HAFAN Y MOR

D Coastal Processes Issues Review

D1. Introduction

Design details for the proposed coastal defences at Hafan y Mor of relevance to this review are presented on drawings SK13-0 to SK13-6 and SK13-10.

SK13-0

This drawing shows the existing area by aerial photograph with the location and orientation of ground-based photographs A to G. The sewage treatment works shown on the bottom left of the drawing has been replaced by a new works further inland. These abandoned works (which are to be removed) were protected by a linear rock revetment which will be removed where it resides within the footprint of the proposed scheme.

The existing linear rock protection was constructed in 1998 and followed the natural shoreline alignment at that time. The presence of the rock protection has resulted in some local erosion in the north-east around the entrance to the watercourse over an alongshore length of around 50m. The SMP calculates the average annual erosion in this area to be 0.3m/year giving a 6.0m potential recession of the independent shoreline in this area between 1998 and 2018. However the use of demolition materials by previous site operators has reduced the natural erosion rate so that actual erosion is only around half of that forecast under natural exposure. The local increase in shoreline erosion caused by the presence of the rock armour is estimated to be around 3.0m. This would have occurred quite quickly after scheme completion in 1998 and once established the shoreline would resort to the average annual erosion rate referred to above. ('Similar end effects' at the north-eastern limit of the proposed scheme will be reduced due to the setting back of the scheme frontage shoreline; shaping of the terminal rock groyne and introduction of a gravel beach as a transition between scheme and natural shoreline – see below).

SK13-1

This drawing shows the existing topographic levels of the hinterland and beach over the proposed scheme frontage. A dotted line outline of proposed scheme features is overlaid to assist general location definition. The upper foreshore gradient is around 1 in 10 flattening to around 1 in 50 across the lower beach. The land behind the existing beaches is generally flat with some lower areas moving back from the existing shoreline (denoted by a low steep cliff to the north-east of the watercourse outlet and by the linear rock armour to the south-west). The proposed coastal defence scheme relocates the shoreline approximately 20m inland from its existing location with rock groynes projecting to seaward from this relocated shoreline to below existing mean high water spring tide level.

SK13-2

This drawing provides proposed scheme levels overlaid onto the existing ground and beach level survey. The setback of the shoreline is achieved by projecting existing beach gradients (around 1 in 10) to landward; excavating the existing hinterland to provide a formation level on which to import a new sand and natural gravel beach. The gradient of the upper gravel beaches is steepened to 1 in 5 around the roots of the rock armour groynes to facilitate public access between new beach and existing hinterland. The rock groynes are located and scaled to enhance stability of the new beaches. The plan shape and profile of the rock groynes are set to facilitate a comfortable interaction with the local wave and tide climate. The mean high water spring tide (MHWST) contour is unchanged by the proposed scheme across Sand Beaches 1 and 2 and Gravel Beach 1.

The MHWST contour is moved landward in Sand Beach 3 (this is caused by the removal of the existing rock armour – to be re-used in the new rock groynes – over this section of shoreline). The boundary of the marine SAC is shown on this drawing transferred from the official NRW website. The boundary is to landward of MHWST across Sand Beaches 1 and 2 and Gravel Beach 1. The boundary is located along existing MHWST across Sand Beach 3.

SK13-3

This drawing provides a definition of the visible surface areas of the proposed scheme. Areas 5.1.1, 5.1.2 and 5.1.3 remain at the same surface level as existing. The beach in these areas will only be removed and replaced with marine sand if the existing material contains a large proportion of clay (these areas will be subject to ground investigation to establish the beach material up to 1.5m below existing beach level). Areas 5.1.1 and 5.1.2 are largely above the existing MHWST contour. The existing beach gradients in areas 5.1 will be extended across areas 5.2 and central sections of area 6 within Sand Beaches 1, 2 and 3.

SK13-4

This drawing provides details of the proposed scheme with typical details of the scheme construction. The minimum rock groyne cross section, and typical cross section I, employs a single-layer armour rock design to minimise cross-sectional area of these structures and optimise their hydraulic efficiency.

The new beach typical cross-sections show the make-up of the new sand and gravel (shingle) beaches. The establishment of a 1.5m depth of sand (or gravel) is necessary for beach stability when subject to breaking wave sub-sea bed pressure fluctuations. The presence of clay within this 1.5m depth below surface destabilises the sand under such conditions. Gravel beaches 3a an 3b provide a stable transition between the rock groynes (3a and 3b) and the outlet for the watercourse. It is considered likely that the higher areas of new gravel beach will support vegetation as the scheme settles in to its service.

Within the scheme frontage between Groyne 3a and Gravel beach 1, the existing demolition material used previously to retard shoreline erosion will be either removed as fill material within the hinterland development or buried within the scheme.

The construction of the rock groynes facilitates any adaption needed during scheme service life including complete setting back if shoreline exposure conditions become more severe than expected. The sand and gravel can also be adapted if required. A 10m wide undeveloped strip of hinterland behind the setback shoreline position adopted by the scheme is also included within the scheme footprint to further facilitate the scheme adaptation during service life (if required).

The first 'fishtail-shaped' rock groyne was constructed on the Wirral in 1981. Over the last 38 years the design has been refined through various applications at other locations around the UK shoreline but the plan shape and function of the specific structural elements have remained the same. There are now over 40 fishtail-groyne coastal structures around the shoreline of England and Wales. In contrast to traditional fence-type groynes the fishtail-shape formed of rock provides a local modification to waves and tides to provide improved beach levels on either side of the structure. The structures are gravity-based and not therefore at risk of undermining and are relatively maintenance-free once established. (Some stones can become dislodged during severe storm events but simple replacement after the storm abates returns the structure to full efficiency – the weight and shape of the rocks minimises loss of essential structure function during such severe events).

The fishtail-splay at the seaward end of the rock groynes is designed to intercept the main inshore wave energy direction spread without creating edge-waves and/or wave reflection off the rock groyne stem. This is a common problem with traditional fence-type groynes. In addition the shaping, profile and surface roughness of the fishtail-splay serve to dissipate wave energy and to redirect remaining reduced wave energy to maintain higher beach levels along the groyne inner perimeters.

The on-offshore overall length of the rock groyne is a compromise between retention of beach material within the embayments between groynes and the maintenance of alongshore movement of sediments from and to adjacent beaches to either side of the scheme alongshore. Groyne crest levels tie in to the local hinterland at the shoreline interface with a gentle slope out to the centre of the splay and then a steeper slope along the fishtail arms to link with the adjacent beach levels around the structures seaward extremity. Groyne crest levels and side slopes are set to optimise wave (and tide) energy dissipation and spreading to provide a smooth transition to accreting sand levels along the groyne flanks.

