Guernsey Coastal Defences

Flood Risk Assessment Studies

Volume II - Local Area Reports & Appendices

States of Guernsey

March 2012

Final Report

9W2890

Guernsey Coastal Defences

Flood Risk Assessment Studies

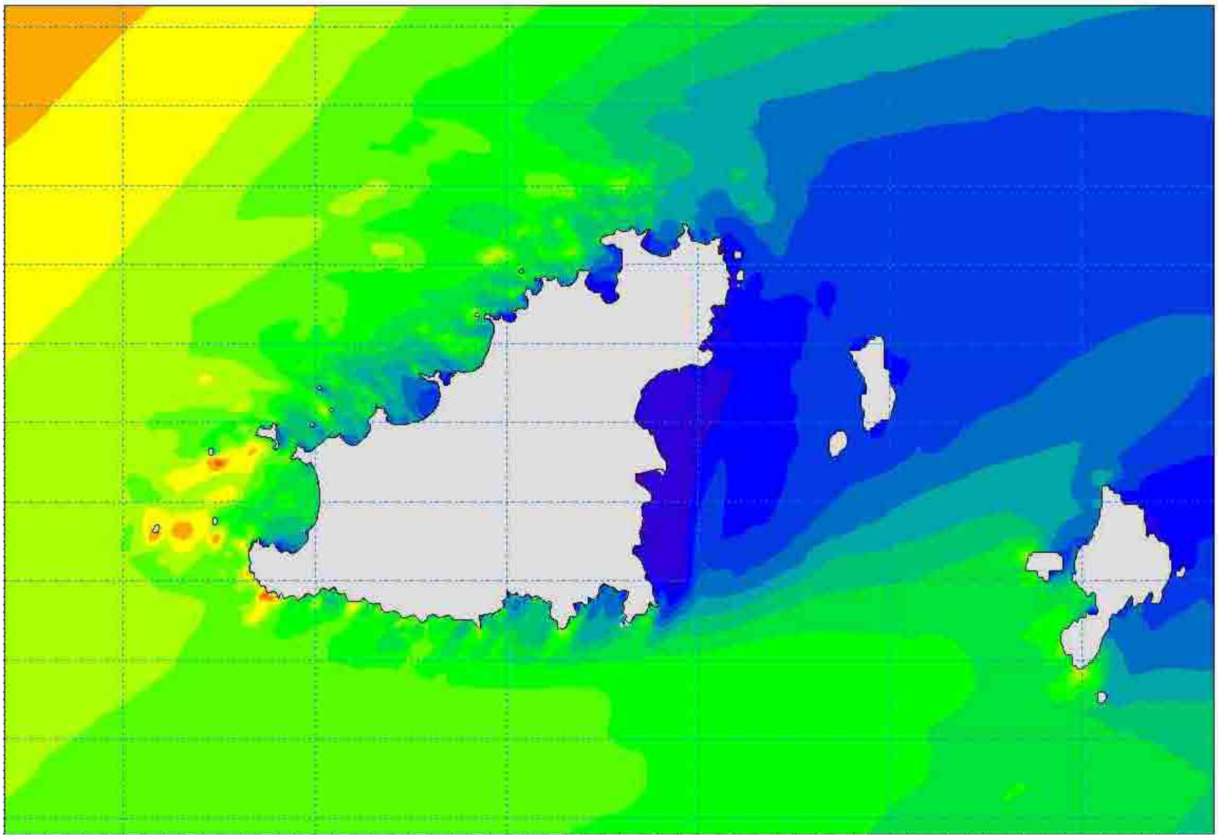
Volume II – Local Area Reports & Appendices

Local Area Reports

Belle Greve Bay
St Sampson and Associated Area of Le Grande Havre
Bordeaux Harbour
Baie de Port Grat and Pêqueries
Cobo and Saline Bay

Background and Technical Studies

Appendix A – Offshore wave model
Appendix B – Overtopping analysis and sensitivity analysis
Appendix C – Tidal inundation model
Appendix D – Flood mapping
Appendix E – Approach to economic appraisal
Appendix F – Outline design drawings



Appendix A: MIKE21 Wave Modelling

States of Guernsey

December 2011
Final Report
9W2890

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SUMMARY

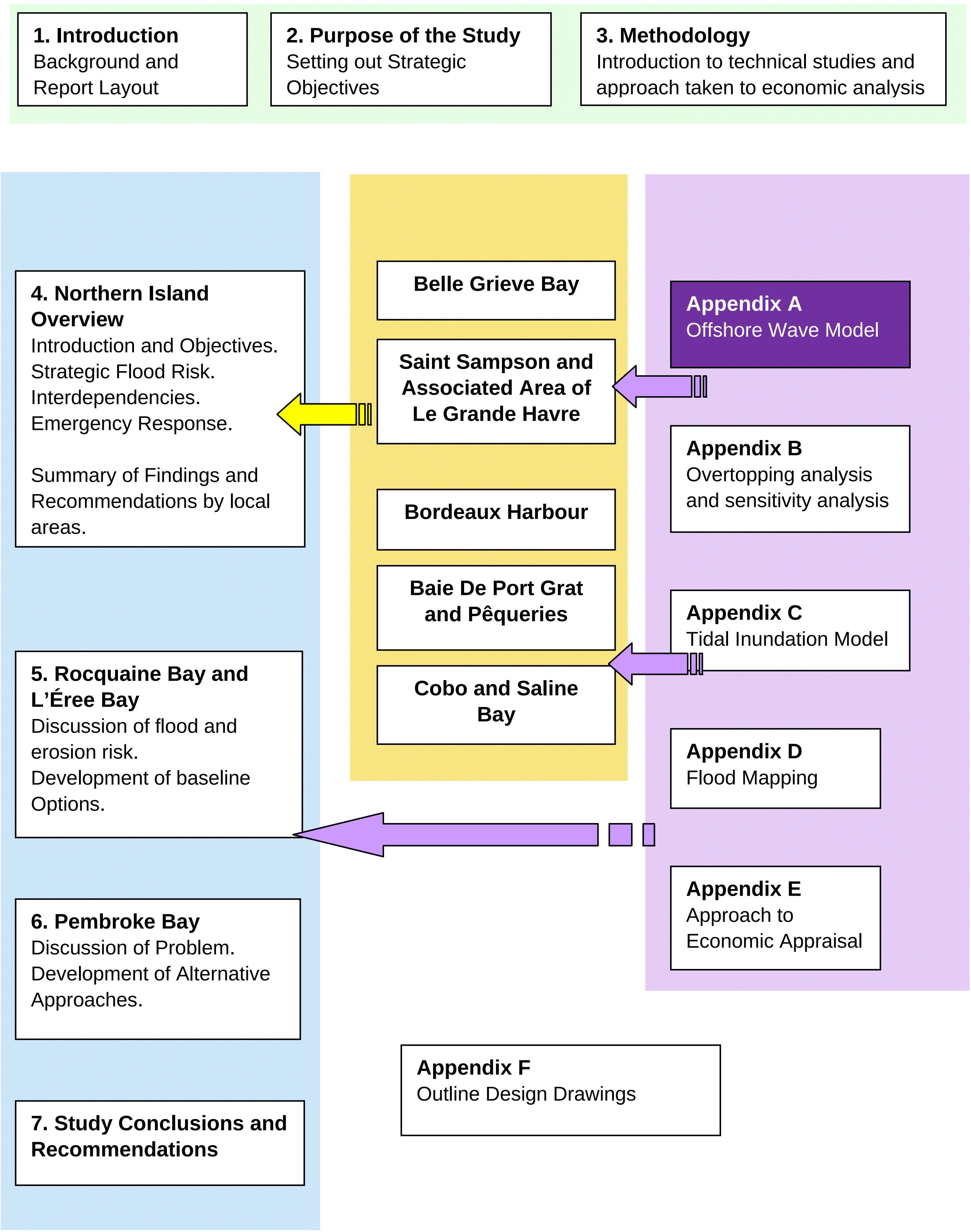
Quantification of coastal flood risk begins with an exploration of offshore wave conditions, and analysis of how they transform as they approach the shore. The modelling tool applied to this problem was MIKE21 SW, an industry standard software package developed by the Danish Hydraulics Institute.

This stage of analysis provided extreme nearshore wave conditions and water levels at locations around the island where overtopping analysis was to be done (see Appendix C). Water levels were estimated through a statistical analysis of tide levels recorded at St Peter Port. A hydrodynamic model of the English Channel was then used to understand how high tides varied around the island. Offshore swell and windwave conditions were also analysed statistically, to estimate high magnitude events. To prevent overestimation of extreme storm conditions, the probabilities of high water levels and high waves were analysed jointly.

A large number of simulations were run to represent conditions around the island. These were used to explore the range of possible sea states, and to identify those that produced the most severe conditions at the shore. The water levels and offshore waves that produced these critical conditions were then modified to represent the influence of climate change over the next hundred years, and the simulations were rerun.

The outputs of this analysis were predictions of critical nearshore wave and water level conditions now and in the future, and a description of the current wave climate, and how it varies around the island.

REPORT STRUCTURE



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1 OBJECTIVES

The wave modelling activities described in this report were an element of the 2010-2011 coastal flood risk assessment undertaken by Royal Haskoning for the States of Guernsey.

The objectives of this element of the project were to:

(1) Predict extreme inshore wave and water level conditions at selected locations for the subsequent assessment of wave overtopping, and

(2) Provide more general information on wave climates around the island.

2 WAVES AND WATER LEVELS AROUND GUERNSEY

The island of Guernsey is exposed to dynamic and complex marine processes that influence the island's vulnerability to coastal flooding. Its situation in the western part of the English Channel means that it is subjected to high winds and large waves, both generated within the channel, and arriving from the north Atlantic. These waves change direction and size as they pass into the shallower waters close to Guernsey, and interact with the archipelago of which it is a part. Shoaling, refraction, diffraction and shadowing all act on the waves, to influence their heights, periods and directions. In addition the tidal range experienced at Guernsey is very high, and this causes significant gradients in water level around the island. Normal tidal cycles are complicated by surge effects, when low pressures passing into the English Channel from the Atlantic force sea levels to temporarily rise. Compounding the complexity of this situation is the expectation of accelerated rates of sea level rise due to global warming, coupled with a change in the behaviour of storms. All of these effects influence the coastal flood risk around the coast of Guernsey, and so are quantified in this report.

The complexity of this situation requires the application of a suite of approaches, including the statistical analysis of recordings and advanced wave modelling. The island is, of course, exposed from all directions. To make the analysis tractable, this exposure considered using twelve directional sectors, each thirty degrees wide. The offshore wave or wind conditions of each of these sectors are treated separately. In many situations it is not possible to tell in advance (or unwise to prejudge), which sector will cause the most severe conditions at the shoreline. Consequently very many conditions are explored, to identify the worst case. A further complication arises from the relationship between high water levels and extreme wave conditions. To suppose that a very high sea level occurs with very large waves may result in an unrealistically improbable situation. The coupled likelihood, or 'joint probability', of simultaneous dangerous waves and water levels must therefore be analysed.

Once the set of offshore conditions has been calculated for each sector, they are translated inshore using a wave model. The model handles the extremely large set of calculations necessary to predict how the many processes of transformation influence the waves as they approach the shore. Importantly the model must represent the surface of the seabed and the islands around Guernsey, as these govern the transformation processes.

Once a wave climate has been derived for a location at the Guernsey shore, it becomes possible to identify the conditions most likely to cause wave overtopping and coastal flooding. These conditions are then projected into the future, accounting for sea level rise and changing patterns of surge. The results are then passed to the next stage of simulation, in which wave activity and overtopping are modelled using the Amazon modelling tool.

3 EXTREME WAVE AND WIND CONDITIONS

When simulating extreme wave climates is it necessary to distinguish between swell and wind waves, which arise from different processes. Swell waves tend to arrive from greater distances, and represent the low frequency products of distant storms. Sea conditions known as ‘wind waves’ are generated more locally, and tend to be characterised by shorter wavelengths, more diffused directions and greater frequency spreading.

When discussing severe events such as unusually high waves, it is necessary to understand and describe how unusual they are. This is done by adopting the concept of a *return period*, which is normally quoted as a particular number of years (e.g. 10 years, or 200 years). In general terms this simply describes how long you should expect to wait, on average, before you experience conditions of that magnitude or greater. This is an average measure which applies over the long term, and so the event being described may occur more or less frequently in any given period of time. In this study the return periods of greatest interest were 1, 10, 50, 100, and 250 years.

Four sets of data were analysed to describe conditions around the entire island. Only the dominant forcing conditions were required. From the northerly, easterly and southerly sectors the largest waves are generated by wind blowing across the English Channel. Swell is clearly dominant from the west, and may also be important from the northeast.

3.1 Northerly windwaves

Data describing windwave conditions were purchased from the Met Office (MO) for location 49.75N and 2.86W, which is around 35 km north-northwest of Guernsey. This was generated with the MO European Wave Model, for the period from December 1988 to October 2008. As with all the offshore wave data this was discretized into 30 degree sectors.

Generalised Extreme Value (Gumbel) distributions were fitted to the sectors describing northerly windwaves from 315 to 75 degrees. An example of this fitting, for the first sector, is shown in Figure 1.

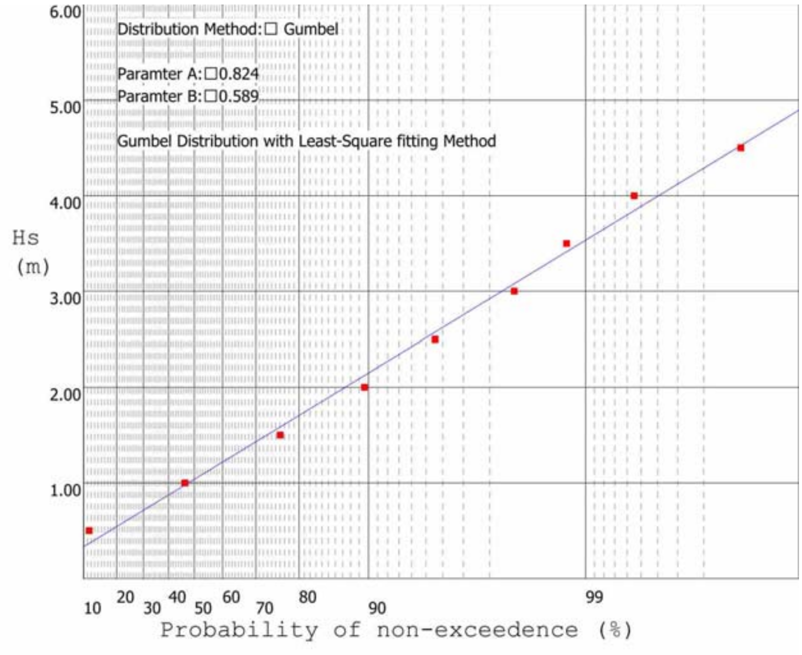

Figure 1. Comparison between windwave data within the 330 degree sector (315 – 345 degrees) and the fitted Gumbel distribution.

Extreme wave heights were estimated from these distributions, and the results are shown in Table 1.

Sector	330 deg		0 deg		30 deg		60 deg	
RP	Height	Period	Height	Period	Height	Period	Height	Period
(years)	(m)	(s)	(m)	(s)	(m)	(s)	(m)	(s)
1	4.1	8.6	4.2	8.3	4.3	8.7	4.7	8.8
10	5.5	10.0	5.6	9.1	5.6	9.8	5.8	9.7
50	6.4	10.9	6.6	9.7	6.5	10.7	6.6	10.4
100	6.8	11.3	7.1	9.9	6.8	11.0	7.0	10.7
250	7.4	11.9	7.7	10.3	7.3	11.5	7.5	11.0

Table 1. Extreme windwave conditions from northerly sectors.

This table also includes wave periods, which were estimated by fitting functions to the Met Office data. Two functional forms were tried, the empirically based expression shown as equation 1, and a simple linear relationship.

$$T = k\sqrt{H} \qquad \text{Equation 1.}$$

Where *T* and *H* are wave period and height respectively, and *k* is a fitted coefficient. The closer fit was achieved with the linear expression, and so this was selected. An example, from the first sector (330), is shown in Figure 2.

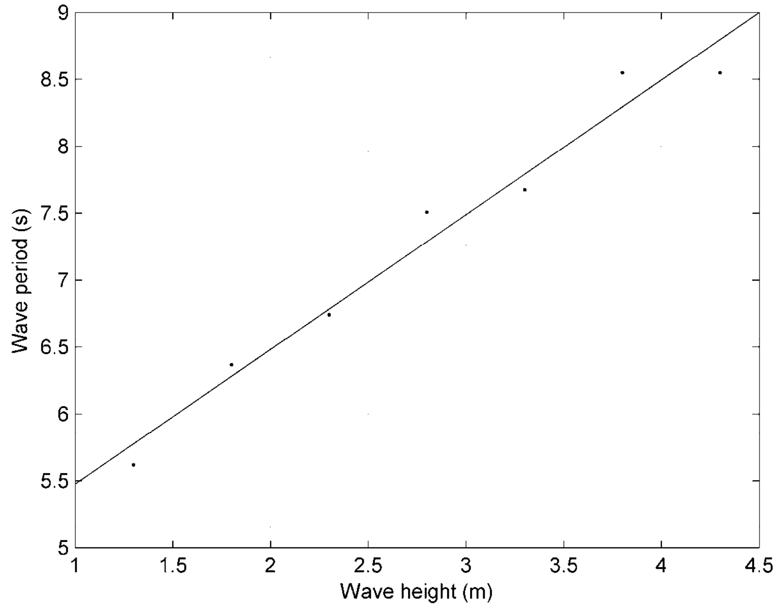

Figure 2. Relationship between wave height and period for sector 330.

3.2 Easterly and southerly wind conditions

Waves arriving from the east and south are generated by relatively local winds acting between the island and the coast of France. The generation of these waves was simulated using estimates of wind conditions of different magnitudes. These estimates were based on wind data for the English Channel derived for a previous study (Royal Haskoning. 2011). These data were compared to records of wind velocity recorded in St Peter Port Harbour, and the results are shown in Figure 3.

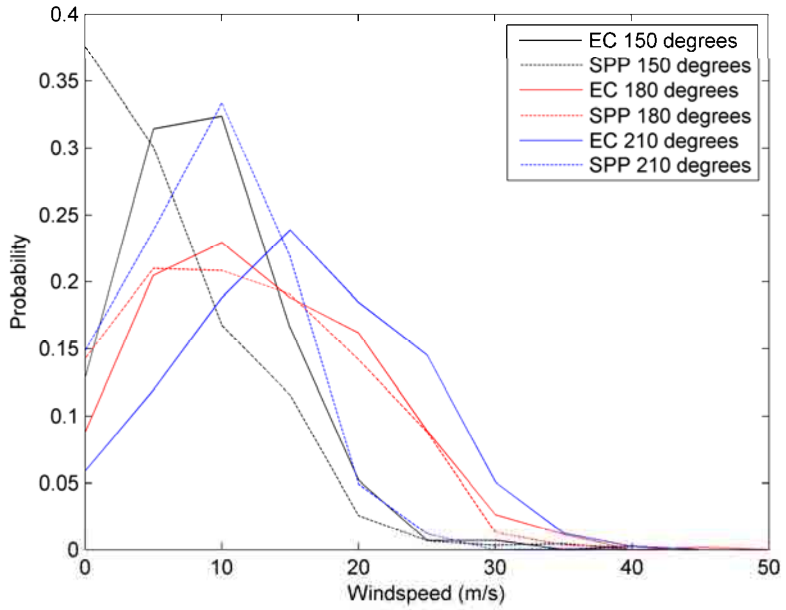

Figure 3. Comparison between English Channel and St Peter Port wind data, by sector.

The three most southerly sectors are shown, capturing all winds from 165 to 225 degrees. The comparison is good, with some variations. Sectors 150 and 180 compare well, with the English Channel data showing generally higher windspeeds. This should be expected given that the St Peter Port data is influenced by the proximity of the island. The largest difference is seen in the 210 degrees (i.e. south southwest), where the St Peter Port data is noticeably smaller. This is also expected, given that winds from this sector have to pass over the island, causing a greater reduction in wind speed than would occur from more easterly sectors. These reasonable variations around the generally close fit demonstrate the validity of the English Channel data for Guernsey.

The extreme wind speeds derived from the English Channel model data are shown in Table 2.

Sector	**90**	**120**	**150**	**180**	**210**	**240**
Return Period	Speed	Speed	Speed	Speed	Speed	Speed
(years)	m/s	m/s	m/s	m/s	m/s	m/s
10	17.8	16.6	19.6	21.3	23.5	27.1
50	19.7	18.8	23.1	23.0	25.1	30.7
100	20.4	19.7	24.6	23.5	25.7	32.3
250	21.3	20.8	26.6	24.2	26.4	34.3

Table 2. Extreme wind speeds from the east and south.

3.3 Swell from the west

Swell approaching from westerly sectors is an important element of the flood risk hazard around Guernsey. Depressions tracking from west to east over the Atlantic generate large storm waves. These persist but separate into their constituent frequencies to form fairly regular waves, and some of these enter the English Channel as westerly swell.

The extreme swell conditions from these sectors have been analysed in a previous study (Royal Haskoning, 2008), and are reproduced in Table 3.

Sector	**210°**		**240°**		**270°**		**300°**	
Return Period	Height	Period	Height	Period	Height	Period	Height	Period
(years)	(m)	(s)	(m)	(s)	(m)	(s)	(m)	(s)
1	5.4	13.0	6.2	13.4	5.4	15.4	5.1	14.4
5	6.8	14.5	7.3	14.5	6.4	16.6	6.4	16.2
10	7.3	15.2	7.7	15.0	6.8	17.2	7.0	16.9
20	7.9	15.8	8.2	15.4	7.2	17.6	7.6	17.6
50	8.7	16.5	8.8	16.0	7.7	18.3	8.3	18.5
100	9.3	17.0	9.2	16.4	8.1	18.7	8.9	19.1
200	9.8	17.6	9.7	16.8	8.4	19.2	9.5	19.7
1000	11.2	18.7	10.6	17.6	9.3	20.1	10.8	21.0

Table 3. Extreme wave heights (metres) and periods for a range of return periods and directions of approach.

These projections are based on a Generalised Extreme Value analysis of Met Office wave model data, south of the Lizard peninsula. The wave periods were derived from a process of fitting empirical relationships using equation 1.

3.4 Swell from the northeast

Swell conditions from the middle of the English Channel northeast of Guernsey have previously been studied and reported (Royal Haskoning, 2011). These waves are less severe than westerly swell, but may nevertheless influence the flood risk around the island. The extreme swell conditions from the northeast sectors are reproduced from the earlier study in Table 4.

Sector	**60**		**90**	
RP	H	T	H	T
(years)	(m)	(s)	(m)	(s)
1	0.9	6.4	1.1	6.7
10	1.2	6.9	1.4	7.1
50	1.5	7.3	1.7	7.5
100	1.7	7.4	1.8	7.7
250	1.8	7.7	2.0	7.9

Table 4. Extreme swell conditions from the northeast.

4 EXTREME WATER LEVELS

Clearly the levels that the sea reaches during the highest parts of its tidal cycles are crucial in governing the flood risk that the island is exposed to. For this reason it is important to analyse and understand high water levels around the island. There is a tide gauge at St Peter Port, and so it is natural to focus water level analysis at this location. Because Guernsey is an island, and one with a particularly large tidal range, it is also important to consider how representative the water levels at St Peter Port are of the rest of the coast.

4.1 Water levels at St Peter Port

The general characteristics of the tidal cycle at St Peter Port have been reported by the State Engineer of the Sates of Guernsey. These levels are reproduced in Table 5.

Stage	Level (m)	
	Chart Datum	Local Ordnance Datum
Highest Recorded Tide (1988 to 2010)	*10.7*	*5.64*
Highest Astronomical Tide	10.3	5.24
Mean High Water Springs	9.3	4.24
Mean High Water Neaps	7.0	1.94
Ordnance Datum	5.06	0
Mean Low Water Neaps	3.6	-1.46
Mean Low Water Springs	1.4	-3.46
CD	0	-5.06

Table 5. Characteristic tide levels at St Peter Port (to Chart Datum).

It can be seen that the difference between Chart Datum and local Ordnance Datum is 5.06 metres. This table does not contain information on surge, i.e. the influence of the atmosphere on sea levels. Information on the magnitude of surge was derived from recorded water levels at St Peter Port Harbour.

The record of water levels, which dated from 1988, was obtained from the UK Hydrographic Office. This provided the data for a statistical analysis to estimate extreme conditions. Some years were absent, and others were missing too much data for inclusion. In addition three years were rejected because of the technical difficulties of accessing the data. In total thirteen years of data were useable, as can be seen in Table 6.

Year	Inclusion	Format	Comments
1988	no	Paper	Incomplete
1989	no	Paper	Two months missing
1990	Yes	Paper	
1991	Yes	Paper	
1992	Yes	Paper	Two weeks missing
1993	Yes	Paper	
1994	Yes	Paper	
1995	Yes	Paper	
1996	Yes	Paper	One month missing
1997	Yes	Paper	
1998	No	Paper	
1999	No	No record	
2000	No	No record	
2001	No	Daily spreadsheets	Unusable
2002	No	Daily spreadsheets	Unusable
2003	No	Daily spreadsheets	Unusable
2004	yes	Monthly spreadsheets	
2005	yes	Monthly spreadsheets	
2006	No	Monthly spreadsheets	3 months missing
2007	Yes	Daily ASCII files	
2008	Yes	Daily ASCII files	
2009	Yes	Daily ASCII files	
2010	No	Daily text files	5 months missing

Table 6. Available water level data, recorded at St Peter Port.

The electronic records were first filtered to remove high frequency 'noise' arising from the short sample period used during the data collection. This processing was necessary to prevent anomalous high water level estimates, and essentially converted the record to the form that it would have had if a fifteen minute sample period had been used. The effect of the filtering can be seen in Figure 4.

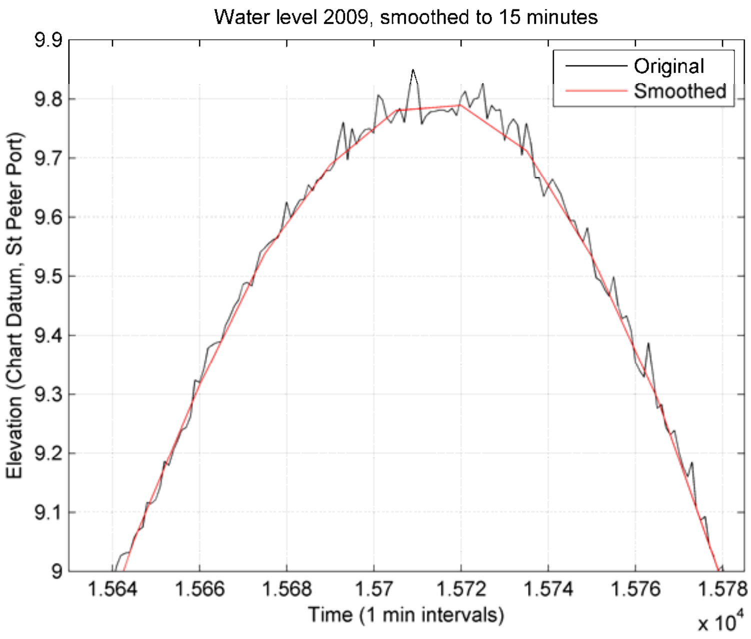

Figure 4. Sample of water level data before and after filtering.

After filtering, the eight highest events were noted for each year, and a set of Generalised Extreme Value distributions were fitted to the resulting set of 104 water levels, as illustrated in Figure 5.

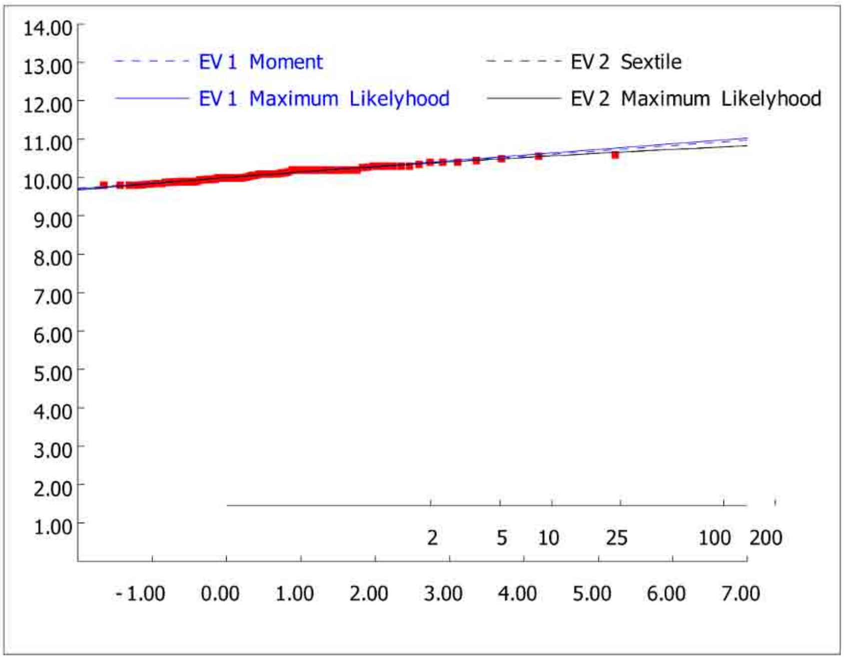

Figure 5. Extreme water levels recorded at St Peter Port (to Chart Datum).

The most reliable match was found with the Extreme Value 1 (Gumbel) Moment method, and so this was adopted for projection of extreme levels.

The resulting extreme water levels are shown in Table 7.

RP	Level	
Years	(m, CD)	(m LOD)
1	10.24	5.18
5	10.51	5.45
10	10.61	5.55
20	10.70	5.64
50	10.83	5.77
100	10.93	5.87
200	11.02	5.96
250	11.05	5.99

Table 7. Estimated extreme water levels at St Peter Port.

4.2 Water levels around the island

To explore spatial variation in water level, it is necessary to understand how tides propagate around and past Guernsey. To this aim, two hydrodynamic model simulations were run at a very large scale, encapsulating tidal progression throughout the English Channel. The domain of the model used for this element of the study is shown in Figure 6.

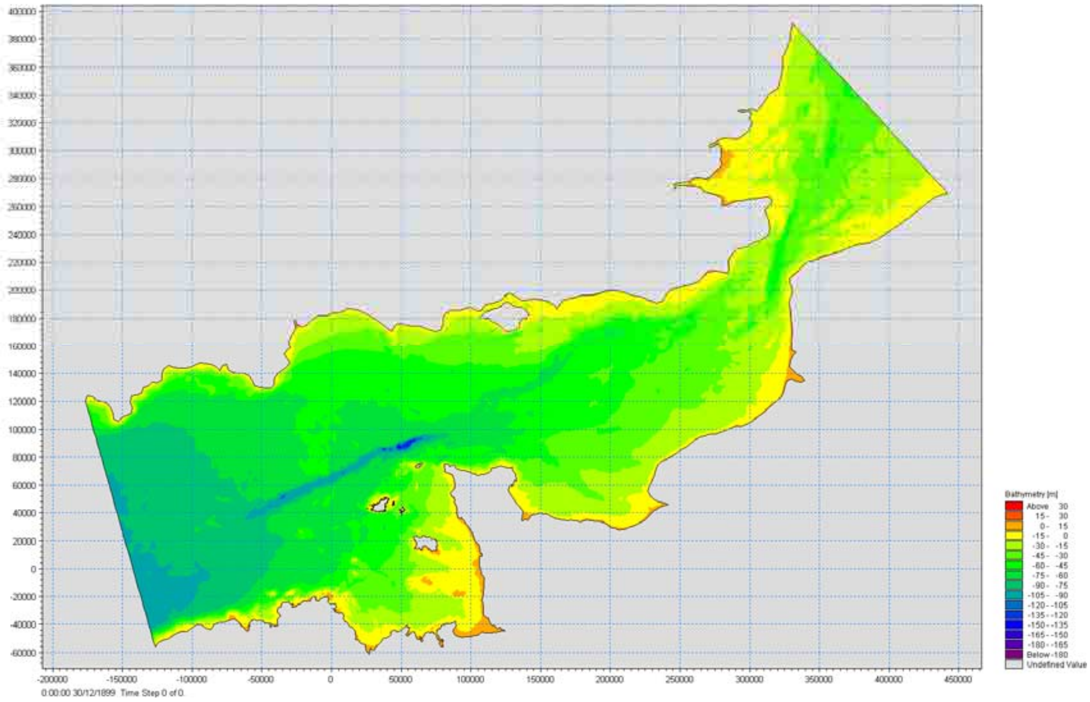

Figure 6. Tide model domain.

The fluctuation of water level through time was 'observed' at 16 locations around the model island, as illustrated in Figure 7.

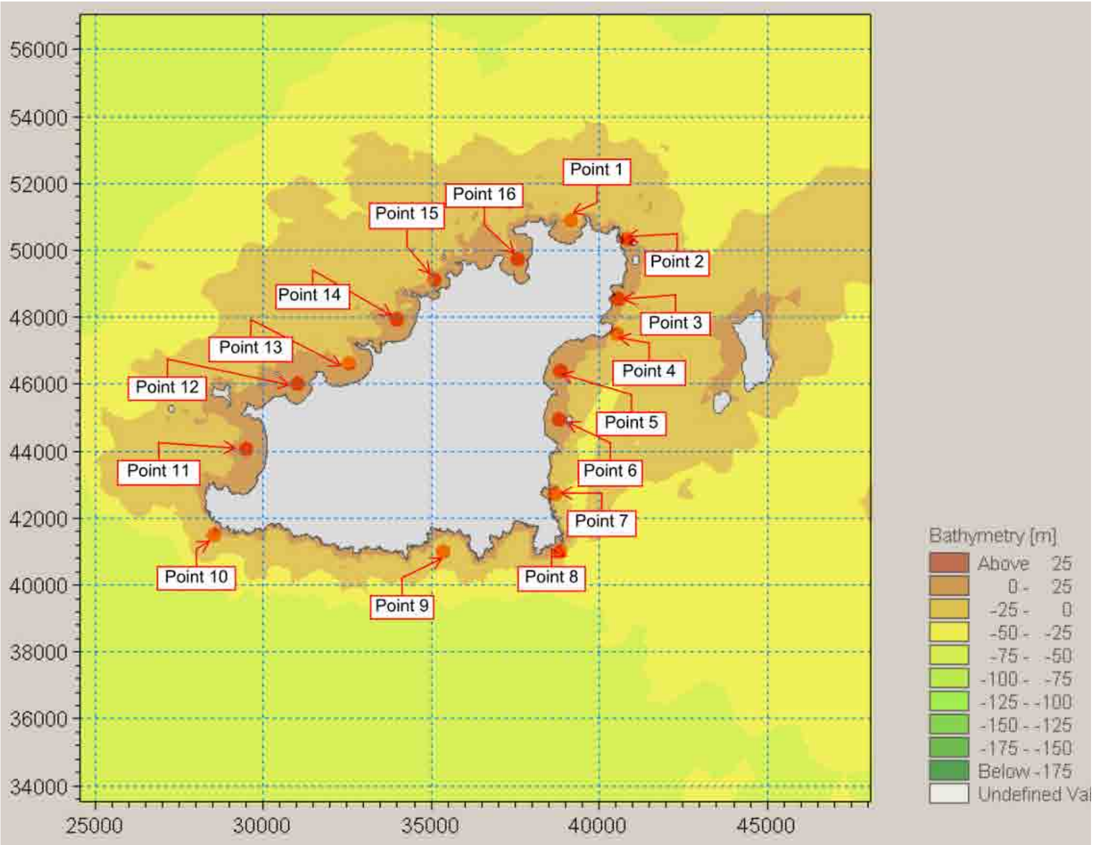

Figure 7. The wave model domain around Guernsey, showing the locations at which water levels were recorded.

The first simulation represented an average spring tide (a MHWS simulation), and this was compared with the astronomical tide at St Peter Port (generated using Admiralty harmonic components). A datum shift of 1.7 metres was introduced to account for differences between chart datum at the model boundary and at Guernsey. It can be seen in Figure 8 that the projected and known MHWS events are very similar in both form and amplitude. This close comparison builds confidence in the ability of the model to simulate water levels and flows around the island.

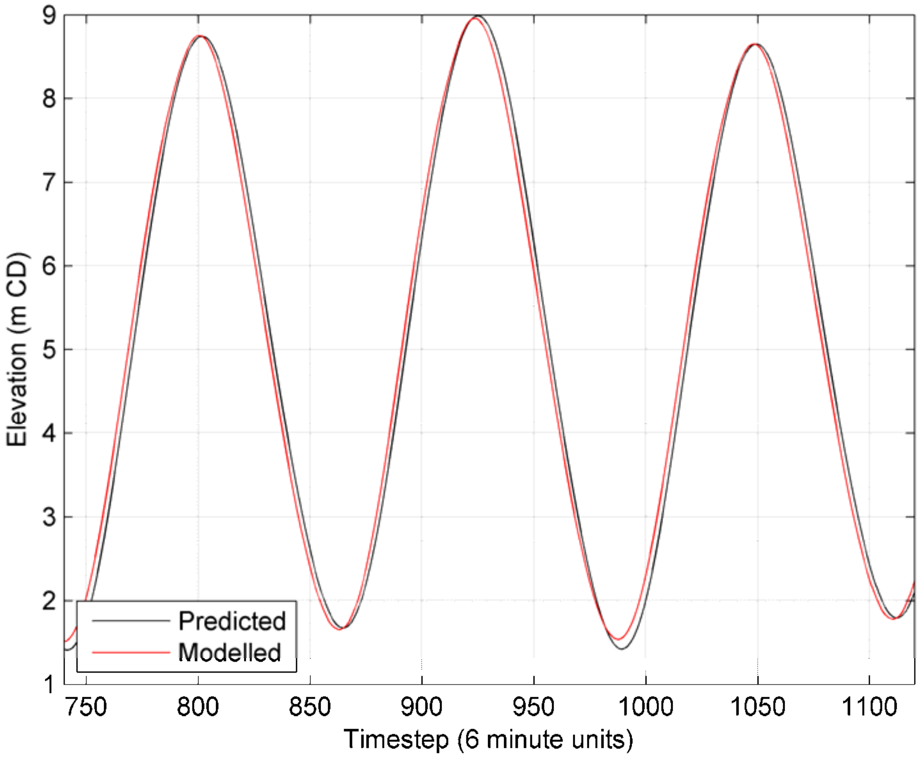

Figure 8. Comparison between a predicted and simulated Mean High Water Spring tide.

The second simulation included an artificial surge superimposed on the astronomical tide, and this is shown, along with the MHWS event, in Figure 9.

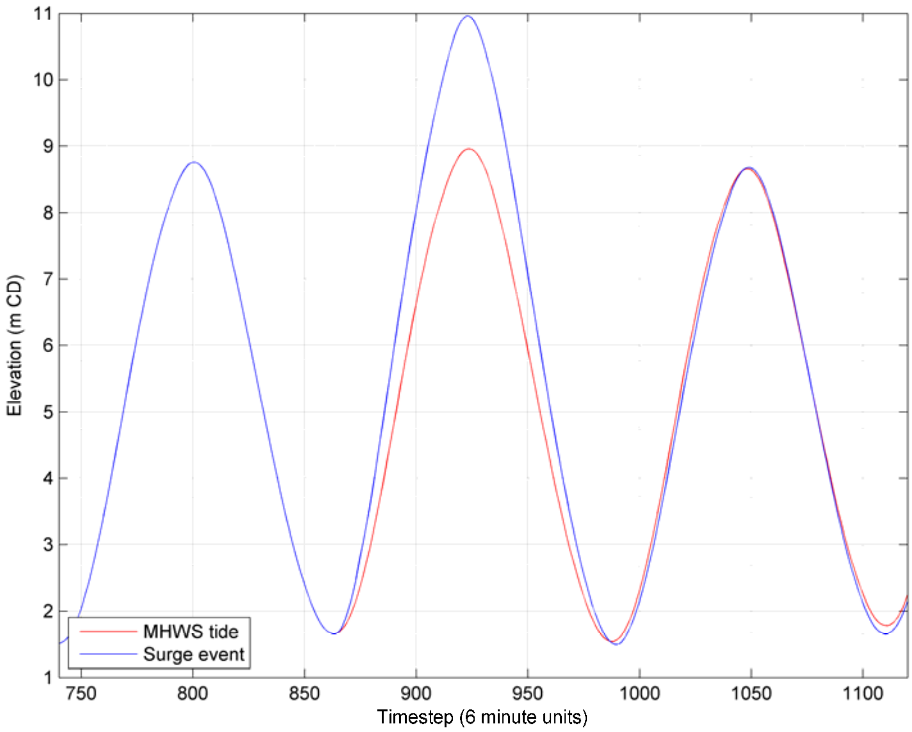

Figure 9. Two simulated tidal events at St Peter Port, corresponding to an average MHWS tide and, approximately, a 1:100 year surge event.

The peak water levels of these two simulations were recorded around the island at the locations shown in Figure 7. High water levels on the western side of the island were found to be lower than at St Peter Port.

