Christchurch Bay and Harbour Flood and Coastal Erosion Risk Management Study

Technical Annex 4: Beach Planshape Modelling

Prepared by

New Forest District Council

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Contents

1 Introduction

The Assessment of the coastline and recycling requirements has been carried out in three stages:

1.1 BEACHPLAN Modelling

The coastline was split into 11 sections and a model set up for each section. Using BEACHPLAN an assessment of the potential longshore sediment flow characteristics was investigated.

Particular questions have been raised over the effectiveness of existing coastal protection structures and this was addressed by investigating a range of scenarios in a number of the sections.

1.2 SHINGLE Modelling

The performance of existing cross-shore beach profile response to extreme nearshore wave conditions was investigated using the SHINGLE model.

Beach profiles designed to effectively respond to extreme nearshore wave conditions were developed following SHINGLE model testing.

1.3 Beach Recharge

Bay wide recharge options were formulated to provide the necessary volume of beach material to offer the required level of protection, enable material to feed around the Bay. Recycling and replenishment have been incorporated in order to form an effective Strategic Beach Management Plan.

2 Beach planshape Modelling

2.1 The BEACHPLAN Model

Developed by HR Wallingford, BEACHPLAN is numerical model designed to predict the response of a beach as it is subjected to wave action. The model is designed for use by engineers to forecast trends in the long-shore sediment transport rate and the changes that occur due to the presence of cross-shore man made structures such as groynes.

BEACHPLAN demonstrates the response of a pre-defined section of beach to wave action over a designated time period in terms of the potential net and gross rate of long-shore transport in terms of material volume. BEACHPLAN also represents the effect of transport by the movement (in plan view) of a single contour.

BEACHPLAN modelling has been undertaken as part of the Christchurch Bay Strategy to assess what is the potential flow volume and net flow direction of material within Christchurch Bay. Changes due to the orientation of the coastline and the effect of varying grain size at different locations around the Bay were taken into account by the BEACHPLAN model. It was therefore possible to evaluate how conditions varied around the Bay and how existing cross-shore structures contribute to reduce the potential flow rate of material.

BEACHPLAN requires accurate and reliable data inputs in order to allow the model to function satisfactorily and produce realistic results. These requirements can be broken down into two user-controlled data files, the **Control file** and the **Wave data file**.

2.2 Control File

The control file describes the initial site-specific conditions in order to start the model. For each of the 11 sections of coastline the parameters that define the profile of the beach, relative to each section of coastline are input into the model. The inputs are measured from a number of sources including aerial photographs, hydrographical & topographical surveys of the specific location. All input criteria is referenced to a baseline, drawn parallel to the coast and referenced with respect to the chainage along this baseline.

The two parameters that define the coastline in BEACHPLAN are the location of the initial shoreline (**original beach position**) and the location of the landward limit of the beach (**seawall**). The **original shoreline** position is a digitised line representing a specific contour (0m OD contour for example) that is derived from contour lines generated from hydrographic and topographic surveys of the location. The **seawall** is a digitised line that represents the position of the back of the beach; this could be the base of a cliff or the position of a seawall etc and is generated from a geo-rectified aerial photograph. Both parameters are referenced with respect to chainage along a baseline. Additional values are required in order to define the section further as shown in Table 2.1. All values are referenced with respect to chainage along the baseline:

Beach Defining Criteria	**Description**
Renourishment	The volume (m^3) of beach material that is added to the modelled section of coast due to renourishment or replenishment, or mining activities (m3).
Closure Depth	The lowest level of the beach at which sediment transport occurs.
Swash Height	The highest level on the beach at which sediment transport
Beach Slope	Angle of the beach slope between the toe and the crest of the
Offshore Contour	Position of a particular contour in the model below the Closure
Longshore	This is the depth of beach toe, if different from closure depth.

Table 2.1: Additional Input Values

Table 2.2 details the values required by the control file to further define the section:

Element	Data required
Beach	Reflection coefficient / depth of beach contour / Angle of the beach / seabed slope offshore / boundary conditions
Waves	Wave breaking coefficient / depth of wave specification / Orientation of the beach /number of conditions / frequency of wave conditions / tidal range / wave spreading function / position of the wave refraction point
Seawall	Slope angle / reflection coefficient / height
Structures (groynes, breakwaters)	Chainage / reflection coefficient / number / height / length / efficiency / rock armour density / crest width / crest height
Sediment transport	Size of sediment / density of sediment / density of seawater / voids of sediment / cross-shore distribution
Output	The run time increment / the output interval

Table 2.2: Section Definitions

2.3 The Wave File

The wave file is a dataset containing regular measurements of significant wave height, period and direction, at a specific location with a known water depth. This data provides the forcing function to which the model responds. The orientation of the coastline changes around Christchurch Bay and as a consequence the wave conditions vary due to the effect of refraction. Consequently, in order for BEACHPLAN to run, the programme requires data that represents the wave conditions for the particular section of coastline that is being modelled. Long datasets were available to NFDC, and it was possible to run BEACHPLAN using ten years of wave data. This length of runtime enabled the yearly drift rate to be averaged out over the ten-year period.

2.3.1 Deriving Data

The wave conditions provide data of recorded wave height (Hs), period (Tz), and direction for a particular location. Using an iterative process based on linear wave theory BEACHPLAN transforms waves into their breaker point in each compartment where the sediment transport due to breaking is calculated (Beachplan User Guide 1999). BEACHPLAN is then able to calculate the sediment volume and transport rate for each modelled section. The wave conditions input into BEACHPLAN are synthetically generated from a hypothetical point, positioned offshore in Christchurch Bay. Wave conditions at this hypothetical point are derived from meteorological data measured at a weather station situated in the English Channel. Once the conditions at the hypothetical point are established, the conditions are transformed to create inshore wave conditions, which take into account the effect of refraction caused by the geomorphology of Christchurch Bay. Between Hengistbury Head and Hurst Spit, synthetic wave data has been created for 17 inshore refraction points, located on the –5m OD contour line around Christchurch Bay.

2.3.2 Refraction point locations

In order for BEACHPLAN to model Christchurch Bay between Hengistbury Head and the start of the shingle bank at Hurst Spit, wave conditions from nine wave refraction points (Christchurch Bay 1 to 9) were used, as shown in Figure 2.1.

2.4 Modelled Sections

Optimum performance from the BEACHPLAN model is achieved when the coastline is linear. In order to achieve the best results, the entire coastline between Hengistbury Head and Hurst Spit was split into a number of smaller sections (approximately 1km in length) (see Figure 2.2). For each section the wave conditions from the refraction point relative to the section of coastline were used in order allow BEACHPLAN to model that particular section of coastline with respect to the appropriate wave conditions for that section, as shown in Table 2.3.

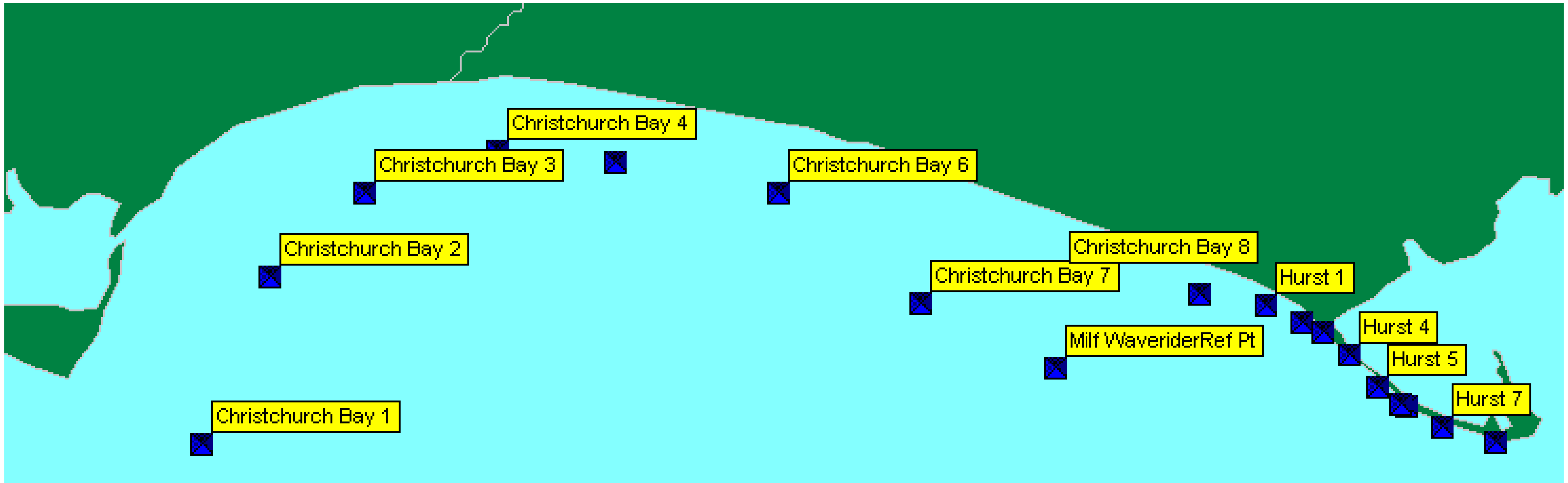


Figure 2.1: Location of wave refraction points

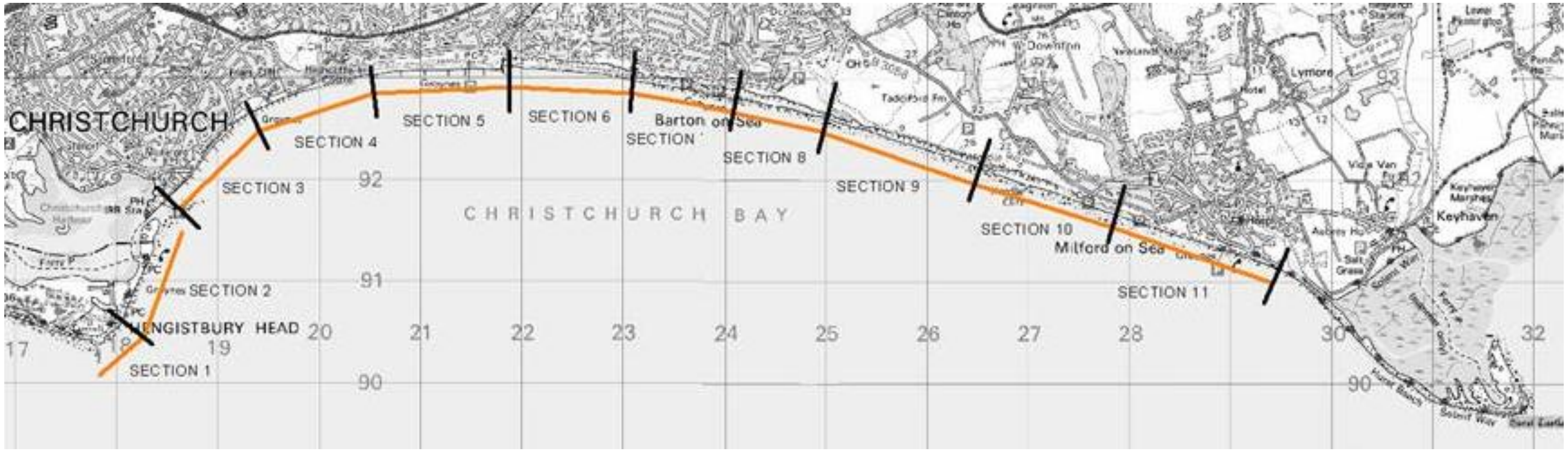


Figure 2.2: Section location in Christchurch

Section Ref.	Section Length (m)	Locality	CMP Unit	Wave Condition File	Section	Structures
1	580	Hengistbury Head (east of Long groyne)	CBY 1	Christchurch Bay 1	Long Groyne to start of Christchurch Sandbank	Rock revetment / Long Groyne / rock groynes
2	1100	Christchurch Sandbank	CBY 1	Christchurch Bay 2	Hengistbury Head to tip of Christchurch Sandbank	Rock revetment / rock groynes
3	1100	Avon Beach	CBY 2	Christchurch Bay 2	Eastern end of Mudeford Quay to Friars Cliff	Concrete & sheet piled seawall / rock groynes / timber groynes /
4	1190	Friars Cliff / Steamer Point	CBY 2	Christchurch Bay 3	Friars Cliff to Highcliffe Castle	Concrete & sheet piled seawall / timber / rock groynes
5	1340	Highcliffe Castle / Highcliffe Cliffs	CBY 2	Christchurch Bay 3	Highcliffe Castle to Chewton Bunny	Rock revetment / rock strongpoints
6	1205	Naish Cliffs	CBY 3	Christchurch Bay 4	Chewton Bunny to West Barton-On-Sea	None
7	1010	West Barton-On-Sea	CBY 4	Christchurch Bay 5	West Barton-On-Sea to East Barton-On-Sea	Rock revetment / rock strongpoints
8	910	East Barton-On-Sea	CBY 4	Christchurch Bay 6	East Barton-On-Sea to Becton Bunny	Rock revetment / rock strongpoints
9	1585	Becton Bunny / Hordle Cliffs	CBY 5	Christchurch Bay 7	Becton Bunny to Hordle Cliffs	Outfall structure & rock protection
10	1430	Hordle Cliffs	CBY 5	Christchurch Bay 8	Hordle Cliffs to east Milford-on-Sea	None
11	1660	Milford-on-Sea	CBY 6	Christchurch Bay 8	East Milford-on-Sea to west Hurst Spit	Rock revetment / concrete & sheet piled seawall / timber groynes / stronggpoints

Table 2.3: Section Details

Once all the input criteria have been put into the model, BEACHPLAN calculates the potential flow volume rate for material transportation and provides a beach planshape image of the section at different time intervals, as shown in Figure 2.3

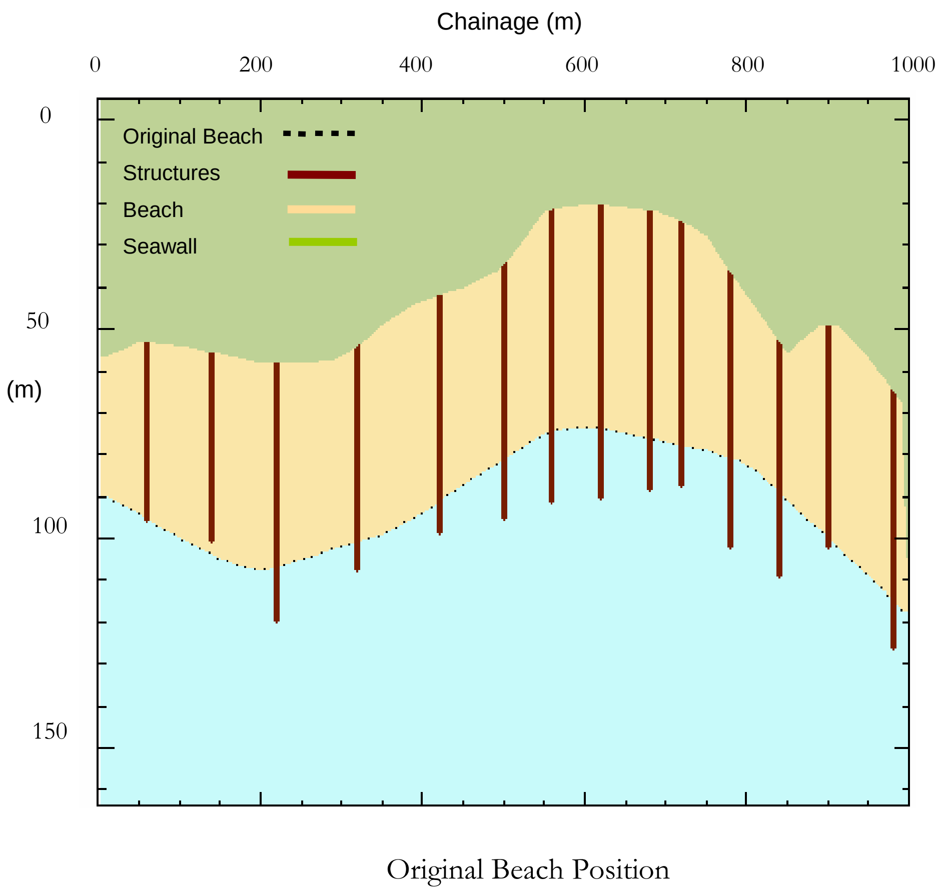


Figure 2.3: The BEACHPLAN model of the original beach created according to input criteria

2.5 Calibration

Once the models for the particular sections have been set up, BEACHPLAN has to be calibrated in order to verify the model and validate the results. In order to do this, results produced by BEACHPLAN were compared to measured survey data. Therefore it was possible to compare **predicted** results, generated by BEACHPLAN, with **actual** survey data.

Within the results file BEACHPLAN generates the predicted future position of a specific beach contour. By comparing the predicted and actual position of this contour line the results that BEACHPLAN is producing can be assessed and, if necessary, calibrated with respect to actual measured data.

BEACHPLAN is designed to model both sand and shingle beaches. However there are variations to the sediment size around Christchurch Bay and although the average grain size appears to increase around the bay from west to east, the beaches are generally mixed sand and shingle beaches. BEACHPLAN performs more efficiently when the beach that is being modelled is of a uniform grain size; therefore this presents a problem when trying to recreate the precise beach environment in the model.

