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Beach Control Structures, Poole

Numerical modelling of scheme options, Sandbanks to Branksome Dene Chine

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Summary

Beach Control Structures, Poole

Numerical modelling of scheme options, Sandbanks to Branksome Dene Chine

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This report summarises a study that used numerical modelling of beach plan shape changes to advise on the best option for beach control structures between Shore Road, Sandbanks and Branksome Dene Chine in Poole. The beaches along this part of the shoreline of Poole Bay have recently been improved by a recharge scheme, during which sand removed from the entrance channel to Poole Harbour was pumped ashore by a dredger. It is anticipated that similar recharge operations will be needed in the future, at approximately 10 year intervals, to maintain the beaches at a sufficient width to protect the seawalls and prevent recession of the soft cliffs along this part of the coast. This strategy will also help maintain and enhance the amenity, tourism and recreational values of Poole Borough's coastline.

To obtain best value from the recharge operations, i.e. to maintain adequate beach widths along the whole frontage, it was always intended that a number of "beach control structures" would be built, and plans for the funding of these were drawn up before the beach recharge scheme was carried out. A previous study, carried out by HR Wallingford in 2006, had reviewed a wide range of possible beach control structures including breakwaters, reefs and various types of groyne, before recommending a short-list of four preferred options that needed to be further examined and refined. This recommendation was accepted by Poole Borough Council, and the present study, commissioned in late 2007, was designed to compare and contrast the four options, identify the best option and then go on to further refine this so that a preferred scheme could be recommended to the Council and taken forward to final design.

The scheme recommended at the end of this study comprises six groynes with a maximum length of 75m and set 150m apart situated at the eastern end of the Borough's coastline. It was concluded that there was no need for control structures along the remainder of the beach, i.e. approximately from Canford Cliffs Chine to Shore Road, Sandbanks. This was a more modest scheme than originally envisioned and has considerable advantages from the viewpoints of costs, amenity and aesthetics. The recommendations of this study were presented to and approved by Poole Borough Council in March 2008.

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1. Introduction

The main purpose of the planned improvements to the beaches between Shore Road, Sandbanks, and the boundary between Poole and Bournemouth Boroughs is to improve the standard of coastal defence, through a combination of beach recharge and the installation of structures designed to control the beach plan shape. The beaches along this part of the shoreline of Poole Bay have recently been improved by a recharge scheme, during which sand removed from the entrance channel to Poole Harbour was pumped ashore by a dredger. It is anticipated that similar recharge operations will be needed in the future, at approximately 10 year intervals, to maintain the beaches at a sufficient width to protect the seawalls and prevent recession of the soft cliffs along this part of the coast. This strategy will also help maintain and enhance the amenity, tourism and recreational values of Poole Borough's coastline.

To obtain best value from the recharge operations, i.e. to maintain adequate beach widths along the whole frontage, it was always intended that a number of "beach control structures" would be built, and plans for the funding of these were drawn up before the beach recharge scheme was carried out.

Phase 1 of the overall study, carried out for Poole Borough Council by HR Wallingford in 2005/ 06, identified a large number of possible beach control structure layouts. Preliminary modelling and a multi-criteria analysis was undertaken to identify and recommend the four most promising schemes. This recommendation was accepted by Poole Borough Council, and the present study was commissioned in late 2007.

This report summarises the Phase 2 study that used numerical modelling of beach plan shape changes to compare and contrast the four options for beach control structures between Shore Road, Sandbanks and Branksome Dene Chine in Poole. The aim was to identify the best option and refine it so that a preferred scheme could be recommended to the Council and then taken forward to final design and construction.

Chapter 2 below briefly summarises the Phase 1 study. This is followed in Chapters 3 and 4 by a description of how the numerical model was established and used to examine the changes in beach widths that would occur without beach control structures. Chapter 4 describes a comparison of the effects of each of the four short-listed schemes, followed by an explanation of how the preferred scheme was chosen and refined in Chapter 5. Chapter 6 presents the conclusions reached during the study.

2. Overview of Phase 1

2.1 ASSESSMENT OF BEACH CONTROL SCHEMES

Phase 1 of this study comprised a review of alternative beach control options for maintaining appropriate beach levels, by reviewing the coastal processes in operation at Poole Bay, and through undertaking a review of experience (both in the UK and internationally) of coastal defence structures. This included consideration of both well-tested schemes, and more novel approaches. From this, a short-list of ten beach control schemes was drawn up which was then refined using a multi-criteria analysis assessing both direct and indirect benefits. The direct benefits assigned the greatest importance were the maintenance of adequate beach widths, the ability to slow longshore drift and construction costs of the scheme. However consideration was also given to maintenance costs, aesthetics, public safety and past experience. A transparent system for weighting the criteria was established, which could be altered to allow for different priorities to be tested.

Following discussions with Poole Borough Council, a criteria weighting was agreed upon to undertake the preliminary engineering assessment of the schemes, as set out below in Table 1, taken from the Phase 1 study report, EX 5200 (HR Wallingford, 2006).

Table 1 Phase 1 assessment criteria

Assessment criterion	Importance	Weighting
Maintaining adequate minimum beach width	**H**	**8**
Slowing longshore drift /sand losses	**M**	**6**
Construction costs (relative)	**M**	**6**
Ease/ costs of maintenance/ adjustment	**M**	**4**
Impact on downdrift beaches (Bournemouth)	**M**	**5**
Tried and tested scheme	**L**	**2**

The four schemes which scored highest during the multi-criteria analysis were as follows:

- Impermeable groynes 75m long at 300m spacing (4:1);
- Impermeable groynes 75m long at 150m spacing (2:1);
- Impermeable groynes 75m long at 225m spacing (3:1);
- Multi-purpose reefs.

This short-list of preferred options was presented to Poole Borough Council with a recommendation that these should be further examined and refined through more detailed numerical modelling of their effects on beach widths. This recommendation was accepted by the Council in May 2006, and the present study, commissioned in late 2007, was designed to compare and contrast the four options and identify and refine the best option. A preferred scheme could then be recommended to the Council and taken forward to final design

2.2 INITIAL MODELLING

The initial stage of the Phase 2 study, described here, was intended to demonstrate that the numerical model of beach plan-shape evolution reproduced the main characteristics of the beach at Poole Bay, between Sandbanks and Branksome Dene Chine, as quantified by the beach surveys provided by Poole Borough Council.

HR Wallingford's BEACHPLAN model was used to predict changes in beach widths along the study frontage. This model was originally developed for beaches that are nearly straight and parallel contoured, although it can be used to study beaches with a significant change in orientation, provided that nearshore wave conditions are available at sufficient locations along the shoreline. For Phase 1 of this study, two separate models were used to model two almost straight sections of the coastline. The more detailed specifics of this modelling are described in CBR3713/TN01.

This numerical modelling achieved:

- Representation of the observed patterns of beach evolution, and its plan-shape;
- Correctly identifying the potential problem areas of narrow beach widths;
- Providing a good basis from which to undertake the detailed modelling and optimisation; and
- Providing information to the multi-criteria analysis methods used to select the four most promising options for beach control structures, which were later approved by the Council as a basis for the Phase 2 studies.

It was recognised, however, that for more detailed modelling of this frontage, to enable assessment of the effects of the short-listed beach control structure schemes, a more complete model would be needed. This model needed to cover the whole of the coastline from Shore Road, Sandbanks, eastward to beyond the Poole Borough boundary, and incorporating the effects of the long timber groynes at the western end of Bournemouth CBC's frontage.

3. Phase 2: Setting up the beach plan-shape model

3.1 REFINING THE EXISTING MODELS

One of the main tasks in Phase 2 of this study was to combine the two separate models described above into one continuous model that can accurately reproduce the change in shoreline orientation along Poole Bay.

The first steps in this process were to revive the existing two numerical models and extend each of them both westwards and eastwards, covering a longer portion of the Poole Bay shoreline, and including artificial straight sections of coastline at either end.

This technique makes it much easier to define the input wave conditions and resulting longshore drift rates at each end of each model, and ensures that these boundary conditions are not altered by changes in the beach in the central part of the model domain. Such changes vary according to the scheme being tested, and without extending the model would result in different rates of longshore drift entering and leaving the study area which would make comparison of different schemes less accurate.

Once the two (part-frontage) models had been extended as described, and previous results from the Phase 1 study had been reproduced, the larger model was created (shown in Figure 1). As the original data extended the length of the shoreline, joining information on the initial beach positions and seawall was straightforward. However, matching the wave conditions was rather more difficult, as discussed later in this Chapter.

3.2 UPDATING MODEL INPUT INFORMATION

3.2.1 Beach information

Since the Phase 1 study was completed, the beaches along the study frontage have been substantially widened, in winter 2005/2006, by a recharge scheme using sand dredged from the approach channel to Poole Harbour. The changes in beach width have been monitored by the Channel Coastal Observatory as part of the South-East Regional Monitoring Programme, and these surveys were obtained for input into the BEACHPLAN model.

Data from a survey in June 2007 was used both to check that the representation of the average beach profile in our model was correct, and to provide an initial beach position for the calibration model runs, using MHW (0.5m ODN). This recharge simplifies the modelling, since the existing short timber groynes between the Borough Boundary and Shore Road were buried and therefore there was no need to represent them. However, the disadvantage of the recharge is that it has dominated the recent evolution of the beach between those locations, so that there is very little information that can be used to show that the model is accurately predicting the evolution of the beach over time.

Cross-sectional groyne profiles for the four Bournemouth Borough Council groynes were obtained and entered in to the model to ensure that their performance was reproduced as accurately as possible.

3.2.2 Definition of nearshore wave conditions

Along the Poole Bay coastline, beach sediment transport and hence changes in the plan-shape and profiles of its beaches, is dominated by wave action. Consequently, a good knowledge of wave conditions along the coastline is required for the calculation of sediment transport rates and shoreline evolution.

In previous studies, the HR Wallingford HINDWAVE model was calibrated to provide an offshore wave climate in Poole Bay using wind data from the anemometer at Portland Coastguard Station. This wind record covered 18 years from January 1974 to February 1992. HINDWAVE produces a set of site-specific offshore wave forecasting tables, giving wave height, period and direction for a wide range of wind speeds, directions and durations. The model then uses these tables with the wind data to produce synthetic wave conditions in the form of an hourly time sequence, at an offshore wave prediction point. This time series was used as input for the evaluation of nearshore wave conditions along the Poole Bay seafront in the Strategy Study carried out by HR Wallingford (1995).

In a subsequent study (HR Wallingford, 2003), these original predictions of offshore wave conditions were supplemented by wave climate data derived by HINDWAVE using wind data from the UK Met. Office European Model for a location offshore of Poole Harbour. This data set covers the period October 1986 to March 2001. A comparison of this wave climate with that produced in our 1995 study showed that there was only a small difference in mean wave direction, i.e. about 2°. This is thought to be a result of differences in wind conditions resulting from different sources of wind data and in the different time periods considered. There was little change in the wave heights predicted. As the differences between the two predicted sets of offshore wave conditions were small, it was decided that the nearshore wave conditions derived in the 1995 Strategy Study would be suitable for use in the modelling of beach plan shape evolution in the present Phase 2 study. However, as explained later, the modelling was repeated using variations in these nearshore wave sequences to carry out sensitivity tests on the beach control structure schemes being studied.

Corresponding inshore wave sequences were produced for several locations along the shoreline of Poole Bay in this same study (HR Wallingford, 1995). Two of these nearshore locations, Points C and D, were located directly offshore from the present study frontage, near Shore Road and Branksome Dene respectively. These were therefore believed to be suitable for modelling beach changes in the present study. In the Phase 1 beach modelling, the waves from each of these locations were used as input to one of two models that represented a part of the overall study frontage. Because there was no inter-dependence of these two "part-frontage" models it did not matter that their input wave conditions at nearshore locations C and D were in different water depths.

3.3 CALIBRATION/VALIDATION OF NEW MODEL

Due to the recent beach recharge, there is insufficient information available to calibrate the BEACHPLAN model. However, it is still necessary to demonstrate that the model does represent the main features of the beaches between Shore Road and the Borough Boundary, and their evolution. This requires matching the observed beach alignments along the whole frontage, and reproducing the accumulation of sand on the western, i.e. updrift side, of the long groynes just to the east of the boundary with Bournemouth Borough.

During the model calibration process it was established that at Point C the predicted wave conditions were questionable, and causing numerical instabilities in the BEACHPLAN model. It is extremely difficult to accurately predict nearshore wave conditions west of Shore Road, because of the complicated and ever-changing seabed topography. Both Hook Sand and the East Looe channel have altered significantly in recent years and can be expected to continue to evolve in coming years. Since the present study was concentrating on beach changes to the east of Shore Road, where the nearshore seabed is much simpler, it was decided to use an alternative method to predict wave conditions at this western end of the study frontage.

For this purpose, it was decided to adjust the predicted wave conditions for Point D (near Branksome Chine) to account for the change in the orientation of the nearshore seabed contours between this location and Shore Road. Following an iterative process, an adjustment of 28.75 degrees in the wave directions at Point D was used to provide input wave conditions at the western end of the beach plan-shape model. This resulted in the best representation of the natural curvature of the bay, and eliminated the problems of numerical instability that affected the initial attempts at modelling the beach plan shape changes.

The main purpose of the numerical modelling in this Phase 2 study was to examine how beach widths would alter in the future with or without one of the preferred beach control structure schemes. It is clearly impossible to predict future wave conditions precisely, and the standard modelling technique is therefore to use a long sequence of wave conditions that have occurred previously. This approach assumes that future wave conditions will have similar characteristics, and that they will occur in a similar sequence, to those in the recent past. Provided all the options are studied using the same set of wave conditions, this produces a reasonable basis for comparing their likely performance.

As discussed in Section 3.2.2, we hold a 17-year long sequence of predicted nearshore wave conditions for Point D that could have been used for the beach plan-shape modelling. Rather than using all of this very long sequence, however, it was decided that it would be preferable to carry out the initial modelling using a shorter sequence, namely five years. This time-series was chosen to have similar characteristics in terms of average rates of alongshore sediment transport, (i.e. the same mean annual drift rate) as the whole 17-year period.

The 5 year period that was most representative of the mean drift conditions was from 1981-1985, with mean net drift of 55,000 m^3 per year (eastward) along the beach landwards of Point D. This 5-year period of wave conditions was used first for the calibration, or “baseline”, run of the model, which assumed that no beach control structures were installed. This simulation could be compared at least qualitatively with the actual changes in the beaches that had occurred since the recharge was carried out in winter 2005/ 2006.

3.4 BASELINE RUN

After a considerable number of model runs, a satisfactory comparison with existing beach characteristics was attained, and this is presented in Figure 2. It is important at this point to note the distorted scale of these figures, which is necessary due to the length of the model, and the fact that the results are resented from the viewpoint of an observer on the beach looking out to sea. The model chainage is shown beginning from 3000m due to the existence of 3km “virtual” shoreline either end of the study frontage, i.e. to the west of Shore Road and the east of the boundary with Bournemouth. This ensures that the model’s boundary conditions are correct, and that no “end effects” influence the model results. The total drift averaged over the five years entering the study frontage at chainage 6200m is ~58,000 m³ per year.

The various “end of year” shoreline positions show the position of the mean high water mark on the beach at five instants during the model run. A comparison of these does indicate that the beach within the study area is predicted to gradually erode, as a result of the net eastwards longshore drift (the negative values on the scale at the right of the figure indicates an eastward rate of sediment transport). In addition, the model has reproduced the general orientation of the shoreline along the whole study frontage. Both of these results accord in a qualitative sense with the observed behaviour of the beach since the recharge in winter 2005/ 2006.

However, the model also predicts a “smoothing” of the initial beach plan-shape, for example rapidly flattening out the seaward bulge at the Shore Road outfall, which in reality has persisted. The reasons for the formation and persistence of this bulge are not known, but may well be related to the pattern of tidal currents along this part of the coastline. Since the BEACHPLAN model does not attempt to include such currents, or their effects, it cannot replicate this localised widening of the beach correctly. As will be seen later, however, this does not affect the recommendations that are reached regarding the preferred beach control scheme.

In Figure 2, five “end of year” shorelines are presented and these indicate the significant variability in beach positions over the time period considered. For example, the beach width on the updrift side of the first (i.e. westernmost) of Bournemouth CBC’s groynes has eroded significantly by the end of year 1; this was a result of intense wave activity from the south-east resulting in a period during which the alongshore movement of sand would have been westwards, i.e. opposite to the normal direction of longshore sediment movement. During such a period of “reverse drift”, the Bournemouth groynes prevent sand passing onto Poole BC’s frontage, resulting in localised and short-term beach erosion, as the sand between the Borough boundary and Branksome Dene Chine is carried further west. However, the width along this section of the beach has recovered almost entirely by the end of the following year.

The result of this type of variability in wave conditions and longshore drift, which can significantly alter beach widths for a period of a few weeks, means that the five “end-of-year” shoreline positions presented in Figure 2 do not necessarily provide a good guide to the overall trends for increases or decreases in beach width. They are simply instantaneous “snapshots” of a constantly changing beach position. Any short-term changes are not evident, and an entirely different perspective could be gained by outputting results on different days.