The locations where inshore wave conditions were required for overtopping analysis were therefore grouped into three regions (Rocquaine Bay, the northwest, and the northeast). The levels in the northeast region were assumed to be the same as those at St Peter Port. Levels at the other two regions were scaled using the output from the two hydrodynamic simulations represented in Figure 8. The extreme water levels in the northwest sector of the island were found to be 0.49 to 0.5 metres lower than at St Peter Port (for all return periods) and at Rocquaine Bay the difference ranged from 0.22 – 0.23 metres. The differences were rounded to 0.5 and 0.22 metres respectively, which were the values associated with longer return period (i.e. more severe) events.

The resulting marginal extreme water levels projected for the three regions are shown in Table 8.

Return Period	Northeast		Northwest		Rocquaine Bay	
(Years)	m, CD	m, LOD	m, CD	m, LOD	m, CD	m, LOD
1	10.24	5.18	9.74	4.68	10.02	4.96
5	10.51	5.45	10.01	4.95	10.29	5.23
10	10.61	5.55	10.11	5.05	10.39	5.33
20	10.70	5.64	10.20	5.14	10.48	5.42
50	10.83	5.77	10.33	5.27	10.61	5.55
100	10.93	5.87	10.43	5.37	10.71	5.65
200	11.02	5.96	10.52	5.46	10.80	5.74
250	11.05	5.99	10.55	5.49	10.83	5.77

Table 8. Estimated marginal extreme water levels around Guernsey.

5 JOINT PROBABILITY ANALYSIS

A coastal flood risk event normally arises due to a combination of high water levels and large waves. As has been demonstrated in the preceding sections, the probability of occurrence of such events can be represented with return periods (e.g. a wave height that might be expected once in one hundred years). As has been outlined above, it is not appropriate when estimating a 100 year coastal flood event to assume that say, a one hundred year wave will occur with a one hundred year water level. Instead their joint probability of occurrence must be quantified.

5.1 Correlation estimation

This joint probability depends on the degree of correlation between wave activity and raised water levels, which varies from place to place. The degree of correlation around Guernsey has not been studied directly, and there are no suitable records of wave activity close to the island on which such a correlation could be calculated. It was therefore necessary, in this study, to estimate this correlation.

Correlation estimates are available for the regions around Great Britain, and these are expressed as coefficients from 0 (representing independence) to 1 (complete dependence). The actual values range from close to zero in the Dover Straits, to 0.58 in the semi-enclosed region between Stranraer and Arran, off the southwest coast of Scotland. Generally west coast values are higher, due to the prevalence of eastward moving storm tracks over the North Atlantic, which bring both large waves and relatively high surge. The correlation coefficient for the coast of Devon and Dorset (which is geographically closest to Guernsey) is 0.37.

A relatively high (i.e. severe) condition should be expected for Guernsey because it is strongly influenced by North Atlantic storms. In addition the island is situated in a region that is partially enclosed by the north coast of France and the Cherbourg peninsula, where there is a tendency for surge to build. It is therefore appropriate to assume a value larger than that associated with the Dorset coast. Given that the largest value around the coast of Great Britain is 0.58, and that this occurs in a more enclosed region than the one in which Guernsey is situated, it is appropriate to select a lower value for Guernsey. A value of 0.5 was chosen as a conservative yet not extreme estimate.

5.2 Estimation of probability contours

The probabilities of wave and water level condition were combined using the technique described by Hawkes, (2005). This provides contours of probability, essentially lines representing conditions of wave height and water level that have equal probability. An example graph is shown in Figure 10.

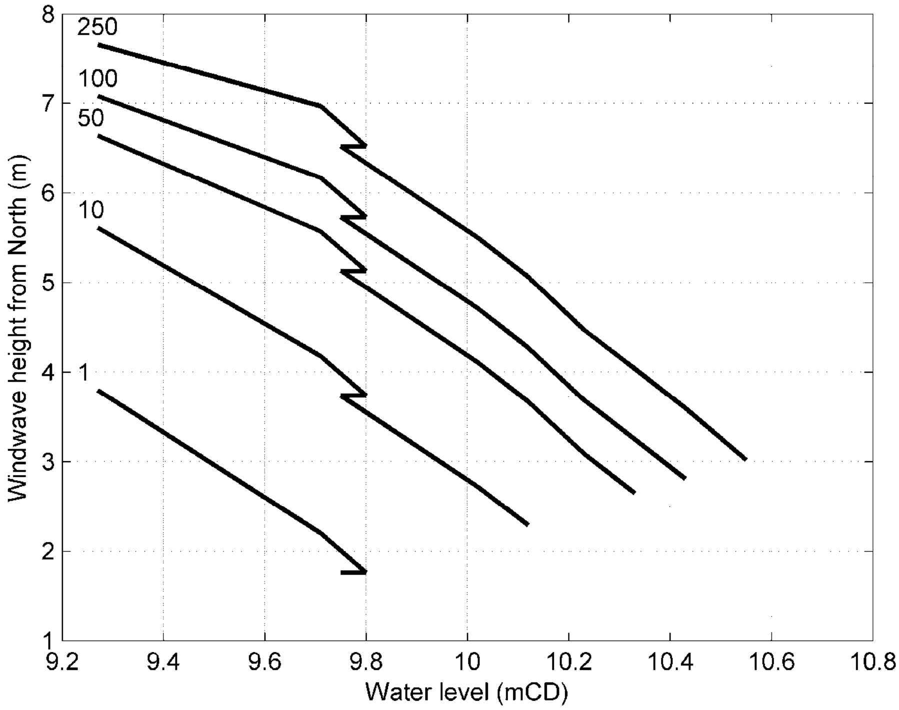

Figure 10. Example illustration of contours of equal probability: windwaves from the North with water level at the northwest region of the island, return periods, in years, are shown against each line.

A large number of these graphs were produced to describe water level, swell, windwave and wind conditions for the different direction sectors.

Such contours describe conditions of equal probability, but not equal severity. Along any individual line the different combinations of wave height and water level will result in different rates of wave overtopping. Due to the limitation on wave height imposed by water depth in the littoral zone, more severe wave overtopping is normally dominated by higher water levels with somewhat lower wave heights. This behaviour can not be guaranteed, however, and so more than one set of conditions is simulated for each return period contour.

In total a set of 233 joint condition combinations were identified and used as input to the wave model to represent present day conditions. Additional simulations were run to represent future conditions, as described below in Section 8.

6 WAVE MODEL CONSTRUCTION

The numerical modelling tool MIKE 21 SW was used to represent the transformation of wave activity from the offshore to the nearshore. It was also used to simulate the generation of waves through wind action on the eastern and southern sides of the island.

MIKE 21 SW is an industry standard package that simulates the growth, decay and transformation of wind-generated waves and swell in offshore and coastal areas. It accounts for the following processes (amongst others):

- Wave growth by action of wind
- Non-linear wave-wave interaction
- Dissipation due to white-capping
- Dissipation due to depth-induced wave breaking
- Refraction and shoaling due to depth variations
- Diffraction

6.1 Model grid

Model construction required data describing the topography of the seabed and intertidal area, also water levels, offshore wave conditions and wind velocities. Bathymetric topographic data were obtained from Cmap, whilst data describing the intertidal area was provided by Digimap.

The topographic data were used to generate a large irregular triangular mesh, for use as a template for the calculations of wave activity and transformation. This mesh extended east and south to the coast of France, around 100 km west of the island and to approximately the middle of the English Channel, as illustrated in Figure 11.

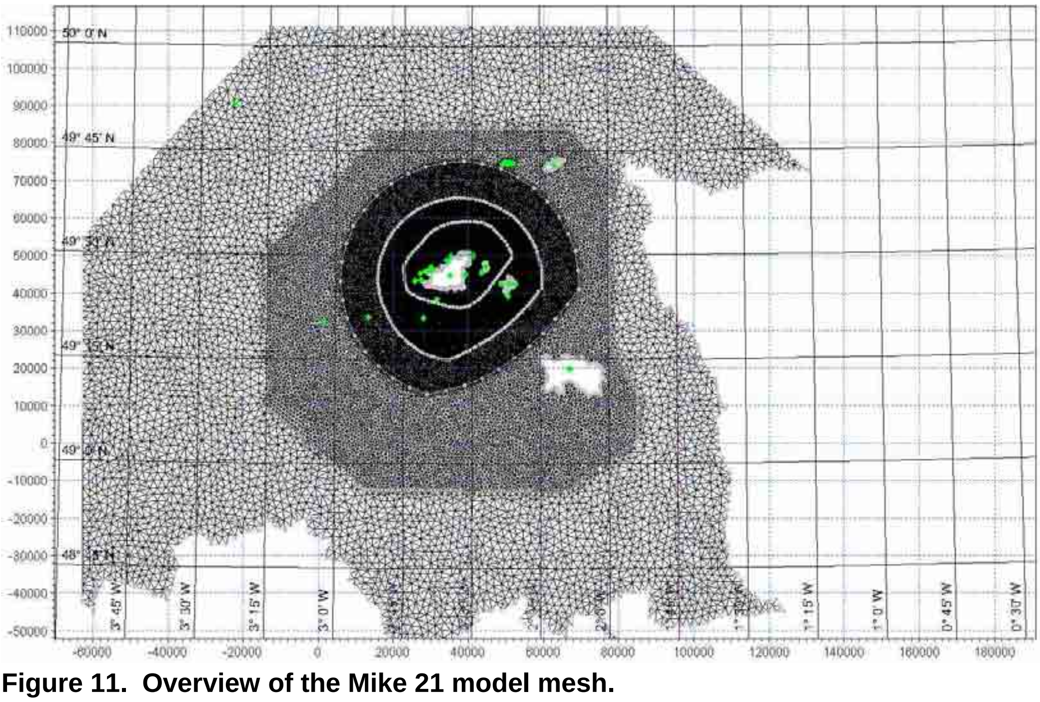

Figure 11. Overview of the Mike 21 model mesh.

The greater the detail of this triangular network the more precise are the calculations, but the greater the processing time needed for each simulation. Precision is most needed close to the island, where bathymetry changes most rapidly, and where features of the shoreline enhance shoaling and refraction effects. For this reason the resolution of the grid was increased with proximity to the island in a series of four steps, as can be seen in Figure 11. The area of highest resolution is reproduced in Figure 12, and an illustration of the level of grid detail is shown in Figure 13.

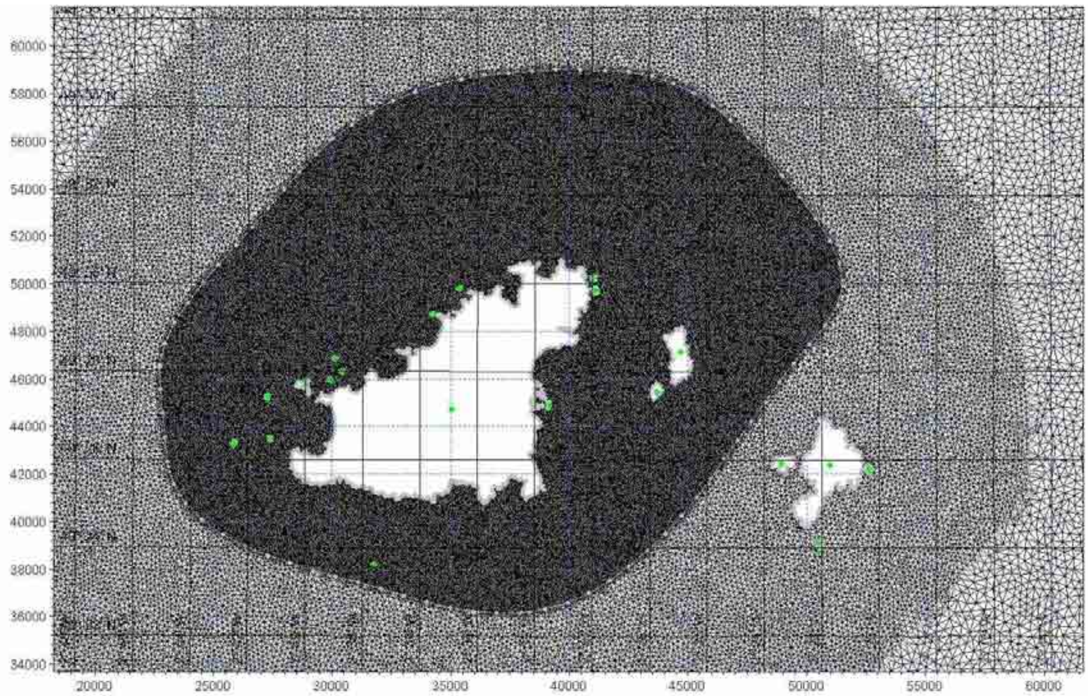

Figure 12. Region of highest resolution in the model mesh.

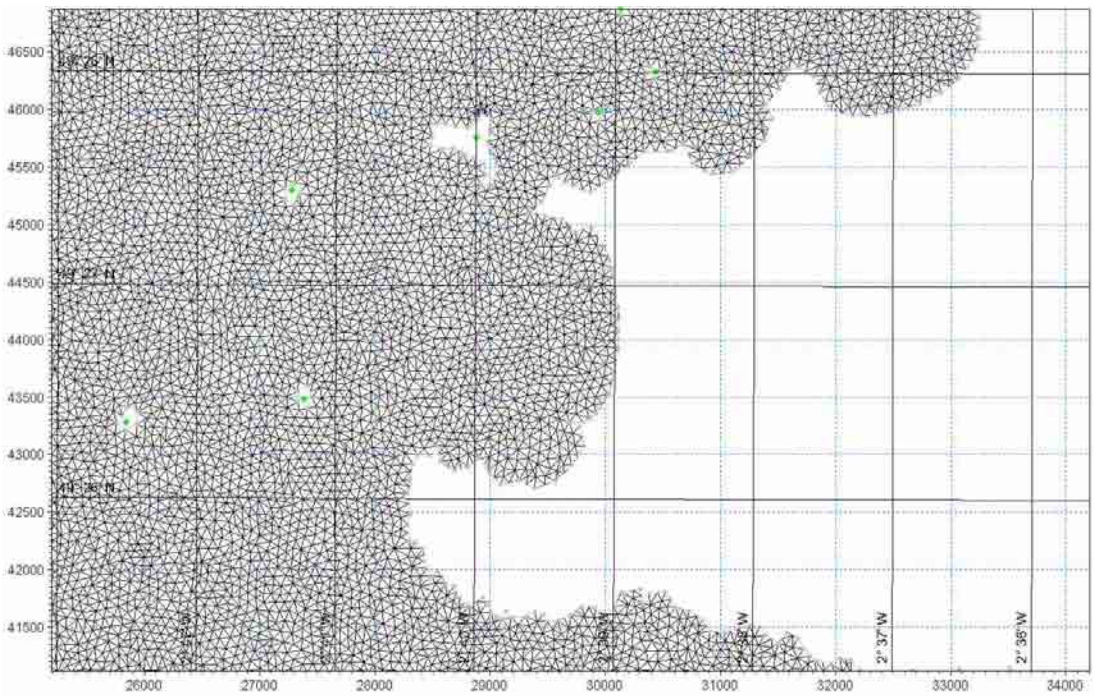

Figure 13. Example mesh detail (Rocquaine Bay).

The model accounts for the seabed level at each node within the grid. These levels are illustrated in Figure 14.

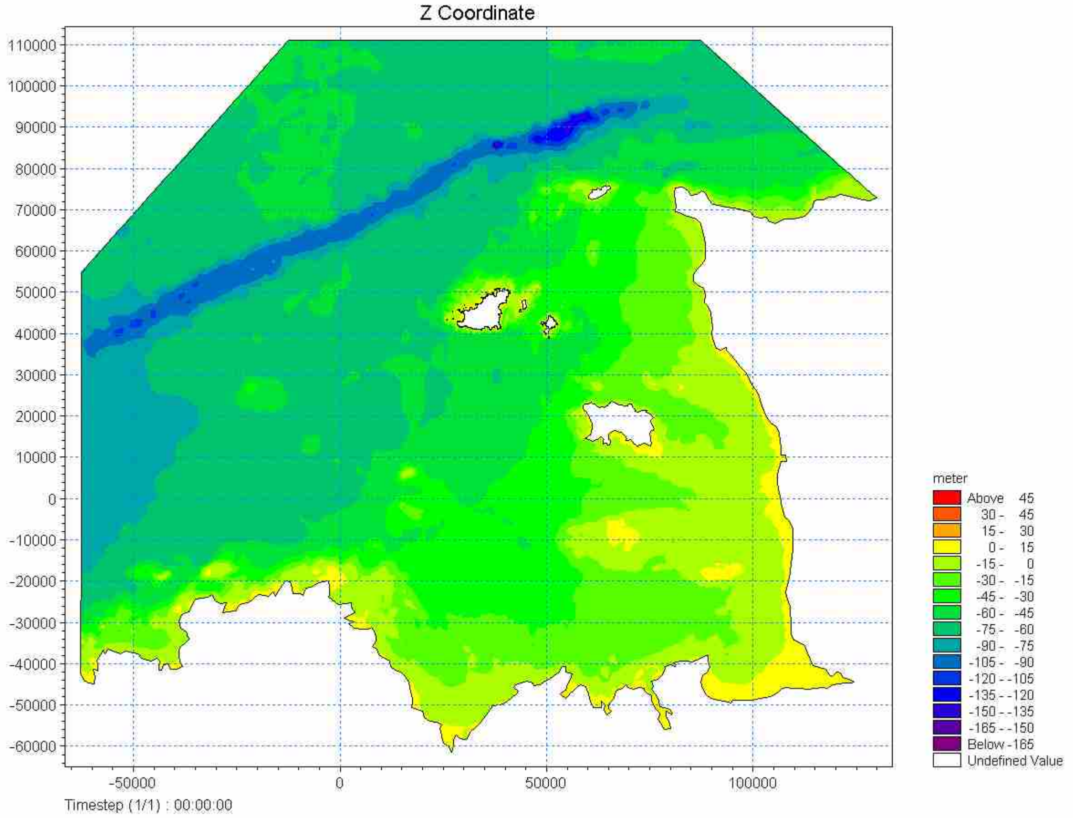

Figure 14. Seabed topography below the model mesh.

6.2 Offshore boundary conditions

The parameters of every simulation included water level, wave height and wave period. Simulations of windwaves also required wind velocities. These conditions were all derived using the joint probability methodology described above.

A large number of simulations were run to identify those that were most severe for the island. These simulations were grouped into three sets (named Rocquaine Bay, Northeast and Northwest) to account for the changes in water level around the island. In each of these areas a range of extreme wave/ water level or wind/ water level conditions were input, and the results were examined to identify the most severe cases.

The 360 degree exposure of the island coupled with the need to repeat simulations for the three different areas of the island led to a total of 233 simulations being required. Figure 15 to Figure 19 show the results of four of these, illustrating wave generation and transformation around Guernsey under different conditions.

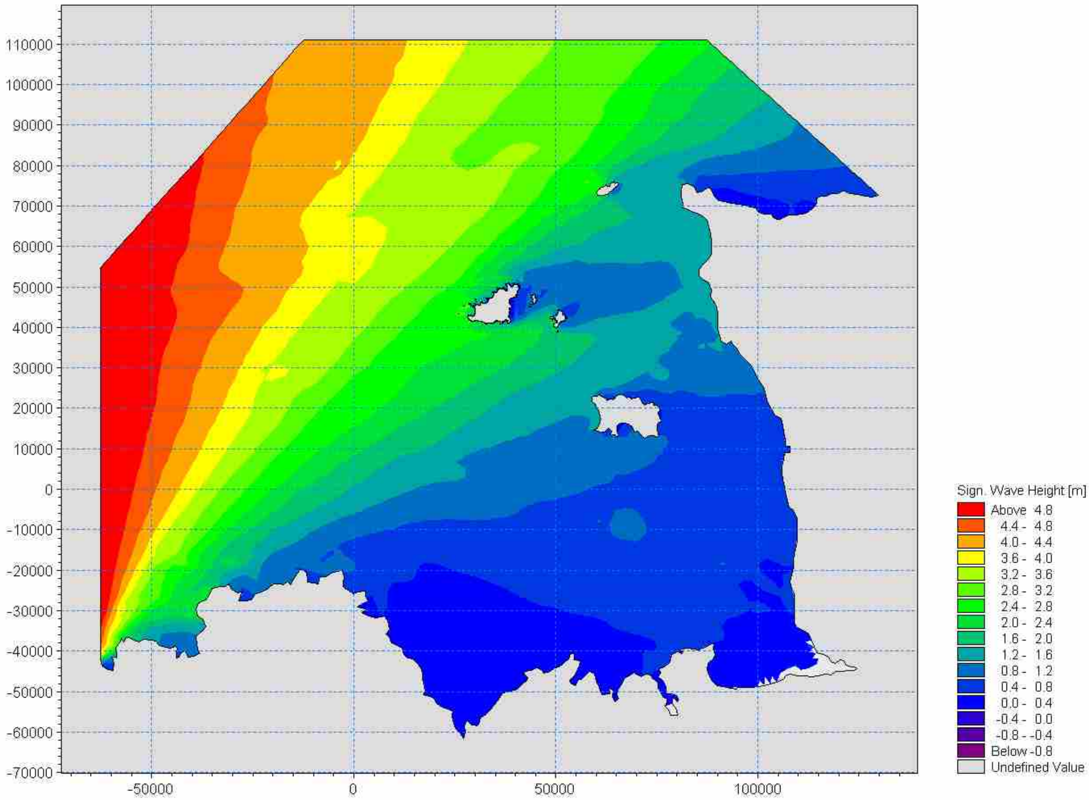

Figure 15. Transformation of 5.4 m high swell waves approaching from 210 degrees.

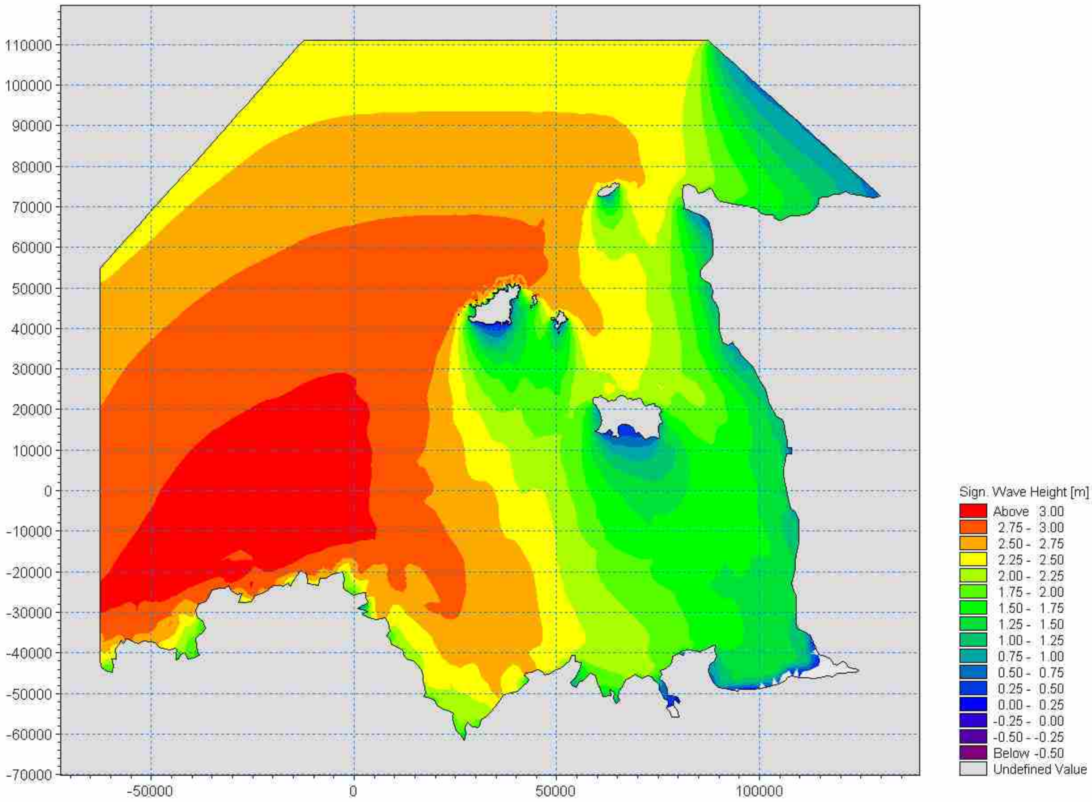

Figure 16. Transformation of a 2.3 m high windwave approaching from the north.

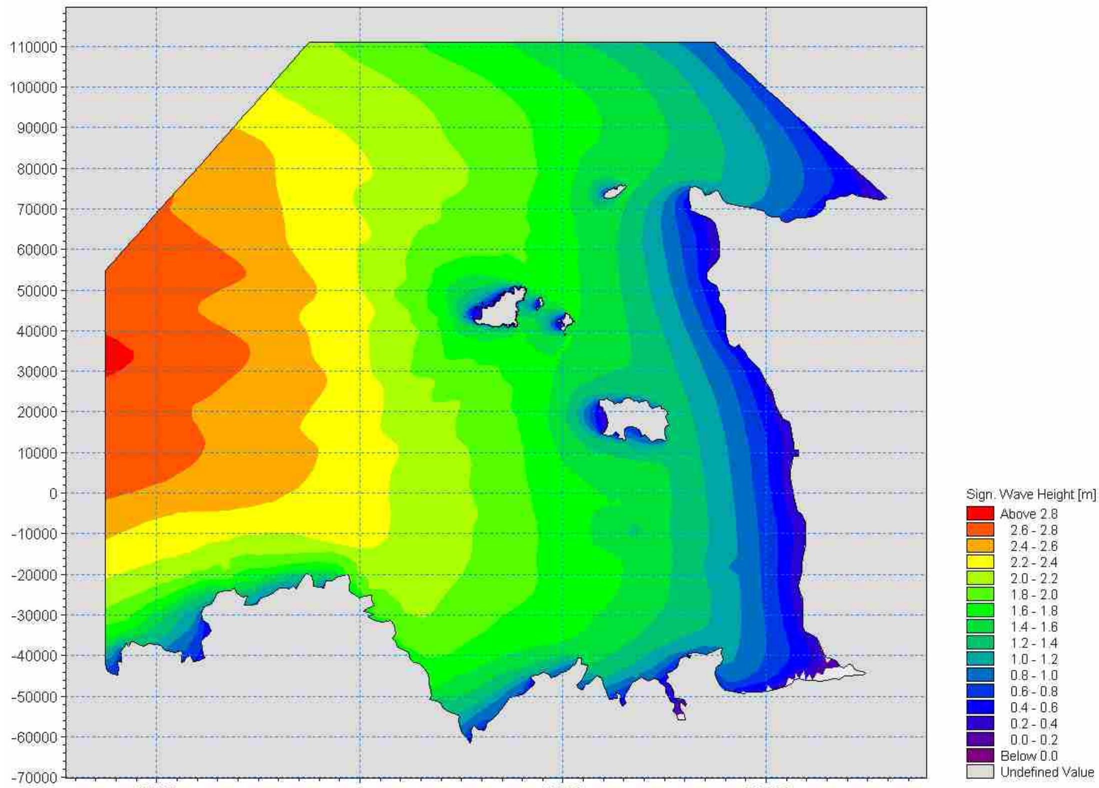

Figure 17. Generation of waves due to a 14m/s wind from the east.

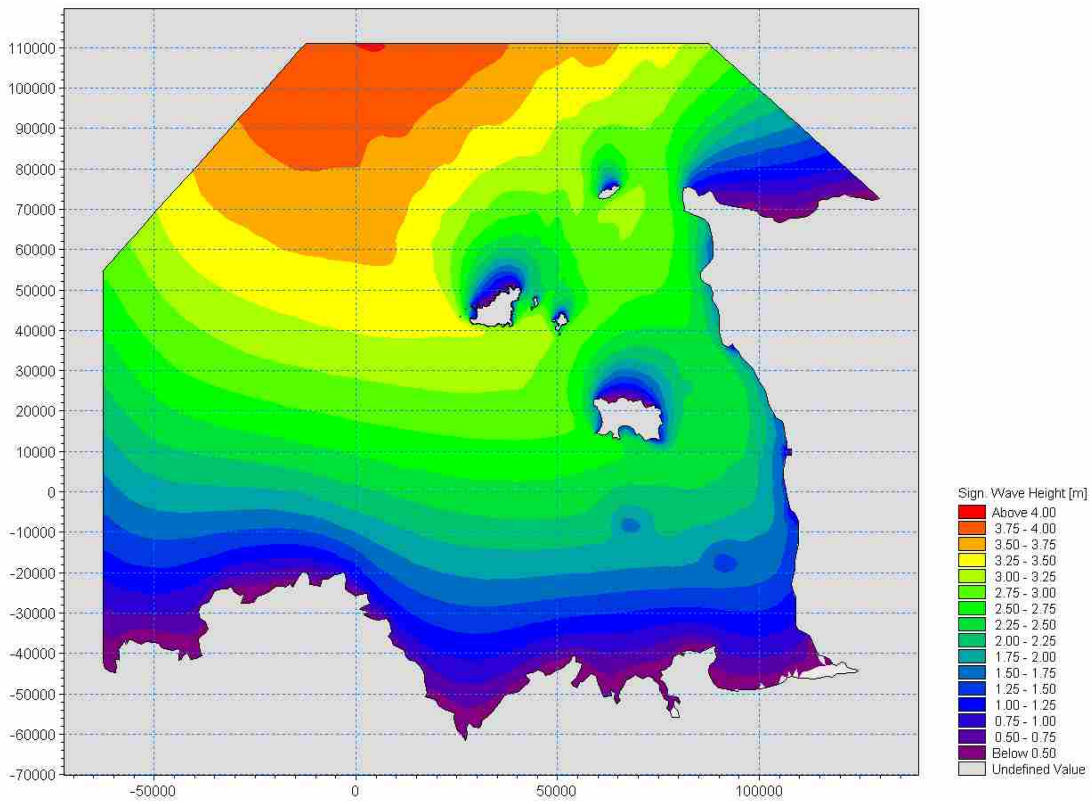

Figure 18. Generation of waves due to a 19.7m/s wind from the south.

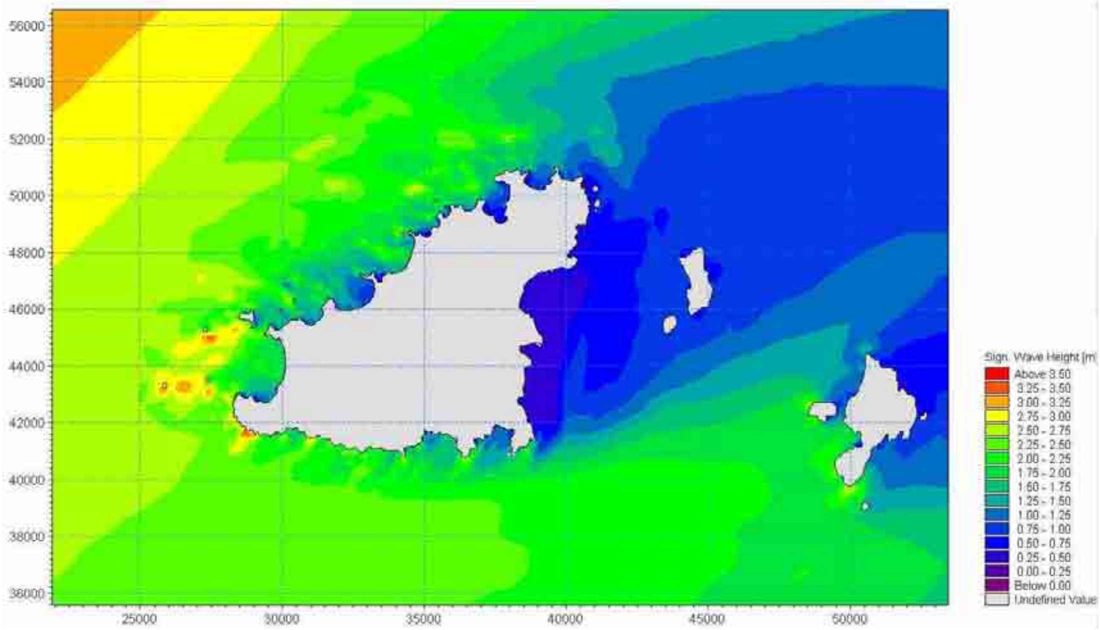

Figure 19. Wave pattern around the island resulting from the transformation of 5.4 m offshore swell waves approaching from 210 degrees.

Data was extracted from each simulation at the 34 locations where overtopping was to be modelled, to create a set of nearly 8000 nearshore wave/ water level conditions. These were examined to identify the most severe cases, which were then used as input to subsequent Amazon simulations, as described in Appendix B.

7 WAVE CLIMATE ANALYSIS

In addition to the simulation of extreme events, a series of wave climates were derived around the island. These employed the same MIKE21 SW model, which was run under a matrix of different wave heights, wave periods, windspeeds and directions. Results were output at a series of 51 points around the island (see Figure 20).

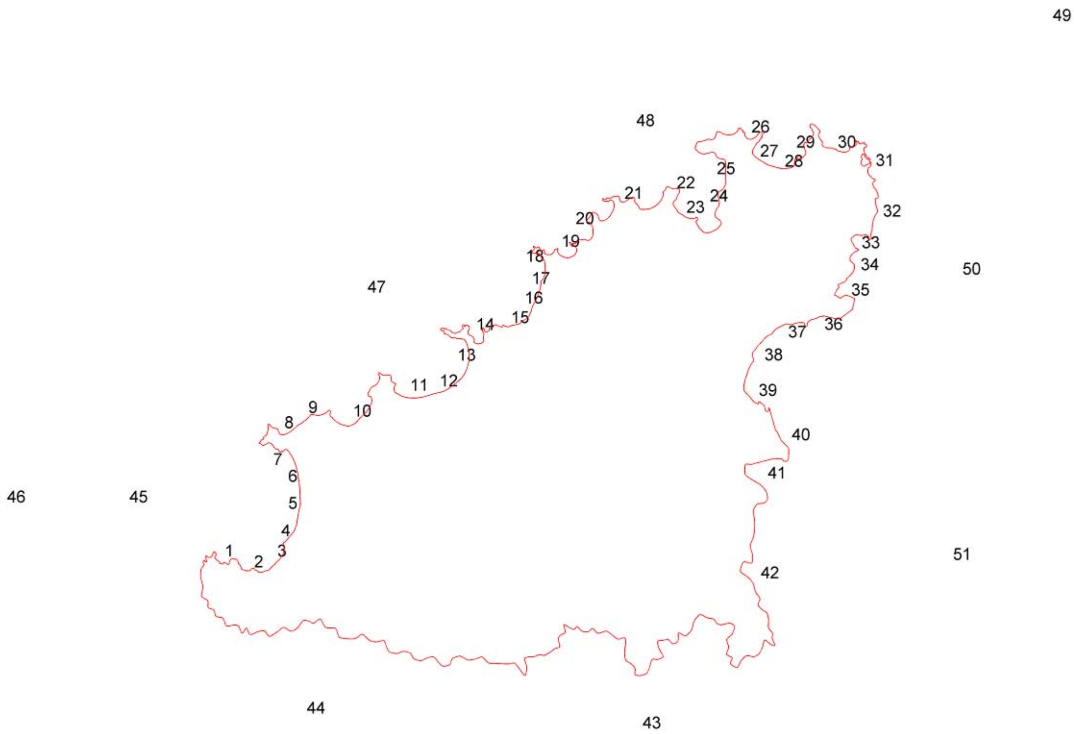

Figure 20. Locations of wave climate estimation.

Each of these results were input to the software package SCATTER, which was used to emulate the wave transformation predicted by the MIKE21 model. Offshore wave frequency data were then coupled to the SCATTER analysis to generate inshore wave frequency tables, which were represented with a set of wave roses. Six of these, representing the general wave climate conditions around the island are shown in the figures below.

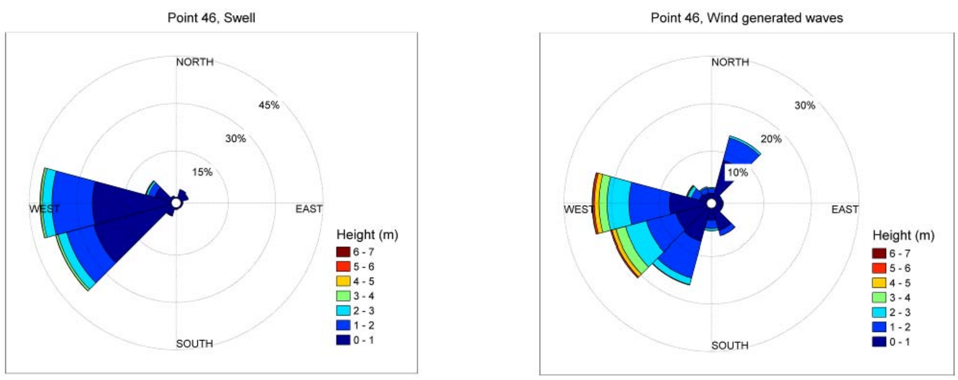

Figure 21. Wave climate at point 46.

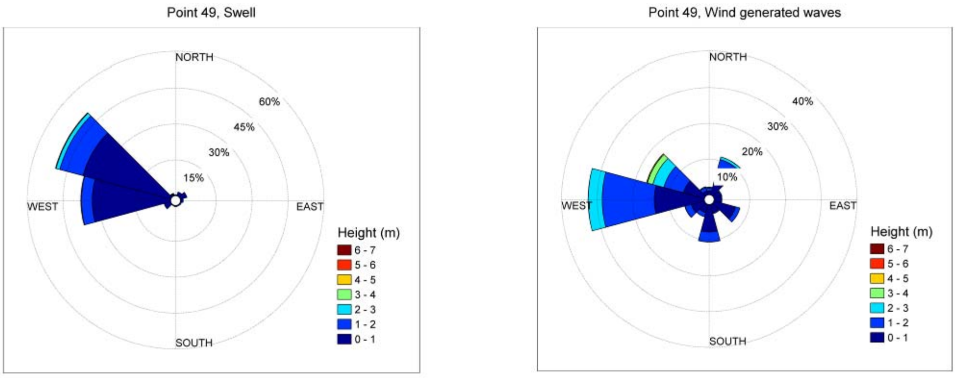

Figure 22. Wave climate at point 49.

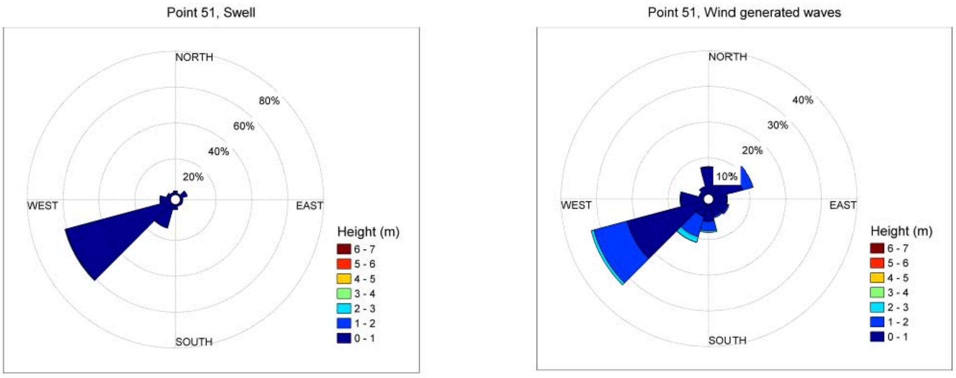

Figure 23. Wave climate at point 51.

These wave roses demonstrate the dominance of westerly and southwesterly conditions around Guernsey. Point 46 shows the most energetic climate, due to its location off the western side of the island. This point also shows the greatest spread of directions, with large waves approaching from the 210 degree sector, to the 270 degree sector. Point 49, which is northeast of the island, demonstrates both a degree of shelter from the southwesterly waves and the effect of diffraction around the northwest of the island, which has increased wave activity from the northwest. At point 51, which is on the eastern side of the island, the predominance of wave from 240 degrees is most marked, due to sheltering here from westerly waves.

8 FUTURE CLIMATE CHANGE

The wave conditions described in the sections above are not expected to persist throughout the next century. Relative sea level levels are increasing at Guernsey, and this is expected to increase due to global warming. In addition surge conditions may respond to global changes, influencing extreme water levels.

8.1 Sea level rise

The magnitude of these changes has been examined by the United Kingdom Climate Impacts Programme (UKCIP). Their most recent projections (named 'UCKP09', see UKCIP, 2009) describe both future sea levels and surge. Importantly, these projections acknowledge the uncertainty that surrounds future conditions. Sea levels are provided under different scenarios of greenhouse gas emissions (Low, Medium and High), and each of these is expressed as a range of possible future conditions. For reasons of conservatism the ‘High’ emissions scenario has been adopted within this study.

Figure 24 shows the UKCP09 ‘High’ projections for Guernsey (represented by the black dashed lines). The projection is represented with two lines, indicating the upper and lower limit of possible change. These couple the global trends with an additional local relative sea level rise of 0.75 mm/year due to isostatic adjustment (tectonic sinking associated with the end of the last ice age).

Despite being published in 2009 the UKCP09 projections begin at 1990, and have therefore diverged by the year 2011; it is not reasonable to adopt them without removing this anomaly. The High emissions curves were therefore processed to pass through zero in the year 2011, and the results are shown n the same figure.