The most recent application of proposed scheme design approach was at Hopton near Great Yarmouth on the east coast of England in 2015. Monitoring of scheme performance to 2018 has shown performance to accord with design forecasts.

The nearshore local tide and wave regime is defined by numerical modelling using known offshore wave and tide data as offshore model boundary conditions (see Hafan y Mor Holiday Park '2030 vision' Master Plan – Modelling Study to inform coastal defence design – ABPmer November 2018).

SK13-6

This drawing shows level sections through the proposed scheme, to show how it relates to existing ground and beach levels. A typical cliff height of over 1.0m is provided over the central sections of Sand Beaches 1, 2 and 3 and Gravel Beach 1, to conserve this type of habitat after scheme completion. Most of the excavation takes place within the existing hinterland and this material is to be used in landscaping of the hinterland development. Where excavation takes place below MHWST then this material will be retained within the marine SAC and used to establish any necessary compensation areas to offset rock groyne projections in to the SAC.

SK13-10

This drawing shows the relative positions of the surveyed shoreline in April 2016 to the aerial photograph of the area and the statutory boundary of the marine SAC. Proposed scheme details are overlaid for ease of reference.

D2 Reconciliation of Proposed Scheme to Shoreline Management Plan (SMP)

The current SMP 2019 has a policy of 'No Active Intervention' for this length of shoreline but with the specific provision that private frontages can maintain their coastal defences subject to normal consenting procedures. Supporting documentation to the current SMP (PDZ12: COASTAL SNOWDONIA – Traeth Dyffryn to Pen y Chain page 4D 179) provides information on 'Potential Baseline Erosion Rates'. The base rate assessed for the SMP from monitoring and historical data is 0.3m/year along the unprotected sections of the coastline between Pen y Chain and the Afon Wen. The proposed scheme lies within this frontage where there are presently private coastal defences.

In acknowledgement of the general SMP policy to allow the shoreline in this area to recess naturally, there has been a sensitive interpretation of the policy provision allowing private coastal defences to be maintained. The proposed scheme sets the shoreline back by 20m at the time of construction with a scheme service life of 25 years, the equivalent annual erosion rate over the service life would be 0.8m/year.

The current SMP includes for a potential increase in annual erosion rates of up to 2.5 times caused by forecast sea level rise scenarios. Applying this rationale at Hafan y Mor would provide a maximum annual erosion rate of 0.75m/year. The proposed scheme includes for a greater setback of the shoreline over its service life than is forecast in the SMP for no active intervention.

The proposed scheme therefore reflects the aspirations of the SMP policy within its initial design. In addition the scheme includes a factor of safety by the retention of a 10m wide strip of hinterland behind the schemes setback shoreline to cope with any unforeseen shoreline exposure increases. The proposed scheme also includes for monitoring, maintenance and adaptation (if required) over its service life.

The proposed scheme has therefore acknowledged both the SMP current policy and its aspiration to let the shoreline recess over the next 25 years. In order to do this it has been necessary to introduce rock groynes to obtain adequate stabilization of the new beaches during periods of storm activity. The footprint of these structures extends in to the marine SAC and it may be necessary to compensate for these incursions by creating more intertidal zone to the north-east of the proposed scheme. This will re-use excavated material from within the marine SAC, removed as part of the proposed scheme and extend the upper beach frontage once cleared of demolition material.

The removal of demolition material over the proposed scheme frontage and that used for any compensation will improve the natural character and thereby general amenity of the area. The proposed scheme will also secure the integrity of the coastal path along the scheme frontage over the service life of the scheme.

D3 Numerical Model Studies

The numerical model studies are reported comprehensively in –

Hafan y Mor Holiday Park '2030 vision' Masterplan, Modelling Study to inform coastal defence design, ABPmer November 2018

The results of this study of relevance to the design of the proposed scheme are summarised below where figure references relate to the above report –

The proposed scheme is located high in the tidal-frame limiting the time when new scheme elements are exposed to sea action. The seaward ends of the new rock groynes are located between MHWST and MHWNT (mean high water neap tides). The scheme setback location derives directly from the design objective to achieve a coastal defence sensitive to the overall SMP policy objectives for the area and the minimising of any works in the marine SAC.

The extent of the numerical model area coverage for water-flows is shown on figure 4 and for waves on figure 10. The extraction locations for results presentation are shown on figure 1.

Figure 17 shows the annual variability of storm activity as it would affect the proposed scheme – there is large variation, with minimum of 10 storms/year and maximum of around 200 storms/year over the period from 1980 to 2015. (A period of 35 years compared to scheme service life of 25 years).

The extreme storm event used in the model testing was for a return period of 35 years from a south-west and a south-east offshore direction. The details of these events and for a 1 in 1 return period event are shown on Table 6. The relevant tidal levels are shown on Table 5. Tidal flows are relatively low for the tidal range but combine with wave-induced flows to provide the nearshore results on Table 7 (locations shown on figure 1).

The main storm direction is from the south-west due to longer fetch lengths than for the south-east. The combined wave and tide flows are essentially shore-parallel as shown on figure 31.

The wave directions incident upon the existing shoreline are similar for both offshore storm directions as shown on figures 21 and 22.

Sediment sampling details are provided on figure 28 – a uniform sediment size of 0.2mm is used for the whole solution domain for modelling purposes. The existing sediment transport regime for the two storm directions is shown on figures 29 and 30. (The larger transport vectors within the 'cobble' area are for sand (0.2mm uniform sediment size) and are not therefore representative of actual beach conditions).

The proposed scheme alters local coastal processes in close proximity to the proposed development mainly for storms from the south-west (highest energy waves). Reference to figure 21 and 22 show how waves from both SW and SE reach the shoreline with similar directions. The new rock groynes are shaped to avoid adverse interaction (regarding integrity of the beaches and shoreline) from the narrow range of incident of wave directions. The most significant scheme affects on water flows (wave-induced and tidal) occur from the SW storm as shown on figure 31. These show alongshore effects on flows to the north-east of the scheme to be limited to around 50m beyond rock groyne 1 – gravel beach 1 covers half of this distance to provide an appropriate transition. Figure 32 provides forecast flow differences and shows how flows are reduced across the lower beaches between the rock groynes – this assists in the retention of the sand beach nourishment within the groyne embayments. The larger increases in flow across the upper beaches occur where the shoreline is to be set back so there is no existing flow in these areas.