In order to compare the actual beach response to the predicted response, a section of coastline was selected to test run in the model. In order to limit the amount of variables, the section of coastline that was selected was an open section of coastline, devoid of any structures (section reference 10). A number of profile lines exist along this section of coastline and surveys at these particular locations have been undertaken at regular intervals 3 or 4 times a year to produce a large dataset survey data for each profile.

From survey data the position of the -0.6m OD contour was calculated for every profile between 1990 and 1996. For each profile location, a graph was then generated to plot the changes to the position of the 0m OD contour over the 6-year period.

In BEACHPLAN the position of the predicted 0m OD contour line is calculated after each month and these positions are presented in the BEACHPLAN results file. In order to compare surveyed data against predicted data, the position where each of the profile locations would lie was referenced with respect its position along the model baseline set up in BEACHPLAN. For each profile location it is then be possible to compare the position of the measured 0m OD contour against the predicted position at the time that the survey was taken. Subsequently a graph was produced for each profile location to compare the measured and predicted position of the 0m OD contour.

The BEACHPLAN is a process filter model and uses linear wave theory and a modified version of the CERC formula to predict beach planshape evolution by modelling the effect that measured wave data will have on the relevant beach. In order to calibrate the model the modified version of the CERC formula contains two time-scale adjustment factors which are designed to compensate for grain size and the effect that this can have with regard to the response of the beach and the rate of drift.

Within BEACHPLAN there are two different methods to calibrate the model. The first directly uses the two time scale adjustment factors in the model the second uses the HR Bedload formulae which is an adaptation of the time scale adjustment factors. During the calibration process it was found that attempting to calibrate using the time scale adjustment factors did not provide very satisfactory results for the sections that are comprised of mixed beach material; however it performed better in sections comprised of sand. The HR Bedload formula enables a D50 value to be used to represent the grain size of the beach. In testing this appeared to better replicate the mixed condition of the beach.

3 Cross-shore Analysis

3.1 The SHINGLE Model

The SHINGLE model calculates the equilibrium beach profile to a storm event based on shingle beach research based at HR Wallingford. SHINGLE models the hydraulic cross-shore response to a set of wave conditions input by the user. The response of the beach to these conditions is generated in the form of a profile response.

In conjunction with predicted extreme storm event data, SHINGLE was used to generate and test a number of hypothetical beach profile which led to the production of the final design profile.

3.2 Wave Climate

Wave conditions vary around Christchurch Bay and in order to accurately replicate this extreme wave analysis was undertaken for all prediction points around Christchurch Bay. Wave data at all 9 wave refraction points is sampled at 3 hourly intervals which has produced a total of 52,547 events between October 15th 1986 and September 6th 2004. Probability analysis was carried out on the datasets in order to identify both the 1:1 year return event and the peak event, see Table 3.1.

Identification of the wave climate conditions provided the necessary input data for the SHINGLE model, in order to test the profile response of the beach under these extreme events.

3.3 SHINGLE analysis

SHINGLE was used to assess how the beaches around Christchurch Bay responded to extreme wave conditions. 19 profile locations were selected around the Bay in defended areas where the policy is currently ‘Hold the Line’ and where beach dependent alongshore structures exist. For each location a recent cross-shore profile was modelled in SHINGLE.

Using SHINGLE, beach profile response analysis was carried out for all 19 beach profiles in order to assess the maximum wave conditions that would generate a beach profile response prior to wave run up exceeding the equilibrium response of the beach. The coastline around Christchurch Bay is generally comprised of mixed sand and shingle beaches with coarser material appearing towards the eastern end of the Bay (Milford and Hurst) with sandy material present to the west (Mudeford Sandspit). The SHINGLE model was therefore run with different D50 values in order to assess the response of the beach as the D50 value was altered. Results of the SHINGLE model testing are presented in Table 3.2.

	1:1 Year Return Period Event				Peak Event			
Wave Refraction Point Reference	Hs (m)	Tp (s)	Return Period	Wave Steepness	Hs (m)	Tp (s)	Return Period	Wave Steepness
Christchurch Bay 1	3.15	8.5 to 10	0.84	0.028	3.65	8.5 to 9	8.4	0.032
Christchurch Bay 2	2.95	8.5 to 10	0.80	0.026	3.35	8.5 to 9	8	0.03
Christchurch Bay 3	2.85	8.5 to 11.5	1	0.025	3.35	8.5 to 9	8.04	0.03
Christchurch Bay 4	2.95	8.5 to 9	0.73	0.026	3.35	8.5 to 9	8.04	0.03
Christchurch Bay 5	2.95	8.5 to 9	0.73	0.026	3.34	8.5 to 9	8.04	0.03
Christchurch Bay 6	2.95	8.5 to 10	0.8	0.026	3.34	8.5 to 9	8.04	0.03
Christchurch Bay 7	2.95	8.5 to 9	0.67	0.026	3.55	8.5 to 9	8.04	0.031
Christchurch Bay 8	2.85	9 to 9.5	0.67	0.023	3.25	8.5 to 9	4	0.029
Christchurch Bay 9	2.65	9 to 9.5	0.8	0.021	3.15	8.5 to 9	2.68	0.028

Table 3.1: Wave climate generated from refraction point data.

Management Unit	Wave Refraction Point Reference	Profile Reference	D50 12.5mm			D50 15mm			D50 20mm		
			Hs (m)	Tm (secs)	Hs/Lm	Hs (m)	Tm (secs)	Hs/Lm	Hs (m)	Tm (secs)	Hs/Lm
CBY6	Hurst 1	5f00070									
CBY6	Christchurch Bay	5f00076	1.5	6.2	0.025	1.5	6.2	0.025	1.5	6.2	0.025
CBY6	Christchurch Bay	5f00086	2.4	7.9	0.025	2.3	7.7	0.025	2.2	7.5	0.025
CBY6	Christchurch Bay	5f00099	2.7	8.1	0.026	2.5	7.8	0.026	2.3	7.5	0.026
CBY3	Christchurch Bay	5f00107	2.9	8.4	0.026	3.5	9.2	0.026	4.6	10.7	0.026
CBY3	Christchurch Bay	5f00202	2.9	8.3	0.028	3.5	9.1	0.028	3.4	8.9	0.028
CBY3	Christchurch Bay	5f00209	2.3	7.4	0.028	2.2	7.2	0.028	2.1	7.1	0.028
CBY3	Christchurch Bay	5f00215	2.8	8.2	0.028	2.6	7.8	0.028	2.4	7.6	0.028
CBY3	Christchurch Bay	5f00222	1.9	6.7	0.028	1.8	6.5	0.028	1.8	6.5	0.028
CBY3	Christchurch Bay	5f00225	2.7	8	0.028	2.5	7.7	0.028	2.4	7.5	0.028
CBY2	Christchurch Bay	5f00257	2.9	8.3	0.028	3.5	9.1	0.028	4.7	10.5	0.028
CBY2	Christchurch Bay	5f00261	2.9	8.3	0.027	3.5	9.1	0.027	4.7	10.5	0.027
CBY2	Christchurch Bay	5f00264	2.9	8.3	0.027	3.5	9.1	0.027	4.7	10.5	0.027
CBY2	Christchurch Bay	5f00272	2.9	8.3	0.027	2.6	7.8	0.027	2.4	7.6	0.027
CBY2	Christchurch Bay	5f00276	2.9	8.3	0.027	2.7	8	0.027	2.6	7.8	0.027
CBY2	Christchurch Bay	5f00280	2.9	8.3	0.027	3.4	9	0.027	4	9.8	0.027
CBY2	Christchurch Bay	5f00284	2.9	8.2	0.028	2.7	7.8	0.028	2.4	7.4	0.028
CBY2	Christchurch Bay	5f00288	2.9	8.2	0.028	3.5	9.1	0.028	4.7	10.4	0.028
CBY2	Christchurch Bay	5f00292	2.9	8.2	0.028	3.5	9.1	0.028	4.7	10.4	0.028
CBY2	Christchurch Bay	5f00296	2.9	8.2	0.028	3.5	9.1	0.028	4.7	10.4	0.028

Table 3.2: SHINGLE modelling test results

Averaged wave steepness values from peak and 1:1 return period events per wave refraction point reference:

Yellow *cell indicates profile response equal or greater than respective peak event*

Orange *cell indicates profile response equal or greater than respective wave refraction point 1:1 year event*

Blue *cell indicates profile response below respective wave refraction point 1:1 year event*

The results of SHINGLE model testing, presented in Table 3.2 has indicated that there are a number of locations where the beach profile is not sufficient to withstand extreme wave conditions. In the areas where beach dependent alongshore structures also exist, this presents a problem to the integrity of the alongshore defence in the event of an extreme event.

3.4 Design Beach Profile Criteria

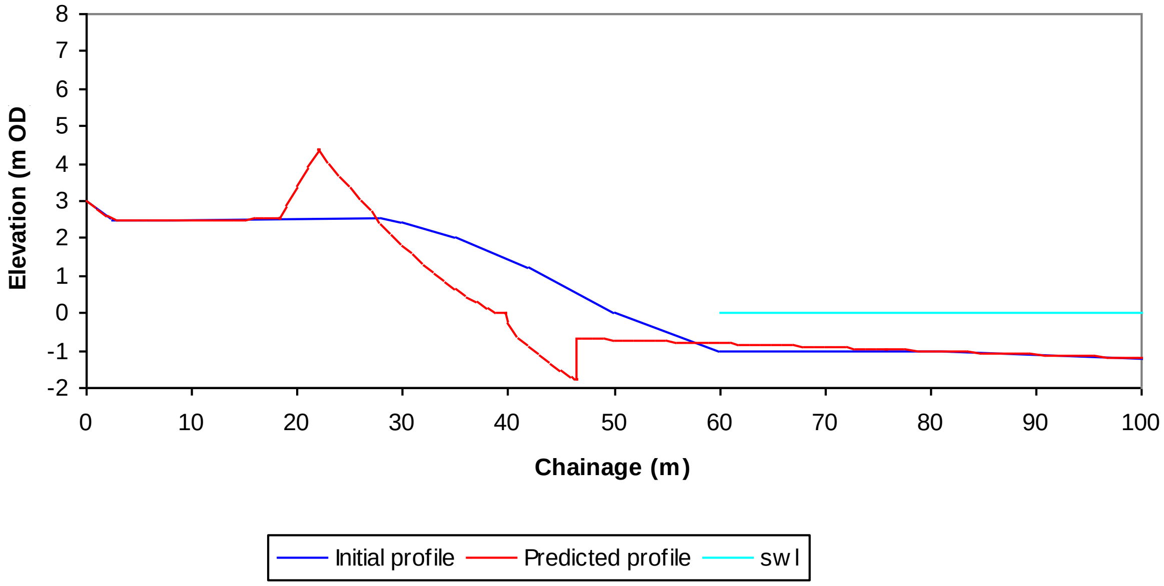
The areas where the beach profile responded favourably to the design conditions were to the west of Christchurch Bay at Avon Beach (profiles 5f00296 / 5f00292 / 5f00288) and the undefended section between Friars Cliff and the section of rock groynes at Highcliffe (profiles 5f00264 / 5f00261 / 5f00257).

By examining the results from the SHINGLE model in association with historical profile data from these profile locations, a number of design profiles have been developed to allow the beach to favourably respond to extreme conditions. The design profiles that responded favourably to the design conditions all had a crest level of approximately 2.5m OD; a crest width of between 15 and 30m and a slope angle of between 1:11 and 1:14 between MHW (0.69m OD) and -0.26m OD (MLW). This design criterion was therefore fundamental to the design profile in order to supplement the existing beach profile in areas where the existing beach response was below the required level to form a storm profile response to extreme conditions. In addition the design profile is required to perform as a natural beach would if suitable material was available in the system, the design must therefore be consistent with existing beach profiles.

Once the design profile was identified, the width of the crest would be ascertained by BEACHPLAN modelling and drift potential calculations in order to calculate what beach recharge volumes are required for the beach recharge option in the Christchurch Bay Strategy.

3.4.1 Design Profiles

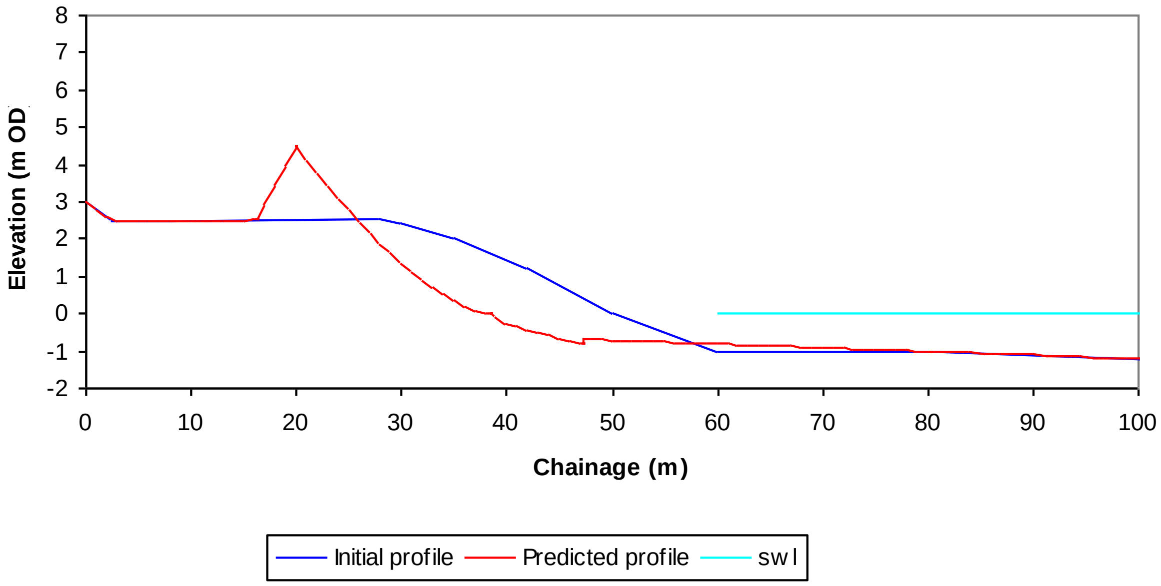
The design profile will vary at different points around Christchurch Bay, due to drift potential and wave climate conditions. The design profile for CBY2 was tested against the 1:1 year return period event and the peak event and the profile response is presented in Figures 3.1 and 3.2.



Input Criteria		Value
Hs	offshore significant wave height	2.9 m
Tm	offshore mean wave period	8.5 s
L	mean deep water wavelength	112.8 m
SWL	still water level	0 m OD
Dw	depth of water at toe of beach	1.02 m
Td	beach toe elevation	-1.02 m
D50	mean sediment diameter	15 mm
M	stratum slope (1:x)	100
Db	depth of beach	10 m
Hs/Lm	wave steepness	0.026

Figure 3.1: 1:1 year return period event beach profile response

1:1 year return period wave input data taken from refraction point analysis see Table 3.1.



Input Criteria		Value
Hs	offshore significant wave height	3.4 m
Tm	offshore mean wave period	8.4s
L	mean deep water wavelength	110.2m
SWL	still water level	0 m OD
Dw	depth of water at toe of beach	1.02 m
Td	beach toe elevation	-1.02 m
D50	mean sediment diameter	15 mm
M	stratum slope (1:x)	100
Db	depth of beach	10 m
Hs/Lm	wave steepness	0.31

Figure 3.2: Peak event beach profile response

Peak wave input data taken from refraction point analysis see Table 3.1.

4 Beach Management Options

The results of BEACHPLAN and SHINGLE modelling for each Management Unit in Christchurch Bay will be presented in this section, together with beach management and recharge options.

4.1 BEACHPLANSHAPE Modelling

4.1.1 CBY2

CBY2 was split into 3 sections; an overview of the sections is presented in Table 4.1.

CBY2				
Section reference	**Section length**	**Locality**	**Wave condition file ref**	**Profile reference**
3	1100	Gundimore / Avon Beach	XCH 2	5f00296 5f00292 5f00288 5f00284 5f00280
4	1200	Friars Cliff / Steamer Point / Highcliffe Castle	XCH 3	5f00276 5f00272 5f00264 5f00261 5f00257
5	1500	Highcliffe Castle / Highcliffe Cliffs	XCH 3	5f00253, 248, 244, 239, 235, 230, 229

Table 4.1: CBY2 section overview

(a) Section 3

Section 3 (Avon Beach) is situated immediately east of Christchurch Quay and is managed by Christchurch Borough Council. The section is backed by a number of alongshore structures (seawalls) and a number of cross-shore defences (rock groynes to the west (5) and timber groyne to the east (8)). Over the past few years the old timber boards that comprise the groyne have been replaced with blocks of Portland Stone rock armour. Technical Annex 7 (Condition Assessment) highlights that the seawall varied between condition 1 & 2 which gave a residual life expiry date of between 2024 and 2034. The groynes varied between condition 1 & 4 with over three quarters being condition 2 or 3.

The Map (Figure 4.1a) and aerial photograph (Figure 4.1c) highlight the section of coastline that was modelled in beachplan for Section 3. Colour coded profile lines (referenced to the table in Figure 4.1b) have been included on the aerial photograph. Underlining of the profile reference number indicates that SHINGLE beach profile response at this location is below respective wave refraction point 1:1 year event (Section 3 SHINGLE analysis). The vulnerable sections of seawall are highlighted in red.

