HORIZON
NUCLEAR POWER

WYLFA NEWYDD

ENERGY WORKING FOR BRITAIN

Wylfa Newydd Project

Supplementary Information on Coastal Processes to Support Wylfa Newydd EIA and Shadow HRA

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1 Introduction

The purpose of this document is to summarise the work undertaken with respect to coastal processes, to provide a summary of additional modelling work undertaken since the submission of the Wylfa Newydd DCO and Marine Licence and to provide a response to comments raised by NRW through the informal advice received on the Marine Licence application. The content of the memo also provides supplementary information requested at the HRA meeting with NRW on the 27th September 2018.

NRW comments relate to the potential effects on Esgair Gemlyn from the Wylfa Newydd Project. Specifically, (through Letter reference: CAS-64863-D6M1) NRW has stated:

The SWAN wave modelling shows an area of wave focussing to the west of Esgair Gemlyn during a NW extreme storm (99 percentile) and attributes this area of focussing and increase in wave height to wave reflection off the Western Breakwater. However, the morphological implications of this area of wave focussing on the Esgair Gemlyn ridge over the duration of the operational period is still unclear due to a gap in associated bed shear stress modelling. There is also a gap in the baseline understanding of the response of Esgair Gemlyn to storm events from different directions. Although north westerly waves may be smaller than north-easterly waves, it may not be a linear association and the biggest impact on the ridge may be from more frequent and/or smaller but more focused events. The baseline understanding of the interaction between the ridge and wave events is largely unknown. There is also conflicting interpretation of what is causing the increased wave height off Esgair Gemlyn – wave modelling (Appendix D12-03 section 4.5.5) cites wave reflection of the western breakwater however, chapter D12 Coastal processes and coastal geomorphology (12.5.37, 12.5.108,12.5.109) reports increased wave heights as shoaling effects due to the ebb delta of the lagoon drainage system.

Although there is a breadth of information pertaining to seabed sediment type in the Wylfa Newydd Development Area, only one sample was taken close to Trwyn Cemlyn Head to represent sediment type in Cemlyn Bay SAC (WS 3). There was also a geophysical boat survey carried out by Titan, but the shoreward extent of this survey would have been limited to below Mean Low Water, and therefore sediment in the nearshore and intertidal area is largely not surveyed. Further information is required of the sediments available with Cemlyn Bay and intertidal zone both in spatial area (only one sample taken) and depth available for mobilisation.

The Delft 3D model provided coupled wave-current bed shear stress estimates for the high north wave and a spring tide. It is evident that excess shear stresses under a high north storm will suspend the mobile sand fraction in Cemlyn Bay. However, it has been stated that the greatest impact in Cemlyn Bay due to wave refocussing from the western breakwater will occur during a north west storm. There is currently no information presented to what the excess shear stresses will be for a north west 99 percentile extreme storm event under spring tide conditions and whether the enhanced shear stresses will mobilise and transport a higher fraction of fines/sand/gravel into suspension which could then be deposited onto the Esgair Gemlyn ridge. Please also note that the shadow HRA (Section 7.4.148) has taken the worst-case scenario for bed shear stress as spring ebb tide with no consideration of excess shear stress under storm wave conditions. Further consideration is required as to whether the spring ebb tide bed shear stress prediction is the worst-case scenario.

If there are fines within the sediment layer in Cemlyn Bay these will be mobilised under extreme storms and could change the sediment matrix of the ridge if deposited onto the ridge. If there is sufficient fine sediment available, and this deposition occurs repeatedly during operation of the breakwater there is potential to change the dynamic behaviour of the ridge due to the increased presence of more cohesive sediments. We advise that further information is required regarding the sediments available in Cemlyn Bay (in terms of both spatial distribution and depth) to assess whether focussed energy from the marine structures may cause deposit of fines, reworking of the gravel or a breach at Esgair Gemlyn. The above information is required to inform NRW PS' HRA.

The comments raised by NRW cross two main themes:

1) The need to understand the effect of the 99 percentile wave condition on the bed shear stress and its implications for the morphological functioning of Esgair Gemlyn; this is addressed in Section 3 of this report.

2) The need for additional sediment data from Cemlyn Bay to inform the spatial distribution of sediment in the area with respect to the potential for remobilisation and subsequent damage to the sediment matrix of the ridge; this is addressed in Section 4 of this report.

2 Approach presented in the Wylfa Newydd Environmental Statement

The following sections provide a summary of the baseline information and assessments presented within chapter D12 (coastal processes and coastal geomorphology, APP-131) of the DCO application which also support the Shadow Habitats Regulations Assessment (APP-050 / 051).

2.1 Description of impact

As part of the Wylfa Newydd Project, there is a requirement to carry out Marine Works which would include the construction of temporary and permanent structures, and the dredging and excavation of the harbour (see chapter D1, proposed development, APP-120 of the Environmental Statement (ES) for further information).

Within chapter D12 (APP-131) it was identified that a pathway to effects exist as a result in the following potential changes:

- increased fine sediment deposition transported via new drainage pathways to the sea;
- increased fine sediment deposition due to dredging/excavation works[1];
- increased fine sediment input into the sea during construction of permanent structures;
- short-term changes to seabed and intertidal zone associated with temporary structures and their removal;
- loss of seabed and intertidal zone geomorphological features associated with permanent structures;
- sediment mobilisation (erosion / deposition) caused by changes of bed shear stress; and
- changes in wave height due to reflected waves off infrastructure.

Changes to coastal and marine processes associated with construction within the Wylfa Newydd Development Area have been identified through hydrodynamic (Delft3D) (appendix D13-8, Marine Hydrodynamic Modelling Report – Wylfa Newydd Development Area, APP-226) and wave (SWAN) (appendix D12-3, Wylfa Newydd Main Site Wave Modelling Report, APP-218) modelling investigations.

Investigations of potential changes to coastal and marine processes during construction have been focused upon two key sets of modelled results. These include both the predicted changes to surface wave conditions (in the SWAN model at the Wylfa Newydd Development Area); as well as the predicted changes to coupled tidal currents and wave (in Delft3D at the Wylfa Newydd Development Area and at the Disposal Site) in relation to:

- effects upon Esgair Gemlyn from changes in wave height as a result of the Licensable Marine Activities; and,
- effects upon seabed shear stress and associated sediment mobilisation patterns resulting from new structures and Licensable Marine Activities associated with the Power Station.

2.2 Waves

To investigate the possible effects of the proposed Licensable Marine Activities upon waves and tidal currents, modelling was presented within the ES to show the effect of various stages of construction

[1] The suspended sediment plots from dredging (figures 164 to 166 of appendix D13-8 (APP-226) does not include background sediment concentration. This means that the plots represent the increase in suspended sediment concentrations as a consequence of the dredging activities.

(partially built and fully built) on the baseline model predictions. This modelling was undertaken using a northerly 99th percentile wave (i.e. with a 1 in 100 probability of occurrence) based on the winter period only (rather than on the whole year), and therefore, represents ‘worst case scenario’ winter storm conditions. For the assessment of effects around Cemlyn Bay an investigation of significant wave heights was undertaken.

Analysis of all wave scenarios run within the SWAN model revealed the greatest potential changes in wave heights for the largest waves approaching the near shore occurs with the most severe winter storm (99th percentile) waves arising from the north-west (figure 1). Waves entering Cemlyn Bay from the north-east wave direction are aligned with the headlands and the orientation of the western breakwater, therefore the marine structures would have a lesser effect upon the height of waves entering from that direction. In contrast, waves entering from the north-west are directed towards the breakwater, therefore a reflection off the structure is observed. The effect of wave reflection at the western breakwater under severe storm conditions is to locally increase wave height. However, within Cemlyn Bay, wave heights are low and changes are very small (up to 0.05 m, and within the limits of resolution of the model); see the bottom two figures of figure 1 below where changes in Cemlyn Bay are extremely subtle.

Figure 2 compares of the differences between a 99%ile wave from the NW direction with the baseline (i.e. existing situation) subtracted from the Project during early construction (i.e. partially built) and during operation (i.e. fully built) and shows that wave heights increase up to 0.05 m as a result of the Project from a reflection of waves off the western breakwater. The increase is localised and dissipates within the outer parts of Cemlyn Bay (figure 2). The only area within the Bay where there is a net increase in wave height for the as-built situation is at the ebb tidal delta of the gravel ridge, but the change is small (up to 0.2 m), highly localised and exists for incident waves from the north-west only. Overall, under the 99th percentile wave condition from the north-west the baseline wave height values in Cemlyn Bay are lower than the baseline values for storm waves from the north-east highlighting that waves from the north-east are more significant for the bay.

Additional wave simulations, carried out using the SWAN wave model, were conducted to explore the sensitivity to offshore wave direction, providing results at 5º spacing within the W, NW, N and NE sectors for the ‘2087 reasonably foreseeable’ conditions, applying the same wind conditions as for the 99th percentile condition in the sector. The results indicate, for waves approaching from the west, a larger extent of potential increase in wave height, ranging between 0.1 and 0.2 m occurring to the west of Cemlyn Bay. Comparison with the baseline wave conditions shows this change to be effective upon smaller wave heights up to 1 m. Therefore, the predicted potential increases in height for storm waves approaching from the west would be within the range of wave conditions currently occurring within Cemlyn Bay for storm waves approaching more directly from the north east.