The sediment transport due to waves and tides extends up to 1.5km offshore in this area as a result of the tidal range and wave exposure. The proposed scheme only affects up to 50m from the shoreline and only up to 20m below existing MHWST. The relevant results are shown on figures 35 to 39 and tables 8 to 15 for extreme events (SW and SE) and average annual maximum (SW and SE). Figure 38 shows how the proposed scheme effects are reduced at 50m to the north-east of rock groyne 1 for the SW storm event.

The proposed scheme is designed to retain the beach nourishment within the groyne embayments during normal storm conditions. The beach modelling results are shown in Table 16 and figures 40 to 42. There are losses of beach material from within the embayment for the 1 in 35 year events from SW and SE,

but such events are assumed to be unlikely to occur more than once in the scheme service life. 1 in 1 year show that beach drawdown resulting in loss of sand outside the embayments is unlikely to occur. It is also relevant to note that the proposed scheme design reduces shore parallel flows so that sand drawn down the beach to beyond rock groyne seaward limits will be able to return to the beach when wave conditions allow.

There are expected to be some losses from the scheme over its service life. The initial beach nourishment is around 7500 cubic metres and allowances made within scheme maintenance budgets for up to 3 renourishment campaigns with a maximum total renourishment volume of 50% of initial. Imported sand either for the initial scheme or for the renourishments during scheme service life (if required) which is 'lost' from the scheme frontage will tend to progress alongshore to the north east but become rapidly spread over the intertidal area within around 100m of the shoreline. The small volume involved (3250 m^3) will be imported (if required) in parts of around 1000 m^3 each on three separate occasions during the 25 year service life. Any alteration to the existing sea bed outside the scheme perimeter from 'losses' of this material from the scheme beaches will be undetectable against natural process fluctuations in this area.

The proposed scheme design rationale for rock groynes 1 and 4 is to provide suitable interface to adjacent sections of shoreline and groyne 3b is a strategic location for reduction of shore-parallel flows across groynes 1 to 3a. Groyne 3a is required to maintain the outlet to the existing watercourse which have environmental value. Groyne 2 was therefore considered for removal and the proposed scheme tested accordingly. The results showed that this groyne was needed to maintain adequate protection to the sand beaches 1 and 2.

The numerical model results show that the proposed scheme effects –

- on water flows to be limited to changes of more than 0.1m/per second within a 50m zone offshore of rock groyne seaward limits
- on alongshore sediment transport to be reduced over the scheme shoreline frontage but with detectable effects alongshore from the scheme to be limited to around 50m
- effects on water flows and alongshore sediment movements to be limited to short periods around high water due to the high elevation of the scheme within the tidal frame

D4 Marine Screening and Scoping Opinion Concerns from NRW

1. Littoral drift – The numerical modelling shows that littoral alongshore drift in this area is from west to east and extends up to 1.5km away from the shoreline due to the wave exposure and tidal range applying at the site. The proposed scheme only extends around 20m below the existing MHWST and modelling results forecast alongshore impacts of the scheme to be limited to around 50m from alongshore scheme limits. In addition, it may be that the scheme will eventually include some compensation works to the north-east which will further reduce any adverse alongshore effects

from the scheme as these works are likely to increase the intertidal area over which any alongshore scheme effects will be spread.

2. Coastal Squeeze – the proposed scheme addresses the issue of coastal squeeze by setting back to beyond the maximum forecast shoreline recession (including sea level rise) over the service life of the scheme using the rates in the current SMP. In addition there is a further 10m wide zone reserved to landward of this setback shoreline to provide a contingency to deal with uncertainties in the SMP forecasts. The scheme is designed throughout to be adaptable with a monitoring, maintenance and management commitment over the schemes service life.

3. Morphological Change of the Foreshore – the surface characteristics of the foreshore show it to be comprised of glacial material – mainly clay, silt and sand. The stability of the new sand beaches depends upon a uniform permeability and porosity of sediment over a depth of 1.5m. Wave action on sand beaches produces pressure fluctuations over such depths. If impermeable material such as clay exists within the upper 1.5m depth then the sand above can be destabilized from wave-induced back-pressures and more vulnerable to movement by waves away from the beach area. Where sections of existing foreshore are to be enclosed within the new embayments it is proposed to remove the existing beach material (where it contains clay) to a depth of 1.5m. This material would be replaced with marine sand of similar characteristics to the natural sand occurring on the beach and sea bed of Cardigan Bay. Where new sections of beach are to be created within the new embayments, these would be formed using imported marine sand of the same characteristics as above. New sections of beach occur above the existing beaches and the natural gradients of these latter beaches are extended landwards across the new beach areas. The new gravel beaches along the set back shoreline are set to similar gradients but are locally steepened around the roots of the new rock groynes to facilitate public access from the hinterland to the foreshore. There will be visible areas of rock groynes exposed above new beach levels formed of 2 to 5 tonne granite rocks imported from a local quarry.

   The model investigations show that there will be no detectable changes to the sea bed outside a zone of 50m width from the seaward boundary of the proposed scheme footprint – both on-offshore and alongshore.

4. Direct Footprint Impacts – As above in item 3.

5. Beach Recharge – There is around 7500 cubic metres of marine sand and 4000 cubic metres of natural gravel/shingle to be imported to construct the proposed scheme. The marine sand will be sourced from existing licenced areas for sand extraction off the Dee Estuary (Hilbre Swash) where sand occurs of similar characteristics to that occurring naturally in Cardigan Bay. The gravel/shingle will be sourced from the local quarry at Cefn-Griainog - this comprises a similar glacial deposit to sea bed

exposures within Cardigan Bay. It is not anticipated that there will be any significant losses of the imported gravel over the service life of the scheme. Sand losses are also forecast to be minimal from model results but allowances have been made to re-nourish the beaches up to 3 times over the scheme service life with a total upper volume limit of 50% of initial nourishment.

6. Hydrodynamic Changes – Because the proposed scheme is at high elevation within the tidal frame the only elevation above existing sea bed below MHWST occurs over around 20m at the seaward ends of the new rock groynes. In these zones local to the new groynes water flows are reduced compared to existing, however such effects only extend up to 50m to seaward of the groyne seaward limits. There are no detectable hydrodynamic effects near the shoreline at a distance of around 70m alongshore to the north-east of groyne 1, and no detectable effects to the south-west of groyne 4. Waves incident upon the shoreline frontage of the new scheme will have their energy dissipated over a larger and more uniform area due to the removal of the existing demolition materials providing a more gradual transition from beach to hinterland.