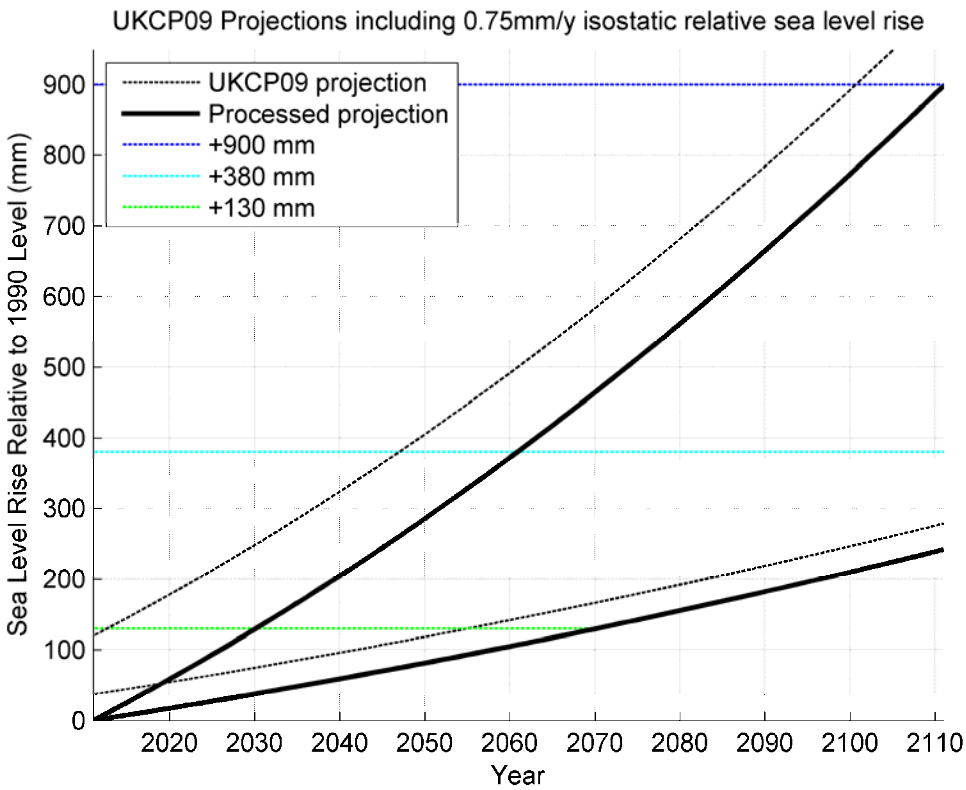

Figure 24. UKCP09 projections of future sea level rise at Guernsey, under the ‘High’ greenhouse gas emissions scenario, indicating the levels that may be achieved in 20, 50 and 100 years time.

It can be seen that after around 20 years the sea may have risen by around 130 mm above 2011 levels. Conversely this level may not be reached until around 2070. Similarly a rise of 380 mm may occur as soon as 2060, but may also not have occurred after 100 years. By 2111 sea levels may have risen by around 900 mm.

8.2 Surge increase

UKCP09 provides the most authoritative information on future surge increase for the coast of Great Britain, but the spatial extent of the reported projections does not include the Channel Islands. Surge conditions at Guernsey are clearly related to those at the south coast of England, and along the coast of Devon, Dorset and Hampshire the surge growth rate was found to be 0.7 mm/y. This level was adopted for Guernsey as being reasonably but not excessively conservative. This rate may be considered in the context that the maximum trend predicted around the whole of Great Britain was 0.9 mm/year.

This surge growth was coupled to the sea level rise described above to derive conditions in, nominally, 2031, 2060 and 2110. The predicted (marginal) levels at St Peter Port are recorded in Table 9.

Return Period	2011	2031	2060	2110
(Years)	(m CD)	(m CD)	(m CD)	(m CD)
1	10.24	10.38	10.65	11.21
10	10.61	10.75	11.02	11.58
50	10.83	10.97	11.24	11.80
100	10.93	11.07	11.34	11.90
250	11.05	11.19	11.46	12.02

Table 9. Future marginal extreme water levels at St Peter Port.

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Hawkes, P. (2005) Use of Joint Probability Methods in Flood Management: A guide to best practice Defra/ EA R&D Technical Report FD2308/TR2. March.

Royal Haskoning, (2008). RNLI The Lizard Numerical Modelling Report.

Royal Haskoning. (2011). Pagham Harbour Updated Conceptual Model.

Appendix B - AMAZON Overtopping Modelling

States of Guernsey

December 2011

Final Report

9W2890

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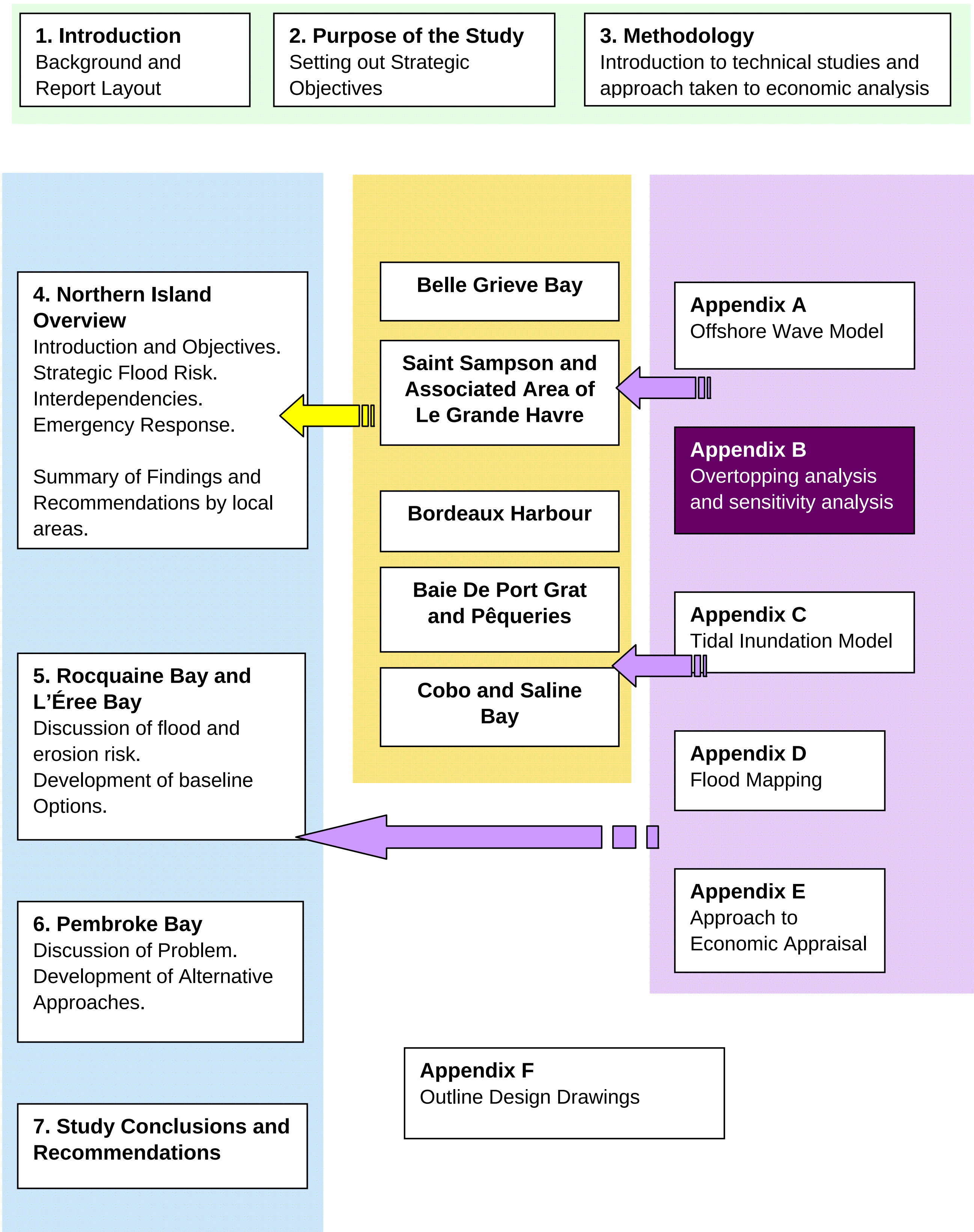
Date/initials approval	………………….	………………….

REPORT STRUCTURE



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1 INTRODUCTION

Following on from the modelling undertaken using MIKE21 to determine extreme wave and tide conditions around Guernsey and to feed into the TUFLOW inundation modelling it was necessary to transform waves from a nearshore position to give wave overtopping rates at each defence. The tool selected for this job was AMAZON, Royal Haskoning's in-house software for calculating overtopping rates at sea defences from a combination of high tides and waves.

AMAZON is one-dimensional modelling software for simulating wave overtopping of coastal structures. The engine behind it is a high-resolution two-dimensional finite volume numerical engine capable of simulating supercritical flow and capturing a moving hydraulic jump, which is based on solving the non-linear shallow water equations. It has been tested for non-breaking wave runup on a slope and a bore wave crossing a vertical step. The results compare very well with known exact solutions. It has also been tested for wave overtopping calculations on simple sloping, bermed sloping and vertical seawalls. Very good agreement has been achieved between the numerical predictions and relevant theoretical results and experimental data.

2 SURVEY AND PROFILE SET-UP

2.1 Coastal Units

During the course of previous strategy work the coastal areas of Guernsey were divided into Coastal Units (CUs), and further sub-divided into Defence Units (DUs). The defence units at risk from wave overtopping and tidal inundation were identified during the course of the Strategy and the focus of the wave and flood modelling for this study has been on these areas.

The Coastal Units are:

- CU3 – Rocquaine Bay
- CU10 – Cobo Bay
- CU11 – Por Soif, Baie de Port Grat
- CU12 – Le Grande Havre
- CU17 – Bordeaux Harbour
- CU18 – St Samson
- CU19 – Belle Greve Bay

These coastal units are referred to henceforth by their number.

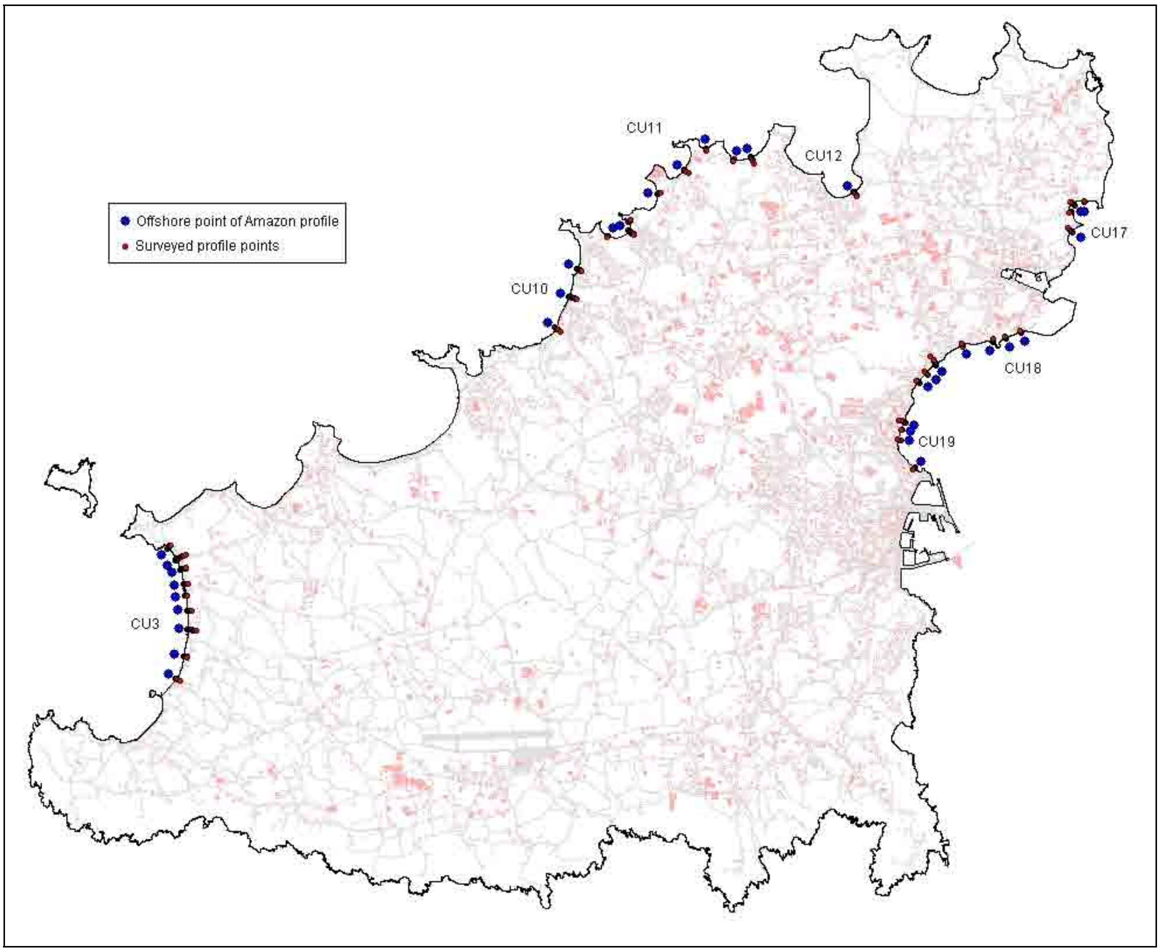


Figure 1 – Profile survey locations

2.2 Survey

Representative topographic survey was gathered (where possible) for each of the distinct DUs within the CUs that were identified. This survey gathered the features of each type of defence including crest height and land height behind and in front of the defence as well as gradients which allowed the development of profiles to feed into the AMAZON model.

2.3 Profiles

The survey data was reviewed and the data input to AMAZON to define the profiles for the runs. A point 100 metres offshore was chosen for the offshore extent of the AMAZON profiles. The elevation of the sea bed was taken at this point from bathymetry and beach survey data and this point was added to the existing survey data.

36 profiles were surveyed and set up in AMAZON.

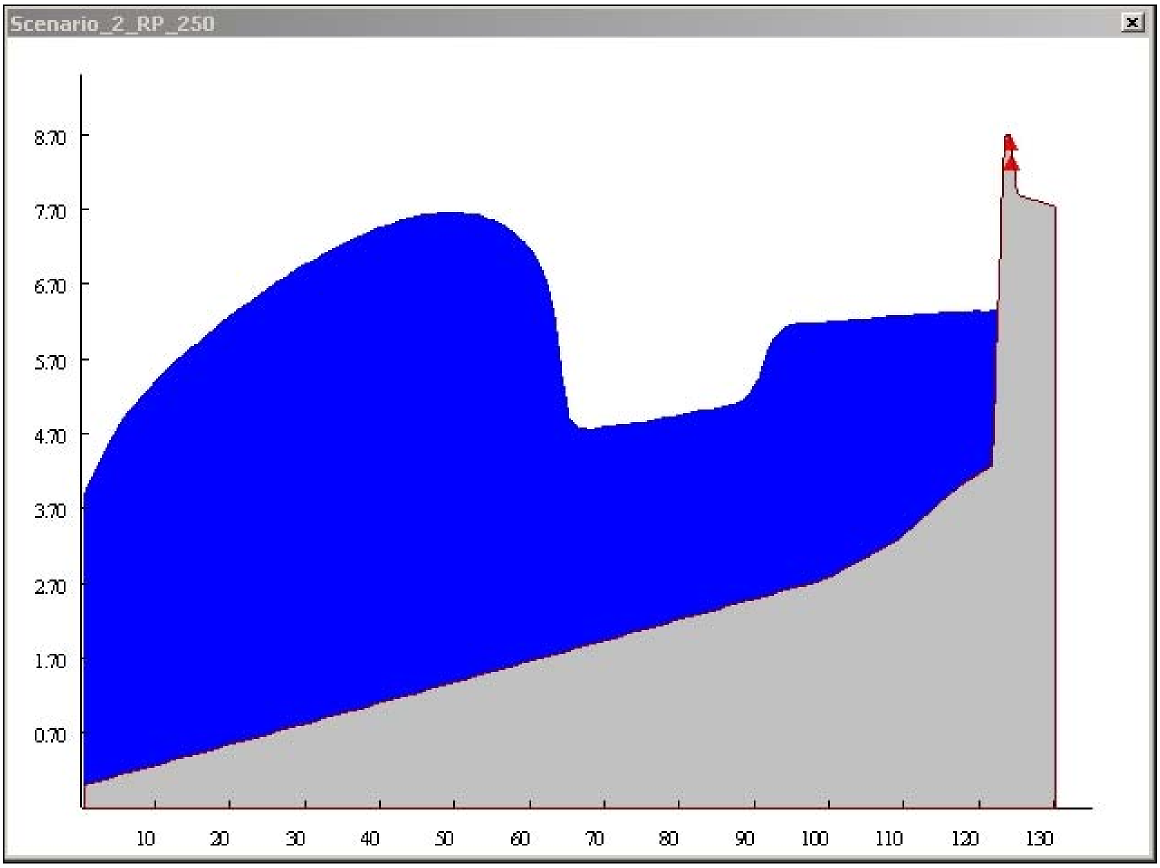


Figure 2 – Example AMAZON profile (during run)

2.4 Discretisation

AMAZON requires that a variable resolution be used to allow the program to resolve the waves through different parts of the profile. It is recommended that regions of fine resolution are present over and adjacent to the sea wall structure, with a smooth increase as the profile moves away. In the case of this study a value of 0.1m has been used for the fine resolution over the structure with values increasing to 0.25m, 0.5m and 1m.

In some instances AMAZON does not deal well with vertical walls, or near-vertical slopes. In these cases the profile has been slightly amended to give a slightly lesser gradient to allow the model to run satisfactorily.

3 INPUT CONDITIONS

Three different parameters are required for input into AMAZON models aside from the topographic data for the profiles. These parameters are:

- Significant wave height, Hs
- Wave Period, Tp
- Water Level

The parameters for input to the AMAZON models have been produced from the MIKE21 Spectral Wave modelling and from modelling of tide levels around the island. There are a number of conditions that have been modelled to give the required information to inform the economic assessment. The different aspects of these conditions are explained in the following sections.

3.1 Epochs

To give an understanding of how risk will change over time due to climate change, four different epochs have been modelled; Present day and in 20, 50 and 100 years time.

3.2 Scenarios

As the study area is an island it was understood (and shown through modelling) that wave and water level conditions vary around the island and that waves from different directions will provide a worst case for different sites. With this in mind the wave overtopping conditions were determined for three different scenarios providing a worst case for CU3, a worst case for CU10, 11 and 12 and a worst case for CU17,18 and 19.

- Scenario 1 – Waves from 240 degrees (southwest)
- Scenario 2 – Waves from 270 degrees (west)
- Scenario 3 – Waves from 180 degrees (south, locally generated waves)

In addition, one further scenario (Scenario 2a) was developed, looking at higher period waves (extreme swell conditions). This formed part of the sensitivity testing undertaken.

3.3 Return Periods

For each of the Epochs and for each of the Scenarios, five different annual event probability (or Return Period) events have been assessed. This is standard practice for a study of this type. The Return Periods selected are the 1 in 1, 10, 50, 100 and 250 year events (or 100%, 10%, 2%, 1% and 0.4% AEP)

Each of the above conditions has been modelled at each profile giving the following:

Profiles	x	Epochs	x	Scenarios	x	Return Periods	=	Total Runs
36	x	4	x	3	x	5	=	2160

Where possible this number has been reduced based on similar tide levels and input conditions for different return periods and epochs.

3.4 Tide Levels

The extreme tide levels corresponding to each location, return period and epoch are displayed in Table 1 below.

Table 1 - Tide Inputs m LOD

	Epoch 0 Return Period					Epoch 20 Return Period				
Location	1	10	50	100	250	1	10	50	100	250
CU3	5.00	5.32	5.54	5.65	5.77	5.14	5.46	5.68	5.79	5.91
CU10, CU11, CU12	4.72	5.04	5.26	5.37	5.49	4.86	5.18	5.40	5.51	5.63
CU17, CU18, CU19	5.22	5.56	5.77	5.87	5.99	5.36	5.68	5.90	6.01	6.13

	Epoch 50 Return Period					Epoch 100 Return Period				
Location	1	10	50	100	250	1	10	50	100	250
CU3	5.42	5.75	5.96	6.07	6.19	5.97	6.29	6.51	6.62	6.74
CU10, CU11, CU12	5.14	5.46	5.68	5.79	5.91	5.69	6.01	6.23	6.34	6.46
CU17, CU18, CU19	5.64	5.96	6.18	6.29	6.41	6.19	6.51	6.73	6.84	6.96

Where the extreme tide level was above the defence crest a portion of the tide curve either side of the peak was used to represent flooding from the tide in the TUFLOW model. This meant that AMAZON models for these situations were not required.

3.5 Wave Inputs

Wave input conditions have been taken directly from outputs from the MIKE21 modelling at the points defined as the seaward end of each AMAZON profile. These input conditions, consisting of wave height and period with the tide levels from Table 1 were recorded in the model setup log.

4 OUTPUTS

The outputs from the overtopping modelling were in the form of an average overtopping rate for each of the runs. The overtopping rate was given as a unit rate in metres cubed per second per metre ($m^3/s/m$). To determine the overtopping for each length of each Defence Unit the overtopping unit rate was multiplied by the defence length (in metres) to give a rate for each run in metres cubed per second (m^3/s). This rate is what has been carried forward to the TUFLOW flood model.

Following the AMAZON model runs for the present day situation it became clear that the runs for Scenarios 2 and 3 gave the worst case overtopping runs at each of the profiles. As this is the case only these runs were carried out for the future epochs and only these results have been carried forward to the TUFLOW modelling.

5 SENSITIVITY

In any location, the actual overtopping that occurs can be quite sensitive to specific local conditions. In addition, it has been recognised that the theoretical overtopping calculations are based on extrapolation of a range of different input parameters. The interrelationship between these parameters is shown schematically in Figure 3 and discussed below.

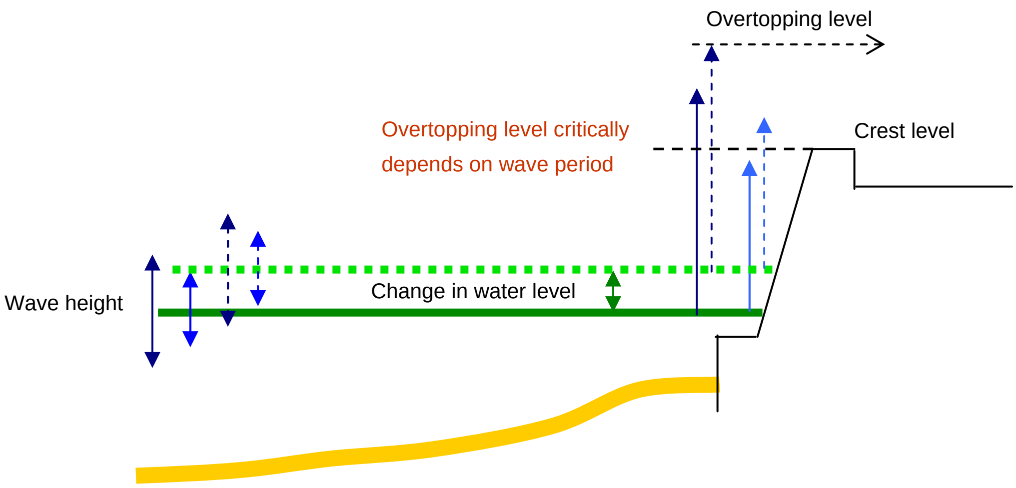


Figure 3 – Key sensitivities in determining overtopping rates.

Water Level.

Quite clearly, overtopping rates are critically dependent on water level, most obviously where water levels exceed the crest level of a defence and overtopping changes from regular wave overtopping to the situation where water weirs over the defence. However, change in water level also critically determines the degree to which waves overtop any defence; increased water levels allow larger waves to impact on a wall and, for any given wave height, an increase in water level increases directly the risk of overtopping.

Figure 4 shows the extreme water levels curve for St Peter Port.

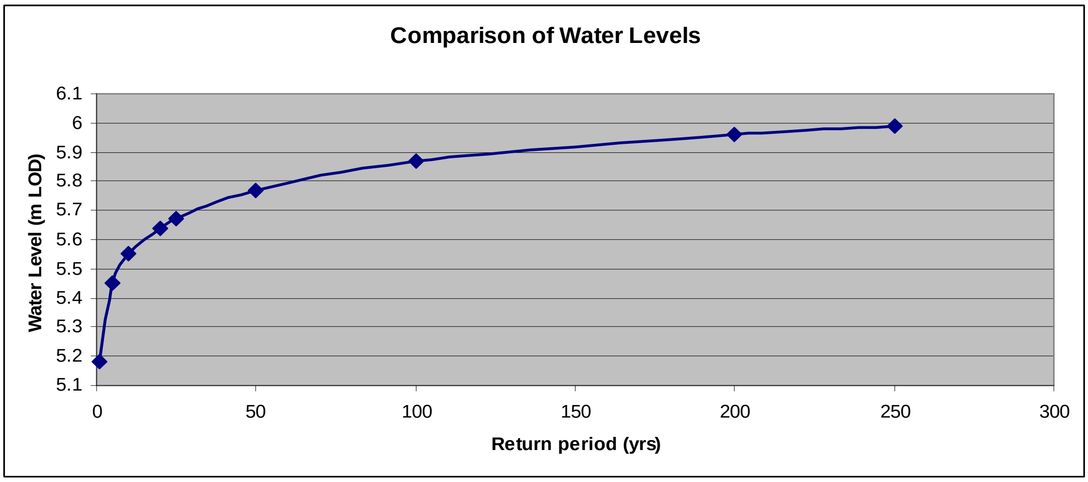


Figure 4. Extreme Water levels

Extreme water level values have been determined (Appendix A) based on data from 13 years over a period of 20 years. The highest value recorded was in 1992 (5.64m LOD) with the second highest record being March 2008 (5.52m LOD); corresponding to a 1: 20 year and 1: 10 year event, respectively. Higher frequency occurrence (i.e over the 1:1 year to 1:20 year period) may be particularly sensitive to the length of data available, with individual records significantly affecting values determined. This may have a significant affect on overtopping rates with the difference in level between 1:1 year and 1:20 year being around 0.5m. Although the classification of a more extreme event (1:100 years to 1:250 years) is sensitive in terms of levels actually recorded (the difference between these two events being only of the order of 0.1m difference in level), the difference in overtopping rates is far more sensitive to wave conditions.

Wave Height

There is significant difference in wave heights determined at locations around the island depending on different wave directions. This is clearly a function of the shape of the coastline, with respect to the shelter provided by headlands and rock outcrops.

As a rule of thumb, as indicated in Figure 3, wave run-up approximates to twice the wave height above still water level. For a difference of 0.5m in wave height, this equates to an increased potential for overtopping of potentially 1m.

Different scenarios of critical wave direction have been assessed, in combination with different water levels (joint probability). A typical variation of wave height with return period is shown in Figure 5.

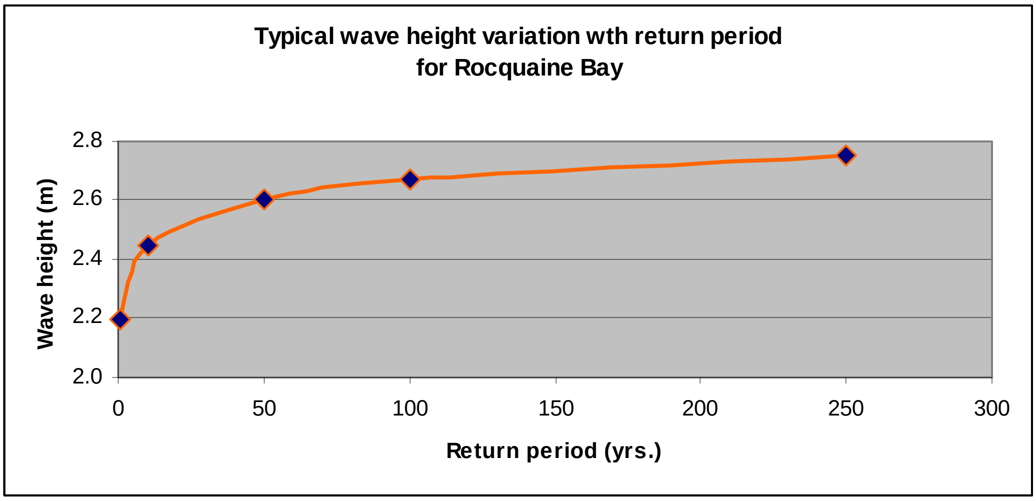


Figure 5. Variation in wave height with return period.

In a similar manner to water levels, higher frequency events are sensitive to the analysis process and the availability of data. There may be variation of 0.3m in wave height between a 1:1 year event and a 1:10 year event, giving rise to significant sensitivity as to the onset of overtopping.

Wave Period

Overtopping rates are very sensitive to wave period. Wave period, in effect, determines wave length and as a consequence reflects the potential volume and time over which water may overtop a defence. In addition, when considering long period waves, the behaviour of the wave at the shoreline tends to change, increasing the ability of a wave to pile-up against a sea wall.

The Guernsey coastline is susceptible to long swell waves approaching from the Channel, particularly on the west coast. Swell waves, with wave periods in excess of 17 seconds are not uncommon, compared to more typical storm wave periods of 12 to 13 seconds. Such conditions would significantly increase wave overtopping.

Each of the factors has to be taken into account in assessing potential overtopping and flood risk. Overall, there is recognised to be a higher sensitivity in assessing higher frequency events (1:1 year to 1:20 year) than in the likely impact from low frequency events. This has to be taken into account in considering the potential for flooding on higher frequency events. It is difficult to attribute a specific range, or uncertainty, associated with this sensitivity at the higher frequency. In using this analysis described in this Appendix this degree of uncertainty has to be assessed on a site by site basis and this is discussed in relation to specific results and anecdotal information in the following sub-sections.

5.1 Belle Greve Bay

The overtopping analysis for two defence units (CU19: DU4 and DU8) within the Bay are discussed below, with plots highlighting the different wave scenarios developed as part of the analysis. The position of defence units are shown in Figure 6.

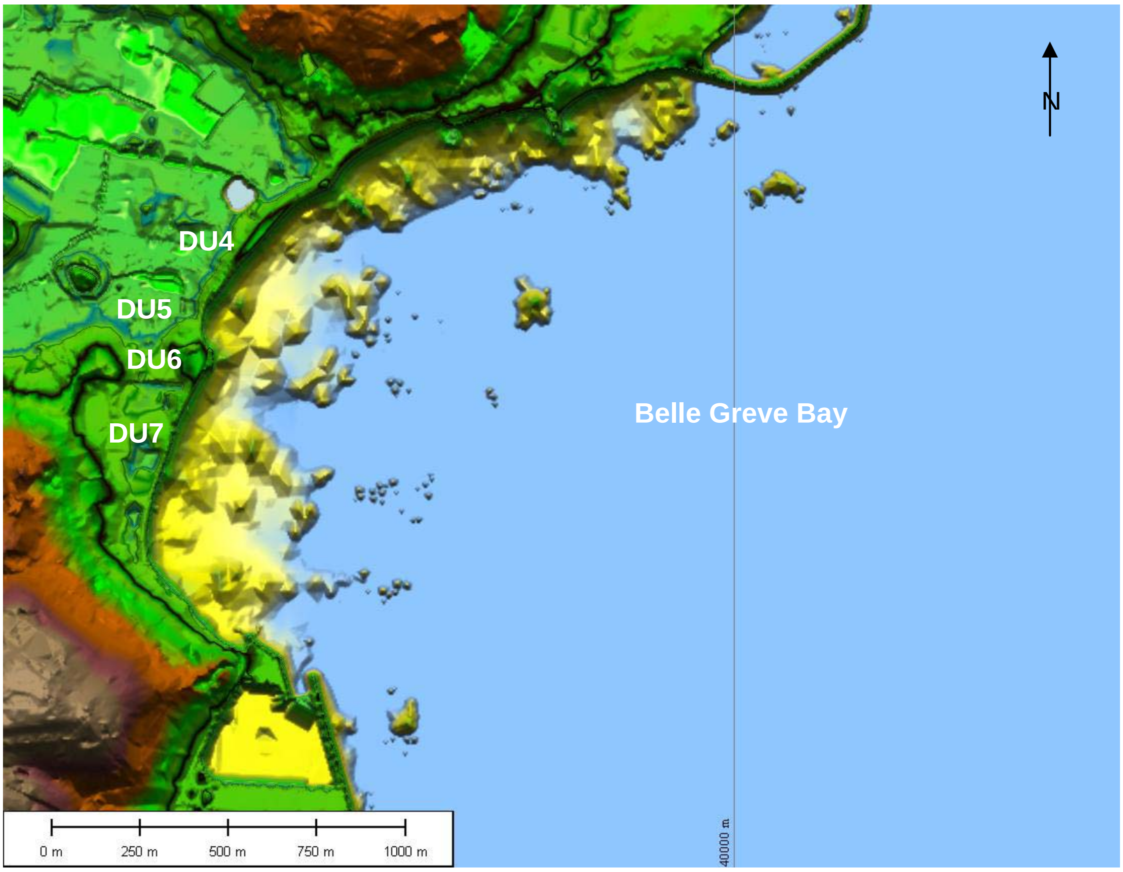
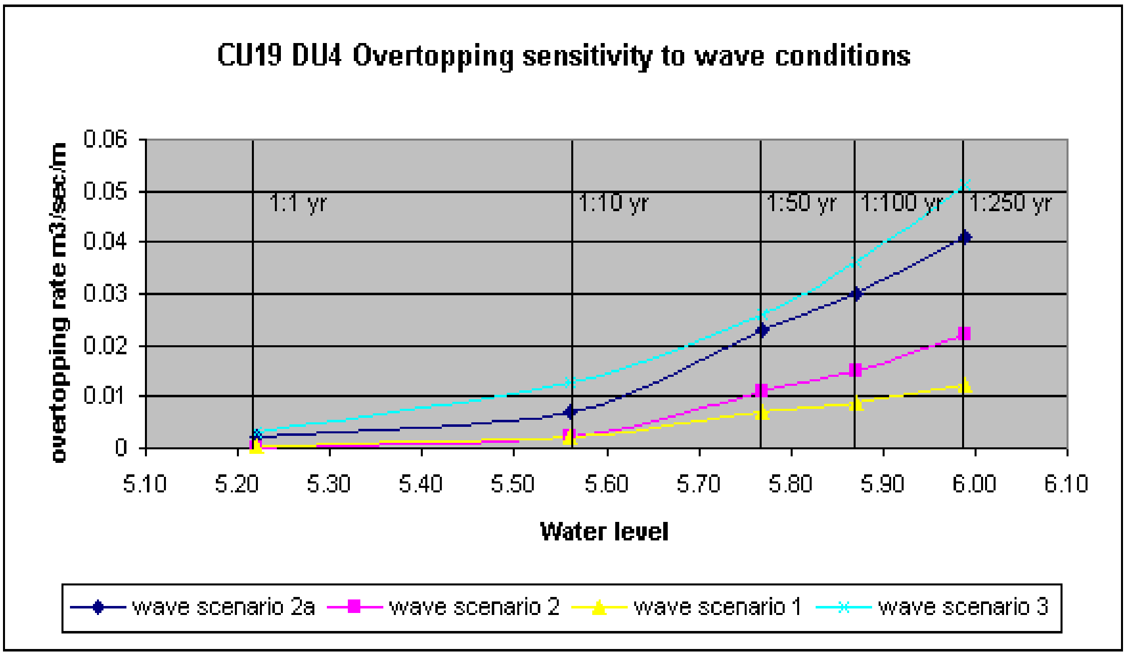


Figure 6. Position of defence units.

Previous Flooding

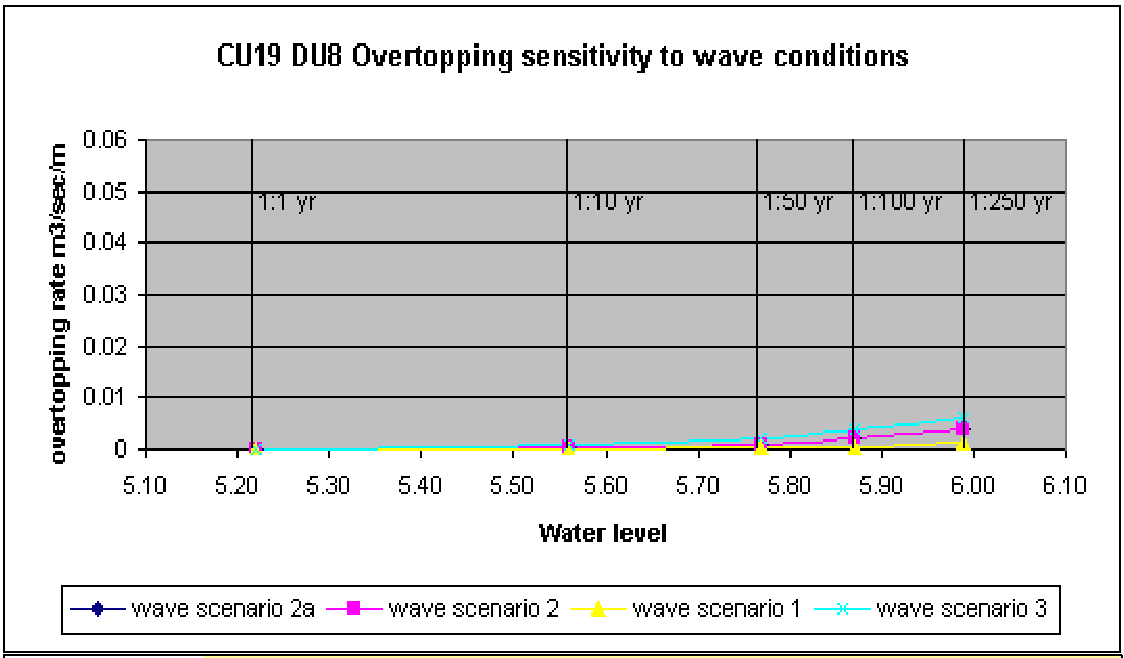
There is a record of significant overtopping, typically 3 times year, particularly to the southern end of DU4 where this unit runs into DU5, with the need for removal of pebbles and weed from the road. Overtopping also occurs further to the south along the DU7 and DU8 frontages. The road itself does not tend to flood, with water draining from the area. The storm in 2008, which appears to have been associated with larger swell conditions, was seen as being exceptional. Normally the most critical conditions are associated with easterly winds.



	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**5.22**	**10**	**5.56**	**50**	**5.77**	**100**	**5.87**	**250**	**5.99**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**0.3**	*10.1*	**0.3**	*10.9*	**0.4**	*11.4*	**0.4**	*11.6*	**0.4**	*11.3*
2	**0.4**	*11.7*	**0.5**	*12.5*	**0.6**	*13.0*	**0.6**	*13.3*	**0.6**	*13.6*
2a	**0.6**	*16.9*	**0.6**	*17.1*	**0.7**	*17.3*	**0.7**	*17.4*	**0.7**	*17.5*
3	**1.5**	*7.1*	**1.5**	*7.1*	**1.5**	*7.1*	**1.5**	*7.1*	**1.5**	*7.1*

Sensitivity.
The analysis of overtopping for DU4 indicates that the two main risk conditions are due to the higher locally generated waves (scenario 3) and under lower wave heights with longer wave period (scenario 2a). This is consistent with observations. More general wave conditions from the west and southwest result in little risk of overtopping unless associated with higher extreme water levels.

Taking the critical conditions there is a significantly increasing risk for events greater than 1:10. With these higher water levels (1:50 or greater) flooding could occur with comparatively low wave heights.



	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**5.22**	**10**	**5.56**	**50**	**5.77**	**100**	**5.87**	**250**	**5.99**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**0.2**	*10.1*	**0.3**	*10.9*	**0.3**	*11.4*	**0.4**	*11.6*	**0.3**	*11.3*
2	**0.4**	*11.7*	**0.5**	*12.5*	**0.5**	*13.0*	**0.6**	*13.3*	**0.6**	*13.6*
2a	**0.5**	*16.9*	**0.6**	*17.1*	**0.6**	*17.3*	**0.6**	*17.3*	**0.6**	*17.4*
3	**0.9**	*6.3*	**0.9**	*6.3*	**0.9**	*6.3*	**0.9**	*6.3*	**0.9**	*6.3*

The results for DU8 are plotted above at the same scale as used for DU4, previously. There is increased shelter from waves from a south-easterly direction (scenario 3) and this tends to reduce overtopping along this frontage for lower return periods. Locally generated waves still give the worse conditions. The shelter provided by the coast to the south also tends to reduce the height of longer period waves from the southwest. As with DU4 the risk of overtopping increases with increased water level.

Summary

Flood risk along Belle Greave Bay increases significantly with water level, typically greater than 1:50 year return period. There is significant variation in profile along DU4 and this may mitigate flooding over the more northerly section of the frontage. The benefit from this change in profile is likely to be reduced on higher water levels such that overtopping acts more consistently over the full length of the frontage.

At present, higher frequency (lower return periods), overtopping is considered to be manageable. The frontage might best be described, therefore, as being at high risk from low frequency (higher return period) conditions. The consequences of this are considered in the analysis of flood risk in the main report.

5.2 St Sampson.

The main risk of flooding occurs with weiring over the Bridge. While this is primarily due to water level, winds from the east will assist weiring. Wave overtopping has not been modelled.