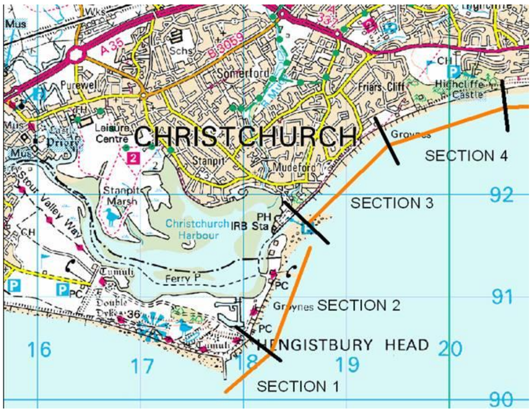


Figure 4.1a Location of Section 3

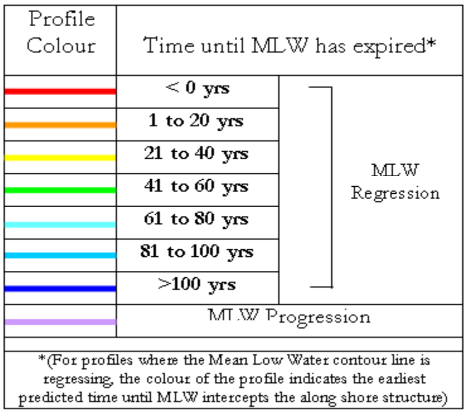


Figure 4.1b Profile line colour references

Figure 4.1c Location of Section 3

After running the wave conditions in BEACHPLAN with 10 years of wave data, Scenario A (Present Conditions) indicates that the potential drift direction is from west to east (see Figure 4.2), and that on average approximately 14 000m³ per year enters Section 3 from the south-west and approximately 8,000m³ leaves from the north-east. The model indicates that the rock groynes to the south-western section are efficient at slowing the potential drift rate, thus allowing accretion to occur. In fact, the model indicates that there could be the potential for a significant amount of material to accrete along the first 300m (the section of rock groynes). This is supported by the long term beach profile analysis (5f00296) which indicates a stable beach and MLW progression. Between 350m & 500m chainage, at the eastern end of the section of rock groynes, the model indicates that there is the possibility for erosion to increase. This is supported by beach profile analysis (5f00292) which indicates MLW is regressing landwards, with the MLW reaching the toe of the seawall in 41 to 60 years time.

Immediately to the north-east of this section is the start of the 650m section of wooden groynes. At their present length the wooden groynes generally appear to be sufficient in maintaining beach material; however, over the 10 year period BEACHPLAN indicates that overall the trend is for the beach contour to gradually regress landwards, resulting in the erosion of the beaches. BEACHPLAN indicated that erosion is likely to be more focused between chainage 850m & 1000m. This is in the vicinity of beach profile reference line 5f00284 where beach profile analysis has indicated that the MLW is regressing landwards and it is likely to have reached the toe of the seawall within 20 years. In addition SHINGLE analysis indicates that the beach profile at location reference 5f00284 is incapable of producing a storm profile response to a 1:1 year return period event. This therefore highlights the seawall at this location to being particularly vulnerable to failure.

Present conditions indicated that the potential flow volume was approximately 11,000m³ between 400m & 850m and erosion is occurring. By increasing the length of the groynes by 10m (scenario B, see Figure 4.3) and 20m (Scenario C, see Figure 4.4) the model indicates that there is a reduction in the potential flow volume, which results in an increase in accretion between chainage 400m & 850m. As the length of groynes in increased by 10m the flow rate reduced to 8,000m³ and by increasing the length by 20m the flow rate reduced to 7,000m³. However as a consequence the model indicates that the erosion identified around chainage 950m is likely to increase, resulting in the seawall becoming even more vulnerable in this location.

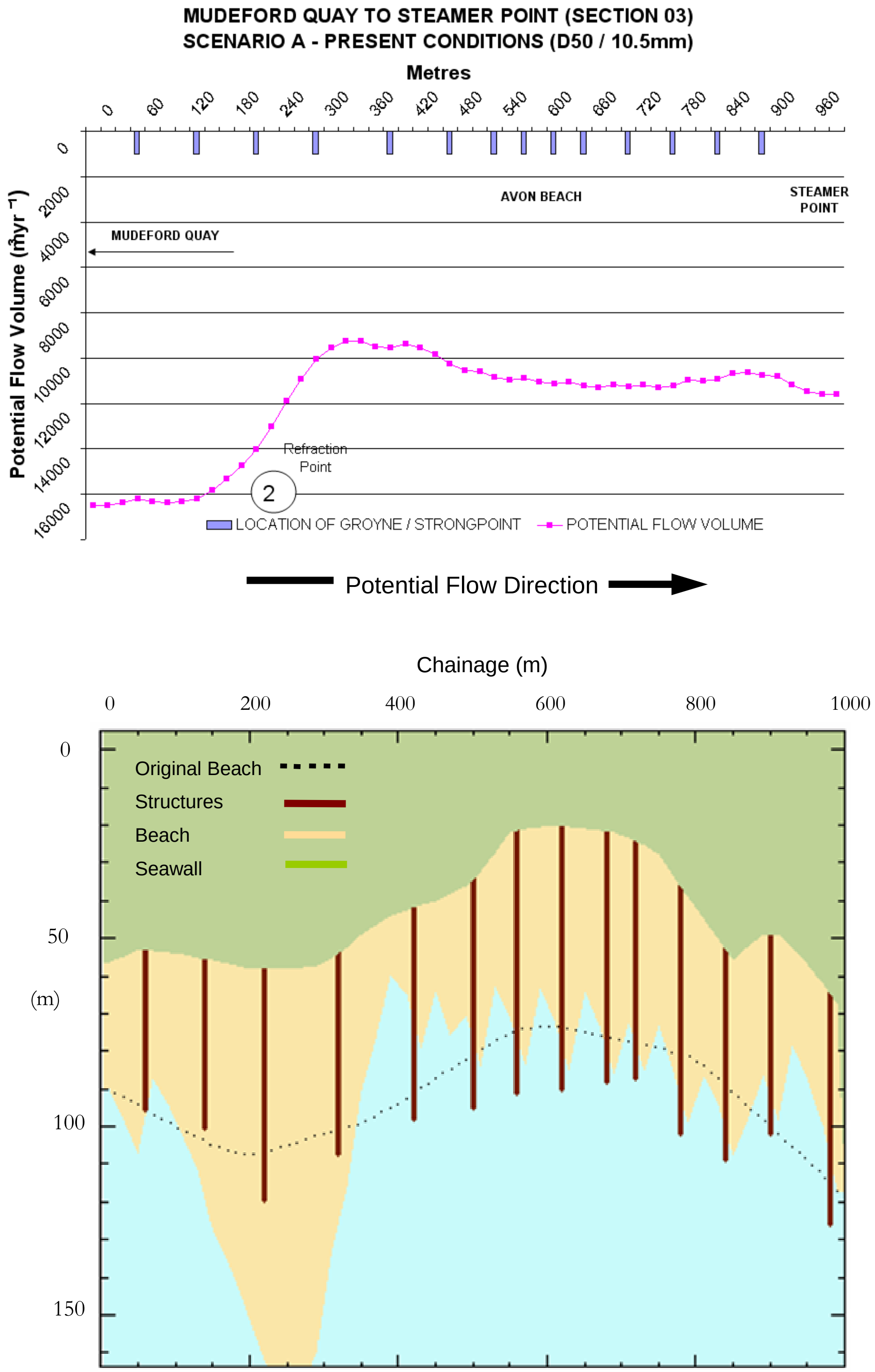


Figure 4.2: Scenario A (Present conditions)

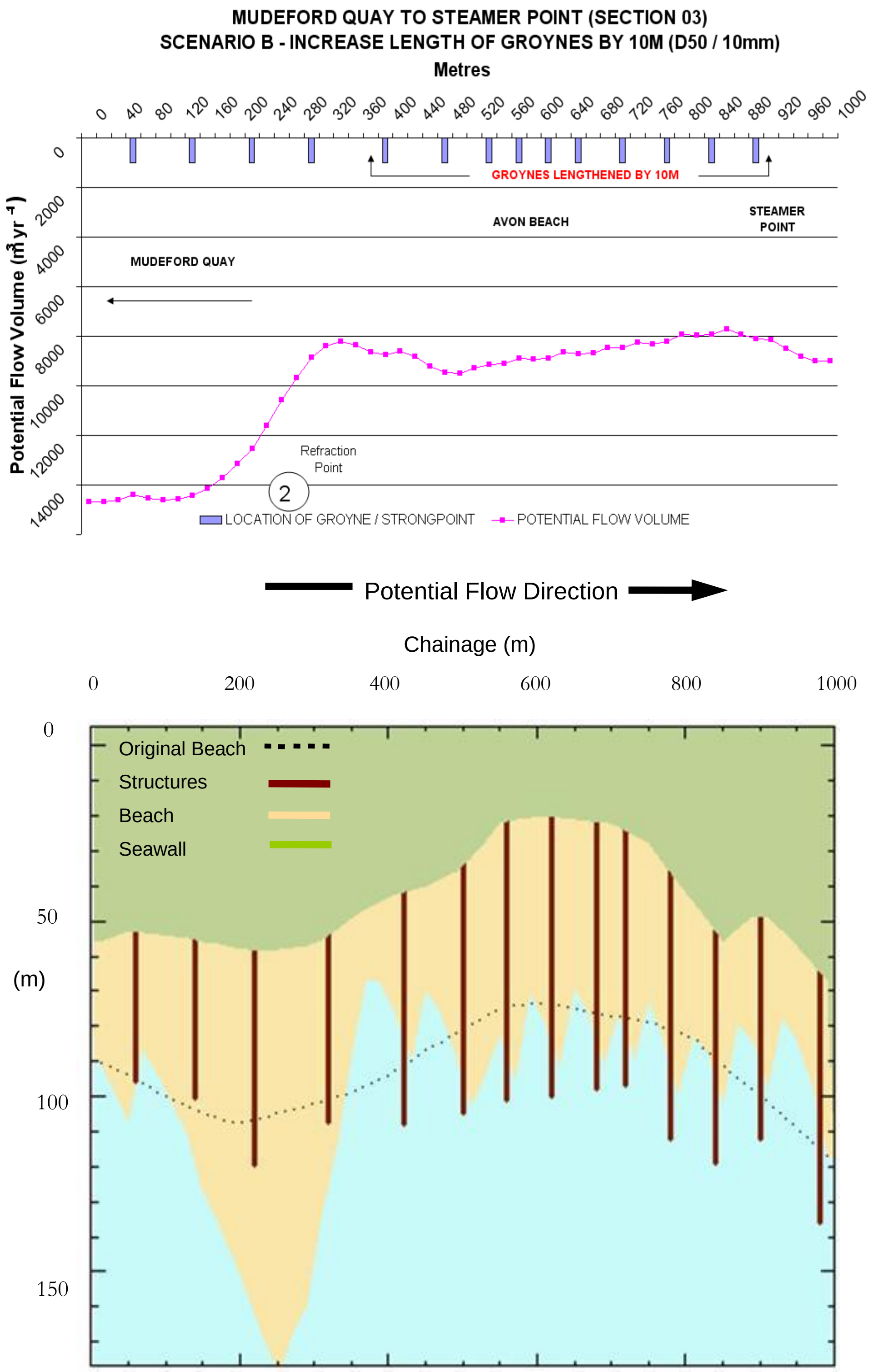
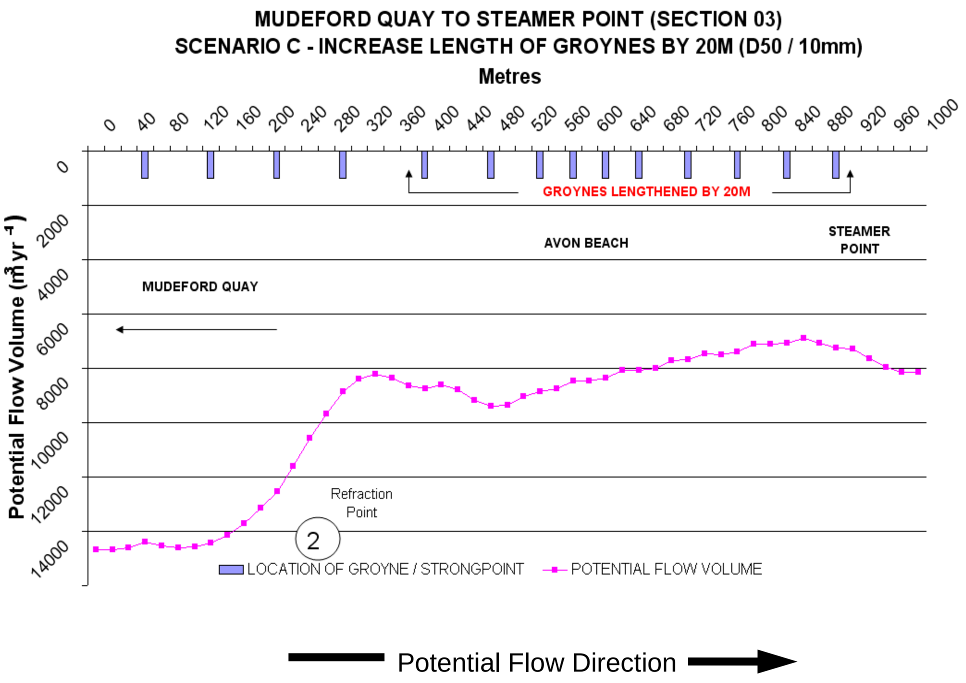
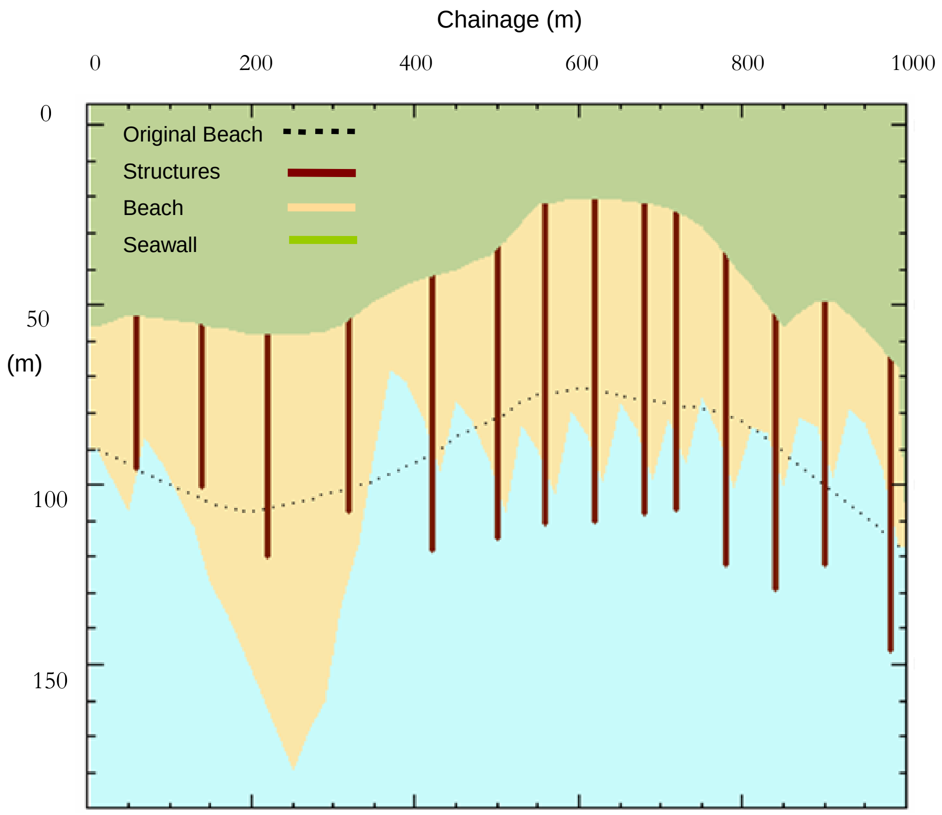


Figure 4.3: Scenario B (Increase the length of the wooden groynes by 10m)





(i) Section 3 Analysis

Figure 4.4: Scenario C (Increase the length of the wooden groynes by 20m)

(b) Section 4

Section 4 (Friars Cliff to Highcliffe Castle) is managed by Christchurch Borough Council and comprises an alongshore structure (seawall) and a number of cross-shore defences (timber groynes) to the west & an undefended section of beach to the east. The condition assessment (Technical Annex 7) highlighted that the seawall varied between condition 2 & 3 which gave a residual life expiry date of between 2014 and 2024. The groynes varied between condition 1 & 3 with over half being condition 2.

The Map (Figure 4.5a) and aerial photograph (Figure 4.5c) highlight the section of coastline that was modelled in beachplan for Section 4. Colour coded profile lines (referenced to the table in Figure 4.5b) have been included on the aerial photograph. Underlining of the profile reference number indicates that SHINGLE beach profile response at this location is below respective wave refraction point 1:100 year event (Section 3 of this Appendix - SHINGLE analysis). The vulnerable sections of seawall are highlighted in red.