7. Sediment Characteristics of Imported Material – to be provided.

8. Removal of Sediment – the proposed scheme includes for the removal of around 3500 cubic metres of beach material below MHWST. This volume may be reduced if existing beach areas within the new embayments are already formed of sand to a depth of 1.5m. It is proposed to utilize this existing beach material within any compensation works to the north-east of gravel beach 1. The excavation arisings above MHWST are to be used for hinterland landscaping purposes – this includes the existing rock armour defences to be removed and the demolition material (suitably broken up) which will be mainly incorporated within the core construction of the rock groynes, particularly groyne 3b where the core volume is largest. No natural material of marine origin is to be removed from the site of the overall development.

9. Ground Preparation and Underlying Geology – A ground investigation has been completed comprising 9 trial pits of around 2.0m depth and 20 beach sampling sites covering the proposed scheme frontage and further to the north-east towards the outlet of the Afon Wen. The beach sampling sites provided beach sand samples for testing, or where no sand was present, a description of the beach surface material. The sand samples provided the material characteristics to be specified for sand to be imported within the proposed scheme. The trial pits were sunk to around 2.0m in depth with description of material encountered recorded and samples taken for appropriate analysis. Within the proposed scheme shoreline setback area the materials found were predominantly clays and sands with some silts typical of the known geology of this area. It is anticipated that beach materials to be removed and replaced with imported sand within the scheme will be of similar composition.

However in order to safeguard against unnecessary disturbance of the sea bed it is proposed to carry out trial pits in these areas to establish the beach materials to a depth of 1.5m. If these areas are identified where natural sand is present to a depth of 1.5m then these areas will not be excavated within the proposed scheme.

10. Climate Change and Sea Level Rise – The proposed scheme adopts a cautious approach to the uncertainties surrounding climate change and sea level rise. The approach has 2 main elements –

- provision within the initial design to accommodate 'worst-case' forecasts within the current SMP
- adaptability of the scheme design within its service life to accommodate any unforeseen changes in climate and/or sea level rise.

The proposed scheme sets the shoreline back by around 20m from its present location – this compares with an SMP forecast 'worst-case' scenario of nearly 19m. In addition, there is a 10m wide strip of hinterland immediately behind the scheme which is reserved for incorporation within the coastal defences if required during scheme service life (25 years).

The scheme is adaptable in that the imported beach sand and gravel can be relocated, reprofiled or supplemented; the rock armour groynes can be reshaped and relocated or reprofiled. The rock armour groyne stability can be increased by import of larger rock and/or reprofiling.

The proposed scheme is comprised of initial construction with monitoring, maintenance and management over its service life so that it can be adapted to cope with uncertainties in climate change and/or sea level rise if required.

D5 Conclusions – the objectives of the proposed scheme are –

- to provide effective coastal defence to the developed park frontage for a period of 25 years
- to improve the amenity value of the beach for users of the park and the coastal path
- to acknowledge the aspirations of the current SMP policy for the area
- to minimise adverse environmental impacts in the scheme design and to offset any residual adverse impacts by mitigation and/or compensation as appropriate
- to utilise natural local materials for scheme construction wherever possible
- to provide full scheme adaptability to deal with uncertainties regarding future shoreline recession rates

- to remove existing defences within scheme alongshore limits including the 'adhoc' demolition rubble protection to the existing shoreline and set back the new defences to effectively remove current coastal squeeze issues over the service life of the scheme.

It is considered that the coastal process issues arising from the scheme objectives have all been addressed satisfactorily in this appendix with the exception of any issues arising from the agreed mitigation and/or compensation which is dealt with elsewhere in this report.

9 Oct 19

Addendum on Wave Overtopping

1. Introduction:

   The issue of wave breaking and run-up is addressed in Section A3 of Appendix A in the ABPmer model report R3056-November 2018. Tables A2 and A3 are relevant for initial assessment of wave overtopping. The run-up (R) is the maximum height above still-water level that wave run-up reaches.

2. Baseline data:

   (i) Table 5 in Section 4.1 of the same report provides water level information.
   (ii) Existing Site Topographic Survey drawing HyM-SK13-1 shows existing hinterland levels and the setback location of the shoreline after scheme completion.
   (iii) Survey cross-sections drawing HyM-SK13-6 shows existing and proposed ground levels at selected locations along the scheme frontage.
   (iv) Proposed groynes and beaches drawing HyM-SK13-2, shows proposed recessed shoreline levels across the proposed scheme frontage.
   (v) NRW recommended minimum caravan base level to be 5.49m AOD, to address tidal/ fluvial flood risk.
   (vi) Shoreline Management Plan PDZ12-Coastal Snowdonia-section 2-coastal processes p.183 assesses the Holiday Park to be only at risk of flooding for the extreme 2.0m sea level rise scenario.
   (vii) Service life of proposed scheme is 25 years.

3. Observations:

   (a) Existing shoreline level is at 6.0m AOD or above for the scheme frontage to the north-east of Groyne 3b (HyM-SK13-1 refers) and is retained at this level in the proposed scheme but now set back 20m behind the existing shoreline extending the width of intertidal zone across which wave run-up has to pass over to cause any wave overtopping. (HyM-SK13-2 refers)
   (b) Existing shoreline level is above 5.0m AOD for the scheme frontage to the south-west of Groyne 3b (HyM-SK13-1 refers). The proposed scheme sets the shoreline back by 20m as in (a) above and lifts the shoreline level to 6.0m AOD (except for a small frontage at the root of Groyne 3b). (HyM-SK13-2 refers).
   (c) Existing ground levels across the 10m wide corridor behind the shoreline are all above 6.0m AOD over the whole scheme frontage (HyM-SK13-1 refers). The proposed location of first caravan bases behind the corridor are all located where existing ground levels are above 6.0m AOD (this compares with the NRW minimum level recommendation of 5.49m AOD).
   (d) The service life of the proposed scheme is 25 years, so an allowance of 200mm for sea level rise over this period is reasonable.

4. Risk Assessment:

   The table set out below calculates the maximum level of wave run-up to be expected over the service life of the scheme for various scenarios. The table utilises information provided in Tables A2 and A3 (reference-introduction above) and Table 5 (reference baseline data (i) above).