To make a reasoned judgement on how the beach is expected to change over the five-year period, with or without beach control structures, it is therefore necessary to seek better ways of presenting BEACHPLAN model results. To this end, Figure 3 presents the predicted mean, minimum and maximum beach positions during the five years of this baseline run.

Of particular interest from a coastal protection viewpoint is the situation where beach widths become very narrow. The points showing the minimum beach width are not joined to form a continuous line in this, or in similar subsequent figures, so as to emphasise the fact that these positions do not occur concurrently. This form of presentation is also used for the mean and maximum beach widths and is considered the most useful way of summarising the important results from the modelling for this and all other scenarios considered.

The minimum predicted beach widths shown in Figure 2 indicate a particularly narrow beach from just west of Branksome Chine to the eastern model boundary, again indicating the potential difficulties when south-easterly waves produce a period of reverse drift. At these times, the beach can become very narrow and low in front of the seawall, and times there would be no visible beach at Mean High Water, with the tide reaching the seawall. The BEACHPLAN model continues to calculate the changes in the beach, predicting how low its level will drop at the toe of the seawall. To show this graphically, the model then uses the beach level and the beach gradient to indicate an “equivalent” position of the Mean High Water contour on the beach face in the absence of the seawall. As a result, the minimum beach position is then shown as being landward of the seawall; the lower the beach levels fall, the further landward this shoreline position is plotted. Whilst it is expected that these minimum levels would only prevail for a limited amount of time, there is the potential for problems with overtopping/scour and even undermining of the seawall during these periods.

In this baseline run, the model has predicted that the minimum beach positions are up to 50m behind the seawall, indicating a very low beach in front of the wall. In addition, the mean beach width is predicted to be considerably narrower than at the start of this baseline run, particularly along the eastern part of the Poole BC frontage i.e. from the Borough boundary westwards past Branksome Chine, indicating a clear tendency for beach erosion.

The main concerns raised from this baseline run, therefore, are the loss of the sand placed during the recent beach recharge and the occasionally very narrow beach close to the Borough Boundary as a result of reverse drift. The main target in the design of different schemes is to reduce these problems through the introduction of beach control structures, namely groynes or reefs.

It is considered that this model calibration and wave conditions form a reasonable basis on which to examine the effects of the short-listed beach control schemes. The five-year period of wave conditions chosen to predict changes in beach widths in the absence of such structures, i.e. the baseline run, produces an average longshore drift rate, and thus provides a reasonable view of the long-term evolution of the beach, identifying the main challenges that need to be met. This same sequence of wave conditions (as predicted for 1981-1985) was used for most of the subsequent testing of the beach control structure schemes.

However, it is also worth noting that while two possible beach control structure schemes may produce similar results under “average” wave conditions, one of these may perform better when the wave conditions are more adverse. In the context of changing beach widths, such adverse conditions occur when drift rates, and the difference between amounts of sediment entering and leaving the frontage modelled, are considerably greater. Consequently, the final scheme options were also tested for a different (hypothetical) five-year period during which there was a greater variation in the longshore drift over the frontage between Shore Road and the Borough boundary, i.e. leading to a more rapid erosion of the beaches between these locations.

4. Testing the preferred scheme options

4.1 INTRODUCTION

Modelling of the four short-listed scheme options (see Section 2.1) has been undertaken using the BEACHPLAN model and beginning with the conventional groyne schemes. These were tested first since their likely effects are more readily understood than those of the multi-purpose reefs. As discussed, the five-year wave sequence producing average drift conditions along the Poole frontage was used to compare the three short-listed groyne scheme options.

The performance of these schemes is assessed according to consideration of their ability to retain the beach sediment, and thus provide an adequate standard of defence. In order to evaluate and compare the three schemes, the minimum beach positions over the five years (as discussed in Section 3.4) were used to predict widths in front of, or beach levels at the toe of the seawalls. Changes in beach areas above MHW were also assessed. These calculations can be used to inform on the ability of the scheme to maintain the sand that is imported during recent and potential future recharge operations. As well as providing a visual representation of the minimum beach widths using the BEACHPLAN model, a quantitative comparison was undertaken by analysing the predicted changes in beach positions in three groyne bays along the frontage.

The representation of the groynes in BEACHPLAN assumes that they are impermeable i.e. not allowing any sediment through the structures. However their length, of 75m, is such that some bypassing will occur around their ends. BEACHPLAN does not differentiate between rock and timber groynes, but the cross-sectional profile of the groynes is specified. In terms of modelling their effects on the evolution of the beach, the variation in the crest level of the groyne with distance seaward of the seawall, and the length, crest height and slope of the groynes is more important than the material which is used to build them. The profiles of the proposed new groynes, in all three of the short-listed schemes tested, have been assumed to be similar to the rock groynes at Sandbanks, while the profiles of the existing timber groynes on Bournemouth’s section of the beach have been based on information supplied by that Council. It is likely that the differences between the three groyne schemes tested would have been very similar if we had chosen to represent the proposed new groynes as being similar to those at the western end of Bournemouth’s beaches.

The three different groyne schemes that were short-listed in the Phase 1 study, and tested in the present study, each involved groynes 75m long, but at different spacing.

Fewer groynes would be needed along the study frontage where they are placed further apart and clearly this would lead to significant cost savings. However, if the groynes are closer together, the variations in beach positions between them will be smaller, and the more effective they will be at retaining the sand placed in beach recharge schemes. This is due to a reduction in amount of sediment building up against, and eventually passing seaward around, the end of each groyne.

4.2 IMPERMEABLE GROYNES AT 4:1 SPACING

The 4:1 spacing groyne scheme envisages the construction of nine groynes, each 75m long and placed at 300m intervals; this scheme was modelled using the same input parameters as the baseline run presented in Figure 2. The first groyne was placed just to the west of the Branksome Dene Chine car park, at a point immediately downdrift of a bulge in the seawall, in order to optimise protection here and leave an appropriate space between it and the existing Bournemouth Borough Council groynes. A further eight groynes were then placed at 300m intervals, extending west to just beyond the Shore Road car park (Figure 4). No attempt was made at this stage to “optimise” the groyne layout, for example to reflect a preference either to place them at pedestrian access points or between these locations. It was considered that such adjustments would be undertaken, if necessary, during any later optimisation of this scheme.

Figure 5 presents the model results for this scheme, and shows the mean beach position during the last of the five years considered, together with the predicted minimum and maximum beach positions throughout the whole of the five years considered.

The minimum beach position within the westernmost two complete groyne bays, and immediately to the west of them indicates that the beach stays near to the initial summer 2007 shoreline, with little loss of beach sediment, even temporarily. The predicted maximum loss of beach width in this area is immediately updrift of the westernmost groyne where there is a loss of 30m. As the beach was initially approximately 65m wide, a narrowing of this magnitude is not a great problem.

To the east of Canford Cliff Chine, however, there is cause for concern. The minimum beach position is predicted to be well landward of the initial shoreline for the remaining stretch of the model frontage, with particularly narrow beaches on the updrift side of six of the new groynes. This loss of beach sediment is by up to 65m landward of the seawall, i.e. a total beach narrowing of 120m near Branksome Dene Chine. The minimum beach widths occur on the western side of the groynes, indicating that they are a result of severe waves from the south-east producing significant reverse drift. On average, the minimum shoreline position east of Canford Cliffs Chine is 15m landward of the seawall, indicating particularly low beach levels along this section of the beach.

The difference between the predicted minimum beach widths, and hence beach levels, at each end of the groyne bay is substantial, with a well defined “saw-tooth” pattern evident in Figure 4. There is generally in the order of 50-70m difference between the most seaward and landward minimum beach positions within each groyne bay; these large oscillations allow sediment to move around the ends of the groynes. In contrast, within the Bournemouth groyne bays to the east of the Borough Boundary, the predicted changes in the position of the shoreline are much smaller because these groynes are set closer together.

Further discussion of the performance of this groyne scheme in comparison with the other two short-listed options is presented in section 4.5 below.

4.3 IMPERMEABLE GROYNES AT 3:1 SPACING

The 3:1 spacing groyne scheme consists of 12 groynes, each 75m long at 220m spacing, and was modelled using the same input parameters as for the baseline run. As before, the easternmost new groyne was placed immediately downdrift of the bulge in the seawall just west of the Branksome Dene Chine car park, with the other groynes placed at 150m intervals up to just beyond the Shore Road car park (see Figure 6). As for the previous option, no attempt was made at this stage to optimise the groyne layout, for example to reflect a preference either to place them at pedestrian access points or between these locations; such adjustments could be made during scheme optimisation.

These model results are shown in Figure 7, which shows the mean beach position during the last of the five years considered, together with the predicted minimum and maximum beach positions throughout the whole of the five years considered. As for the previous scheme, the model predicts that the beach widths at the western end of the study frontage will remain healthy, with the mean position (in year 5), being similar to or slightly seaward of the starting position.

The minimum predicted beach widths are satisfactory west of Flag Head Chine but become gradually worse, particularly on the updrift side of groynes, along the rest of the frontage. The mean (fifth year) shoreline position similarly deteriorates eastwards. In comparison with the predictions for the groynes at 4:1 spacing (see Figure 5), the variation in beach positions within each groyne bay is smaller (typically about 30-50m). The minimum beach positions just west of each groyne are less far landward than for the wider-spaced groynes, indicating rather higher beach levels against the toe of the seawall in periods when the normal pattern of eastward drift is reversed. The mean beach positions east of Branksome Chine are also noticeably better for this scheme.

Further discussion of the performance of this groyne scheme in comparison with the other two short-listed options is presented in section 4.5 below.

4.4 IMPERMEABLE GROYNES AT 2:1 SPACING

The 2:1 spacing groyne scheme comprises 17 groynes each 75m long and placed at 150m intervals, and was modelled in the same way as the two previous options. As for the other two groyne schemes, the easternmost groyne was placed immediately downdrift of the bulge in the seawall just west of the Branksome Dene Chine car park. The aim of this was to improve mean beach levels in front of the seaward bulge in the seawall at this location. A further 16 groynes, at 150m intervals and extending westward to just beyond the Shore Road car park were then represented (Figure 8). As for the other two groyne layouts, no attempt was made at this stage to "optimise" the groyne layout, for example to reflect a preference either to place them at pedestrian access points or between these.

The minimum, mean (fifth year) and maximum shoreline positions from this model run are presented in Figure 9. At the very western end of the model (i.e. from Shore Road to the model boundary) the beach retains its width, such that the minimum shoreline over the five year period is at the position of the initial 2007 shoreline. The mean shoreline, in year 5, at this location is well seaward of the initial shoreline, by a maximum of 40m. The modelling thus shows that these groynes are not only retaining the sand placed in the recent recharge operations but trapping extra sand that is arriving from west of Shore Road.

The situation, however, is less healthy for the remainder of the study shoreline particularly on the updrift side of the groynes, which is again suggestive of a period of severe weather causing reverse drift. The minimum shoreline positions indicate narrow beach widths that are of particular concern from chainage 4500m eastwards (i.e. from about midway between Canford Cliffs Chine and Branksome Chine). Here, as with the other schemes, many of the minimum beach positions are shown as being landward of the seawall. The variations in beach widths between the groyne are, however, smaller than for the previous schemes (typically in the region of 20-45m within each bay).

Further discussion of the performance of this groyne scheme in comparison with the other two short-listed options is presented in Section 4.5 below.

4.5 PREFERRED GROYNE SPACING

The three groyne schemes (i.e. the "conventional" options from the shortlist) were tested first, since their likely effects are more widely understood than multi-purpose reefs, and thus the validity of the model could be ensured. Also it is sensible to eliminate two of the groyne schemes before considering the "novel" reefs, as various groyne schemes are easily comparable and the preferred option identified.

In order to do this, the ability of the schemes to prevent low beach levels at the seawall was assessed by comparing the minimum beach positions over the 5 years at three locations along the frontage, namely immediately downdrift of the bulge in the seawall at Branksome (chainage 3800m), towards the centre of the model (chainage 4600m) and immediately in front of Canford Cliffs Chine (chainage 5130m). As the groyne bays are of varying lengths for each of the schemes tested, however, it is not sensible to compare beach widths at these precise locations, which might be just west of a groyne in one scheme and just east of one in another. Instead, the predicted minimum beach width (i.e. the distance from the seawall to the beach position) in the groyne bay containing these locations is presented for each of the three schemes in Table 2 below.

Table 2 Minimum beach position in groyne bays

Chainage (m)	Beach control scheme		
	4:1 groynes	3:1 groynes	2:1 groynes
3800	-64.4	-32.8	-32.8
4600	-39.8	-19.1	-15.6
5130	-28.8	-16	16.6

The negative numbers in the table indicate that the position of the high water contour has been extrapolated from the model results as described previously and predicted to be landward of the seawall, indicating low beach levels at the toe of the seawall. The situation is worst immediately downdrift of the seawall bulge at Branksome, with the 4:1 groynes causing extremely severe erosion here for a period of time during the model run. The 3:1 and 2:1 groynes perform similarly in this location, in terms of minimum beach position. However, for the other two locations, the 2:1 groynes clearly produce better results, predicting higher beach levels at the toe of the seawall. Indeed at 5130m, the 2:1 groynes have at least 16m beach width (at MHW) in front of the seawall at all times during the model run, whereas the 4:1 and 3:1 are represented as being landward by 28.8m and 16m respectively. In the majority of cases, these minimum beach positions occurred at the eastern end of the groyne bays, indicating that they were due to a period of severe weather from the south-east.

The schemes have also been assessed in terms of their ability to retain sand placed in the recent recharge operations. In Table 3 below, the entries give the total beach area, above MHW and seaward of the seawall, calculated at the end of each year of the modelling period. The areas are calculated from just west of the Bournemouth Borough Council groynes to chainage 6200m i.e. just west of Shore Road. Since the beach slope along the coastline in the model is assumed constant, these values are indicative of total beach volumes.

Table 3 Beach areas above MHW (Poole Borough frontage)

Year	Beach area above MHW (m²)			
	Baseline	**4:1**	**3:1**	**2:1**
0	152,700	152,700	152,700	152,700
1	139,900	149,200	147,000	150,600
2	135,700	139,900	133,500	131,600
3	139,200	158,100	153,400	156,800
4	152,800	180,100	175,000	180,600
5	145,900	159,100	159,000	161,200
Overall change	-6,800	6,400	6,300	8,500

The beach areas shown indicate that beach control structures are necessary since the beach is losing sediment in the baseline scenario. All three of the groyne schemes show an increase of beach area after 5 years, whereas the “baseline run” with no groynes indicates a loss of beach volume over that period. While these results are perhaps optimistic, since they assume a continuing and healthy supply of sand into the study frontage from the west, the comparison between the schemes is reliable.

All 3 groyne schemes suffered a loss of beach area in years 1 and 2 in relation to the initial beach. At the end of the second year, the 2:1 groynes have a beach area above MHW of 131,600 m² which represents a loss of 21,100 m² from the initial beach, which is greater than the baseline or the other schemes. However, this is likely to be a result of anomalous weather conditions, and the beach has recovered by the end of the following year. Although the yearly areas vary, the 4:1 and 3:1 groynes both result in a similar increase in total area at the end of the 5 year period. The 2:1 groynes predicted an overall area increase of 8,500m², an increase in the region of 2,500m² over the other two groyne schemes. Overall the 2:1 groynes have performed the best in relation to both the baseline scenario, and the initial beach position.

The analysis above indicates that the 2:1 spaced groynes are the preferred groyne option in terms of providing protection and maintaining beach widths. This is supported by conventional wisdom, as well as the evidence from Bournemouth’s successful 2:1 groyne field.

The other and very important conclusion drawn from the modelling of these groyne schemes was that there is no need for beach control schemes of any nature in the western section of the beach, from at least Canford Cliffs Chine westwards.

Examination of the modelling results presented in Figures 5, 7 and 9 shows that along this part of the frontage, the initial beach width has been maintained, and indeed the MHW position is generally seawards of the groyne tips for most of the five year period. The groyne schemes have all led to a slight increase in beach volumes along this part of the beach, although the beaches have become narrower further east, for example at Branksome and Branksome Dene Chines. Further as would be expected, the minimum beach widths within the groyne bays west of Canford Cliffs Chine occur close to each groyne and this tendency could be expected to reduce if no groynes were present. It was therefore deduced that groynes along this part of the frontage were unlikely to improve the overall standards of defence for the whole frontage, would be detrimental to maintaining beach widths further east as well as adding to the expense and the aesthetic and amenity value of this part of the frontage.

This conclusion is supported by the fact that there have historically been few groynes along this section of the shoreline in the past. Further, based on observations made by HR Wallingford staff and Poole Borough Council, since the recent recharge, the beaches along this part of the frontage have maintained acceptable widths without any groynes being present.