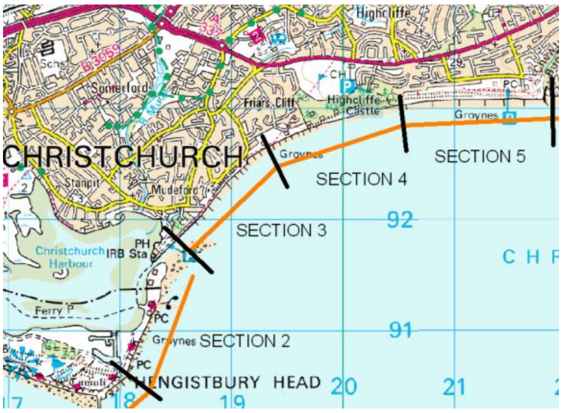


Figure 4.5a Location of Section 4

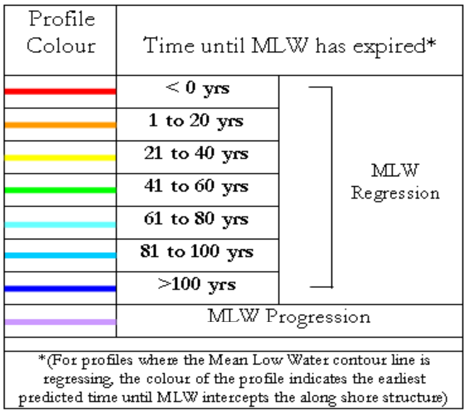


Figure 4.5b Profile line colour references

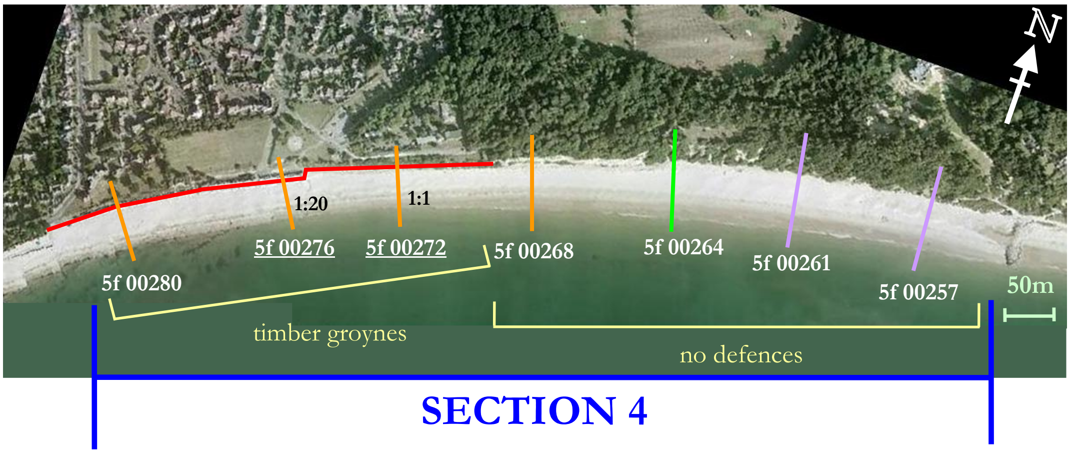


Figure 4.5c Location of Section 4

After running the wave conditions in BEACHPLAN with 10 years of wave data, Scenario A (Present Conditions) (see Figure 4.6) indicates that the potential drift direction is from west to east. Annually on average approximately 13,500m³ enters Section 4 from the south-west and that approximately 8,000m³ leaves to the north-east. There is therefore a net increase of approximately 5,500m³ of beach material in this section each year.

BEACHPLAN indicates that the timber groynes to the south-western section (chainage 0 to 300) are efficient at maintaining a stable beach however there is no net accretion or erosion along this section. Between chainage 300m and the end of the timber groynes at chainage 600m BEACHPLAN indicates that it is likely for accretion to occur as there is a seaward progression of the beach contour. Beach profile analysis however indicate that the seawall is vulnerable along this section as the MLW contour at all three profiles (5f00280, 5f00276 & 5f00272) is regressing landwards and that the MLW will reach the seawall within the next 20 years. In addition SHINGLE analysis has indicated that the beach profiles at 5f00276 & 5f00272 are incapable of producing a storm profile response to a 1:1 year return period event, which indicates that the seawall at this location is particularly vulnerable to failure. As the net drift direction is west to east the, beach in the vicinity of 5f00280, 5f00276 & 5f00272 is likely to be becoming progressively starved of sediment due to the groynes west. Although BEACHPLAN does not reiterate this trend, the wall has been highlighted as vulnerable based on the profile analysis.

BEACHPLAN indicates that there is the potential for a significant build up of material along the undefended section of beach and towards the east of the section (adjacent to the rock strongpoint below Highcliffe Castle). BEACHPLAN indicates that along this section the annual potential flow rate falls by approximately 4,000m³, thus suggesting an accretion of similar volume. This volume of accretion however relies on a sufficient amount of material entering the section from the groyne system to the west.

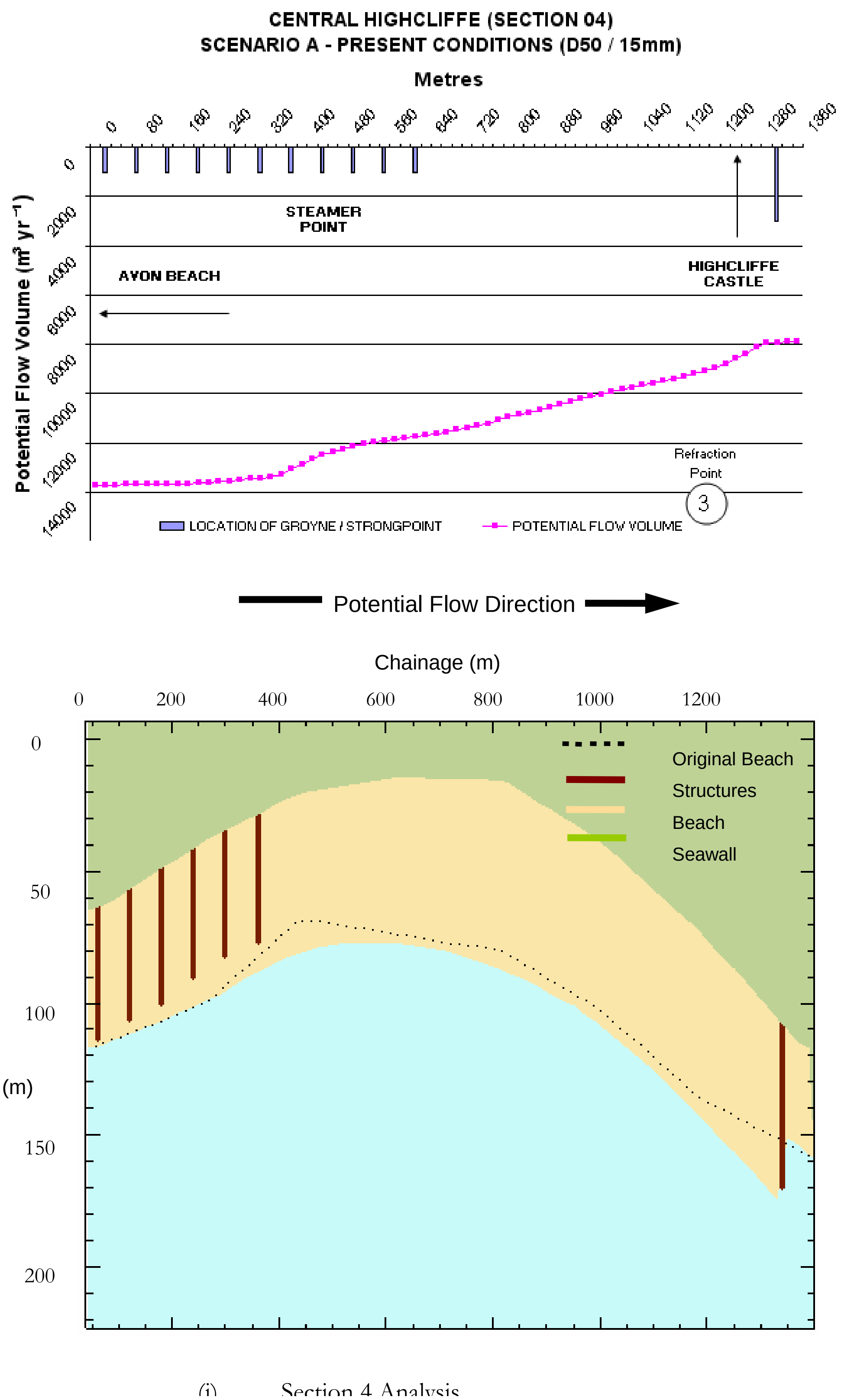


Figure 4.6: Scenario A (Present Conditions)

(c) Section 5

Section 5 (Highcliffe Castle to Chewton Bunny) is managed by Christchurch Borough Council and comprises an alongshore structure (rock revetment) and a number of cross-shore defences (long rock groynes interspersed with shorter intermediate rock groynes). The condition assessment (Technical Annex 7) highlighted that the revetment was condition 2, giving a residual life expiry date of 2019. The rock groynes varied between condition 1 & 3 with over 60% being condition 2.

The Map (Figure 4.7a) and aerial photograph (Figure 4.7c) highlight the section of coastline that was modelled in beachplan for Section 5. Colour coded profile lines (referenced to the table in Figure 4.7b) have been included on the aerial photograph.

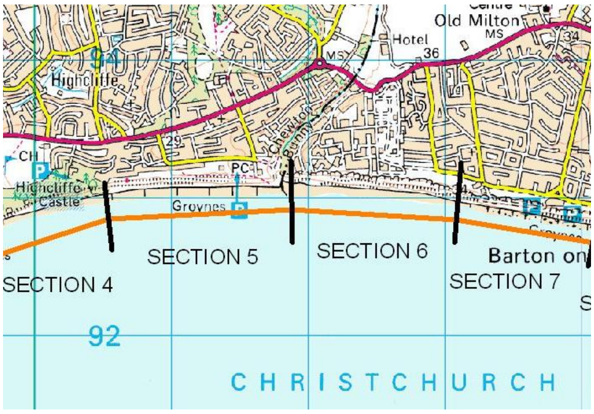


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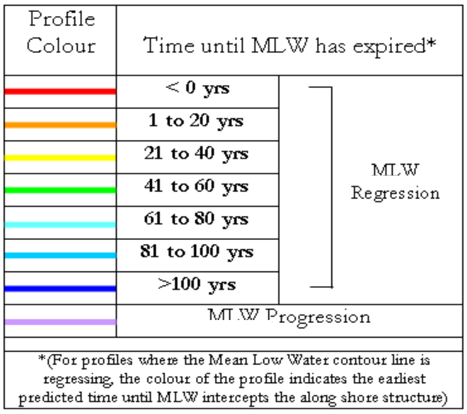
Figure 4.7a Location of Section 5



Profile Colour	Time until MLW has expired*	
	< 0 yrs	MLW Regression
	1 to 20 yrs	
	21 to 40 yrs	
	41 to 60 yrs	
	61 to 80 yrs	
	81 to 100 yrs	
	>100 yrs	
	MLW Progression	

*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)

Figure 4.7b Profile line colour references

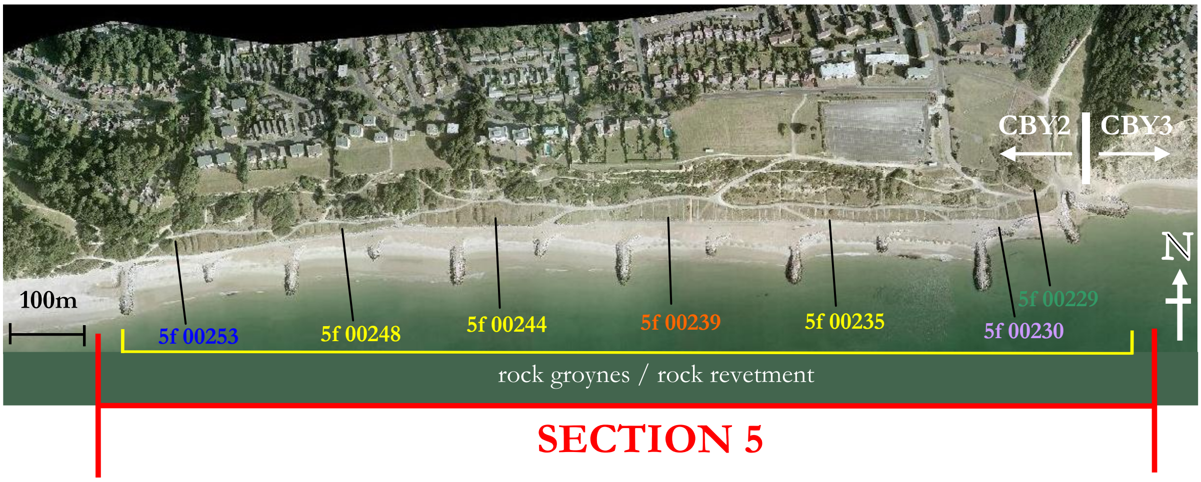


Figure 4.7c Location of Section 5

Four different scenarios were run in BEACHPLAN using 10 years of wave data. Scenario A (Present Conditions) (see Figure 4.8) indicates that the potential drift direction is from west to east. The model indicates that annually on average approximately 8,000m³ enters Section 5 from the south-west and that approximately 3,000m³ leaves to the north-east. There is therefore a net increase of approximately 5,000m³ of beach material in this section each year which is largely due to the cross shore strongpoints along the length of this section. BEACHPLAN indicates that the accreted material does not distributed evenly along the section and that accretion is chiefly concentrated between chainage 0 & 500m. Between chainage 0 m and 250m of the section the potential flow rate decreases from 8,000m³ to below 2,000m³ resulting in a significant accretion of material along this section. Between chainage 250m & 500m the potential flow rate decreases from 2,000m³ to 0 m³ and further accretion occurs. Beyond chainage 500m the model suggests that the potential flow rate is greatly reduced (between 0 m³ & 1 000m³), due to material being held up further to the west. As material moves in an easterly direction the model predicts that erosion will occur immediately to the east of the rock strongpoints and accrete along the west strongpoints.

Beach profile analysis supports the results of the BEACHPLAN model, which indicate that the seawall is vulnerable along this section as the MLW contour at all three profiles (5f00280, 5f00276 & 5f00272) is regressing landwards and that the MLW will reach the seawall within the next 20 years. In addition SHINGLE analysis has indicated that the beach profiles at 5f00276 & 5f00272 are incapable of producing a storm profile response to a 1:1 year return period event, which indicates that the seawall at this location is particularly vulnerable to failure. As the net drift direction is west to east, the beach in the vicinity of 5f00280, 5f00276 & 5f00272 is likely to be becoming progressively starved of sediment due to the groynes west. Although BEACHPLAN does not reiterate this trend, the wall has been highlighted as vulnerable based on the profile analysis.

BEACHPLAN indicates that there is the potential for a significant build up of material along the undefended section of beach and towards the east of the section (adjacent to the rock strongpoint below Highcliffe Castle). BEACHPLAN indicates that along this section the annual potential flow rate falls by approximately 4,000m³, thus suggesting an accretion of similar volume.

Three alternative scenarios B, C and D have also been tested - reduction of strongpoints by 20m (Figure 4.9), 40m (Figure 4.10) and removal of all strongpoints (Figure 4.11).