Figure 1: Comparison of wave heights

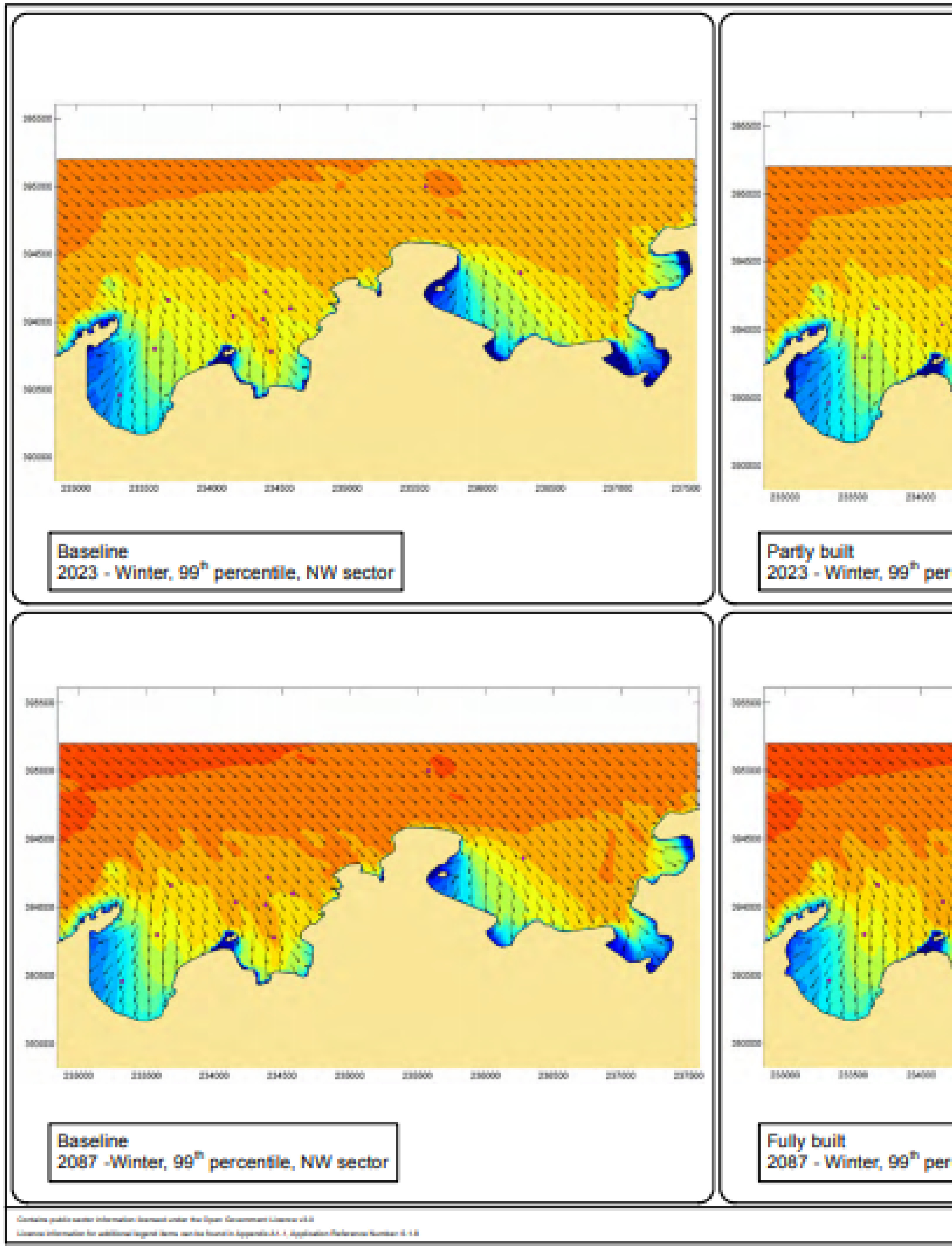
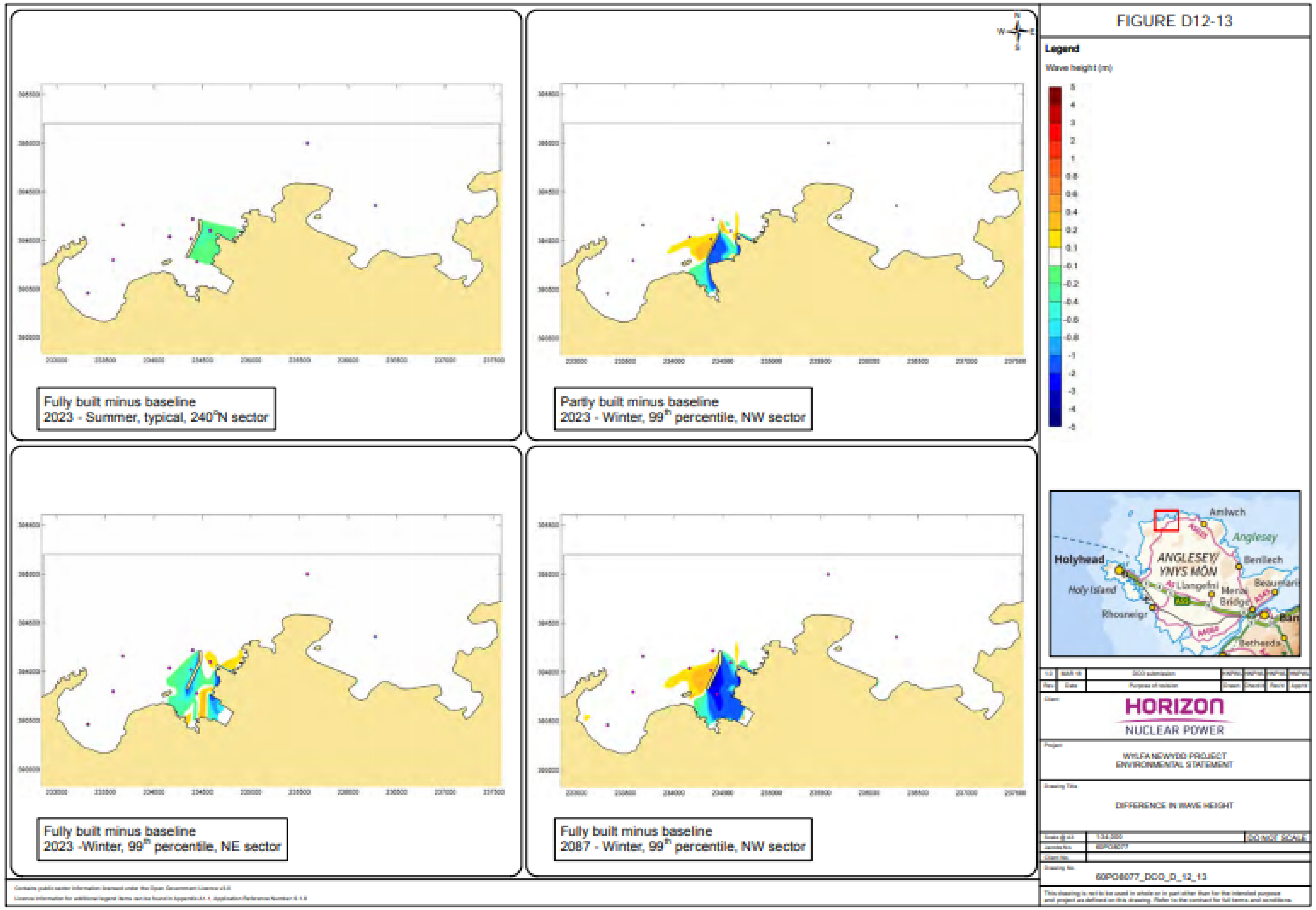


Figure 2: Difference in wave height, figure D12-13 from the Wylfa Newydd ES (APP-237 / 238)



2.3 Bed shear stress

Analysis of the present baseline conditions for sediments and their potential for transportation along the seabed within the study area included an investigation of expected bed shear stress. Shear stresses [measured as Newtons per square metre or N/m^2] arise at the seabed due to water motions related to tidal and wave induced currents. Shear stress was calculated using the hydrodynamic Delft3D model for a range of scenarios (appendix D13-8, APP-226). Characterisation of baseline seabed shear stress for tide only scenarios included investigation of spring and neap phases for mid-flood and mid-ebb conditions.

A range of coupled tide and wave scenarios for these conditions have also been run to include the typical wave condition, the winter wave condition and the high north wave condition using the 98th percentile wave. The results reveal a wide range of baseline shear stress. The highest (current-induced) bed shear stresses are found during powerful spring tides specifically during the mid-ebb phase; co-occurrence of waves during spring tides potentially enhances the bed shear stress in sufficiently shallow waters.

For all scenarios modelled, the seabed shear stress energy levels remain highest offshore. The lower values are located within the coastal embayments. During the summer, wave energy from comparatively small waves does not penetrate to the seabed within the embayments. However, during winter shear stresses, due to the presence of larger waves, increase across these inshore areas in particular, when wave direction is from the north.

Under baseline conditions, particles of sand would only be mobilised within the bays under high (north) energy wave and spring tidal regimes, and this area is widespread in inshore regions. Gravel mobilisation is largely confined to the offshore zone, but isolated pockets of gravel transport under the high north wave occur inshore in each of the major bays (Cemaes, Cemlyn, Porth-y-pistyll).

The modelling shows that the bed shear stresses for the fully built scenario (coupled with a 98%ile wave) depict the same areas of highest bed shear stress; these being close to the shore near the headlands to the west of Cemlyn Bay (Trwyn Cemlyn) for all wave conditions. Under both baseline and fully built scenarios, values greater than $12N/m^2$ (with potential to mobilise coarse gravels where present) have been predicted in the same locations, with slightly different spatial coverage predicted at Porth-y-pistyll due to the presence of the new structures.

Under a high north wave scenario, coupled with a 98%ile wave, the patterns of bed shear over a full spring tidal cycle are changed by the presence of the breakwaters but do not increase in their magnitude. At Esgair Gemlyn, a small decrease in bed shear stress has been indicated towards the eastern end of the shingle ridge. Within Cemlyn Bay the changes to bed shear stress from the presence of the breakwaters are highly localised areas of increased and decreased bed shear, that have been predicted in various locations under all wave scenarios. These changes lie mainly within the lowest ranges of $+0.1N/m^2$ to $+0.5N/m^2$ and $-0.1N/m^2$ to $-0.5N/m^2$. In the head region of Cemlyn Bay near to the ridge the results show no change in bed stress, except for a small localised zone to the north and associated with the ebb tidal delta of the lagoon drainage system. However, this would appear to occur during storms from the north-west only, and such would have only very minor temporally limited impacts on the net sediment transport.

Based upon the results of the modelling studies, overall changes in bed shear stress have been found to range mostly between $-0.1N/m^2$ and $+0.1N/m^2$ (figure D12-15) (APP-237 / 238). Changes in bed shear stress ranging between $-0.1N/m^2$ and $+0.1N/m^2$ are judged to generate no more than minor differences in terms of the transportable sediment fraction for both sands and gravels. Far larger differences in stress are required to generate significant changes to mobilisation of these grain sizes.

2.4 Cooling Water discharge

The Cooling Water (CW) outfall will be located at Porth Wnal, adjacent to the outfall of the Existing Power Station. CW discharges could cause localised changes to coastal and marine processes and effect the seabed as a consequence of locally increased shear stresses, as assessed in chapter D12, (APP-131).

A hydrodynamic model study was undertaken to assess potential impacts of the operation of CW intake and outfall during the lifetime of the project using Delft3D (chapter D13, APP-132) and including the discharge flows from the CW outfall. Changes to bed shear stress depicted in figure 15 (figure D12-15) indicate small areas of increased bed shear at the CW outfall location. However, these coincide with locations where soft sediments are not present and therefore no changes to sediment mobilisation would occur. At the CW intake, some decreases in bed shear are predicted under winter and high north wave scenarios; however, under no wave and typical wave scenarios, there would be no discernible change. It has therefore been assessed that the magnitude of effect upon the seabed (a low value receptor), of the operation of both the cooling water intake and outfall would be negligible, resulting in a negligible significance of effect.

2.5 Assessment on Esgair Gemlyn in the Environmental Statement

2.5.1 Potential for increased fine sediment deposition resulting from construction

The outcomes of baseline studies (reported in appendix D12-2, APP-217) show no linkage or pathway between potential sources of fine sediment from fluvial sources and Esgair Gemlyn. Furthermore, the modelling investigations (see appendix D13-8, APP-226) also depict the potential movement and deposition of fine sediment from dredging activities and drainage discharge during construction under calm conditions (representing a worst case scenario) to be limited to a localised area close to where the dredging of sediment would occur and at the point of discharge from the land surface within the Wylfa Newydd Development Area. Potential worst-case deposition is predicted to be less than 0.1cm at Esgair Gemlyn.

The magnitude of potential change in fine sediment deposition upon Esgair Gemlyn, was therefore assessed to be negligible, resulting in a negligible significance of effect.

2.5.2 Changes resulting from coastal processes

Potential changes in wave height indicated by model outputs suggest there could be an effect during a narrow band of high energy waves coming from northerly directions. During typical summer conditions the increase was shown to be negligible (appendix D12-3, APP-218). For several wave scenarios, a decrease in wave height was predicted by the model, especially for waves from the northeast.

Modelling of worst case scenarios, such as rare (99th percentile) winter waves arising from north-westerly directions during construction activities, showed that there could be a potential increase in wave height up to approximately +4%. However, this is lower than that of baseline storm waves arising from the northeast, consequently this change is considered within the range of natural variation.

The magnitude of change resulting from changes in wave height has been assessed to be small, resulting in a minor significance of effect on Esgair Gemlyn.

2.5.3 Potential for increased overtopping

To analyse the potential increase in overtopping at Esgair Gemlyn, three sets of data were examined:

- LiDAR transects based on 2010 and 2017 surveys (figure D12-10, reported in chapter D12, APP-131);
- baseline tidal water levels, more specifically Highest Astronomical Tide (HAT) of 3.9 mOD (reported in chapter D12, APP-131);
- baseline wave heights (Hs) in the nearshore area, based on the modelling of a 99%ile NW wave;

Figure 3 below shows the location of transects, their elevations, the difference between 2010 and 2017 LiDAR surveys, and the corresponding baseline wave heights in the vicinity of each transect. At Esgair Gemlyn, baseline extreme wave heights (based on the nearshore transformation of a 99%ile NW wave) were found to be smallest (around 0.8 m) closer to the Cemlyn Lagoon ebb tidal delta (to the west) and greatest (between 1.8 and 2 m) at the centre of Esgair Gemlyn. To the east, wave heights were found to have intermediate values (between 1 and 1.4 m).

The potential changes in extreme wave height of up to 0.2 m were only predicted for a small and localised area to the west of Cemlyn Bay, close to the Cemlyn Lagoon ebb tidal delta. This area corresponds to Transects P11 and P13. For this analysis, Transect P11 was chosen, given it is the lowest with an elevation of approximately 4.7 mOD (figure 3).

