Bridgend County Borough Council

# Porthcawl Sandy Bay Coastal Scheme

## WFD Compliance Assessment

WFD/01

Final | 14 June 2019

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Job number 264874-00

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# 1 Introduction

Arup has been commissioned by Bridgend County Borough Council to undertake a Water Framework Directive (WFD) Assessment for the scheme known as Porthcawl Sandy Bay Coastal Scheme.

Under the WFD[1], all proposed schemes with the potential to impact upon WFD-designated water bodies must be assessed to ensure:

- no deterioration of the current status or potential of any WFD quality elements; and
- no prevention of future attainment of the 'good' status or potential objectives of any WFD quality elements.

This is also consistent with the Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.

This report follows guidance produced by Natural Resources Wales[2] (NRW) to produce a WFD Assessment Report which identifies the activities related to the scheme that may cause deterioration or prevent a water body from meeting its objectives. The report follows the scoping template provided as part of this guidance, along with a detailed impact assessment of residual risk identified.

[1] European Commission. Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.
Water Environment (Water Framework Directive) (England and Wales) Regulations 2017.
[2] Natural Resources Wales / Environment Agency. Water Framework Directive assessment: estuarine and coastal water. Available at: https://www.gov.uk/guidance/water-framework-directive-assessment-estuarine-and-coastal-waters

# 2 Project Details

| Your activity | Description, notes or more information |
|---|---|
| Applicant name | Bridgend County Borough Council |
| Application reference number (where applicable) | |
| Name of activity | **Area/Structure** — **Outline Business Case Preferred Option**<br>Western Breakwater — Priority remedial works and works to ensure long term structural integrity.<br>Eastern Promenade — Crest raising and strengthening of the existing parapet wall to reduce overtopping combined with land raising to minimise visual impact. Manage inundation/residual overtopping volumes.<br>Relict Dunes — Monitoring and minor management.<br>Rhych Point — Provision of a rock armour revetment to protect the neck of the headland. |
| Brief description of activity | **Area/Structure** — **Activity**<br>Western Breakwater — Recommended priority remedial works comprise;<br>1. General masonry repairs – repointing<br>2. Patch repairs to concrete cladding in zone D<br>3. Strengthening works to fill voids beneath the revetments and concrete deck slabs, and works reduce the risk of wash-out of fine material<br>4. Repair and strengthening of the masonry parapets using Cintec anchors<br>5. Construction of a cut off wall to around roundhead and along revetment to prevent further loss of material and scour<br>Eastern Promenade — 1. Parapet/revetment to be strengthened and repaired locally where required<br>2. Existing parapet crest to be modified to reduce wave overtopping where required<br>3. Installation of an integrated solution for managing wave overtopping volumes consisting of a secondary containment wall and/or landscaping and drainage strategy.<br>4. Raising of the promenade ground level to maintain views over parapet<br>5. Installation of landscaping features, furniture, lighting and/or ancillary structures<br>6. Provision for ducts for future installation of utilities.<br>Relict Dunes — Monitoring and minor management to conserve and enhance the relict dunes in their current stable and re-naturalised state.<br>Rhych Point — Natural rock revetment on both the west and east side of Rhych Point, although there is scope to rationalize the design on |

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|---|---|
| | the east side because it benefits from a sheltering effect.<br>Continuous use of vehicle ramp and access to Lifeguard building to be maintained. |
| Location of activity (central point XY coordinates or national grid reference) | Western Breakwater: SS819763<br>Eastern Promenade: SS820767<br>Relict Dunes: SS826768<br>Rhych Point: SS827766 |
| Footprint of activity (ha) | **Area/Structure** — **Asset footprint (approximate)**<br>Western Breakwater — 170m<br>Eastern Promenade — 410m<br>Relict Dunes — 3.5ha<br>Rhych Point — 0.2ha |
| Timings of activity (including start and finish dates) | Due to works at low tide, the timeframe is uncertain until a contractor is appointed. It is expected the timescale for the works at Western Breakwater will be on the scale of 3 months minimum, potentially up to one year. |
| Extent of activity (for example size, scale frequency, expected volumes of output or discharge) | **Area/Structure** — **Size, scale of activity**<br>Western Breakwater — Pressure grouting to fill voids beneath the revetment and concrete deck slabs and construction of a concrete cut off wall with rock armour scour protection around roundhead and along revetment to prevent further loss of material and scour.<br><br>General masonry repairs/repointing/replacement of missing stonework to the limestone upstand in zones. This is to be followed by repair and strengthening of the masonry upstands using Cintec anchors.<br><br>Concrete patch repairs to spalled regions by specialist contractor. Repairs using an SBR modified mortar following defect survey to capture all areas that require repair.<br><br>Construction of a mass-concrete revetment embedded with large boulders/facing stone with scour/cut off protection detail to reduce the wave energy impact at the breakwater parapets. This will be constructed in sections with precast concrete blocks added to dug trenches with a JCB and filled behind with mass concrete during low tide.<br>Eastern Promenade — Crest raising will be undertaken in the following areas:<br>- 0m to 55m chainage, raised to +9.0mAOD (tapering to existing |

| | |
|---|---|
| | level between 0m and 5m chainage)<br>- 368m to 445m chainage, raised to +9.3mAOD<br>Relict Dunes — Fencing may be targeted to constrain footfall to certain areas, or even formalised with a boardwalk. Certain dune areas, where excessive erosion has occurred are to be fenced to allow regeneration, whilst scrub removal is recommended (sea buckthorn) to maintain a dune habitat and avoid this non-native species from colonising swathes of the spatially restricted relict dune system. Similarly, storm related damage may be repaired locally with softer measures such as: dune grass planting, reprofiling or fencing as required.<br>Rhych Point — Rock armour revetment is proposed to focus on the narrow 'neck' of the headland |
| Use or release of chemicals (state which ones) | Relevant potentially polluting sources include: raised suspended sediment concentrations and accidental spills; e.g. concrete or fuel oils from construction plant. |

# 3 WFD Baseline Information

| **Water body[3]** | **Description, notes or more information** |
|---|---|
| WFD water body name | *Bristol Channel Outer North coastal water body* |
| Water body ID | *GB611008590001* |
| River basin district name | *Western Wales* |
| Water body type (estuarine or coastal) | *Coastal* |
| Water body total area (ha) | *89,963* |
| Overall water body status (2015) | *Moderate* |
| Ecological status | *Moderate* |
| Chemical status | *Good* |
| Target water body status and deadline | *Good by 2021* |
| Hydromorphology status of water body | *Not designated* |
| Heavily modified water body and for what use | *No* |
| Higher sensitivity habitats present | *Polychaete Reef 90m south of Rhych Point and adjacent, east of Western breakwater* |
| Lower sensitivity habitats present | *Intertidal Soft Sediment within the bay*<br>*Rocky shore at Rhych Point, along Eastern Promenade and at Western breakwater* |
| Phytoplankton status | *Good* |
| History of harmful algae | *NA (Not a category in Wales data)* |
| WFD protected areas within 2km | *Kenfig / Cynffig SAC 1.3km east of Rhych Point*<br>*Porthcawl Shellfish Waters 2014 (50.68km$^2$) along the coastline*<br>*Porthcawl is also designated as a Shellfish Water[4] (although this has been superseded by the Marine and Coastal Access Act[5]).* |

[3] *Water body information can be found in the Natural Resource Wales's 'Water Watch Wales' and the water body summary table. Magic maps provide additional information on habitats and protected areas. Links to these information sources can be found in the WFD assessment guidance for estuarine and coastal waters.*
[4] http://magic.defra.gov.uk/MagicMap.aspx
[5] *Shellfish Waters Directive repealed in 2013 and requirements transferred into the Water Framework Directive. The Sandy Bay area is no longer classified as a Shellfish Water (https://naturalresources.wales/media/676244/shellfish-water-protected-areas-wales-2016-8-feb-002.pdf)*

# 4 Screening Assessment

The proposed operational activities for all four areas / structures are considered to present low risk to WFD status of the neighbouring water body. Due to the nature of the works, the monitoring and minor management of Relict Dunes is considered not to pose a risk to surrounding waterbodies and is therefore screened out from further assessment.

Due to proposal for works within the Bristol Channel Outer North coastal water body, the construction phase for Western Breakwater, Eastern Promenade and Rhych Point are anticipated to pose a potential pathway to effect to the current WFD status of the Bristol Channel Outer North coastal water body (GB611008590001). Therefore, these activities have been screened in to the WFD Scoping Assessment.

# 5 Scoping Assessment

## 5.1 Hydromorphology

| Consider if your activity: | Yes | No | Hydromorphology risk issue(s) |
|---|---|---|---|
| Could impact on the hydromorphology (for example morphology or tidal patterns) of a water body at high status | | Impact assessment not required | *Not a WFD waterbody of high status* |
| Could significantly impact the hydromorphology of any water body | | Impact assessment not required | *The development of new coastal infrastructure has the potential to affect local and sediment transport regimes. The Coastal Processes assessment confirms that there would be no change to wider-scale coastal processes through implementation of the scheme. No further assessment required (Appendix B).* |
| Is in a water body that is heavily modified for the same use as your activity | | Impact assessment not required | *Not a HMWB* |

## 5.2 Biology

### Habitats

| Higher sensitivity habitats[6] | Lower sensitivity habitats[7] |
|---|---|
| chalk reef | cobbles, gravel and shingle |
| clam, cockle and oyster beds | intertidal soft sediments like sand and mud |
| intertidal seagrass | rocky shore |
| maerl | subtidal boulder fields |
| mussel beds, including blue and horse mussel | subtidal rocky reef |
| polychaete reef | subtidal soft sediments like sand and mud |
| saltmarsh | |
| subtidal kelp beds | |
| subtidal seagrass | |

| Consider if the footprint[8] of your activity is: | Yes | No | Biology habitats risk issue(s) |
|---|---|---|---|
| $0.5km^2$ or larger | Yes to Higher Sensitivity Habitat; requires impact assessment. | | Combined area of the schemes does not exceed $0.5km^2$ |
| 1% or more of the water body's area | | | Not ≤ 1% of water body area |
| Within 500m of any higher sensitivity habitat | | | Polychaete Reef (*Sabellaria alveolata*) 90m south of Rhych Point and circa 60m west of Western Breakwater. |
| 1% or more of any lower sensitivity habitat | | | Intertidal Soft Sediment within the bay. Footprint of the scheme does not affect ≥1% area.<br><br>Rocky shore at Rhych Point, along Eastern Promenade and at Western Breakwater. The footprint of the scheme affects 1% or more of each of these individual areas; but less than 1% of the overall area of the habitat. |

[6] Higher sensitivity habitats have a low resistance to, and recovery rate, from human pressures.
[7] Lower sensitivity habitats have a medium to high resistance to, and recovery rate from, human pressures.
[8] Note that a footprint may also be a temperature or sediment plume. For dredging activity, a footprint is 1.5 times the dredge area.

## Fish

| Consider if your activity: | Yes | No | Biology fish risk issue(s) |
|---|---|---|---|
| Is in an estuary and could affect fish in the estuary, outside the estuary but could delay or prevent fish entering it or could affect fish migrating through the estuary | | No - Go to next section | N/A |
| Could impact on normal fish behaviour like movement, migration or spawning (for example creating a physical barrier, noise, chemical change or a change in depth or flow) | | No | N/A |
| Could cause entrainment or impingement of fish | | No | N/A |

## 5.3 Water Quality

| Consider if your activity: | Yes | No | Water quality risk issue(s) |
|---|---|---|---|
| Could affect water clarity, temperature, salinity, oxygen levels, nutrients or microbial patterns continuously for longer than a spring neap tidal cycle (about 14 days) | Requires impact assessment | | *Potential for construction activities to displace sediment; particularly at Western Breakwater. Potential pathway for temporary increase in suspended solids and decreased oxygen levels.* |
| Is in a water body with a phytoplankton status of moderate, poor or bad | | No - Impact assessment not required | *Phytoplankton status 'Good'* |
| Is in a water body with a history of harmful algae | | No - Impact assessment not required | *NA (Not a category in Wales data)* |
| **If your activity uses or releases chemicals (for example through sediment disturbance or building works) consider if:** | **Yes** | **No** | **Water quality risk issue(s)** |
| The chemicals are on the Environmental Quality Standards Directive (EQSD) list | | No - Impact assessment not required | None identified within WFD data. GI showed no EQSD chemicals identified within sediment in Western Breakwater area. |
| It disturbs sediment with contaminants above Cefas Action Level 1[9] | | No - Impact assessment not required | None identified within WFD data. GI showed no CEFAS Action Level 1 contaminants present within sediment in Western Breakwater area. |

[9] Cefas Action Level 1 compounds: https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans#sample-plans-and-sediment-analysis

| If your activity has a mixing zone (like a discharge pipeline or outfall) consider if: | Yes | No | Water quality risk issue(s) |
|---|---|---|---|
| The chemicals released are on the Environmental Quality Standards Directive (EQSD) list | | No - Impact assessment not required | No discharge or outfall proposed. Products used during construction to be rock armour and marine grade concrete. |

## 5.4 WFD Protected Areas

| Consider if your activity is: | Yes | No | Protected areas risk issue(s) |
|---|---|---|---|
| Within 2km of any WFD protected area[6] | Requires impact assessment | | Kenfig / Cynffig SAC 1.3km east of Rhych Point. |

## 5.5 Invasive Non-Native Species (INNS)

| Consider if your activity could: | Yes | No | INNS risk issue(s) |
|---|---|---|---|
| Introduce or spread INNS | Impact assessment required | | No terrestrial or invasive plant species were recorded during the Phase 1 survey, however there is a potential risk of introduction of invasive species via machinery. RAMS to include biosecurity risk assessment[10]. |

## 5.6 Scoping Summary

| Receptor | Potential risk to receptor? | Note the risk issue(s) for impact assessment |
|---|---|---|
| Hydromorphology | No | N/A |
| Biology: habitats | Yes | Higher Sensitivity Habitats: Polychaete Reef 90m south of Rhych Point and 60m west of Western breakwater.<br><br>Lower Sensitivity Habitats: Rocky shore at Rhych Point, along Eastern Promenade and at Western breakwater. The footprint of the scheme affects 1% or more of each of these individual areas; but less than 1% of the overall area of the habitat. |
| Biology: fish | No | |
| Water quality | Yes | Potential for construction activities to displace sediment; particularly at Western Breakwater. Potential pathway for construction compounds to enter waterbody. |

[10] Cook, E.J., Macleod, A. Payne, R.D., and Brown, S. (2014) edited by Natural England and Natural Resources Wales (2015). *Marine Biosecurity Planning – Guidance for producing site and operation-based plans for preventing the introduction and spread of non-native species in England and Wales*.

| Receptor | Potential risk to receptor? | Note the risk issue(s) for impact assessment |
|---|---|---|
| Protected areas | Yes | Kenfig / Cynffig SAC 1.3km east of Rhych Point. HRA Stage 1: Screening confirms no effect. |
| Invasive Non-Native Species | Yes | Potential risk of introduction of invasive species via machinery to be covered within RAMS biosecurity risk assessment. |

# 6 Detailed Assessment

The WFD Scoping Assessment identified potential risks to the following receptors: higher sensitivity habitats, protected areas, water quality and INNS.

