	Depth (m)	Arsenic	Copper	Lead	Cadmium	Chromium	Nickel	Zinc	Dibutyltin	Monobutyltin	Tributyltin	Mercury	Material
VC	209B	3.65	6.2	15.9	15.3	0.2	39.8	19.7	80	0	0	0	0.02	Clay
VC	216B	0.5	13.1	12.6	15.9	0	9.2	8.3	77.7	0.12	0	0	0.01	Sand
VC	216B	1.5	10.8	9.8	9	0.4	6.8	6	40	0.12	0	0	0	Sand
VC	216B	2.5	7.5	2.9	5.1	0	5.9	4.5	29.9	0.1	0	0	0	Sand
VC	216B	3.5	6.4	7.8	5.6	0	8.6	6	25.2	0.1	0	0	0	Sand
VC	216B	4.5	8.6	4.7	7.5	0	16.4	8.9	37.1	0	0	0	0	Sand
BH	101	0.5	8.3	14.3	11.2	0	17.5	11.4	36.5	2	0	0	0.01	Sand
BH	101	11.75	10.2	13.1	9	0.1	40.1	27	52.4	0.03	0	0	0	Gravel
BH	102	0.5	8.2	15.2	20.2	0	24.7	13.1	72.9	0.03	0	0	0.01	Sand
BH	102	1	7.5	7.9	5.9	0	10	6.8	22.4	2	0	0	0	Sand
BH	102	1.5	7.5	6.6	5.6	0	9.5	6.7	18.7	0.04	0	0	0	Sand
BH	102	3	7.5	10.6	11.2	0	34.1	17.5	44.8	0.02	0	0	0	Clay
BH	103	12.25	9.1	14.6	9.9	0.3	42.5	30.3	60.7	0.03	0	0	0	Sand
BH	104	1	10.4	9.7	10.8	0	14.6	8.1	70.4	0.02	0	0	0	Sand
BH	104	2	7.8	7.3	6.7	0	12.4	7.3	37.1	0.05	0	0	0	Sand
BH	104	4.5	7.7	8.6	11.1	0.1	34.2	17.3	45	0.07	0	0	0	Silt
BH	105	1	12.4	12.1	15.5	0	13.9	9.4	83.8	0.02	0	0	0	Sand
BH	105	2	8.2	10.1	10.1	0	10.5	6.7	31	0.03	0	0	0	Sand
BH	105	3	7	5.8	6.2	0	10.7	6.7	21.3	0.05	0	0	0	Sand
BH	105	14.25	9.4	16.3	11.2	0.1	35.2	24.7	65.7	2	0	0	0	Gravel
BH	107	10	12	28.7	13.7	0.6	42	38	94.6	0			0.03	Gravel
BH	107	12	9.2	20.9	10.7	0.4	43.8	31.5	70.9	0			0.02	Gravel
BH	107	14	7.4	16.7	10.8	0.4	39	27.5	72.8	0			0.03	Gravel
Number samples Below Level 1			66	63	64	59	55	53	64	67	64	64	66	
Number samples Above Level 1			1	4	3	8	12	14	3	0	0	0	1	
Number samples Above Level 2			0	0	0	0	0	0	0	0	0	0	0	