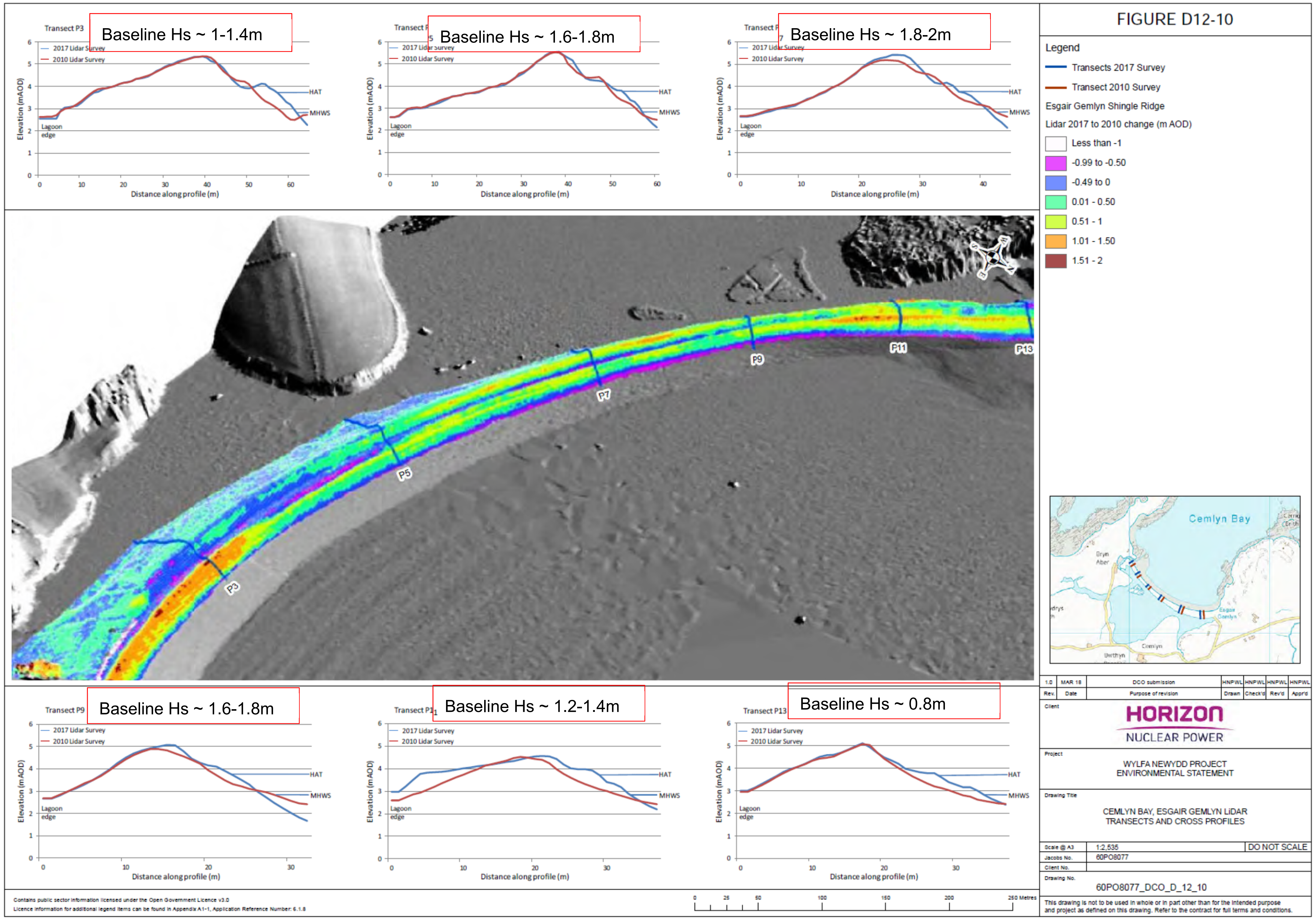
Considering that water levels during an extreme storm event would be caused by an extreme wave height coupled with high spring tides, extreme water levels would have an elevation of around 5.3 mOD (HAT of 3.9 mOD and extreme wave height of 1.4 m at the vicinity of Transect P11). This, therefore, indicates that, during extreme events, Esgair Gemlyn currently experiences some degree of overtopping. This is further corroborated by the description of the Cemlyn Bay Special Area of Conservation (SAC) in the Joint Nature Conservation Committee (JNCC) website[2]:

> *Cemlyn lagoon on the north coast of Anglesey, north Wales, is considered to be the best example of a saline **coastal lagoon** in Wales. The lagoon is separated from the sea by a shingle bank with a narrow channel at the western end, across which a sluice system was built in the 1930s. Seawater exchange occurs mainly through the sluice and by percolation through the shingle bank, although in extreme storms coinciding with spring tides waves break over the top of the shingle bank.*

The localised increase of up to 0.2 m in extreme wave heights in the vicinity of Cemlyn Lagoon ebb tidal delta, therefore, is not likely to significantly change the present baseline condition, given that the ridge already experiences overtopping during extreme conditions.

[2] Cemlyn Bay SAC, Coastal Lagoons 1150, Annex I. Available on: http://jncc.defra.gov.uk/protectedsites/sacselection/sac.asp?EUCode=UK0030114. Consulted on: 18 Oct 2018.

Figure 3: Difference in LiDAR images between 2010 and 2017 surveys, and transects extracted using LiDAR along Esgair Gemlyn, Cemlyn Bay. Text within red boxes indicates baseline wave heights (Hs) in the nearshore region, based on modelling with a 99 percentile NW wave.



3 Coupled hydrodynamics and 99th percentile wave condition

This section of the report provides the results of the more recent modelling (post application) that was undertaken to look at the effect of coupling the 99th percentile wave condition with the hydrodynamics to examine bed shear stress.

3.1 Supplementary Modelling (post DCO Submission)

The additional modelling has simulated the differences in depth averaged flow field and bed shear stress during baseline (no Project) and fully built (operational) scenarios due to the tidal flow combined with waves. The wave condition simulated was an extreme case being the 99%ile winter wave used in the SWAN modelling undertaken by HR Wallingford (appendix D12-3, APP-218). The wave condition used in the study was a 99thpercentile winter wave with a direction 300° north of Wylfa Head. This 99th percentile wave was based on the winter period only (rather than on the whole year), which is representative of a true worst-case scenario of infrequent and extreme condition.

The modelling shows that the inclusion of the extreme wave condition increases the inshore bed shear stress particularly in the nearshore shallow areas of the bays either side of Wylfa Head. The general distribution of bed shear stress under the fully built scenario with waves has been found to be similar to that for the baseline with the exception of localised areas in the vicinity of the breakwaters and intake structures.

The modelling was completed to show the effects of both a spring and neap tide on mid ebb and mid flood under the fully built scenario when compared against the baseline. The results are shown in figures 4 to 11 below. In all of the modelling scenarios presented it is evident that the presence of the western breakwater acts to reduce the bed shear stress across the majority of Cemlyn Bay when compared with the pre-construction scenario, with only localised areas of increase close to the shoreline (right hand images).

Figure 7 shows the difference in maximum bed shear stress between pre-construction baseline and operational conditions with a spring tide mid-ebb scenario (99th percentile wave). This shows that the presence of the marine structures results in an increase in the bed shear stress near to the western shore in Cemlyn Bay of less than 0.5 N/m^2. In the vicinity of the bay entrance the difference ranges from 0.5 N/m^2 to 5 N/m^2. However, in the centre and to the south-east of the bay the shear stress is reduced compared to baseline. Under the spring tide mid-flood scenario (figure 5), the presence of the marine structures results in a small reduction in bed shear stress in the offshore area, with a change in Cemlyn Bay in the order of ±1 N/m^2.

For the neap tide mid-ebb and mid-flood scenarios (figures 9 and 11), there are shown to be largely small decreases in bed shear stress, although there are also localised increases of up to 1 N/m^2 near the shore in Cemlyn Bay and a band of higher shear stress (up to 4 N/m^2) across the northern edge of the Bay.

Figure 4: Comparison of bed shear stress with no waves and 99th percentile waves for a spring tide mid flood with baseline (pre-construction) and fully built (post-construction) scenarios.

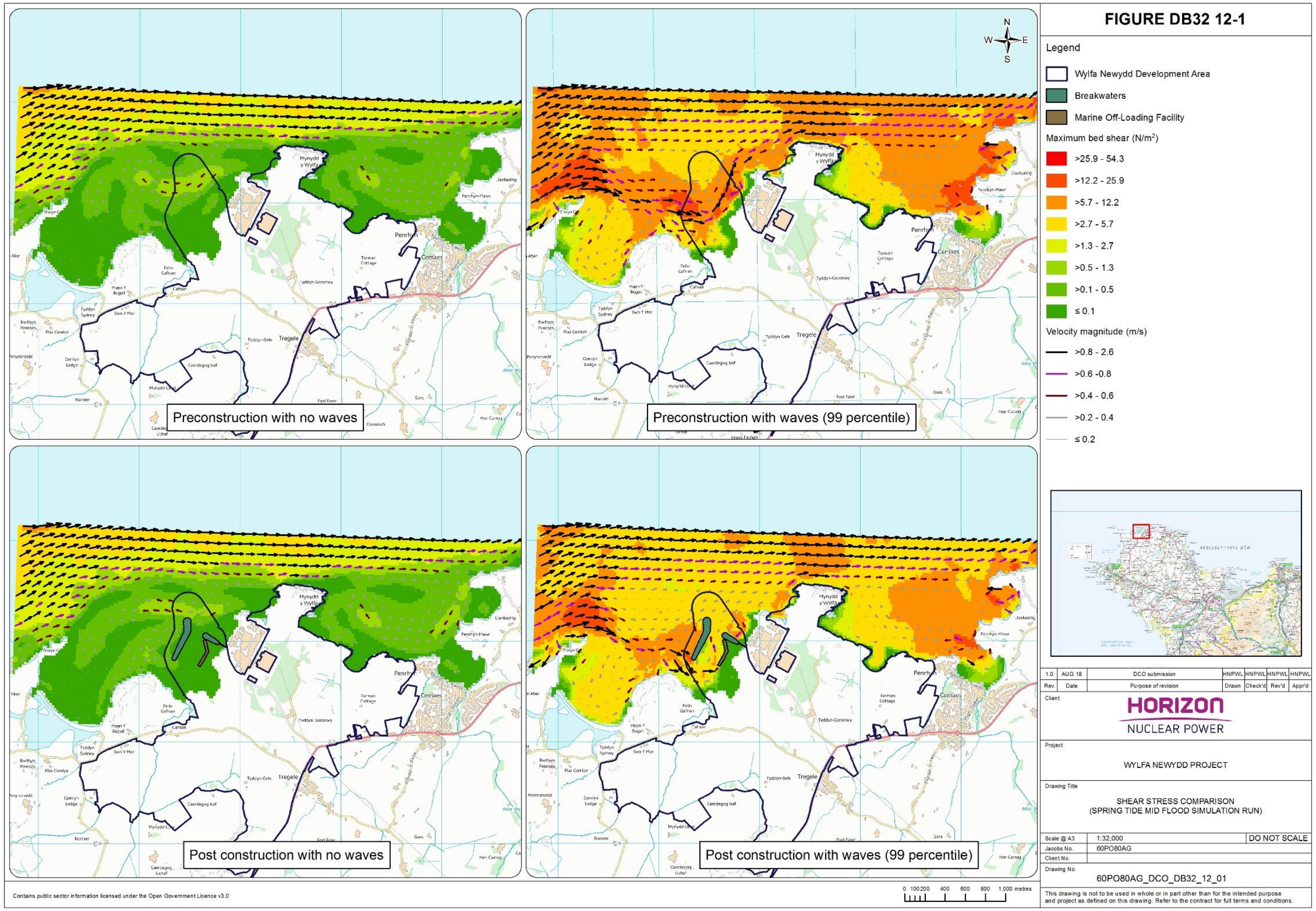


Figure 5: Difference in maximum bed shear stress between baseline and fully built scenarios, with a 99 percentile NW wave on a spring tide mid-flood. Green arrows indicate current direction without the development; black arrows indicate current directions with the development.