A Preliminary Habitats Regulation Assessment (HRA) was prepared for the works in June 2019 (Appendix A). This has assessed the potential for impacts to protected areas in detail. For brevity, the findings of the HRA have been used to inform the conclusion of this assessment as they relate to the same works and protected areas. Both assessments will support a Marine Licence application for the works.

The majority of Sandy Bay is classed as Lower Sensitivity Habitat under the WFD with the Bay itself recorded as Intertidal Soft Sediment and areas along the western shoreline and around the eastern headland designated as Intertidal Rock habitat.

The Higher Sensitivity Habitat Polychaete Reef: *Sabellaria alveolata* (honeycomb worm) was identified during the Extended Phase 1 Habitat Survey and in past studies[11]; the distribution aligns with the southern margins of Rhych Point and 60m to the west of the Western Breakwater.

Erosion has potentially severe implications to the current stable equilibrium of the sediment transfer system in Sandy Bay; i.e. if Rhych Point were to erode, this equilibrium would collapse. Therefore, re-instating the rock armour to absorb wave energy and restrict erosion to protect the integrity of the headland would have a positive impact by providing a more stable habitat.

## 6.1 Potential Risks

### 6.1.1 Higher and Lower Sensitivity Habitats

The majority of Sandy Bay is classed as Lower Sensitivity Habitat under the WFD with the Bay itself recorded as Intertidal Soft Sediment (intertidal mudflats and sandflats) and Rhych Point, the Eastern Promenade and Western Breakwater recorded as Intertidal Rock.

South of Rhych Point, circa 100m south of MHWS, the seabed is recorded as polychaete reef (*Sabellaria alveolata*), an ephemeral Higher Sensitivity Habitat. *Sabellaria alveolata* was recorded during the December 2018 Extended Phase 1 Habitat Survey with its extent aligning with desk study records[11]. However, as per this feature's ephemeral nature, the feature was not observed at this location during the previous November 2016 survey. With the inclusion of the Western Breakwater works, the December 2018 survey covered a wider study area and recorded *Sabellaria alveolata* reefs approximately 60m west of the Western Breakwater on the seaward rocky shore.

[11] Countryside Council for Wales. 1996. Phase I Intertidal survey for Wales. WFD Habitats: Higher Sensitivity: http://magic.defra.gov.uk/MagicMap.aspx

In the absence of best practice, nearby higher and lower sensitivity habitats may be at risk of direct effects or pollution incidents; e.g. sedimentation (from excavations, jetting or vehicle tracking) or accidental spillage (leaks from machinery/plant).

Construction works will affect localised areas of intertidal mudflats and sandflats but will not directly affect rocky reef; however, the intertidal soft sediment habitats will be restored naturally on each tidal cycle. Works are proposed at low water so sedimentation risks, increased suspended sediment and smothering, will not impact either the lower or higher sensitivity habitats. Infauna associated with the mudflats and sandflats are mobile and unaffected by increases in sedimentation, whilst epifauna of rocky reefs are naturally acclimated to such conditions.

The higher sensitivity habitat of *Sabellaria alveolata* reef is confined to intertidal rocky outcrops with sufficient spatial separation from the proposed works at Rhych Point and the Western Breakwater to avoid any direct impacts. Increased suspended sediment loading during works are unlikely, considering works are proposed at low water; however, any increase in suspended solids may be beneficial to the polychaete reefs by providing additional tube-building material. Ground investigation also confirmed the absence of contaminants that could be mobilised during works; as discussed in Section 6.1.2.

The rock armour proposed at the Western Breakwater may also provide new refugia and colonisation habitat such that the extent of *S. alveolata* may increase and provide an enhancement. Similarly, at Rhych Point, the additional habitat complexity provided by the rock armour may encourage settlement and colonisation of *Sabellaria* reef to the benefit of the SINC. Settlement on coastal defences has been recorded in the vicinity of Porthcawl but is ultimately dependent upon local sediment supply. Rhych Point may be too sheltered and too elevated to provide sufficient mobile sediment to promote tube building, relative to the Western Breakwater; however, design levels will be reviewed at detailed design.

Best practice pollution prevention measures will be employed for marine working, as follows; in addition to biosecurity measures as discussed in Section 6.1.4.

- Site-specific methods will ensure that all site activities are controlled and are in accordance with standard operating procedures; e.g. Pollution Prevention Guidelines (PPG) and CIRIA best practice.
- Limiting the physical works footprint and the dimensions of the access corridor as far as reasonably practicable.
- All plant will be sourced from a trusted reputable company and will come with spill kits which site personnel will be trained to use.
- Utilising a marine specific product; rapid set marine grade concrete.
- Vehicles will be loaded with all plant and materials necessary to undertake the works to minimise plant movements below MHWS.

- Minimal quantities of fuels, materials, etc. will be taken on to the foreshore with biodegradable fuel oils implemented where practicable.
- All storage containers will remain within the site compound and be appropriately bunded to prevent any spillages or leaks. No storage of materials or refuelling operations will be permitted outside the site compound.

As such, it is reasonable to conclude that no adverse impacts are predicted on either lower or higher sensitivity habitats, but that enhancement is likely; particularly at the Western Breakwater.

### 6.1.2 Water Quality

Construction activities will displace sediment below MHWS; particularly at Western Breakwater. This provides a potential pathway for effect through sub-surface sediment being exposed to surface waters.

The Ground Investigation Report (GIR) (Appendix C) show that it not considered there would be a risk of significant contamination of groundwater during construction works from made ground identified at the Western Breakwater. Works to construct the cut off wall will comprise a shallow trench in the sand to put in place pre-cast concrete blocks and rock armour; thus, by removing the need for in-situ concrete pours and removing the risk of inadequate drying time within the tidal cycle.

The Risk Assessment Method Statement (RAMS) will be reviewed when available to ensure standard best practice pollution control measures as detailed in Section 6.1.1 above are included.

### 6.1.3 Protected Areas

Kenfig / Cynffig SAC is located 1.3km east of Rhych Point. The potential pathways for effect: pollution incident and change in coastal processes, are assessed within the Preliminary HRA Stage 1: Screening.

The HRA concludes that potential effects on the Kenfig / Cynffig SAC have been screened out due to the nature of the proposed works, spatial separation and negligible likelihood of interaction between potential effects and receptors.

The development of new coastal infrastructure has the potential to affect local sediment transport regimes. Such potential changes in coastal processes may alter sediment supply to the frontages of either section of the Kenfig SAC, representing a pathway for effect on coastal habitat features. The Porthcawl Coastal Defences: Coastal Processes Assessment[12] (Appendix B), demonstrates that the predominant sediment transport regime and tidal regime in the regional environment comprises westerly movements with dynamics within Sandy Bay being relatively stable and self-contained. As such, the Coastal Processes assessment confirms that there would be no change to wider-scale coastal processes through implementation of

[12] ABPmer. 2017. Sandy Bay Porthcawl Coastal Defences: Porthcawl Conceptual Understanding [Coastal Processes Report].

the scheme and no change in sediment supply to either element of the Kenfig SAC, particularly at a distance of 1.3km and 4km respectively.

No construction phase water quality effects are predicted from the proposed works and no mitigation measures are proposed to avoid, reduce or cancel potential effects. As standard best practice, the Outline CEMP will include requirements to adhere to best practice pollution prevention; e.g. GPP5 and CIRIA guidance.

As such, the HRA states that it is reasonable to conclude that there are **no effects**, either alone or in-combination with other plans and projects, resulting from the proposed improvement works.

### 6.1.4 Invasive Non-Native Species

Introducing plant to the marine environment incurs the risk of transporting INNS from one site to the next. To address this risk, the Contractor will include a Biosecurity Risk Assessment within their RAMS to ensure that all plant and equipment is deep-cleaned prior to arrival on site and following completion of works. The biosecurity measures proposed will accord with the latest NRW guidance[10].

## 6.2 Mitigation Measures

The driver behind this scheme is to reduce coastal flood risk. Remediating and ensuring the future stability of the coastal defences results in operational enhancements to the water environment.

The Risk Assessment / Method Statement (RAMS) will be assessed when available and will outline the mitigation measures incorporated into the construction of the scheme; including the following:

- Site-specific methods will ensure that all site activities are controlled and are in accordance with standard operating procedures; e.g. Pollution Prevention Guidelines (PPG) and CIRIA best practice.
- Limiting the physical works footprint and the dimensions of the access corridor as far as reasonably practicable.
- All plant will be sourced from a trusted reputable company and will come with spill kits which site personnel will be trained to use.
- Utilising a marine specific product; rapid set marine grade concrete.
- Vehicles will be loaded with all plant and materials necessary to undertake the works to minimise plant movements below MHWS.
- Minimal quantities of fuels, materials, etc. will be taken on to the foreshore with biodegradable fuel oils implemented where practicable.
- All storage containers will remain within the site compound and be appropriately bunded to prevent any spillages or leaks. No storage of materials or refuelling operations will be permitted outside the site compound.

- The scheme being undertaken in compliance with the relevant GPP and industry best practice (e.g. Guidance for Pollution Prevention: works and maintenance in or near water: GPP5, PPG 21, CIRIA best practice).

# 7 Conclusion

The assessment has considered the potential risks to receptors associated with the proposed works to Porthcawl Sandy Bay Coastal Scheme which include:

- Priority remedial works and works to ensure long term structural integrity at Western breakwater;
- Crest raising and strengthening of the existing parapet wall to reduce overtopping combined with land raising to minimise visual impact at Eastern Promenade;
- Monitoring and minor management at the Relic Dunes; and
- Provision of a rock armour revetment to protect the neck of the headland at Rhych Point.

The key receptors are Kenfig / Cynffig SAC 1.3km east of Rhych Point and polychaete reef (*Sabellaria alveolata*), a Higher Sensitivity Habitat known to be ephemeral; located to the west of the Western Breakwater and South of Rhych Point.

Given that the potential impacts relate to protected areas, the findings of the Preliminary HRA prepared for the works have been used to inform the conclusion of this assessment.

This assessment considers that the risk which the scheme poses to the water environment does not, either alone or in-combination with other projects, give rise to any adverse effects upon WFD water bodies or habitats or prevent them from attaining good status in the future.

This assessment has been based on currently available WFD baseline data and design information for the scheme. It is considered a 'live' document and should be reviewed and updated during detailed design and construction, particularly if:

- NRW update or provide additional WFD baseline data for the relevant water bodies; and/or
- Significant changes to the nature, spatial extent, scale or construction methods of the scheme are made.

The outcomes of this assessment should be shared and agreed with NRW (as the regulatory authority for the WFD in Wales) as part of the Marine Licencing process.

# Appendix A Preliminary Habitats Regulation Assessment 2019

On request

# Appendix B Porthcawl Conceptual Understanding 2019

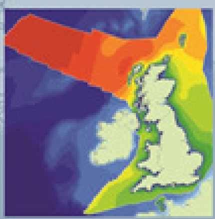
# Porthcawl Conceptual Understanding

## Porthcawl PAR

Arup

January 2017

Creating sustainable solutions for the marine environment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# Porthcawl Conceptual Understanding

Porthcawl PAR

January 2017

# Document Information

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# 1 Introduction

## 1.1 Study

The aim of the project for Bridgend County Borough Council (BCBC) is to investigate options for managing coastal flooding and erosion risk and preparation of a Project Appraisal Report (PAR) at Porthcawl. Improvements in the defences and flood risk are essential to fulfil the Councils' aspirations for regeneration and improved tourism around the Eastern Promenade and Sandy Bay frontages.