The main benefit of the short-listed groyne schemes with spacing: length ratios of 4:1 and 3:1 was the reduced number of structures required, which minimises costs as well as increasing amenity and aesthetics. The cost-savings of adopting such widely-spaced groynes will be much reduced, however, given that the frontage over which groynes are needed is so substantially reduced. In view of this, it was decided that the best groyne option would be 75m long groynes at 150m spacing, but restricted to the eastern part of the frontage, i.e. between Canford Cliff Chine and the Borough boundary. This was therefore the groyne scheme taken through to the next stage of the study, where the remaining beach control scheme options were optimised and the preferred option chosen.

4.6 MULTI-PURPOSE REEFS

The short-listed multi-purpose reef scheme presented in EX 5200 (HR Wallingford, 2006) comprised four reefs distributed evenly along the study frontage. However, since the modelling of the groyne schemes indicated that there was no need for beach control structures along the western part of the study frontage, it was decided to consider a modified scheme involving the construction of only two of these.

The first reef was placed offshore from Branksome Dene Chine, and the second west of Branksome Chine (layout shown in Figure 10). These structures are each 100m long and positioned approximately parallel to the shoreline 180-200m offshore. This location means that they are at -2.5 - -3.5m ODN and thus in a depth of approximately 3-4m water at MHW. The efficiency of the reefs in terms of reducing wave heights passing over them has been simplified by treating them as low-crested breakwaters within the model, each having an assumed capacity to reduce wave heights by 20%. Other dimensions of these reefs such as their crest height and cross-sectional profile were not specified, as it is their efficiency and thus ability to affect the wave conditions that the model uses.

As with the three groyne schemes, the minimum, and maximum shoreline positions of the model run are presented in Figure 11. The minimum beach widths over the 5 years are narrower than the initial shoreline position throughout the model. However there are three areas of particularly narrow beach widths where the position of MHW is predicted to be landward of the seawall, thus indicating low beach levels at the structure toe. These are from Canford Cliffs Chine eastwards for about 500m, between Branksome Chine and Branksome Dean Chine, and between Branksome Dene Chine and the Borough Boundary. These minimum beach positions are typically 30-40m landward of the seawall. Although the presence of the reefs has resulted in some shelter from the wave conditions, indicated by the minimum beach positions improving immediately behind the structures, the beach widths here are still narrow.

As before the beach areas above MHW have been calculated and are presented in Table 4 below with the corresponding areas for the baseline run. The multi-purpose reefs have retained more beach area, and hence sand volumes, than in the situation with no beach control structures. Overall, however, the beach has still lost sediment (area loss of 3,100 m²), about half of that predicted to be lost from Poole's frontage under the baseline condition.

Table 4 Beach areas for multi-purpose reefs

Year	Beach area above MHW (m²)	
	Baseline	Reefs
0	152,700	152,700
1	139,900	145,400
2	135,700	138,800
3	139,200	141,200
4	152,800	159,400
5	145,900	149,600
Overall change	-6,800	-3,100

In comparison with the beach areas above MHW for each of the three groyne schemes (Table 3), the reefs have been predicted to perform significantly less well. All the groyne schemes that were modelled were predicted to increase the beach area during the period modelled. The main disadvantages of this reef scheme lie in the reduction in beach widths along the western part of the frontage.

In terms of minimum beach positions over the five years, along the worst sections of the frontage, i.e. where the minimum beach positions are shown as being landward of the seawall, the extent of narrowing seems fairly constant with the beach typically 30-40m behind the wall. This is comparable to the predictions of beach narrowing made for the 4:1 groyne scheme, save at Branksome where the 4:1 groynes resulted in worse erosion. Generally, again excluding the Branksome frontage, the two other groyne schemes (3:1 and 2:1 spacing) are predicted to have greater minimum beach widths.

The length of frontage over which the model predicts severe beach narrowing can also be used to compare the schemes. Where this occurs in the groyne schemes, it is usually just at one end of the groyne bay, whereas the reefs have caused low levels for continuous stretches of the frontage. Immediately updrift of the westernmost reef, for example, the model predicts a continuous length of frontage of 620m where the minimum beach positions are behind the seawall.

At the vulnerable eastern end of the frontage, in the region of the "bulge" in the seawall at Branksome, the mean beach position presented in Figure 11 indicates that generally the beach stays reasonably healthy. This is an improvement on the groyne schemes, where at this end of the frontage, all three of them result in mean shoreline positions at, or approaching, the seawall. This analysis indicates that although overall the reefs have not performed as well as the 2:1 groynes, there are some benefits to them, such as the improved mean beach positions (fifth year) over the eastern part of the study frontage.

In view of this, it was decided that this reef scheme should also be taken on to the final stage of the modelling study, in which the proposed layouts were refined and a final decision taken on the preferred scheme option.

5. *Choosing the preferred scheme*

From the above discussion of results, the two schemes that were refined in the final phase of the modelling study, before a final preferred scheme was chosen, were the groyne scheme where the spacing to length ration was 2:1, and the two multi-purpose reefs. These schemes only need to protect the eastern part of the shoreline because, as previously discussed, the western section does not require beach control structures.

For both of the two remaining scheme options, we altered the dimensions of the structures (and indeed number of structures in the case of the groyne scheme), both to reduce costs, and to improve their performance by:

1. Maintaining average beach positions as far seawards as possible; and
2. Avoiding beach widths that become so narrow that the seawall would be exposed to severe wave action.

5.1 ASSESSMENT CRITERIA

The assessment criteria used to refine and eventually choose between the remaining schemes are based on those previously proposed in the Phase 1 study (HR Wallingford, 2006) that were used to identify the short-listed scheme options that have been modelled in this Phase 2 study. However, these criteria have been modified in light of the modelling undertaken since that report was issued, and our better understanding of the key issues regarding beach widths.

The two schemes, after optimisation, need to be compared and assessed in order to recommend a preferred option. Although priority will be given to morphological scheme effects, other criteria used in the Phase 1 study such as costs of construction and maintenance, and impact on aesthetics and amenity may still be considered. Indeed, should the analysis of the effects on beach evolution not produce a clear preferred scheme, consideration to these factors is important.

The two criteria used to analyse these schemes were:

- Ability to maintain an adequate minimum beach width to avoid damage to, or overtopping of, the seawall/promenade; and
- Slowing longshore drift/sand losses so that the most recent and proposed future recharge operations provide appropriate coastal protection for as long as possible.

By slowing longshore drift across the frontage, less sand will be lost from the system which will enable adequate beach widths to be maintained from Sandbanks to the Borough Boundary for longer. From a coastal protection viewpoint, the ideal scenario is to maintain an equal beach width along the entire frontage, so that none of the sand imported by recharge operations is wasted in providing, at some locations, a greater beach width that that needed to protect the seawall. Thus a uniform narrowing of the beaches along the entire Poole frontage would occur, rather than localised reductions in beach width at critical locations.

The above criteria can be assessed using consideration of the minimum beach widths produced by the refined schemes, as in Chapter 4, along with the beach areas above MHW. It is also important to concentrate on the known vulnerable locations, such as the bulge in the seawall at Branksome Chine, where low beach levels have previously been a problem.

This criterion will need to be assessed using a degree of engineering judgement of the modelling results, as applied to all numerical modelling of beach evolution. The mean beach widths are also useful in terms of showing ability of the beach to retain sediment.

Although the minimum beach positions indicate the possibility of the seawall being endangered, the mean position shows overall ability to maintain the widths, which has associated amenity, aesthetic and economic benefits. Instead of presenting the minimum, mean and maximum shoreline positions of the whole survey period, it has instead been considered appropriate to consider yearly ranges from two separate years, namely 4 and 5. Analysing just these last two years ensures that any initial shoreline response to the introduction of the scheme is disregarded. The variations in wave conditions during these two years result in different shoreline responses, thus providing a better basis for comparing and assessing the remaining two scheme options.

5.2 OPTIMISED 2:1 GROYNES – ASSESSMENT

As discussed, the 2:1 spaced groynes have been chosen for optimisation as these structures are more able to maintain beach widths than when there are longer bays between the groynes, i.e. 3:1 and 4:1 spacing: length ratios.

The numerical model was used to investigate a range of alternative groyne layouts starting by removing all groynes west of Canford Cliffs Chine. Successive modelling runs were undertaken seeking to reduce the number and length of groynes necessary. During this process, it became clear that there were always going to be problems of narrow beach widths just west of the westernmost groyne. Standard practice dictates that the groynes installed become shorter as one progresses into the area of beach erosion with the aim of spreading the effects of erosion during periods of reverse drift along a greater length of shoreline rather than concentrating it in one place. The results for these successive improvements to the original scheme are not presented in this report.

The original scheme layout of 17 groynes has therefore been reduced to just six groynes spaced at 150m intervals. One of these groynes was placed roughly centrally in the bay between the westernmost Bournemouth groyne and the first groyne from the original 2:1 scheme to try to reduce the predicted loss of sediment here. The groynes have been tapered westwards, with the first 3 groynes remaining the full 75m length, the other groynes shortened to 60m, 45m and 30m respectively (scheme layout presented in Figure 12). The ain of this is to reduce the extent of beach narrowing in each location. This helps to achieve the aim of uniform changes in beach width rather than allowing localised areas of beach lowering at the toe of the seawall in one or two locations.

The minimum, mean and maximum shoreline positions from year 4 of the model run are presented in Figure 13. The wave conditions in this year (1984) provide eastward drift stronger than the average of 55,000m^3 per year. A similar figure for year 5 of the model run is presented in Figure 14. This year (1985), however, contains some severe weather from the south-east, such that the net drift from this year is reversed i.e. westward.

In year 4, the minimum, mean and maximum beach positions are all very close together, generally with less than 10m range in beach width west of the structures, indicating that there is little variability throughout the year. These positions diverge more within the groyne bays, as would be expected, although the minimum beach positions stay seaward of the seawall over the whole Poole frontage. Even though the net drift is strongly eastward, the areas within the groyne bays where the minimum beach positions are worst are just at the western side of the groyne, indicating that the erosion still takes place during episodes of reverse drift. Beach positions have remained close to the initial shoreline throughout, apart from where some smoothing of irregularities in the original shoreline has occurred.

The difference between beach positions during year 4 and year 5 are significant. Minimum beach positions are much further landward in year 5, see Figure 13, and the length of shoreline over which this occurs is longer. Within the new groyne bays, the minimum beach position narrows westwards, until it moves landward of the seawall in the last two. This continues for 400m at the end of the bays, with the shoreline up to 40m behind the seawall, typically 30-35m. West of Canford Cliffs Chine, the minimum beach position is very similar to both the maximum year five shoreline, and the initial beach, indicating little variability in this part of the frontage. The mean beach position is landward of the initial shoreline for the majority of the Poole frontage, but still maintaining a relatively healthy beach width, particularly along the western part of the frontage.

Table 5 shows the beach areas above MHW at the end of each of year of the model run, along with the overall change for the optimised groynes, and the baseline run for comparative purposes. As with the previous groyne schemes, there is an increase in beach area after five years. However this is greater than for the initial 2:1 spacing scheme (see section 4.4), indicating that this optimised scheme is predicted to manage better at retaining the sediment from the current and any future recharges. In total, there is predicted to be an increase in beach area above MHW of 13,200m², although as discussed previously, the amount of sediment assumed able to enter the model at the western end is potentially optimistic.

Table 5 Beach areas for optimised 2:1 groynes

Year	Beach area above MHW (m²)	
	Baseline	Optimised 2:1 groynes
0	152,700	152,700
1	139,900	156,000
2	135,700	152,400
3	139,200	152,200
4	152,800	175,500
5	145,900	165,900
Overall change	-6,800	13,200

5.3 OPTIMISED MULTI-PURPOSE REEFS – ASSESSMENT

The multi-purpose reefs presented in Section 4.6 have been optimised to minimise impacts on beach widths at the eastern end of the Poole Borough frontage. As with the groyne refinement described in Section 5.2, the numerical model was used to establish the performance of alternative schemes, mainly through a process of trial and error. As before, the results of these successive schemes have not been presented in this report.

The scheme consists of two structures, as with the initial scheme presented in Section 4.6, although their locations have been refined to minimise the erosion effects at vulnerable places along the shoreline. The first structure is located between Branksome Dene Chine and Branksome Chine, and the second west of Branksome Chine (Figure 15). The reefs are 80m long, and are orientated approximately parallel to the shoreline. They are situated about 190m offshore, at -2.5 – -3.5m ODN and thus in a depth of approximately 3-4m water at MHW. As before, the reefs have an assumed capacity to reduce wave heights by 20%.

Figure 16 shows the minimum, mean and maximum beach positions for year 4 of the modelling period. The wave conditions in this year (1984) provide eastward drift stronger than the average of 55,000m^3 per year. The results from year 5 of the model run are presented in Figure 17. This year (1985), however, contains some severe weather from the south-east, such that the net drift is reversed i.e. westward. In year 4, the minimum and maximum shoreline positions are generally very close together indicating that there is little shoreline variability over the year. This position is close to the initial shoreline over most of the Poole frontage suggesting that the beach has not, in general, changed a great deal. However the two reefs and the Bournemouth groynes have caused localised effects, with the minimum beach width decreasing on the western side of these structures. At three locations the minimum beach position reaches, or is landward of, the seawall, although these extremely narrow beach widths are only present over small sections. Beach positions in general have remained close to the original shoreline.

The severe weather in year 5 has resulted in rather more beach narrowing. Again it is immediately west of the structures that this effect is predicted to be greatest. Under these conditions, the minimum shoreline position is predicted to be well landward of the seawall in three locations, to a maximum of 50m just east of Canford Cliffs Chine. Here, the beach is predicted to remain landward of the seawall for over 500m.

As with the optimised groyne scheme, the worst minimum beach positions predicted as a result of the wave conditions in both years 4 and 5 are as a result of reverse westwards drift, as they occur on the western side of the structures. This suggests that although the average drift direction is eastwards, periods of reverse drift caused by south-easterly storms have the biggest impact on beach positions, and thus pose the biggest threat to the seawalls.

Beach areas above MHW are presented in table 6 for both the baseline scenario and the optimised reef scheme. The reefs have gained sediment in comparison with the baseline scenario, although overall the beach has lost volume over the 5 years, with the total area after 5 years 2,200m^2 less than the initial beach. This indicates that the reefs do not perform as well as the refined groyne scheme discussed in section 5.2 in their ability to retain the sand place during the recent (and any proposed future) recharge scheme.

Table 6 Beach areas for optimised multi-purpose reefs

Year	Beach area above MHW (m^2)	
	Baseline	Optimised reefs
0	152,700	152,700
1	139,900	149,000
2	135,700	140,300
3	139,200	141,800
4	152,800	159,600
5	145,900	150,500
Overall change	-6,800	-2,200

5.4 SENSITIVITY TESTING

The long-term evolution of beaches along this part of Poole Bay is dominated by the likelihood that sand, including that placed during recharge operations, will migrate eastwards, thus reducing beach widths. This is a problem that could only be remedied through periodic recharge. Thus far, the various schemes designed to reduce this loss of beach sediment have been tested under wave conditions that result in approximately average alongshore drift conditions.

However, it is possible that this process may occur more rapidly in the future, for example should there be an increase in the percentage or energy of waves approaching from west of south. It is therefore sensible at this point to assess the likely response of the beach against such a possible change. For this purpose, the BEACHPLAN model has been re-run for a hypothetical five-year period during which there was a greater variation in longshore drift over the frontage between Shore Road and the Borough boundary, leading to a more rapid erosion of the beaches between these locations.

We have first considered and modelled again the baseline scenario, i.e. predicting what would happen if no structures were built, and then gone on to predict the effects the two optimised schemes under this more pessimistic assumption. To show how the beach will respond under this scenario, allowing comparisons with the average drift conditions used for the majority of the study, the minimum, mean and maximum shoreline positions from year five have been plotted for each of these three scenarios.

Figure 18 presents the minimum and maximum positions for the baseline run over the five years, and the mean position from the final year. In comparison with the results from the wave conditions giving average drift conditions, see Figure 3, it is apparent that there would be a more rapid reduction in the beach widths, particularly at the western end of the model. This is indicated by the mean beach positions which are generally worse west of chainage 4600m. The implication of this is that, under this scenario, recharge operations would be required more frequently to maintain adequate beach widths.

Only adjacent to the westernmost Bournemouth Borough Council groyne, which has a strong effect on coastal evolution close to the Borough Boundary, do the beach widths remain similar in the two figures. Had this pessimistic drift scenario have been used for the majority of the modelling, it may have been decided that beach control structures were required to cover a greater length of the frontage, perhaps as far west as chainage 4600m.

Minimum beach positions are also generally worse in Figure 18 than in Figure 3, i.e. for the average drift scenario, apart from at the eastern end of the Poole frontage. Here the increased west to east drift helps to reduce the localised and short-term problems of beach narrowing during periods of reverse drift, i.e. during south-easterly storm conditions. As discussed previously, this effect has caused many of the most severe minimum beach positions throughout.

Turning now to the effects of the two refined beach control schemes under the pessimistic drift scenario, we first considered the optimised groynes at 2:1 spacing. The minimum, mean and maximum shoreline positions from year five of the alternative wave conditions are shown in Figure 19. These can be compared with Figure 14. Again it is apparent that there is a greater amount of eastwards drift under the new conditions, such that the mean beach position is worsened along the western part of the study frontage. The changes in mean beach width in the bays between the proposed new groynes, however, are predicted to be modest, i.e. the groynes are proving effective at retaining beach sand despite the greater eastward drift rate.