Previous Flooding
Typically the road has to be closed to one way traffic once a year. Flooding has occurred at Lowlands Road with water funnelling down Nocq Road. On normal events water drains rapidly.

Sensitivity.
The critical sensitivity relates to water level and the height of the road along the bridge. The crest level at the Bridge varies between 4.85m LOD and 5.2m LOD. This gives a risk of weiring over on events between 1:1 year and 1: 5 years. A 1:10 year event (5.55m LOD) or greater would certainly result in flood risk.

Water levels have been assessed as being the same as St Peter Port. The modelling, however, does suggest that water levels may be 0.1m lower than St Peter Port. The calculation of Highest Astronomic Tide (HAT) at St Peter Port, defined by 2010 Admiralty Tide Tables (ATT) had been recorded as 5.34 m LOD (10.4m CD). This has been reduced in the 2011 edition of the ATT to 5.24m LOD (10.3m CD). While this does not reflect any change in the analysis of probabilistic extreme water levels, it does highlight the high sensitivity around the critical land levels in this area of the coast.

Summary
The risk of overtopping is critically determined by land levels around the harbour and particularly across the Bridge. These levels lie within a range of water level where there is a degree of uncertainty. It may be concluded, therefore, that there is a potential of onset of flood risk at around a 1:1 year return period but that, in reality, significant flooding may not actually occur on events less than 1:5 years. On lower frequency return periods, however, the land level threshold would be exceeded on events greater than 1:10 years. The volume of weiring increases rapidly as water levels increase. There is, therefore, quite clearly a significant risk to the area.

The consequences of this are considered in the analysis of flood risk in the main report.

5.3 Bordeaux Harbour.

The overtopping analysis for defence unit CU17 DU4 to the southern side of Bordeaux Harbour are discussed below, with a plot highlighting the different wave scenarios developed as part of the analysis. Harbour is relatively enclosed and gains further protection from offshore wave action as a result of the offshore islands (Figure 7).

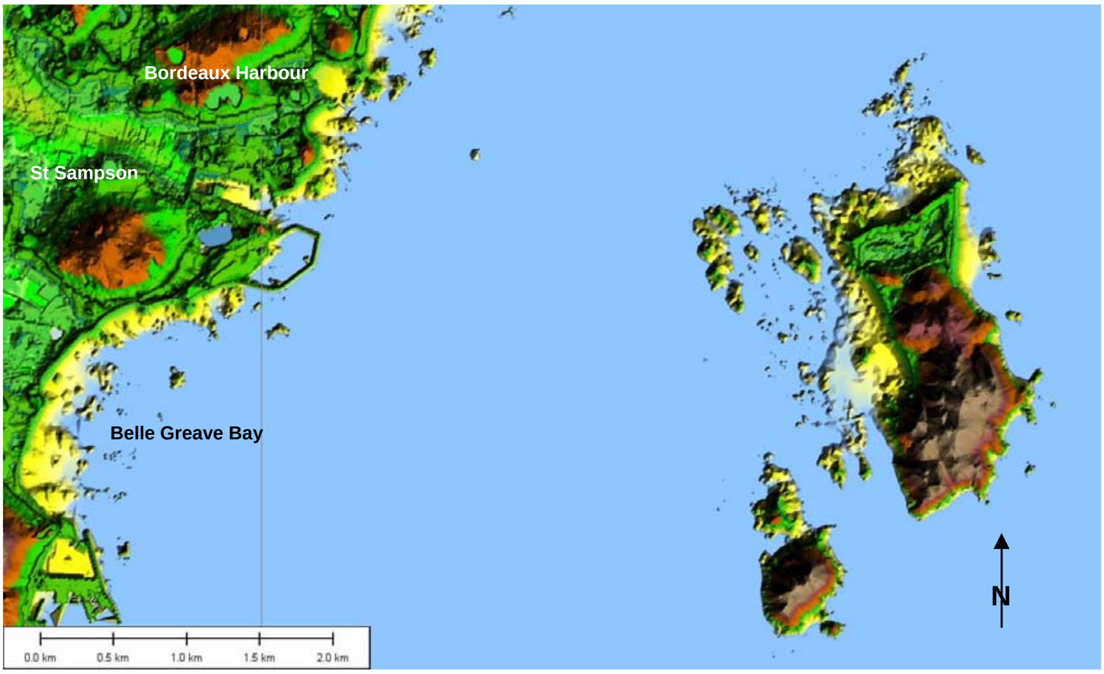


Figure 7. Location Plan of Bordeaux Harbour

Previous Flooding

Generally only limited overtopping occurs within the harbour area, with significant overtopping being reported some 20 years ago (probably 1992) and again more recently in 2008. On the first of these occasions, wave heights of around 1m were reported, with waves weiring over the defence to a depth of about 0.3m. The waves were reported as tumbling over the wall as they ran along it. During the more recent event, waves were described as being long swell, with a similar record of waves surging over the wall.

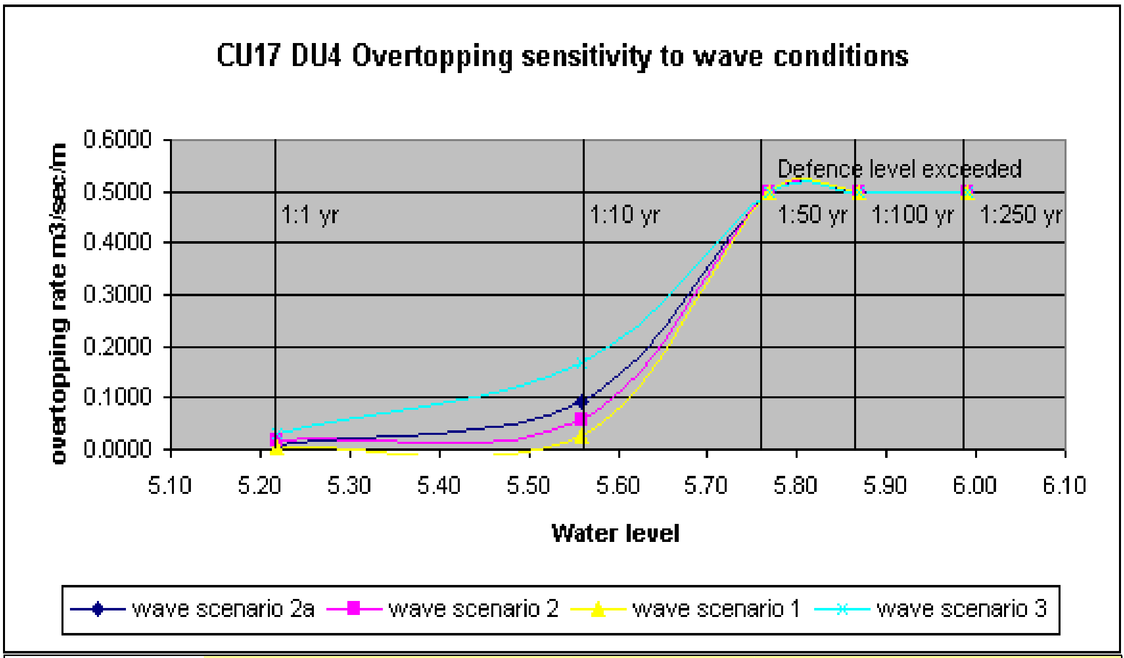
Flooding recorded during 2008, extended over the road and into the front garden of the property behind the road.

More typically wave overtopping tends to drain back off the road. The road rarely needs cleaning. However, sand can be pushed up the path at the edge of the dunes.

Sensitivity.

The plot below shows the analysis of overtopping modelling under different wave conditions. Wave heights have been taken from the model, reported in Appendix A, at the entrance to the harbour. There is likely to be some reduction in wave height as waves spread within the wider area of the bay but waves will also tend to run along the wall (DU4) along the southern edge of the harbour.

Waves approaching the head of the Bay (DU5) will tend to surge up the beach against the small dune system.



	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**5.22**	**10**	**5.56**	**50**	**5.77**	**100**	**5.87**	**250**	**5.99**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**0.2**	*10.1*	**0.3**	*10.9*	**0.4**	*11.4*	**0.4**	*11.6*	**0.4**	*11.3*
2	**0.3**	*11.6*	**0.4**	*12.5*	**0.5**	*13.0*	**0.5**	*13.2*	**0.6**	*13.5*
2a	**0.5**	*16.8*	**0.6**	*17.1*	**0.6**	*17.2*	**0.7**	*17.3*	**0.6**	*17.4*
3	**1.1**	*7.1*	**1.2**	*7.1*	**1.2**	*7.1*	**1.2**	*7.1*	**1.2**	*7.2*

The crest level of DU4 is typically 5.6m LOD; equivalent to somewhere between 1: 10 year and 1: 20 year level as determined at St Peter Port.

Observations from what is taken as being the storm event in 1992, suggests that still water level at high water was some 0.2m below the crest of the wall. A similar assessment is made from a single photograph taken during the 2008 surge event. This would indicate that water levels at Bordeaux Harbour were around 5.4m LOD compared to levels of 5.64m LOD (1992) and 5.52m LOD (2008), recorded at St Peter Port.

The modelling shows that water levels at Bordeaux Harbour may be slightly lower than at St Peter Port by potentially some 0.2m under certain events. This would be consistent with the above observations but cannot be fully relied upon as this variation can depend on specific conditions driving surge events.

Irrespective of wave conditions, it may be concluded that there is a risk of direct overtopping of the defence on a surge event of 1:20 years to 1: 50 years.

Based on water levels at St Peter Port, the above plot indicates that on a 1:1 year event there would be limited overtopping. This is consistent with observations. On lower frequency events, it may be seen that overtopping rapidly increases with locally generated wave height (scenario 3) and with increased wave period.

Summary

There is some uncertainty as to the onset of direct overtopping of the wall (DU4). The modelling indicates this would be on events greater than 1:20 years; taking observed values of water level, direct overtopping might occur on events greater than 1:50 years.

Wave overtopping from locally generated waves may be overestimated in the model due to the shelter affect within the bay. However, even so, significant overtopping will happen, as has been observed to occur, when low long period waves occur during return periods of 1:10 years to 1:20 years.

5.4 Cobo and Saline Bays

The overtopping analysis for two defence units (CU10 DU2 and DU3) are discussed below, with plots highlighting the different wave scenarios developed as part of the analysis. Modelling of the profile at DU4 indicates an onset of overtopping on events greater than a 1:50 year event. The position of defence units are shown on Figure 8.

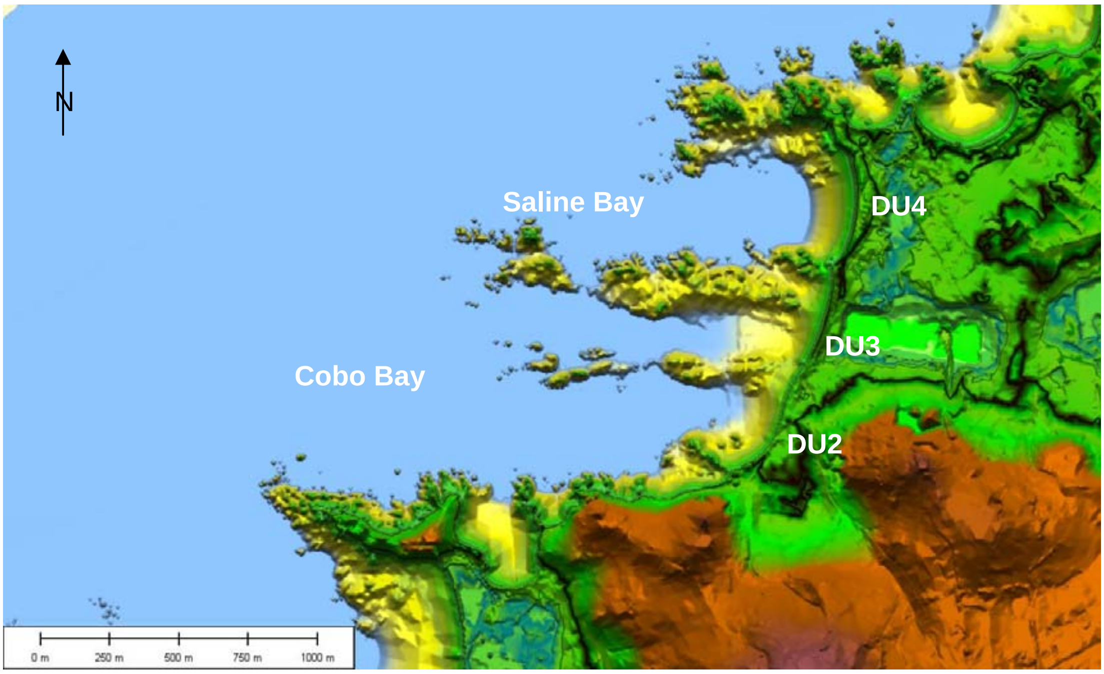


Figure 8. Location Plan of Defence Units.

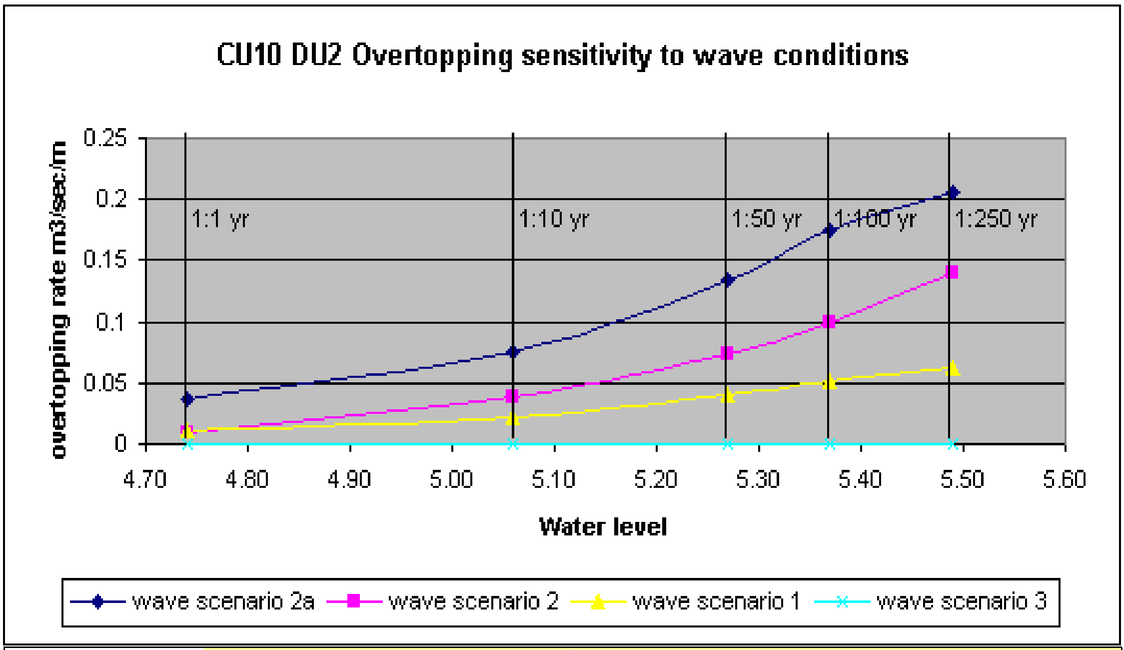
Previous Flooding
There have been no records of significant overtopping within DU4, Saline Bay.

There have been 3 to 4 events resulting in overtopping along the northern section of Cobo Bay (DU3, in the area of Route de Carteret) over the last 10 years. Flooding tends to drain back through the road gullies.

The road between the Cobo tea room through to the Rockmount (DU2) suffers from overtopping 4 to 5 times a year, with a need to clear the road of sand and pebbles.

Sea water flooding to the low lying area behind DU3 has not been recorded even under extreme conditions. Rain water will lie in pools in this area after heavy rain.

Sensitivity.
Cobo Bay gains protection from waves approaching from the southwest but is exposed to waves from more westerly wave conditions. The frontage is subject to long swell waves. The northern section of the bay (DU3) is subject to slightly higher waves than the southern section (DU2). Even so modelling of overtopping, shown in the plots below, indicates higher overtopping of the DU2 frontage. This is consistent with the observations recorded above.



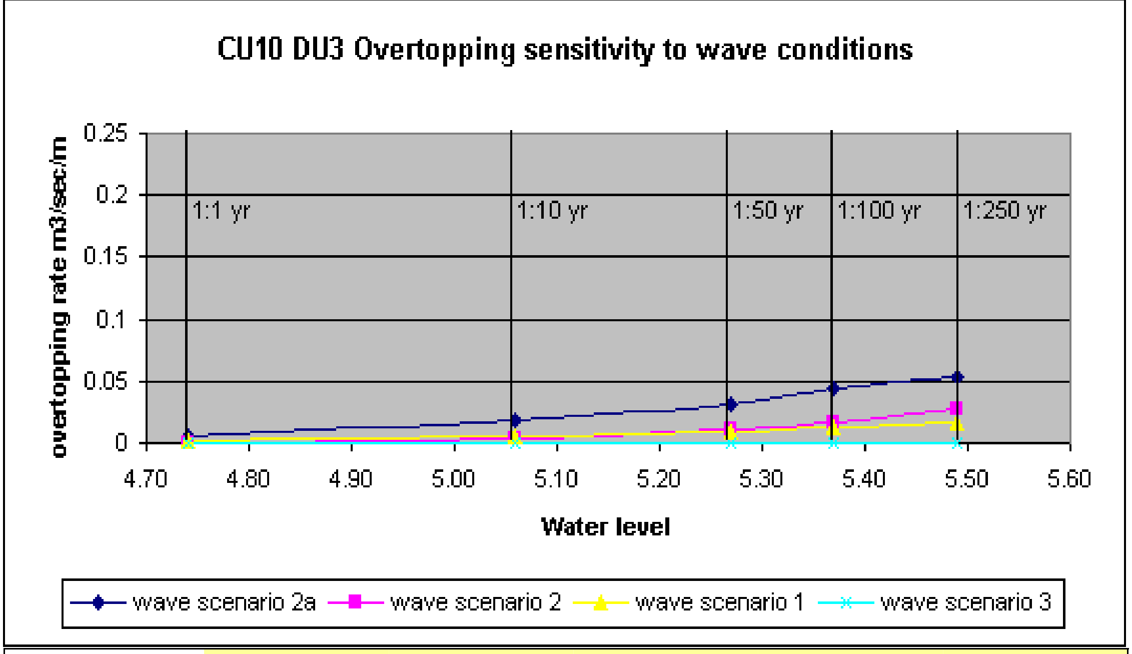
	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**4.74**	**10**	**5.06**	**50**	**5.27**	**100**	**5.37**	**250**	**5.49**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**1.5**	*10.1*	**1.8**	*10.9*	**2.0**	*11.4*	**2.0**	*11.5*	**2.0**	*11.3*
2	**1.9**	*11.6*	**2.2**	*12.4*	**2.3**	*13.0*	**2.4**	13.2	**2.5**	*13.5*
2a	**2.1**	*16.7*	**2.3**	*17.0*	**2.5**	*17.1*	**2.6**	*17.2*	**2.6**	*17.3*
3	**0.4**	*4.8*	**0.4**	*4.5*	**0.4**	*4.4*	**0.4**	*4.4*	**0.4**	*4.4*

Wave scenario 2a examines the influence of long wave period on overtopping. While high long period waves may be an exceptional event, it may be seen that the affect is to substantially increase overtopping rates. This affect is most notable at lower water levels, with potentially three times greater overtopping from a 17 second wave as compared to waves with a period of 12 seconds (scenario 2). It is difficult to attribute a return period for such an extreme wave condition. It has to be concluded that the frontage is vulnerable to such an event but that such occurrence may relate to very specific offshore conditions. Quite possibly, this would relate to a very high energy meteorological system, which would imply that it is only likely to occur with exceptional low frequency water levels.

More generally, overtopping rates increase more sharply with water level and become more sensitive to increase in wave height with that increase in water level. At a 1:1 year water level overtopping rates are relatively low and insensitive to wave height/wave (comparison between scenario 1 and 2). With an increase in water level of 0.3m (1:10 year event), the additional 0.4m wave height between scenario 1 and 2, results in over topping rates nearly doubling.

Based on observed performance in relation to DU2, it is reasonable to conclude that typical wave heights might lie between scenario 1 and 2. However, in considering the potential risk it is sensible to take the values determined by scenario 2, certainly when considering lower frequency occurrence.

Over the critical section of DU2, there is a variety of low and higher walls in front of properties, to the back of the road. Considering the level of overtopping being modelled, these local defences may be considered important in preventing flooding over a more extensive area and particularly preventing flooding into the low lying hinterland behind DU3. On more extreme events, the level of overtopping being predicted for the frontage may result in widespread flooding.



	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**4.74**	**10**	**5.06**	**50**	**5.27**	**100**	**5.37**	**250**	**5.49**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**1.8**	*10.1*	**2.1**	*10.8*	**2.3**	*11.3*	**2.4**	*11.5*	**2.3**	*11.2*
2	**2.1**	*11.6*	**2.3**	*12.4*	**2.5**	*13.0*	**2.6**	*13.2*	**2.7**	*13.5*
2a	**2.3**	*16.7*	**2.6**	*16.9*	**2.7**	*17.1*	**2.8**	*17.2*	**2.8**	*17.3*
3	**0.5**	*5.7*	**0.5**	*5.5*	**0.5**	*5.4*	**0.5**	*5.3*	**0.5**	*5.3*

The plot of overtopping rates for DU3 is shown at the same scale as for DU2. It may be seen that in terms of sensitivity to wave period, there is similar concern as identified for DU2, but with lower overall overtopping rates.

There is very low overtopping predicted for the frontage even with water levels up to a 1:50 year return period, despite higher wave heights. This seems consistent with observations. It may also be seen that overtopping is less sensitive to wave direction. It is only on the extreme water levels that overtopping increases significantly.

Summary
The whole frontage is vulnerable to long period waves but it is difficult to ascribe a sensible return period for such an event.

The majority of overtopping and flood risk would be expected to result from overtopping along DU2 and this is consistent with observations.

Local defences to the rear of the road along DU2 are likely to restrict widespread flooding but are likely to be less effective on lower frequency events (events greater than 1:50 year return period).

The frontage is sensitive to water level. Higher water levels will result in a disproportional greater flood risk.

5.5 Rocquaine and L'Eree Bay

The overtopping analysis for three defence units (CU3: DU3, DU4 and DU5) are discussed below, with plots highlighting the different wave scenarios developed as part of the analysis. The position of defence units are shown on Figure 9.

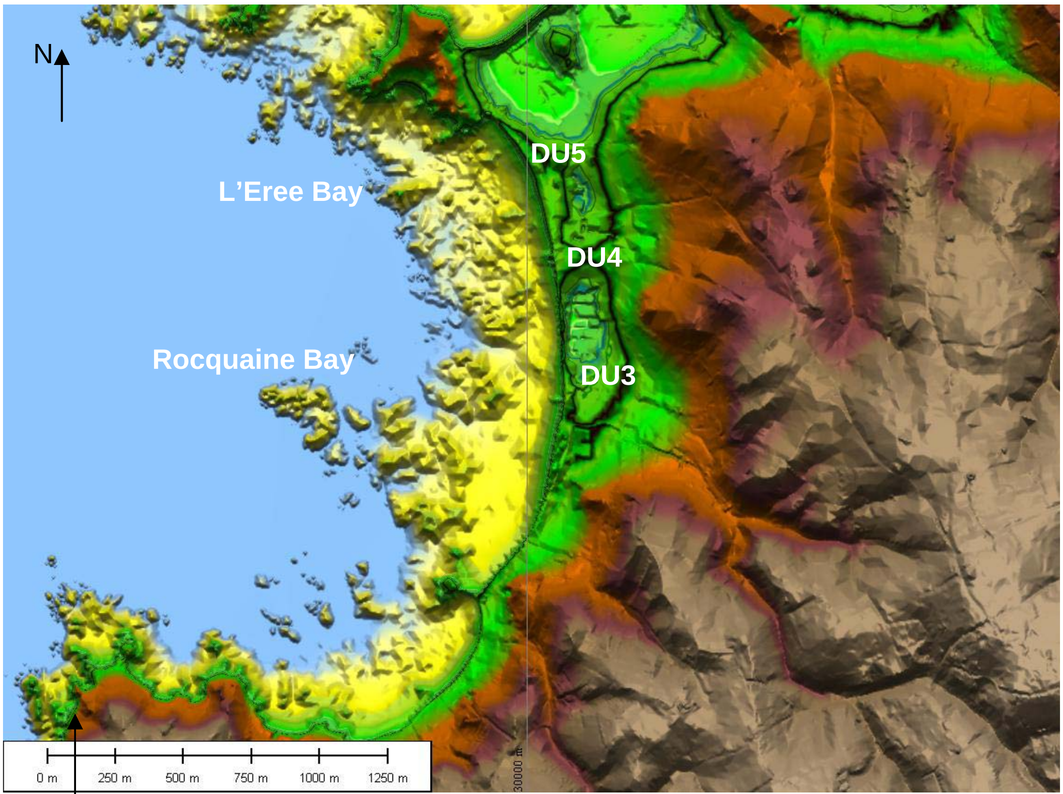


Figure 9. Location Plan of Defence Units

Previous Flooding

Overtopping of the sea wall occurs in areas around the whole of this frontage. There is regular overtopping at the corner just to the north of Les Salines (DU3) with spray over the roof of Staples Bungalow and the gardens of "Les Salines" properties are subject to flooding.

There is regular overtopping of the highest section of sea wall along the Route de la Rocque Poision (DU4).

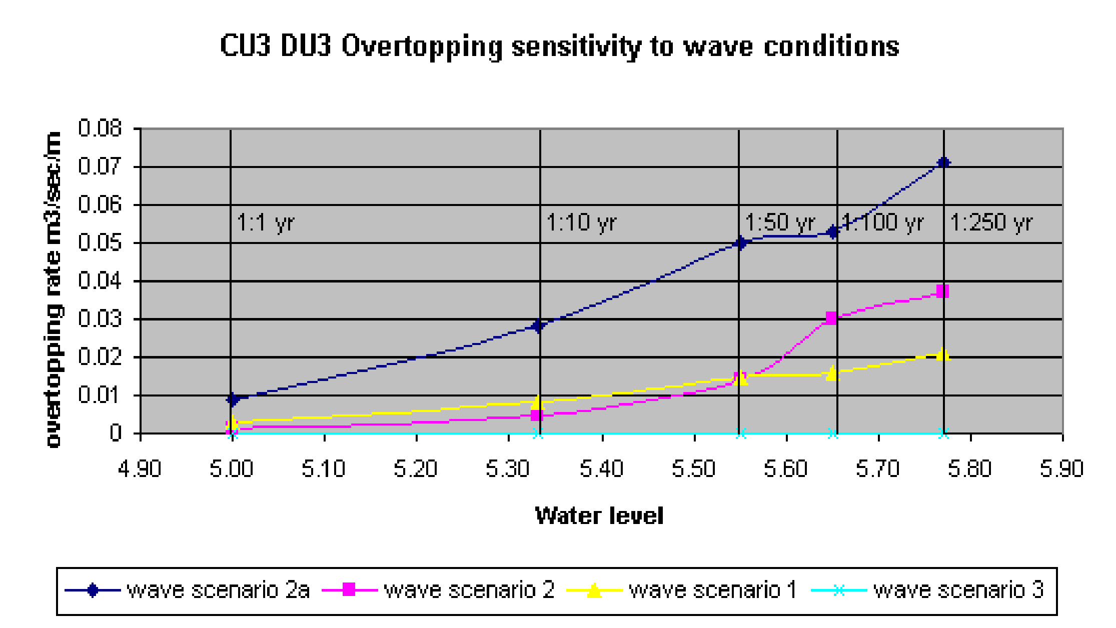
There is limited overtopping recorded over the northern section of the Bay (DU5).

The worse conditions are typically with westerly winds.

Sensitivity

The analysis for DU3 shown below indicates a similar general overtopping risk from waves from the southwest through to west (scenarios 1 and 2) on 1:1 year and 1:10 year events, increasing with water level on a 1:50 year event. There is a marked increased rate of overtopping with higher water levels and the increased wave height tested under waves from a more westerly direction. The relatively small increase in wave height between scenario 1 and 2 (increase by 0.1m on a 1:100 year event, and

0.3m on a 1:250 year return period) coupled with increased wave period gives rise to potentially twice the rate of overtopping.

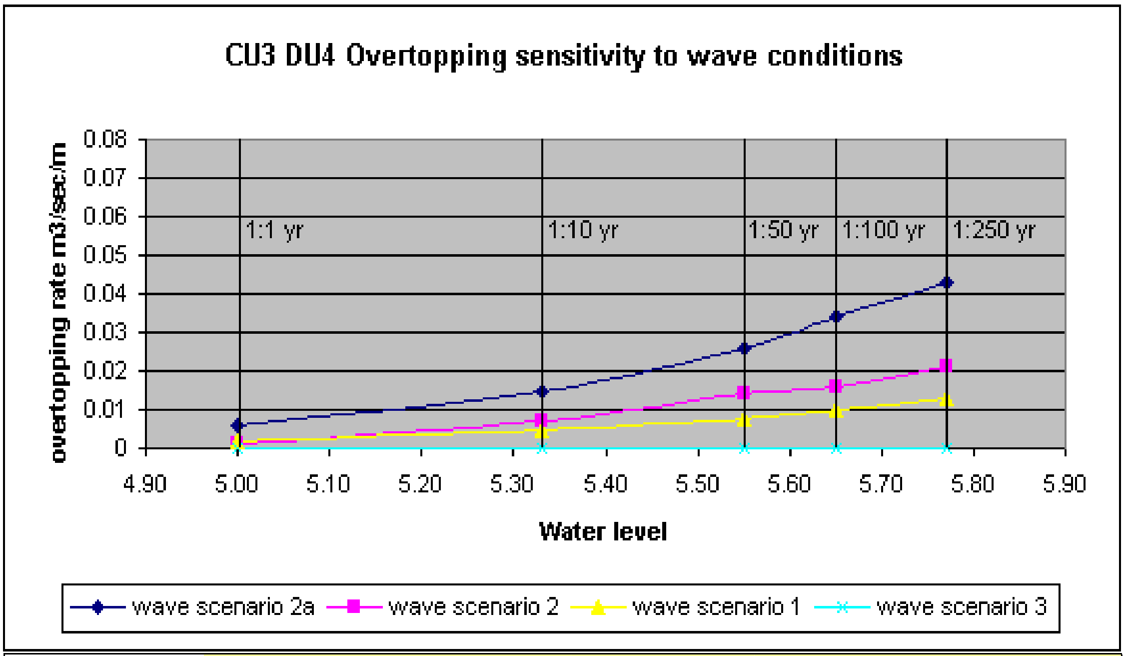


	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**5.00**	**10**	**5.33**	**50**	**5.55**	**100**	**5.65**	**250**	**5.77**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**2.0**	*10.1*	**2.3**	*10.8*	**2.5**	*11.3*	**2.6**	*11.5*	**2.5**	*11.2*
2	**2.2**	*11.6*	**2.4**	*12.4*	**2.6**	*12.9*	**2.7**	*13.1*	**2.8**	*13.4*
2a	**2.5**	*16.7*	**2.7**	*16.9*	**2.9**	*17.0*	**2.9**	*17.1*	**2.9**	*17.2*
3	**1.0**	*7.2*	**1.0**	*7.1*	**1.0**	*7.1*	**1.0**	*7.1*	**1.0**	*7.1*

The sensitivity to wave period is tested in scenario 2a. While high long period waves may be an exceptional event, it may be seen that the affect is to substantially increase overtopping rates, typically increasing rates of overtopping by 4 to 5 times compared to shorter wave period scenarios. It is difficult to attribute a return period for such an extreme wave condition. It has to be concluded that the frontage is vulnerable to such an event but that such occurrence may relate to very specific offshore conditions. Quite possibly, this would relate to a very high energy meteorological system, which would imply that it is only likely to occur with exceptional low frequency water levels.

DU3 shows potentially the highest overtopping rates of any of the profiles tested around the bay. However, there is significant variation along this unit. In some locations beach levels are relatively high, while in other areas the shape of the wall and the land levels over the crest and behind the road will tend to reduce the extent of flood risk. The modelled results are consistent with observations, with regular, relatively severe overtopping at specific locations. There is, due to increased water level and wave height, a step change in the level of overtopping that is likely to occur on events greater than 1:50 year return period.

These results are compared to the situation along DU4 shown in the plot below. These results are plotted at the same scale as DU3.



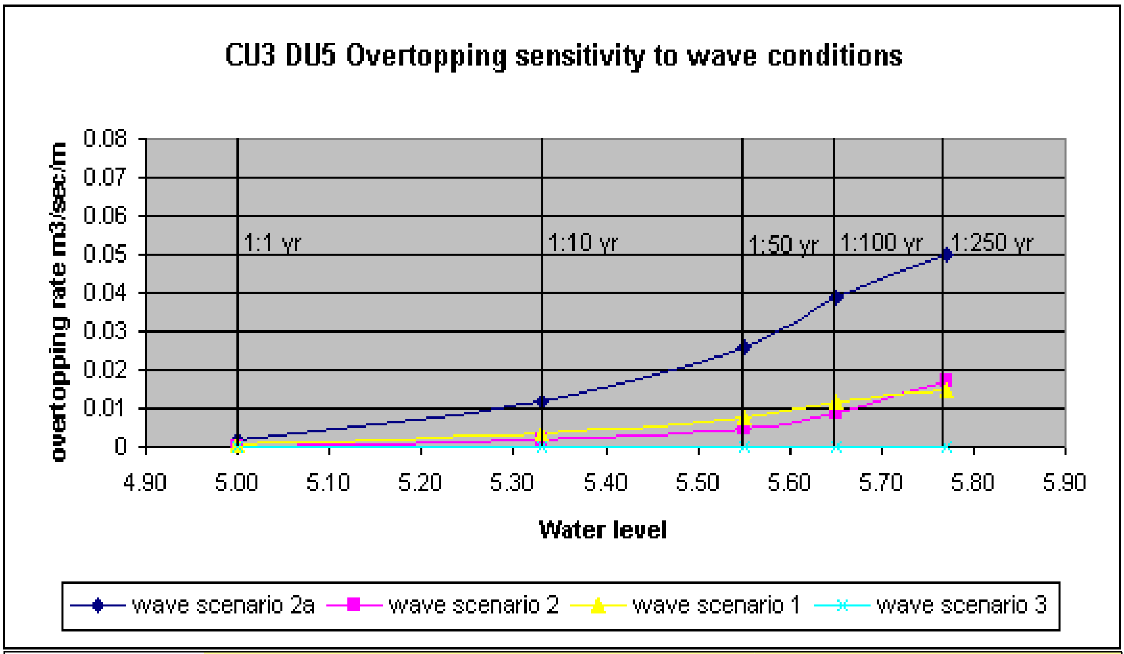
	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**5.00**	**10**	**5.33**	**50**	**5.55**	**100**	**5.65**	**250**	**5.77**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**2.0**	**10.1**	**2.3**	**10.8**	**2.5**	**11.3**	**2.6**	**11.5**	**2.5**	**11.2**
2	**2.2**	**11.6**	**2.5**	**12.4**	**2.7**	**12.9**	**2.7**	**13.2**	**2.8**	**13.4**
2a	**2.5**	**16.7**	**2.8**	**16.9**	**2.9**	**17.1**	**3.0**	**17.1**	**3.0**	**17.3**
3	**1.0**	**7.2**	**1.0**	**7.2**	**1.0**	**7.1**	**1.0**	**7.1**	**1.0**	**7.1**

As with DU3, this unit is also vulnerable to high long period waves, particularly on events greater than 1:50 year return period.

More typically, the analysis shows regular overtopping even on a 1:1 year event. Despite, similar wave conditions, the profile shows less sensitivity to the more extreme water level condition. Overtopping rates increase more linearly with water level. Even so there is a substantial increase in overtopping between the 1:10 year and the 1:50 year events.

The overtopping rates shown for 1:1 year, through to 1:10 year return periods seem consistent with observations. The analysis of water level data extends back over effectively 20 years (even though discontinuously). The highest values for water level in this set were for 1992 and this has been assessed as being of the order of a 1:20 year event. The higher rates of overtopping indicated on a 1:50 year event are unlikely to have been witnessed over recent times.

The plot for DU5 is shown below and generally shows a further reduction in potential overtopping, compared to units DU3 or DU4. This is consistent with observations that overtopping is not seen as a major issue along this frontage, based on the lower return period events. As highlighted above, however, more extreme events, quite possibly not recorded during recent history do still give rise to significant levels of overtopping.



	water level		water level		water level		water level		water level	
	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)	Return (yr.)	Level (m)
	1	**5.00**	**10**	**5.33**	**50**	**5.55**	**100**	**5.65**	**250**	**5.77**
wave scenario	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.	Hs.	Tp.
1	**1.7**	**10.1**	**2.0**	**10.8**	**2.2**	**11.3**	**2.3**	**11.5**	**2.2**	**11.2**
2	**1.9**	**11.6**	**2.2**	**12.4**	**2.3**	**12.9**	**2.4**	**13.2**	**2.5**	**13.5**
2a	**2.2**	**16.7**	**2.5**	**16.9**	**2.6**	**17.1**	**2.7**	**17.2**	**2.7**	**17.3**
3	**1.1**	**7.3**	**1.1**	**7.2**	**1.1**	**7.2**	**1.1**	**7.2**	**1.1**	**7.2**

The growth in overtopping rate with water level is evident and, given the general consistency with observations on higher frequency events, seems realistic.

The modelling does highlight the vulnerability of the frontage to high long period wave conditions. The occurrence of such events, as discussed earlier, is highlighted as a possibility but Is likely to be associated with specific meteorological conditions, to which it is difficult to put a specific return period.

Summary

As with Cobo Bay, the Rocquaine and L'Eree Bay area is vulnerable to high, long period wave conditions. These may be considered to be exceptional events but are highlighted in the modelling as being possible.

More generally, DU3 shows the most significant risk of overtopping but it is recognised that this may be specific to individual locations. The profile along DU4 is more uniform and the rates of overtopping are seen as being consistent with observations. The extrapolation to lower frequency events is seen as being realistic with significantly greater potential for overtopping and risk of flooding.

DU5 shows lowest overtopping rates but, as noted above, on lower frequency events these rates would be significant.

5.6 Overview of Sensitivity

The commentary given above considers the overtopping modelling results in relation to on the ground observations. The analysis shows relatively good consistency between these observations and the model results.

At *Belle Greve Bay*, the observed record of flooding would suggest that the full DU4 defence line may not experience overtopping to the same degree as seen along the modelled southern section of this frontage. This is recognised in splitting the frontage, testing two profile positions. The overtopping at DU5, just to the south of DU4 has also been modelled and has similar results to that defined for the southern section of DU4.

This frontage, as a whole Is, sensitive to the predicted water level associated with any return period. It is recognised therefore, that lower return periods (higher frequency events) may slightly overestimate overtopping. However, on higher return periods (lower frequency events) the sharp increase in overtopping is realistic. It may be concluded, therefore, that while overtopping may from experience be quite manageable, the area becomes far more vulnerable to overtopping as water level increase. This would apply equally with respect to sea level rise, such that even on lower return periods flood risk will increase significantly.

At *St Sampson*, flooding is determined primarily by water level. The current land levels are at a return period level of 1:1 year to 1:5 year. There is an indication that on specific surge events water levels may, at St Sampson, be lower (potentially by 0.1m) than as recorded at St Peter Port. This conclusion from the modelling is only indicative and depends critically on the nature of any surge event. There is some uncertainty with respect to the impact of lower return periods, with the potential for results to overestimate the flood risk. However, given that the onset of severe flooding is in effect determined by a threshold level, the risk of higher return period flooding is far more certain.

At *Bordeaux Harbour*, although far more affected by wave conditions, there is a similar threshold level defined by the sea wall along DU4. As above, this threshold level, with respect to the change in degree of overtopping, lies critically in the region of the 1:10 year through to the 1:20 year return period. Local orientation of the wall also makes this specific length of defence sensitive to waves running along and weiring over the wall. While the modelling may slightly overestimate the wave height due to the local shelter around the entrance, this is mitigated by the way in which waves may then interact with the DU4 defence length. Higher water levels on lower frequency events will override the sensitivity identified on lower water levels in that the crest level of the wall would be exceeded. The same consideration occurs with sea level rise.