ABPmer has been commissioned by Ove Arup and Partners Limited ('Arup') to review the coastal processes to determine the parameters that cause potential flood risk at Porthcawl and within Sandy Bay. An extremes analysis has been completed to determine the volumes of wave overtopping of the defences for different return period events under existing conditions and allowing for 100 year climate change. These results have been provided separately as a series of spreadsheets.

The wave overtopping results are supported with two deliverable documents containing:

- **Process Understanding** (this document) - A summary of the coastal processes affecting the defences and the conceptual understanding of the dynamics of the Bay, particularly with respect to the influence on defences and stability of the beach and foreshore.

- **Extremes Analysis** (separate document, ABPmer 2017) - A technical note which sets out the modelling results for the wave, water level and overtopping criteria for various sections (defined from the analysis) of the two frontages.

This analysis and associated documents provide input information for the assessment of the existing situation, the flood inundation modelling of extreme events and the development of protection options.

## 1.2 Coastal flood risk

With increasing pressures on the coastal zone, sustainable management of coastal flooding is becoming increasingly important. Contributing factors to coastal flooding such as Sea Level Rise (SLR), storm surge levels, tidal heights, wave heights, wind speeds and existing coastal defence structures all are highly variable both spatially and temporally. Gaining a fundamental understanding of the physical process interaction with the shoreline is key to providing accurate flood risk analysis such as overtopping rates and inundation levels, as well as identifying the risks of coastal erosion and defence failure due to beach lowering.

Whilst coastal flooding can also result from fluvial activity, the location of Porthcawl is a sufficient distance (approximately 4 km) from the nearest estuarine system, the River Ogmore, not to have an influence. The commissioned work therefore focuses on coastal flood risk from offshore processes (i.e. those mentioned above).

# 2 Site Description

## 2.1 Sandy Bay, Porthcawl

This area of the coastline forms part of the Shoreline Management Plan (SMP) area 7. Sandy Bay forms part of unit 7.3, and the policy is hold the line for all epochs. The SMP states that much of the existing segments currently containing defence structures are expected to fail either within the current epoch, or in the medium term.

For the purpose of both the conceptual understanding and the additional modelling analysis, Sandy Bay is divided into five segments (Figure 1):

- The eastern breakwater to Porthcawl Marina, extending due north inside of the main breakwater (Western Breakwater) for around 100 m and contains the existing marina.

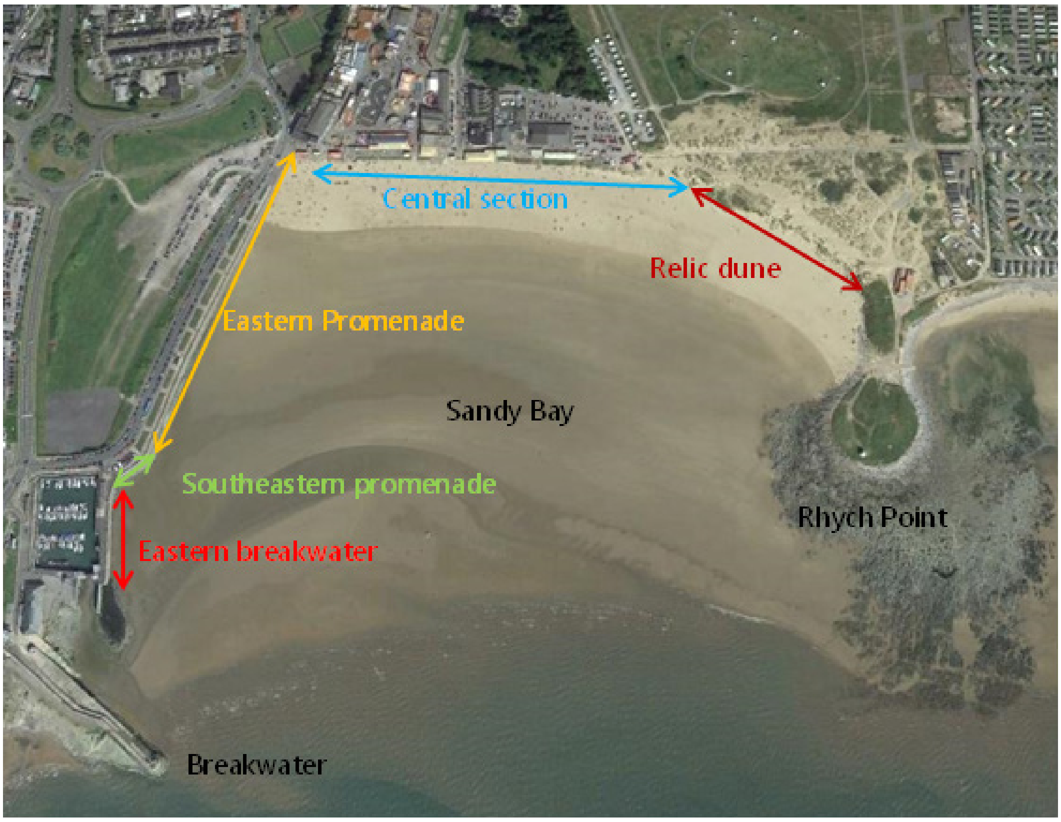
- The southeastern promenade to Porthcawl, a short frontage around 50 m in width of steeper incident angle to that of the eastern breakwater.

- The eastern promenade to Porthcawl, a 400 m stretch of seawall that runs north-to-south for around 400 m between the harbour immediately to the north of the marina, and the amusement park. Behind the promenade are the infilled remnants of the old inner harbour.

- The central section, of which the upper beach is backed by Coney Beach Amusement Park. The amusement park is defended by various seawalls and revetments. This extends due east along the upper beach of Sandy Bay for around 350-400 m, merging into the relic dune system.

- The east side of the Bay contains a relic dune system, with barely vegetated land immediately behind which was a former campsite. This dune system rotates in an increasingly southerly direction for around 300 m out to a limestone raised shore platform known as Rhych Point, which contains a viewing tower. The point has previously been stated to be importance in maintaining the overall shape of the Bay (Halcrow 2005).

This section provides a detailed description of the marine and coastal physical processes within and around Sandy Bay. This characterisation forms the basis from which appraisal assessments of potential defence options can be carried out. The focus of the baseline has been tailored towards providing sufficient detail to support the options appraisal. Of particular interest are the water levels and local wave climate which will directly interact with coastal defence structures and the resulting overtopping (reported separately) during extreme events. This baseline understanding also informs assessment of potential changes to the defence structures to improve flood risk.




Source: Google Earth, 2015. Map data ©2016 Google. Image © 2016 Terrametrics. Data © SIO, NOAA, U.S. Navy, NGA, GEBCO

**Figure 1. Aerial photography of Porthcawl and Sandy Bay. Process Understanding**

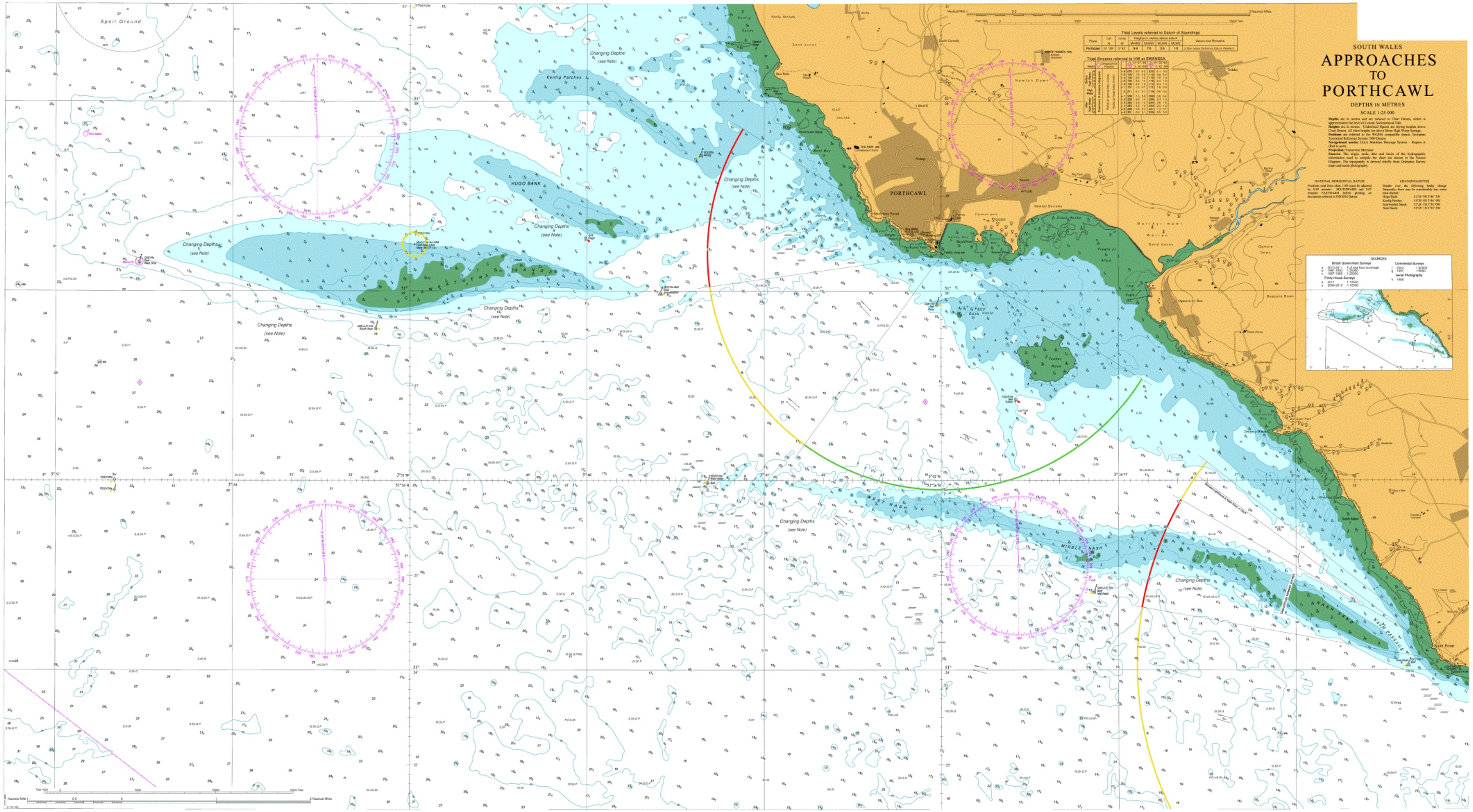
## 2.2 Offshore seabed description

The Bristol Channel is relatively deep, with maximum depths of approximately 60 m near its entrance. Depths decrease eastwards to about 20 m near Lavernock Point. A shallower shelf area, ranging in width from 4.5 to 20 km, extends along the northern side between the Gower Peninsula and Lavernock Point. Much of the Inner Bristol Channel sea floor lacks accumulated sediments due to the strong tidal currents. Areas of slightly muddy sands occur in northern Swansea Bay (British Geological Survey, 1986; Pantin, 1991). The thickness of sediments is generally less than 10 m (Pye & Blott, 2009).

The sediment regime of the Bristol Channel is an ebb-dominated system (Halcrow 2005). The resulting net sediment transport is westwards in the centre of the channel. Under normal wave conditions the littoral drift is towards the east due to the dominant westerly and south-westerly waves. Under extreme events the dominant littoral drift is also eastwards.

The coarse grained sediments form low amplitude dunes and mega-ripples. The medium to fine sand areas exhibit either higher amplitude dunes or plane bed features. The bed morphology that occurs is dependent on the local near-bed current speeds (Collins, 1993). The principal sediment source is the reworking of Quaternary sediments in the offshore zone. Large quantities of finer sediments (mud and fine sand) are supplied to the Bristol Channel by the rivers (mainly the River Severn) and supplemented with coastal cliff erosion (Pye & Blott, 2009).

Offshore of Porthcawl the seabed morphology is determined by three large linear sand banks called Nash Bank, Scarweather Sands and Tusker Rock. These are oriented east-west direction and extend seawards from headlands at Nash Point, Porthcawl and Ogmore-by-Sea respectively, reducing the general seabed depths by between 10 and 20 m (Figure 2 and Figure 3).