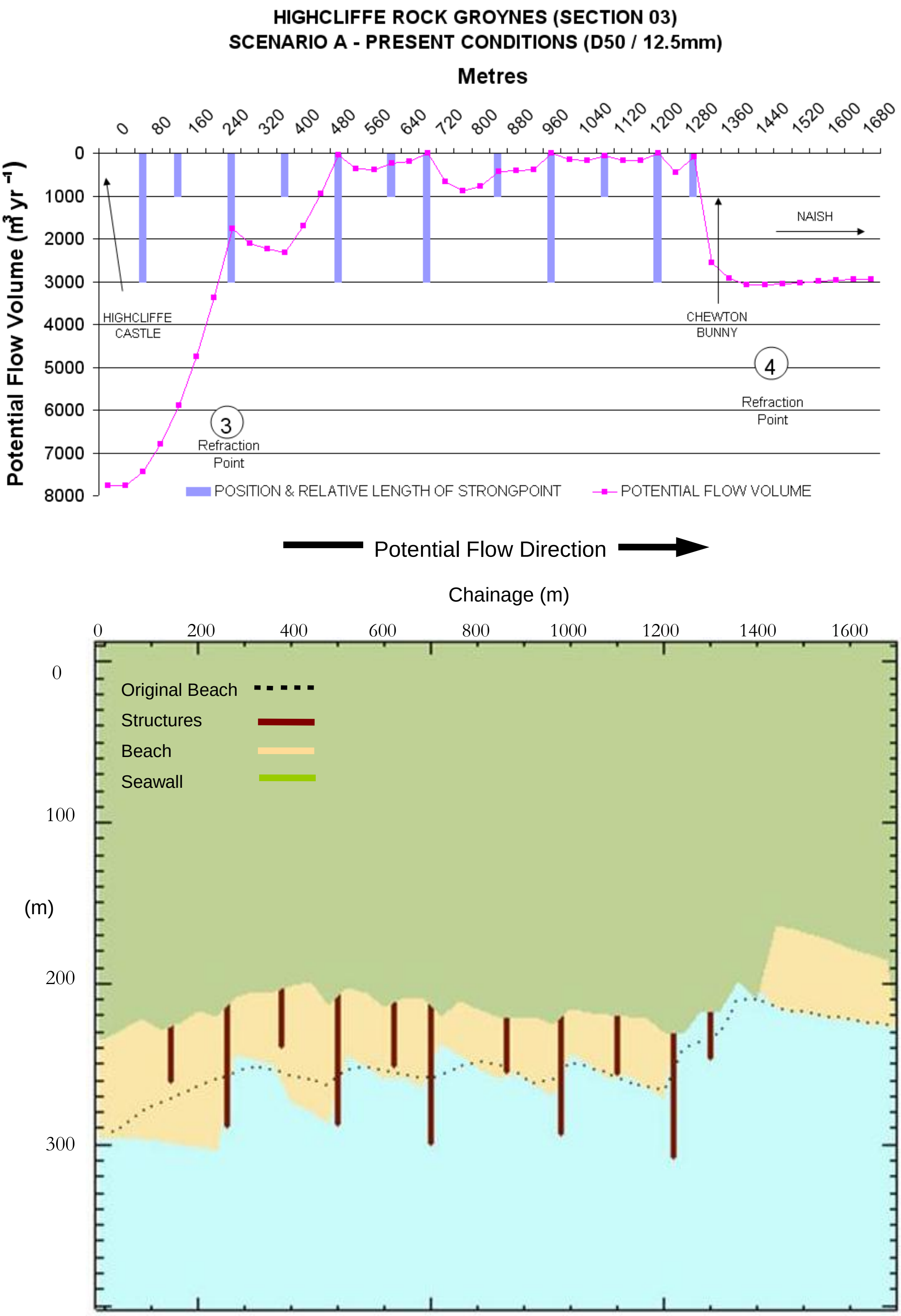


Figure 4.8: Scenario A (Present Conditions)

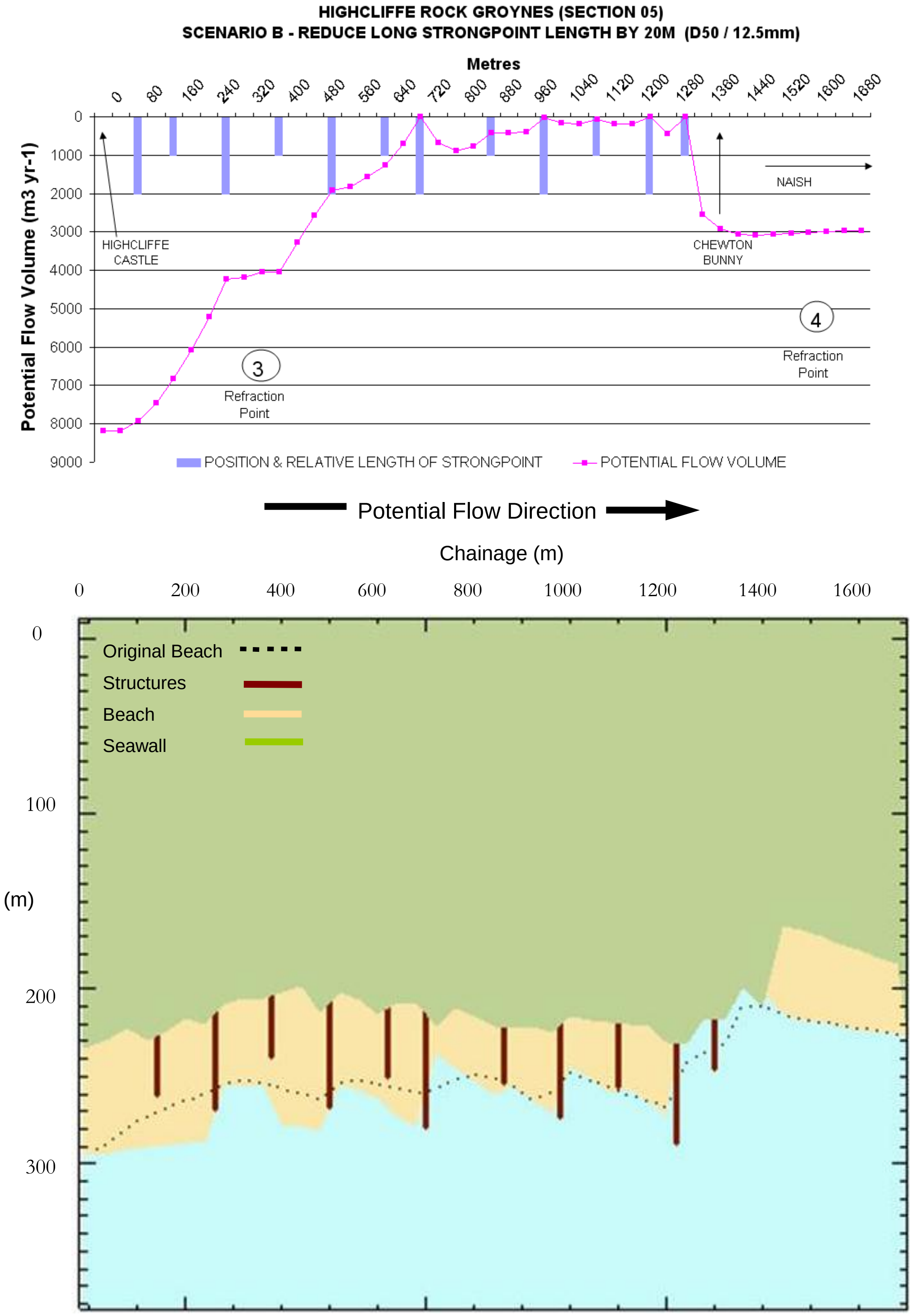


Figure 4.9: Scenario A (Present Conditions) Reduction of strongpoint by 20m

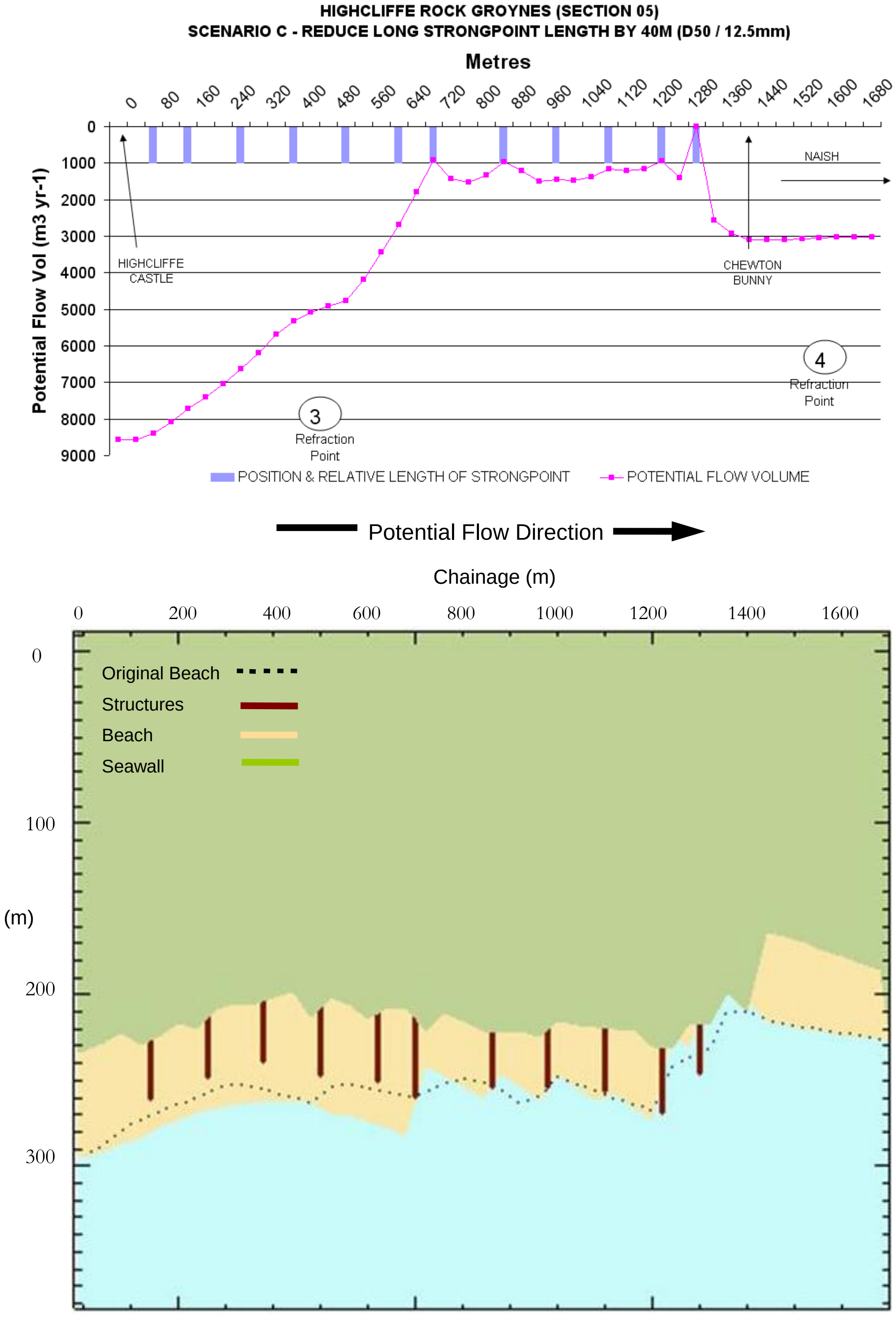
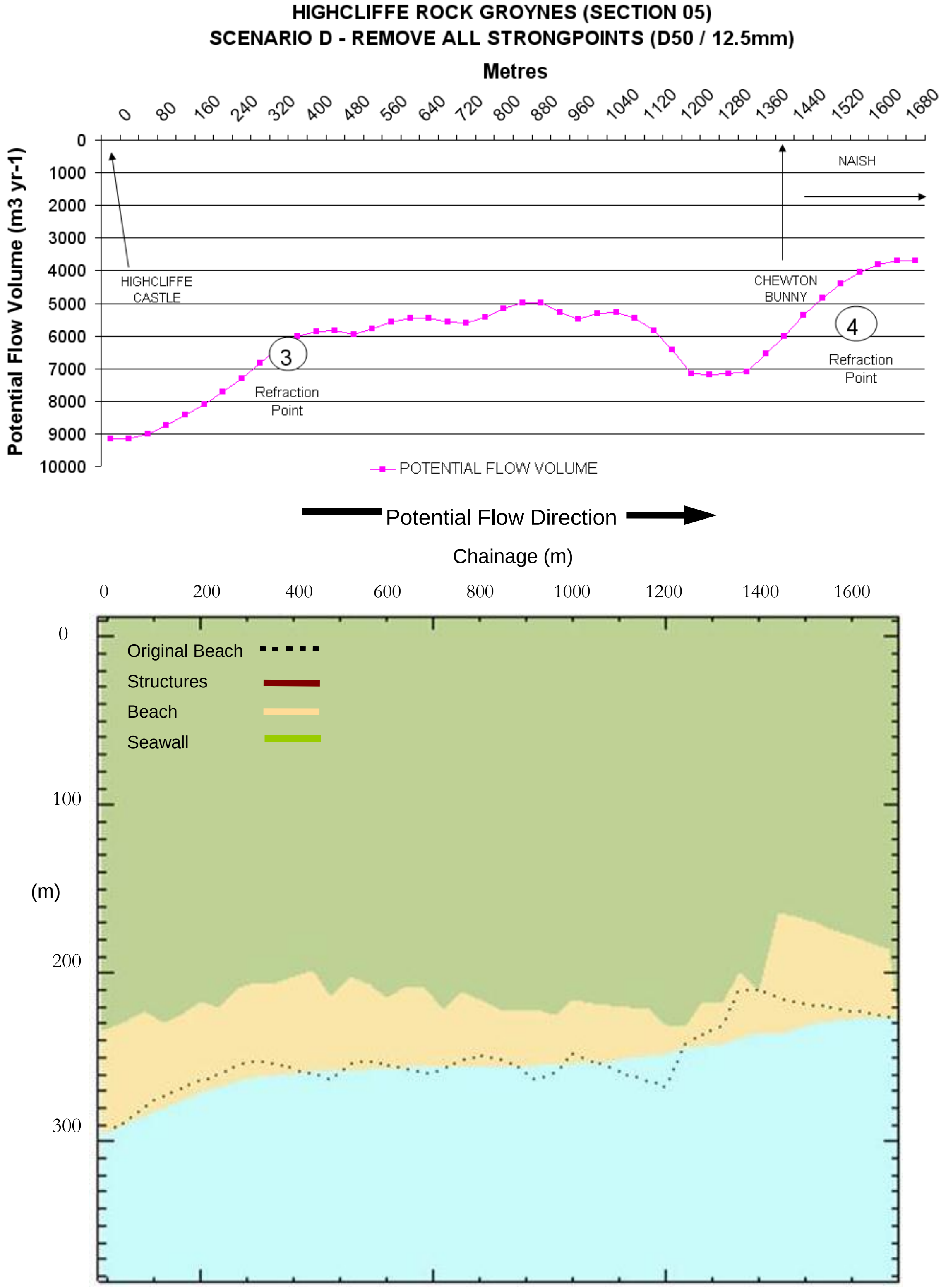


Figure 4.10: Scenario A (Present Conditions) Reduction of strongpoint by 40m



(i) Section 5 Analysis

Figure 4.11: Scenario A (Present Conditions) Removal of all strongpoints

4.1.2 CBY3

CBY3 was modelled as one section; an overview of the section is presented in Table 4.2.

CBY3				
Section reference	**Section length (m)**	**Locality**	**Wave condition file reference**	**Profile reference**
6	1205	Naish Cliffs	XCH 4	5f00225 5f00222 5f00215 5f00209 5f00202

Table 4.2: CBY3 section overview

(a) Section 6

Section 6 (Naish Cliffs) is situated to the east of Chewton Bunny and is managed by New Forest District Council. There are no defences along this section.

The Map (Figure 4.12a) and aerial photograph (Figure 4.12c) highlight the section of coastline that was modelled in beachplan for Section 6. Colour coded profile lines (referenced to the table in Figure 4.12b) have been included on the aerial photograph.

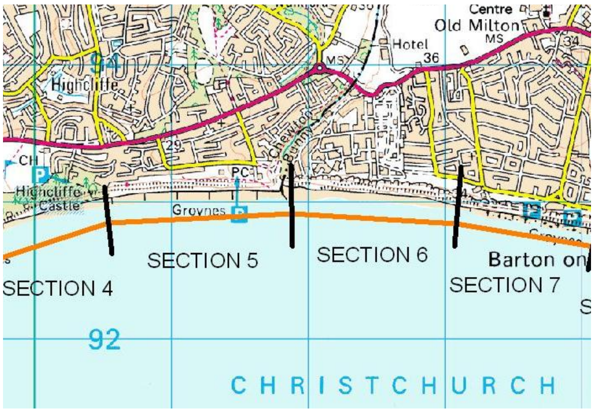


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Figure 4.12a Location of Section 6

Profile Colour	Time until MLW has expired*	
Red	< 0 yrs	MLW Regression
Orange	1 to 20 yrs	
Yellow	21 to 40 yrs	
Green	41 to 60 yrs	
Light cyan	61 to 80 yrs	
Light blue	81 to 100 yrs	
Dark blue	>100 yrs	
Lilac	MLW Progression	

*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)

Figure 4.12b Profile line colour references

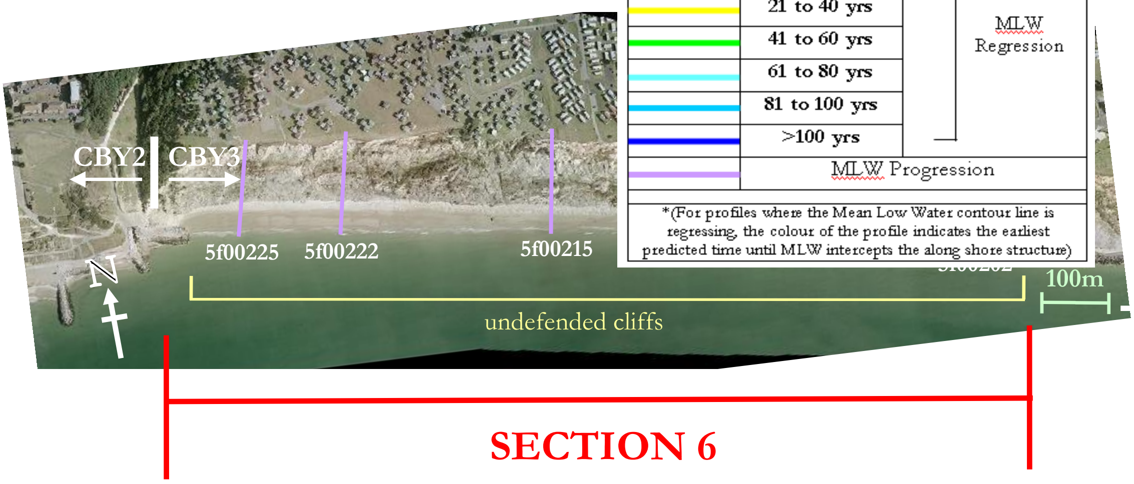


Figure 4.12c Location of Section 6

After running the wave conditions in BEACHPLAN with 10 years of wave data, Scenario A (Present Conditions) (See Figure 4.13) indicates that the potential drift direction is from west to east, and that on average approximately 13,500m³ enters Section 4 from the south-west annually. It appears that the timber groynes to the south-western section are efficient at maintaining a beach, thus allowing accretion to occur. In fact, the model indicates that there could be the potential for a significant amount of material to accrete along the first 350m (the section of rock groynes). This is supported by the long term beach profile analysis (5f00296) which indicates a stable beach.