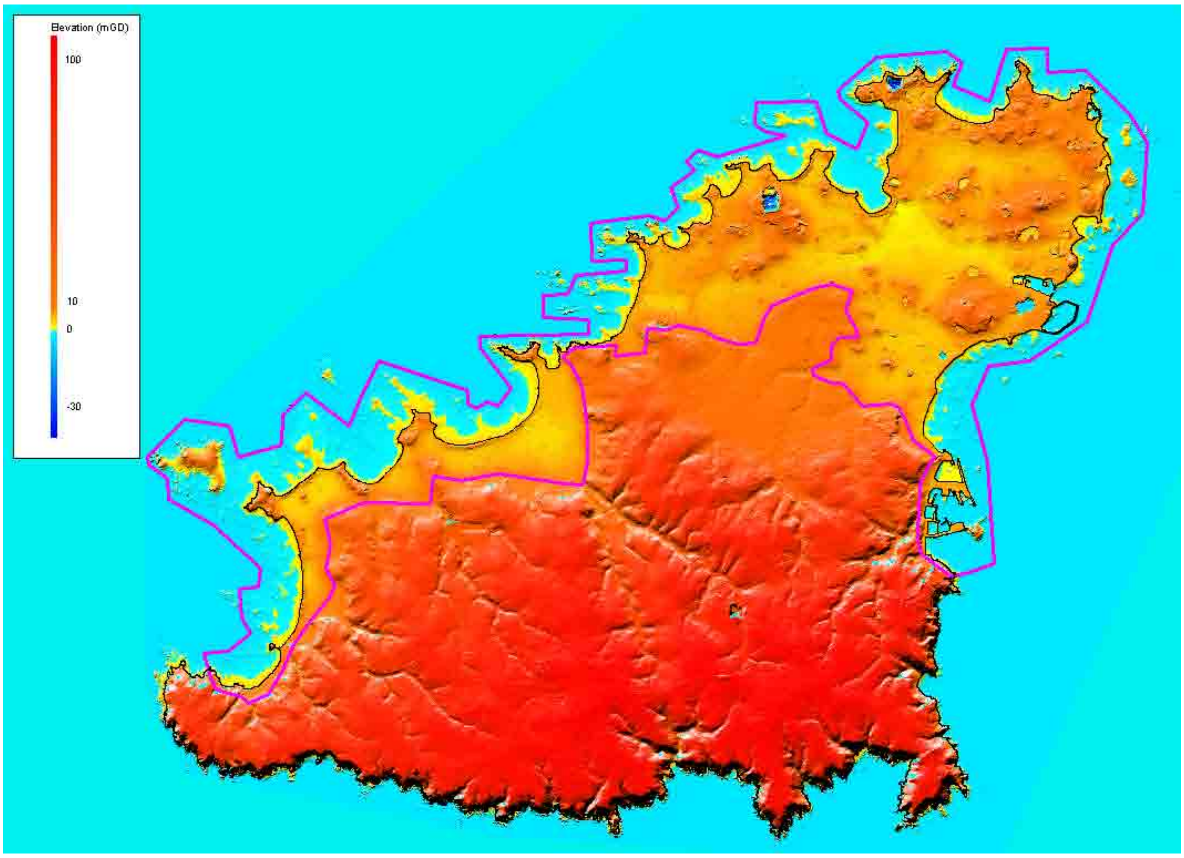
All frontages on the west coast have been identified as being vulnerable to high, long period wave action. This substantially increases the risk of overtopping and flooding. It is difficult to sensibly define a return period associated with such conditions and such conditions may relate to quite specific meteorological systems. The analysis highlights this as a possible extreme event but is not taken forward to the flood modelling.

At *Cobo Bay*, DU2 is clearly identified as being at highest risk from overtopping, with minor overtopping indicated for DU3 and DU4 on lower return periods. During lower return period events, the extent of flooding may be contained by local defences to the back of the road along DU2 and by the ability for water to drain back seaward. The increase in overtopping on higher return period events will increase the risk of wider spread flooding. Overtopping rates increase with water level and the frontage will be at significantly greater risk with sea level rise.

At *Rocquaine and L'Eree Bay* the highest overtopping rates occur along DU3, although this can critically depend on specific local defence profiles. Overtopping along DU4 is more consistently high. DU5 shows less risk of overtopping on lower return periods.

Overtopping increases significantly with water level, particularly on 1:50 year and greater return periods.

The results of the overtopping analysis have been taken forward to modelling of flood risk and flood extent. The high, long period wave condition (scenario 2a) has not, however, been used as this is considered to be an exceptional condition. It is, however, highlighted in the main report in the discussion of consequences and potential risk. Excluding this exceptional condition, the worse condition for the east coast tends to be locally generated waves (scenario 3) and waves from the west (scenario 2) for the west coast. It is recognised that local sensitivities and conditions as described above may influence the results of flood extents for lower return periods. This sensitivity is discussed in interpretation of results for each location in the main report.



Appendix C – TUFLOW Flood Modelling

States of Guernsey

January 2012

Final Report

9W2890

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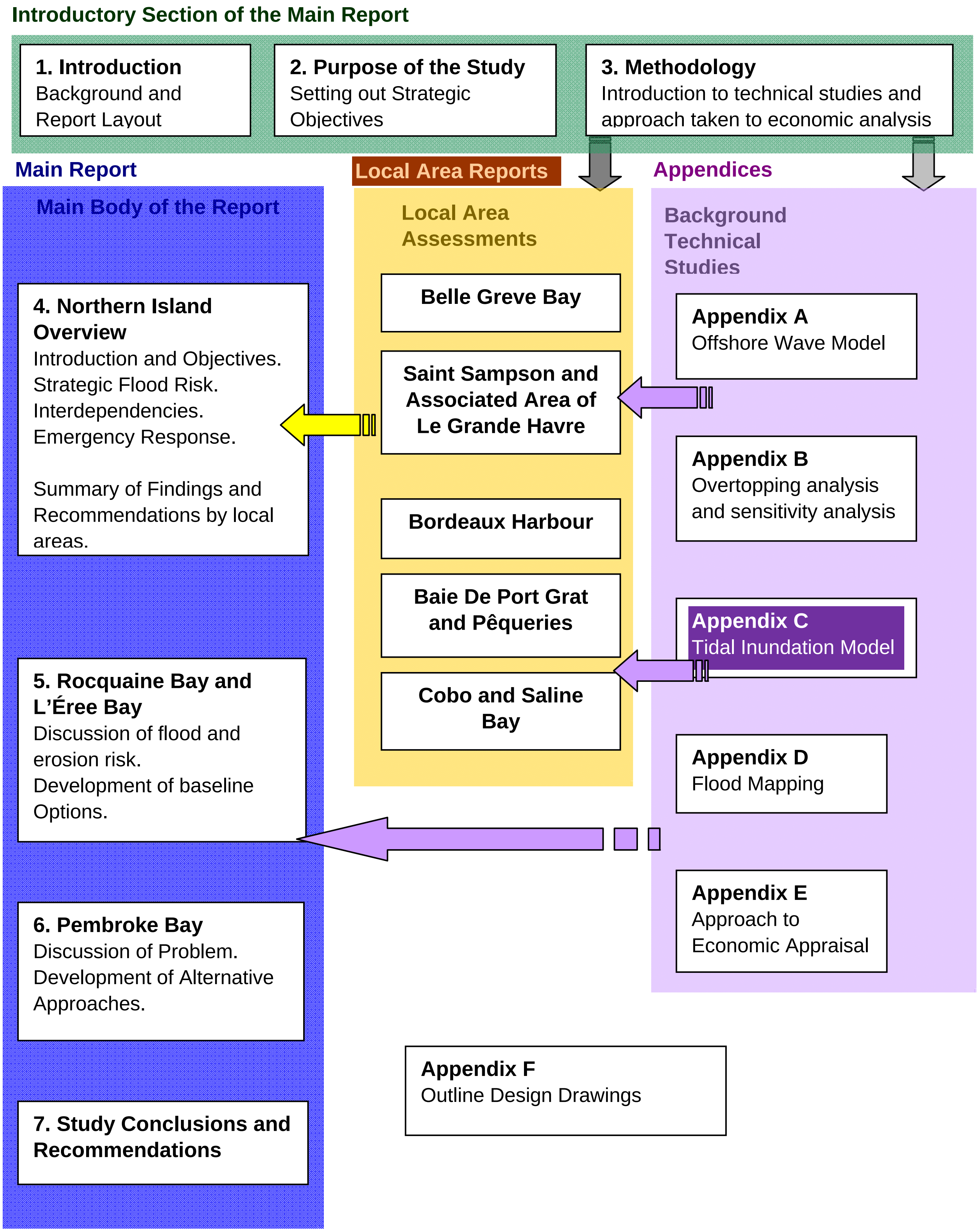
OVERALL REPORT STRUCTURE



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1 INTRODUCTION

Following on from the modelling to determine extreme wave and tide conditions around Guernsey using MIKE21 and the modelling undertaken in AMAZON to determine the overtopping rates caused by these conditions, it was required a flood model be built. This model would allow the collection of flood depths under different conditions at each property affected, to define flood extent maps and to view the propagation of flooding through overland routes.

The software selected for this purpose was TUFLOW. TUFLOW (Two-dimensional Unsteady FLOW) is used for simulating depth-averaged two dimensional flows such as tides and floods. It solves the shallow water equations used for modelling 'long' waves (ie, where the wavelength is significantly longer than the water depth) such as floods, tides and storm surges.

2 MODEL DEVELOPMENT

2.1 Domain

The main element of a TUFLOW model is the model domain. This is defined by the code file which was drawn around the coast exceeding the 7m contour line inland and the MLWS (Mean Low Water Springs) contour offshore.

The digital terrain model (DTM) of the model was derived from survey data supplied by Digimap. This was supplied as individual survey points and these were interpolated to produce a grid with a resolution of 5m. The surface created from this grid was interrogated to assign elevations to the grid points which define the elevations of the TUFLOW model domain.

2.2 Defences

During the course of previous strategy work the coastal areas of Guernsey were divided into Coastal Units (CUs), and further sub-divided into Defence Units (DUs). The defence units at risk from wave overtopping and tidal inundation were identified during the course of the Strategy and the focus of the wave and flood modelling for this study has been on these areas.

The defence for each DU was represented in the TUFLOW model with a z-line, including z-points for each survey point representing the top of the defence. Cells that were intersected by the z-line were raised to match that of the defence.

The defence z-line, inflow cells, code file and DTM are shown in Figure 2 at the end of this appendix.

The model has a cell size of 10m, with a time step of 5 seconds and model run duration of 12 hours.

2.3 Inflows

Based on the locations of the DUs, inflows have been set up in the TUFLOW model to correspond to these and to the outputs from the AMAZON modelling. The inflows were referenced by name to the profiles modelled in AMAZON and the overtopping rates were applied to a line of cells immediately inland from the defences using a flow time relationship. Further information on how the inflows were derived and applied can be seen in Section 3.1.

2.4 Roughness

Roughness regions in the model were based on GIS polygons supplied by Digimap. A description of these polygons and the roughness co-efficients used in the model are shown in Table 1.

Table 1 – Roughness values used in the Guernsey TUFLOW model.

Polygon Name	Description	Roughness coefficient (Mannings '*n*' value)
Land Parcel	Open land, fields, gardens, parks	0.06
Roads	Road surface	0.02
Buildings	Properties, churches & greenhouses	3.00
Inland Water	Lakes, reservoirs, quarries	1.00

Some parts of the model required 'stability patches'. These are small areas with a high roughness coefficient that are required to moderate rapid transmission of water across a cell or rapid wetting and drying of cells which results in instability. The roughness coefficient (Manning's '*n*' value) of a stability patch was 0.6. The roughness coefficient of a stability patch over-rides that of the material polygon beneath it.

2.5 Model Files

Table 2 details the files used in the Guernsey TUFLOW model.

Table 2 – Files used in the Guernsey TUFLOW model.

TUFLOW File Schedule for Guernsey model		
Filename	**Type**	**Function**
gnsy_ScenarioX_Y.tcf	TUFLOW control file	Defines files to run TUFLOW. Present day, Scenario X, Return Period Y
Epoch20_gnsy_ScenarioX_Y.tcf	TUFLOW control file	Defines files to run TUFLOW. Epoch 20, Scenario X, Return Period Y
Epoch50_gnsy_ScenarioX_Y.tcf	TUFLOW control file	Defines files to run TUFLOW. Epoch 50, Scenario X, Return Period Y
Epoch100_gnsy_ScenarioX_Y.tcf	TUFLOW control file	Defines files to run TUFLOW. Epoch 100, Scenario X, Return Period Y
gnsy.tgc	TUFLOW geometry file	Identifies model elevation features
gnsy.tbc	Boundary condition file	Defines boundary conditions for model
gnsy.tmf	Materials file	Identifies roughness areas

TUFLOW File Schedule for Guernsey model		
Filename	**Type**	**Function**
2d_zpt_gnsy.mif	Point file	Elevation of cells derived from DTM
2d_code_gnsy.MIF	Code file	Defines model extent
2d_grd_gnsy.mif	Grid file	Defines model grid
2d_loc_gnsy.MIF	Location file	Defines orientation of grid
2d_bc_gnsy_tide_CU3.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 3
2d_bc_gnsy_tide_CU10.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 10
2d_bc_gnsy_tide_CU11.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 11
2d_bc_gnsy_tide_CU12.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 12
2d_bc_gnsy_tide_CU17.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 17
2d_bc_gnsy_tide_CU18.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 18
2d_bc_gnsy_tide_CU19.MIF	2D HT boundary condition	Tidal inflow for Coastal Unit 19
2d_sa_gnsy_CU3.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 3
2d_sa_gnsy_CU10.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 10
2d_sa_gnsy_CU11.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 11
2d_sa_gnsy_CU12.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 12
2d_sa_gnsy_CU17.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 17
2d_sa_gnsy_CU18.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 18
2d_sa_gnsy_CU19.MIF	2D QT boundary condition	Overtopping inflow for Coastal Unit 19
bc_dbase_gnsy.csv	csv	Overtopping rates from AMAZON
ScenarioX_QY.csv	csv	Overtopping rates for Present day, Scenario X, event Y
Epoch20_ScenarioX_Y.csv	csv	Overtopping rates for Epoch20, Scenario X, event Y
Epoch50_ScenarioX_Y.csv	csv	Overtopping rates for Epoch50, Scenario X, event Y
Epoch100_ScenarioX_Y.csv	csv	Overtopping rates for Epoch100, Scenario X, event Y
2d_zln_gnsy_cu3.MIF	z-line and z-point file	Defence crest with spot heights
2d_zln_gnsy_cu10.MIF	z-line and z-point file	Defence crest with spot heights
2d_zln_gnsy_cu11.MIF	z-line and z-point file	Defence crest with spot heights
2d_zln_gnsy_cu12.MIF	z-line and z-point file	Defence crest with spot heights
2d_zln_gnsy_cu17.MIF	z-line and z-point file	Defence crest with spot heights
2d_zln_gnsy_cu18.MIF	z-line and z-point file	Defence crest with spot heights
2d_zln_gnsy_cu19.MIF	z-line and z-point file	Defence crest with spot heights
2d_mat_gnsy_inlandwater.MIF	Materials file for ponds, lakes, reservoirs and quarries	Defines roughness values
2d_mat_gnsy_land.MIF	Materials file for gardens, shrubland, fields	Defines roughness values
2d_mat_gnsy_properties.MIF	Materials file for properties including	Defines roughness values

TUFLOW File Schedule for Guernsey model		
Filename	**Type**	**Function**
	churches & greenhouses	
2d_mat_gnsy_roads.MIF	Materials file for roads	Defines roughness values
2d_mat_gnsy_stability.MIF	Stability patch	Increases model stability

2.6 Assumptions

Some assumptions were necessary in order to implement the model sufficiently without excessive model development or run times.

It is assumed that the overtopping of the defence profile used for each DU is consistent along the entire defence. This does not take into account any defence crest level changes or small openings in the defence such as access steps and slipways.

The overtopping rates are based on an average overtopping flow. There is currently no allowance for surface water drains that may drain any overtopping back out to sea. It has been assumed that in an extreme event the net effect of these is zero – any overtopping flow draining out is balanced by forced inflow through the defence during wave impact. In general the drains are un-flapped, and are used to reduce surface water ponding behind the defence from localised rain events rather than tidal inundation.

The overland flow is based on an interpolated DTM based on a grid of survey points. This means that small features such as kerbs, walls and drainage do not have significant impact on the direction of overland flow, other than through the effects of a variance in roughness.

It is important to note that walls and other manmade obstructions other than the coastal defences have not been included in the model. It is likely that these would have some affect on overland flows however, given the broadscale nature of the study and model it is impractical to include this sort of detail, particularly where the integrity of the walls and their ability to resist flood waters is unknown.

3 INFLOWS

3.1 Overtopping

The rate of overtopping was supplied from the AMAZON modelling, which provided the average rate of overtopping in $m^3/s/m$. The overtopping rate for each DU was determined by multiplying the overtopping rate from each AMAZON run by the length of defence. For the purpose of this study it was assumed that any flooding from overtopping would occur over one high tide, and as such the average overtopping rates from AMAZON have been applied for 1.5 hours. This value was arrived at following examination of tide curve shapes for the island.

As discussed in Appendix B – AMAZON Overtopping Modelling, the conditions carried forward to the TUFLOW modelling are for those from Scenarios 2 and 3, wave conditions from 270 degrees and from 180 degrees respectively, as these gave the worst case nearshore wave conditions and hence overtopping rates at each of the profiles modelled.

Inflow rates for the TUFLOW modelling can be seen in the tables at the end of this Appendix.

3.2 Tides

Tides have been applied to the model using an HT or Head-Time boundary in TUFLOW, where the extreme tide level is above the surveyed level of the defences. As with the overtopping rates, flooding is assumed to occur over the course of one high tide, hence one peak of a tide curve, adjusted so that the peak value is at the appropriate extreme storm surge level, has been applied. Extreme tide levels can be seen in Table 3.

Table 3 - Tide Levels

	Epoch 0 Return Period					**Epoch 20 Return Period**				
Location	**1**	**10**	**50**	**100**	**250**	**1**	**10**	**50**	**100**	**250**
CU3	5.00	5.32	5.54	5.65	5.77	5.14	5.46	5.68	5.79	5.91
CU10, CU11, CU12	4.72	5.04	5.26	5.37	5.49	4.86	5.18	5.40	5.51	5.63
CU17, CU18, CU19	5.22	5.56	5.77	5.87	5.99	5.36	5.68	5.90	6.01	6.13

	Epoch 50 Return Period					**Epoch 100 Return Period**				
Location	**1**	**10**	**50**	**100**	**250**	**1**	**10**	**50**	**100**	**250**
CU3	5.42	5.75	5.96	6.07	6.19	5.97	6.29	6.51	6.62	6.74
CU10, CU11, CU12	5.14	5.46	5.68	5.79	5.91	5.69	6.01	6.23	6.34	6.46
CU17, CU18, CU19	5.64	5.96	6.18	6.29	6.41	6.19	6.51	6.73	6.84	6.96

To apply the effects of a tide to the model a portion of the Mean High Water Spring (MHWS) tide curve for St Peter Port was used. This curve was shifted to match the peak of the extreme tide as produced from the MIKE21 modelling for each of the 3 locations around the island. The MHWS curve used can be seen in Figure 1 below.

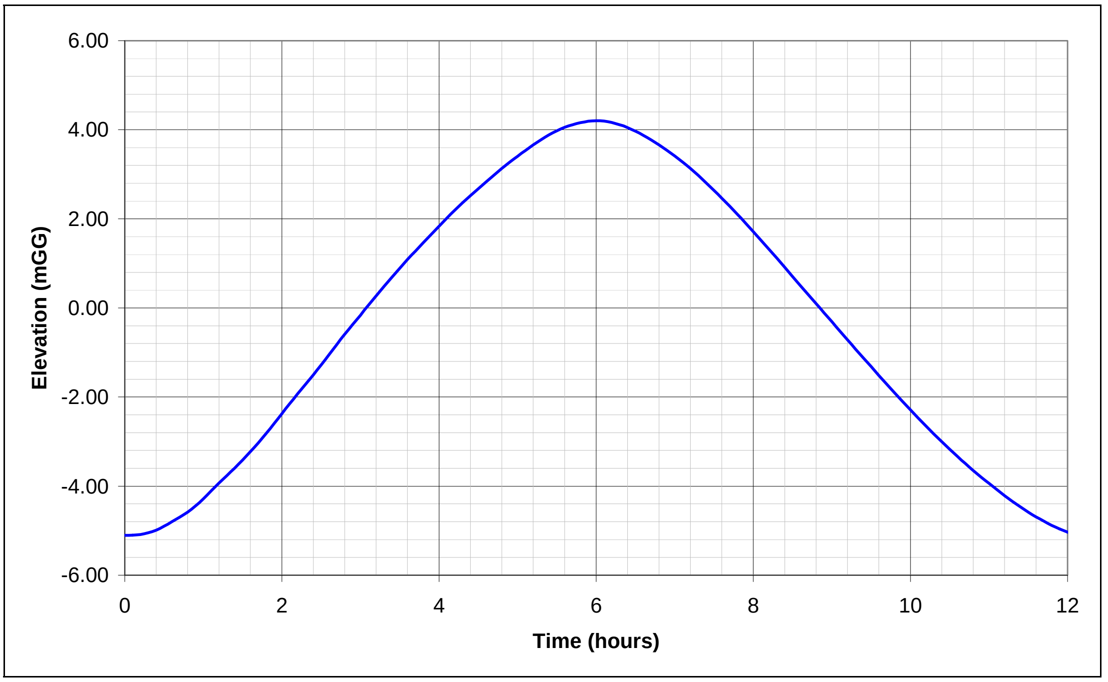


Figure 2 – Section of MHWS tide curve for St Peter Port.

4 OUTPUTS

4.1 Flood Extents

Outputs from the TUFLOW models present as depth, velocity and flow data for each grid cell within the model for each output step of the model. These outputs are processed to allow the creation of animations and flood extent maps and to provide flood depth information to inform the economic assessment.

4.2 Modelling Uncertainties

Due to the broadscale nature of the modelling there are naturally some assumptions that have been made and uncertainties which are encountered. As with all models it is a tool which should be reviewed and interpreted by appropriate parties, particularly in the case of a study such as this where calibration data is unavailable and opportunities for verification are limited.

For a study of this type it is important to undertake an appropriate assessment with regard to scale and level of detail as resources are not inexhaustive. It is then of great importance that results are reviewed, interpreted and, where appropriate, amended using expert judgement, local knowledge and a review of complementary data. In some limited instances for this modelling, where anomalies are apparent it has been necessary to make minor amendments to overtopping rates and flood extents to bring them in line with what is known about local conditions. This type of amendment is usual practice with flood mapping in England and Wales, particularly for a study of this type where the modelling is, of necessity, at a high level and some local fine detail can be inadequately represented.

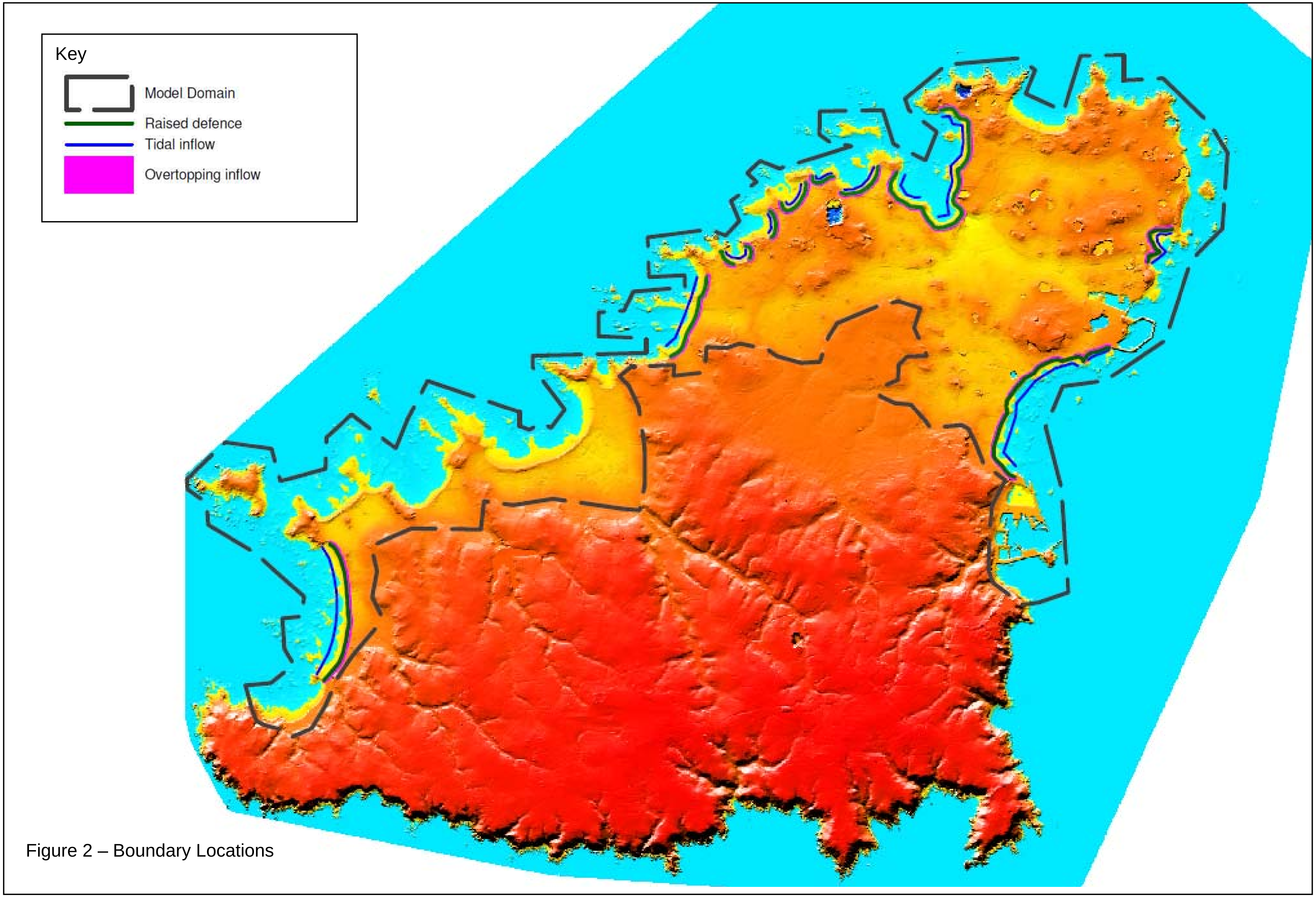


Figure 2 – Boundary Locations

Epoch	**0**															
Scenario	**1**				Return Period		250		100		50		10		1	
Coastal Unit	Defence Unit	Profile name	Crest height		Length (Km)	Length (m)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)
CU3	DU1	Profile 1	8.79	CU3_DU1_1	0.414	414	0.005	1.86	0.004	1.49	0.002	0.99	0.001	0.50	0.000	0.12
CU3	DU2	Profile 1	11.17	CU3_DU2_1	0.25	250	0.000	0.08	0.000	0.08	0.000	0.08	0.000	0.02	0.000	0.00
CU3	DU3	Profile 1	8.31	CU3_DU3_1	0.393	393	0.021	8.37	0.016	6.25	0.015	5.90	0.008	3.30	0.003	1.06
CU3	DU4	Profile 1	8.57	CU3_DU4_1	0.1034	103.4	0.013	1.33	0.010	1.05	0.008	0.81	0.005	0.47	0.002	0.19
CU3	DU4	Profile 2	8.7	CU3_DU4_2	0.224	224	0.006	1.34	0.006	1.34	0.004	0.94	0.002	0.47	0.000	0.00
CU3	DU5	Profile 1	8.84	CU3_DU5_1	0.1204	120.4	0.005	0.61	0.005	0.58	0.004	0.43	0.002	0.22	0.000	0.04
CU3	DU5	Profile 2	8.32	CU3_DU5_2	0.1401	140.1	0.011	1.51	0.008	1.09	0.002	0.34	0.001	0.13	0.001	0.08
CU3	DU5	Profile 3	7.66	CU3_DU5_3	0.1743	174.3	0.015	2.61	0.012	2.04	0.008	1.36	0.004	0.63	0.001	0.10
CU3	DU5	Profile 4	7.36	CU3_DU5_4	0.0881	88.1	0.013	1.16	0.010	0.87	0.006	0.56	0.003	0.26	0.001	0.05
CU10	DU2	Profile 1	6.75	CU10_DU2_1	0.4841	484.1	0.062	29.92	0.052	25.27	0.040	19.46	0.023	11.04	0.011	5.23
CU10	DU3	Profile 1	7.73	CU10_DU3_1	0.3964	396.4	0.016	6.30	0.013	5.23	0.009	3.69	0.005	2.14	0.002	0.59
CU10	DU4	Profile 1	7.89	CU10_DU4_1	0.3102	310.2	0.009	2.70	0.007	2.14	0.006	1.77	0.002	0.74	0.001	0.19
CU11	DU3	Profile 1	8.3	CU11_DU3_1	0.1179	117.9	0.001	0.07	0.000	0.04	0.000	0.04	0.000	0.00	0.000	0.00
CU11	DU4	Profile 1	10.24	CU11_DU4_1	0.0486	48.6	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU5	Profile 1	7.65	CU11_DU5_1	0.1661	166.1	0.004	0.70	0.003	0.50	0.002	0.30	0.001	0.10	0.000	0.01
CU11	DU7	Profile 1	9.17	CU11_DU7_1	0.384	384	0.003	1.04	0.002	0.81	0.001	0.46	0.000	0.12	0.000	0.00
CU11	DU8	Profile 1	7.02	CU11_DU8_1	0.613	613	0.017	10.30	0.014	8.28	0.009	5.52	0.005	2.76	0.002	0.92
CU11	DU9	Profile 1	8.03	CU11_DU9_1	0.35	350	0.014	4.83	0.013	4.52	0.009	3.15	0.004	1.47	0.001	0.42
CU11	DU10	Profile 1	7.56	CU11_DU10_1	0.18	180	0.006	1.03	0.004	0.76	0.003	0.49	0.001	0.22	0.000	0.05
CU11	DU10	Profile 2	9.81	CU11_DU10_2	0.494	494	0.001	0.59	0.001	0.44	0.001	0.30	0.000	0.15	0.000	0.01
CU12	DU2	Profile 1	8.45	CU12_DU2_1	3.187	3187	0.000	0.38	0.000	0.19	0.000	0.19	0.000	0.00	0.000	0.00
CU17	DU2	Profile 1	6.72	CU17_DU2_1	0.2222	222.2	0.002	0.53	0.003	0.67	0.001	0.27	0.001	0.13	0.000	0.00
CU17	DU3	Profile 1	6.98	CU17_DU3_1	0.1128	112.8	0.002	0.20	0.001	0.10	0.001	0.07	0.000	0.03	0.000	0.00
CU17	DU4	Profile 1	5.58	CU17_DU4_1	0.2533	253.3		0.00		0.00		0.00	0.028	6.99	0.002	0.61
CU17	DU5	Profile 1	7.07	CU17_DU5_1	0.2248	224.8	0.008	1.69	0.006	1.28	0.005	1.01	0.002	0.47	0.001	0.13
CU18	DU5	Profile 1	8.56	CU18_DU5_1	0.1483	148.3	0.000	0.04	0.000	0.04	0.000	0.02	0.000	0.00	0.000	0.00
CU18	DU6	Profile 1	7.6	CU18_DU6_1	0.209	209	0.002	0.38	0.002	0.31	0.001	0.25	0.000	0.06	0.000	0.01
CU19	DU1	Profile 1	7.09	CU19_DU1_1	0.1361	136.1	0.003	0.45	0.002	0.33	0.002	0.24	0.001	0.12	0.000	0.02
CU19	DU3	Profile 1	7.4	CU19_DU3_1	0.316	316	0.000	0.04	0.000	0.02	0.000	0.02	0.000	0.00	0.000	0.00
CU19	DU4	Profile 1	6.71	CU19_DU4_1	0.2944	294.4	0.012	3.62	0.009	2.65	0.007	2.03	0.002	0.62	0.001	0.18
CU19	DU4	Profile 2	7.7	CU19_DU4_2	0.1592	159.2	0.001	0.14	0.001	0.10	0.001	0.10	0.000	0.01	0.000	0.00
CU19	DU5	Profile 1	7	CU19_DU5_1	0.1034	103.4	0.003	0.31	0.003	0.28	0.001	0.12	0.001	0.06	0.000	0.01
CU19	DU7	Profile 1	7.41	CU19_DU7_1	0.2888	288.8	0.000	0.03	0.000	0.03	0.000	0.01	0.000	0.00	0.000	0.00
CU19	DU7	Profile 2	6.82	CU19_DU7_2	0.0807	80.7	0.001	0.10	0.001	0.05	0.000	0.02	0.000	0.00	0.000	0.00
CU19	DU8	Profile 1	6.85	CU19_DU8_1	0.1789	178.9	0.001	0.21	0.001	0.11	0.000	0.05	0.000	0.03	0.000	0.00
CU19	DU9	Profile 1	6.62	CU19_DU9_1	0.3874	387.4	0.001	0.35	0.001	0.23	0.000	0.12	0.000	0.03	0.000	0.00

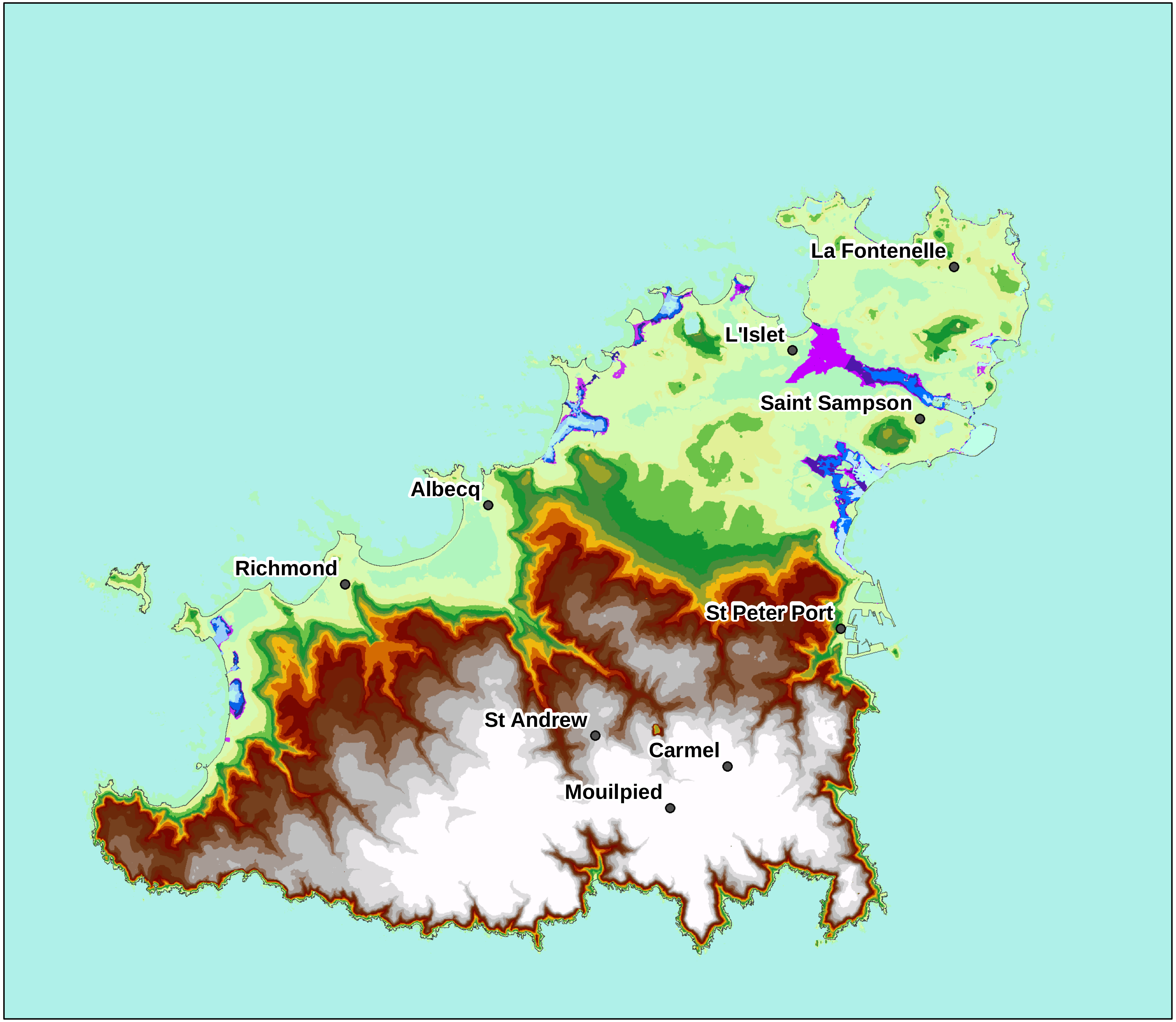
(pink) Where still water level above Amazon defence crest

Epoch	0															
Scenario	**2**				Return Period		250		100		50		10		1	
Coastal Unit	Defence Unit	Profile name	Crest height		Length (Km)	Length (m)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)
CU3	DU1	Profile 1	8.79	CU3_DU1_1	0.414	414	0.006	2.48	0.005	2.07	0.003	1.24	0.001	0.41	0.000	0.00
CU3	DU2	Profile 1	11.17	CU3_DU2_1	0.25	250	0.000	0.03	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU3	Profile 1	8.31	CU3_DU3_1	0.393	393	0.037	14.54	0.030	11.79	0.014	5.50	0.005	1.97	0.001	0.39
CU3	DU4	Profile 1	8.57	CU3_DU4_1	0.1034	103.4	0.021	2.17	0.016	1.65	0.014	1.45	0.007	0.72	0.001	0.10
CU3	DU4	Profile 2	8.7	CU3_DU4_2	0.224	224	0.010	2.24	0.006	1.34	0.003	0.67	0.000	0.04	0.000	0.00
CU3	DU5	Profile 1	8.84	CU3_DU5_1	0.1204	120.4	0.007	0.84	0.004	0.48	0.002	0.24	0.001	0.12	0.000	0.00
CU3	DU5	Profile 2	8.32	CU3_DU5_2	0.1401	140.1	0.013	1.82	0.006	0.84	0.004	0.56	0.001	0.14	0.000	0.00
CU3	DU5	Profile 3	7.66	CU3_DU5_3	0.1743	174.3	0.017	2.96	0.009	1.57	0.005	0.87	0.002	0.35	0.000	0.00
CU3	DU5	Profile 4	7.36	CU3_DU5_4	0.0881	88.1	0.017	1.50	0.009	0.79	0.006	0.53	0.001	0.09	0.000	0.00
CU10	DU2	Profile 1	6.75	CU10_DU2_1	0.4841	484.1	0.140	67.77	0.099	47.93	0.073	35.34	0.039	18.88	0.009	4.36
CU10	DU3	Profile 1	7.73	CU10_DU3_1	0.3964	396.4	0.027	10.70	0.016	6.34	0.011	4.36	0.003	1.19	0.000	0.00
CU10	DU4	Profile 1	7.89	CU10_DU4_1	0.3102	310.2	0.018	5.58	0.010	3.10	0.006	1.86	0.001	0.31	0.000	0.00
CU11	DU3	Profile 1	8.3	CU11_DU3_1	0.1179	117.9	0.001	0.12	0.000	0.04	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU4	Profile 1	10.24	CU11_DU4_1	0.0486	48.6	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU5	Profile 1	7.65	CU11_DU5_1	0.1661	166.1	0.012	1.99	0.006	1.00	0.003	0.50	0.001	0.17	0.000	0.00
CU11	DU7	Profile 1	9.17	CU11_DU7_1	0.384	384	0.003	1.15	0.002	0.77	0.001	0.38	0.000	0.00	0.000	0.00
CU11	DU8	Profile 1	7.02	CU11_DU8_1	0.613	613	0.034	20.84	0.020	12.26	0.015	9.20	0.006	3.68	0.001	0.61
CU11	DU9	Profile 1	8.03	CU11_DU9_1	0.35	350	0.028	9.80	0.017	5.95	0.011	3.85	0.004	1.40	0.000	0.11
CU11	DU10	Profile 1	7.56	CU11_DU10_1	0.18	180	0.007	1.26	0.003	0.54	0.002	0.36	0.000	0.07	0.000	0.00
CU11	DU10	Profile 2	9.81	CU11_DU10_2	0.494	494	0.002	0.99	0.001	0.49	0.000	0.15	0.000	0.00	0.000	0.00
CU12	DU2	Profile 1	8.45	CU12_DU2_1	3.187	3187	0.000	0.64	0.000	0.32	0.000	0.00	0.000	0.00	0.000	0.00
CU17	DU2	Profile 1	6.72	CU17_DU2_1	0.2222	222.2	0.010	2.22	0.003	0.67	0.002	0.44	0.000	0.02	0.000	0.00
CU17	DU3	Profile 1	6.98	CU17_DU3_1	0.1128	112.8	0.005	0.56	0.001	0.11	0.001	0.11	0.000	0.00	0.000	0.00
CU17	DU4	Profile 1	5.58	CU17_DU4_1	0.2533	253.3		0.00		0.00		0.00	0.057	14.44	0.016	4.05
CU17	DU5	Profile 1	7.07	CU17_DU5_1	0.2248	224.8	0.013	2.92	0.006	1.35	0.005	1.12	0.002	0.45	0.000	0.00
CU18	DU5	Profile 1	8.56	CU18_DU5_1	0.1483	148.3	0.000	0.06	0.000	0.03	0.000	0.00	0.000	0.00	0.000	0.00
CU18	DU6	Profile 1	7.6	CU18_DU6_1	0.209	209	0.003	0.63	0.002	0.42	0.001	0.21	0.000	0.04	0.000	0.00
CU19	DU1	Profile 1	7.09	CU19_DU1_1	0.1361	136.1	0.008	1.09	0.005	0.68	0.003	0.41	0.001	0.14	0.000	0.00
CU19	DU3	Profile 1	7.4	CU19_DU3_1	0.316	316	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU19	DU4	Profile 1	6.71	CU19_DU4_1	0.2944	294.4	0.022	6.48	0.015	4.42	0.011	3.24	0.002	0.59	0.000	0.00
CU19	DU4	Profile 2	7.7	CU19_DU4_2	0.1592	159.2	0.002	0.32	0.001	0.16	0.000	0.06	0.000	0.00	0.000	0.00
CU19	DU5	Profile 1	7	CU19_DU5_1	0.1034	103.4	0.005	0.52	0.001	0.10	0.001	0.10	0.000	0.00	0.000	0.00
CU19	DU7	Profile 1	7.41	CU19_DU7_1	0.2888	288.8	0.000	0.03	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU19	DU7	Profile 2	6.82	CU19_DU7_2	0.0807	80.7	0.004	0.32	0.001	0.08	0.000	0.03	0.000	0.00	0.000	0.00
CU19	DU8	Profile 1	6.85	CU19_DU8_1	0.1789	178.9	0.004	0.72	0.002	0.36	0.001	0.18	0.000	0.05	0.000	0.00
CU19	DU9	Profile 1	6.62	CU19_DU9_1	0.3874	387.4	0.004	1.55	0.002	0.77	0.000	0.12	0.000	0.08	0.000	0.00