Source: UKHO , 1999

**Figure 2. UKHO chart of Porthcawl, including offshore sandbanks at Scarweather/Tusker Rock/West Nash**

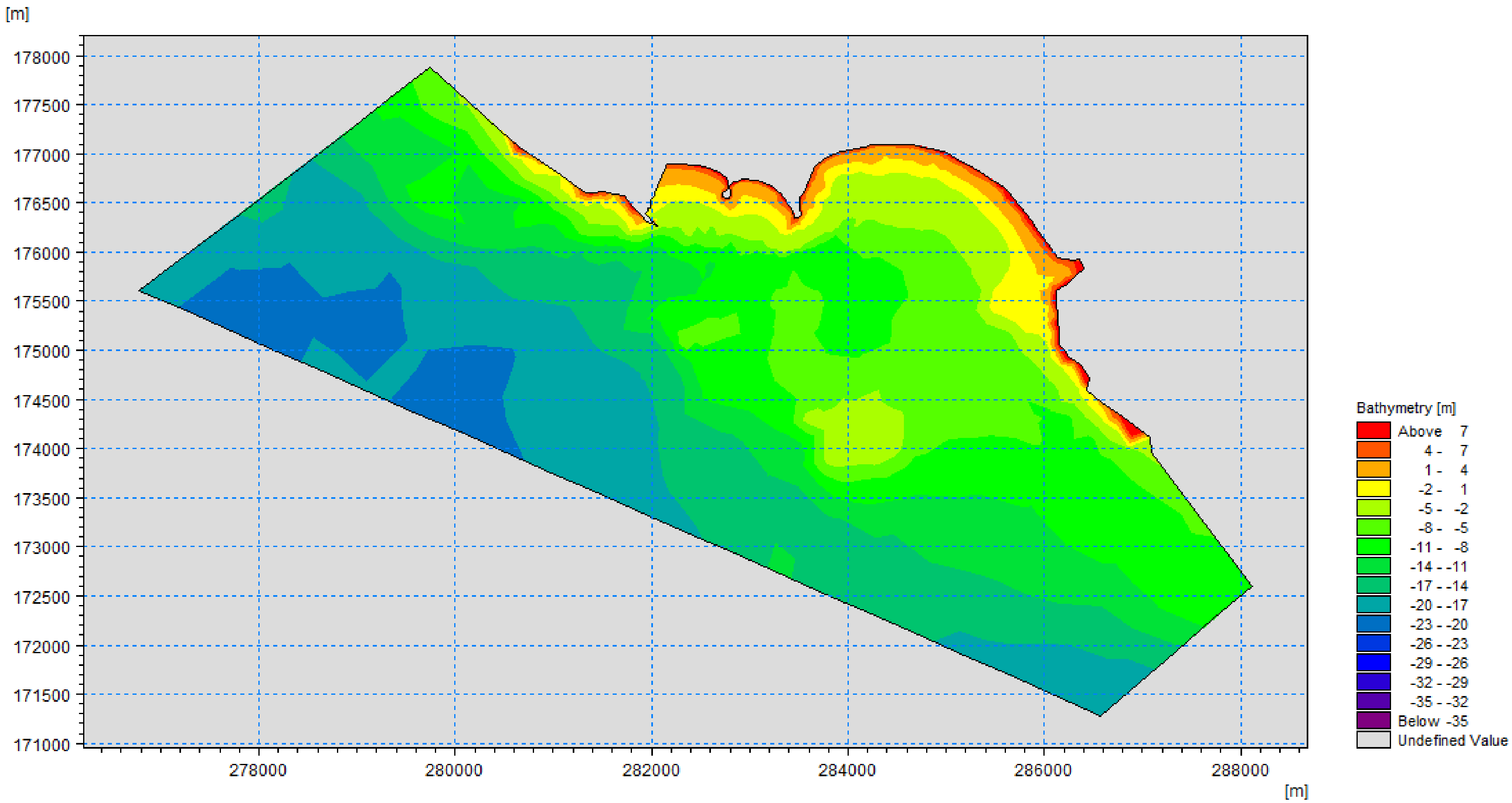



**Figure 3. SEASTATES model bathymetry of Porthcawl and Sandy Bay (Output units are in mODN)**

# 2.3 Coastal description and morphology

## 2.3.1 Coastal description

The fundamental geomorphological character of the South Wales coast is controlled by resistant rock outcrops. The outcrops give rise to a series of headlands, sections of cliffed coast with intertidal shore platforms, and intervening Bays backed by sandy beaches and dunes (Pye & Blott, 2009). This is the case of Sandy Bay, Porthcawl; however the natural processes occurring within the Bay are modified due to the construction of an approximately 180 m long Western Breakwater south-eastwards from Porthcawl Point, which provides protection from waves into the west side of the Bay.

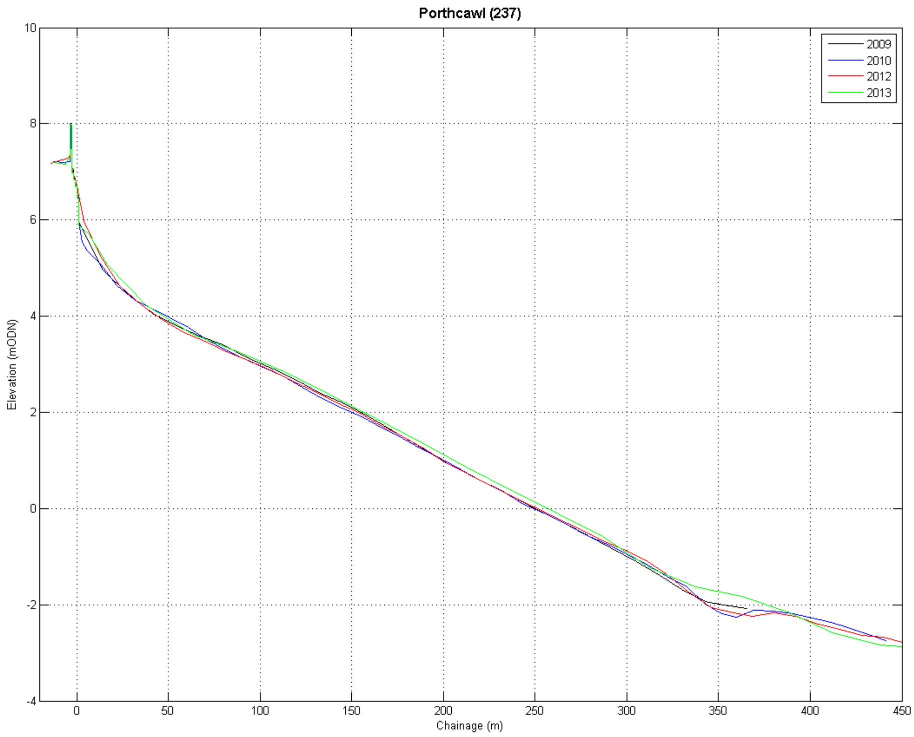
Several historic developments have been made to the harbour at Porthcawl within the last 200 years. The inner harbour was constructed in the mid nineteenth century (Halcrow 2005), replacing the original outer harbour (of which is now filled in and accommodates a car park behind the eastern promenade). A redevelopment of the inner harbour was undertaken in 2013 to install a new lock gate in order to provide an all-tide facility, which now provides protection from waves within the inner harbour.

## 2.3.2 Sandy Bay morphology

Sandy Bay is a small intertidal embayment infilled by a wide, shallow (1:50) gradient sandy beach with depths over 7 m above chart datum (mCD) near the upper beach in front of the central section. This shallow beach results in an extensive breaker zone. The intertidal consists predominantly of sand with gravel deposits located high on the foreshore (Halcrow 2005). The area behind the beach forms part of a dune system that extends 1 to 3 km inland (Pye & Blott, 2009) but has been heavily developed to the west side of the Bay behind man-made sea defences (Halcrow, 2005). This dune system consists mainly of dunes and sand sheets, with localised development of fore dune ridges and hummock dunes (Halcrow, 2012). The sediment within the dunes is largely relict; however, an active interchange exists between the beach and the dunes. For the past 25 years the dune system has been heavily managed and a variety of stabilisation measures have been employed, but accumulations of wind-blown sand and evidence of trample erosion are present (Figure 6, Halcrow 2005). The eastern-most dune toe is protected by a natural gravel revetment around 10 m wide.

Sediment transport modelling conducted by Halcrow (2005) showed that the annual volume change is less than 6,000 $m^3$ in Sandy Bay. To support the understanding of beach and shoreline change, relevant beach profile surveys (Pye & Blott 2013) have been examined and results provided in Figures 4 to 7. A profile to the west of the Western Breakwater (236) has been included to understand current and future risk to the structure throughout the “do nothing” scenario, along with two profiles located Sandy Bay (237 & 238). Between 2009 and 2013 beach levels were generally stable throughout the Bay, with profiles 237 (Figure 5) and 238 (Figure 6) showing variation at the defence/dune toe of less than 0.2 m. Similar values have been previously reported (Cedm 2005) and considered to indicate no change in overall beach levels within the Bay. At the location of profile 238 the dune toe is surveyed between 6-6.5 mODN. This is lower than both 2011 LiDAR (7-7.5 mODN) and previous reports (7.5-8 mODN, Halcrow 2005) suggest, and is therefore a conservative estimate in terms of exposure to toe scour.


Figure 4. **Topographic profile locations along Porthcawl front and within Sandy Bay**



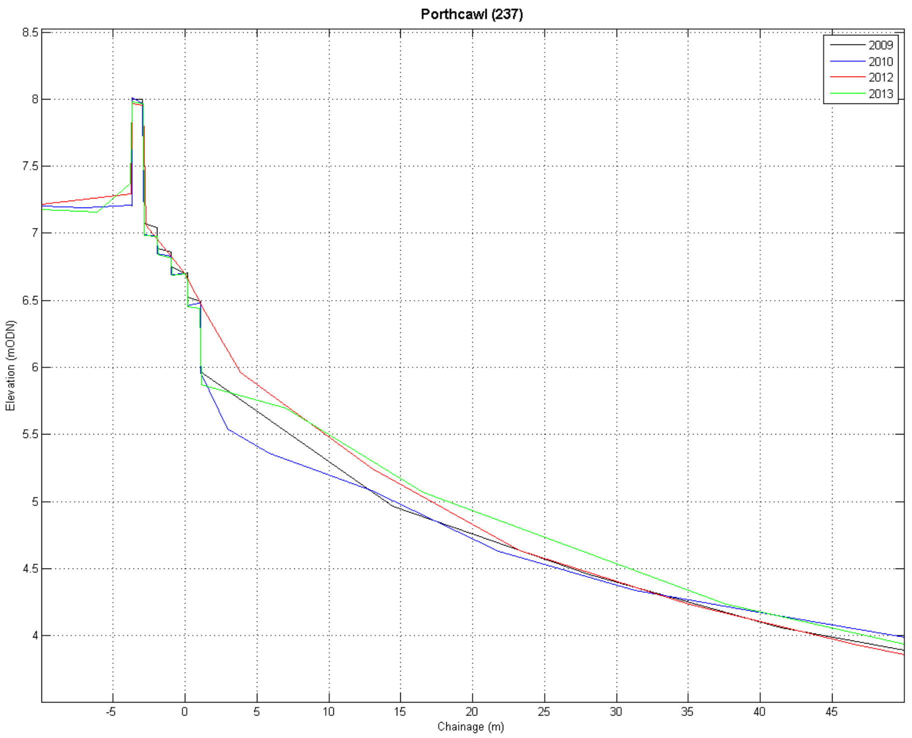




**Figure 5. Profile 237, located in the central section. Note the lower point density for 2012 survey**

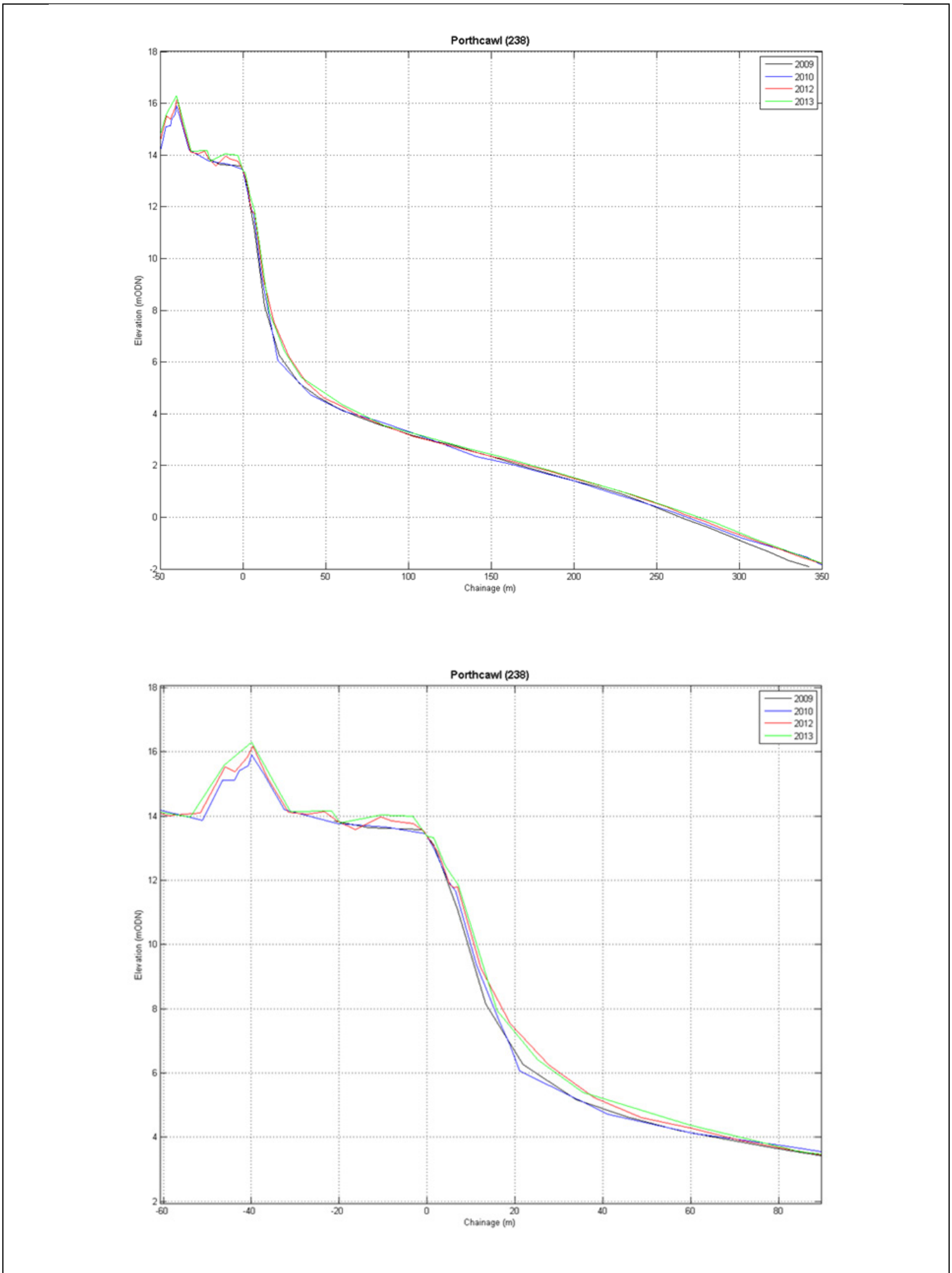



**Figure 6. Profile 238 within the relic dune. Note the height of the dune toe compared to relative still water levels (Table 1)**