To the east of the groynes the model indicates that the undefended section is stable and there is an indication that the beach is accreting.

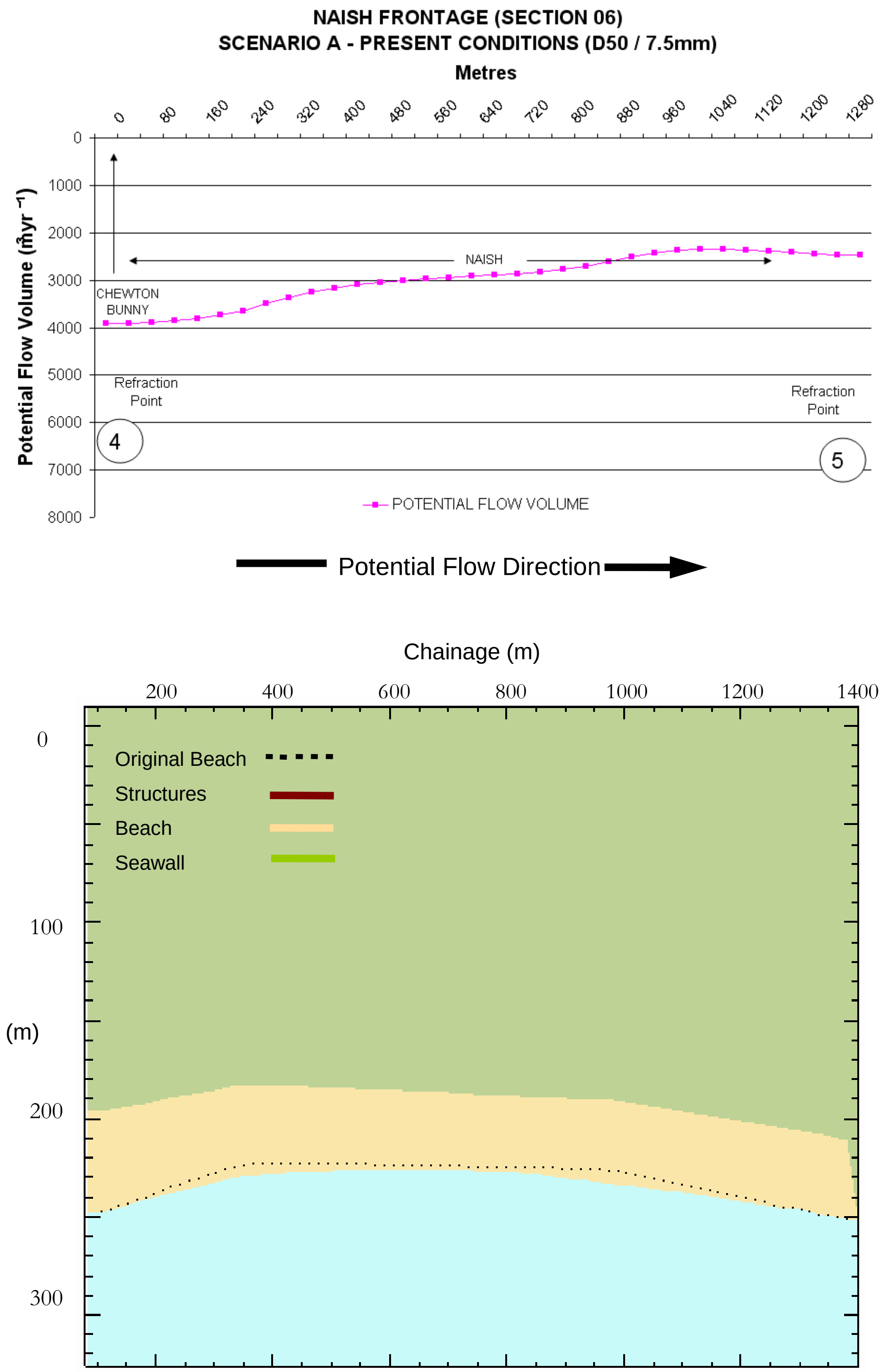


Figure 4.13: Scenario A (Present Conditions)

4.1.3 CBY4

CBY4 was s split into 2 sections; an overview of the section is presented in Table 4.3.

CBY4				
Section reference	**Section length**	**Locality**	**Wave condition file ref**	**Profile reference**
7	1010	Barton-on-Sea (West)	XCH 5	5f00197, 195, 191, 186
8	910	Barton-on-Sea (East)	XCH 6	5f00181, 175, 169, 165

Table 4.3: CBY4 section overview

(a) Sections 7 & 8

Sections 7 & 8 (Barton-on-Sea (west & east)) are situated to the east of Naish cliff and is managed by New Forest District Council. The sections comprise an alongshore structure (rock revetment) and a number of cross-shore defences (rock strongpoints). The condition assessment (see Technical Annex 7) of the revetment varied between condition 1 & 4, giving a residual life expiry date between year 2009 and 2054; although over half of the structures are condition 2 (2024). The section where the condition of the revetment is located is immediately at the western end of Barton-on-Sea, to the east of the undefended Naish section. A landslide in 2001 displaced the whole revetment along an approx 200m section. The revetment has since been repaired however the fact that the structure has moved has had a bearing on the condition. The rock strongpoints vary between condition 2 & 3 which gives a residual expiry date of between year 2014 & 2019.

The Map (Figure 4.14a) and aerial photograph (Figure 4.14c) highlight the section of coastline that was modelled in beachplan for Section 7. Colour coded profile lines (referenced to the table in Figure 4.14b) have been included on the aerial photograph.

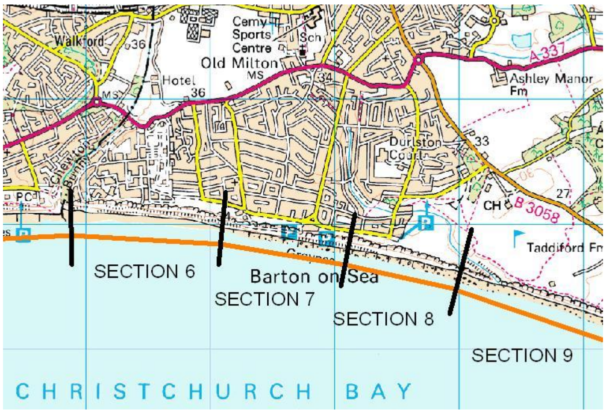


Figure 4.14a Location of Section 7

Profile Colour	Time until MLW has expired*	
(red)	< 0 yrs	MLW Regression
(orange)	1 to 20 yrs	
(yellow)	21 to 40 yrs	
(green)	41 to 60 yrs	
(light blue)	61 to 80 yrs	
(blue)	81 to 100 yrs	
(dark blue)	>100 yrs	
(lilac)	MLW Progression	
*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)		

Figure 4.14b Profile line colour references

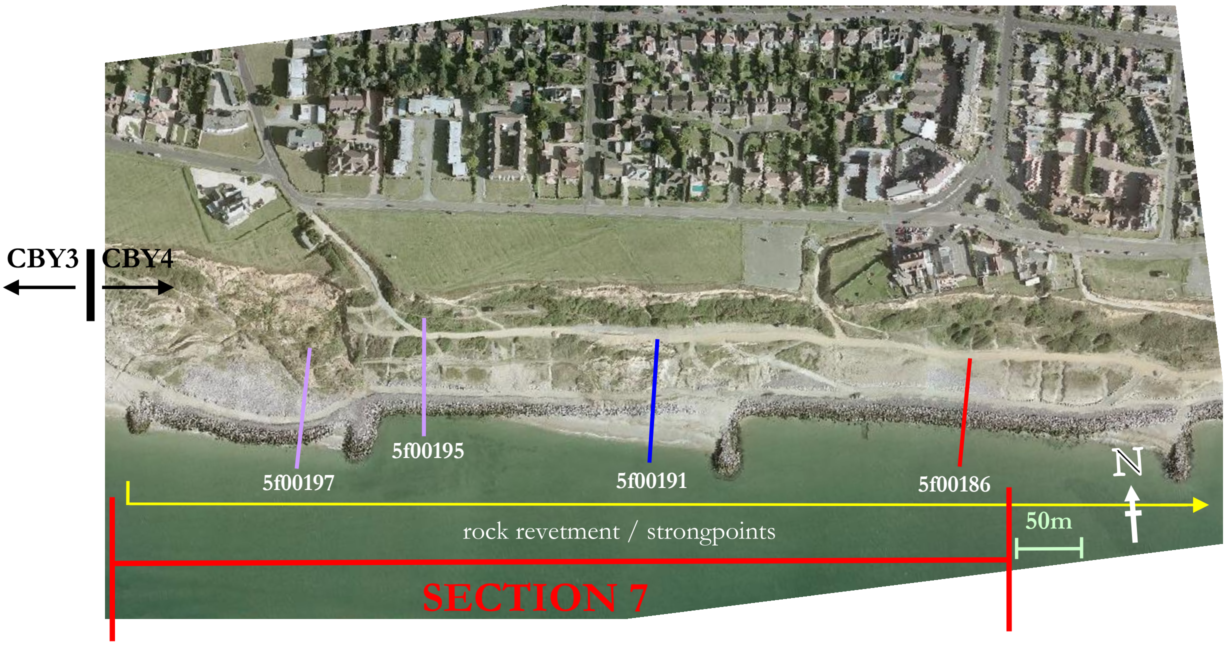
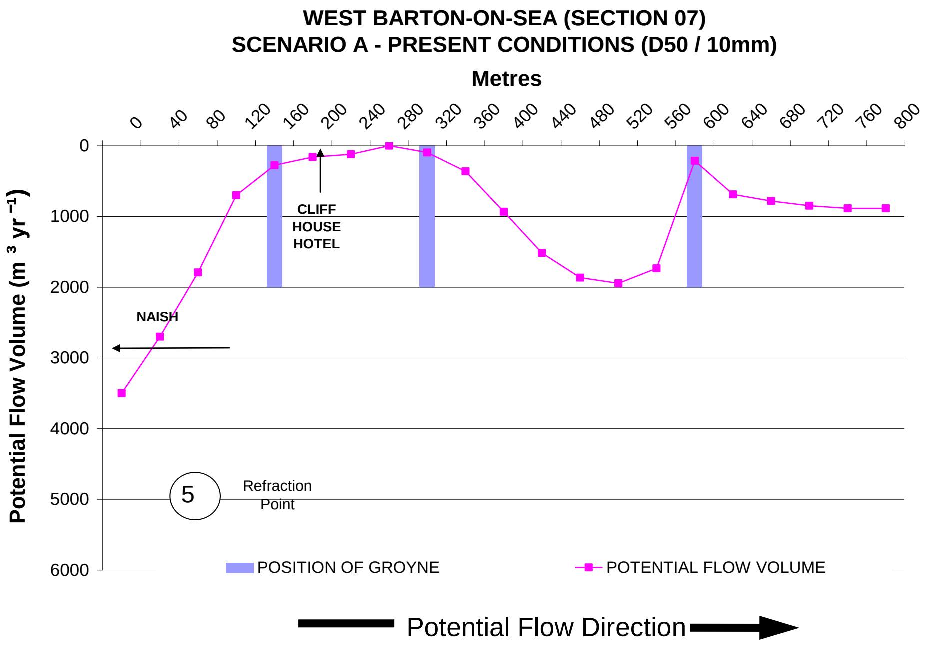


Figure 4.14c Location of Section 7



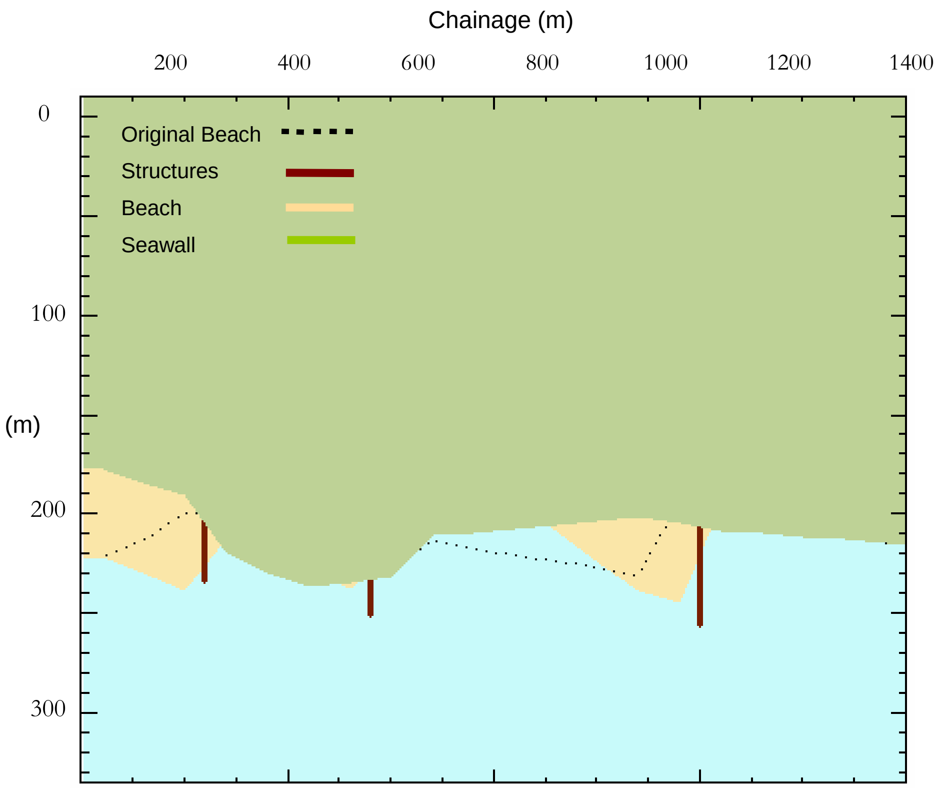
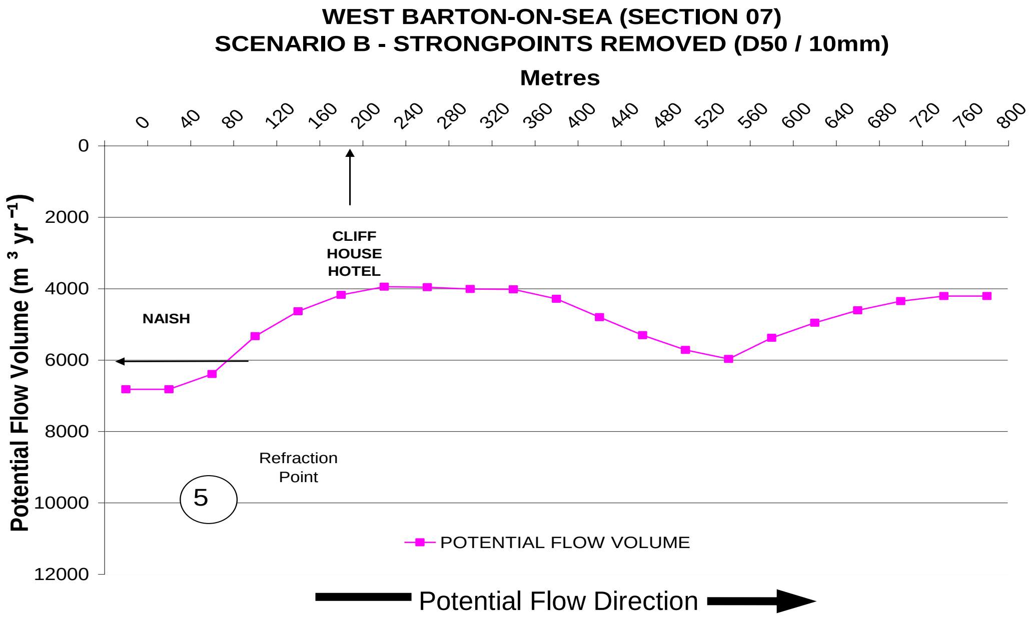


Figure 4.15: Scenario A (Present Conditions)



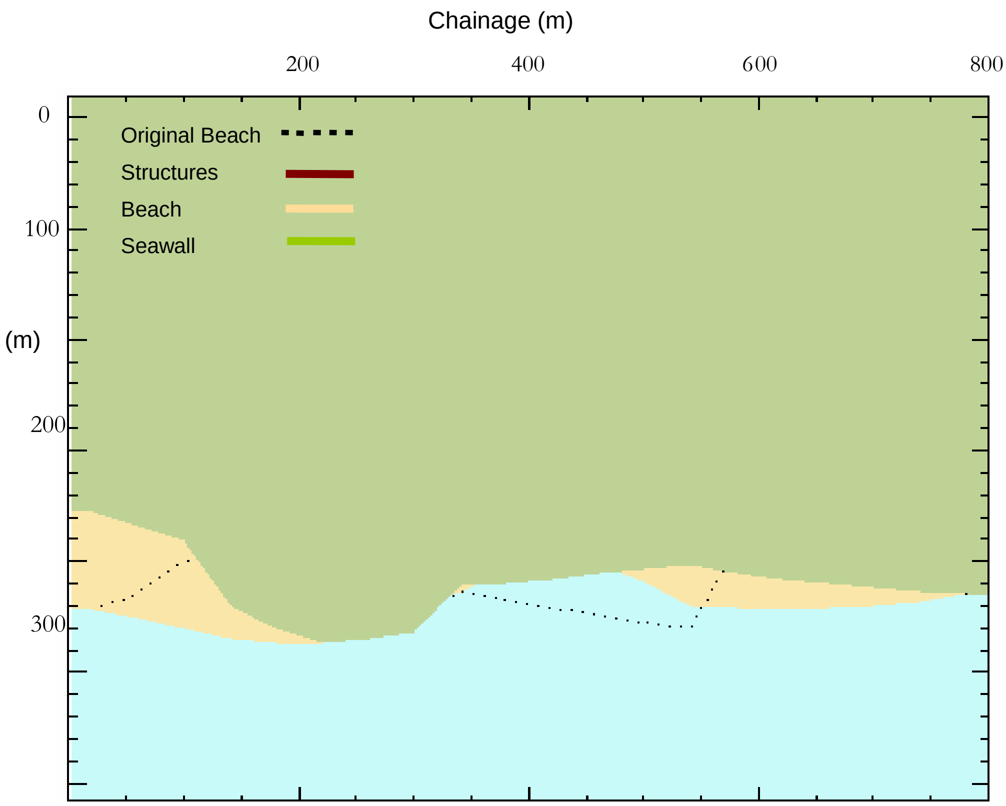


Figure 4.16: Scenario A (Strongpoints removed)

The Map (Figure 4.17a) and aerial photograph (Figure 4.17c) highlight the section of coastline that was modelled in beachplan for Section 8. Colour coded profile lines (referenced to the table in Figure 4.17b) have been included on the aerial photograph.