(Pink) Where still water level above Amazon defence crest

Epoch	0														
Scenario	**3**				Return Period		250		100		50		10		1
Coastal Unit	Defence Unit	Profile name	Crest height		Length (Km)	Length (m)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)	Overtopping rate (m3/s/m)	Overtopping quantity (m3/s)
CU3	DU1	Profile 1	8.79	CU3_DU1_1	0.414	414	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU2	Profile 1	11.17	CU3_DU2_1	0.25	250	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU3	Profile 1	8.31	CU3_DU3_1	0.393	393	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU4	Profile 1	8.57	CU3_DU4_1	0.1034	103.4	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU4	Profile 2	8.7	CU3_DU4_2	0.224	224	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU5	Profile 1	8.84	CU3_DU5_1	0.1204	120.4	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU5	Profile 2	8.32	CU3_DU5_2	0.1401	140.1	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU5	Profile 3	7.66	CU3_DU5_3	0.1743	174.3	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU3	DU5	Profile 4	7.36	CU3_DU5_4	0.0881	88.1	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU10	DU2	Profile 1	6.75	CU10_DU2_1	0.4841	484.1	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU10	DU3	Profile 1	7.73	CU10_DU3_1	0.3964	396.4	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU10	DU4	Profile 1	7.89	CU10_DU4_1	0.3102	310.2	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU3	Profile 1	8.3	CU11_DU3_1	0.1179	117.9	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU4	Profile 1	10.24	CU11_DU4_1	0.0486	48.6	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU5	Profile 1	7.65	CU11_DU5_1	0.1661	166.1	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU7	Profile 1	9.17	CU11_DU7_1	0.384	384	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU8	Profile 1	7.02	CU11_DU8_1	0.613	613	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU9	Profile 1	8.03	CU11_DU9_1	0.35	350	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU10	Profile 1	7.56	CU11_DU10_1	0.18	180	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU11	DU10	Profile 2	9.81	CU11_DU10_2	0.494	494	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU12	DU2	Profile 1	8.45	CU12_DU2_1	3.187	3187	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU17	DU2	Profile 1	6.72	CU17_DU2_1	0.2222	222.2	0.048	10.67	0.035	7.78	0.022	4.89	0.010	2.22	0.001	0.22
CU17	DU3	Profile 1	6.98	CU17_DU3_1	0.1128	112.8	0.008	0.90	0.004	0.45	0.003	0.34	0.001	0.11	0.000	0.00
CU17	DU4	Profile 1	5.58	CU17_DU4_1	0.2533	253.3		0.00		0.00		0.00	0.167	42.30	0.032	8.11
CU17	DU5	Profile 1	7.07	CU17_DU5_1	0.2248	224.8	0.003	0.67	0.002	0.45	0.002	0.45	0.001	0.22	0.000	0.00
CU18	DU5	Profile 1	8.56	CU18_DU5_1	0.1483	148.3	0.009	1.33	0.006	0.89	0.004	0.59	0.002	0.30	0.000	0.01
CU18	DU6	Profile 1	7.6	CU18_DU6_1	0.209	209	0.006	1.25	0.003	0.63	0.002	0.42	0.001	0.21	0.000	0.00
CU19	DU1	Profile 1	7.09	CU19_DU1_1	0.1361	136.1	0.027	3.67	0.020	2.72	0.014	1.91	0.007	0.95	0.001	0.14
CU19	DU3	Profile 1	7.4	CU19_DU3_1	0.316	316	0.004	1.26	0.002	0.63	0.001	0.32	0.000	0.13	0.000	0.00
CU19	DU4	Profile 1	6.71	CU19_DU4_1	0.2944	294.4	0.051	15.01	0.036	10.60	0.026	7.65	0.013	3.83	0.003	0.88
CU19	DU4	Profile 2	7.7	CU19_DU4_2	0.1592	159.2	0.003	0.48	0.002	0.32	0.001	0.16	0.000	0.03	0.000	0.00
CU19	DU5	Profile 1	7	CU19_DU5_1	0.1034	103.4	0.004	0.41	0.002	0.21	0.001	0.10	0.000	0.02	0.000	0.00
CU19	DU7	Profile 1	7.41	CU19_DU7_1	0.2888	288.8	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00
CU19	DU7	Profile 2	6.82	CU19_DU7_2	0.0807	80.7	0.004	0.32	0.002	0.16	0.001	0.08	0.000	0.02	0.000	0.00
CU19	DU8	Profile 1	6.85	CU19_DU8_1	0.1789	178.9	0.006	1.07	0.004	0.72	0.002	0.36	0.001	0.13	0.000	0.00
CU19	DU9	Profile 1	6.62	CU19_DU9_1	0.3874	387.4	0.026	10.07	0.017	6.59	0.012	4.65	0.005	1.94	0.000	0.00

(pink) Where still water level above Amazon defence crest



Key:

Flood Extents

- Current Day 1 in 1 year event
- Current Day 1 in 10 year event
- Current Day 1 in 50 year event
- Current Day 1 in 100 year event
- Current Day 1 in 250 year event

Terrain m AOD

-39 - 0	40 - 45
0 - 5	45 - 50
5 - 10	50 - 55
10 - 15	55 - 60
15 - 20	60 - 65
20 - 25	65 - 70
25 - 30	70 - 75
30 - 35	75 - 80
35 - 40	80 - 85
	85 - 90
	90 - 95

Source:
(c) State opf Guernsey. License no. 151

Title:
Overview
2061 Flood Outline

Project:
Guernsey Coastal Defences
Further Studies

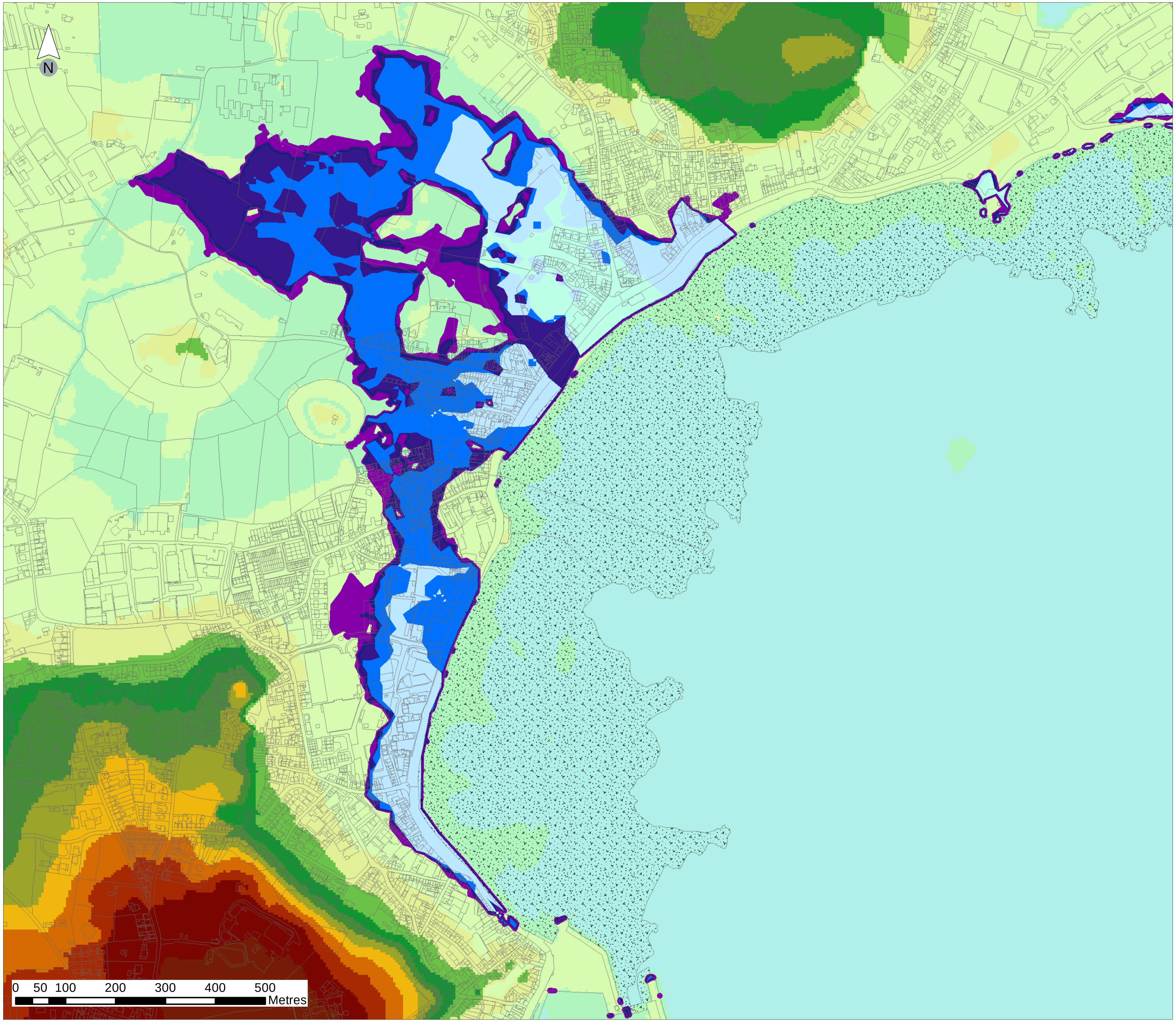
Client:
States of Guernsey

Date: April 2011

Scale: 1:50,000 @ A3

Figure: Appendix D1.1

ROYAL HASKONING



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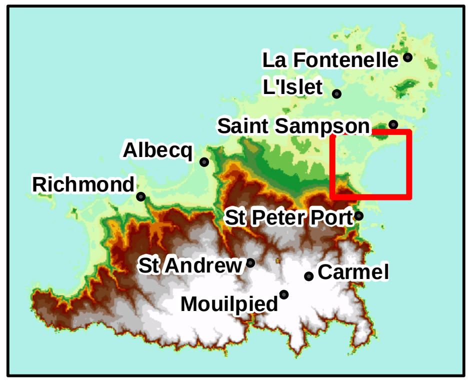

Source:
(c) State of Guernsey. License no. 151

Title:
Belle Greve Bay
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

Client:
States of Guernsey

Date:
April 2011

Scale:
1:7,500 @ A3

Figure:
Appendix D1.2

ROYAL HASKONING

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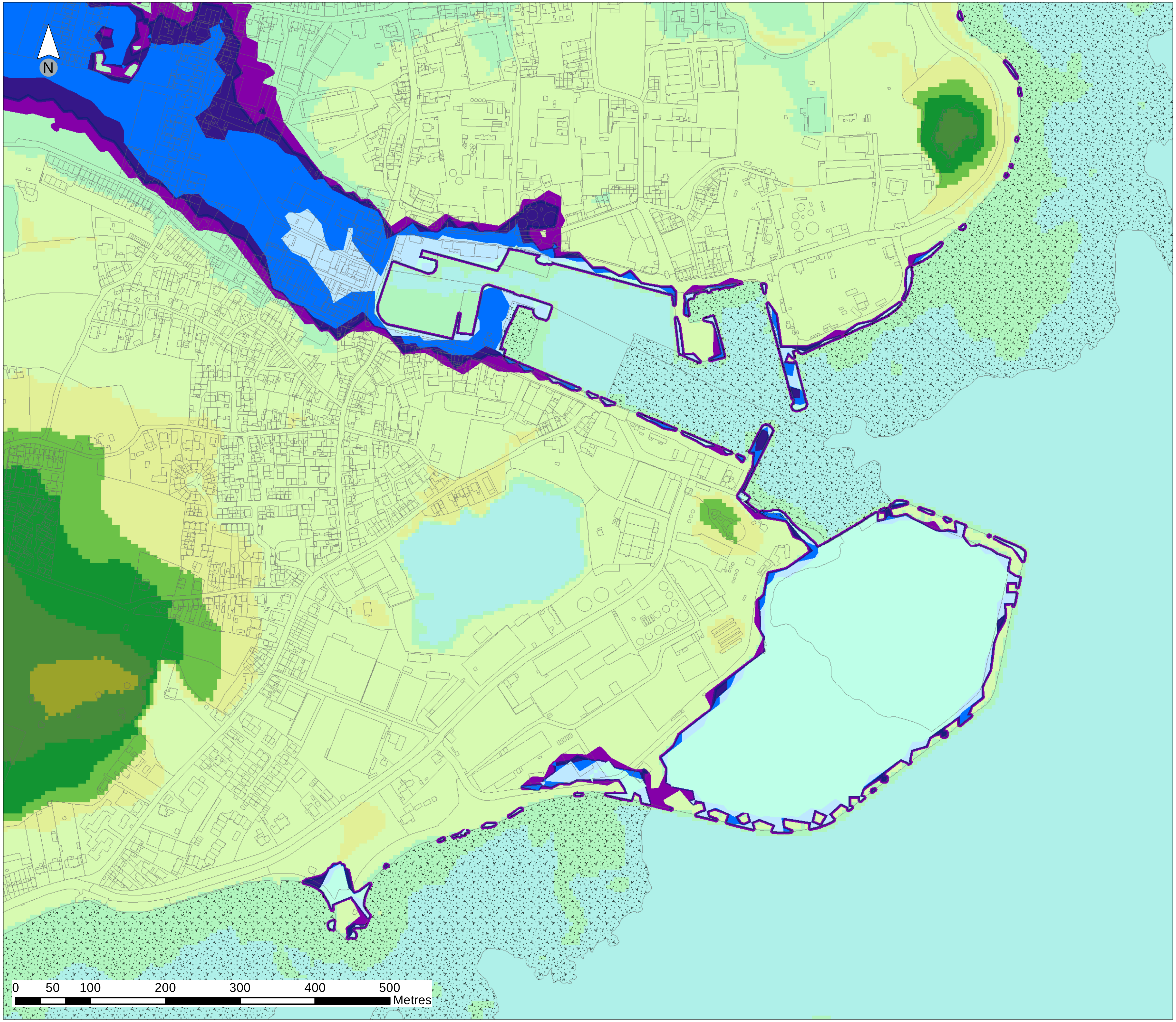

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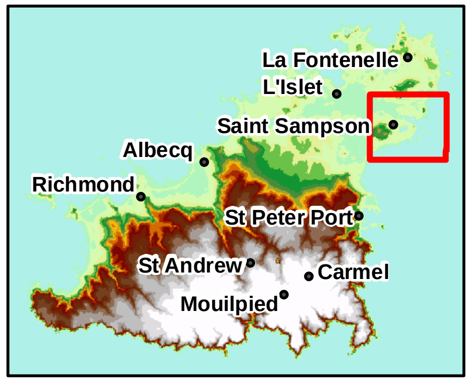

Source:
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Title:
Saint Sampson Bay
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

Client:
States of Guernsey

Date:	Scale:
April 2011	1:5,000 @ A3

Figure:
Appendix D1.3

ROYAL HASKONING

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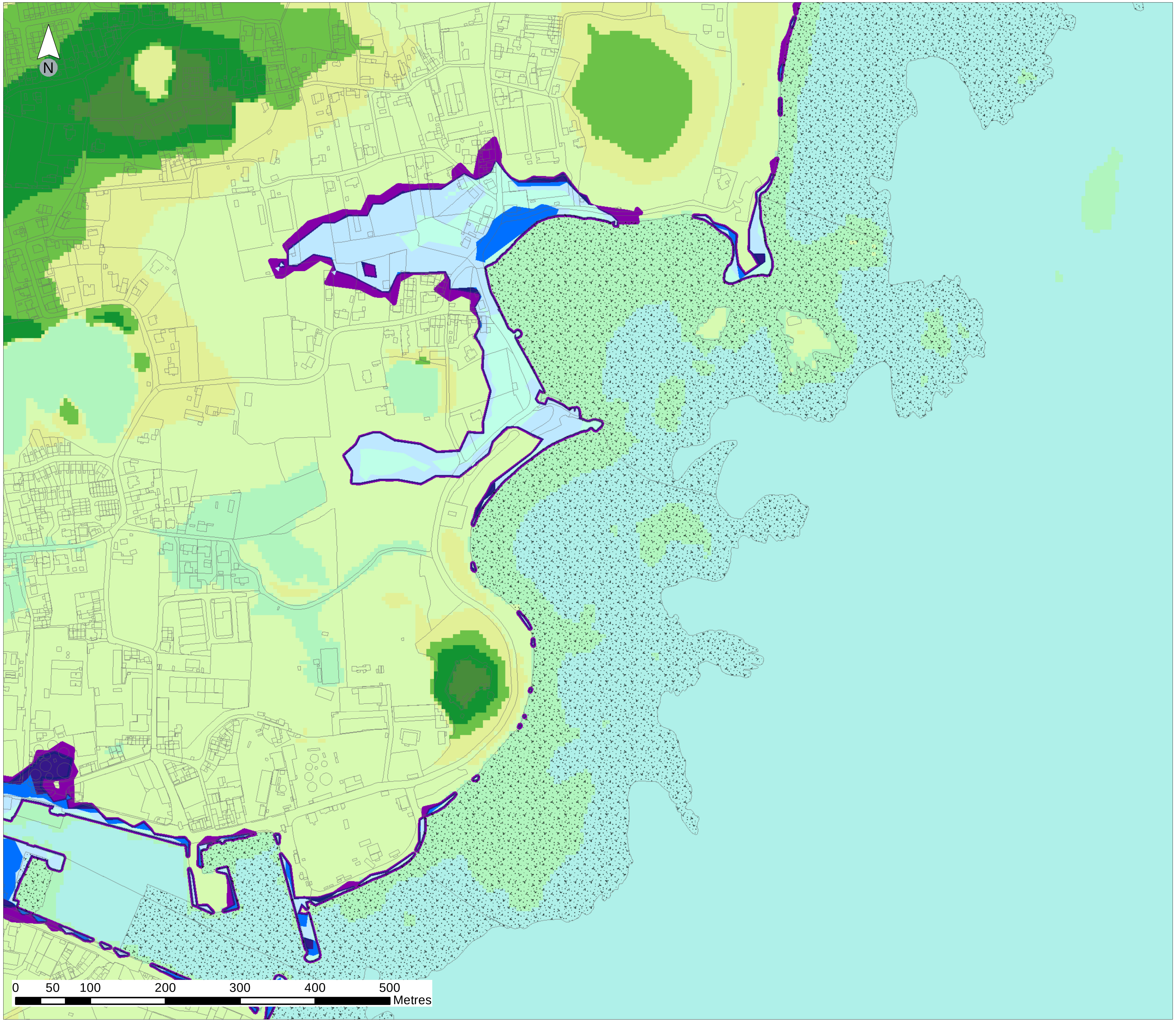

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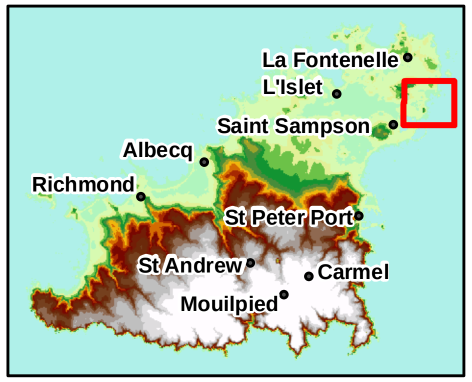

Source:
(c) State of Guernsey. License no. 151

Title:
Bordeaux Harbour
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

Client:
States of Guernsey

Date:
April 2011

Scale:
1:5,000 @ A3

Figure:
Appendix D1.4

ROYAL HASKONING

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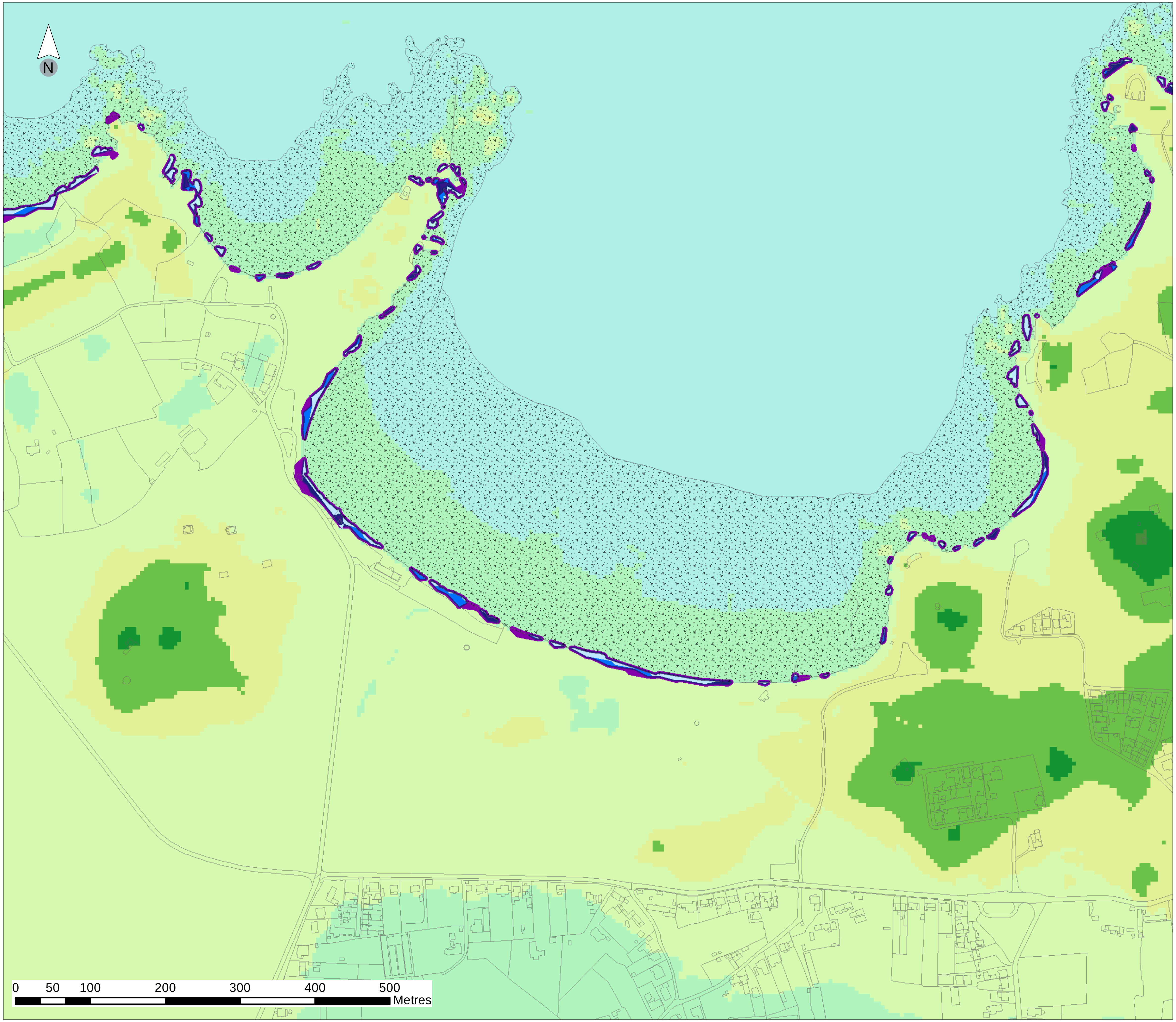

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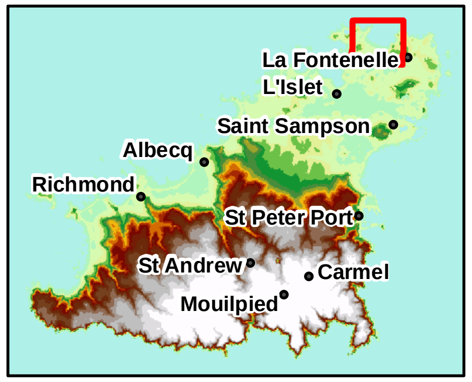

Source:
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Title:
Pembroke Bay
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

Client:
States of Guernsey

Date:
April 2011

Scale:
1:5,000 @ A3

Figure:
Appendix D1.5

ROYAL HASKONING

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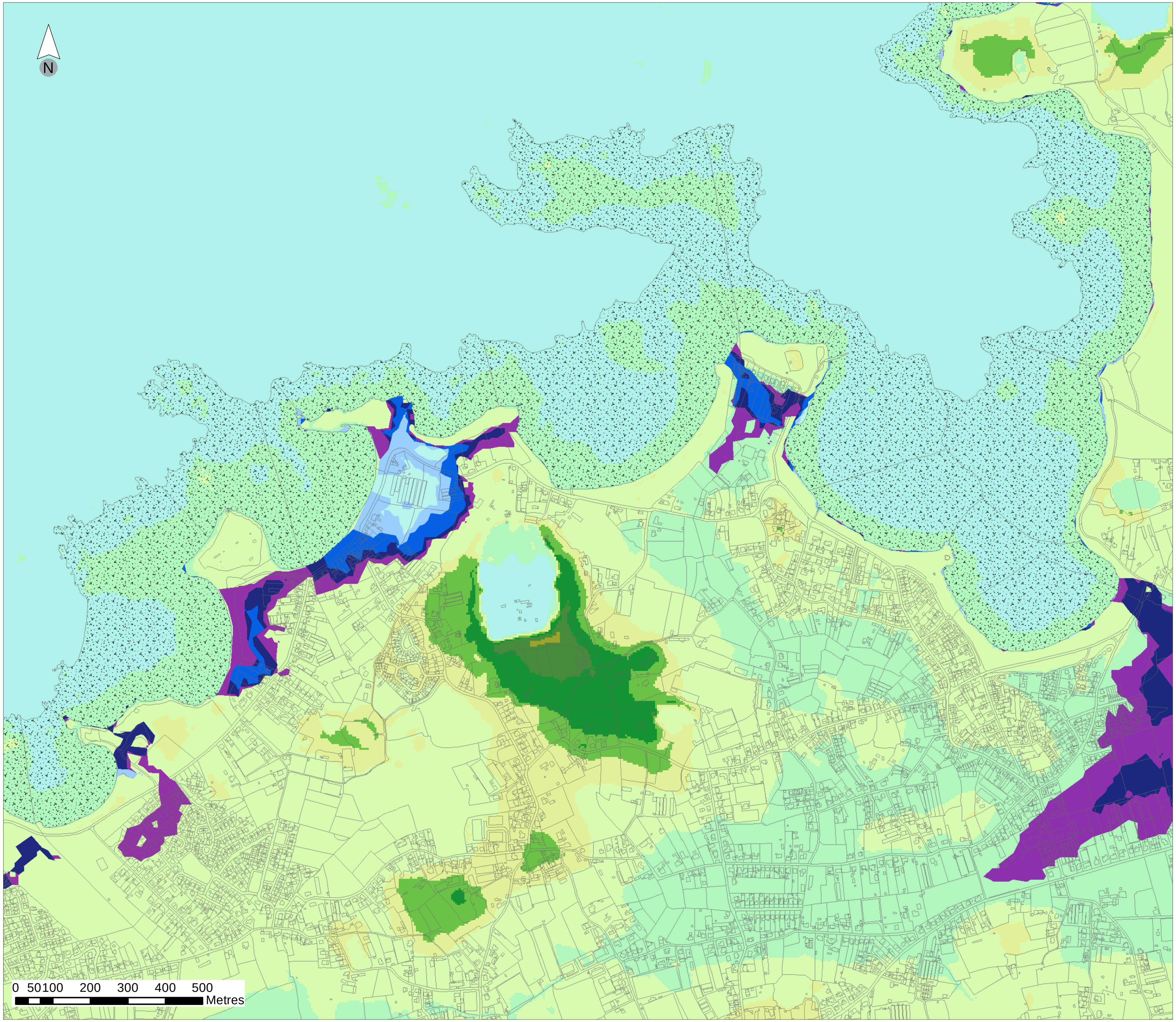

Key:

- Current Day 1 in 1 year event
- Current Day 1 in 10 year event
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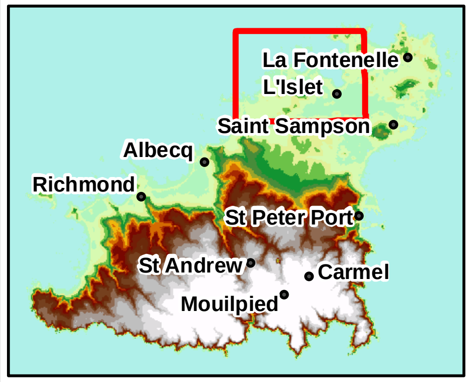


Source:

Title:
Le Grand Havre & Baie de Port Grat
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

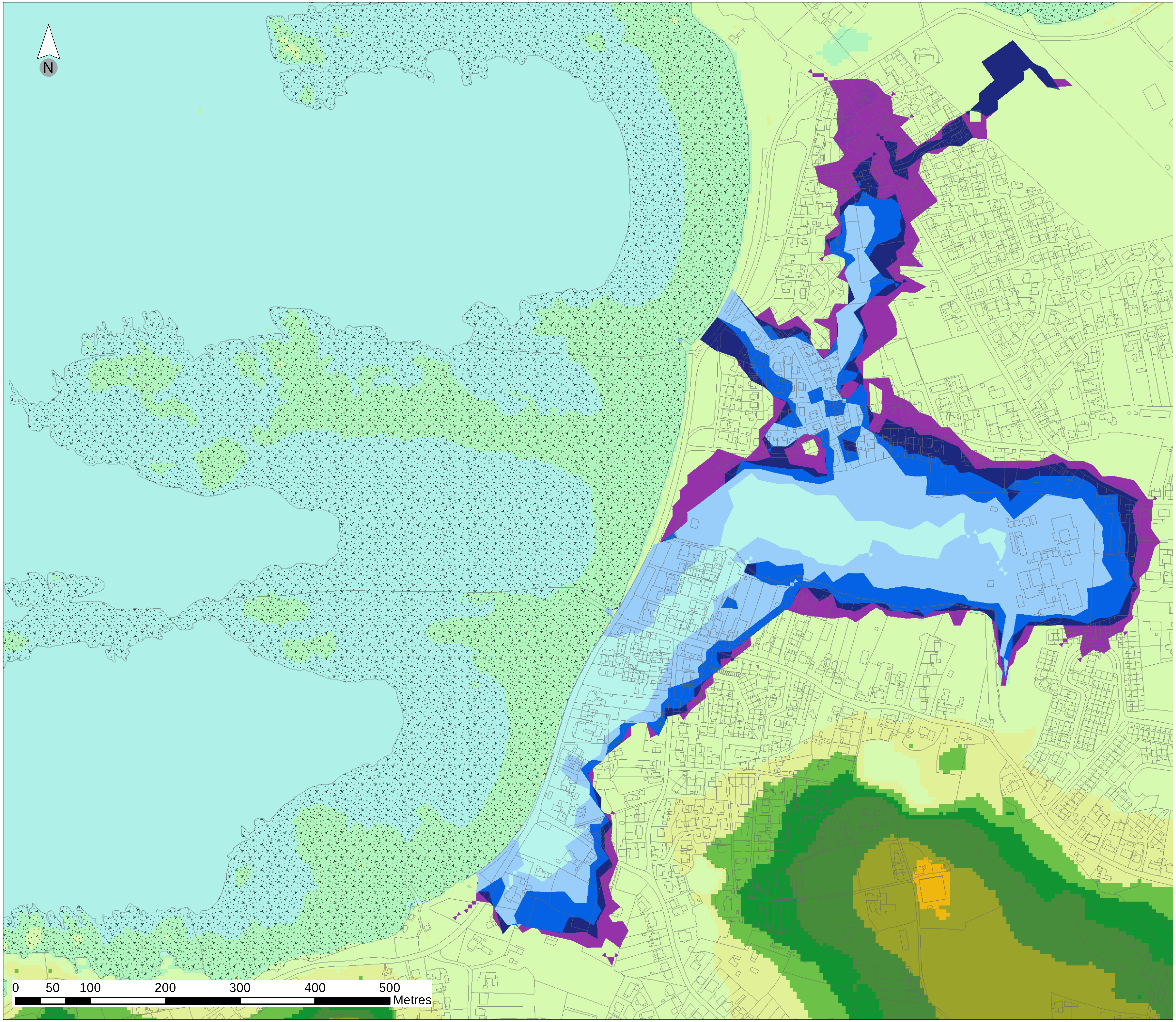
Client:
States of Guernsey

Date:
April 2011

Scale:
1:10,000 @ A3

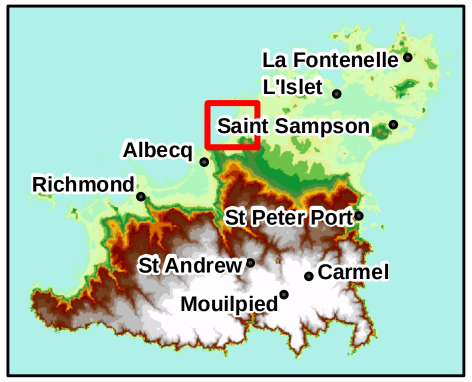
Figure:
Appendix D1.6

ROYAL HASKONING



Key:

- Current Day 1 in 1 year event
- Current Day 1 in 10 year event
- Current Day 1 in 50 year event
- Current Day 1 in 100 year event
- Current Day 1 in 250 year event



Source:
(c) State of Guernsey. License no. 151

Title:
Cobo Bay
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

Client:
States of Guernsey

Date:	Scale:
April 2011	1:5,000 @ A3

Figure:
Appendix D1.7

ROYAL HASKONING

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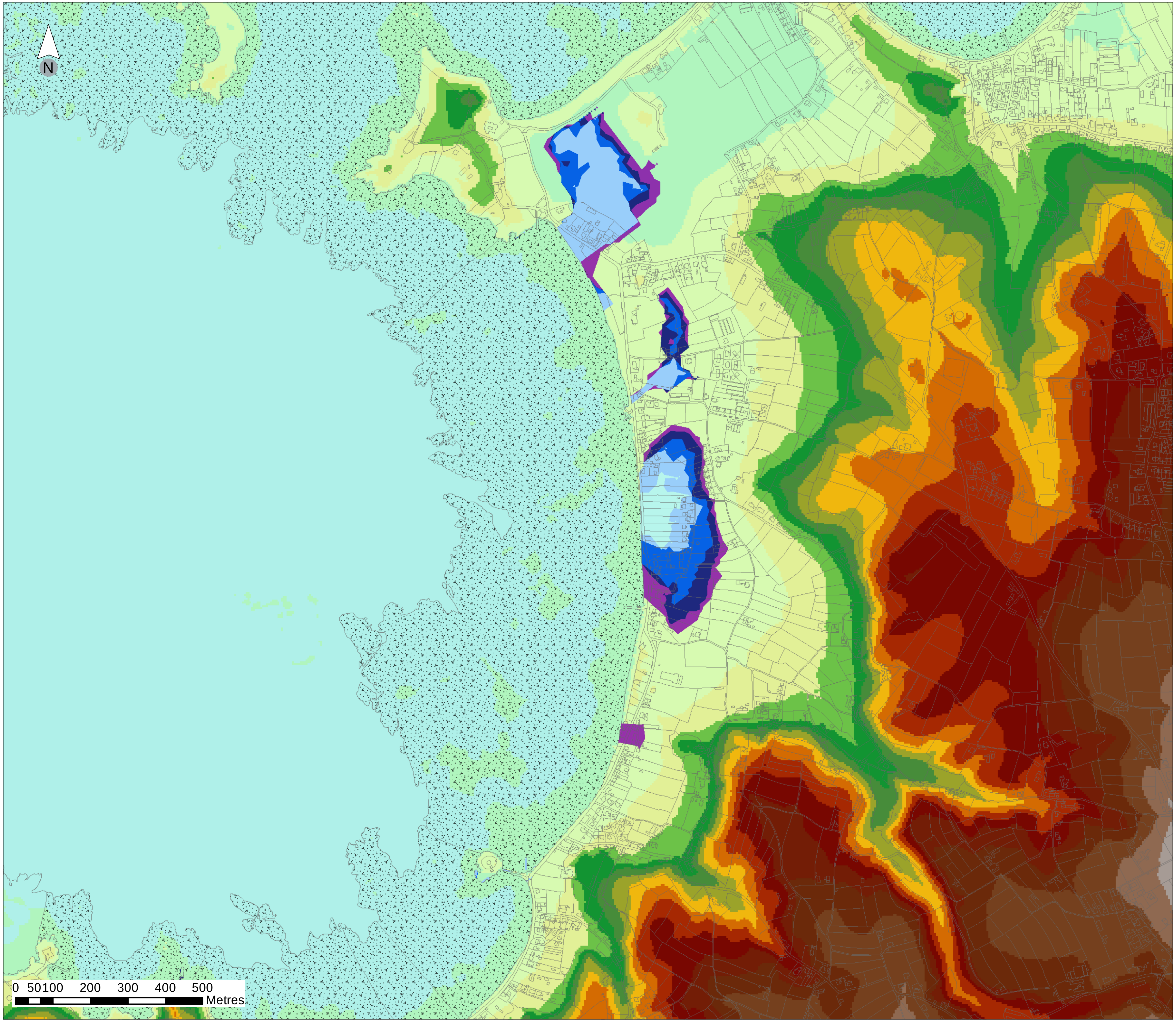
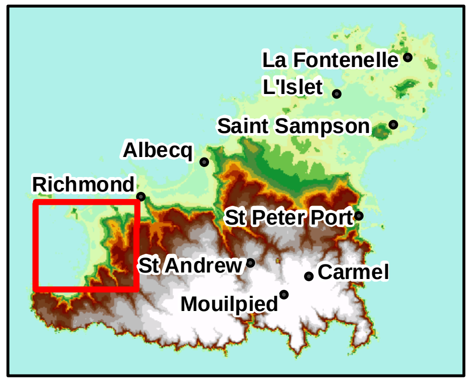


Key:

Current Day 1 in 1 year event
Current Day 1 in 10 year event
Current Day 1 in 50 year event
Current Day 1 in 100 year event
Current Day 1 in 250 year event



Source:
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Title:
Roquanine Bay
Current Day Flood Extents

Project:
Guernsey Coastal Defences
Further Studies

Client:
States of Guernsey

Date:
April 2011

Scale:
1:10,000 @ A3

Figure:
Appendix D1.8

ROYAL HASKONING

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Appendix E
Economic Appendix

States of Guernsey

May 2012
Final Report
9W2890

A COMPANY OF

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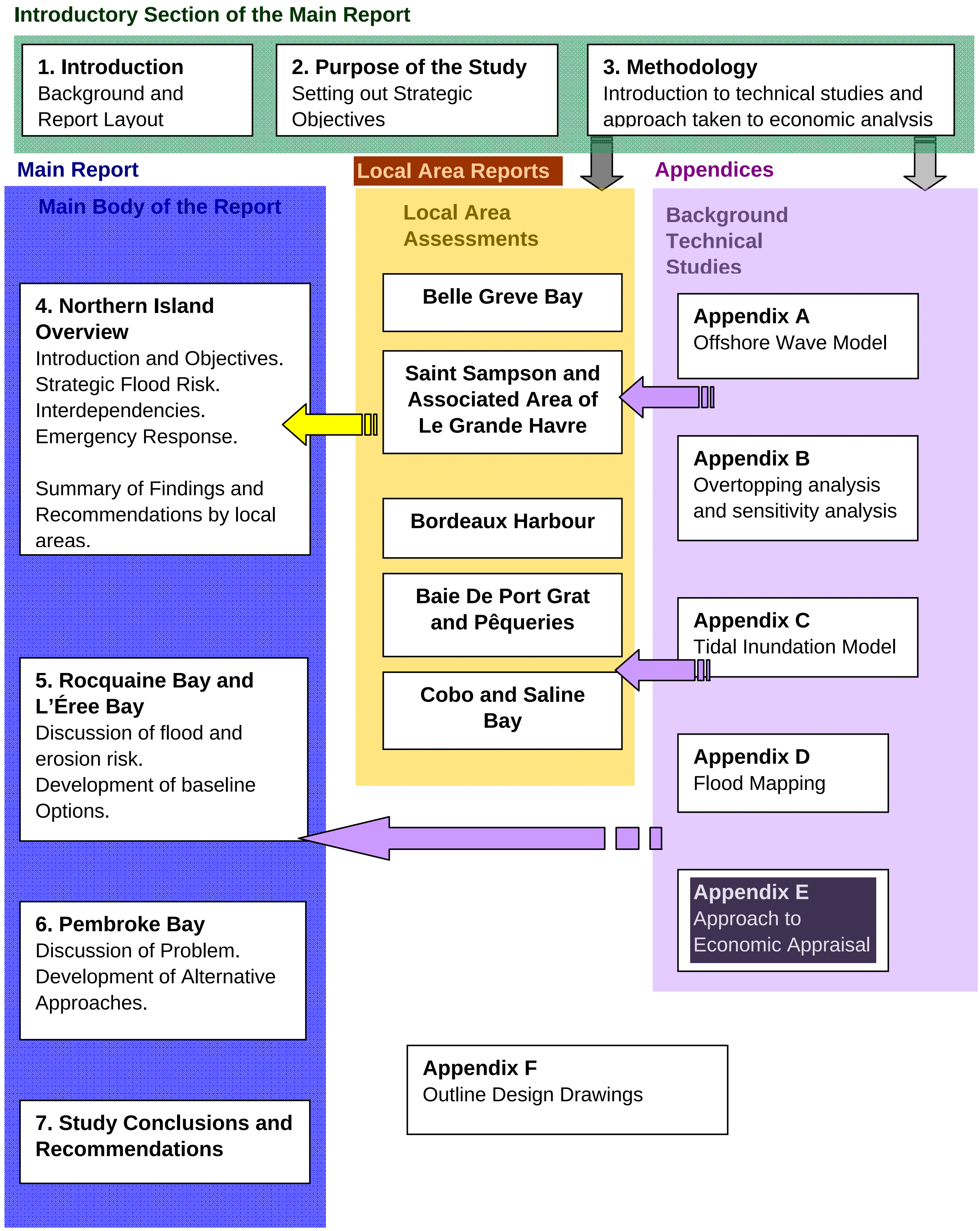
Document title	Appendix E Economic Appendix
Document short title	
Status	Final Report
Date	May 2012
Project name	Guernsey Coastal Defences – Flood Risk Assessment Studies
Project number	9W2890
Client	States of Guernsey
Reference	9W2890/R/303666/Exet

Drafted by	Ben Orriss / JGL Guthrie	
Checked by	Tara Leigh Eggiman	
Date/initials check	………………….	………………….
Approved by	Greg Guthrie	
Date/initials approval	………………….	………………….