	Tide Levels (m AOD)	Breaking Wave Height (m)	Maximum Run-up (m)	Maximum Run-up Level (m AOD)	Shoreline Level (m AOD)
HAT	3.36	1.50	0.60	3.96	6.00
MHWST	2.56	1.50	0.60	3.16	6.00

   If sea level rise of 0.20m is introduced, then the available water depth over the beach increases allowing an increase in breaking wave height which, in turn, increases maximum level of wave run-up. Even if the maximum run-up is doubled to 1.20m and combined with an HAT water level the freeboard between maximum level of run-up and the top of the beach is over 1m (1.44m). There is no likelihood of any significant wave overtopping over the service life of the scheme with the proposed monitoring, maintenance and management, and wave overtopping does not need to be a material consideration within the FCA.

11 Dec 19

N

N.G. NORTH

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Aerial photograph from Google Earth

CLIENT

Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Existing Site
Aerial Photograph

Date	Scale	Plan No.	Revision
15.12.2017	1:500 at A1	HYM-SK13-0	

Gravel Beach 1
Gravel Beach 2a
Gravel Beach 2b
Sand Beach 1
Groyne 2
Sand Beach 2
Groyne 3a
Gravel Beach 3a
Gravel Beach 3b
Groyne 3b
Gravel Beach 4
Sand Beach 3
Groyne 4

243700E 243750E 243800E 243850E 243900E 243950E 244000E
336900N 336850N 336800N 336750N 336700N

Outlet of Existing Watercourse to Beach
Existing Sewerage Treatment Works in this area
SCREEN PLANTING
DENSE VEGETATION UNABLE TO SURVEY WITHOUT EXTENSIVE SITE CLEARANCE
ROCK ARMOUR INTERFACE TO BEACH
ROCK ARMOUR
TIMBER GROYNE
LINE OF CHANGE CONTROL
STONE WALL
TOP OF EMBANKMENT
TARMAC
GRASS
GRAVEL
BOULDERS/GRAVEL
GRAVEL/SAND
BRAMBLES
BUSHES

Key

- Proposed Scheme
- 5.96 Grey levels in the area of the sewerage treatment works taken from the September 2017 survey
- Top of significant slope
- Bottom of significant slope
- Existing contours at 1.0m intervals
- Existing intermediate contours at 0.5m locations

N.G. NORTH

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Survey backcloth from Survey Operations drawing no.:16C149, April 2016.

CLIENT

Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Existing Site Survey

Date	Scale	Plan No.	Revision
15.12.2017	1:500 at A1	HYM-SK13-1	

Gravel Beach 2a
Gravel Beach 1
Groyne 1
Sand Beach 1
Gravel Beach 2b
Groyne 2
Sand Beach 2
Groyne 3a
Gravel Beach 3a
Outlet of Existing Watercourse to Beach
Gravel Beach 3b
Gravel Beach 4
Groyne 3b
Sand Beach 3
Groyne 4
Existing Sewerage Treatment Works in this area
Section of upstand between back of beach and hinterland
Local landscaping to tie in to back of gravel beach
Termination of rock armour groyne to be constructed at a gradient of 1:1 with local landscaping to tie in with gravel beach and hinterland levels
Area where rock armour of groyne is exposed through gravel beach
Open Public Access to the Foreshore
DENSE VEGETATION UNABLE TO SURVEY WITHOUT EXTENSIVE SITE CLEARANCE
243700E
243750E
243800E
243850E
243900E
243950E
244000E
336900N
336850N
336800N
336750N
336700N

Key

- Proposed Groyne Perimeter
- Proposed Groyne Centreline
- Proposed Groyne Crest Width
- Proposed Gravel Beach Perimeter
- Upstand area between existing ground level and proposed gravel beach
- 5.96 Grey levels in the area of the sewerage treatment works taken from the September 2017 survey
- MHWS unchanged by beach construction
- MHWS altered by beach construction
- SAC Designation area from ABPmer

N

N.G. NORTH

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Survey backcloth from Survey Operations drawing no.:16C149, April 2016.