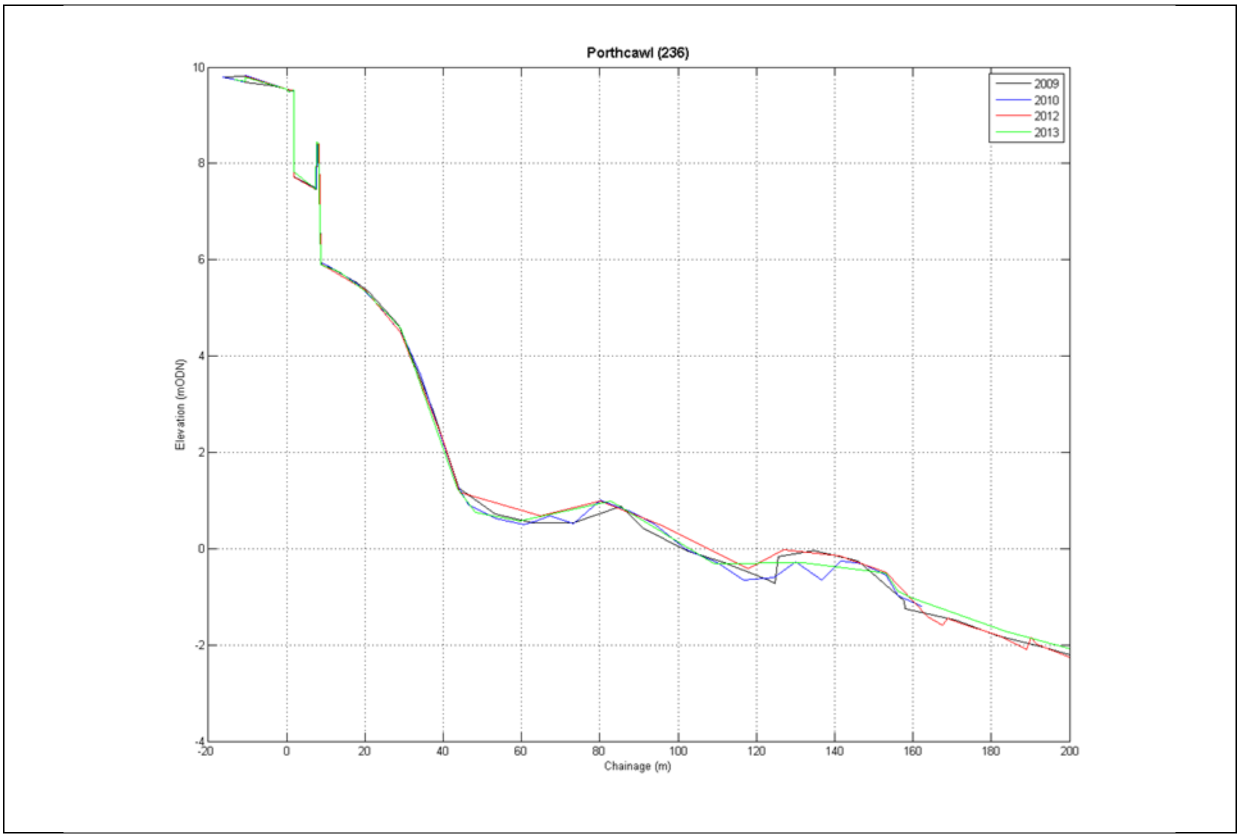



**Figure 7. Profile 236, located west of the Western Breakwater.**

Insufficient LiDAR coverage of Porthcawl is available to provide a direct temporal comparison with topographic survey data. However analysis of beach elevation change between LiDAR flights in 2006 and 2011 (Figure 8) suggest small amounts of erosion in-between the rocky raised beach platforms to the west of the Western Breakwater (*A*), along the toe of the sea wall in the west of the Bay (*B*) and dune scarping in the north and northeast corner of the dune system (*C*).

A moderate area of accretion is apparent immediately to the north of the Western Breakwater (*D*), most likely due to more benign wave activity as a direct result of the breakwater presence. Beach crest level surveys show that the crest and toe levels of Sandy Bay generally increase from west to east (Halcrow, 2005), and both the LiDAR and topographic profiles support this with an elevation increase towards the eastern end of the dune system (*E* & Figure 6) between surveys. The net littoral drift is therefore in a predominantly eastward direction, particularly to the east side of the Bay. The elevated eastern side is likely due to the relict dune system and/or potential rotation from the variable wave climate. An onshore berm migration between the LiDAR flights is also suggested (*F*), of which is likely to be a seasonal variance.

The current understanding of the shoreline evolution from Futurecoast predicts for an "unconstrained" scenario that the dune system would remain reasonably stable over the next century (Halcrow, 2002). Foreshore steepening and scarping is predicted to occur as a result of continued sea level rise (Halcrow, 2005), although the rocky headland at Rhych Point is expected to provide some protection for the dunes (Halcrow, 2012). The conservative estimate of the dune toe level (Figure 6) and the majority of beach lowering (Figure 9) occur higher than 6 mODN, over 1 m above MHWS level but less than 0.5 m to HAT. Therefore current scarping is only expected to occur throughout storm or surge events, as suggested previously (Halcrow 2005).

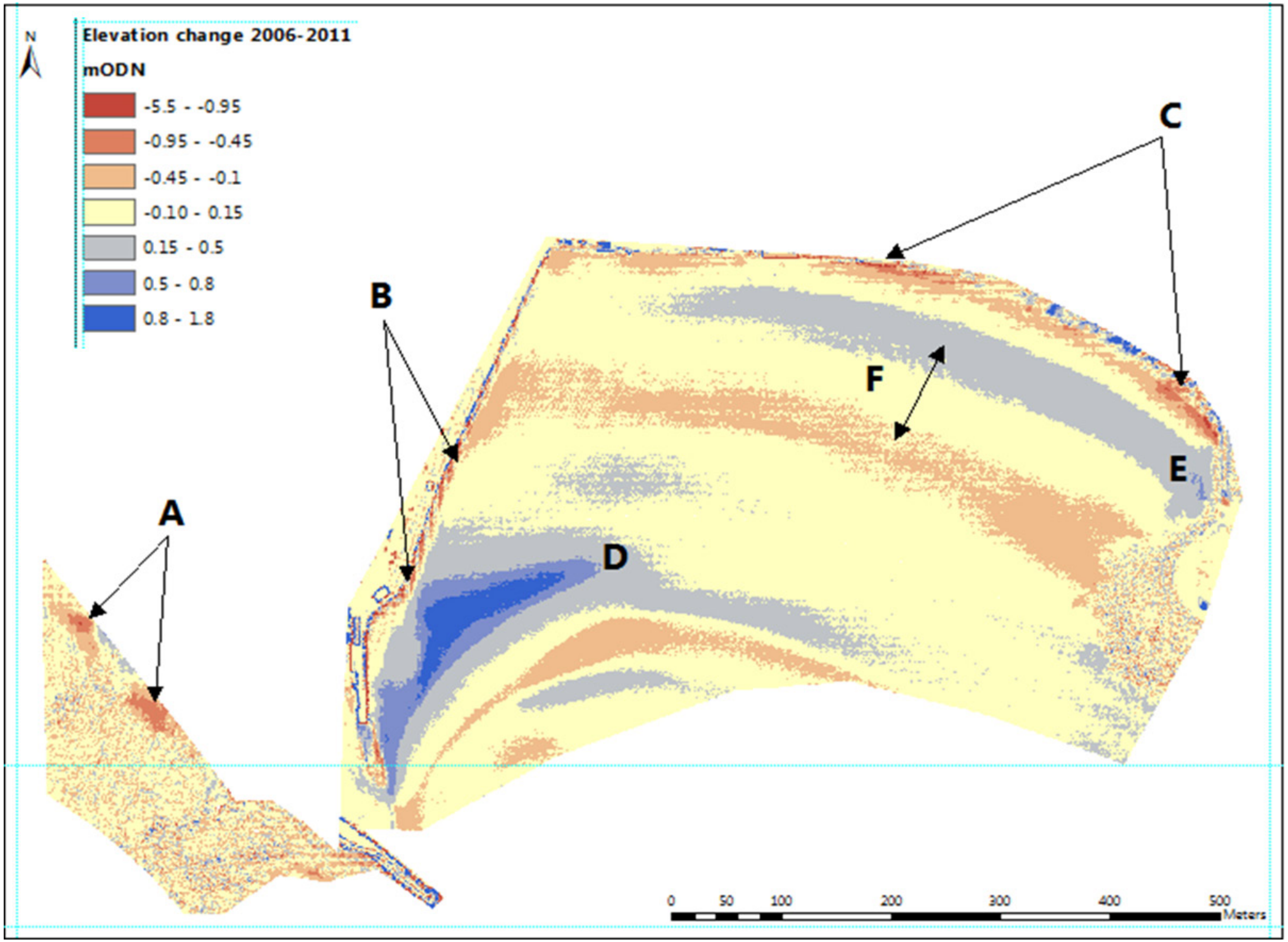



**Figure 8.** **Beach elevation change between 2006 and 2011 LiDAR**

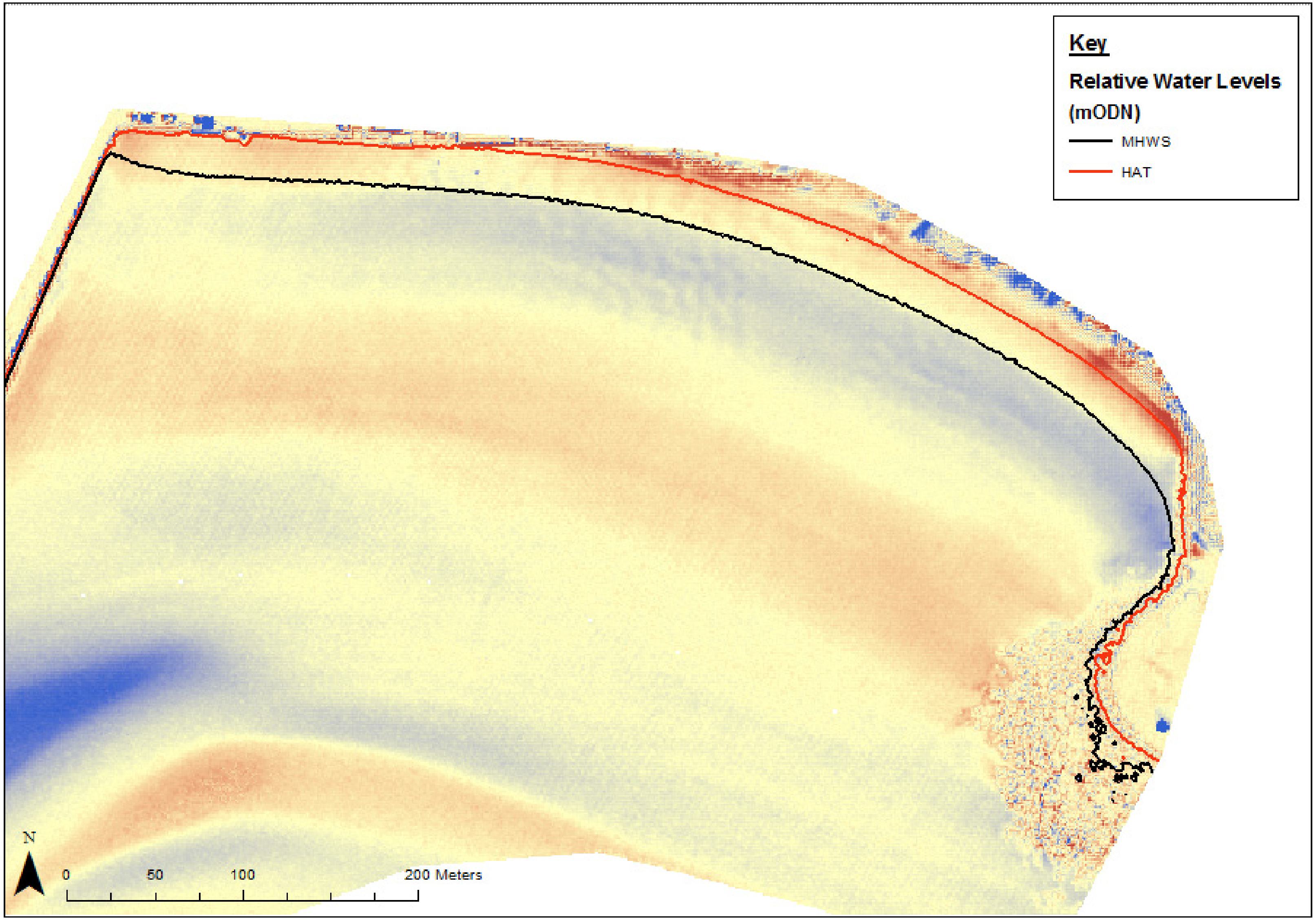



**Figure 9. Elevation change in relation to relative still water levels (mODN). Note the location of MHWS level in relation to erosion activity**

# 2.4 Water levels

## 2.4.1 Tidal water levels

The study area is within the Bristol Channel, which is within a hyper-tidal environment, with a spring tidal range in excess of 6 m. This is due to the behaviour of the tidal wave originating in the North Atlantic and the funnelling effect of the channel, which in turn modifies the behaviour of the tidal wave. Within the study area, the tidal range is approximately 8 m during spring tides, reducing to 4 m during neap tides (Table 1), which is characteristic for coastal locations within the Outer Bristol Channel. The conversion from chart datum to mODN for Mumbles and Porthcawl is -5.0 m and -5.3 m respectively.