OVERALL REPORT STRUCTURE



ROYAL HASKONING

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1 INTRODUCTION

To provide a basis for the selection of the preferred flood defence strategy for Guernsey an economic assessment of the damages caused by flooding was undertaken for the chosen study areas.

This economic assessment was undertaken for the following study area:

- Belle Greve Bay (Coastal Unit 19)
- St Sampson (Coastal Unit 18)
- Bordeaux Harbour (Coastal Unit 17)
- Le Grande Havre (Coastal Unit 12)
- Baie de Prot Grat and Pequerues (Coastal Unit 11)
- Cobo Bay (Coastal Unit 10)
- Rocquaine Bay (Coastal Unit 3)

Flood damages for each of the study areas were calculated and appropriate design options were costed.

1.1 Benefits of the 2011 study

The 2007 Strategy document calculated damages on Guernsey from an assumed flood level of 6.0mGG applied evenly across the island. This value was chosen based on the Highest Astronomical Tide of 5.34mGG and an allowance for storm surge conditions. The combinations of events were assumed to be exceeded typically every 5 -10 years, resulting in the assumed flood extent.

With the benefit of the new hydraulic models: Mike 21, Amazon and TUFLOW; we were able to represent more accurately the anticipated flood extent across the island for a range of return periods. The information provided by the Mike 21 model, Amazon and TUFLOW modeling allowed property flood depths to be calculated, and therefore a more accurate assessment of flood damages based on the frequency of property flooding.

1.2 Review of Coastal Flooding Damages

The flood extents calculated from the overtopping of the coastal structures were provided using the 2 – Dimensional hydraulic model, TUFLOW. Anticipated flood extends are provided in Appendix D.

2 METHODOLOGY

This section describes the methodology for the economic assessment of flood risk. The method adopted is outlined, comprising of two principle elements: input data sources and economic procedure:

2.1 Input data for the assessment of flood depths

i) Overtopping or outflanking of defences was calculated using our in house model overtopping model AMAZON. The input conditions were tide levels and wave heights from the MIKE 21 Model developed by Royal Haskoning.

ii) The predicted flood extents were calculated using the 2 – Dimensional hydraulic model, TUFLOW. This provided a numbers of properties and flood depths at a range of return periods.

iii) The effects of future climate change was incorporated into the economic assessment according to the guidance provided in the UKCP09 document. This took account of the effects of eustatic and isostatic variation in sea levels applicable to Guernsey.

iv) Following from the modelling output the results were assessed and the best method to evaluate the flood risk in the study area was decided. This was determined by the number of potential flood routes within the study area and determining any areas at risk of flooding from multiple sources.

2.2 Input data for property threshold levels

i) Information regarding property types and floor area (where required) was obtained from GIS data. Digital Terrain Models (DTMs) and accompanying property datasets provided approximated threshold levels for properties. Digimap Ltd provided topographic (spot levels) data, bathymetric data and property data sets. Topographic data was supplemented by survey data compiled by a Royal Haskoning sub-consultant.

ii) Threshold levels were assumed as a uniform value above surrounding ground level. A suitable universal threshold value of 200mm was assumed based on inspection of a limited selection of properties during a site visit. This approach provided values for the calculation of flood damages without the need for extensive property surveying.

2.3 Economic Evaluation Procedure

The economic assessment was completed using methods contained within the Multi Coloured Manual, 2005 (MCM) and Multi Coloured Handbook, 2010 (MCH) produced by the Flood Hazard Research Centre. The appraisal period was 100 years. The implications of climate change were included in the assessment to ensure flood protection to properties was maintained during the 100 year appraisal period.

The economic assessments required a baseline scenario for benefits to be calculated against. For this report the baseline was developed using the current 'do existing' situation; continual maintenance of the existing coastal and inland structures. This method allowed the damages associated with the overtopping of the defences to be calculated respective to the current situation.

Structures providing flood defence were assumed to be maintained in a functional condition for the next 100 years. Where we considered the risk of failure of the structure within 100 years is significant/likely, we reviewed the flood mechanism and considered the site in more detail.

Damages were assessed at a number of different return periods for each site to ensure that damages are calculated close to the threshold of flooding, to improve accuracy. Present values damages (PVd) (the discounted total damages that will occur over the 100 year appraisal period) were capped at the local market values, where appropriate. Local and open market property information for Guernsey was derived using the last four quarter prices (to remove seasonal variation), 2009-2010, provided by the Policy Council. The assessment process focused on the assessment of damages and benefits for the highest value assets (residential and non-residential properties). Recreational and agricultural benefits / damages were identified but not evaluated.

Using expert judgement we estimated whole life costs for the options being appraised. For appraisals in the UK an allowance for Optimism Bias is usually applied to the costs, initially at 60% at appraisal stage, reducing as the designs are developed and finalised. A similar approach was taken in assessing potential management options, allowing for uncertainty.

The discount rate (the annual percentage rate at which the present value of a future pound is assumed to fall away through time) was as set out in the HM Treasury Green Book (the Green Book sets out the core principles for all economic assessment in the public sector for the UK). The discount rates are as follows:

0 - 30 years	3.5%
31-75 years	3.0%
76-125 years	2.5%

Royal Haskoning also undertook a sensitivity analysis and robustness test to determine whether, within the reasonable bounds of confidence:

- the project is economically worthwhile (benefits outweigh the costs)
- the option choice is robust (where the option choice would not change to another option under reasonable changes to the assumptions made during the appraisal).

3 DAMAGES

The Coastal Units (CUs) were assessed to provide anticipated current day and future flood extends from each flood source (coastal unit). This output from the TU-FLOW modelling was reviewed and current day damage assessments were completed for each of the study areas using the approach described in section 2.

An example of the damages table produced for each of the coastal units assessed is provided below in table 3.1.

Table 3.1 – Example of Flood Damage estimation table

UBI	STOREYS	BUILD_H	SHAPE_AREA	TRP_TYPE	250 yr Flood depth with 200mm Threshold	100 yr Flood depth with 200mm Threshold	50 yr Flood depth with 200mm Threshold	10 yr Flood depth with 200mm Threshold	1 yr Flood depth with 200mm Threshold	Property SOP	WAAD Value - Part 1	WAAD Value - Part 2	NPv
24605	1	2.65	67.2595	Bungalow	0.66	0.56	0.48	0.31	0.09	0	8721	8721	260054
24603	1	2.83	113.995	Bungalow	0.63	0.55	0.47	0.32	0.13	0	8721	8721	260054
24648.01	1	2.87	31.1697	Commercial_Building	0.83	0.69	0.57	0.40	0.12	0	806	2314	69006
24648	2	5.3	59.4165	Commercial_Building	0.65	0.52	0.41	0.27	0.03	0	806	4273	127432
24631.01	2	5.15	18.8083	House	1.22	1.10	0.99	0.80	0.51	0	8721	8721	260054
24649.01	1	1.92	20.1678	House	0.66	0.53	0.42	0.28	0.01	0	8721	8721	260054
24672.01	1	3.16	20.9787	House	0.96	0.83	0.71	0.53	0.24	0	8721	8721	260054
24674.01	2	5.44	21.8532	House	1.35	1.22	1.11	0.90	0.61	0	8721	8721	260054
24612.02	1	2.15	26.025	House	0.82	0.70	0.59	0.40	0.12	0	8721	8721	260054
24634.02	1	2.63	34.7342	House	1.77	1.65	1.54	1.34	1.05	0	8721	8721	260054
24635	2	4.99	44.1129	House	1.38	1.26	1.15	0.95	0.87	0	8721	8721	260054
24631	2	5.08	45.5442	House	1.32	1.20	1.09	0.89	0.61	0	8721	8721	260054
24628	2	4.95	45.7114	House	0.70	0.59	0.50	0.32	0.07	0	8721	8721	260054
24629	2	4.9	45.9425	House	0.76	0.66	0.56	0.38	0.11	0	8721	8721	260054
24630	2	4.98	46.0825	House	0.90	0.79	0.68	0.50	0.23	0	8721	8721	260054
24634	2	4.95	46.4573	House	1.45	1.33	1.22	1.02	0.74	0	8721	8721	260054
24632	2	5.08	46.5402	House	1.09	0.96	0.85	0.66	0.36	0	8721	8721	260054
24633	2	5.11	46.8915	House	1.03	0.90	0.79	0.60	0.30	0	8721	8721	260054
24672	2	5.46	47.114	House	0.80	0.66	0.54	0.36	0.09	0	8721	8721	260054
24674	2	5.6	50.3263	House	1.09	0.96	0.84	0.63	0.34	0	8721	8721	260054
24852	2	5.22	50.5653	House	0.84	0.72	0.60	0.31	0.03	0	8721	8721	260054
24673	2	5.48	51.2789	House	0.94	0.81	0.69	0.49	0.21	0	8721	8721	260054
24853	2	5.21	51.9687	House	0.82	0.70	0.58	0.30	0.01	0	8721	8721	260054
24641	2	7.47	70.5229	House	0.64	0.52	0.41	0.21	0.04	0	8721	8721	260054
24642	2	8.89	87.5897	House	1.06	0.94	0.82	0.62	0.34	0	8721	8721	260054
6711	3	8.15	22.0431	Apartment_Block	0.43	0.37	0.32	0.17	9999.00	1	8721	8721	260054
6968	2	9.88	25.4949	Apartment_Block	0.68	0.62	0.56	0.42	9999.00	1	8721	8721	260054
6887	5	15.6	30.1185	Apartment_Block	0.50	0.41	0.32	0.04	9999.00	1	8721	8721	260054
6961	4	12.2	30.1195	Apartment_Block	0.75	0.69	0.64	0.51	9999.00	1	8721	8721	260054
6922	4	12.2	30.1196	Apartment_Block	0.43	0.34	0.26	0.06	9999.00	1	8721	8721	260054
6975	3	9.65	33.9899	Apartment_Block	1.25	1.19	1.13	0.99	-9999.00	1	8721	8721	260054
24610.01	1	3.21	41.0605	Apartment_Block	0.46	0.35	0.25	0.06	9999.00	1	8721	8721	260054
6930	2	6.45	53.2473	Apartment_Block	0.47	0.39	0.30	0.08	9999.00	1	8721	8721	260054
6948	2	6.45	53.2475	Apartment_Block	0.59	0.53	0.46	0.31	9999.00	1	8721	8721	260054
6969	1	3.21	54.6991	Apartment_Block	1.11	1.06	1.00	0.86	9999.00	1	8721	8721	260054
6980	1	3.21	67.9202	Apartment_Block	1.21	1.15	1.09	0.95	-9999.00	1	8721	8721	260054
6972	1	3.21	67.9202	Apartment_Block	1.21	1.15	1.09	0.95	9999.00	1	8721	8721	260054
6987	1	3.21	67.9202	Apartment_Block	1.21	1.15	1.09	0.95	9999.00	1	8721	8721	260054
6993	1	2.71	70.1966	Apartment_Block	0.49	0.43	0.38	0.23	9999.00	1	8721	8721	260054

This damage assessment was undertaken for the following study area:

- Belle Greve Bay (Coastal Unit 19)
- St Sampson (Coastal Unit 18)
- Bordeaux Harbour (Coastal Unit 17)
- Le Grande Havre (Coastal Unit 12)
- Baie de Prot Grat and Pequerues (Coastal Unit 11)
- Cobo Bay (Coastal Unit 10)
- Rocquaine Bay (Coastal Unit 3)

Due to the large size of the spreadsheets required for this process, this data is provided in an electronic format separately.

4 OPTION COSTS

An economic appraisal of the design options proposed in each of the study areas was completed. Option costs for the options discussed in the main report are provided in this section. The appraisal results for the individual coastal units are identified individually.

Option costs are provided for the following study areas:

- Belle Greve Bay (Coastal Unit 19)
- St Sampson (Coastal Unit 18)
- Bordeaux Harbour (Coastal Unit 17)
- Le Grande Havre (Coastal Unit 12)
- Baie de Prot Grat and Pequerues (Coastal Unit 11)
- Cobo Bay (Coastal Unit 10)

4.1 Belle Greve Bay (Coastal Unit 19)

Strategic Option S1

S1 initial works to DU4
S1 initial works to DU5
S1 initial works to DU8/9

Strategic Option S2

Strategic Option S3

Short term works options:

DU4
DU5
DU8/9

Belle Greve Bay - Strategic Option S1

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
general maintenance				£	1,500
Annual Total				£	1,500
PV total				£	***44,700***
Nominal value				£	**50,000**
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
420m embankment in Defence Unit 4 parallel to Les Bas Courtils Road (19m2 section)	7980	45	m3	£	359,100
1 No flood gates	1	50000	Gate	£	50,000
DU 5 raise wall by 0.5m	110	1000	m	£	110,000
4 No. flood gates	4	50000	Gate	£	200,000
				£	-
DU 9 raise wall by 0.65	350	2800	m	£	980,000
DU7/8 raise wall by 0.5m	280	2000	m	£	560,000
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**2,259,100**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	406,638
Other misc. Construction Costs		3%		£	56,478
Sub total				£	*463,116*
Nominal percentage		**25%**		**£**	**564,775**
Construction costs total				**£**	**2,823,875**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	14,119
Consultant costs inc RC design costs & detailing		9.5%		£	268,268
Site Supervision (including ECC PM)		3.5%		£	98,836
Site Investigation Costs		0.3%		£	8,472
ECI Costs		0.5%		£	14,119
Utility Diversion Costs		1.0%		£	28,239
Statutory Approval Costs		0.2%		£	5,648
Compensation and Land Purchase Costs		1.0%		£	28,239
Land Agents Costs		0.4%		£	11,296
PR Costs		0.4%		£	11,296
Sub total				£	*488,530*
nominal percentage sub total		20%		£	**564,775**
Total (Construction+Fees)				**£**	**3,388,650**
Optimism Bias					
Optimism Bias		60%		£	2,033,190
Future works					
Wall raising in Defence Units 3, 5, 7, 8, 9 (total 1169Lm)	1169	3000	m	£	711,921
crest wall DU4 (420m)	420	1500	m	£	127,890
sub total				£	**839,811**
Total Option Cost				**£**	**6,311,651**

Belle Greve Bay - Strategic Option S1, DU4 Local

Maintenance Costs	Quty	Rate	Unit		Annual Cost
general maintenance					
Annual Total				£	-
PV total				£	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
420m embankment in Defence Unit 4 parallel to Les Bas Courtils Road (19m2 section)	7980	45	m3	£	359,100
1 No flood gates	1	50000	Gate	£	50,000
		1000	m	£	-
		50000	Gate	£	-
				£	-
		2800	m	£	-
		2000	m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**409,100**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	73,638
Other misc. Construction Costs		3%		£	10,228
Sub total				*£*	*83,866*
Nominal percentage		25%		£	**102,275**
Construction costs total				£	**511,375**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	2,557
Consultant costs inc RC design costs & detailing		9.5%		£	48,581
Site Supervision (including ECC PM)		3.5%		£	17,898
Site Investigation Costs		0.3%		£	1,534
ECI Costs		0.5%		£	2,557
Utility Diversion Costs		1.0%		£	5,114
Statutory Approval Costs		0.2%		£	1,023
Compensation and Land Purchase Costs		1.0%		£	5,114
Land Agents Costs		0.4%		£	2,046
PR Costs		0.4%		£	2,046
Sub total				*£*	*88,468*
nominal percentage sub total		20%		£	**102,275**
Total (Construction+Fees)				**£**	**613,650**
Optimism Bias					
Optimism Bias		60%		£	368,190
Future works					
		3000	m	£	-
		1500	m	£	-
sub total				£	-
Total Option Cost				**£**	**981,840**

Belle Greve Bay- Option S1, DU5 Local

Maintenance Costs	Quty	Rate	Unit		Annual Cost
general maintenance					
Annual Total				£	-
PV total				£	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
		45	m3	£	-
		50000	Gate	£	-
DU 5 raise wall by 0.5m	110	1000	m	£	110,000
4 No. flood gates	4	50000	Gate	£	200,000
				£	-
		2800	m	£	-
		2000	m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**310,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	55,800
Other misc. Construction Costs		3%		£	7,750
Sub total				£	*63,550*
Nominal percentage		25%		£	***77,500***
Construction costs total				£	**387,500**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	1,938
Consultant costs inc RC design costs & detailing		9.5%		£	36,813
Site Supervision (including ECC PM)		3.5%		£	13,563
Site Investigation Costs		0.3%		£	1,163
ECI Costs		0.5%		£	1,938
Utility Diversion Costs		1.0%		£	3,875
Statutory Approval Costs		0.2%		£	775
Compensation and Land Purchase Costs		1.0%		£	3,875
Land Agents Costs		0.4%		£	1,550
PR Costs		0.4%		£	1,550
Sub total				£	*67,038*
nominal percentage sub total		20%		£	***77,500***
Total (Construction+Fees)				£	**465,000**
Optimism Bias					
Optimism Bias		60%		£	279,000
Future works					
		3000	m	£	-
		1500	m	£	-
sub total				£	-
Total Option Cost				**£**	**744,000**

Belle Greve Bay - Option S1, DU 8/9 Local

Maintenance Costs	Quty	Rate	Unit		Annual Cost
general maintenance					
Annual Total				£	-
PV total				*£*	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
		45	m3	£	-
		50000	Gate	£	-
		1000	m	£	-
		50000	Gate	£	-
				£	-
DU 9 raise wall by 0.65	350	2800	m	£	980,000
DU7/8 raise wall by 0.5m	280	2000	m	£	560,000
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,540,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	277,200
Other misc. Construction Costs		3%		£	38,500
Sub total				*£*	*315,700*
Nominal percentage		**25%**		**£**	**385,000**
Construction costs total				**£**	**1,925,000**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	9,625
Consultant costs inc RC design costs & detailing		9.5%		£	182,875
Site Supervision (including ECC PM)		3.5%		£	67,375
Site Investigation Costs		0.3%		£	5,775
ECI Costs		0.5%		£	9,625
Utility Diversion Costs		1.0%		£	19,250
Statutory Approval Costs		0.2%		£	3,850
Compensation and Land Purchase Costs		1.0%		£	19,250
Land Agents Costs		0.4%		£	7,700
PR Costs		0.4%		£	7,700
Sub total				*£*	*333,025*
nominal percentage sub total		**20%**		**£**	**385,000**
Total (Construction+Fees)				**£**	**2,310,000**
Optimism Bias					
Optimism Bias		**60%**		£	1,386,000
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**3,696,000**

Belle Greve Bay - Strategic Option S2

Maintenance Costs		Rate	Unit	Annual Cost
general maintenance				£ 1,500
Annual Total				£ 1,500
PV total				*£ 44,700*
Nominal value				**£ 50,000**
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**
420m embankment in Defence Unit 4 parallel to Les Bas Courtils Road (11m2 section)	4620	45	m3	£ 207,900
1 No flood gates	1	50000	Gate	£ 50,000
Breakwater to 4.25m (50m2) @ 150m and 200m long	17500	80	m3	£ 1,400,000
4 No. flood gates	4	50000	Gate	£ 200,000
recharge 3m @1:10 (75m2/m) 750 long	56,250	28	m3	£ 1,575,000
0.5m over 350m wall	350	1,750	sum	£ 612,500
Breakwater to 4.25m (88m2) @ 250m long	22,000	80	m3	£ 1,760,000
recharge 4.5m @1:10 (304m2/m) 750 long	170240	28	m3	£ 4,766,720
				£ -
				£ -
				£ -
Sub total				**£ 10,572,120**
Overhead and other costs		**Rate**		**Total**
General Site Preliminaries		18%		£ 1,902,982
Other misc. Construction Costs		3%		£ 264,303
Sub total				*£ 2,167,285*
Nominal percentage		20%		**£ 2,114,424**
Construction costs total				**£ 12,686,544**
Professional Fees / Associated Costs		**Rate**		**Total**
States of Guernsey Fees		0.5%		£ 63,433
Consultant costs inc RC design costs & detailing		6.5%		£ 824,625
Site Supervision (including ECC PM)		3.5%		£ 444,029
Site Investigation Costs		0.3%		£ 38,060
ECI Costs		0.5%		£ 63,433
Utility Diversion Costs		1.0%		£ 126,865
Statutory Approval Costs		0.2%		£ 25,373
Compensation and Land Purchase Costs		1.0%		£ 126,865
Land Agents Costs		0.4%		£ 50,746
PR Costs		0.4%		£ 50,746
Sub total		14.3%		*£ 1,814,176*
nominal percentage sub total		15%		**£ 1,902,982**
Total (Construction+Fees)				**£ 14,589,526**
Optimism Bias				
Optimism Bias		60%		£ 8,753,715
Future works				
replenish beach 25% in 2045	57,000	28	m	£ 505,932
raise back defence in year 50	1050	3000	m	£ 639,450
sub total				**£ 1,145,382**
Total Option Cost				**£ 24,538,623**

Belle Greve Bay - Strategic Option S3

Maintenance Costs	Quty	Rate	Unit		Annual Cost
general maintenance				£	1,500
Annual Total				£	1,500
PV total				£	*44,700*
Nominal value				£	50,000
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
420m embankment in Defence Unit 4 parallel to Les Bas Courtils Road (19m2 section)	7980	45	m3	£	359,100
1 No flood gates	1	50000	Gate	£	50,000
adavnce the line DU5 and part 6	230	7500	m	£	1,725,000
1 nNo. Flood gate	1	50000	Gate	£	50,000
				£	-
adavnce th line 15m to DU9	350	7500	m	£	2,625,000
DU7/8 raise wall by 0.5m	280	2000	m	£	560,000
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**5,369,100**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	966,438
Other misc. Construction Costs		5%		£	268,455
Sub total				*£*	*1,234,893*
Nominal percentage		**25%**		**£**	**1,342,275**
Construction costs total				**£**	**6,711,375**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.4%		£	26,846
Consultant costs inc RC design costs & detailing		7.0%		£	469,796
Site Supervision (including ECC PM)		3.5%		£	234,898
Site Investigation Costs		1.0%		£	67,114
ECI Costs		1.0%		£	67,114
Utility Diversion Costs		3.0%		£	201,341
Statutory Approval Costs		0.5%		£	33,557
Compensation and Land Purchase Costs		2.0%		£	134,228
Land Agents Costs		0.4%		£	26,846
PR Costs		0.2%		£	13,423
Sub total		*19.0%*		*£*	*1,275,161*
nominal percentage sub total		20%		**£**	**1,342,275**
Total (Construction+Fees)				**£**	**8,053,650**
Optimism Bias					
Optimism Bias		60%		£	4,832,190
Future works					
Wall raising in Defence Units 3, 4 and 5 (total 620m)	620	1500	m	£	188,790
Adavance line DU 7 and 8	450	7500	m	£	327,375
sub total				**£**	**516,165**
Total Option Cost				**£**	**13,452,005**

Belle Greve Bay - DU4 short term works

Maintenance Costs		Rate	Unit		Annual Cost
not included				£	-
Annual Total				£	-
PV total				£	-
Nominal value				£	-
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
300m embankment in Defence Unit 4 parallel to Les Bas Courtils Road (11m2 section)	330	45	m3	£	14,850
1 No flood gates	1	50000	Gate	£	50,000
walls around carpark area	100	1000	m	£	100,000
		50000	Gate	£	-
				£	-
		2800	m	£	-
		2000	m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**164,850**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	29,673
Other misc. Construction Costs		3%		£	4,121
Sub total				*£*	*33,794*
Nominal percentage		**25%**		**£**	**41,213**
Construction costs total				**£**	**206,063**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	1,030
Consultant costs inc RC design costs & detailing		10.0%		£	20,606
Site Supervision (including ECC PM)		3.5%		£	7,212
Site Investigation Costs		0.3%		£	618
ECI Costs		0.5%		£	1,030
Utility Diversion Costs		1.0%		£	2,061
Statutory Approval Costs		0.2%		£	412
Compensation and Land Purchase Costs		1.0%		£	2,061
Land Agents Costs		0.4%		£	824
PR Costs		0.4%		£	824
Sub total		17.8%		*£*	*36,679*
nominal percentage sub total		20%		**£**	**41,213**
Total (Construction+Fees)				**£**	**247,275**
Optimism Bias					
Optimism Bias		30%		£	74,183
Future works					
not included				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**321,458**

ROYAL HASKONING

Belle Greve Bay - DU5 Short Term Works

Maintenance Costs		Rate	Unit		Annual Cost
not included				£	-
Annual Total				£	-
PV total				£	-
Nominal value				£	-
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
			m3	£	-
1 No flood gates	1	50000	Gate	£	50,000
DU 5 raise wall typically by 0.3m	110	800	m	£	88,000
				£	-
Local rock groynes to DU6 x 2 No. @ 30m length	1000	80	m3	£	80,000
			m	£	-
			m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**218,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	39,240
Other misc. Construction Costs		3%		£	5,450
Sub total				*£*	*44,690*
Nominal percentage		25%		£	**54,500**
Construction costs total				£	**272,500**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	1,363
Consultant costs inc RC design costs & detailing		10.0%		£	27,250
Site Supervision (including ECC PM)		3.5%		£	9,538
Site Investigation Costs		0.3%		£	818
ECI Costs		0.5%		£	1,363
Utility Diversion Costs		1.0%		£	2,725
Statutory Approval Costs		0.2%		£	545
Compensation and Land Purchase Costs		1.0%		£	2,725
Land Agents Costs		0.4%		£	1,090
PR Costs		0.4%		£	1,090
Sub total		17.8%		*£*	*48,505*
nominal percentage sub total		20%		£	**54,500**
Total (Construction+Fees)				£	**327,000**
Optimism Bias					
Optimism Bias		30%		£	98,100
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				£	**425,100**

Belle Greve Bay- DU8/9 Short Term Works

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
not included				£	-
Annual Total				£	-
PV total				*£*	-
Nominal value				£	-
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
			m3	£	-
				£	-
				£	-
				£	-
				£	-
DU 9 raise wall by 0.3	350	1000	m	£	350,000
DU7/8 raise wall by 0.3m	280	1000	m	£	280,000
minor rock works to DU8	500	80	m3	£	40,000
				£	-
				£	-
				£	-
Sub total				**£**	**670,000**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	120,600
Other misc. Construction Costs		3%		£	16,750
Sub total				*£*	*137,350*
Nominal percentage		25%		**£**	**167,500**
Construction costs total				**£**	**837,500**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.5%		£	4,188
Consultant costs inc RC design costs & detailing		9.5%		£	79,563
Site Supervision (including ECC PM)		3.5%		£	29,313
Site Investigation Costs		0.3%		£	2,513
ECI Costs		0.5%		£	4,188
Utility Diversion Costs		1.0%		£	8,375
Statutory Approval Costs		0.2%		£	1,675
Compensation and Land Purchase Costs		1.0%		£	8,375
Land Agents Costs		0.4%		£	3,350
PR Costs		0.4%		£	3,350
Sub total				*£*	*144,888*
nominal percentage sub total		20%		**£**	**167,500**
Total (Construction+Fees)				**£**	**1,005,000**
Optimism Bias					
Optimism Bias		30%		£	301,500
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**1,306,500**

4.2 St Sampson (Coastal Unit 18)

Strategic Option S1

S1 element L1
S1 element L2
S1 element L3

Strategic Option S2

S2 element L1
S2 element L2
S2 element L3

Strategic Option S3

S3 element L1
S3 element L2

St Sampson - Strategic Option S1, element L1

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
general maintenance					
Annual Total				£	-
PV total				*£*	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
510m flood defence wall surrounding Saint Sampson Harbour. Height varies between 1.5 metres (max) and tapering to high ground.	510	2500	m	£	1,275,000
2 No Floodgates installed in new flood defence wall	2	50000	Gate	£	100,000
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,375,000**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	247,500
Other misc. Construction Costs		3%		£	34,375
Sub total				*£*	*281,875*
Nominal percentage		**25%**		**£**	**343,750**
Construction costs total				**£**	**1,718,750**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.7%		£	12,031
Consultant costs inc RC design costs & detailing		8.0%		£	137,500
Site Supervision (including ECC PM)		5.0%		£	85,938
Site Investigation Costs		1.0%		£	17,188
ECI Costs		1.0%		£	17,188
Utility Diversion Costs		2.0%		£	34,375
Statutory Approval Costs		1.0%		£	17,188
Compensation and Land Purchase Costs		2.0%		£	34,375
Land Agents Costs		0.5%		£	8,594
PR Costs		0.5%		£	8,594
Sub total				*£*	*372,969*
nominal percentage sub total		**22%**		**£**	**378,125**
Total (Construction+Fees)				**£**	**2,096,875**
Optimism Bias					
Optimism Bias		60%		£	1,258,125
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**3,355,000**

ROYAL HASKONING

St Sampson - Strategic Option S1, element L2

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
general maintenance					
Annual Total				£	-
PV total				***£***	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
430m flood defence wall surrounding Saint Sampson Harbour. Height varies between 1.5 metres (max) and tapering to high ground.	430	2500	m	£	1,075,000
1 No Floodgates installed in new flood defence wall	1	50000	Gate	£	50,000
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,125,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	202,500
Other misc. Construction Costs		3%		£	28,125
Sub total				*£*	*230,625*
Nominal percentage		25%		**£**	**281,250**
Construction costs total				**£**	**1,406,250**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.7%		£	9,844
Consultant costs inc RC design costs & detailing		8.0%		£	112,500
Site Supervision (including ECC PM)		5.0%		£	70,313
Site Investigation Costs		1.0%		£	14,063
ECI Costs		1.0%		£	14,063
Utility Diversion Costs		2.0%		£	28,125
Statutory Approval Costs		1.0%		£	14,063
Compensation and Land Purchase Costs		2.0%		£	28,125
Land Agents Costs		0.5%		£	7,031
PR Costs		0.5%		£	7,031
Sub total				*£*	*305,156*
nominal percentage sub total		22%		**£**	**309,375**
Total (Construction+Fees)				**£**	**1,715,625**
Optimism Bias					
Optimism Bias		60%		£	1,029,375
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**2,745,000**

St Sampson - Strategic Option S1, element L3

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
general maintenance					
Annual Total				£	-
PV total				***£***	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
410m flood defence wall surrounding Saint Sampson Harbour. Height varies between 1.5 metres (max) and tapering to high ground.	410	2500	m	£	1,025,000
2No Floodgates installed in new flood defence wall	2	50000	Gate	£	100,000
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,125,000**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	202,500
Other misc. Construction Costs		3%		£	28,125
Sub total				*£*	*230,625*
Nominal percentage		**25%**		**£**	**281,250**
Construction costs total				**£**	**1,406,250**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.7%		£	9,844
Consultant costs inc RC design costs & detailing		8.0%		£	112,500
Site Supervision (including ECC PM)		5.0%		£	70,313
Site Investigation Costs		1.0%		£	14,063
ECI Costs		1.0%		£	14,063
Utility Diversion Costs		2.0%		£	28,125
Statutory Approval Costs		1.0%		£	14,063
Compensation and Land Purchase Costs		2.0%		£	28,125
Land Agents Costs		0.5%		£	7,031
PR Costs		0.5%		£	7,031
Sub total				*£*	*305,156*
nominal percentage sub total		**22%**		**£**	**309,375**
Total (Construction+Fees)				**£**	**1,715,625**
Optimism Bias					
Optimism Bias		60%		£	1,029,375
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**2,745,000**

St Sampson - Strategic Option S2, element L1

Maintenance Costs	Quty	Rate	Unit		Annual Cost
general maintenance					
Annual Total				£	-
PV total				*£*	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
200m flood defence wall surrounding Saint Sampson Harbour. Height varies between 1.5 metres (max) and tapering to high ground.	200	2500	m	£	500,000
3 No Floodgates installed in new flood defence wall	3	50000	Gate	£	150,000
Works to highway around Nocq Road	2044	55	m2	£	112,420
Works to highway around North Side	1769	55	m2	£	97,295
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**859,715**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	154,749
Other misc. Construction Costs		3%		£	21,493
Sub total				*£*	*176,242*
Nominal percentage		**25%**		**£**	**214,929**
Construction costs total				**£**	**1,074,644**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.7%		£	7,523
Consultant costs inc RC design costs & detailing		8.0%		£	85,972
Site Supervision (including ECC PM)		5.0%		£	53,732
Site Investigation Costs		1.0%		£	10,746
ECI Costs		1.0%		£	10,746
Utility Diversion Costs		2.0%		£	21,493
Statutory Approval Costs		1.0%		£	10,746
Compensation and Land Purchase Costs		2.0%		£	21,493
Land Agents Costs		0.5%		£	5,373
PR Costs		0.5%		£	5,373
Sub total				*£*	*233,198*
nominal percentage sub total		22%		**£**	**236,422**
Total (Construction+Fees)				**£**	**1,311,065**
Optimism Bias					
Optimism Bias		60%		£	786,639
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**2,097,705**

St Sampson - Strategic Option S2, element L1

Maintenance Costs					
		Rate	**Unit**		**Annual Cost**
general maintenance					
Annual Total				£	-
PV total				***£***	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
200m flood defence wall surrounding Saint Sampson Harbour. Height varies between 1.5 metres (max) and tapering to high ground.	200	2500	m	£	500,000
3 No Floodgates installed in new flood defence wall	3	50000	Gate	£	150,000
Works to highway around Nocq Road	2044	55	m2	£	112,420
Works to highway around North Side	1769	55	m2	£	97,295
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**859,715**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	154,749
Other misc. Construction Costs		3%		£	21,493
Sub total				*£*	*176,242*
Nominal percentage		**25%**		**£**	**214,929**
Construction costs total				**£**	**1,074,644**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.7%		£	7,523
Consultant costs inc RC design costs & detailing		8.0%		£	85,972
Site Supervision (including ECC PM)		5.0%		£	53,732
Site Investigation Costs		1.0%		£	10,746
ECI Costs		1.0%		£	10,746
Utility Diversion Costs		2.0%		£	21,493
Statutory Approval Costs		1.0%		£	10,746
Compensation and Land Purchase Costs		2.0%		£	21,493
Land Agents Costs		0.5%		£	5,373
PR Costs		0.5%		£	5,373
Sub total				*£*	*233,198*
nominal percentage sub total		**22%**		**£**	**236,422**
Total (Construction+Fees)				**£**	**1,311,065**
Optimism Bias					
Optimism Bias		60%		£	786,639
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**2,097,705**

St Sampson - Strategic Option S2, element L2

Maintenance Costs		**Rate**	**Unit**		**Annual Cost**
general maintenance					
Annual Total				£	-
PV total				*£*	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
400m flood defence wall to North side. Height varies between 1.5 metres (max) and tapering to high ground.	400	2500	m	£	1,000,000
1 No Floodgate installed in new flood defence wall	1	50000	Gate	£	50,000
		55	m2	£	-
		55	m2	£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,050,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	189,000
Other misc. Construction Costs		3%		£	26,250
Sub total				*£*	*215,250*
Nominal percentage		25%		**£**	**262,500**
Construction costs total				**£**	**1,312,500**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.7%		£	9,188
Consultant costs inc RC design costs & detailing		8.0%		£	105,000
Site Supervision (including ECC PM)		5.0%		£	65,625
Site Investigation Costs		1.0%		£	13,125
ECI Costs		1.0%		£	13,125
Utility Diversion Costs		2.0%		£	26,250
Statutory Approval Costs		1.0%		£	13,125
Compensation and Land Purchase Costs		2.0%		£	26,250
Land Agents Costs		0.5%		£	6,563
PR Costs		0.5%		£	6,563
Sub total				*£*	*284,813*
nominal percentage sub total		22%		**£**	**288,750**
Total (Construction+Fees)				**£**	**1,601,250**
Optimism Bias					
Optimism Bias		60%		£	960,750
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**2,562,000**

St Sampson - Strategic Option S2, element L3

Maintenance Costs		Rate	Unit		Annual Cost
general maintenance					
Annual Total				£	-
PV total				***£***	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
250m flood defence wall to North side. Height varies between 1.5 metres (max) and tapering to high ground.	250	2500	m	£	625,000
2 No Floodgate installed in new flood defence wall	1	50000	Gate	£	50,000
450m flood defence wall to North side. Height varies between 1.5 metres (max) and tapering to high ground.	250	2500	m2	£	625,000
2 No Floodgate installed in new flood defence wall	2	50000	Gate	£	100,000
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,400,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	252,000
Other misc. Construction Costs		3%		£	35,000
Sub total				*£*	*287,000*
Nominal percentage		25%		**£**	**350,000**
Construction costs total				**£**	**1,750,000**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.7%		£	12,250
Consultant costs inc RC design costs & detailing		8.0%		£	140,000
Site Supervision (including ECC PM)		5.0%		£	87,500
Site Investigation Costs		1.0%		£	17,500
ECI Costs		1.0%		£	17,500
Utility Diversion Costs		2.0%		£	35,000
Statutory Approval Costs		1.0%		£	17,500
Compensation and Land Purchase Costs		2.0%		£	35,000
Land Agents Costs		0.5%		£	8,750
PR Costs		0.5%		£	8,750
Sub total				*£*	*379,750*
nominal percentage sub total		22%		**£**	**385,000**
Total (Construction+Fees)				**£**	**2,135,000**
Optimism Bias					
Optimism Bias		60%		£	1,281,000
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**3,416,000**

St Sampson - Strategic Option S3, element L1

Maintenance Costs	Quty	Rate	Unit	Annual Cost
general maintenance				
Annual Total				£ -
PV total				£ -
Nominal value				
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**
42metre long x 12 metre high radial gate operated by hydraulic cylinders. Gate housed in recess in cill when open.		6500000	gate	£ 6,500,000
				£ -
				£ -
				£ -
				£ -
				£ -
				£ -
				£ -
				£ -
				£ -
				£ -
Sub total				**£ 6,500,000**
Overhead and other costs		**Rate**		**Total**
General Site Preliminaries		18%		£ 1,170,000
Other misc. Construction Costs		5%		£ 325,000
Sub total				*£ 1,495,000*
Nominal percentage		25%		**£ 1,625,000**
Construction costs total				**£ 8,125,000**
Professional Fees / Associated Costs		**Rate**		**Total**
States of Guernsey Fees		0.5%		£ 40,625
Consultant costs inc RC design costs & detailing		8.0%		£ 650,000
Site Supervision (including ECC PM)		5.0%		£ 406,250
Site Investigation Costs		1.0%		£ 81,250
ECI Costs		1.0%		£ 81,250
Utility Diversion Costs		2.0%		£ 162,500
Statutory Approval Costs		1.0%		£ 81,250
Compensation and Land Purchase Costs		5.0%		£ 406,250
Land Agents Costs		0.5%		£ 40,625
PR Costs		0.5%		£ 40,625
Sub total		24.5%		*£ 1,990,625*
nominal percentage sub total		25%		**£ 2,031,250**
Total (Construction+Fees)				**£ 10,156,250**
Optimism Bias				
Optimism Bias		60%		£ 6,093,750
Future works				
				£ -
				£ -
sub total				£ -
Total Option Cost				**£ 16,250,000**