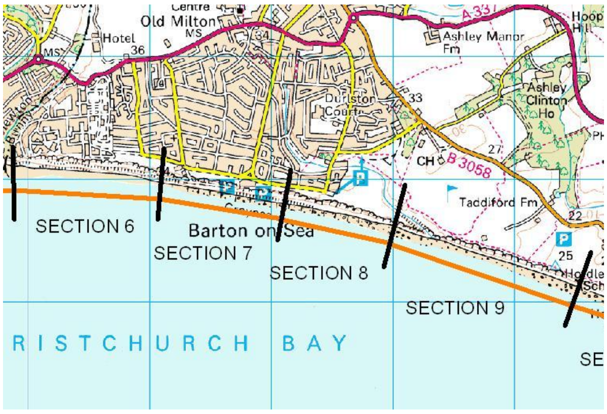


Figure 4.17a Location of Section 8

Profile Colour	Time until MLW has expired*	
(red)	< 0 yrs	MLW Regression
(orange)	1 to 20 yrs	
(yellow)	21 to 40 yrs	
(green)	41 to 60 yrs	
(light blue)	61 to 80 yrs	
(blue)	81 to 100 yrs	
(dark blue)	>100 yrs	
(lilac)	MLW Progression	

*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)

Figure 4.17b Profile line colour references

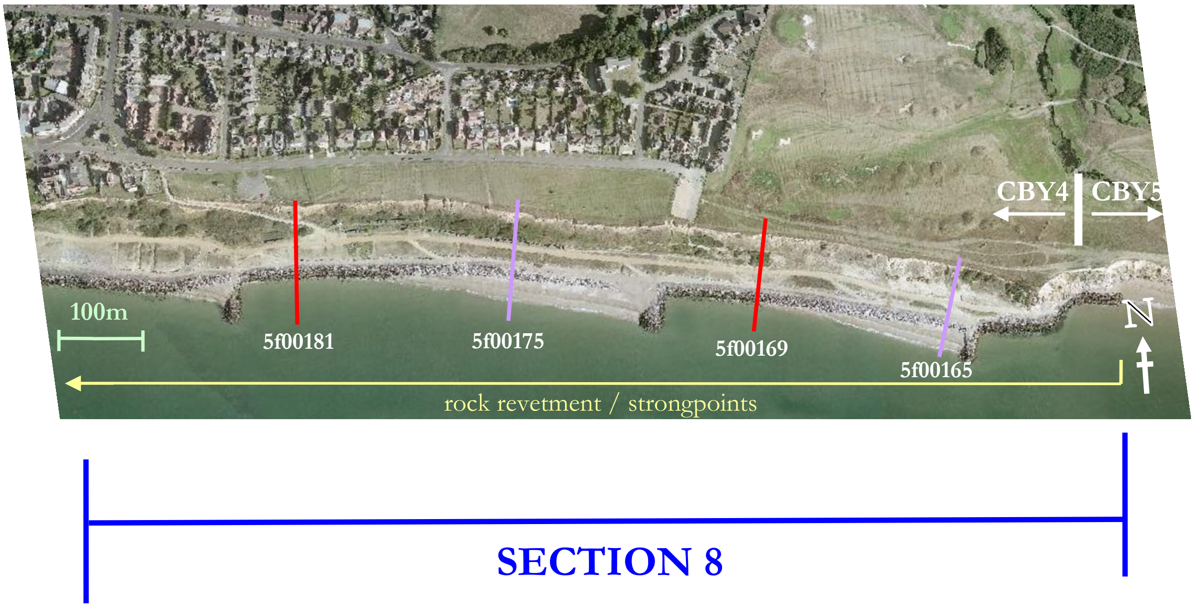


Figure 4.17c Location of Section 8

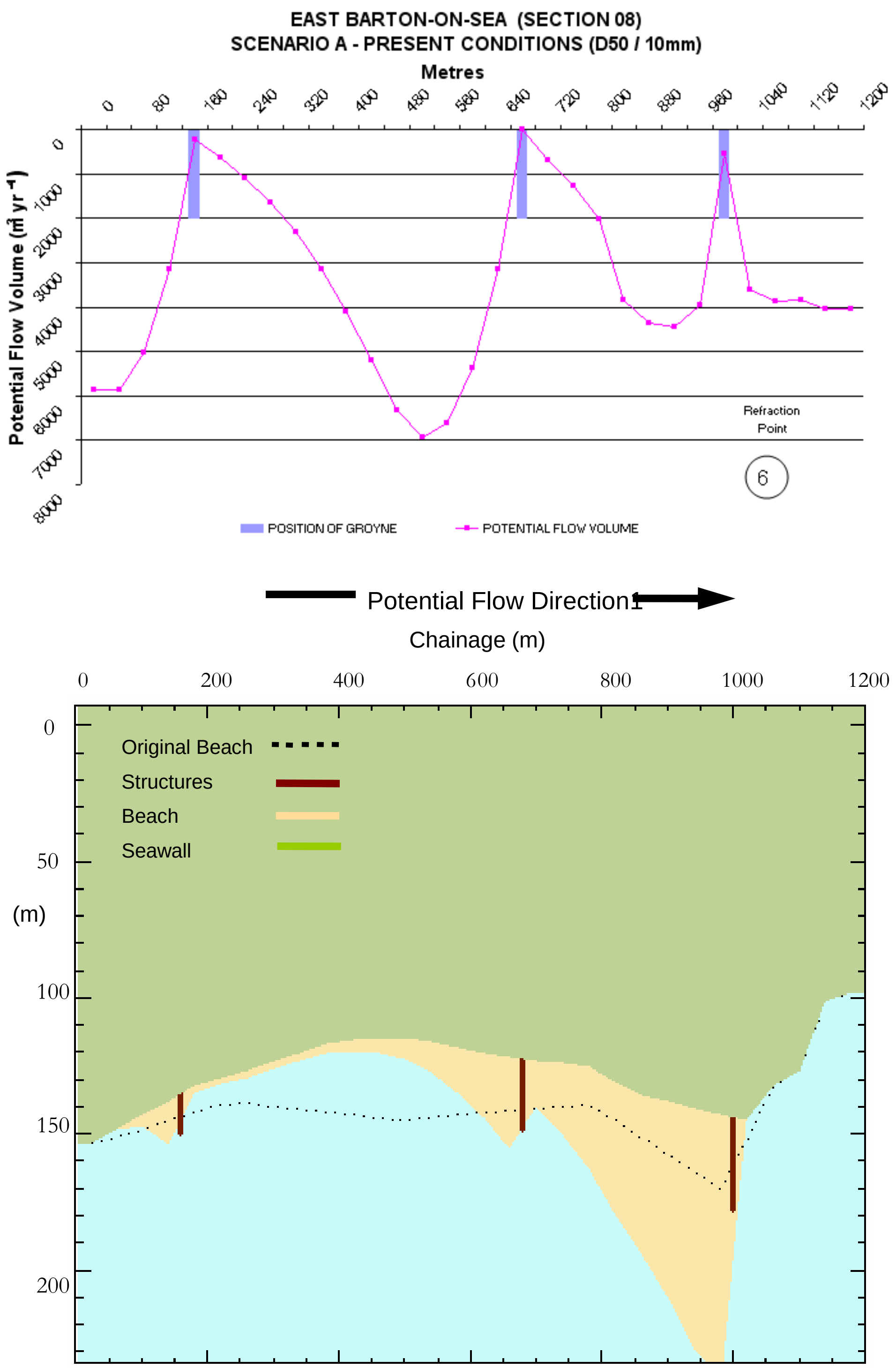


Figure 4.18: Scenario A (Present Conditions)

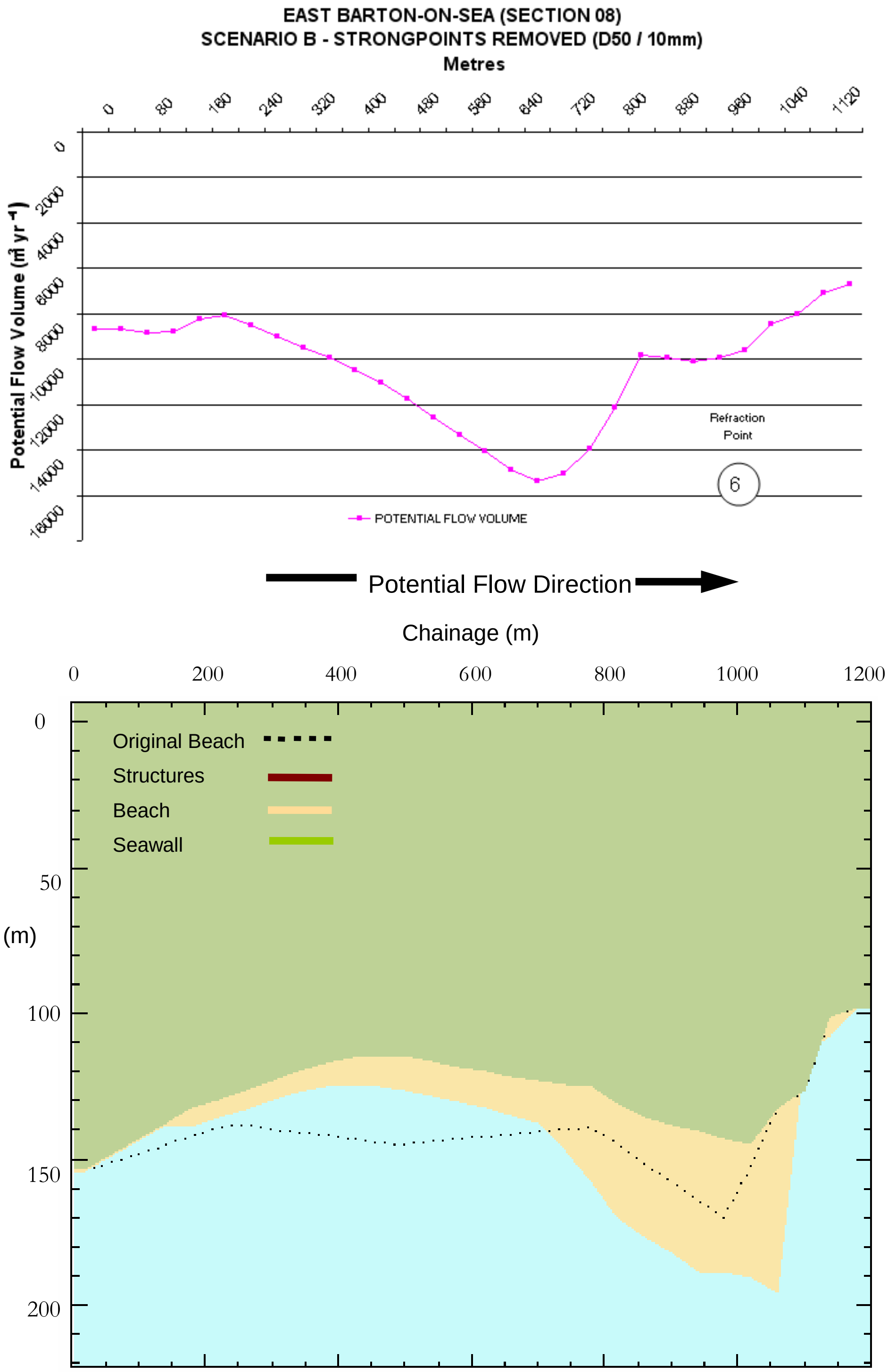


Figure 4.19: Scenario B (Strongpoints removed)

4.1.4 CBY5

CBY5 was s split into 2 sections; an overview of the section is presented in Table 4.4.

CBY5				
Section reference	**Section length**	**Locality**	**Wave condition file ref**	**Profile reference**
9	1760	Becton Bunny / Hordle Cliffs	XCH7	5f00161, 155, 145, 140, 135, 130
10	1	Hordle Cliffs	XCH8	5f00130, 125, 121, 107, 099

Table 4.4: CBY5 section overview

(a) Section 9

Section 9 (Becton Bunny to Hordle Cliffs) is situated to the east of Naish cliff and is managed by New Forest District Council. The section comprises an alongshore structure (rock revetment) and a number of cross-shore defences (rock strongpoints). The condition assessment (see Technical Annex 7) of the revetment varied between condition 1 & 4, giving a residual life expiry date between year 2009 and 2054; although over half of the structures are condition 2 (2024). The section where the condition of the revetment is located is immediately at the western end of Barton-on-Sea, to the east of the undefended Naish section. A landslide in 2001 displaced the whole

The Map (Figure 4.20a) and aerial photograph (Figure 4.20c) highlight the section of coastline that was modelled in beachplan for Section 9. Colour coded profile lines (referenced to the table in Figure 4.20b) have been included on the aerial photograph.

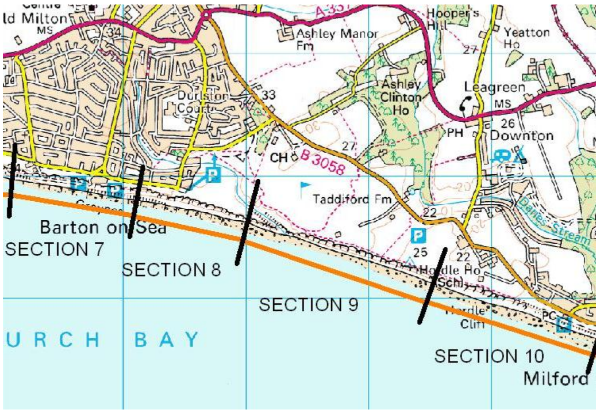


Figure 4.20a Location of Section 9

Profile Colour	Time until MLW has expired*	
	< 0 yrs	MLW Regression
	1 to 20 yrs	
	21 to 40 yrs	
	41 to 60 yrs	
	61 to 80 yrs	
	81 to 100 yrs	
	>100 yrs	
	MLW Progression	

*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)