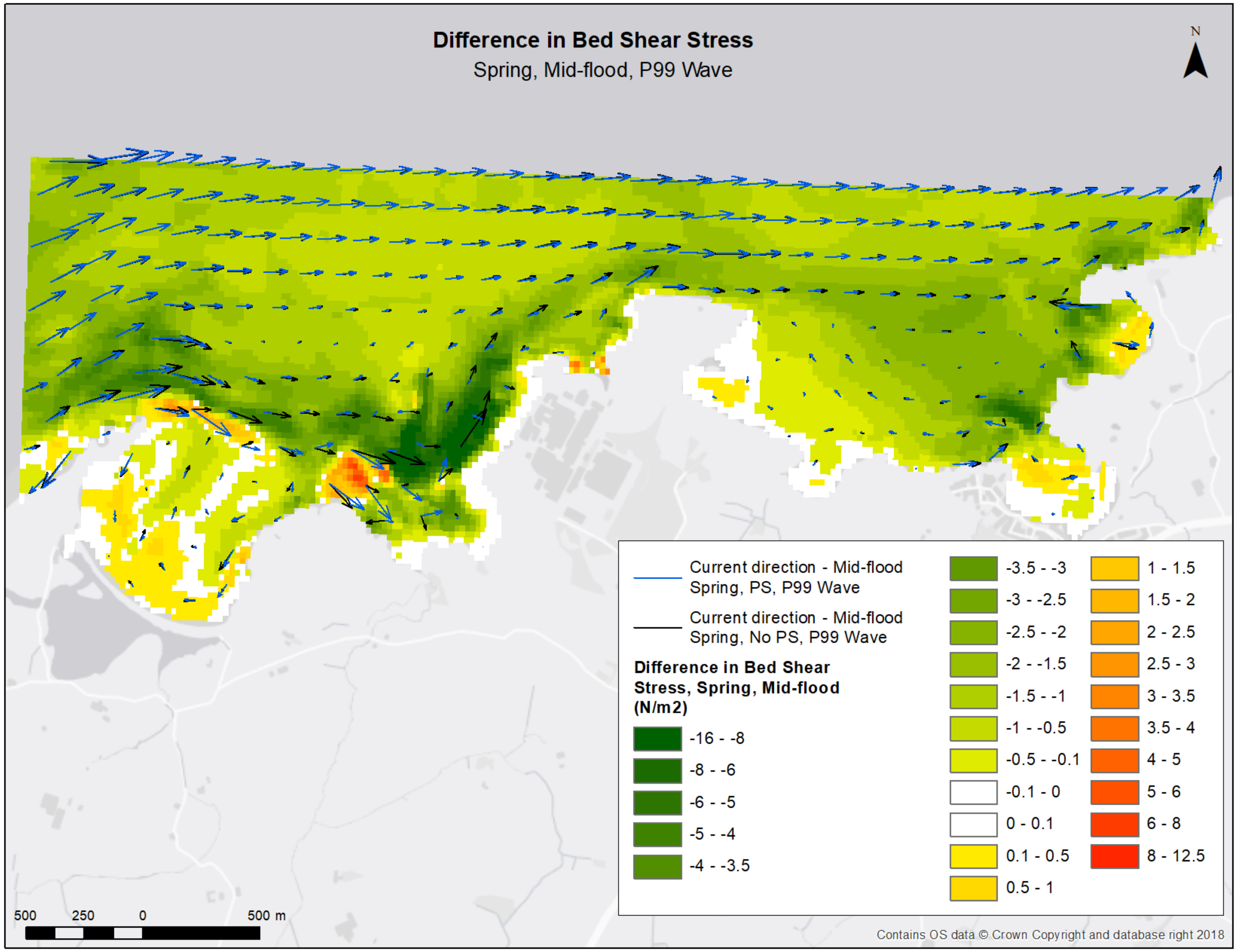


Figure 6: Comparison of bed shear stress with no waves and 99th percentile waves for a spring tide mid ebb with baseline (pre-construction) and fully built (post-construction) scenarios.

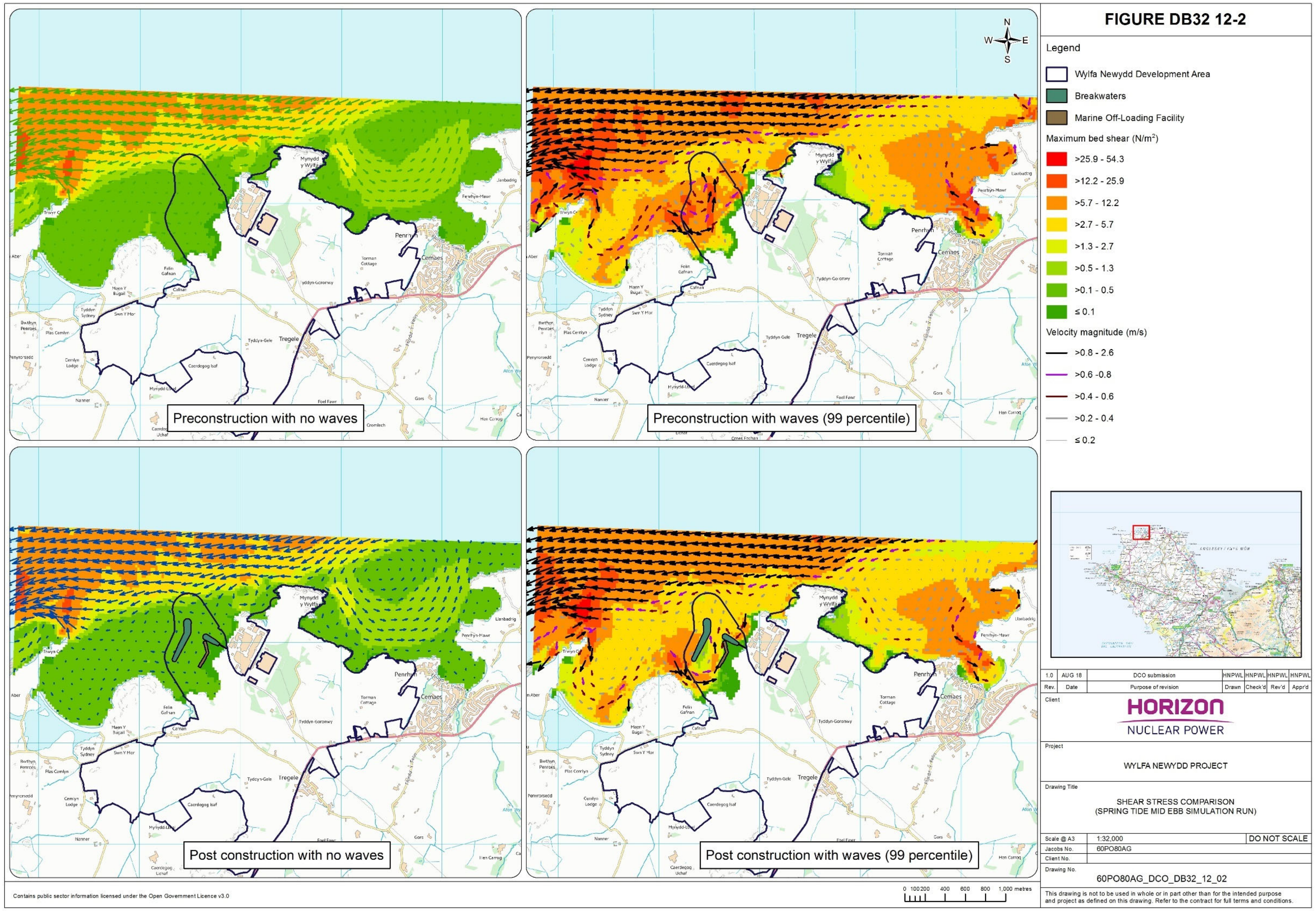


Figure 7: Difference in maximum bed shear stress between baseline and fully built with a 99 percentile wave on a spring tide mid ebb. Green arrows indicate current direction without the development; black arrows indicate current directions with the development.

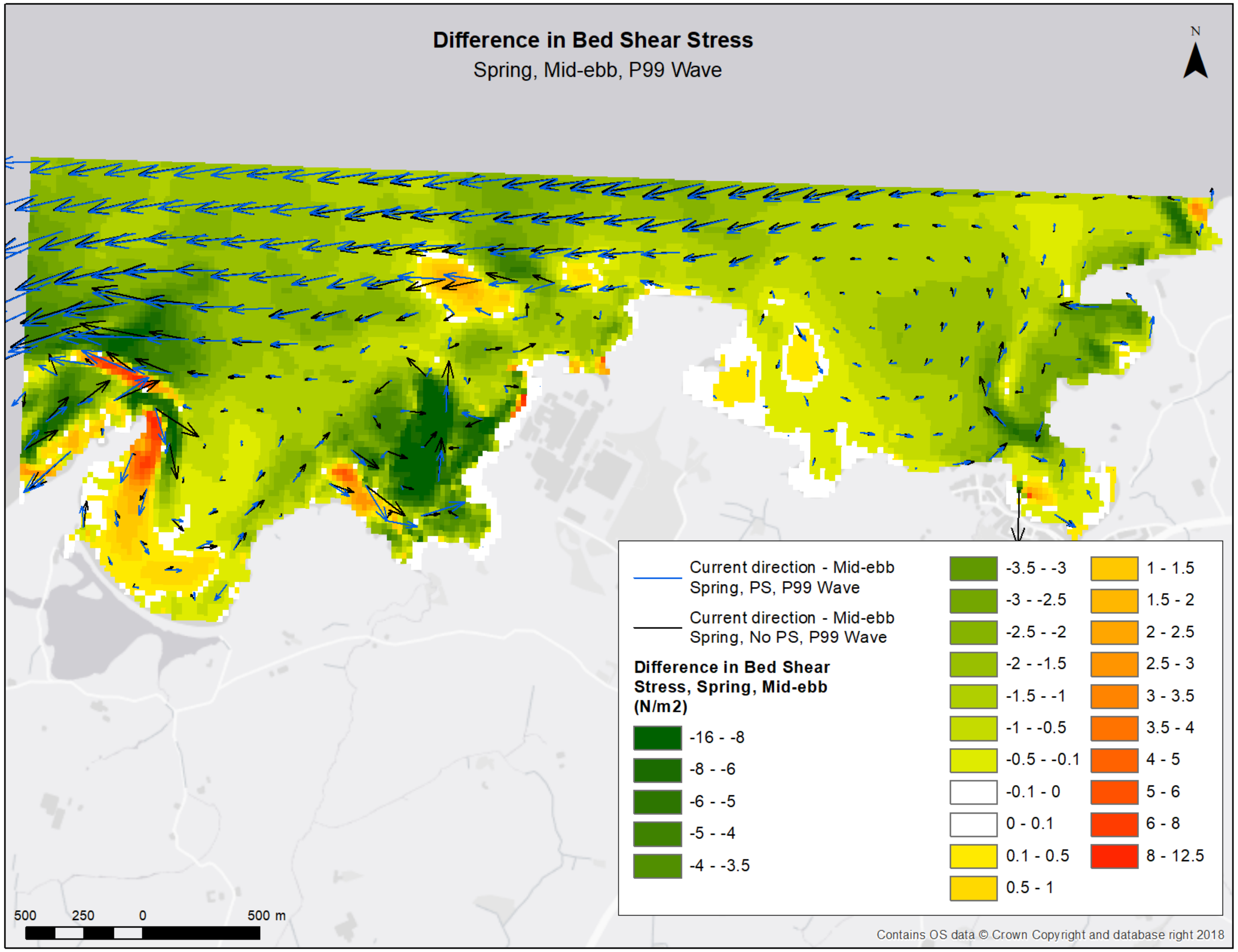


Figure 8: Comparison of bed shear stress with no waves and 99th percentile waves for a neap tide mid flood with baseline (pre-construction) and fully built (post-construction) scenarios.

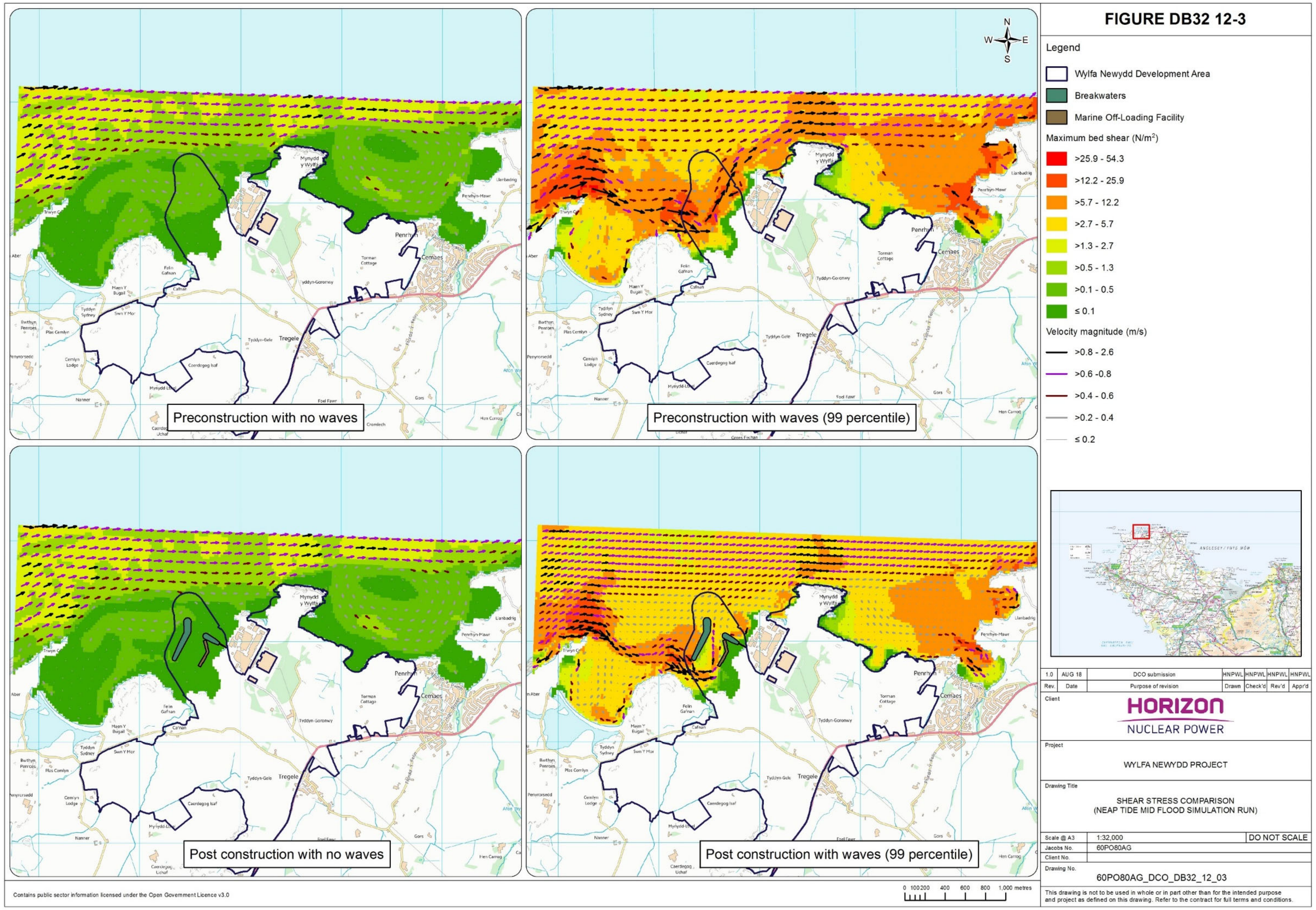


Figure 9: Difference in maximum bed shear stress between baseline and fully built scenarios, using 99 percentile NW wave on a neap tide mid-flood. Green arrows indicate current direction without the development; black arrows indicate current directions with the development.