Not surprisingly under this pessimistic drift scenario, the minimum beach positions are also predicted to be seaward of the seawall further west than those shown in Figure 14, and this indicates low beach levels at the toe of the seawalls for a greater proportion of the frontage. As mentioned above, with such a scenario further tapered groynes may be necessary under such conditions. Within the new groyne bays, however, the minimum beach positions are no worse with the increased drift, which indicates that the structures are performing well at retaining the recharge material.

Lastly, the results of testing of the optimised multi-purpose reefs under the increased drift scenario are shown in Figure 20, and can be compared to the corresponding results shown in Figure 17 for the average drift scenario.

Eastward of about chainage 4600m, the minimum beach positions are very similar in both scenarios, but further west the reduction in beach widths for this scheme is significantly worse than for the 2:1 groynes (Figure 19) , indicating that the reefs are not performing so well at retaining the recharge sediment

The minimum beach positions westward of about chainage 4600m are, however, better for this scheme than for the 2:1 groynes under the increased drift scenario. Although the beach high water positions are still shown as landward of the seawall, indicating low beach levels at the structure toe, the distance landward is reduced.

5.5 PREFERRED SCHEME

The key considerations in selecting a preferred beach control structures scheme were to maintain adequate minimum beach widths and to retain sand placed on the beach during recent (and any future proposed) recharge. These primary considerations relate to the coastal defence attributes of any scheme, but there is a range of other desirable scheme attributes relating for example to its costs, and impacts on the amenity and aesthetics of the frontage. Consideration has also to be given to not causing any unnecessary adverse effects across the Borough Boundary into the Bournemouth frontage.

This modelling exercise has demonstrated that no structures are necessary along the western part of the study frontage, which immediately helps achieve the above secondary objectives. Whichever of the two options taken forward for refinement was chosen, it would clearly be preferable on these grounds to the options short-listed at the end of the Phase 1 study.

In terms of adverse impacts on the Bournemouth frontage, the schemes chosen have no greater effect on the natural evolution of the beach than groynes of the same type that have already been built on the western end of the Bournemouth shoreline. By adopting structures that are no more efficient than those already constructed at Bournemouth, it is reasonable to argue that the schemes adopted would not have unreasonably adverse effects on that shoreline.

Based on the above general considerations, the two schemes presented in Sections 5.2 and 5.3, namely the optimised groynes at 2:1 spacing and the multi-purpose reefs, both perform well. It is possible that the scheme involving two multi-purpose reefs could be refined even further and has the advantage of using less construction material than the refined groyne scheme. The sensitivity testing has indicated that while the groyne scheme reduces the overall loss of beach sediment under the greater drift scenario, the reef scheme performs slightly better in terms of the minimum beach widths retained.

Choosing between the two optimised schemes has therefore been difficult. In making this choice, we have borne in mind the following factors:

The costs of future beach recharge operations may increase steeply, especially if there is no need for more that minor dredging of the navigation channel into Poole Harbour;

There is a recognised need to take into account changes in wave conditions, particularly in wave heights and directions, as a result of climate change. Any coastal defence scheme should be capable of being adjusted to cope with such changed circumstances;

It is likely that, for whatever scheme is built, the beaches at the base of the seawalls will occasionally fall to low levels. It is likely that direct improvements to the seawalls and promenade, for example by underpinning the seawall toe, will be needed at vulnerable locations, and it would be cost-effective to extend such improvements along a greater length of frontage rather than investing in more a extensive beach control structure scheme.

Based on the performance of the schemes in retaining beach sand for longer, and bearing in mind the relative ease by which adjustments to the scheme could be made if necessary, we have concluded that the 2:1 groyne option shown in Figure 12 is the better of the two schemes.

6. Conclusions and recommendations

6.1 CONCLUSIONS

The numerical modelling of the Poole frontage between Shore Road, Sandbanks and the Borough boundary undertaken for Phase 2 of this study, has resulted in the following main conclusions:

- There is no need for beach control structures along the western part of the frontage. This results in a considerable reduction in the costs and adverse impacts on amenity/ aesthetics of the short-listed schemes identified in the Phase 1 study;

- The major difficulty in maintaining of adequate minimum beach widths arises during storms from the south-east, which cause periods of reverse (i.e. westward) drift. In such circumstances the long, closely spaced groynes at the western end of the Bournemouth Borough frontage leads to the temporary starvation of sand, and thus narrowing of beaches, at Branksome Dene Chine and Branksome Chine;

- It is not possible to entirely eliminate this problem through use of beach control structures along the eastern part of the Poole frontage. However, it is possible to spread the effects to avoid intense and localised beach lowering problems beyond the westernmost of the proposed beach control structures;

- Sensitivity testing of the best two schemes has indicated that were wave conditions to change in the future so as to cause greater eastwards drift, it may be necessary to consider protecting a greater length of the frontage;

- The schemes developed for the Poole frontage have less effect on sediment transport and thus beach evolution than those already located on the Bournemouth Borough side. This is deemed sufficient to achieve the objective of not causing unreasonable adverse impacts on the adjacent Bournemouth frontage;

- The multi-purpose reefs have been shown to work almost as well as the conventional groyne scheme eventually recommended as the best option. However this type of scheme is difficult to optimise using our existing modelling methods and these structures would be difficult to adjust once built. Although the construction materials required to build the reefs would perhaps be less than the groynes, the scheme is unlikely in this area to have great benefits in terms of increased use of frontage by surfers;

- A reef scheme, being potentially cheaper to construct, may therefore be worth pursuing either here (should there be a significant delay in obtaining funding for the optimised groyne scheme or if the expected amount of that funding is decreased significantly) or in similar situations elsewhere; and

- The refined groyne scheme comprising six groynes up to 75m long and spaced at 150m intervals is the preferred option. It is assumed that these would be of similar type to those successfully used at Sandbanks, i.e. constructed of rock with horizontal crest above the level of high water, thus allowing the optional addition of a walkway along them. Their spacing and length is in line with established practice, and the scheme over the boundary into the Bournemouth frontage. Such a scheme is capable of being adjusted and/ or extended should this be necessary (for example in response to difficulties to undertaking future beach recharge schemes).

6.2 RECOMMENDATIONS

It is recommended that a regular monitoring programme is established in order to assess shoreline evolution along the Poole frontage, and performance of the new scheme. This should involve monitoring of beach widths particularly within the new groyne bays, and should include plan-shape surveys as well as profile surveys.

The beach control scheme recommended will not be able to prevent localised beach lowering problems at times. It may therefore be necessary to accommodate this problem by increasing the resilience of the seawall to the threats of undermining and overtopping. Undermining could be prevented by protecting the toe of the seawall, for example by underpinning, or installing a rock apron, and overtopping by establishing a warning system or by reinforcing the promenade surface and rear upstand wall.

7. References

HR WALLINGFORD, 1995. *Poole Borough Coastal Strategy Study*. EX 2881. HR Wallingford, Wallingford.

HR WALLINGFORD, 2003. *Poole Bay & Harbour Strategy Study, Computational Modelling Studies*. EX 4555. HR Wallingford, Wallingford.

HR WALLINGFORD, 2006. *Beach Control Structures Poole – Alternative coastal defence options, Sandbanks to Branksome Dene Chine.* EX 5200. HR Wallingford, Wallingford.

Figures

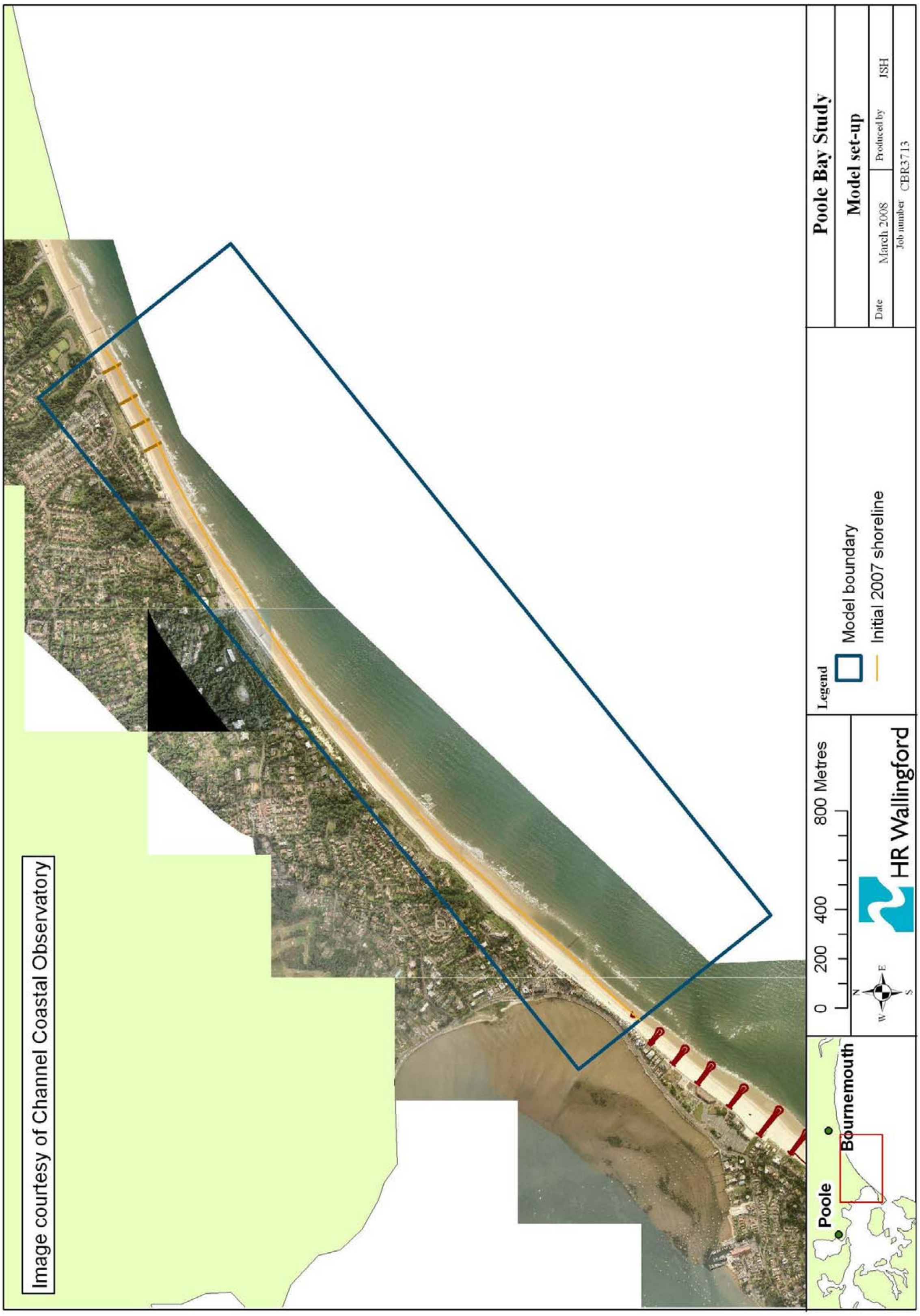

Figure 1 BEACHPLAN model set-up

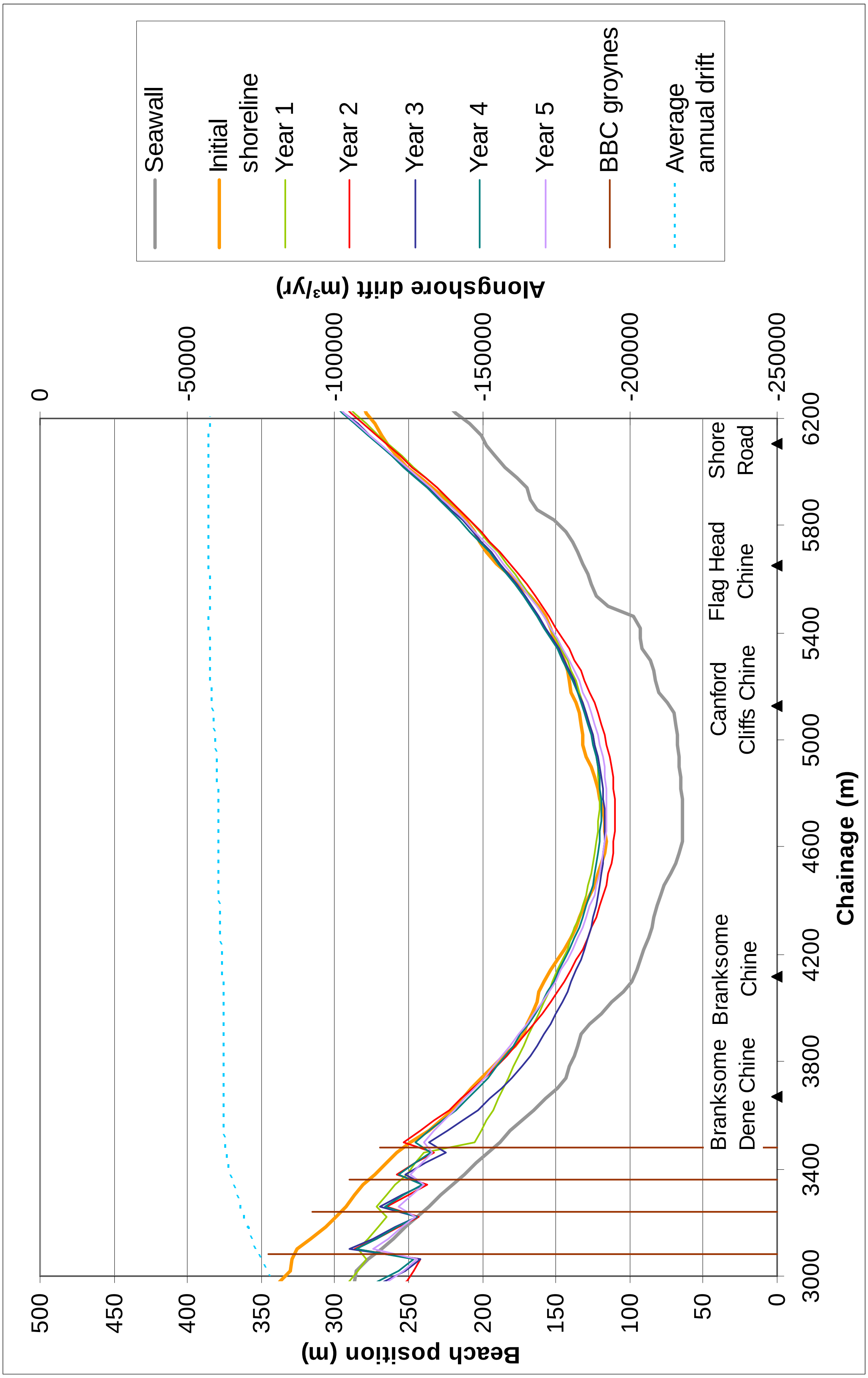

Figure 2 Baseline BEACHPLAN run

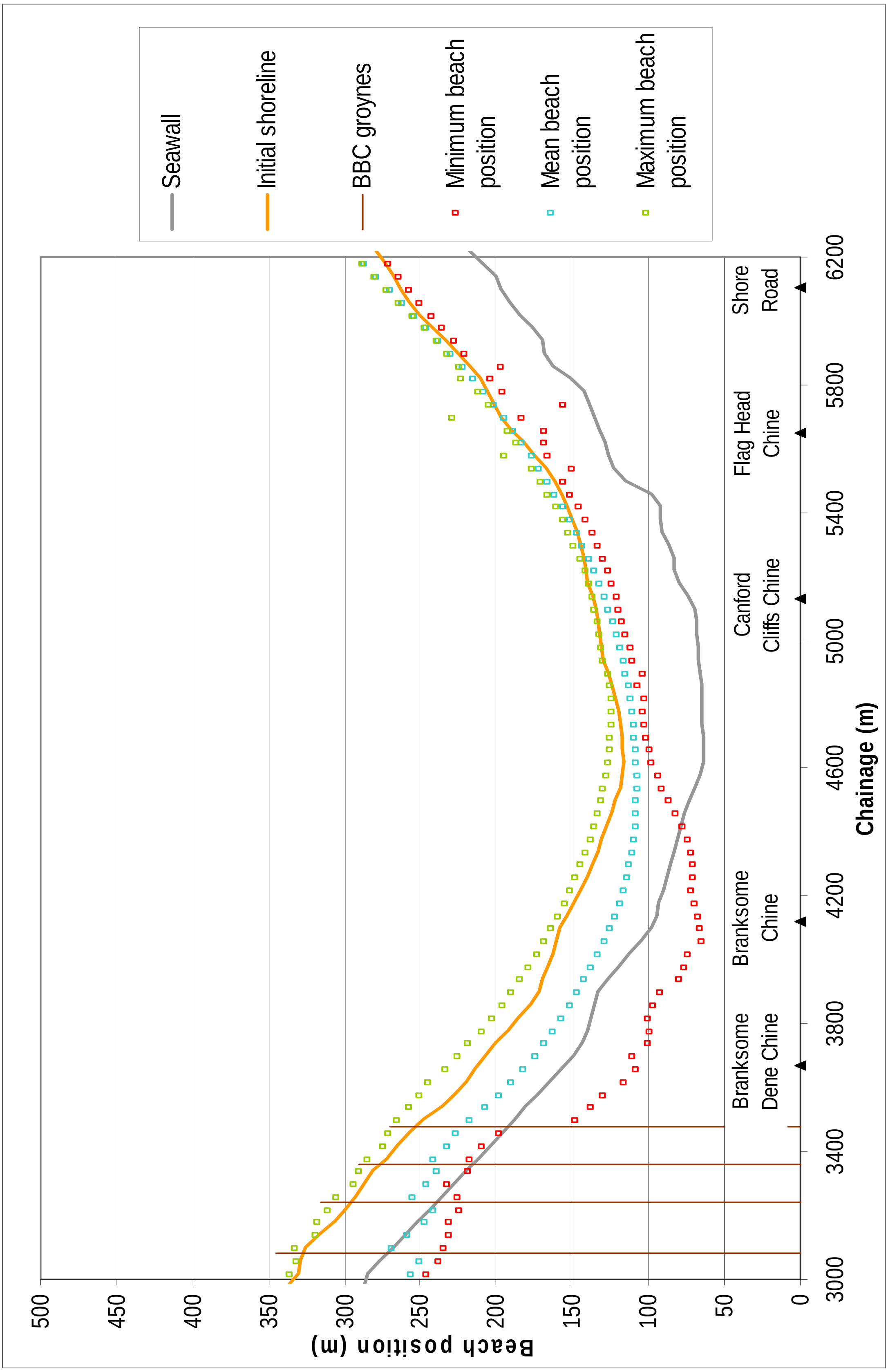

Figure 3 **Minimum, mean and maximum shoreline positions for the baseline run over 5 years**