**Table 1. Tidal characteristics at Mumbles and Porthcawl**

| Location | Reference Still Water Level | | | | | | | Mean Range (m) | |
|---|---|---|---|---|---|---|---|---|---|
| | HAT | MHWS | MHWN | MSL | MLWN | MLWS | LAT | Spring | Neap |
| Mumbles (mCD) | 10.5 | 9.5 | 7.2 | 5.2 | 3.3 | 1.1 | 0.1 | 8.4 | 3.9 |
| Mumbles (mODN) | 5.5 | 4.5 | 2.2 | 0.2 | -1.7 | -3.9 | -4.9 | | |
| Porthcawl (mCD) | 11.0 | 9.9 | 7.5 | 5.3 | 3.3 | 1.0 | 0.1 | 8.9 | 4.2 |
| Porthcawl (mODN) | 5.7 | 4.6 | 2.2 | 0.0 | -2.0 | -4.3 | -5.2 | | |

Source: 2016 Admiralty Tide Tables

The hyper-tidal range at Porthcawl and shelving intertidal zone means that the existing sea defences on the west of Sandy Bay and immediately shore-side of the amusement park are only exposed to the incident wave climate for periods of the tidal cycle (Figure 10). Whilst the MHWS level extends along much of the Eastern Promenade seawall, MSL and MHWN level only cover between 25 to 50% of its overall length; therefore exposure to overtopping is limited by the tidal dynamics and is only likely to occur for much of the defences under either extreme weather events that occur at the time of spring tide water levels or lower levels enhanced by surge events.

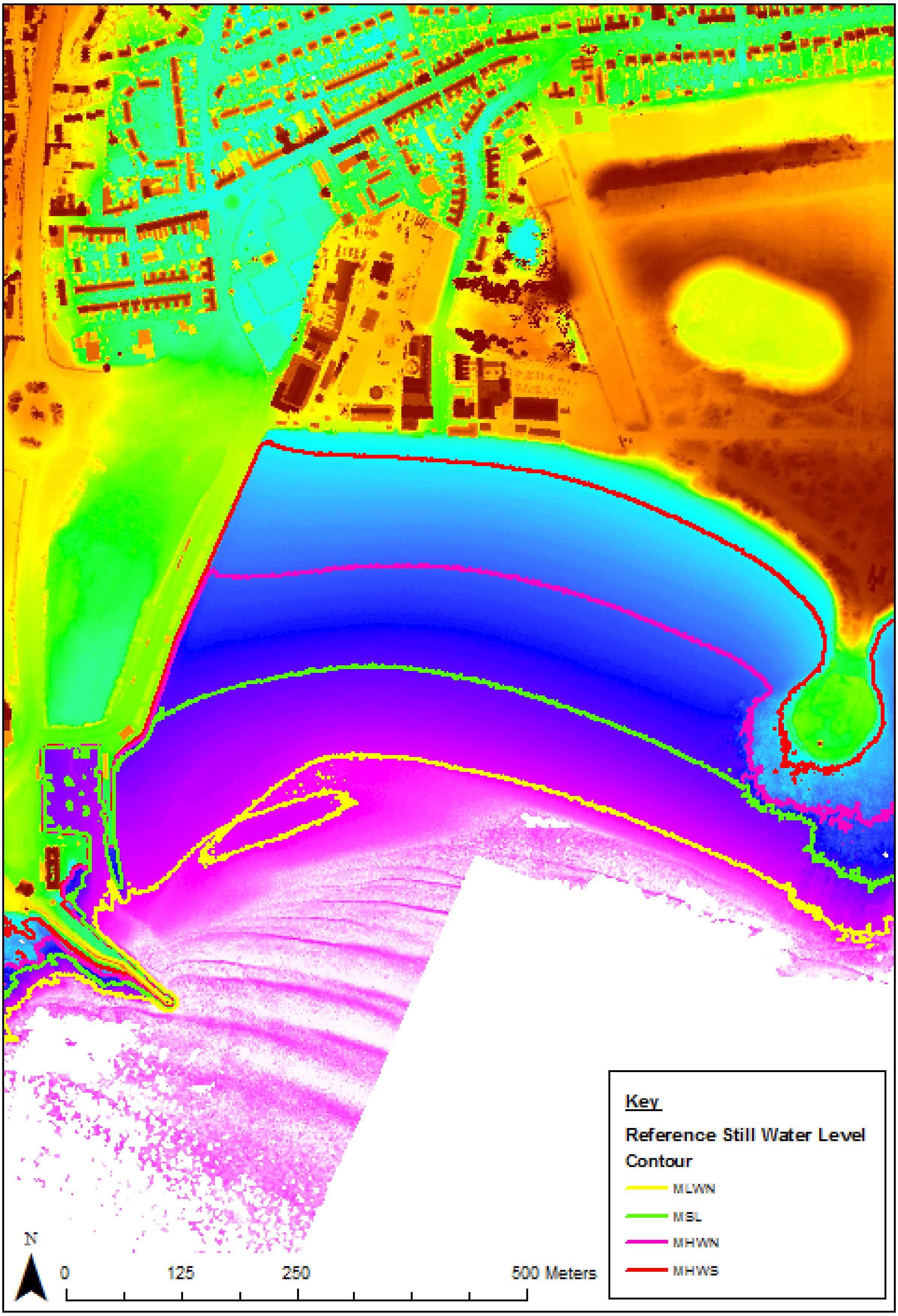



**Figure 10.** Water level contours for Porthcawl (mODN) overlaid onto 1 m DSM LiDAR

### 2.4.2 Surge

The Bristol Channel is affected by storm surges which are generated by the movement of Atlantic depressions across the UK. The most significant storm surges are associated with the events which track southerly across Ireland and generate strong south westerly winds. These winds force water up the Bristol Channel. The occurrence of surge events within the Bristol Channel has the potential to increase water levels. At Mumbles, west of Porthcawl, the largest surge height recorded by the tide gauge between 1990 and 2014, measured approximately 2 m. UKCP09 predictions for future change in storm surge across the region indicate an increase in the 1 in 50-year storm surge height of up to 0.8 mm/yr (Lowe *et al*., 2009). This projected increase remains an uncertain estimate as there is inherent difficulty in predicting storm surge events due to the complicated interaction of many marine and meteorological factors.

### 2.4.3 Extreme water levels

The Environment Agency (EA) coastal flood boundary dataset (CFBD) provides an assessment of extreme water levels offshore of Sandy Bay, which are summarised in Table 2 for the locations shown in Figure 11. These provide the extreme still water levels associated with different return periods ranging from 1 in 1 year to 1 in 1,000 years. Table 2 indicates that extreme water levels offshore of Porthcawl are in the order of about 6.4 mODN up to the 1 in 200 year event. Generally, it is the coincident occurrence of extreme surge heights with high water levels that is considered to bring about extreme water levels within the study region.

Observed occurrences of extreme water levels at Porthcawl between 1992 and 2014, indicated a height of 5.81 mODN, recorded on the on 20th February 2007. Over the 24 year observation period, there were eight occurrences of water levels at or above HAT (Table 3).

**Table 2. EA extreme water levels (mODN) for base year of 2008**

| EA Chainage | Return Periods (years) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1:1 | 1:10 | 1:20 | 1:50 | 1:100 | 1:200 | 1:1,000 |
| **460** | 5.7 | 5.92 | 6.0 | 6.12 | 6.23 | 6.36 | 6.73 |
| **462** | 5.6 | 5.86 | 5.95 | 6.07 | 6.18 | 6.31 | 6.66 |

**Table 3. Water levels approximately reaching (or above) HAT at Porthcawl with associated dates.**

| Date and Time | Water Level (mODN) |
|---|---|
| 20/02/2007 08:00 | 5.81 |
| 03/01/2014 07:00 | 5.73 |
| 28/09/2007 19:00 | 5.69 |
| 19/02/2007 07:00 | 5.69 |
| 08/10/2006 19:00 | 5.67 |
| 29/08/1992 19:00 | 5.67 |
| 02/03/2014 07:00 | 5.67 |
| 10/03/2008 08:00 | 5.66 |
| Observations from Mumbles tide gauge were locally adjusted for Porthcawl, with SEASTATES model filling any gaps within the time series. Red values indicate levels above HAT. | |

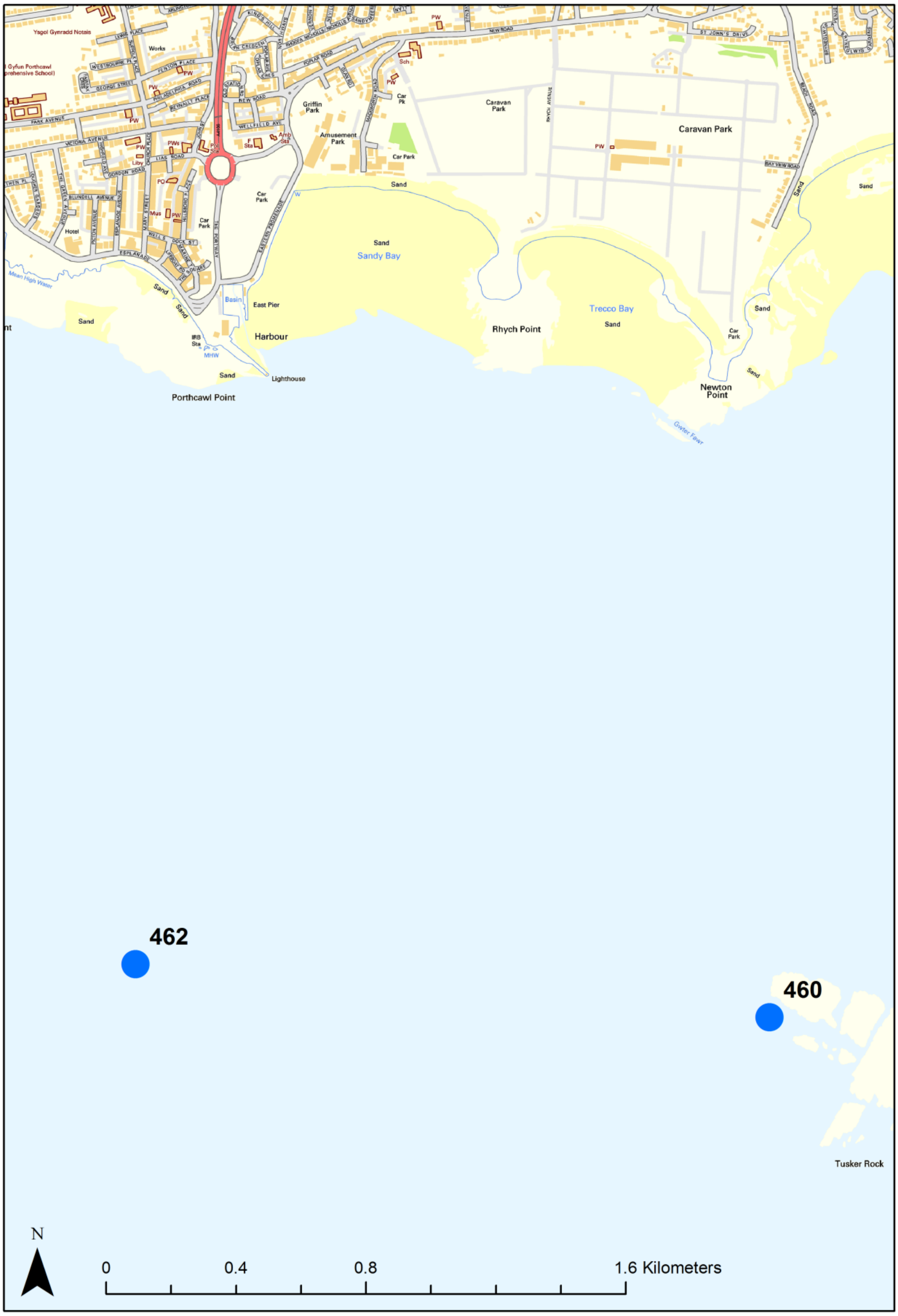



**Figure 11. Location of UKCP09 grid cells for Porthcawl**

### 2.4.4 Relative sea level rise

The Bristol Channel has historically experienced changes in relative sea levels. More recently, the general trend for the southwest of the United Kingdom (UK) (as given at Newlyn, between 1916 and 1996) is of an increase in relative mean sea-level at an average rate of 1.7 ± 0.12 mm per year (Woodworth, *et al.*, 1999). A further analysis of the tide gauge data from Mumbles (PSMSL, 2014) over a shorter period (between 1990 and 2010) suggests a rate of increase of 1.1 mm per year.