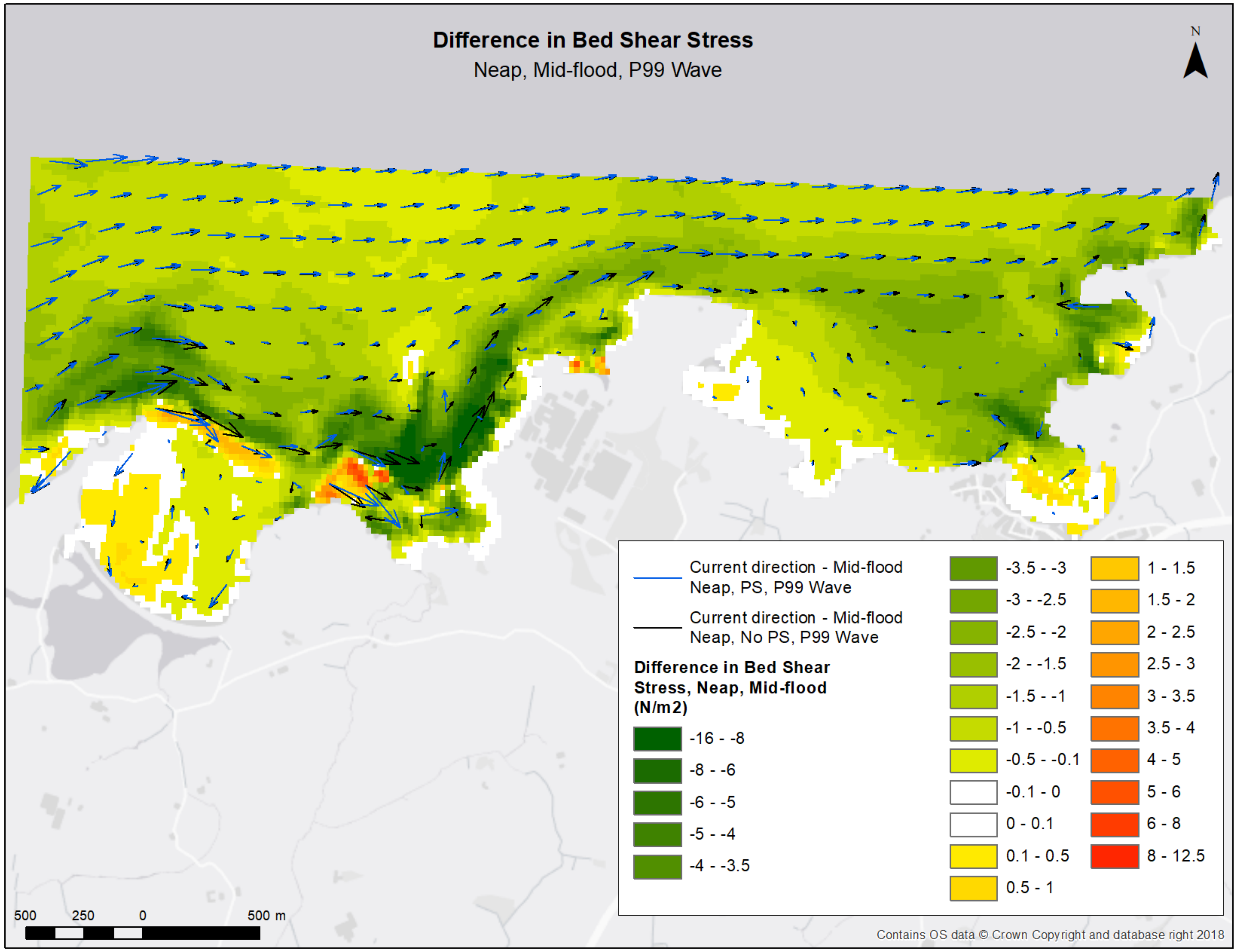


Figure 10: Comparison of bed shear stress with no waves and 99th percentile waves for a neap tide mid ebb with baseline (pre-construction) and fully built (post-construction) scenarios.

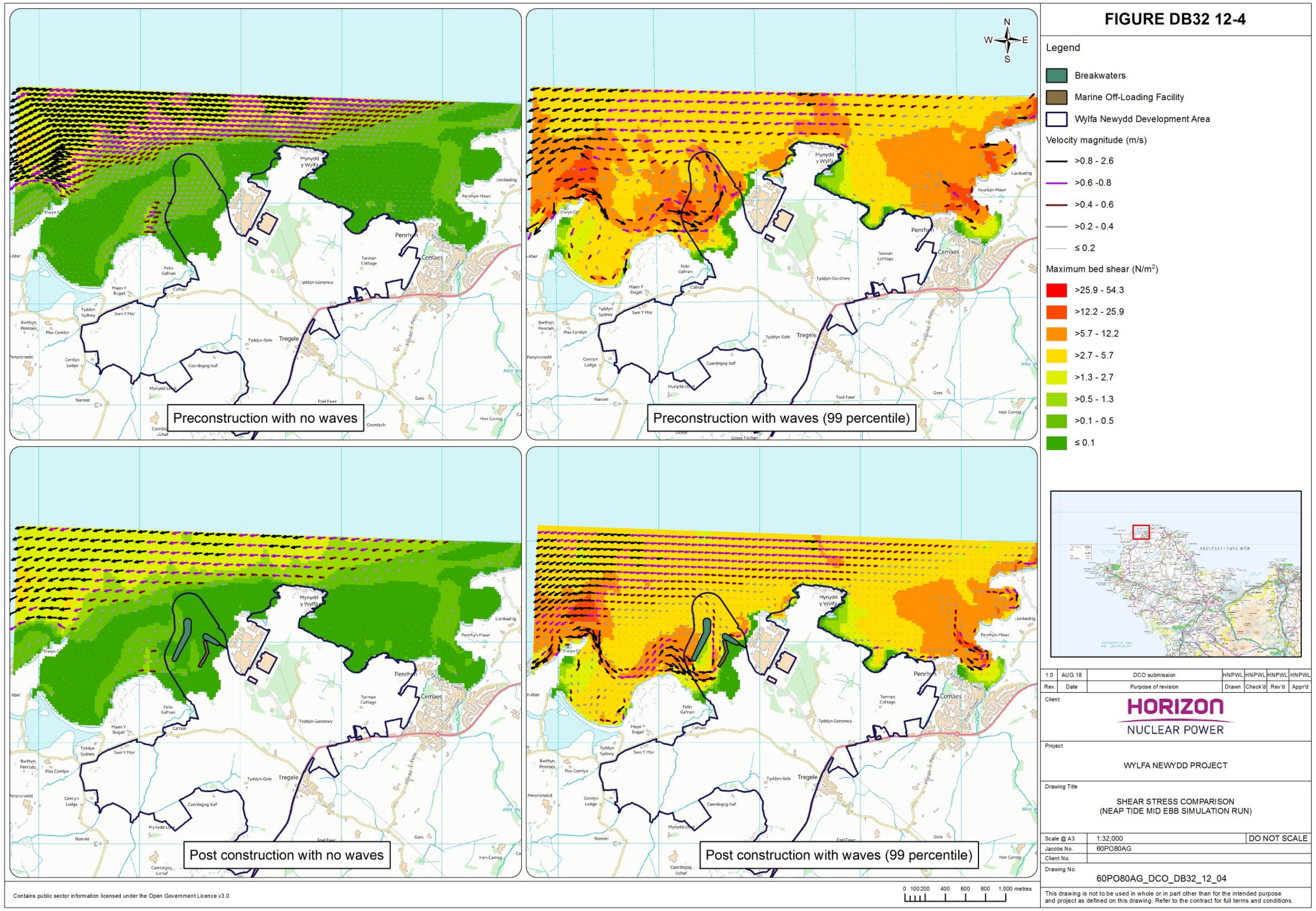
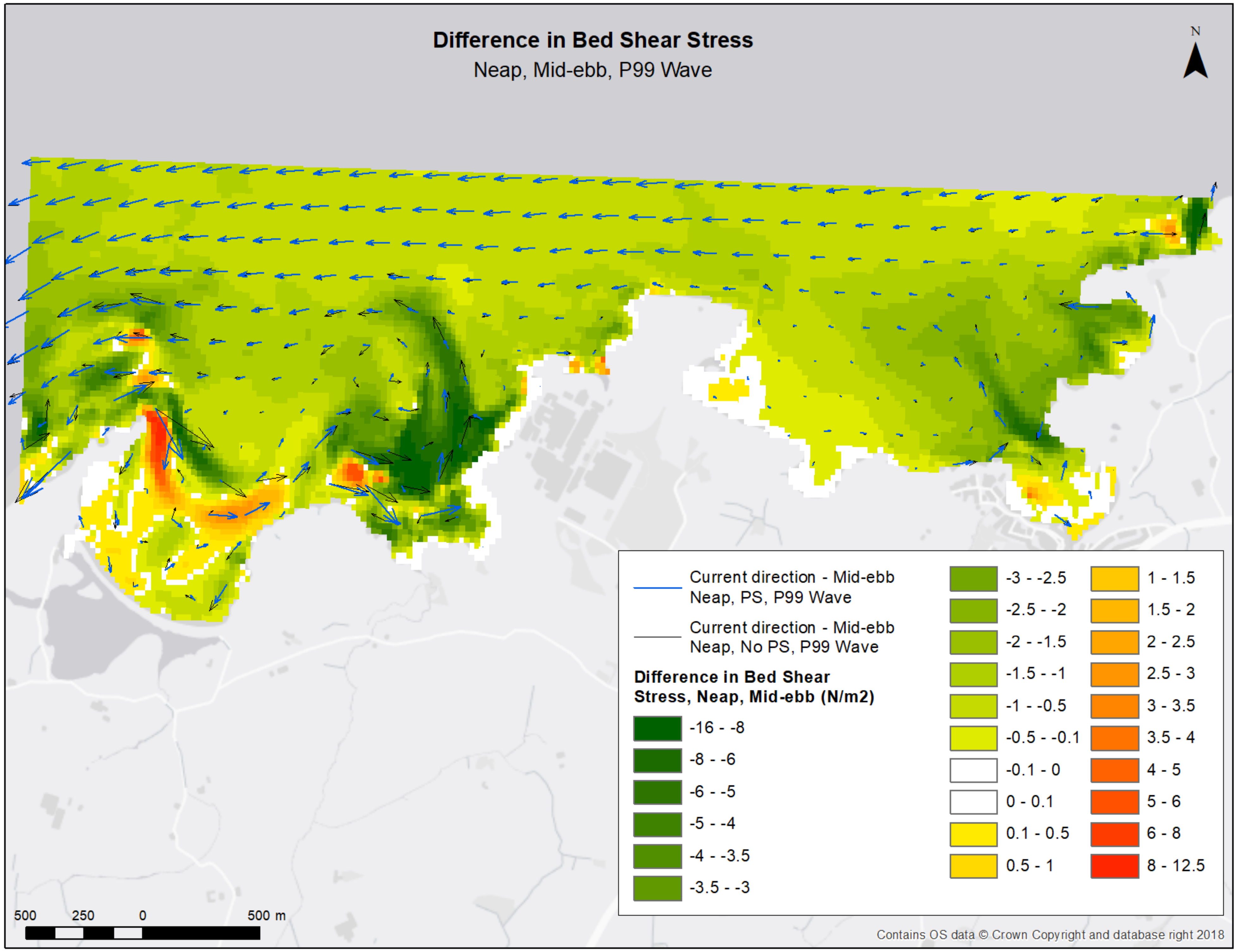


Figure 11: Difference in maximum bed shear stress between baseline and fully built scenarios, using 99 percentile NW wave on a neap tide mid-ebb. Green arrows indicate current direction without the development; black arrows indicate current directions with the development.