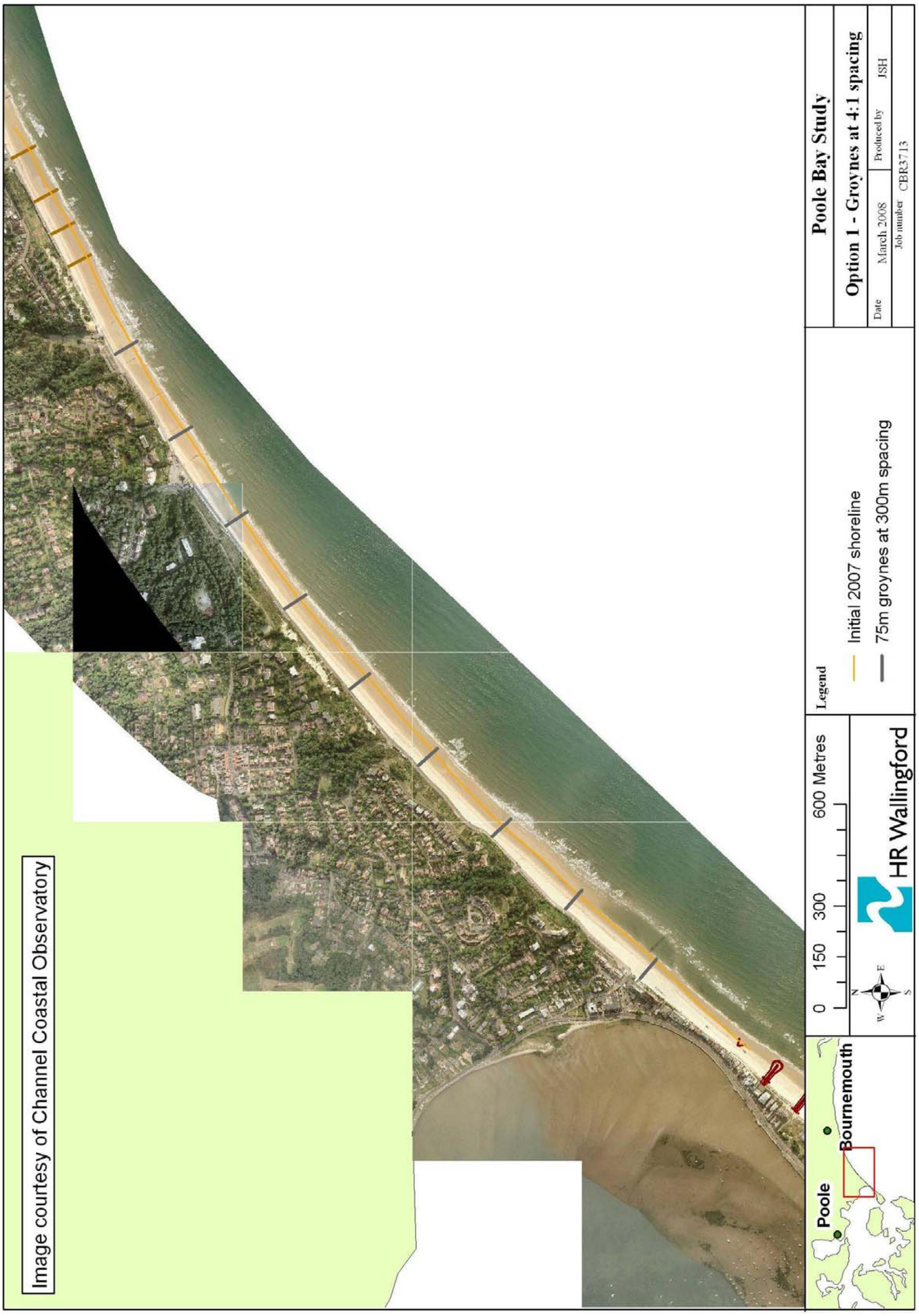

Figure 4 Scheme layout for groynes at 4:1 spacing

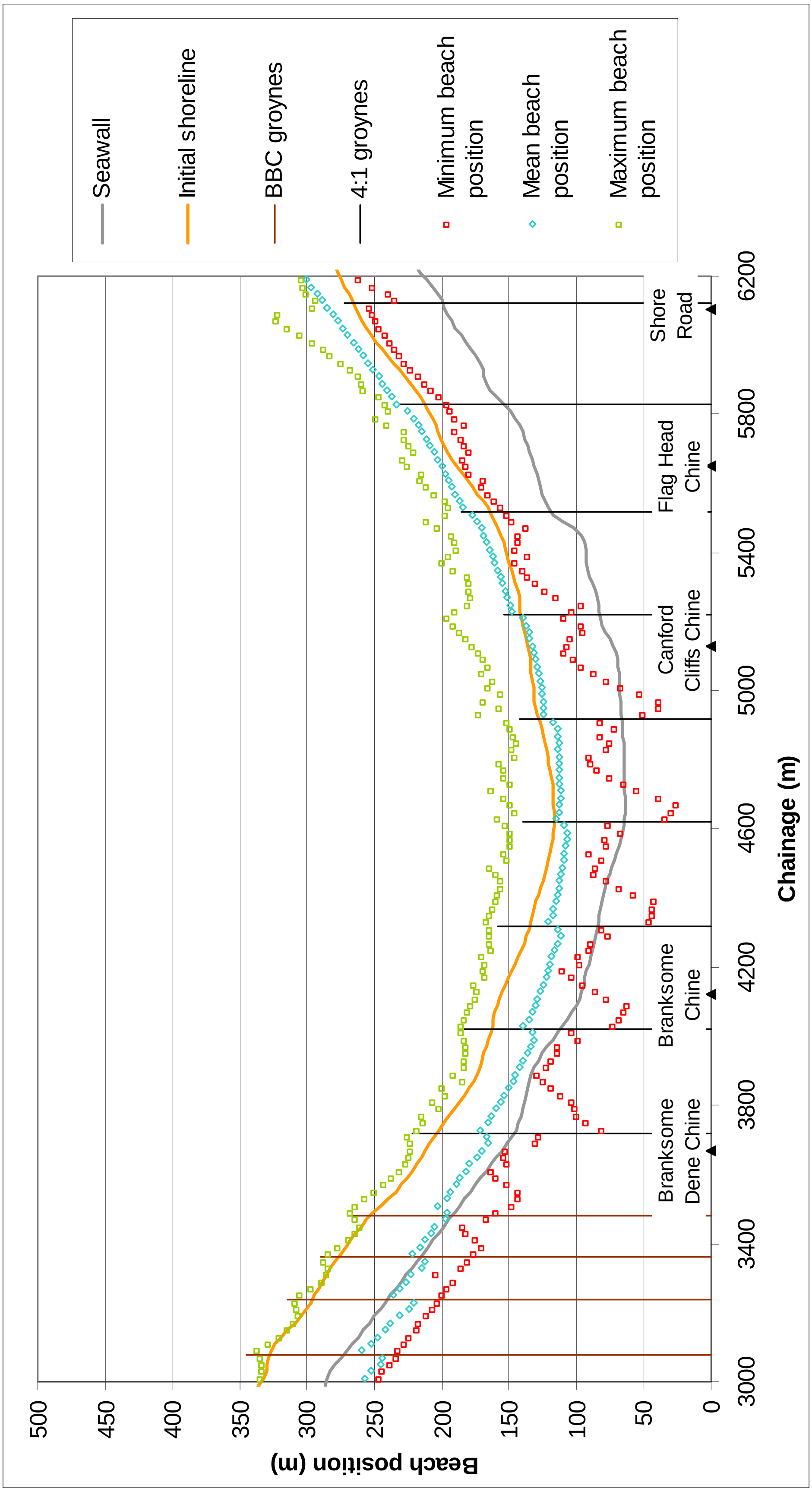

Figure 5 BEACHPLAN results for groyne scheme at 4:1 spacing

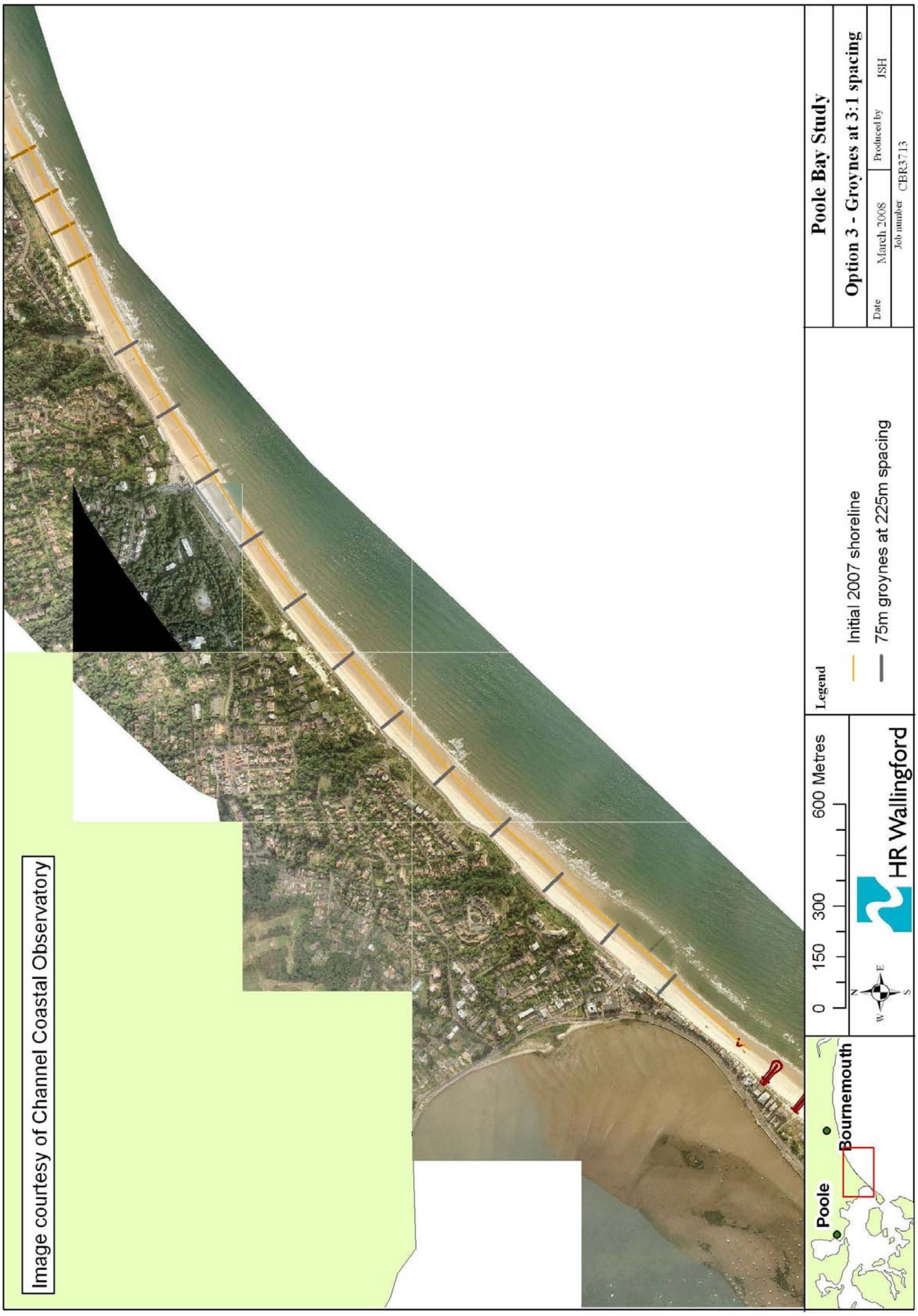

Figure 6 Scheme layout for groynes at 3:1 spacing

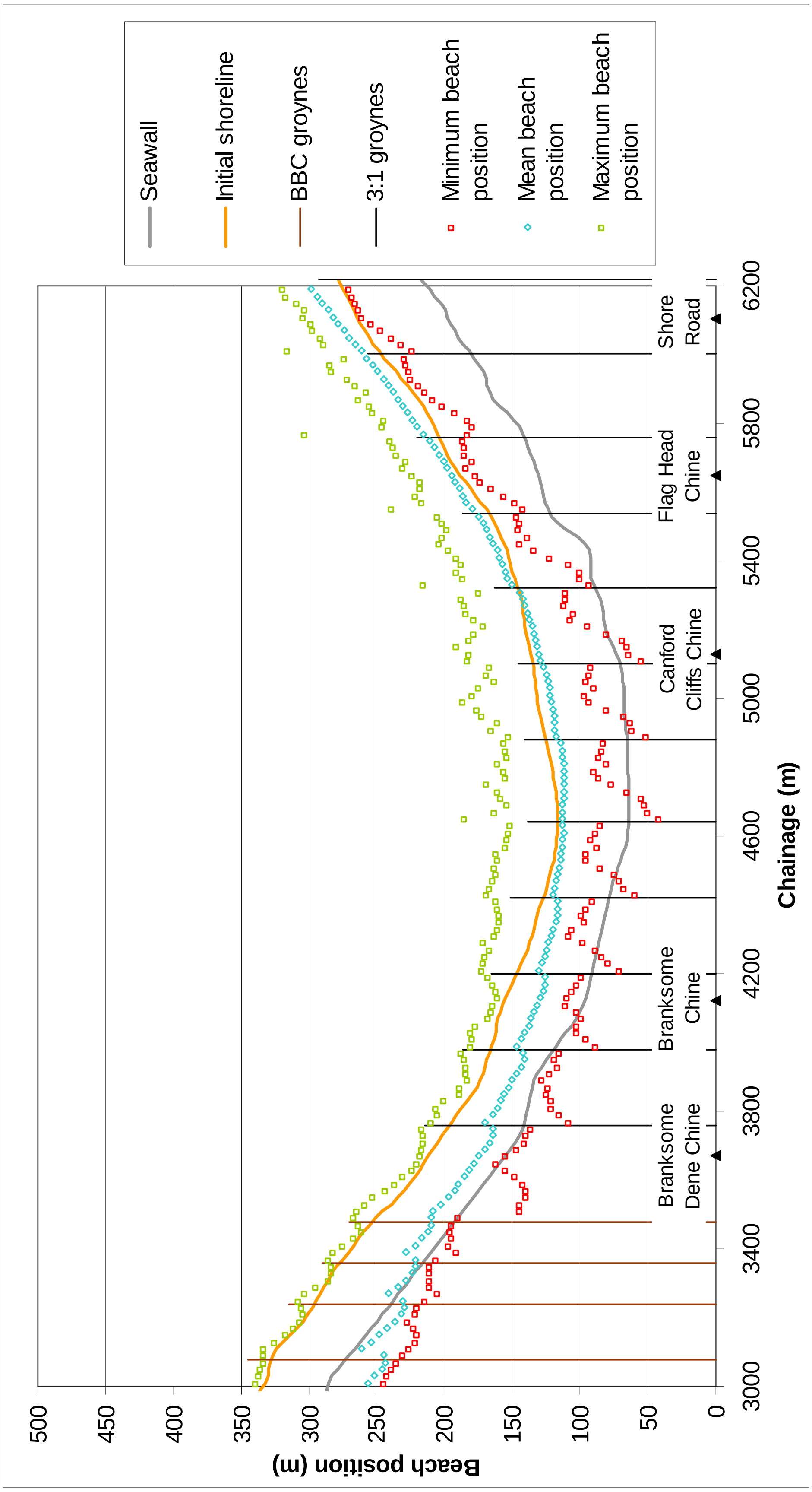

Figure 7 BEACHPLAN results for groynes at 3:1 spacing

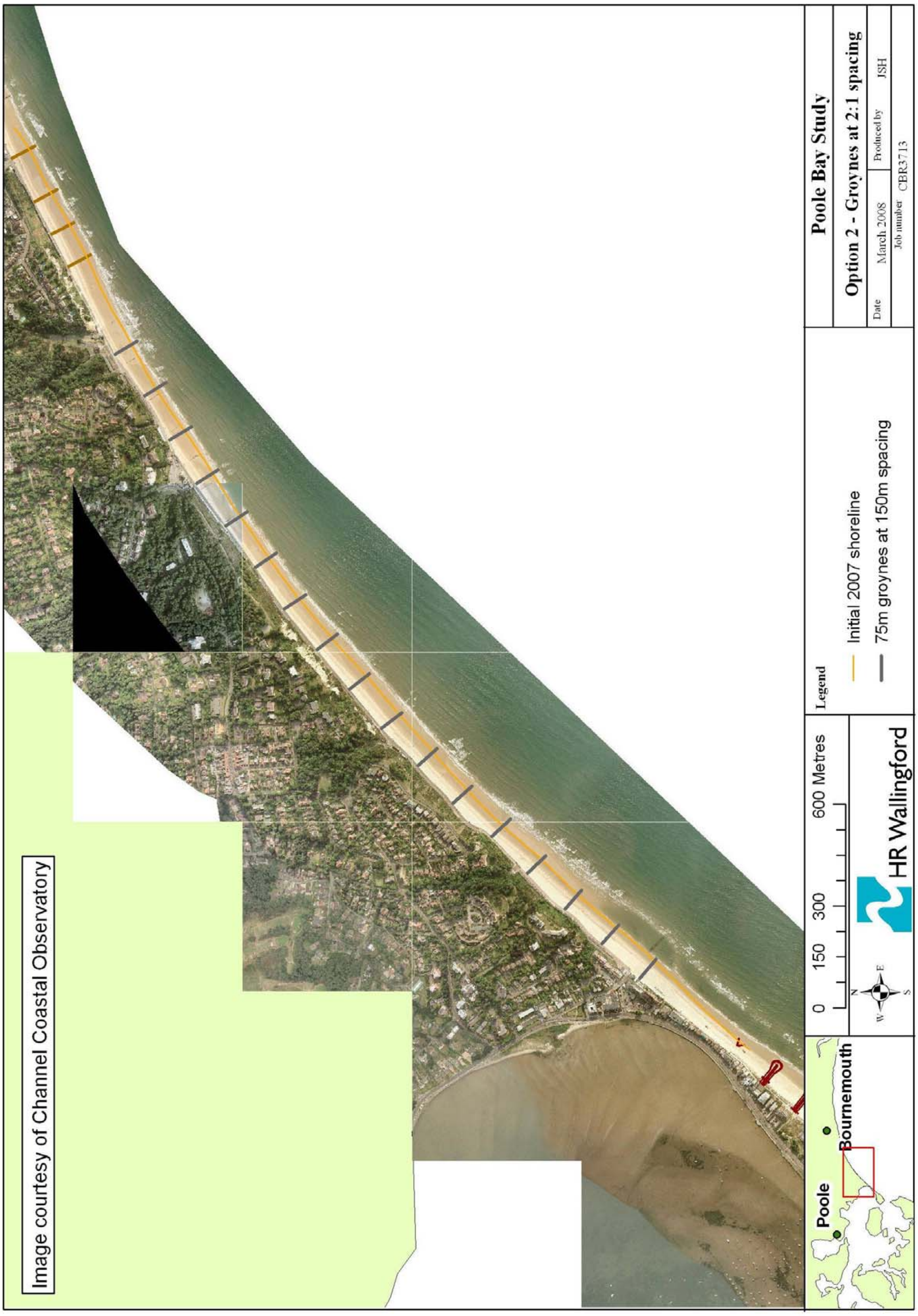