Future changes in relative sea level (RSL) are quoted as the net effect of geological adjustments in land levels and the projected absolute changes in mean sea level. A summary of the UKCP09 relative sea level rise projections up to 2100 for the grid cell 23470 at Sandy Bay, based on the medium emission scenario, for the range of confidence intervals are provided in Table 4. For the climate change simulations the medium emission scenario 95 percentile for an epoch *circa* 100 year in the future was calculated at 0.75 m (base year 2018) for 2118 as per Welsh Government Adapting to Climate Change Guidance (2011).

**Table 4. Medium emission scenario predicted relative sea level rise since 1990 (in m) for Porthcawl.**

| Year | Confidence intervals |
|---|---|
| | 95 %ile |
| 2000 | 0.044 |
| 2010 | 0.093 |
| 2018 | 0.135 |
| 2020 | 0.146 |
| 2030 | 0.203 |
| 2040 | 0.265 |
| 2050 | 0.331 |
| 2060 | 0.402 |
| 2070 | 0.477 |
| 2080 | 0.556 |
| 2090 | 0.640 |
| 2100 | 0.728 |
| 2118 | 0.890 |

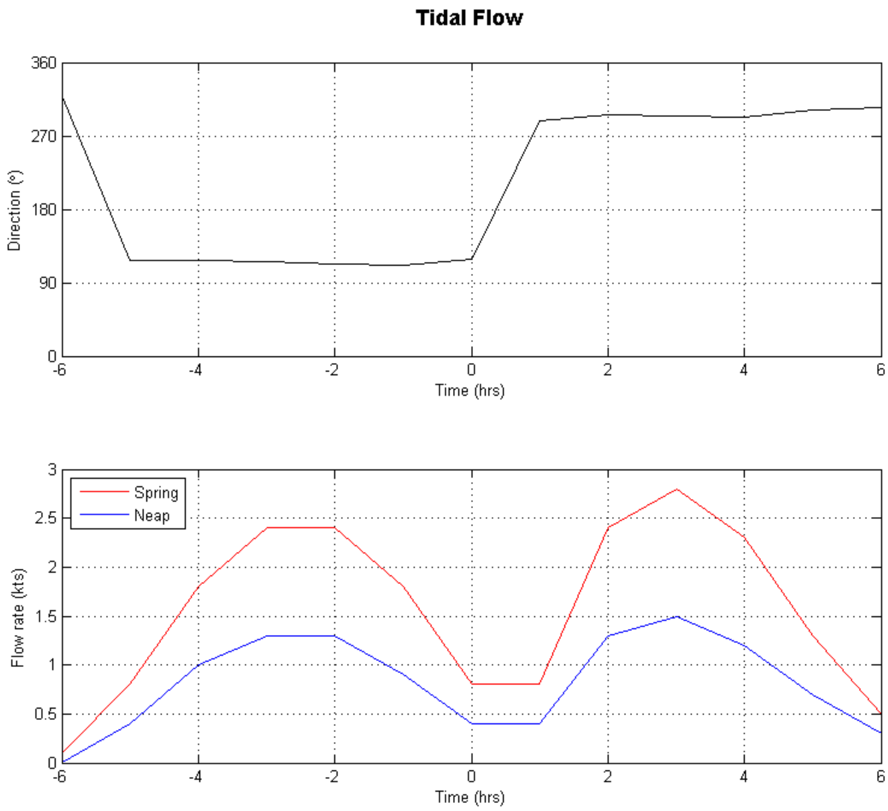
Source: UKCP09 grid cell 23470

A general increase in RSL may result in a number of effects, such as, displacing the high water mark towards the shoreline, enabling wave energy to move further towards the coast (exposing the shoreline to greater periods of wave and tidal energy) and therefore creating increased potential for flood risk. The magnitude of these effects will vary depending upon the rate of predicted sea level rise and the timing relative to the 18.6 year lunar nodal cycle variations (which will impart a larger positive and negative variation in amplitude over shorter timescales).

# 2.5 Currents

## 2.5.1 Tidal currents

The tidal regime within the Bristol Channel is characterised by strong tidal flows, on an east-west axis, as a result of the large tidal range and channel morphology. The current speeds vary spatially both along and across the coastline in line with channels, sandbanks and intertidal flats. In proximity to Porthcawl, information on Admiralty charts (Figure 12) indicates strong near easterly and westerly flows on the flood and ebb respectively of around 2.5 knots (approximately 1.25 m/s) on spring tides.




Source: UKHO, 1999

**Figure 12. Tidal stream data approximately 3 km due south of Porthcawl**

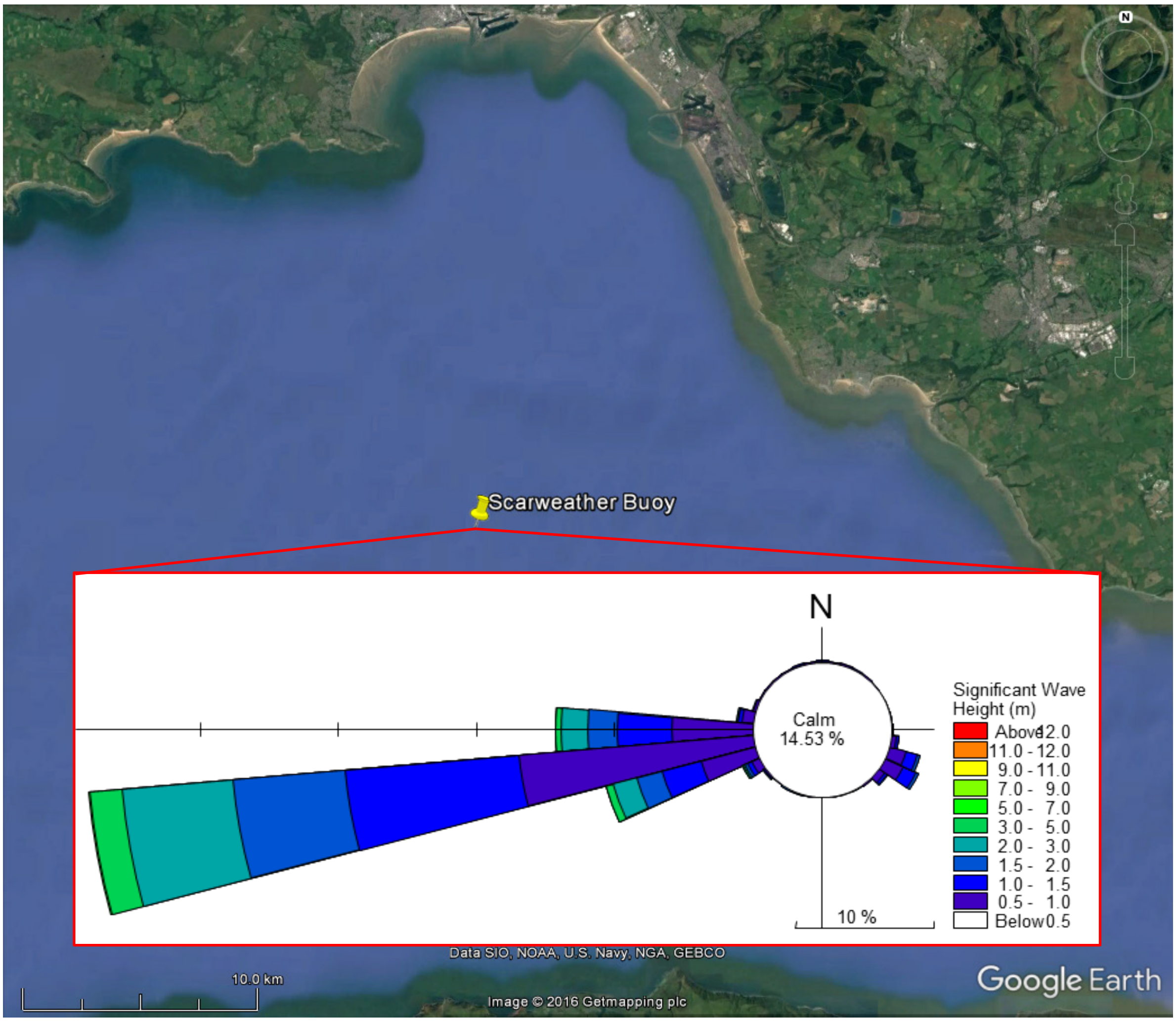
Peak current speeds generally increase in an easterly direction as the tidal range increases. Within the channel however, the westerly ebb flow is stronger, generating a residual in this direction, despite the marginally longer but weaker easterly flood flow (Mackie *et al.*, 2006; James *et al.*, 2004; Posford Duvivier & ABP Research & Consultancy, 2000; Collins, 1987). The large tidal range within the Bristol Channel influences the extent to which waves interact with the seabed and are able to supply additional forcing to the tidal current regime.

# 2.6 Waves

## 2.6.1 Regional wave climate

The Bristol Channel is exposed to both long period swell waves generated in the Atlantic and shorter period wind-waves generated locally within the Channel, which are limited by wind speed and fetch length. The largest and most frequent waves which approach the study area are from a WSW direction. During periods of low water and neap tides waves are modified by the local topography, as are long period westerly waves in water depths less than 20 m.

Data from the Scarweather WaveNet buoy located further west of Porthcawl in the Outer Bristol Channel (Latitude 51° 25′.99N, Longitude 003° 55′.99W, Figure 13) at 35 m water depth is used to inform the offshore wave climate. At the buoy an average significant wave height (Hs) of 1.2 m and average peak wave period (Tp) of 8.6 seconds was observed for the period between July 2005 and November 2015. The time series suggests a dominant wave approach from WSW direction for nearly 50% of the time, with significant wave heights of up to 7 m (Figure 13). The largest recorded significant wave height in the time series is 11.11 m on the 10th of May 2014. Similar wave approach and maximum Hs values associated with a 1:100 year event have been previously suggested at this location (Halcrow 2005).




Map data ©2016 Google. Image © 2016 Terrametrics. Data © SIO, NOAA, U.S. Navy, NGA, GEBCO.

**Figure 13. Significant wave height at the Scarweather WaveNet buoy between July 2005 and November 2015**

From differing directions waves are either limited in their fetch length (easterly) or are likely to be dissipated via the presence of offshore sandbanks (Scarweather to the west and Tusker Rock/West Nash to the south) particularly during a 2-4 hour window surrounding LW depending on the stage of the spring/neap tidal cycle (Figure 2).

### 2.6.2 Local wave climate

Figure 14 and Table 5 show the nearshore wave climate derived from transforming a 37 year hindcast time series of wave heights and water levels at the Western Breakwater and the frontage toe (derived from a combination of LiDAR cross section profiles and known height of the defence toe from existing drawings) within Sandy Bay. This method is discussed in the supporting modelling assessment (ABPmer 2017). Within this section we have included the Western Breakwater (Figure 1) as an existing structure, as this combined with the local morphology is considered to be highly influential in the reduction and modification of waves from offshore regions entering Sandy Bay (Figure 13).

The raised shore platform at Rhych Point (Figure 1) appears to enhance refraction of waves entering the eastern sections of Sandy Bay following initial diffraction around the Western Breakwater. The platform may also provide wave dissipation during higher water level conditions (Figure 10).

The intertidal zone surrounding Porthcawl containing a raised shore platform has a refraction effect on waves entering the nearshore, with waves in front of the Western Breakwater initially backing to a SSW direction (Figure 14) from the more westerly directions seen offshore at Scarweather (Figure 13). Dissipation of these waves is also apparent over the intertidal area of the Bay, with a reduction in average significant wave height to less than 1 m (Table 5, Figure 14). Historical OS analysis (Envirocheck 2006) indicates that this extent of intertidal has changed little with time, giving indication of a relatively stable foreshore. Further sheltering and refraction effects as a result of the Western Breakwater are witnessed, with consistently smaller Hs values of less than 0.4 m at the frontage toe locations within the Bay (Table 5, Figure 14). Average significant wave heights increase in value west (0.07 m) to east (0.35 m) throughout the frontage locations in the Bay. This is combined with a rotation in wave direction to that immediately parallel to the bathymetric contours (Figure 3, Figure 10).

**Table 5. Average wave statistics at the toe of the Western Breakwater and throughout Sandy Bay.**

| Toe Frontage ID | Average Significant Wave Height Hs (m) | Average Peak Wave Period Tp (s) | Average Wave Direction (°) |
|---|---|---|---|
| 1 | 0.16 | 8.5 | 147 |
| 2 | 0.16 | 7.9 | 147 |
| 3 | 0.29 | 7.0 | 185 |
| 4 | 0.31 | 6.9 | 208 |
| 5 | 0.75 | 8.7 | 197 |
| 6 | 0.35 | 7.3 | 225 |
| 7 | 0.07 | 7.7 | 142 |

Locations are shown within Figure 14.