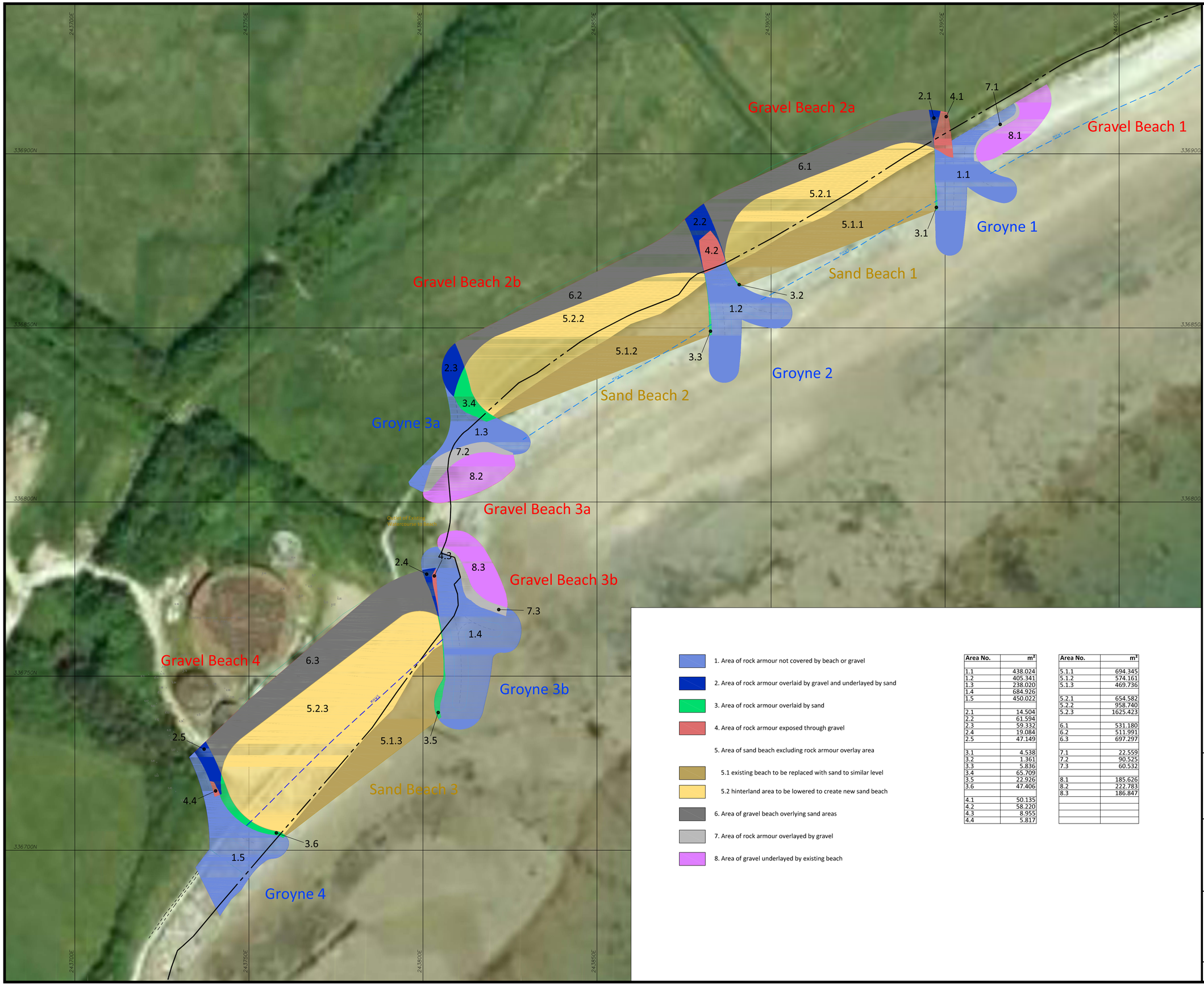
CLIENT

Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Proposed Groynes and Beaches

Date	Scale	Plan No.	Revision
15.12.2017	1:500 at A1	HYM-SK13-2	



Key

- MHWS unchanged by beach construction
- MHWS altered by beach construction
- SAC Designation area from ABPmer

N.G. NORTH

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Survey backcloth from Survey Operations drawing no.:16C149, April 2016.

1. Area of rock armour not covered by beach or gravel
2. Area of rock armour overlaid by gravel and underlayed by sand
3. Area of rock armour overlaid by sand
4. Area of rock armour exposed through gravel
5. Area of sand beach excluding rock armour overlay area
   - 5.1 existing beach to be replaced with sand to similar level
   - 5.2 hinterland area to be lowered to create new sand beach
6. Area of gravel beach overlying sand areas
7. Area of rock armour overlayed by gravel
8. Area of gravel underlayed by existing beach

Area No.	m²
1.1	438.024
1.2	405.341
1.3	238.020
1.4	684.926
1.5	450.022
2.1	14.504
2.2	61.594
2.3	59.332
2.4	19.084
2.5	47.149
3.1	4.538
3.2	1.361
3.3	5.836
3.4	65.709
3.5	22.926
3.6	47.406
4.1	50.135
4.2	58.220
4.3	8.955
4.4	5.817

Area No.	m²
5.1.1	694.345
5.1.2	574.161
5.1.3	469.736
5.2.1	654.582
5.2.2	958.740
5.2.3	1625.423
6.1	531.180
6.2	511.991
6.3	697.297
7.1	22.559
7.2	90.525
7.3	60.532
8.1	185.626
8.2	222.783
8.3	186.847

CLIENT

Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Proposed Groynes and Beaches
Area Definition

Date	Scale	Plan No.	Revision
11.12.2017	1:500 at A1	HYM-SK13-3	

Key

- Scheme Boundary
- MHWS unchanged by beach construction
- MHWS altered by beach construction
- SAC Designation area from ABPmer
- Area of Scheme to landward of SAC Boundary

A1, A2	Area enclosed by scheme boundary landward of SAC boundary
B1, B2	Area enclosed by scheme boundary seaward of SAC boundary
C1, C2	Area where MHWS is seaward of the SAC boundary
C3	Area where MHWS is landward of the SAC boundary

Area A1 = 2793m²
Area A2 = 2912m²

Area B1 = 3056m²
Area B2 = 1413m²

Area C1 = 937m²
Area C2 = 947m²
Area C3 = 374m²

N

N.G. NORTH

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Aerial photograph from Google Earth

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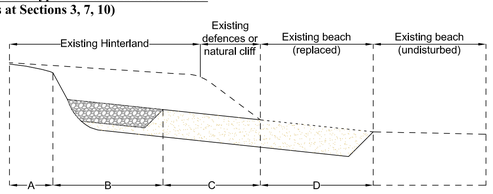
Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Scheme Footprint in Respect of the SAC
Boundary and MHWS Contour Line

Date	Scale	Plan No.	Revision
18.12.2017	1:500 at A1	HYM-SK13-4	

New Beach - Typical Construction Section I
(Applies at Sections 3, 7, 10)



Zones

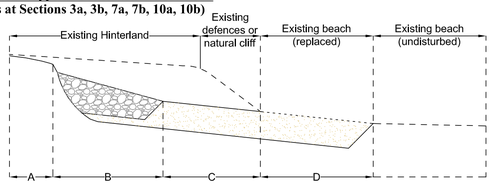
A: Recessed shoreline, new location with local landscaping to tie in with existing ground levels

B: New shingle beach, variable depth to facilitate public access to the beach overlying new sand beach, 0.5m depth

C: New sand beach, 1.5m depth within existing hinterland

D: New sand beach, 1.5m depth replacing existing beach at similar slope levels

New Beach - Typical Construction Section II
(Applies at Sections 3a, 3b, 7a, 7b, 10a, 10b)



Zones

A: Recessed shoreline, new location with local landscaping to tie in with existing ground levels

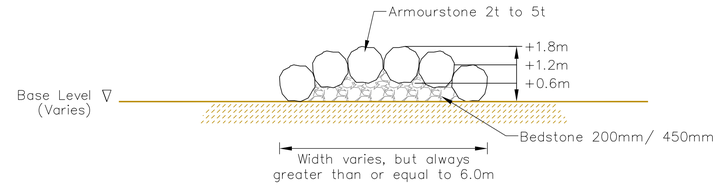
B: New shingle beach, 1.0m depth overlying new sand 0.5m depth

C: New sand beach, 1.5m depth within existing hinterland

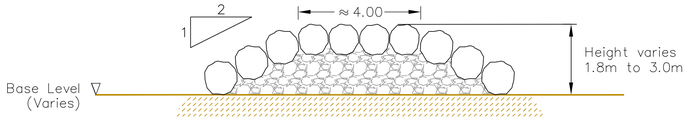
D: New sand beach, 1.5m depth replacing existing beach at similar slope levels