Figure 8 Scheme layout for groynes at 2:1 spacing

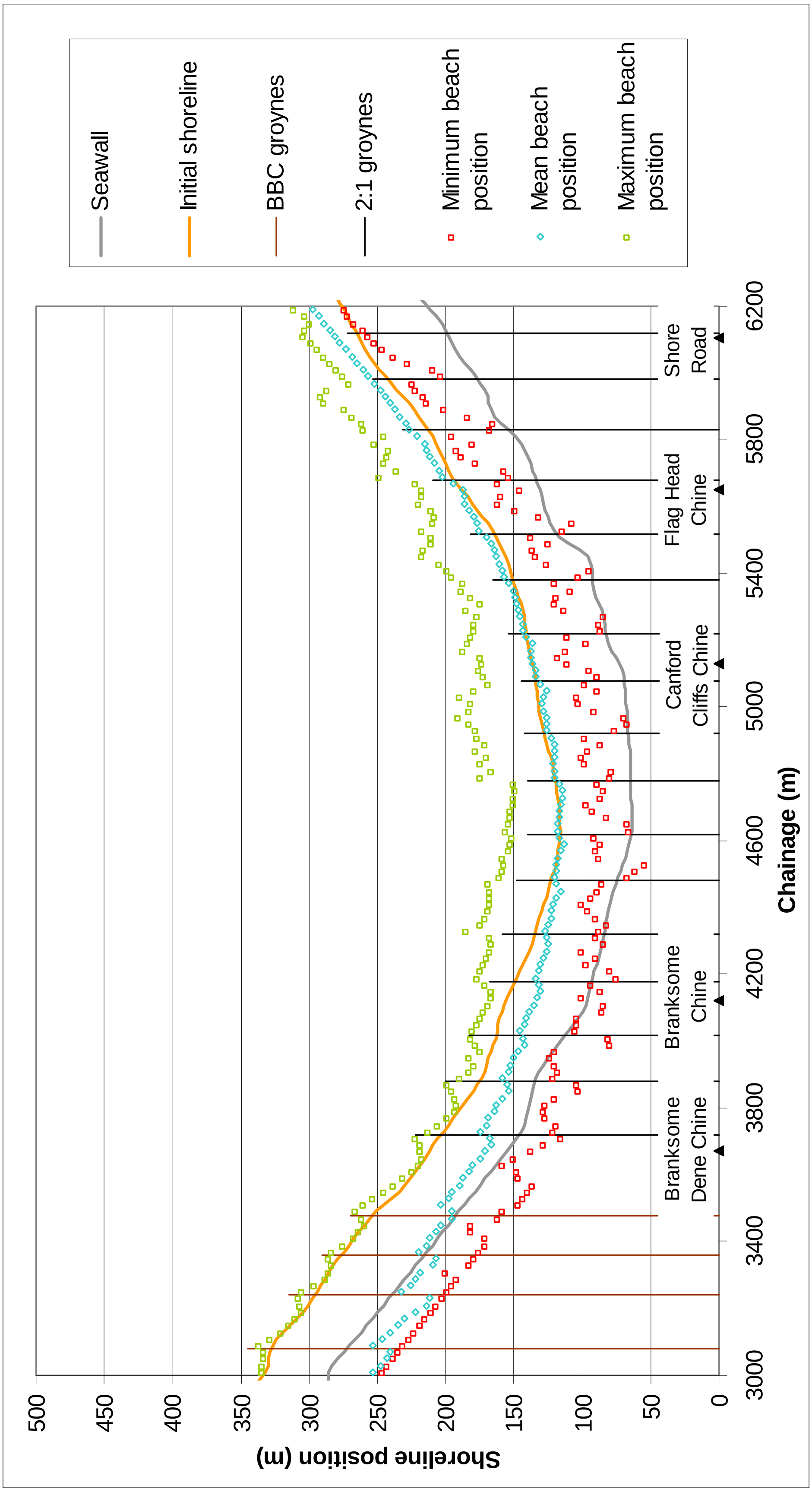

Figure 9 BEACHPLAN results for groynes at 2:1 spacing

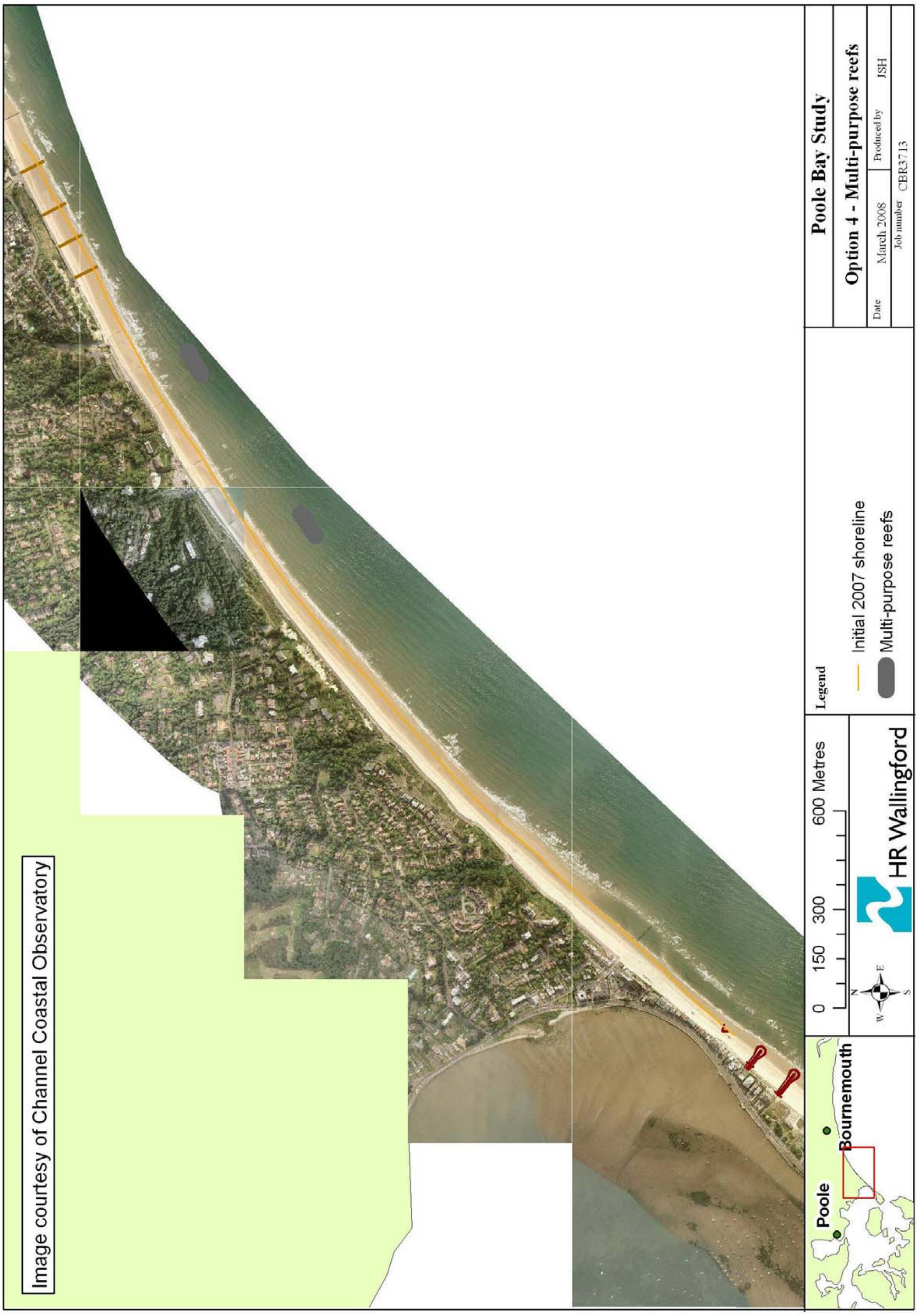

Figure 10 Scheme layout for multi-purpose reefs

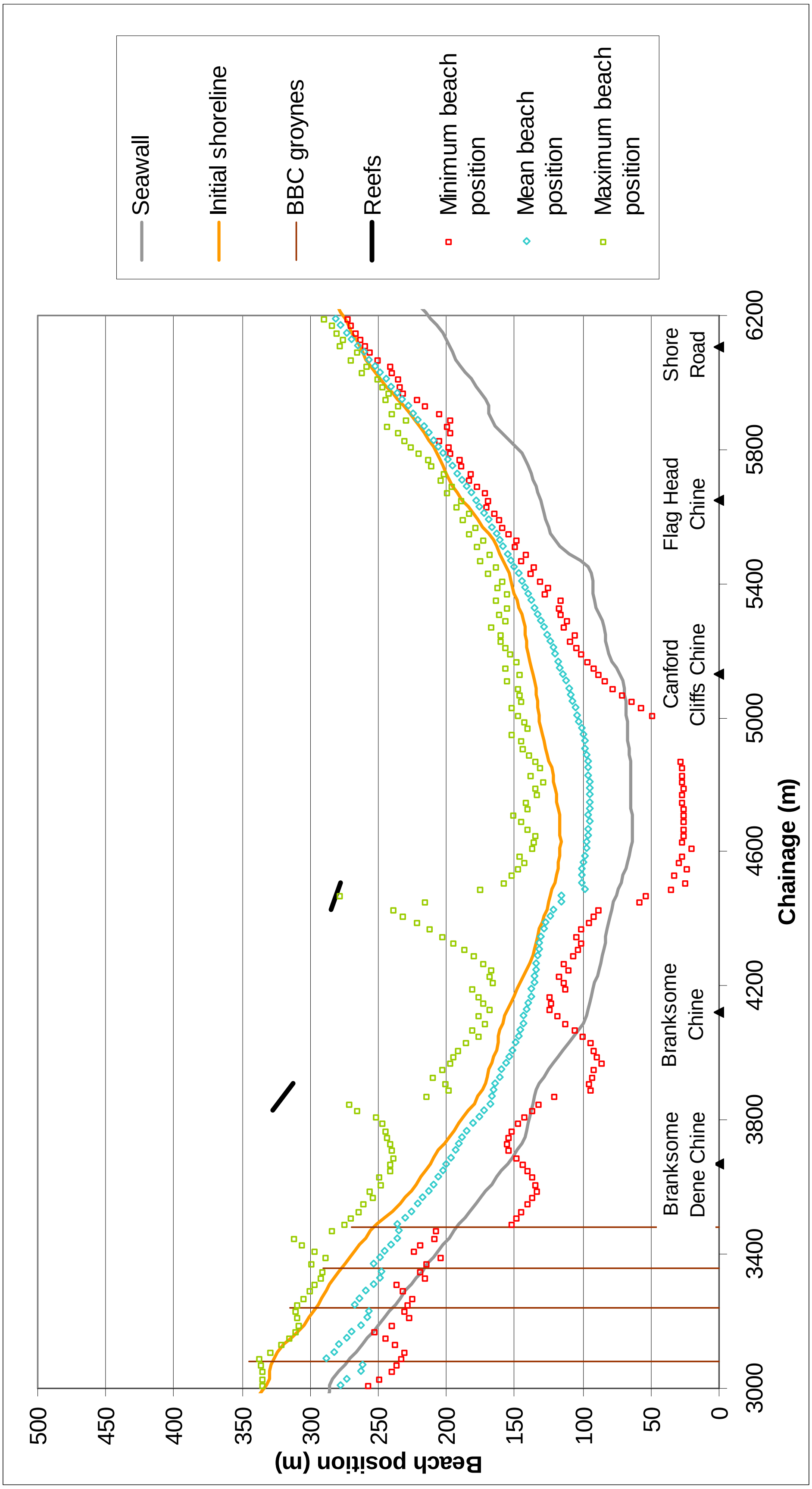

Figure 11 BEACHPLAN results for multi-purpose reefs

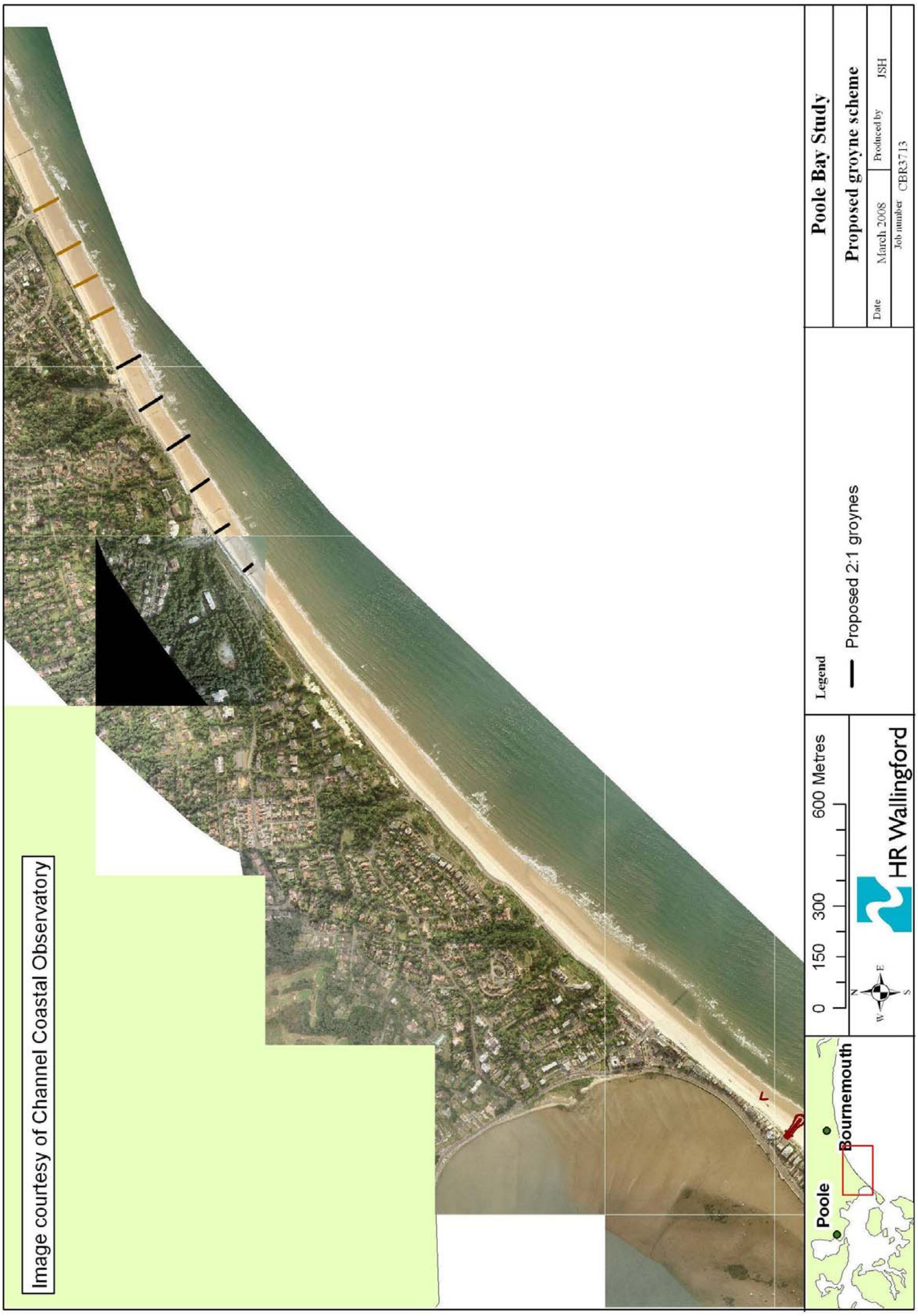

Figure 12 Scheme layout for optimised groynes at 2:1 spacing

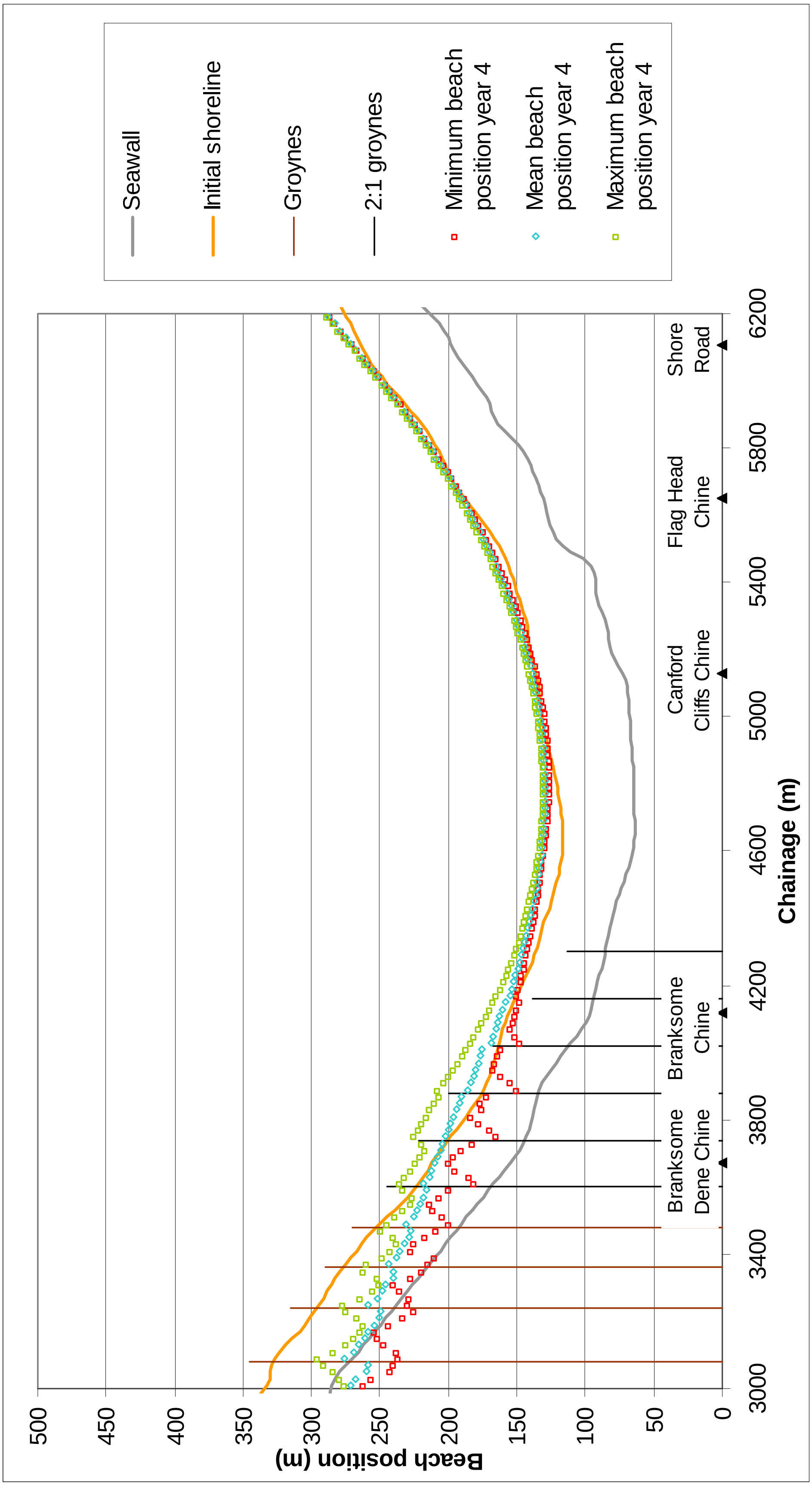