3.2 Significance in the context of the assessment

3.2.1 Assessment of potential impacts within Cemlyn Bay and Esgair Gemlyn

It has been shown, through the modelling undertaken as part of the Wylfa Newydd ES and presented within chapter D12 (APP-131) that high energy events from the north and north-east dominate coastal and sedimentary processes, and control the present day morphological evolution of Cemlyn Bay and Esgair Gemlyn. Whilst accepting that there would be a small degree of wave reflection at the western breakwater during storms from the north-west, effects associated with this within Cemlyn Bay are minor in comparison to the spectrum of energetics the Bay experiences during northerly and north-easterly storm conditions which directly hit the bar.

The refocussing of the wave energy in Cemlyn Bay is sensitive to the wave direction. Results of the SWAN modelling (appendix D12-3, APP-218) indicates that 99th percentile waves from the north-west sector (Hs = 4.03 m at Offshore Point 3) would display an increase in wave height compared with baseline around the western breakwater of the order of 0.1 - 0.4 m. There would be a potential increase of ~0.1 m (on wave heights of 0.4-1.2m) in the vicinity of the Cemlyn Lagoon ebb tide delta. This localised difference in wave height is not anticipated to give rise to substantially different sediment resuspension rates on the seabed, nor to changes to local sediment transport patterns. Furthermore, in the context of the wave heights and associated energy impacting upon the foreshore of Esgair Gemlyn, during northerly and north-easterly storms, wave heights immediately in front of Esgair Gemlyn would be of the order of 1.2 - 2m. This would be expected to impact more significantly on seabed resuspension. In this respect changes to wave heights and wave energy due to reflection at the western breakwater are considered minor in relation to the larger waves and associated sediment resuspension and transport processes occurring during northerly/north-easterly storms.

Assessments have demonstrated that under various conditions (spring tides with i) typical wave; ii) winter waves; and iii) high northerly wave) there would be little or no change to the bed shear stress, and hence also to the local sediment transport regime, within inner Cemlyn Bay and in particular along the shore face and intertidal areas of Esgair Gemlyn. Modelling has shown that bed shear stress is predicted to increase by up to 0.5 N/m^2 (under a spring tide with a north wave 98th percentile) in a small area to the west of Cemlyn Bay. This increase would result in a bed shear stress of between 3.2 to 6.2 N/m^2, compared with a baseline of 2.7 to 5.7 N/m^2. Table 1 shows that the elevated stresses would mobilise largely the same sediment as the baseline situation (possibly marginally coarser material) over a slightly greater area.

The increased values resulting from the presence of the marine infrastructure are within the same range as baseline and would mobilise similar grain sizes. This is further supported by the 99th percentile modelling of bed shear stress with a north-west wave which show a potential increase of up to 1 N/m^2 across the spring tide in the west of Cemlyn Bay. This increase would result in a bed shear stress of between 3.7 to 6.7 N/m^2 which again does not represent a significant change to the baseline conditions in terms of bed shear stress and associated effect on sediment mobilisation.

It is concluded that the predicted effects are not substantially different to the baseline situation, and hence it is predicted that no significant morphological or compositional changes would occur at the ridge as a result.

Table 1: Critical bed shear stress (N/m^2) for different sediment grain size.

Sea bed sediment / feature label	Average particle diameter (D50) range (mm)	Critical bed shear stress (τ_c) (N/m^2)
Very coarse gravel	32 - 64	>25.9
Coarse gravel	16 - 32	12.2 – 25.9
Medium gravel	8 - 16	5.7 – 12.2
Irregular sandy gravel	4 - 8	2.7 – 5.7
Smooth sandy gravel	2 - 4	1.3 – 2.7
Very coarse sand	1 - 2	0.5 - 1.3
Sand - featureless	0.1 - 1	0.1 – 0.5

A conceptual understanding was produced to assess all the potential changes (even small ones) that could be caused in relation to coastal processes and Esgair Gemlyn. This has also helped assess the potential for erosion and/or scour of the ridge. The conceptual understanding is shown in figure 12 and considered a number of datasets:

1) Small changes in magnitude of ebb and flood flows coupled with wave induced currents, using the outcome of the 99%ile NW wave modelling. These differences can be observed in figures 4 to 11.

2) Sediment type within the Cemlyn Bay, using the outcome of sediment samples and geophysical survey. This has been reported in appendix D12-2, (APP-217). In general terms, geophysical surveys identified that most of Cemlyn Bay comprised featureless smooth sandy seabed and bedrock, with a small area to the west of smooth sandy gravel seabed. To corroborate and validate the geophysical surveys, sediment samples were taken and sample WS3 located at the entrance of Cemlyn Bay showed a particle size distribution of very fine to medium sands (around 95%) with a very small content (around 5%) of silt and clay.

3) Analysis of sediment sizes along Esgair Gemlyn. This has been reported in chapter D12, APP-131). Table D12-8 of chapter D12 (reproduced below as table 2) showed that the shingle ridge comprised a range of sediments from fine sandy gravel at the lower foreshore to medium gravel on the ridge crest. The mid to upper beach was reported to be moderately sorted, whilst the lower beach was poorly sorted.

4) Potential changes in bed shear stress across the bay under the worst-case scenario (spring tide mid-ebb). This can be observed in figure 7 and showed a general increase of bed shear stress of up to 0.5 N/m2 across the centre-western side of the Cemlyn Bay and a reduction of same magnitude on the eastern. Localised increases were observed on the western of the Bay, up to 5 N/m2.

5) Beach profiles of the ridge using the outcome of LiDAR transect analysis (figure 3). This has been reported in chapter D12, (APP-131). In general, the transect analysis showed that beach profiles have been stable over the period of analysis (between 2010 and 2017), with small changes likely to be seasonal related.

Table 2: Characterisation of sediment on shingle ridge (Source: [RD13] in chapter D12 (APP-131), page 25)

Location	Sorting	Type	Average particle size (D50)
Upper beach/ ridge crest	Moderately well sorted	Medium gravel	20-35mm
Mid-beach	Moderately sorted	Finer gravel	7-17mm
Lower beach	Poorly sorted	Fine/ sandy gravel	5-9mm

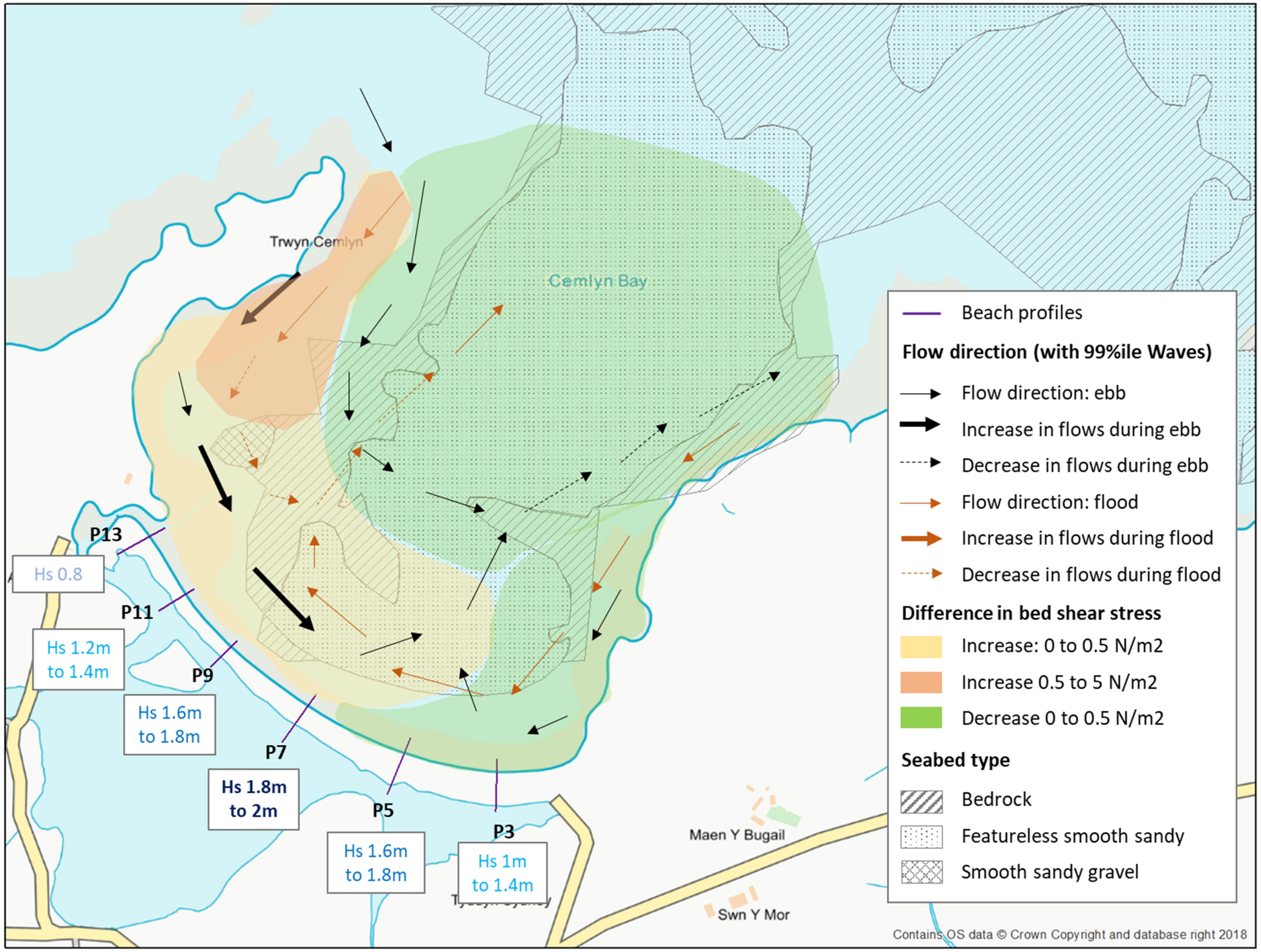
The conceptual understanding of the potential changes (figure 12) showed that a small increase in ebb flows (coupled with a 99%ile NW wave) is likely to occur in the nearshore area between Trwyn Cemlyn and Esgair Gemlyn, whilst a decrease is expected for ebb flows on the eastern part of Cemlyn Bay, adjacent to Trwyn Pencarreg, and for flood flows (coupled with a 99%ile NW wave) to the western of Cemlyn Bay. It is important to note that the description of potential changes below include the marine area of Cemlyn Bay, which is within the Anglesey Terns Special Protection Area (SPA) and North Anglesey Marine candidate Special Area of Conservation (cSAC), as well as the Cemlyn Bay SAC, SSSI and Cemlyn Bay and The Skerries SPA.

These would result in the pattern of bed shear stress described previously. Mostly at the area of small increase in ebb flows, bed shear stress would increase up to 0.5 N/m2 (west of Cemlyn Bay, where seabed comprises smooth sandy gravel) and in the area of small decrease of ebb flows (east of Cemlyn Bay, where seabed comprises irregular sandy gravel), a decrease of the same magnitude (0.5 N/m2) would be expected in bed shear stress. Given the very similar types of seabed and the small potential change in bed shear stress, changes in sediment drift and deposition are unlikely.

The changes in bed shear stress of up to ±5 N/m2 were observed (spring tide mid-ebb scenario) to be very localised in two main areas: to the west part of Cemlyn Bay (figure 12). This could mobilise medium gravel instead of the currently baseline of smooth sandy gravel, which would be transported along Esgair Gemlyn. In the worst-case scenario, this could slightly change the sorting of sediments along the ridge, but the composition of the sediments is not expected to change given medium gravel is within the spectrum of grain sizes found in the ridge. Moreover, the decrease in ebb flows on the eastern side of Cemlyn Bay would mean that any resuspended sediments due to an increase of bed shear stress would not be lost offshore and, instead, would be kept within the bay. Effects for the wider Cemlyn Bay SAC are, therefore, unlikely.

The stable condition observed across all the transects analysed along Esgair Gemlyn leads to the conclusion that the ridge is currently in a dynamic equilibrium. According to Reeve et al. (2012), the equilibrium beach slope will reduce with increasing wave steepness. Given that wave heights or lengths would not significantly change with the development in place, and baseline wave period would not be predicted to change, it is reasonable to believe that the beach slopes would remain in equilibrium for the lifetime of the project.