Hafan Y Mor
Rock Groynes - Typical Cross Sections

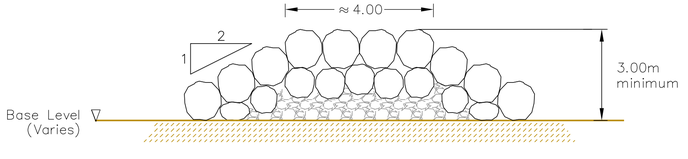
Minimum Groyne Cross-Section



Typical Groyne Cross-Section - I



Typical Groyne Cross-Section - II



Notes:
1. Groyne foundation level to be around 1.0m below existing sea bed level
2. Imported sand beaches 1, 2 and 3 to extend through groynes assuming a 40% void infill of armourstone volume – likewise for gravel beaches where appropriate
3. Bedstone to be laid on suitable geotextile with geotextile to extend up the back of the edge armour to the top of the bedstone layer

Key

- Proposed Groyne Perimeter
- Proposed Groyne Centreline
- Proposed Groyne Crest Width
- Proposed Gravel Beach Perimeter
- Upstand area between existing ground level and proposed gravel beach
- 5.96 Grey levels in the area of the sewerage treatment works taken from the September 2017 survey
- MHWS unchanged by beach construction
- MHWS altered by beach construction
- SAC Designation area from ABPmer

Survey cross sections are presented on drawing no. HYM–SK13–6.

N

N.G. NORTH

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Survey backcloth from Survey Operations drawing no.:16C149, April 2016.

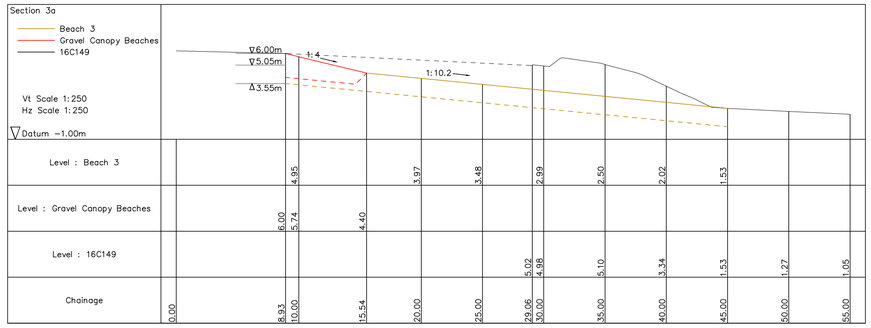
CLIENT

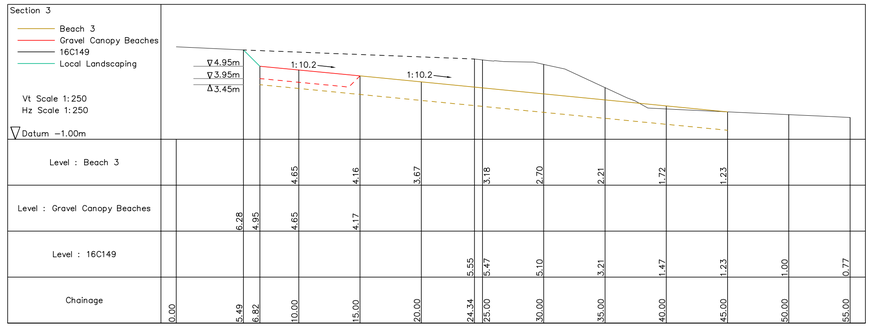
Alastair Tindle

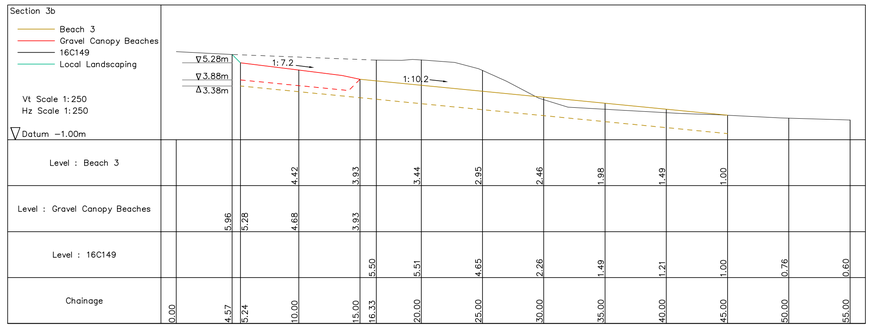
TITLE

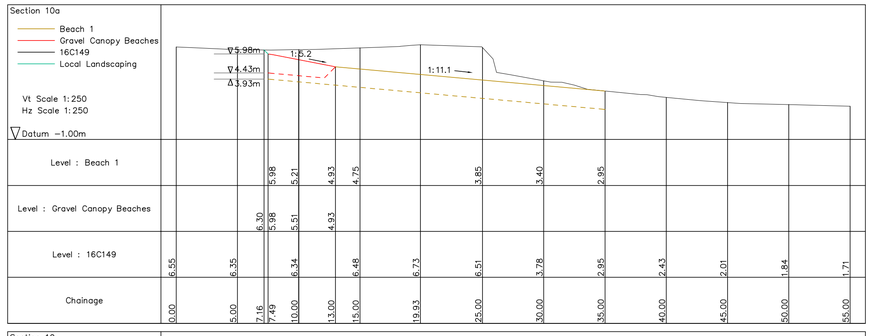
Land at Hafan Y Mor
Pwllheli
Proposed Groynes and Beaches
Construction Details

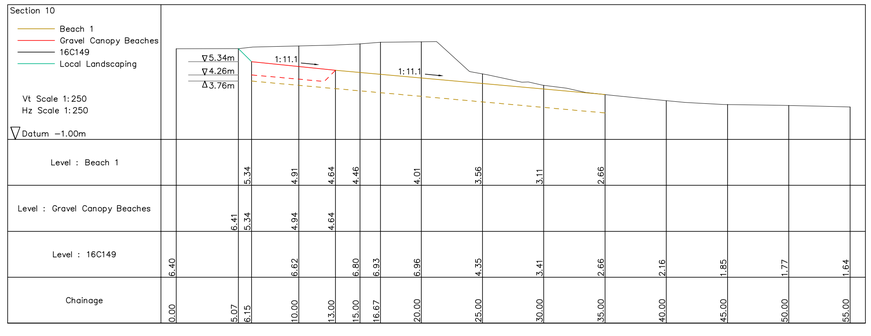
Date	Scale	Plan No.	Revision
15.12.2017	1:500 at A1	HYM–SK13–5	