Figure 13 BEACHPLAN results for optimised groynes at 2:1 spacing– year 4

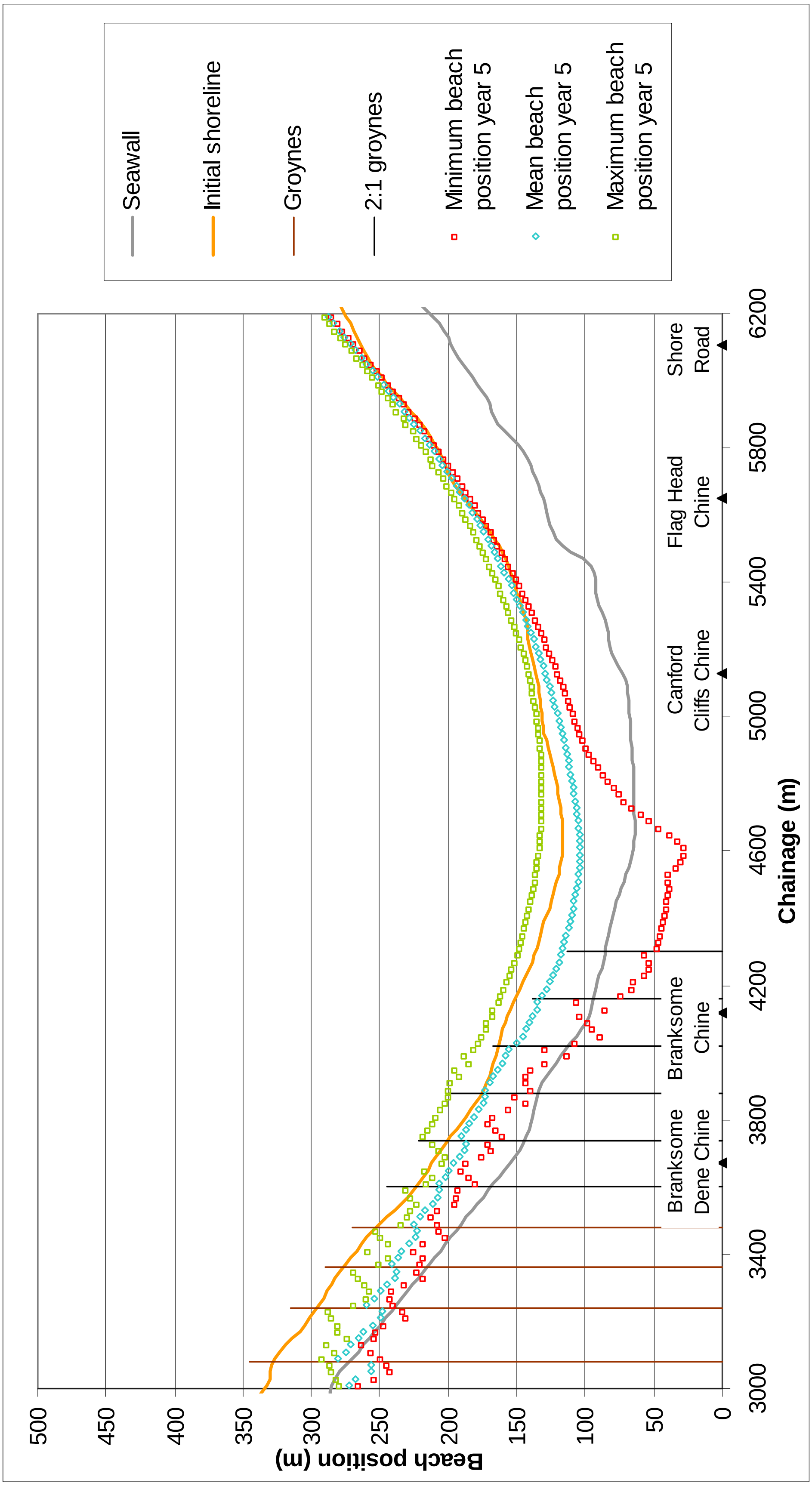

Figure 14 BEACHPLAN results for optimised groynes at 2:1 spacing – year 5

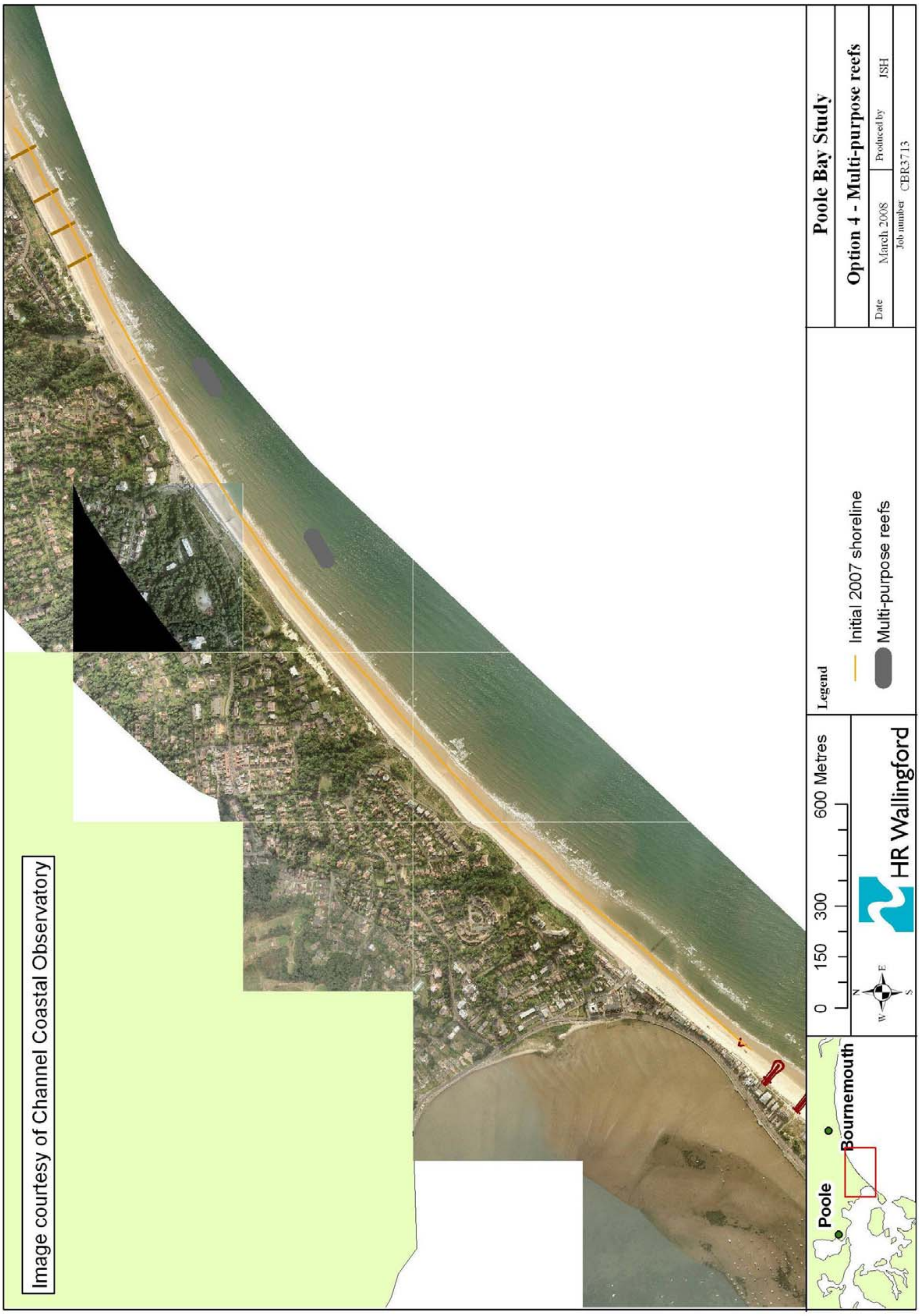

Figure 15 Scheme layout for optimised multi-purpose reefs

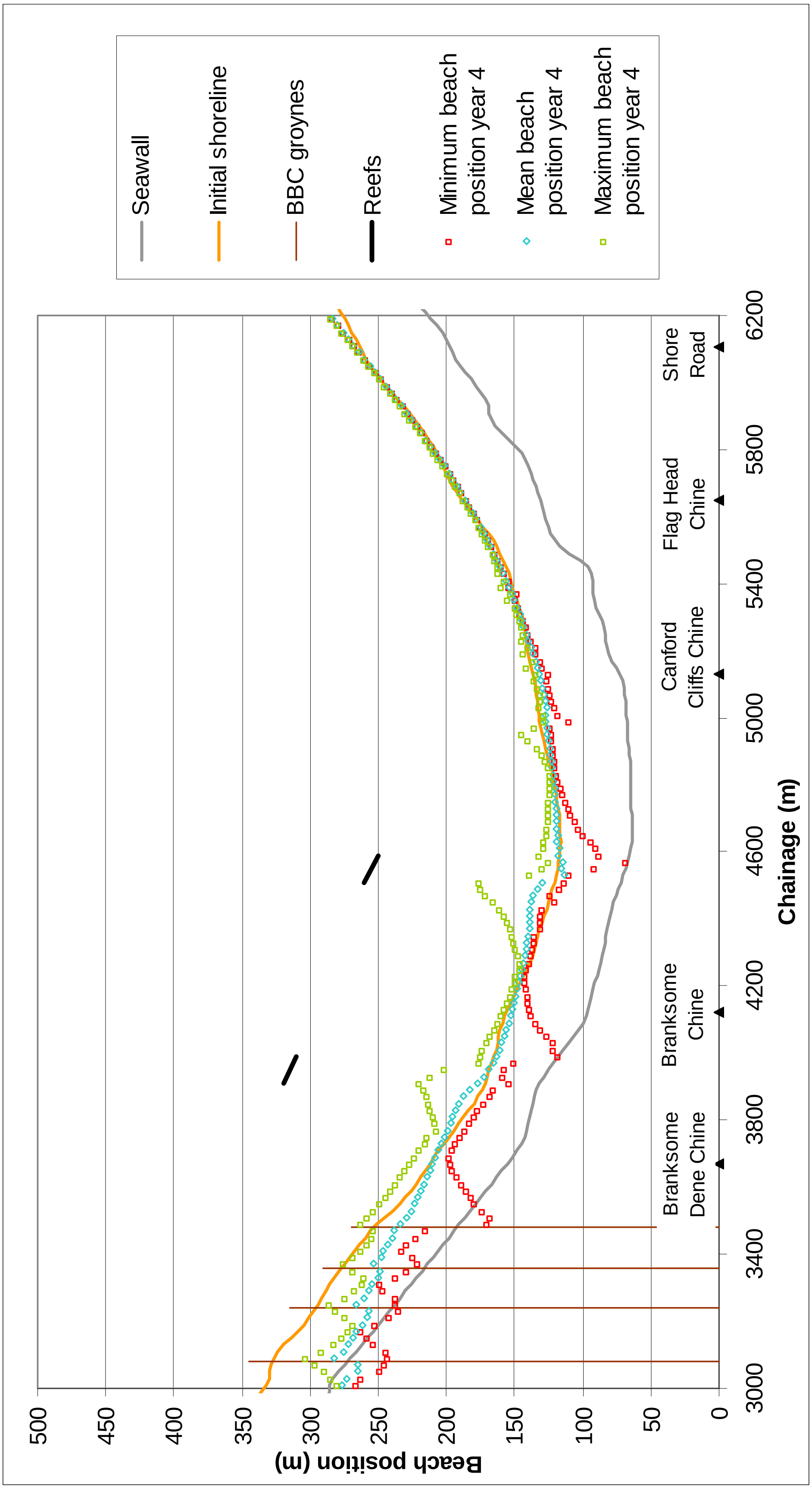

Figure 16 BEACHPLAN results for optimised multi-purpose reefs – year 4

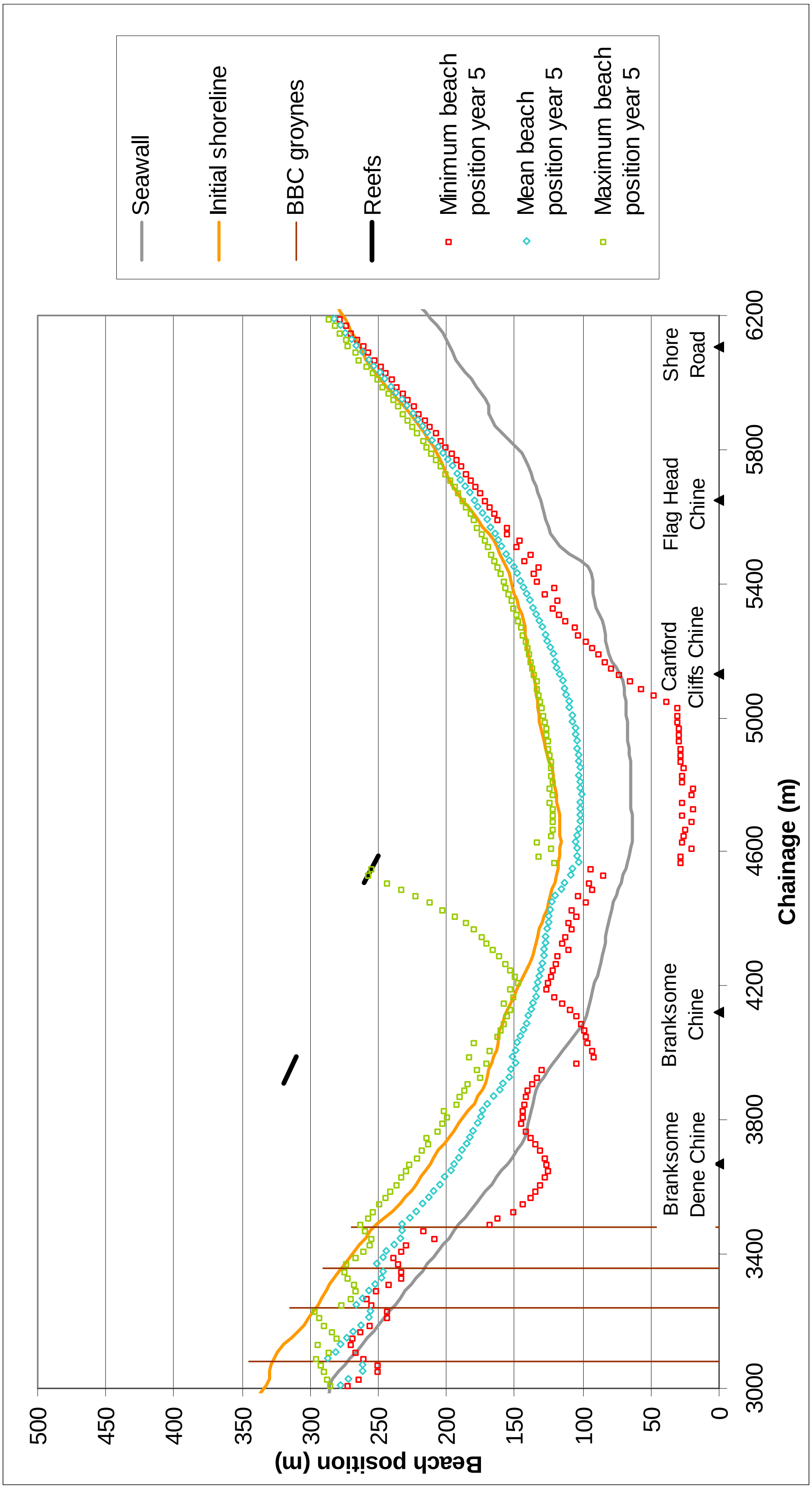