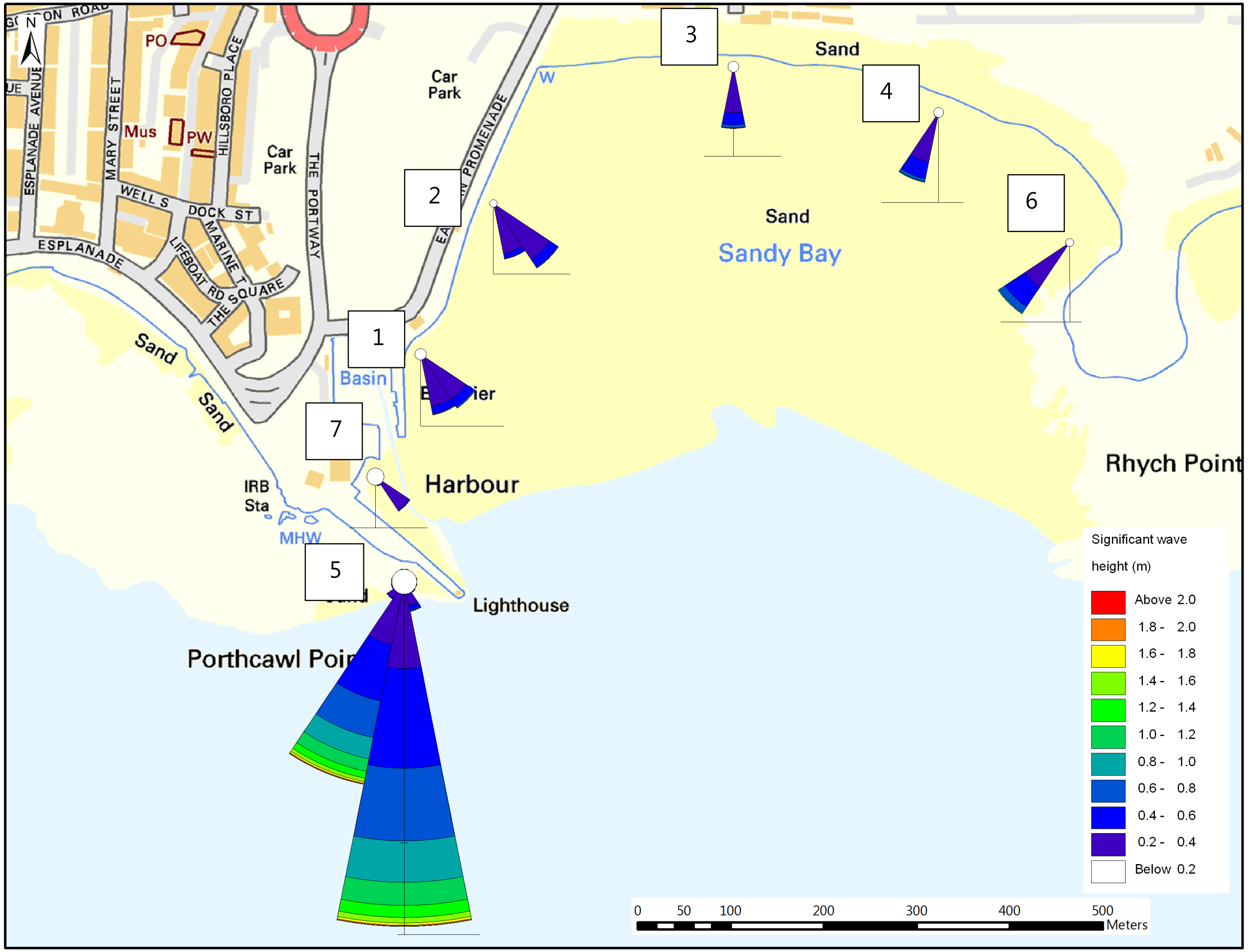



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**Figure 14. SEASTATES significant wave heights and mean wave directions for the nearshore within Sandy Bay and at Porthcawl Western Breakwater**

### 2.6.3 Extreme waves

The period between mid-December 2013 and mid-February 2014 according to the Met Office, was the stormiest period of weather that the UK had seen for at least 20 years, with the storms during early and mid-February being particularly severe. Subsequent analysis (Haigh *et al*. 2016) has identified that this winter season contains the largest number of extreme sea level events in any season in the last 100 years. At the Scarweather buoy, on 12 February 2014 (which coincided with a neap tidal period), a significant wave height (Hs) of 8.2 m was recorded, associated with peak wave period (Tp) of nearly 12 seconds (and zero-crossing wave period Tz of 10.3 seconds), approaching from the west-southwest. Although it is likely that waves of a smaller magnitude will have reached the nearshore during this period, significant overtopping along Porthcawl Point occurred (Figure 15).

Source: ITV, 2017

**Figure 15. Wave overtopping along Porthcawl Point during a storm event on 12/02/2014**

A study by Halcrow (2005) derived nearshore wave data at the -10 mCD contour using *circa* 10 years of data UK Met Office data. Atkins (2012) used this data for wave disturbance modelling. This modelling found the most significant wave disturbance in Porthcawl Harbour was caused by the south easterly wave. Atkins (2012) did not model south westerly waves due to the sheltering effect within the Bay and harbour entrance caused by the Western Breakwater. The offshore values from the Halcrow (2005) study are presented in Table 6. Conditions from the southwest and northwest were not considered due to the lack of wave impacts within the Porthcawl Harbour. Comparison of Table 6 with Figure 14 suggest that the extremes based within 120-180 degrees are likely to be greater than those which occur if all directions are accounted for; which will change the return period of the event.

**Table 6. Offshore extreme waves conditions**

| Direction | 120° | | 150° | | 180° | |
|---|---|---|---|---|---|---|
| **Return Period (years)** | **Wave height (m)** | **Wave Period (s)** | **Wave height (m)** | **Wave Period (s)** | **Wave height (m)** | **Wave Period (s)** |
| 1 | 1.66 | 4.9 | 2.02 | 5.4 | 1.95 | 5.3 |
| 5 | 1.96 | 5.3 | 2.25 | 5.7 | 2.15 | 5.6 |
| 20 | 2.19 | 5.6 | 2.42 | 5.9 | 2.31 | 5.8 |
| 100 | 2.44 | 5.9 | 2.60 | 6.1 | 2.48 | 6.0 |

Source: Halcrow, 2005.

The Environment Agency (EA) assessment of extreme wave conditions, derived from a gridded model cell in close proximity to Sandy Bay (outside of the effects of the Western Breakwater), indicate waves heights of around 3-3.5 m for different return periods (Table 7 and Table 8) with zero-crossing periods (Tz) up to 12 s. As represented in the observed data, the largest waves generally approached from the southwest.

**Table 7. EA extreme swell waves (m) for cell GL2396**

| Wave Approach Direction | Return periods (years) | | | | | |
|---|---|---|---|---|---|---|
| | 1:1 | 1:10 | 1:20 | 1:50 | 1:100 | 1:200 |
| Southwest | 3.0 | 3.3 | 3.4 | 3.4 | 3.5 | 3.5 |
| Northwest | 2.3 | 2.8 | 2.9 | 3.0 | 3.1 | 3.2 |

**Table 8. EA extreme swell wave period (seconds) for cell GL2396**

| Significant Wave Height (Hs, m) | Zero-crossing wave period (Tz, seconds) | | | | | |
|---|---|---|---|---|---|---|
| | <8 | 8 - 10 | 10 - 12 | 12 - 14 | 14 - 16 | >16 |
| <1 | 0.53 | 0.24 | 0.13 | 0.08 | 0.02 | N/A |
| 1-2 | 0.43 | 0.28 | 0.16 | 0.09 | 0.03 | N/A |
| 2-3 | 0.42 | 0.41 | 0.15 | 0.02 | N/A | N/A |
| 3-4 | 0.67 | 0.22 | 0.11 | N/A | N/A | N/A |
| 4-5 | N/A | N/A | N/A | N/A | N/A | N/A |
| Measures relate to percentage occurrence in each wave height/period zone | | | | | | |

Due to the short period data used in both the Halcrow (2005), EA (2011) CFBD waves and the Atkins (2012) study it was considered these data did not reflect the complete wave climate of the area for use of deriving overtopping. For this study ABPmer has used the SEASTATES database of hindcast offshore data (ABPmer 2013, 2016). SEASTATES is a fully spectral wave model which covers the North Atlantic and European shelf seas, and is driven by the spatially and temporally varying CFSR (Climate Forecast System Reanalysis) wind fields developed by NOAA (National [American] Oceanic and Atmospheric Administration). The SEASTATES hindcast has been previously validated against 28 buoys within UK and European waters. 37 years of hindcast wave conditions are coupled with 37 years of modelled water levels to represent the complexities of the wave climate in the immediate nearshore (Figure 14). This method allows for all wind, wave and water level conditions to be incorporated in the overtopping calculations.

The results of this analysis and the model transformation of the data to Sandy Bay, extreme analysis and then sea defence overtopping analysis is presented in ABPmer (2017). This analysis provides overtopping information for locations at the defence frontage, taking account of the refraction and partial diffraction effects around the Western Breakwater, as well as wave shoaling, wave refraction and wave breaking within the intertidal area of the Bay.

# 3 Conceptual Understanding

A combination of the nearshore morphological properties within the intertidal area of Sandy Bay and the existing defence frontages (including the main Western Breakwater) significantly modify wave properties entering Porthcawl. Prior to entering the nearshore waves are filtered in direction and height by a series of offshore sandbanks (mainly Nash and Scarweather) located to the south and west. Upon entering the nearshore, dissipation and refraction occur over the rock raised shore platform and then around the Western Breakwater at the west side of the Bay, with further dissipation and refraction occurring throughout the raised shore platform at Rhych Point. This occurs during both normal and extreme conditions. As a consequence the west side of the Bay is relatively sheltered from the most extreme wave activity, sufficient to allow sand to deposit in the Western Breakwater lee off the entranced to Porthcawl harbour. Around the rest of the Bay the shallow gradient intertidal zone causes refraction so that waves tend to approach the Sandy Bay defences and fronting sand dunes approximately perpendicular. Diffraction around the end of the Western Breakwater will radiate the waves towards the north-west corner of the Bay, causing waves to impact at an angle to the Eastern Promenade. Under certain circumstances waves would have the potential to run along the sea defence into the corner of the Bay. This corner will be disturbed with incident and reflected waves interacting at the highest water levels creating wave breaking and the potential for water splash if not direct overtopping.

Sediment transport throughout Sandy Bay is limited, with a slight west-to-east accretion of beach levels in recent years. This is likely due to a combination of the east-west axis of tidal flow, and the predominantly westerly and south-westerly direction of wave conditions both offshore and within the nearshore. The large tidal range also varies the level of beach exposure to waves temporally, with approximately 300 m of cross-shore exposure change between MHWS and MLWN level. Beach levels at the toe of the central frontage are considered to be stable from the information available, with no significant pattern of erosion or accretion over the longer term. However erosion is likely to occur throughout storm and surge events (not extensively monitored at the site), and therefore under benign conditions the intertidal zone has the ability to recover its former profile. As a consequence beach draw-down is considered to be limited in the longer term and therefore any level variations at the frontage which could affect wave overtopping around the Bay are likely to only be a function of the change in tidal events with Sea Level Rise (SLR), rather than the greater combined effect should draw-down be an ongoing process.

Effects of future climate change particularly in the longer term will increase the general water depths within the Bay. As a consequence there is greater potential for higher waves to reach the defences at increased frequency, and hence an increased wave overtopping, flood risk and potential sea wall damage. As noted above, beach draw-down and sea defence by erosion is limited and therefore an 'undercutting' of the sea defence and dune system is not considered to be a high risk, particularly if toe protection of the structures are provided and dune stabilisation is continued. In general it is suggested that beach erosion is not a problem at the site, however the frequency of scarping events (and consequent sediment removal from eastern sections of the Bay) is likely to increase with sea level rise.

The above analysis is based on the continuing presence of the Western Breakwater. Should this be allowed to decay, then significant additional exposure to the dominant SSW waves will occur; particularly on the eastern side of the Bay. The wide intertidal zone and large tidal range will still create depth limited wave conditions, but there would be greater potential for wave overtopping (hence flood risk and additional impact on the defences), increasing the potential for structural failure and the need for greater maintenance.

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# 5 Abbreviations/Acronyms

| | |
|---|---|
| BCBC | Bridgend County Borough Council |
| CFBD | Coastal flood boundary dataset |
| EA | Environment Agency |
| FRA | Flood Risk Assessment |
| HAT | Highest Astronomical Tide |
| Hs | Significant wave height |
| LAT | Lowest Astronomical Tide |
| mCD | Metres relative to Chart Datum |
| mODN | Metres relative to Ordnance Datum Newlyn |
| MHWN | Mean High Water Neap |
| MHWS | Mean High Water Spring |
| MLWN | Mean Low Water Neap |
| MLWS | Mean Low Water Spring |
| PAR | Project Appraisal Report |
| RSL | Relative Sea Level |
| SLR | Sea Level Rise |
| Tp | Peak wave period |
| Tz | Peak zero crossing period |

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

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# Appendix C Porthcawl Breakwater Ground Investigation Report (GIR) 2018

On request