Figure 12: Conceptual understanding of potential changes in coastal process within Cemlyn Bay and Esgair Gemlyn.



The changes described above are confined to the area of Cemlyn Bay and in the vicinity of the development (i.e. Porth-y-pistyll). Any changes further afield, i.e. to the west Trwyn Cemlyn and in the offshore area around 400 m offshore of the western breakwater are likely to be due to noise of the numerical model.

3.2.2 Assessment of potential impacts in coastal processes due to Cooling Water discharge

To analyse the influence of the Cooling Water (CW) discharge on coastal processes on both the inner and outermost grids, differences in bed shear stress were produced as follows:

1) Under a scenario with Power Station (PS), differences in bed shear stress with CW flows and without CW flows. were calculated. These plots used a typical wave under spring tide mid-flood (figure 13) and spring tide mid-ebb (figure 14) scenarios, and are shown for the innermost grid.

2) Differences in bed shear stress with PS plus with CW flows and baseline (no PS) were calculated. These plots used a 99%ile wave under spring tide mid-flood (figure 15) and spring tide mid-ebb (figure 16) scenarios, and are shown for the outermost grid.

Figure 13: Difference in bed shear stress (N/m^2) with the development in place during spring tide mid-flood, with and without CW flows

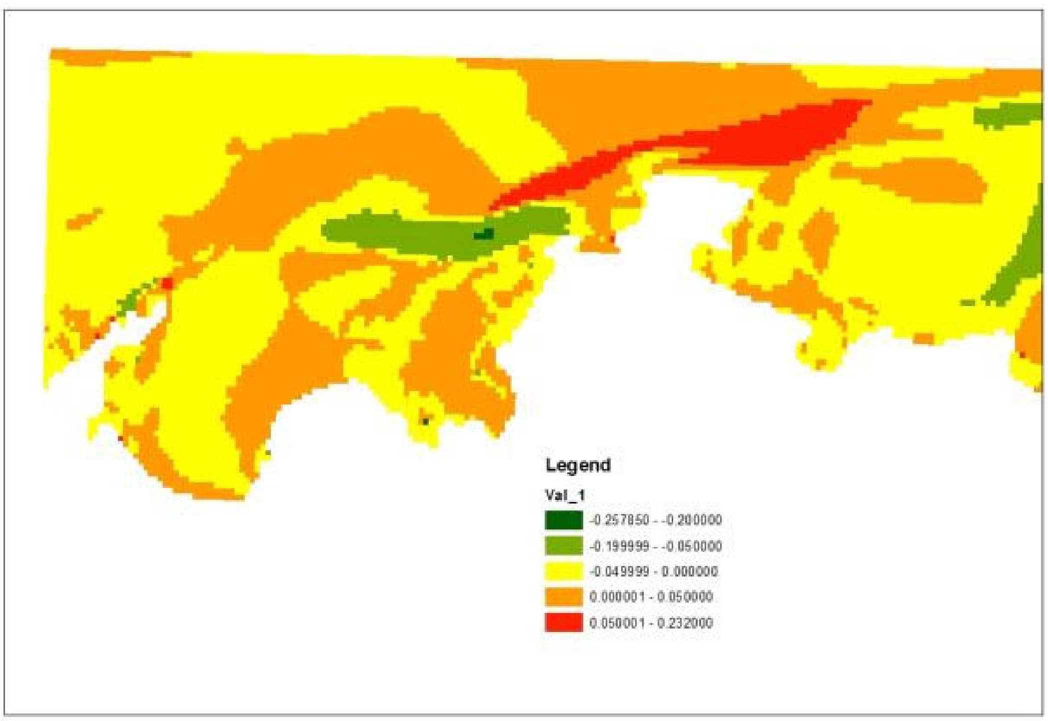


Figure 14: Difference in bed shear stress (N/m2) with the development in place during spring tide mid-ebb, with and without CW flows.

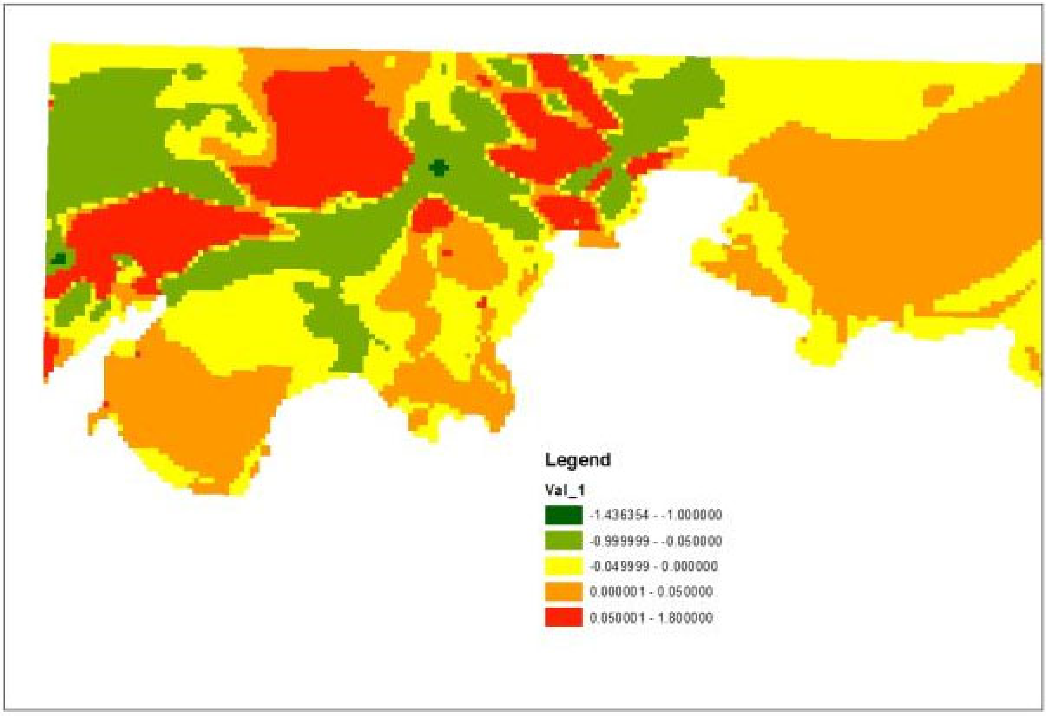


Figure 15: Difference in bed shear stress (N/m2) with the development in place and CW flows minus baseline (with a 99%ile wave) during spring tide mid-flood.

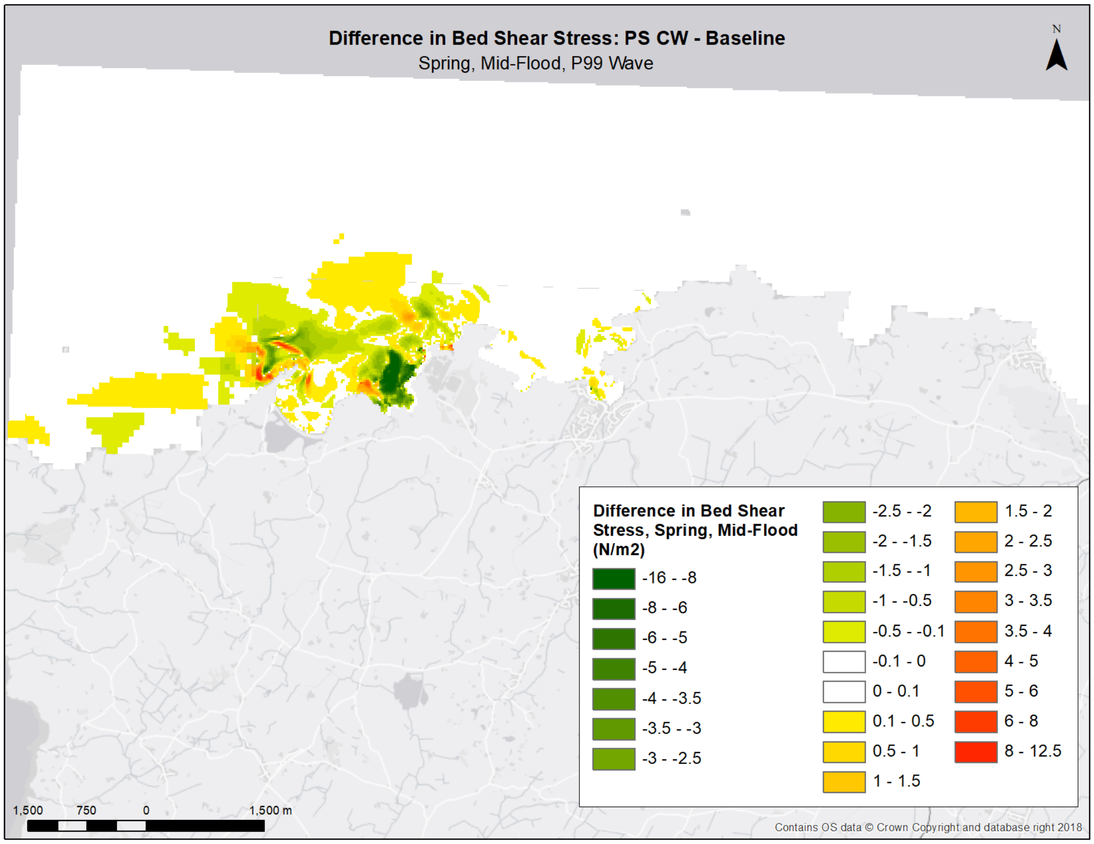
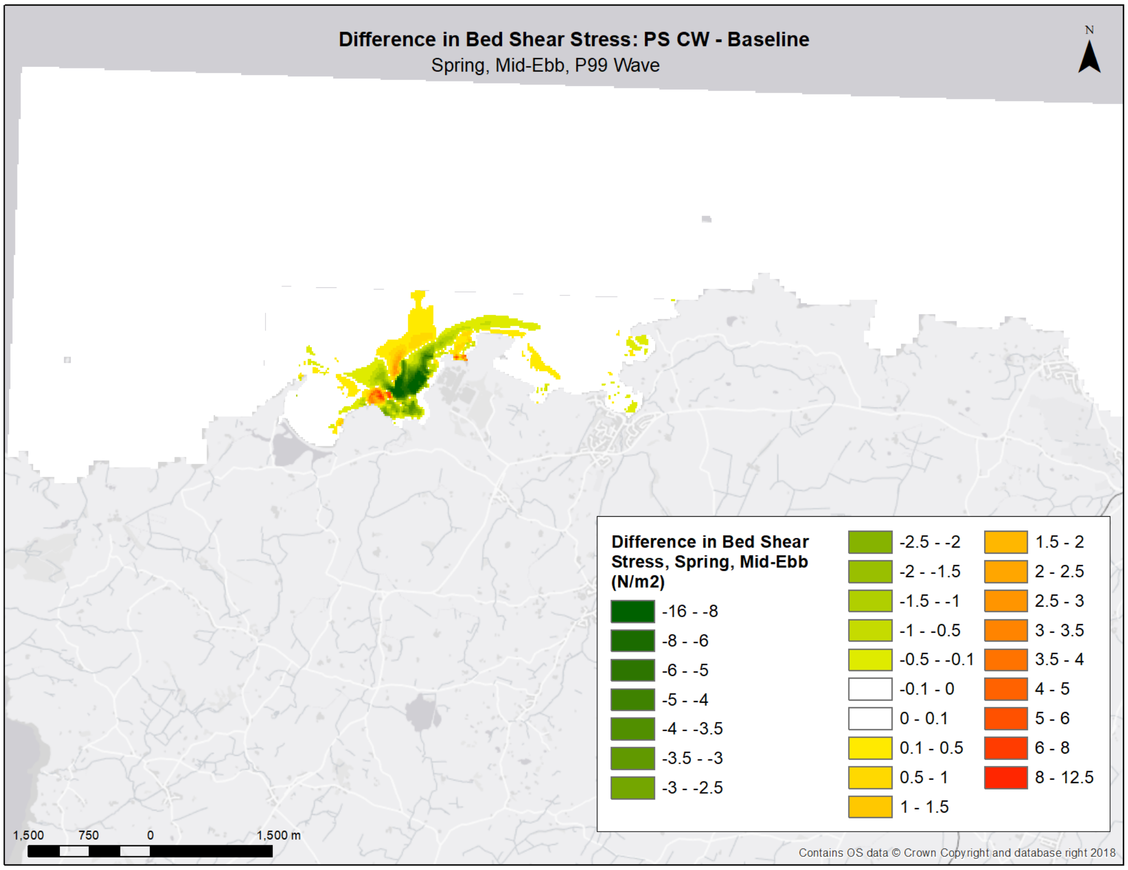


Figure 16: Difference in bed shear stress (N/m2) with the development in place and CW flows minus baseline (with a 99%ile wave) during spring tide mid-ebb.