Figure 17 BEACHPLAN results for optimised multi-purpose reefs – year 5

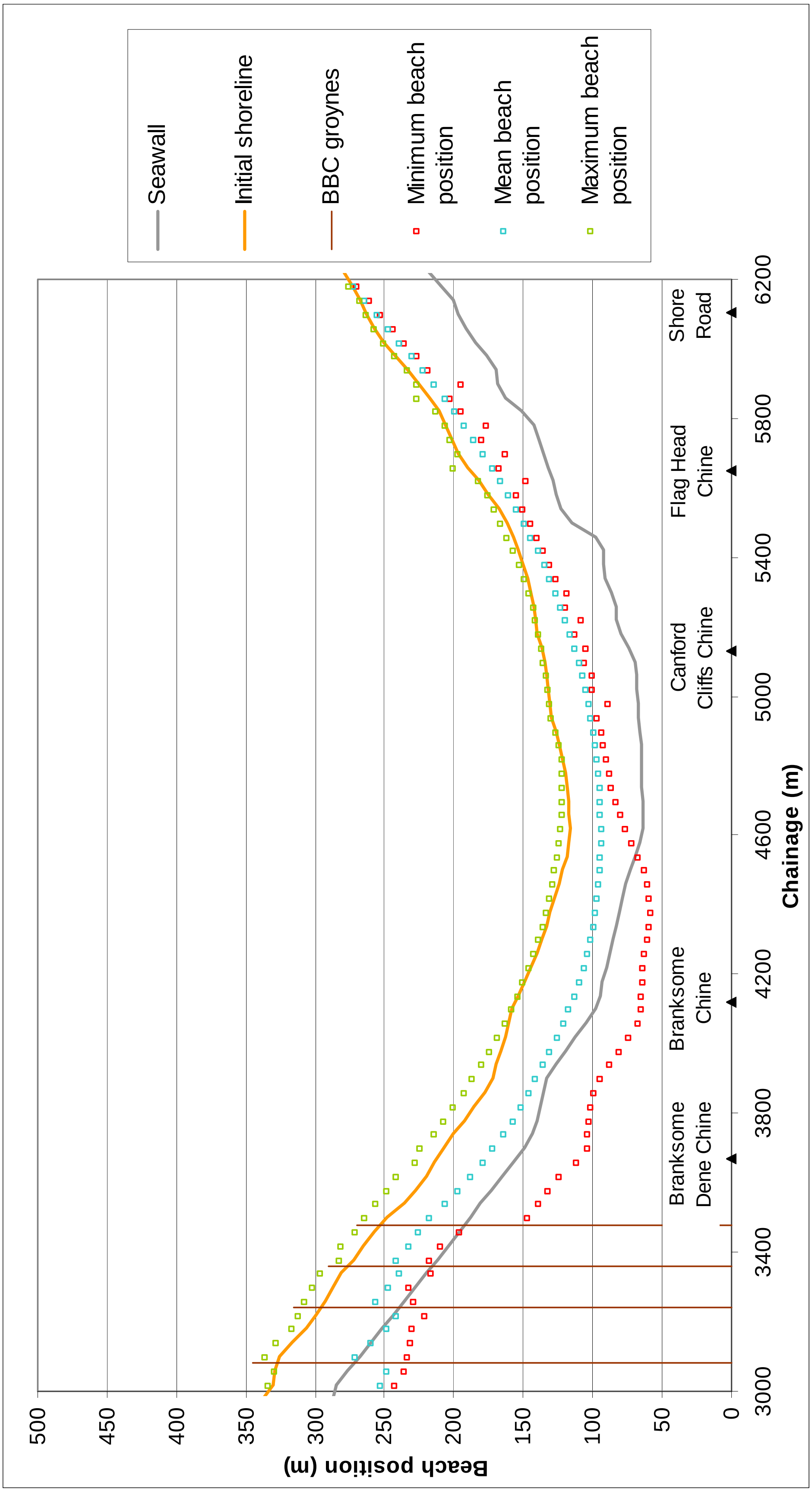

Figure 18 Sensitivity testing BEACHPLAN results for the baseline scenario

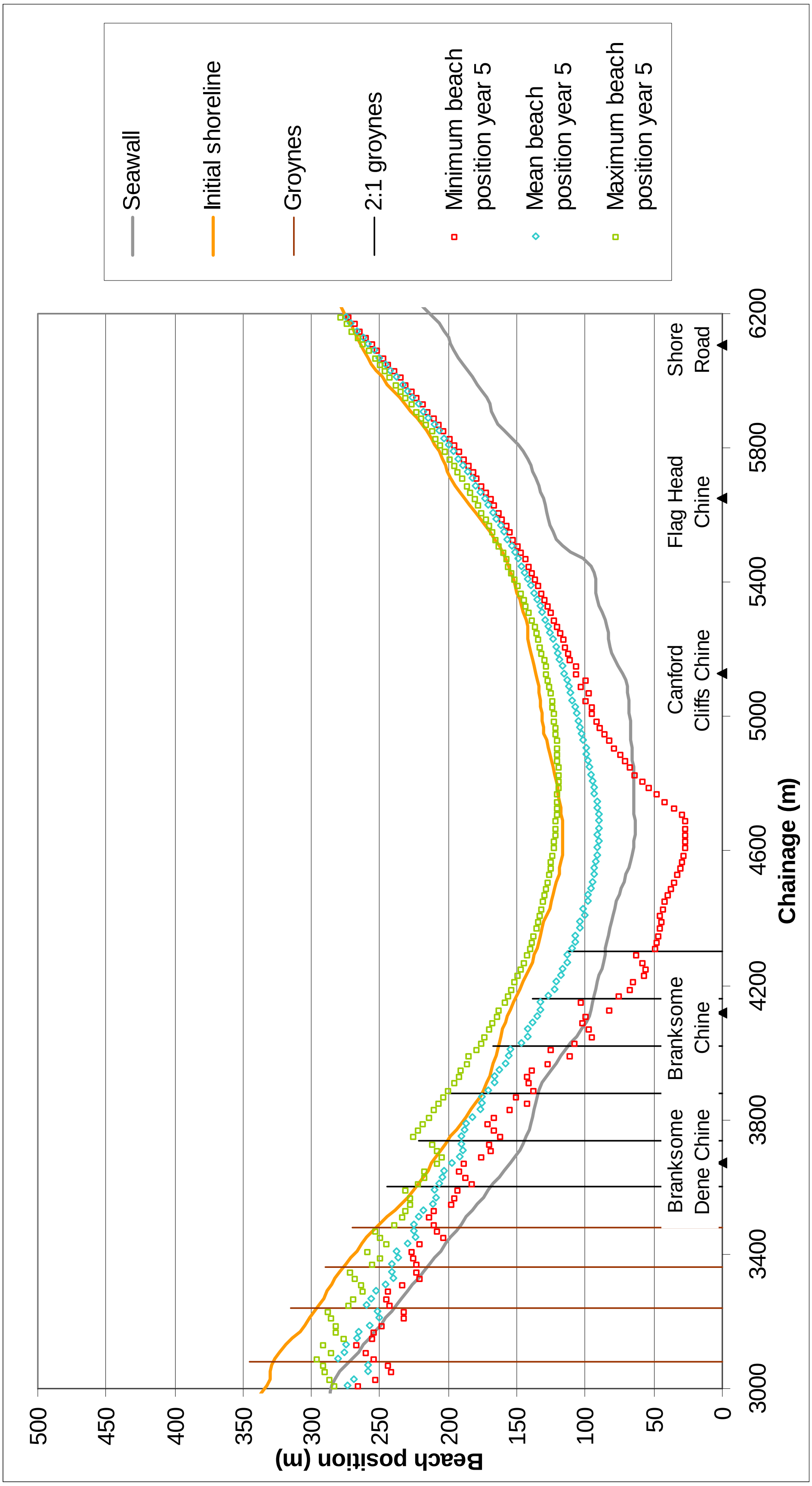

Figure 19 Sensitivity testing BEACHPLAN results for the optimised groyne scenario

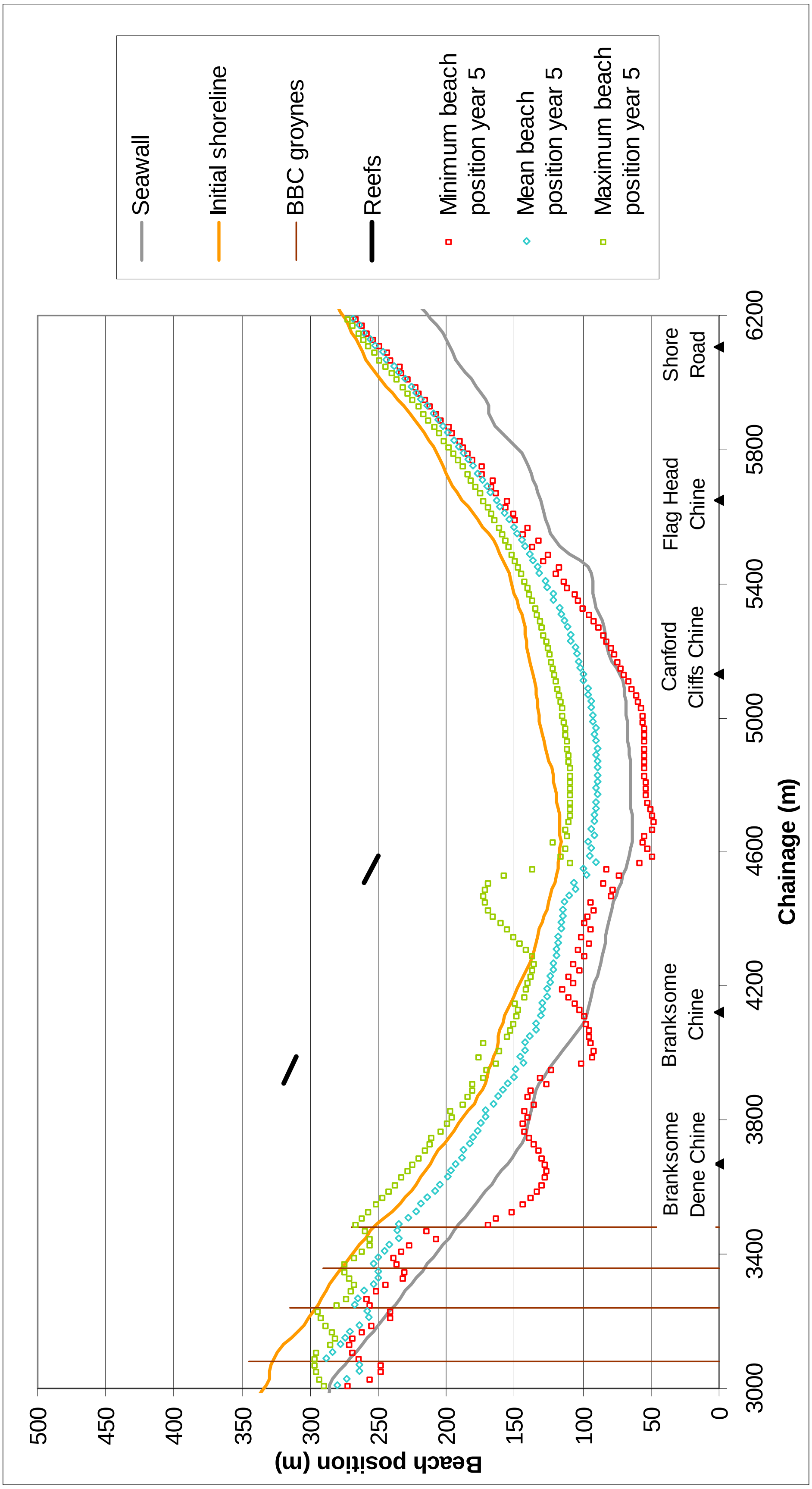

Figure 20 Sensitivity testing BEACHPLAN results for the optimised reefs