Figure 4.20b Profile line colour references

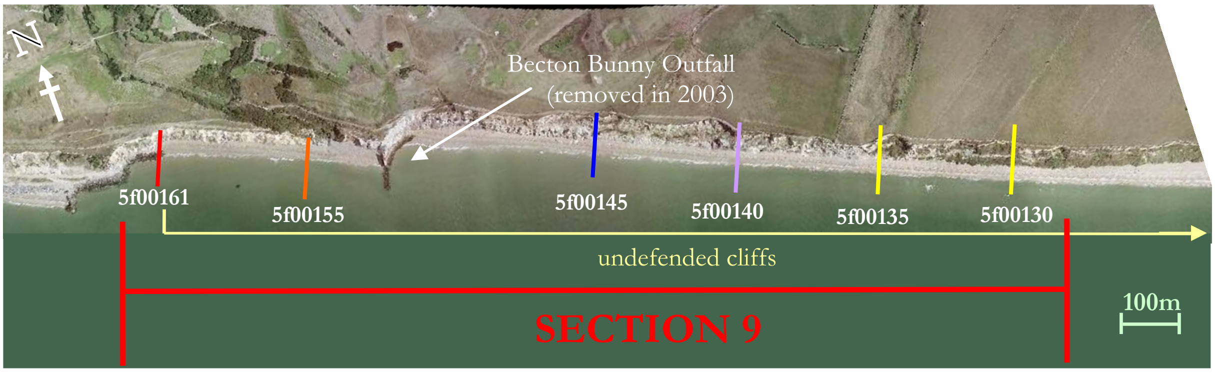


Figure4.20c Location of Section 9

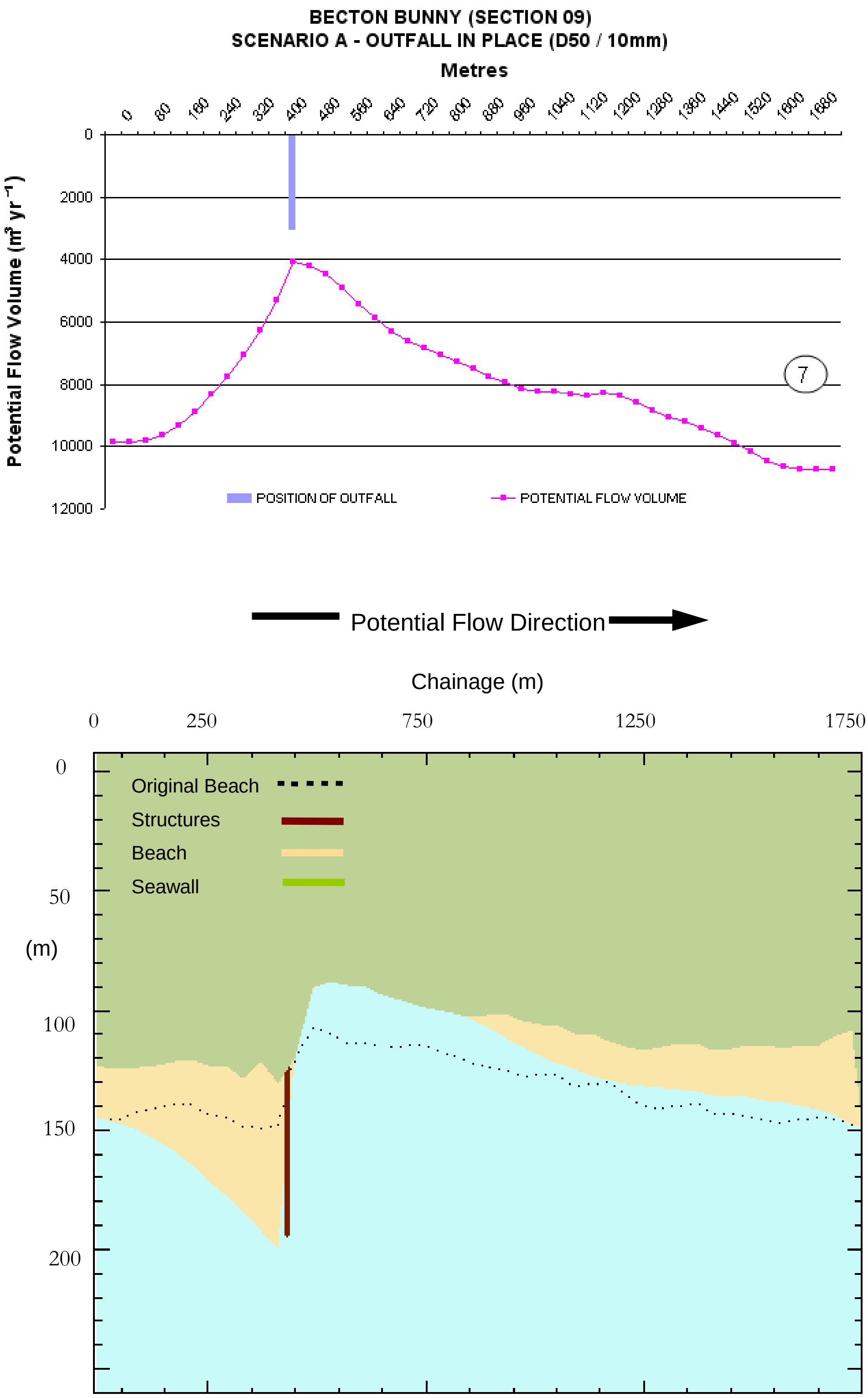


Figure 4.21: Scenario A (Present Conditions)

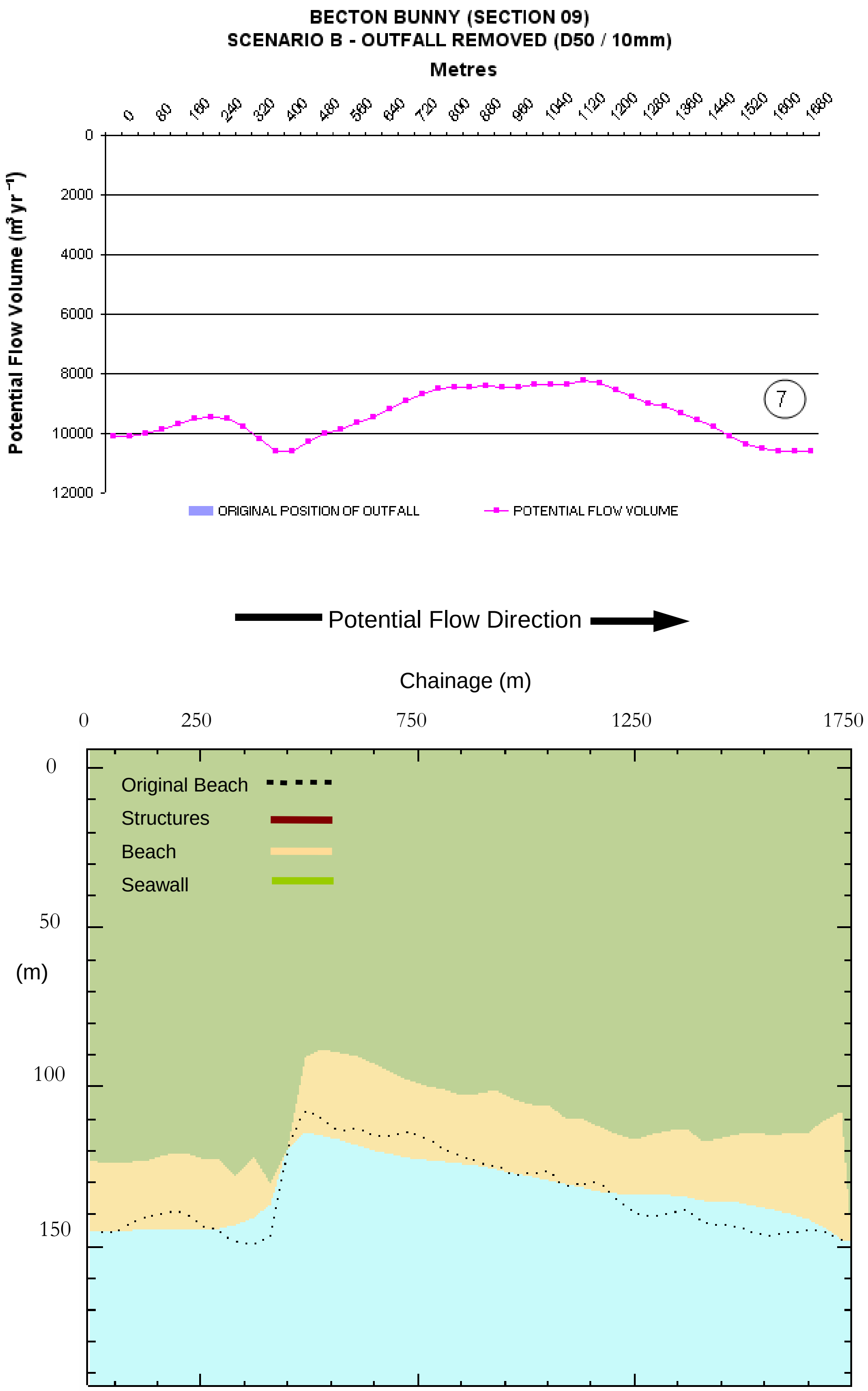


Figure 4.22: Scenario B (outfall removed)

(b) Section 10

Section 10 (Hordle Cliffs) is situated to the east of Naish cliff and is managed by New Forest District Council. The section comprises an alongshore structure (rock revetment) and a number of cross-shore defences (rock strongpoints). The condition assessment (see Technical Annex 7) of the revetment varied between condition 1 & 4, giving a residual life expiry date between year 2009 and 2054; although over half of the structures are condition 2 (2024). The section where the condition of the revetment is located is immediately at the western end of Barton-on-Sea, to the east of the undefended Naish section.

The Map (Figure 4.23a) and aerial photograph (Figure 4.23c) highlight the section of coastline that was modelled in beachplan for Section 10. Colour coded profile lines (referenced to the table in Figure 4.23b) have been included on the aerial photograph.

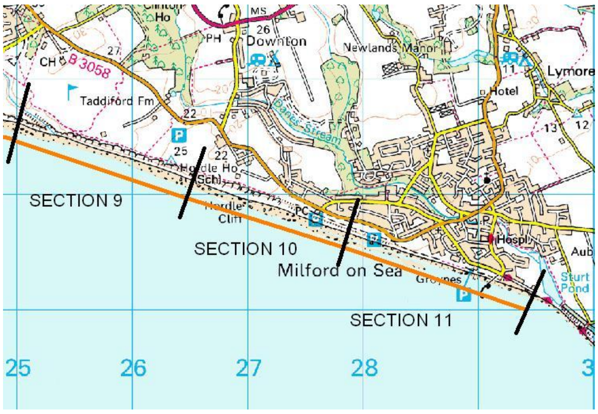


Figure 4.23a Location of Section 10

Profile Colour	Time until MLW has expired*	
	< 0 yrs	MLW Regression
	1 to 20 yrs	
	21 to 40 yrs	
	41 to 60 yrs	
	61 to 80 yrs	
	81 to 100 yrs	
	>100 yrs	
	MLW Progression	
*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)		

Figure 4.23b Profile line colour references

Figure 4.23c Location of Section 10

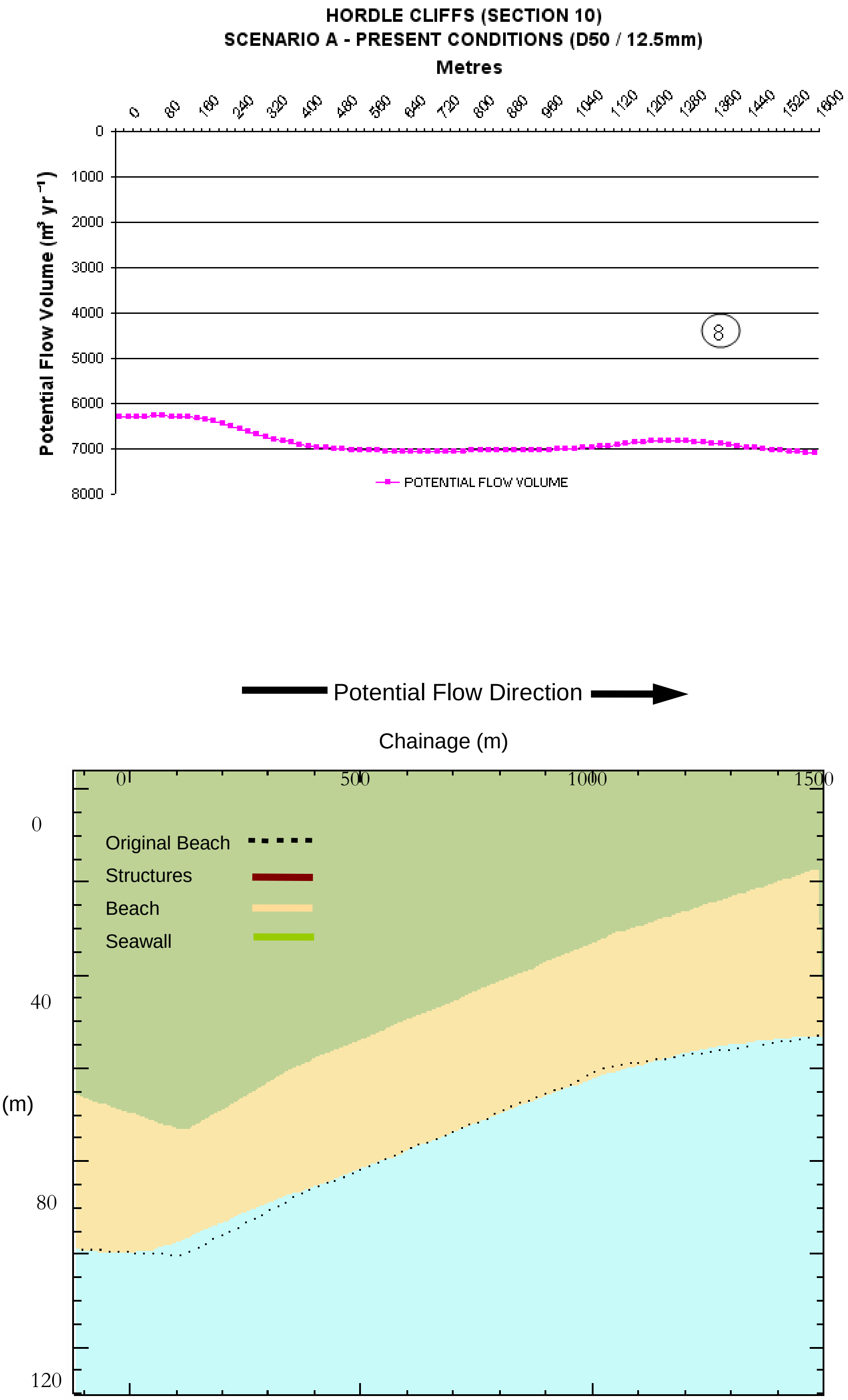


Figure 4.24: Scenario A (Present Conditions)

4.1.5 CBY6

CBY6 was modelled as one section; an overview of the section is presented in Table 4.5.

CBY6				
Section reference	**Section length (m)**	**Locality**	**Wave condition file reference**	**Profile reference**
11			XCH	5f0099, 091, 082, 076, 070

Table 4.5: CBY6 section overview

(a) Section 11

Section 11 (Naish Cliffs) is situated to the east of Chewton Bunny and is managed by New Forest District Council. There are no defences along this section.

The Map (Figure 4.25a) and aerial photograph (Figure 4.25c) highlight the section of coastline that was modelled in beachplan for Section 11. Colour coded profile lines (referenced to the table in Figure 4.25b) have been included on the aerial photograph.

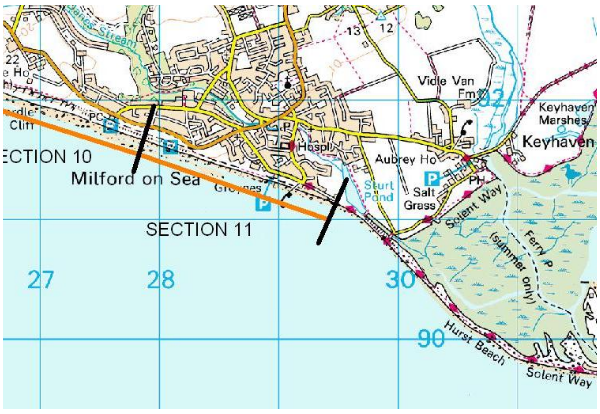


Figure 4.25a Location of Section 11

Profile Colour	Time until MLW has expired*	
[red]	< 0 yrs	MLW Regression
[orange]	1 to 20 yrs	
[yellow]	21 to 40 yrs	
[green]	41 to 60 yrs	
[light cyan]	61 to 80 yrs	
[light blue]	81 to 100 yrs	
[dark blue]	>100 yrs	
[lilac]	MLW Progression	

*(For profiles where the Mean Low Water contour line is regressing, the colour of the profile indicates the earliest predicted time until MLW intercepts the along shore structure)

Figure 4.25b Profile line colour references

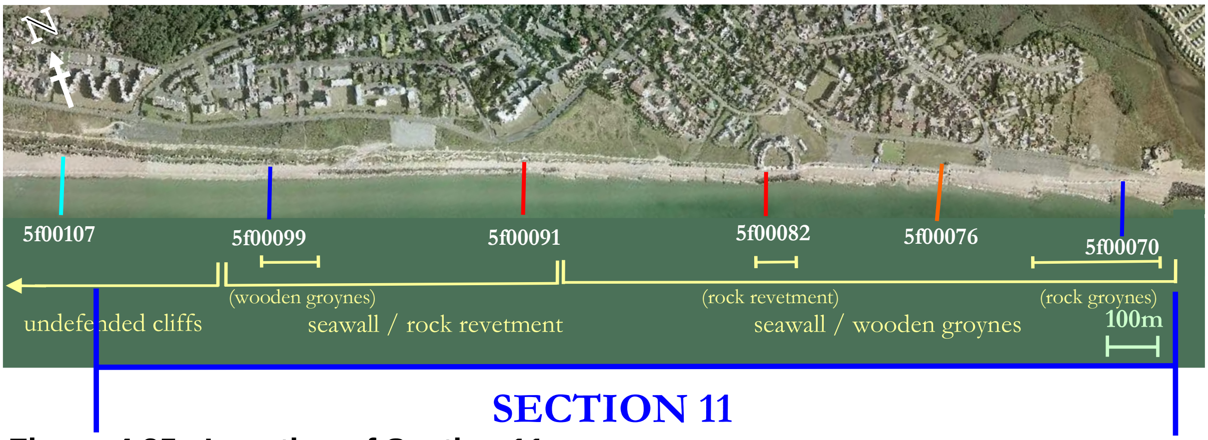


Figure 4.25c Location of Section 11