Figures 13 and 14 showed that the inclusion of the CW flow for typical wave varies nearshore bed shear in Cemlyn Bay by ± 0.05 N/m2, which is likely to be within the accuracy of the model. Figures 15 and 16 showed that the CW flows would have a greater influence in bed shear stress under an extreme wave during mid-flood rather than during mid-ebb tides. Changes in bed shear stress during mid-flood would be greater than ±2 N/m2 at the location of the development and at localised sites to the west of Trwyn Cemlyn. An increase of between 0.1 and 0.5 N/m2 would be possible as far as 1 km north of the development. During mid-ebb tide, differences in bed shear stress between the scenario with CW flows and baseline (with 99%ile wave) were mainly expected to occur in the area of the development.

These plots showed, therefore, that changes in bed shear stress due to the CW flows are likely to occur offshore, where the baseline shear stress is higher than at the nearshore areas. Small changes in bed shear stress up to ±0.2 N/m2 are, however, likely to be related to the model resolution and noise, instead of impacts due to the CW flows.

3.2.3 Conclusion

It is concluded that sediment transport related to resuspension of bottom silts/sand/gravels, swash processes potentially affecting/modifying gravel ridge morphology, and cross shore sediment transport processes would be nominally the same for the fully built situation (operation stage) as they are for the baseline situation.

In light of the above information there are no changes to the conclusions presented in chapter D12 (APP-131), and the Shadow HRA (APP-050 / 051) with respect to bed shear stress and the potential effects of coastal processes on Esgair Gemlyn in that there are no significant differences from baseline conditions. Based on the additional modelling scenarios undertaken and reported above, it can be concluded that the 98th and 99th percentile wave conditions are comparable worst cases in terms of the effect on bed shear stress and potential to affect coastal processes.

The evidences presented in the previous section together with the conceptual understanding of the potential changes to Cemlyn Bay and Esgair Gemlyn led to the conclusion that coastal processes within the Bay and the dynamic equilibrium of the ridge would be unlikely to change due to the presence of the western breakwater. Erosion and/or scour of the ridge would be unlikely given that sediment supply would not be expected to change and any variations in ebb and flood flows would likely be small.

4 Baseline sediment data

Whilst from a scientific perspective more data are always valuable, it is considered that the collection of additional sediment data from Cemlyn Bay for the purposes of this assessment would be unwarranted. As shown in sections 2 and 3 above, based on the extensive modelling efforts completed during the preparation of the Wylfa Newydd ES, combined with the opinion of the various experts that have inputted to the assessment, there would be very little or no significant change to coastal processes/oceanographic conditions within Cemlyn Bay and the associated feature of Esgair Gemlyn as a consequence of the Project.

The rationale for this judgement is that high energy events from the north and north-east dominate coastal and sedimentary processes and control the present day morphological evolution of Cemlyn Bay and Esgair Gemlyn. Whilst accepting that there would be a degree of wave reflection at the western breakwater during storms from the north-west, which could increase the occurrence (or the number of) waves reaching Cemlyn Bay from a north-east direction. Effects associated with this within Cemlyn Bay including very localised increases in bed shear stress in the western area of the bay, would be within the spectrum of energetics the Bay experienced from the north and north-east. The spectrum of energetics within the Bay would be unlikely to change as wave heights and wave periods are similar under both baseline and fully-built scenarios. The increase in occurrence of waves, observed for waves with heights between 0 and 0.5 m, would not be expected to result in changes in cross-shore and longshore sediment drifts as the beach profile, once in equilibrium, would not change with the same wave reaching once or twice. Wave direction has also been observed to be as per baseline, so no change to sediment drift patterns is expected.

As the proposed development does not cause significant impact to these processes it becomes increasingly difficult to justify why additional sediment data from these locations would be necessary.

The potential for sediment resuspension and transport in Cemlyn Bay, and subsequent morphological adjustment of the storm beach/gravel ridge of Esgair Gemlyn, would be greatest during conditions of highest energy and that those conditions are experienced in this area during storms and associated waves originating from the north and north-east sectors. The wave modelling undertaken has confirmed that the most energetic conditions impacting upon Cemlyn Bay and Esgair Gemlyn arise during northerly and north-easterly storms. These events generate waves unimpeded by the morphology of the coastline (i.e. headlands) and directly transmitted into the bay. This situation remains the same for the baseline, partially built and fully built scenarios that have been modelled.

The scenarios modelled with a coupled hydrodynamic and wave model during the preparation for the Wylfa Newydd ES (figure 17) shows the differences in maximum bed shear stress for the fully built scenario. It demonstrates that under various conditions (spring tides with i) typical wave; ii) winter waves; and iii) high northerly wave) that there would be small localised changes or no change to the bed shear stresses, and hence also to the local sediment transport regime, within inner Cemlyn Bay and in particular along the shore and intertidal areas of Esgair Gemlyn. Therefore, it is considered reasonable to suggest that sediment transport related to such events including resuspension of bottom silts/sand/gravels, swash processes affecting or modifying gravel ridge morphology, and cross shore sediment transport processes would be nominally the same for the fully built situation (operation stage) as they are for the baseline situation.

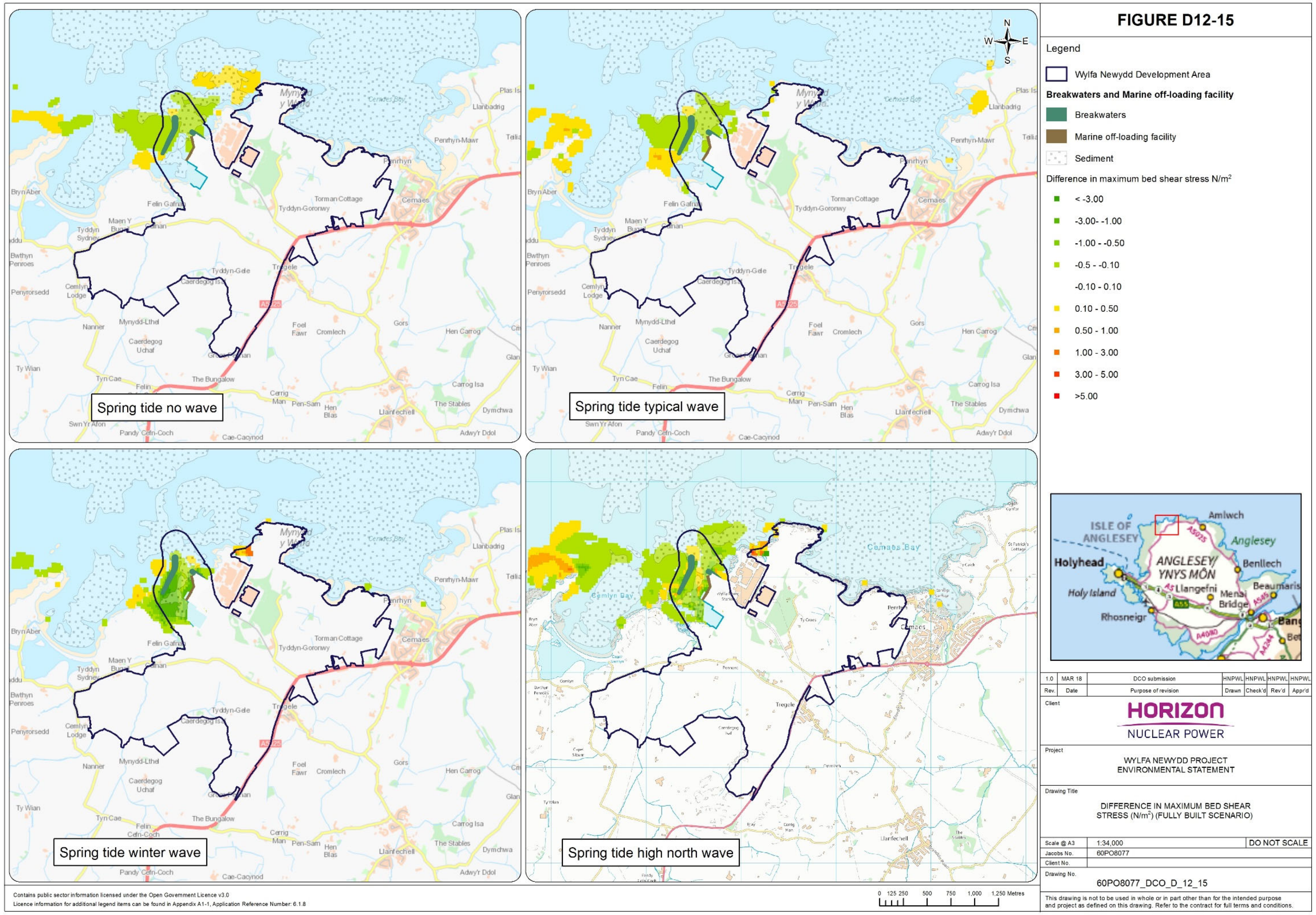
The refocussing of the wave energy in Cemlyn Bay is sensitive to the wave direction. The SWAN modelling (appendix D12-3, APP-218) indicates that 99th percentile waves from the north-west (Hs = 4.03 m at Offshore Point 3) display an increase in wave height, from baseline conditions, around the western breakwater of the order of 0.1 - 0.4 m and a potential increase of ~0.1 m (on wave heights of 0.4-1.2m) in the vicinity of the Cemlyn Lagoon ebb tide delta. This localised difference in wave height would not be anticipated to give rise to substantially different sediment resuspension rates on the seabed (potential for slightly elevated local suspended sediment concentrations only), nor to changes to local sediment transport patterns. Furthermore, in the context of the wave heights and associated energy impacting upon the foreshore of Esgair Gemlyn, during northerly and north-easterly storms, as noted above, wave heights immediately in front of Esgair Gemlyn would be of the order of 1.2 - 2m, which would be expected to impact more significantly on seabed resuspension. In this respect changes to wave heights and wave energy due to reflection at the western breakwater are considered minor in relation to the larger waves and associated sediment resuspension and transport processes that would occur during northerly and north-easterly storms.

The very presence of the morphological feature of Esgair Gemlyn, a predominantly gravel barrier/storm beach, at the head of Cemlyn Bay, indicates that the dominant processes acting upon the Bay and controlling its' modern-day geomorphology and seabed sediment distribution would be low frequency high magnitude events such as storms and associated waves. The largest of these events, that impact upon the Bay and beach, have been shown to be derived from the north and north-east sectors. It has been demonstrated through the modelling for the Wylfa Newydd Project that wave events and processes from these directions would not be significantly impacted upon by the Project.

NRW have raised concern that if there are fines within the sediment layer in Cemlyn Bay these would be mobilised under extreme storms and could change the sediment matrix of the ridge if deposited onto it. The baseline data presented within chapter D12 (APP-131) of the DCO application has shown that, cohesive sediments (silts and muds) are present in very small quantities within Cemlyn Bay, and therefore, availability for deposition within the ridge is very unlikely. Coupled with this, section 3.2 above, shows that the presence of the marine structures does not substantially alter what is being observed under the baseline situation, and therefore no significant morphological or compositional changes to the ridge would be anticipated as a result.

If such a mechanism might be active within Cemlyn Bay, then it would be expected that there may be some evidence of this as a result of storm activity from visual walkover surveys conducted to date. There is no evidence from site visits that the ridge is impacted by storm-generated release of fine material; indeed, the extreme energetics of the swash zone during storms would limit any permanent deposition of such material. Moreover, given the dimensions of the ridge, and the disparity of the grain size of the material comprising the ridge and natural fine sediments, a significant volume of fine sediment (many cubic tonnes), were it to be liberated by re-focussing of wave energy on the western Cemlyn Bay area, would be required to demonstrably change the dynamic behaviour of the ridge. This is considered to be a very remote possibility.

Figure 17: Differences in maximum bed shear stress (N/m²) figure D12-15 from the DCO application (APP-237 / 238)



4.1.1 Conclusion

Whilst storms from the north-west give rise to a reflected wave condition within Cemlyn Bay, these waves (and their reflected components near to the ebb tidal delta) would result in a small increase in wave height and bed shear stress in a very localised area (the western fringes) of Cemlyn Bay only. It is therefore not envisaged that to modify the sediment transport regime to any significant degree in comparison to energetic events arising from the north sector. In this respect, it is the northerly storms that are considered to govern the largest scale morphological adjustments within the Bay and along the Esgair Gemlyn ridge, and not lower energy events.

It is therefore considered that the development and operation of Wylfa Newydd would not impact significantly upon the coastal process and geomorphology of Cemlyn Bay and Esgair Gemlyn and as such the collection of additional sediment data is unwarranted and not required.