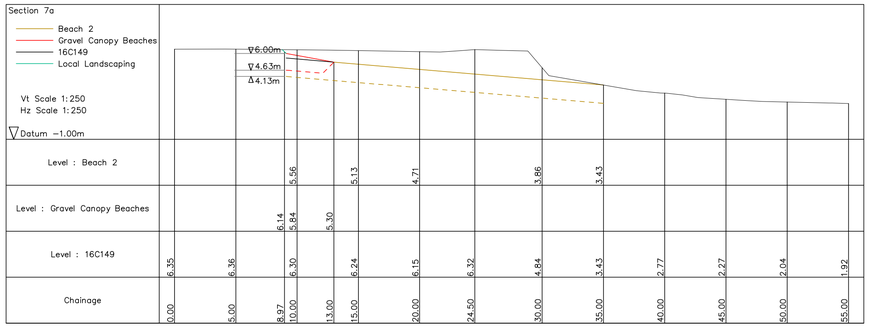


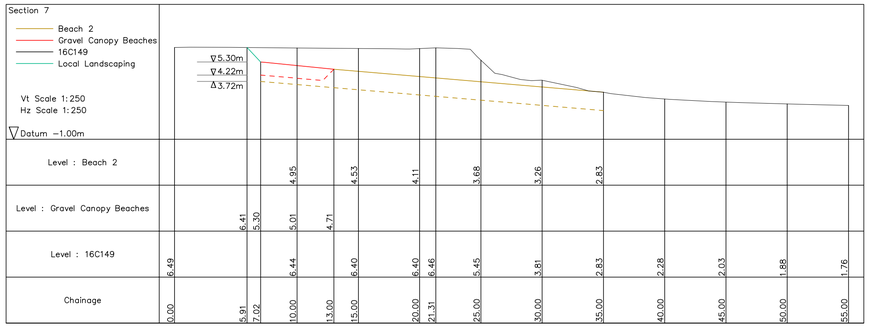


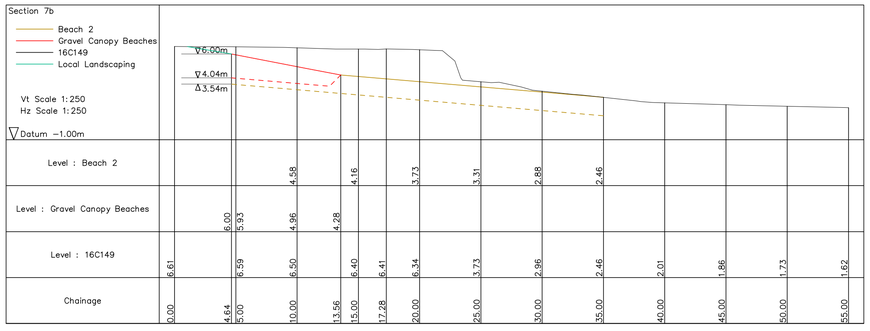


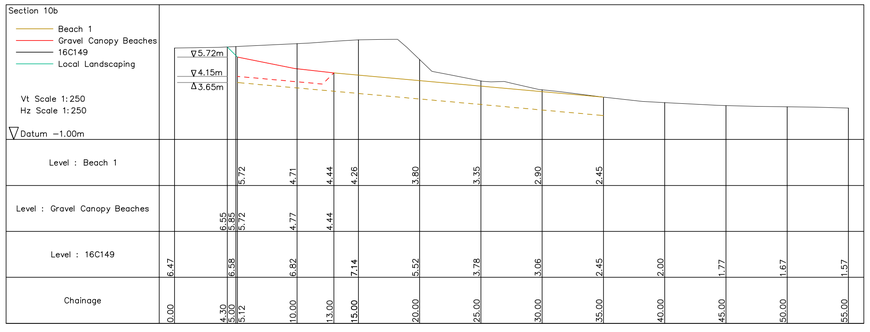












Survey cross section locations are presented on drawing no. HYM−SK12−5.

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

CLIENT

Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Survey Cross Sections

Date	Scale	Plan No.	Revision
15.12.2017	1:500 at A1	HYM−SK13−6	

243700E
243750E
243800E
243850E
243900E
243950E
244000E
336900N
336850N
336800N
336750N
336700N
Gravel Beach 1
Gravel Beach 2a
Gravel Beach 2b
Gravel Beach 3a
Gravel Beach 3b
Gravel Beach 4
Groyne 1
Groyne 2
Groyne 3a
Groyne 3b
Groyne 4
Sand Beach 1
Sand Beach 2
Sand Beach 3
Outlet of Existing Watercourse to Sea
Section of upstand between back of beach and hinterland
Local landscaping to tie in to back of gravel beach
Local landscaping to tie in to back of gravel beaches
Termination of rock armour groyne to be constructed at a gradient of 1:1 with local landscaping to tie in with gravel beach and hinterland levels
Area where rock armour of groyne to be exposed through gravel beach
MHWS
MLWS
N.G. NORTH

Key

- Proposed Groyne Perimeter
- Proposed Groyne Centreline
- Proposed Groyne Crest Width
- Proposed Gravel Beach Perimeter
- Upstand area between existing ground level and proposed gravel beach
- 5.96 Grey levels in the area of the sewerage treatment works taken from the September 2017 survey
- MHWS unchanged by beach construction
- MHWS altered by beach construction
- SAC Designation area from ABPmer
- Shoreline from survey drawing 16C149

Tide Levels for Hafan Y Mor

MHWS : 5.0m Above Chart Datum
(Mean High Water Springs)

MHWN : 3.4m Above Chart Datum
(Mean High Water Neaps)

MLWN : 1.9m Above Chart Datum
(Mean Low Water Neaps)

MLWS : 0.5m Above Chart Datum
(Mean Low Water Springs)

Note: Ordnance Datum Newlyn is 2.44m above Chart Datum

Survey backcloth from Survey Operations drawing no.:16C149, April 2016.

CLIENT

Alastair Tindle

TITLE

Land at Hafan Y Mor
Pwllheli
Proposed Groynes and Beaches

Date	Scale	Plan No.	Revision
21.02.2018	1:500 at A1	HYM–SK13–10	