St Sampson - Strategic Option S3, element L2

Maintenance Costs	Quty	Rate	Unit		Annual Cost
general maintenance					
Annual Total				£	-
PV total				£	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
620m flood defence wall surrounding Saint Sampson Harbour. Height varies between 1.5 metres (max) and tapering to high ground.	620	2500	m	£	1,550,000
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**1,550,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	279,000
Other misc. Construction Costs		3%		£	38,750
Sub total				£	*317,750*
Nominal percentage		25%		£	**387,500**
Construction costs total				£	**1,937,500**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.7%		£	13,563
Consultant costs inc RC design costs & detailing		8.0%		£	155,000
Site Supervision (including ECC PM)		5.0%		£	96,875
Site Investigation Costs		1.0%		£	19,375
ECI Costs		1.0%		£	19,375
Utility Diversion Costs		2.0%		£	38,750
Statutory Approval Costs		1.0%		£	19,375
Compensation and Land Purchase Costs		2.0%		£	38,750
Land Agents Costs		0.5%		£	9,688
PR Costs		0.5%		£	9,688
Sub total				£	*420,438*
nominal percentage sub total		22%		£	**426,250**
Total (Construction+Fees)				**£**	**2,363,750**
Optimism Bias					
Optimism Bias		60%		£	1,418,250
Future works					
				£	-
				£	-
sub total				£	-
Total Option Cost				**£**	**3,782,000**

4.3 Bordeaux Harbour (Coastal Unit 17)

Strategic Option S1

S1 epoch1
S1 epoch 2
S1 epoch 3

Strategic Option S2

S2 epoch1
S2 epoch 2
S2 epoch 3

Bordeaux harbour - Strategic option S1, epoch1

Maintenance Costs		Rate	Unit		Annual Cost
not included				£	550
Annual Total				£	550
PV total				£	*16,390*
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
90 m length of wall and improvement to revetment	90	1800	m	£	162,000
225m wall raising to DU4 (1.6m)	225	2200	m	£	495,000
			m	£	-
				£	-
			m3	£	-
			m	£	-
			m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**657,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	118,260
Other misc. Construction Costs		5%		£	32,850
Sub total				£	*151,110*
Nominal percentage		25%		£	**164,250**
Construction costs total				£	**821,250**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	4,106
Consultant costs inc RC design costs & detailing		11.0%		£	90,338
Site Supervision (including ECC PM)		5.0%		£	41,063
Site Investigation Costs		1.0%		£	8,213
ECI Costs		1.0%		£	8,213
Utility Diversion Costs		3.0%		£	24,638
Statutory Approval Costs		1.0%		£	8,213
Compensation and Land Purchase Costs		2.0%		£	16,425
Land Agents Costs		0.5%		£	4,106
PR Costs		0.5%		£	4,106
Sub total		25.5%		£	*209,419*
nominal percentage sub total		25%		£	**205,313**
Total (Construction+Fees)				£	**1,026,563**
Optimism Bias					
Optimism Bias		60%		£	615,938
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				£	**1,642,500**

ROYAL HASKONING

Bordeaux harbour - Strategic option S1, epoch2

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
not included				£	550
Annual Total				£	550
PV total				*£*	***16,390***
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
90 m length of wall raising	90	1000	m	£	90,000
225m wall raising to DU4 (0.5m)	225	1000	m	£	225,000
95 wall raising to DU3	95	800	m	£	76,000
50m raise embankment to DU5 (6m3)	300	45	m3	£	13,500
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**404,500**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	72,810
Other misc. Construction Costs		5%		£	20,225
Sub total				*£*	*93,035*
Nominal percentage		25%		£	**101,125**
Construction costs total				**£**	**505,625**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.5%		£	2,528
Consultant costs inc RC design costs & detailing		11.0%		£	55,619
Site Supervision (including ECC PM)		5.0%		£	25,281
Site Investigation Costs		1.0%		£	5,056
ECI Costs		1.0%		£	5,056
Utility Diversion Costs		3.0%		£	15,169
Statutory Approval Costs		1.0%		£	5,056
Compensation and Land Purchase Costs		2.0%		£	10,113
Land Agents Costs		0.5%		£	2,528
PR Costs		0.5%		£	2,528
Sub total		*25.5%*		*£*	*128,934*
nominal percentage sub total		25%		**£**	**126,406**
Total (Construction+Fees)				**£**	**632,031**
Optimism Bias					
Optimism Bias		60%		£	379,219
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**1,011,250**

Bordeaux harbour - Strategic option S1, epoch3

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
not included				£	550
Annual Total				£	550
PV total				***£***	***16,390***
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
90 m length of wall raising	90	2200	m	£	198,000
225m wall raising to DU4 (0.5m)	225	1000	m	£	225,000
95 wall raising to DU3	95	800	m	£	76,000
50m raise embankment to DU5 (12m3)	600	45	m3	£	27,000
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**526,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	94,680
Other misc. Construction Costs		5%		£	26,300
Sub total				*£*	*120,980*
Nominal percentage		25%		**£**	**131,500**
Construction costs total				**£**	**657,500**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	3,288
Consultant costs inc RC design costs & detailing		11.0%		£	72,325
Site Supervision (including ECC PM)		5.0%		£	32,875
Site Investigation Costs		1.0%		£	6,575
ECI Costs		1.0%		£	6,575
Utility Diversion Costs		3.0%		£	19,725
Statutory Approval Costs		1.0%		£	6,575
Compensation and Land Purchase Costs		2.0%		£	13,150
Land Agents Costs		0.5%		£	3,288
PR Costs		0.5%		£	3,288
Sub total		25.5%		*£*	*167,663*
nominal percentage sub total		25%		**£**	**164,375**
Total (Construction+Fees)				**£**	**821,875**
Optimism Bias					
Optimism Bias		60%		£	493,125
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**1,315,000**

Bordeaux harbour - Strategic option S2, epoch1

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
not included				£	550
Annual Total				£	550
PV total				***£***	***16,390***
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
90 m length of wall and improvement to revetment	90	1800	m	£	162,000
				£	-
Embankment between northwest corner of the harbour to high ground, 130m long (sectional area 19m2.)	2470	45	m3	£	111,150
Improve road access to Rue de Chateau	120,000	1	sum	£	120,000
			m3	£	-
			m	£	-
			m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**393,150**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	70,767
Other misc. Construction Costs		5%		£	19,658
Sub total				*£*	*90,425*
Nominal percentage		25%		**£**	**98,288**
Construction costs total				**£**	**491,438**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.5%		£	2,457
Consultant costs inc RC design costs & detailing		11.0%		£	54,058
Site Supervision (including ECC PM)		5.0%		£	24,572
Site Investigation Costs		1.0%		£	4,914
ECI Costs		1.0%		£	4,914
Utility Diversion Costs		3.0%		£	14,743
Statutory Approval Costs		1.0%		£	4,914
Compensation and Land Purchase Costs		2.0%		£	9,829
Land Agents Costs		0.5%		£	2,457
PR Costs		0.5%		£	2,457
Sub total		25.5%		*£*	*125,317*
nominal percentage sub total		25%		**£**	**122,859**
Total (Construction+Fees)				**£**	**614,297**
Optimism Bias					
Optimism Bias		60%		£	368,578
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**982,875**

Bordeaux harbour - Strategic option S2, epoch2

Maintenance Costs	Quty	Rate	Unit		Annual Cost
not included				£	550
Annual Total				£	550
PV total				£	*16,390*
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
90 m length of wall raising	90	1000	m	£	90,000
				£	-
95 wall raising to DU3	95	800	m	£	76,000
Minor road arising to northern road	120	65	m3	£	7,800
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**173,800**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	31,284
Other misc. Construction Costs		5%		£	8,690
Sub total				£	*39,974*
Nominal percentage		25%		£	**43,450**
Construction costs total				£	**217,250**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	1,086
Consultant costs inc RC design costs & detailing		11.0%		£	23,898
Site Supervision (including ECC PM)		5.0%		£	10,863
Site Investigation Costs		1.0%		£	2,173
ECI Costs		1.0%		£	2,173
Utility Diversion Costs		3.0%		£	6,518
Statutory Approval Costs		1.0%		£	2,173
Compensation and Land Purchase Costs		2.0%		£	4,345
Land Agents Costs		0.5%		£	1,086
PR Costs		0.5%		£	1,086
Sub total		25.5%		£	*55,399*
nominal percentage sub total		25%		£	**54,313**
Total (Construction+Fees)				£	**271,563**
Optimism Bias					
Optimism Bias		60%		£	162,938
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				£	**434,500**

Bordeaux harbour - Strategic option S2, epoch3

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
not included				£	550
Annual Total				£	550
PV total				***£***	***16,390***
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
90 m length of wall raising	90	2200	m	£	198,000
raise north closure embankment	130	1000	m	£	130,000
95 wall raising to DU3	95	800	m	£	76,000
250m long, construct closure embankment behind DU5(19m2)	4750	45	m3	£	213,750
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**617,750**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	111,195
Other misc. Construction Costs		5%		£	30,888
Sub total				*£*	*142,083*
Nominal percentage		25%		**£**	**154,438**
Construction costs total				**£**	**772,188**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.5%		£	3,861
Consultant costs inc RC design costs & detailing		11.0%		£	84,941
Site Supervision (including ECC PM)		5.0%		£	38,609
Site Investigation Costs		1.0%		£	7,722
ECI Costs		1.0%		£	7,722
Utility Diversion Costs		3.0%		£	23,166
Statutory Approval Costs		1.0%		£	7,722
Compensation and Land Purchase Costs		2.0%		£	15,444
Land Agents Costs		0.5%		£	3,861
PR Costs		0.5%		£	3,861
Sub total		*25.5%*		*£*	*196,908*
nominal percentage sub total		25%		**£**	**193,047**
Total (Construction+Fees)				**£**	**965,234**
Optimism Bias					
Optimism Bias		60%		£	579,141
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**1,544,375**

4.4 Baie de Port Grat and Pêqueries (including Rousse Headland)

(**Coastal Unit 11 &12)**

Rousse Headland

Epoch 1
Epoch 2

Pequeries Strategic Option S1 elements L1 and L2

Rousse Headland - Epoch 1

Maintenance Costs		**Rate**	**Unit**		**Annual Cost**
not included				£	1,100
Annual Total				£	1,100
PV total				*£*	*32,780*
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
Inspection and repair to exsitng wall along seaward edge of Les dicqs road.	170	400	m	£	68,000
Install new infill wall sections in existing wll to maintain continuous flood defence and extend existing wall to hgh ground	30	1500	m	£	45,000
new road alignement at western end of Dicqs road to convey highway on to high ground.	35	1250	m	£	43,750
New Highway raod ramp to maintain access / egress to eastern approach to boat yard 0.5m high.	1	15000	sum	£	15,000
Improve condition to rock revetment	75	1000	m	£	75,000
			m	£	-
			m	£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**246,750**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	44,415
Other misc. Construction Costs		5%		£	12,338
Sub total				*£*	*56,753*
Nominal percentage		25%		**£**	**61,688**
Construction costs total				**£**	**308,438**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	1,542
Consultant costs inc RC design costs & detailing		9.0%		£	27,759
Site Supervision (including ECC PM)		6.0%		£	18,506
Site Investigation Costs		2.5%		£	7,711
ECI Costs		0.5%		£	1,542
Utility Diversion Costs		2.5%		£	7,711
Statutory Approval Costs		0.5%		£	1,542
Compensation and Land Purchase Costs		3.0%		£	9,253
Land Agents Costs		1.0%		£	3,084
PR Costs		1.0%		£	3,084
Sub total		26.5%		*£*	*81,736*
nominal percentage sub total		27%		**£**	**83,278**
Total (Construction+Fees)				**£**	**391,716**
Optimism Bias					
Optimism Bias		60%		£	235,029
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**626,745**

Rousse Headland - Epoch 2

Maintenance Costs	Quty	Rate	Unit		Annual Cost
not included				£	1,100
Annual Total				£	1,100
PV total				***£***	***32,780***
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
replace existjng wall with reinfroced concrete wall 1.5m	150	1000	m	£	150,000
Raise new infill wall sections	30	1000	m	£	30,000
				£	-
raise road ramp to maintain access / egress to eastern approach to boat yard 1.5m high.	1	30000	sum	£	30,000
New embankment to southLes Dicqs road (80m by 9m2)	720	45	m3	£	32,400
New embankment to west (180 by 4m2	640	45	m3	£	28,800
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**271,200**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	48,816
Other misc. Construction Costs		5%		£	13,560
Sub total				*£*	*62,376*
Nominal percentage		25%		£	**67,800**
Construction costs total				**£**	**339,000**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.5%		£	1,695
Consultant costs inc RC design costs & detailing		11.0%		£	37,290
Site Supervision (including ECC PM)		5.0%		£	16,950
Site Investigation Costs		1.0%		£	3,390
ECI Costs		1.0%		£	3,390
Utility Diversion Costs		3.0%		£	10,170
Statutory Approval Costs		1.0%		£	3,390
Compensation and Land Purchase Costs		2.0%		£	6,780
Land Agents Costs		0.5%		£	1,695
PR Costs		0.5%		£	1,695
Sub total		25.5%		*£*	*86,445*
nominal percentage sub total		25%		£	**84,750**
Total (Construction+Fees)				**£**	**423,750**
Optimism Bias					
Optimism Bias		60%		£	254,250
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**678,000**

Pequeries - Strategic Option 1, elemnets L1 and L2

Maintenance Costs		**Rate**	**Unit**	**Annual Cost**	
not included				£	1,100
Annual Total				£	1,100
PV total				***£***	***32,780***
Nominal value				£	**33,000**
Construction Costs	**Quty**	**Rate**	**Unit**	**Total**	
500m rock revetment to pequeries bay frontage, sectional area 18m2	9000	80	m3	£	720,000
200m embankmmet north of Pequeries, sectional area 13m2	2600	45	m3	£	117,000
				£	-
Future works 2031 discounted at 0.52				£	-
100m embankment to Portinfer bay,including improvement to garden embankments. Sectional area 7m2	700	23.4	m3	£	16,380
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**853,380**
Overhead and other costs		**Rate**		**Total**	
General Site Preliminaries		18%		£	153,608
Other misc. Construction Costs		5%		£	42,669
Sub total				*£*	*196,277*
Nominal percentage		25%		£	**213,345**
Construction costs total				**£**	**1,066,725**
Professional Fees / Associated Costs		**Rate**		**Total**	
States of Guernsey Fees		0.5%		£	5,334
Consultant costs inc RC design costs & detailing		7.0%		£	74,671
Site Supervision (including ECC PM)		6.5%		£	69,337
Site Investigation Costs		2.0%		£	21,335
ECI Costs		0.5%		£	5,334
Utility Diversion Costs		2.0%		£	21,335
Statutory Approval Costs		0.5%		£	5,334
Compensation and Land Purchase Costs		2.0%		£	21,335
Land Agents Costs		1.0%		£	10,667
PR Costs		0.5%		£	5,334
Sub total		22.5%		*£*	*240,013*
nominal percentage sub total		23%		£	**240,013**
Total (Construction+Fees)				**£**	**1,306,738**
Optimism Bias					
Optimism Bias		60%		£	784,043
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**2,123,781**

4.5 Cobo and Saline Bay (Coastal Unit 10)

Strategic Option 1

Strategic Option 2

Epoch 1
Epoch 2

Cobo and Saline - Strategic Option 1

Maintenance Costs	Quty	Rate	Unit		Annual Cost
include					
Annual Total				£	-
PV total				£	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
new sea wall at DU2 to ncrease crest level to 7.75m	300	2500	m	£	750,000
wall arisng to DU3 by 0.5m to a level of 8.25m	240	1750	m	£	420,000
				£	-
No future works				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				£	**1,170,000**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	210,600
Other misc. Construction Costs		5%		£	58,500
Sub total				£	*269,100*
Nominal percentage		25%		£	**292,500**
Construction costs total				£	**1,462,500**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		1.5%		£	21,938
Consultant costs inc RC design costs & detailing		11.0%		£	160,875
Site Supervision (including ECC PM)		5.0%		£	73,125
Site Investigation Costs		3.0%		£	43,875
ECI Costs		0.5%		£	7,313
Utility Diversion Costs		0.0%		£	-
Statutory Approval Costs		1.0%		£	14,625
Compensation and Land Purchase Costs		2.5%		£	36,563
Land Agents Costs		1.0%		£	14,625
PR Costs		1.0%		£	14,625
Sub total		26.5%		£	*387,563*
nominal percentage sub total		25%		£	**365,625**
Total (Construction+Fees)				£	**1,828,125**
Optimism Bias					
Optimism Bias		60%		£	1,096,875
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				£	**2,925,000**

Cobo and Saline - Strategic Option 2, epoch 1

Maintenance Costs		**Rate**	**Unit**		**Annual Cost**
include					
Annual Total				£	-
PV total				£	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
Detached breakwater 1 northern (90m)	19545	80	m3	£	1,563,600
Detached breakwater 2 (90m)	7984	80	m3	£	638,720
Detached breakwater 3 (90)	16313	80	m3	£	1,305,040
Detached breakwater 4 (130m)	30775	80	m3	£	2,462,000
Detached breakwater 5 southern (125m)	27809	80	m3	£	2,224,720
beach renurishment	184000	17.5	m3	£	3,220,000
extension of outfall	120	1000	m	£	120,000
raise wall to DU2 by 0.5m	250	1750	m	£	437,500
				£	-
				£	-
				£	-
Sub total				**£**	**11,971,580**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	2,154,884
Other misc. Construction Costs		2%		£	239,432
Sub total				*£*	*2,394,316*
Nominal percentage		20%		**£**	**2,394,316**
Construction costs total				**£**	**14,365,896**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.2%		£	28,732
Consultant costs inc RC design costs & detailing		5.0%		£	718,295
Site Supervision (including ECC PM)		1.5%		£	215,488
Site Investigation Costs		0.4%		£	57,464
ECI Costs		0.5%		£	71,829
Utility Diversion Costs		0.2%		£	28,732
Statutory Approval Costs		0.2%		£	28,732
Compensation and Land Purchase Costs		0.5%		£	71,829
Land Agents Costs		0.1%		£	14,366
PR Costs		0.1%		£	14,366
Sub total		8.7%		*£*	*1,249,833*
nominal percentage sub total		10%		**£**	**1,436,590**
Total (Construction+Fees)				**£**	**15,802,486**
Optimism Bias					
Optimism Bias		60%		£	9,481,491
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**25,283,977**

Cobo and Saline - Strategic Option 2, epoch 2

Maintenance Costs		**Rate**	**Unit**		**Annual Cost**
include					
Annual Total				£	-
PV total				***£***	-
Nominal value					
Construction Costs	**Quty**	**Rate**	**Unit**		**Total**
replishment	55,200	17.5	m3	£	966,000
raise breakwaters	4042	80	m3	£	323,360
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
				£	-
Sub total				**£**	**1,289,360**
Overhead and other costs		**Rate**			**Total**
General Site Preliminaries		18%		£	232,085
Other misc. Construction Costs		2%		£	25,787
Sub total				*£*	*257,872*
Nominal percentage		**20%**		**£**	**257,872**
Construction costs total				**£**	**1,547,232**
Professional Fees / Associated Costs		**Rate**			**Total**
States of Guernsey Fees		0.2%		£	3,094
Consultant costs inc RC design costs & detailing		5.0%		£	77,362
Site Supervision (including ECC PM)		1.5%		£	23,208
Site Investigation Costs		0.4%		£	6,189
ECI Costs		0.5%		£	7,736
Utility Diversion Costs		0.2%		£	3,094
Statutory Approval Costs		0.2%		£	3,094
Compensation and Land Purchase Costs		0.5%		£	7,736
Land Agents Costs		0.1%		£	1,547
PR Costs		0.1%		£	1,547
Sub total		*8.7%*		*£*	*134,609*
nominal percentage sub total		**10%**		**£**	**154,723**
Total (Construction+Fees)				**£**	**1,701,955**
Optimism Bias					
Optimism Bias		60%		£	1,021,173
Future works					
no used			m	£	-
not used			m	£	-
sub total				£	-
Total Option Cost				**£**	**2,723,128**

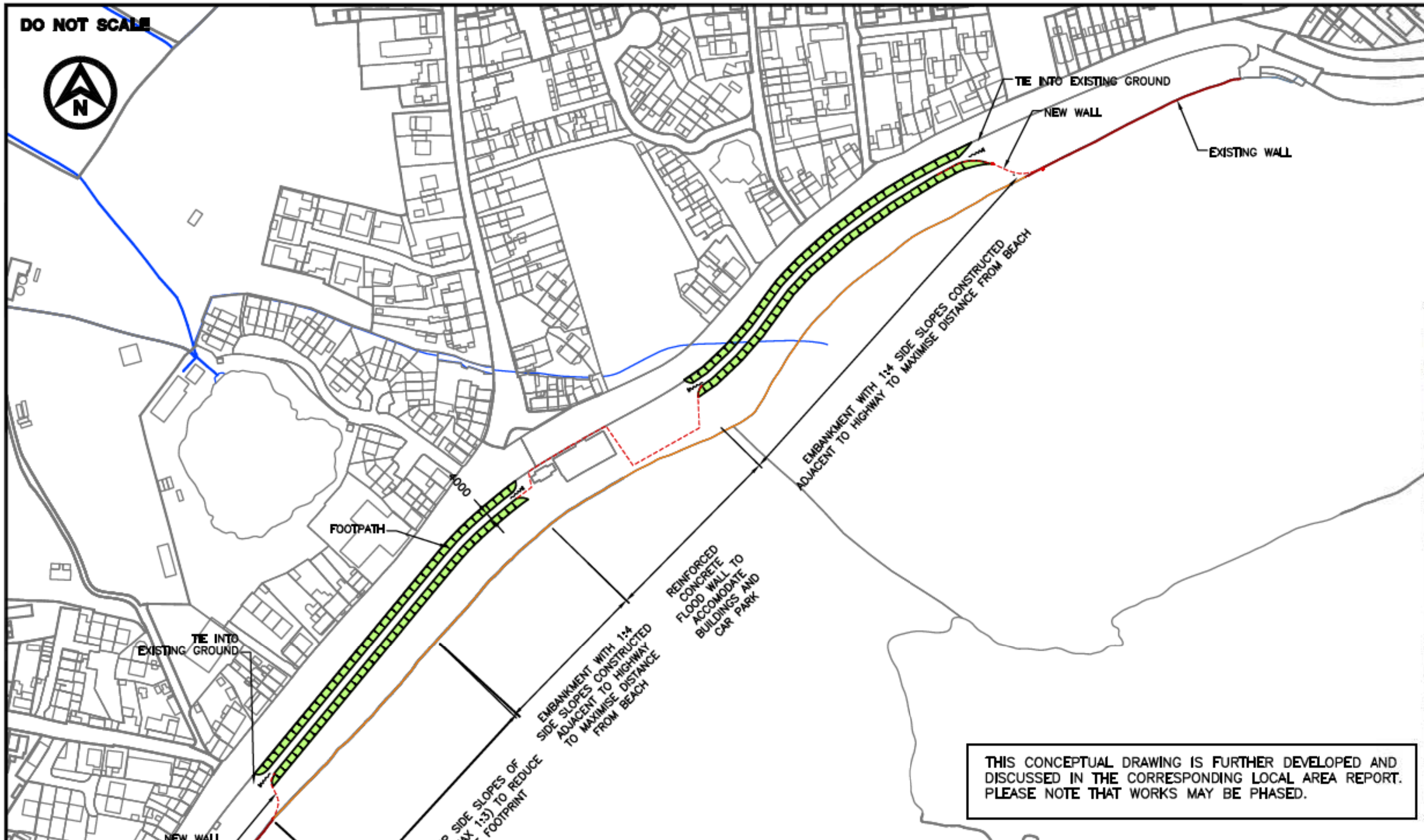
4.6 Rocquaine Bay (Coastal Unit 3)

Option C2 – Rock Revetment DU3 / DU4

Rocquaine Bay - Option C2, Rock Revetment DU3/DU4

Maintenance Costs	Rate	Unit		Annual Cost
Annual inspection at £500/ visit			£	500
Annual Total			£	500
PV total			£	**14,900**
Construction Costs	**Rate**	**Unit**		**Total**
200m long rock revetment including 15,600 m3 rock armour	80	m3	£	1,248,000
Sub total			£	**1,248,000**
Overhead and other costs	**Rate**			**Total**
General Site Prelims	20%		£	249,600
Temporary haul roads / access costs	0%		£	-
Other mis. Construction costs	10%		£	124,800
Sub total			£	374,400
Construction costs total			£	**1,622,400**
Professional Fees / Associated Costs	**Rate**			**Total**
States of Guernsey Fees	5%		£	81,120
Consultant costs inc RC design costs & detailing	6%		£	97,344
Site Supervision (including ECC PM)	5%		£	81,120
Site Investigation Costs	1%		£	16,224
ECI Costs	1%		£	16,224
Utility Diversion Costs	1%		£	16,224
Statutory Approval Costs	1%		£	16,224
Compensation and Land Purchase Costs	5%		£	81,120
Land Agents Costs	1%		£	8,112
PR Costs	1%		£	8,112
Sub total			£	421,824
	26%			
Total (Construction+Maintenance+Fees)			**£**	**2,059,124**
Optimism Bias				
Optimism Bias	60%		£	1,235,474
Total Option Cost			**£**	**3,294,598**

DO NOT SCALE

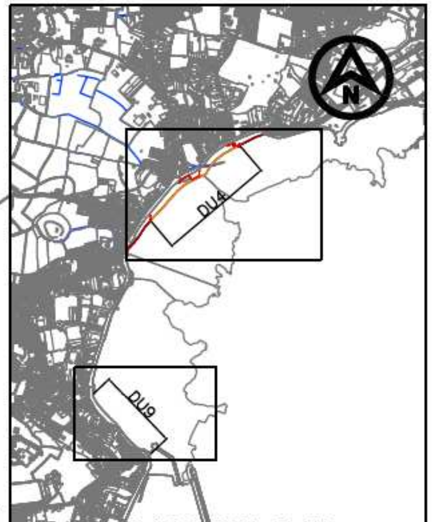


NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES RELATIVE TO GUERNSEY DATUM UNLESS NOTED OTHERWISE.

LEGEND

- EXISTING WALL
- NEW FLOOD DEFENCE WALL
- EMBANKMENT
- BACK OF BEACH



SITE LOCATION PLAN
SCALE 1:25000

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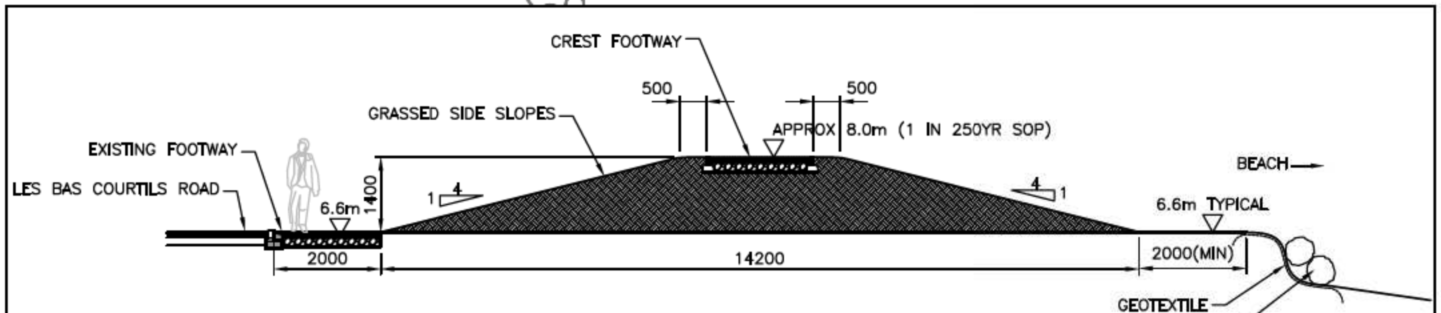

TYPICAL CROSS SECTION
SCALE 1:100

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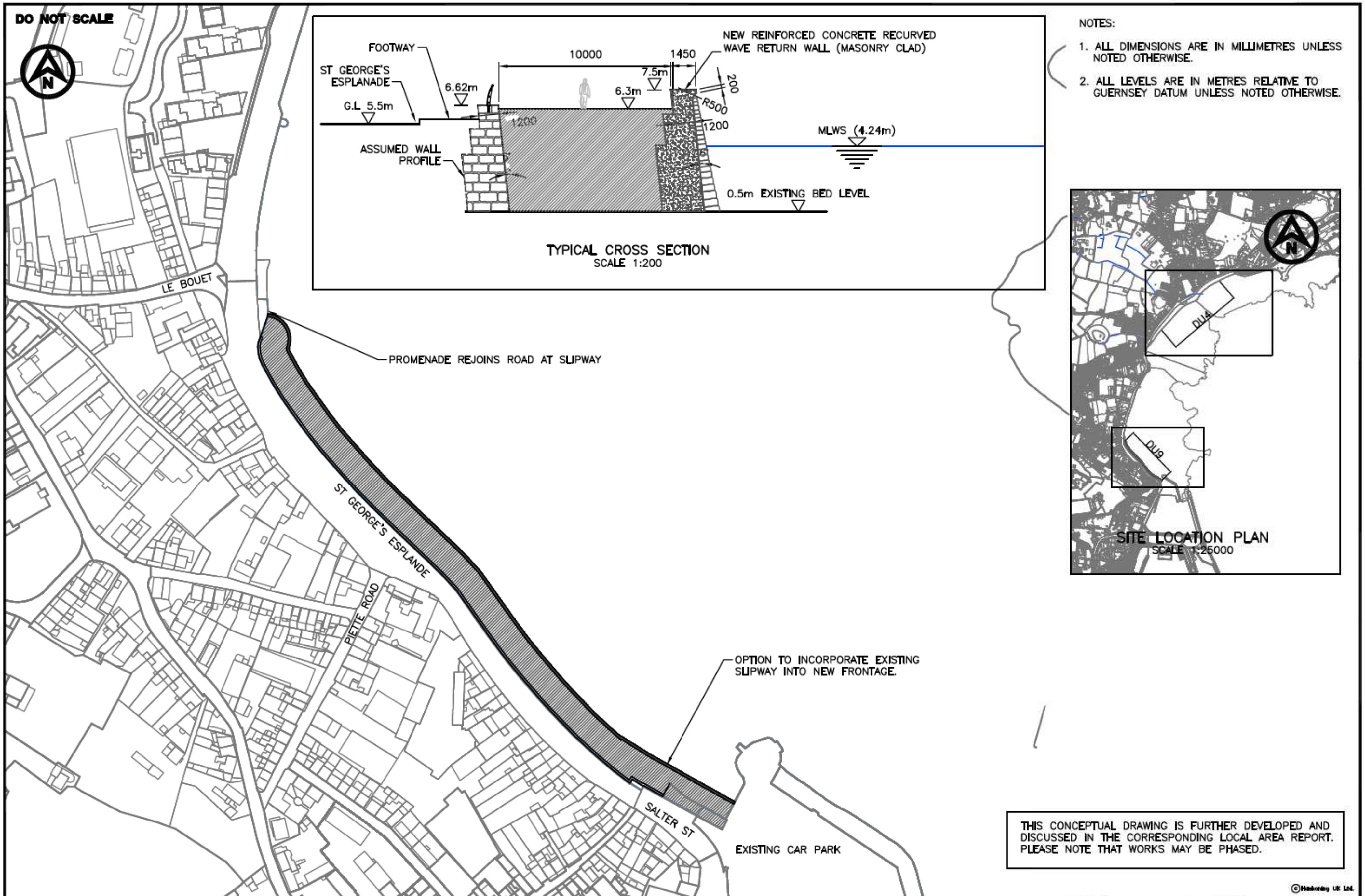
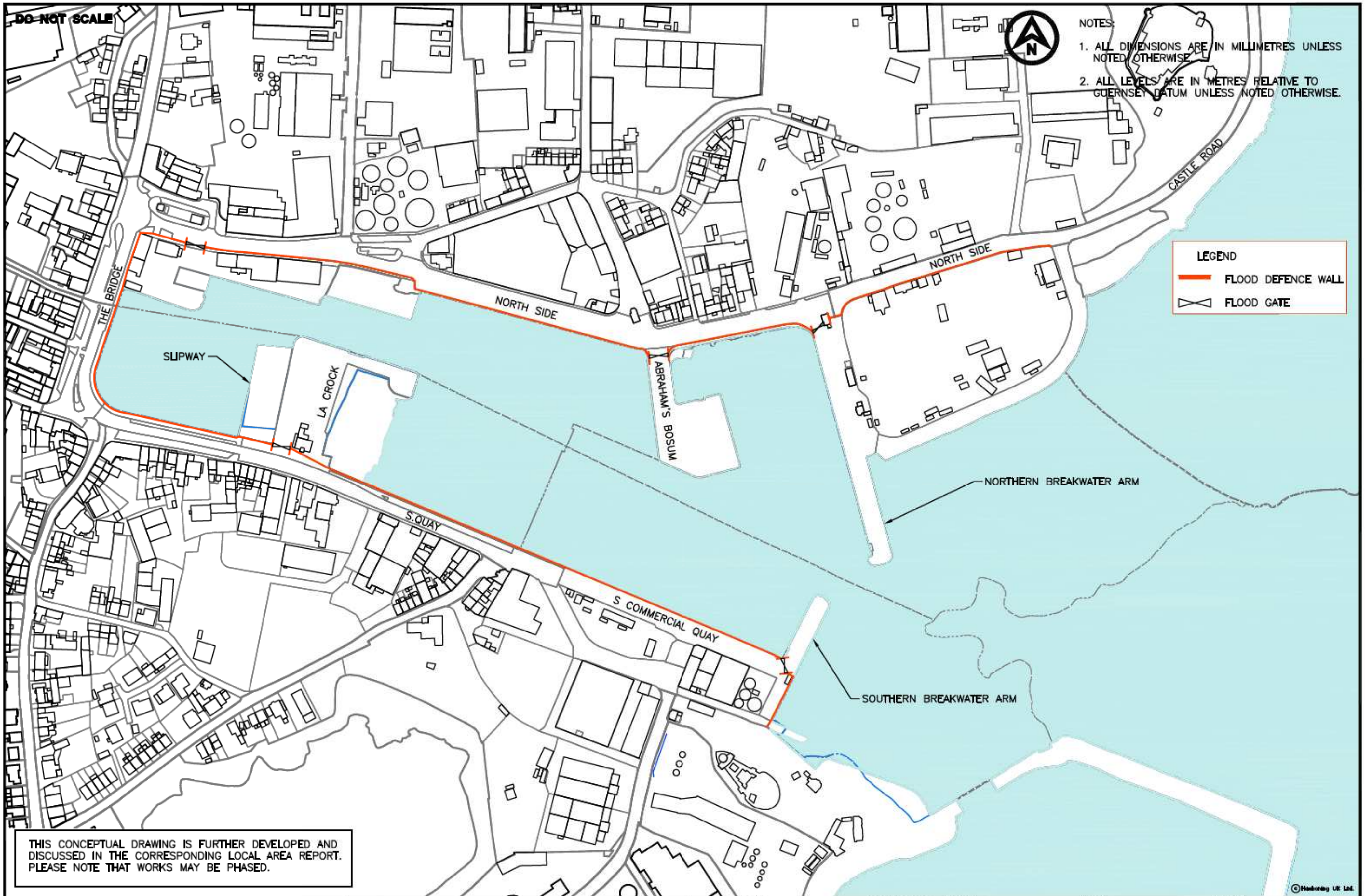
TITLE: BELLE GREVE BAY PROPOSED FLOOD DEFENCE EMBANKMENT STRATEGIC OPTION 1 CENTRAL SECTION OF BELLE GREVE BAY	PROJECT: GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING — HASKONING UK LTD COASTAL AND RIVERS DIVISION, Stratus House, Emperor Way, Exeter, EX1 3QS; +44 (0)1392 447999 Telephone; +44 (0)1392 446148 Fax; info@exeter.royalhaskoning.com E-mail; www.royalhaskoning.com Internet	Job No. 9W2890	DATE FEB'11	SCALE AS SHOWN
			ACAD Ref. 9W2890–1000	CHECKED BO	PASSED PW
			DRAWN GG	DRG No. 9W2890–1000	REV APP.F



TITLE BELLE GREVE BAY OUTLINE APPROACH TO ADVANCE THE LINE TO DU9	PROJECT GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING HASKONING UK LTD COASTAL AND RIVERS DIVISION Stratus House Emperor Way Exeter, EX1 3QS +44 (0)1392 447999 Telephone +44 (0)1392 446148 Fax info@exeter.royalhaskoning.com E-mail www.royalhaskoning.com Internet	Job No. 9W2890 ACAD Ref. 9W2890–1001 DRAWN GG	DATE FEB'11 CHECKED BO DRG No. 9W2890–1001	SCALE AS SHOWN PASSED PW REV APP.F



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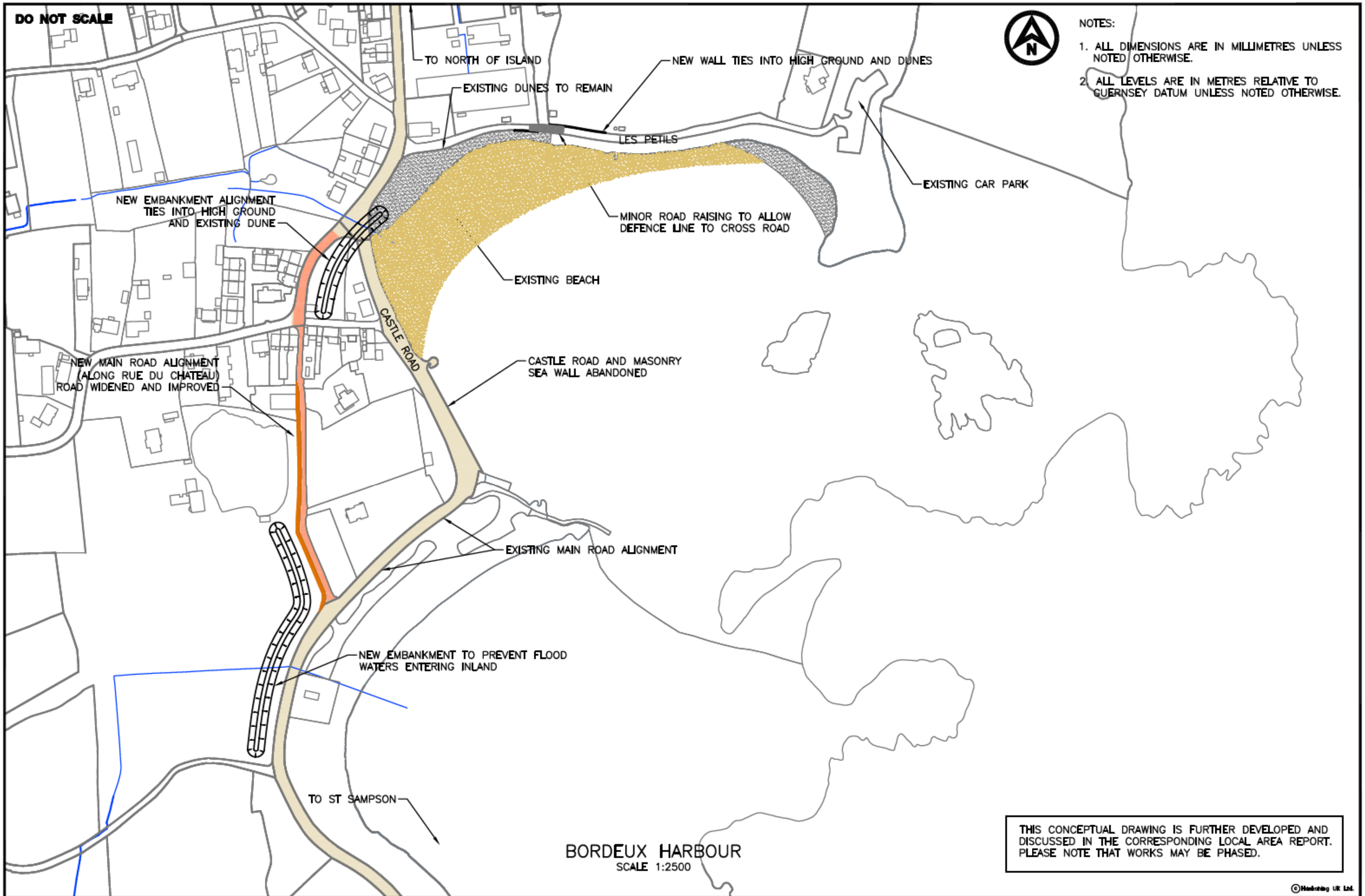
TITLE: ST SAMPSON PLAN GENERAL ARRANGEMENT OF FLOOD DEFENCE AROUND THE HARBOUR	PROJECT: GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING HASKONING UK LTD COASTAL AND RIVERS DIVISION Stratus House Emperor Way Exeter, EX1 3QS +44 (0)1392 447999 Telephone +44 (0)1392 446148 Fax info@exeter.royalhaskoning.com E-mail www.royalhaskoning.com Internet

Job No. 9W2890	DATE FEB'11	SCALE 1:2500
ACAD Ref. 9W2890–2000	CHECKED BO	PASSED PW
DRAWN GG	DRG No. 9W2890–2000	REV APP.F



NOTES:

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2. ALL LEVELS ARE IN METRES RELATIVE TO GUERNSEY DATUM UNLESS NOTED OTHERWISE.

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TITLE: BORDEUX HARBOUR STRATEGIC APPROACH TO DEFENCE WITH SET BACK EMBANKMENTS	PROJECT: GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING	

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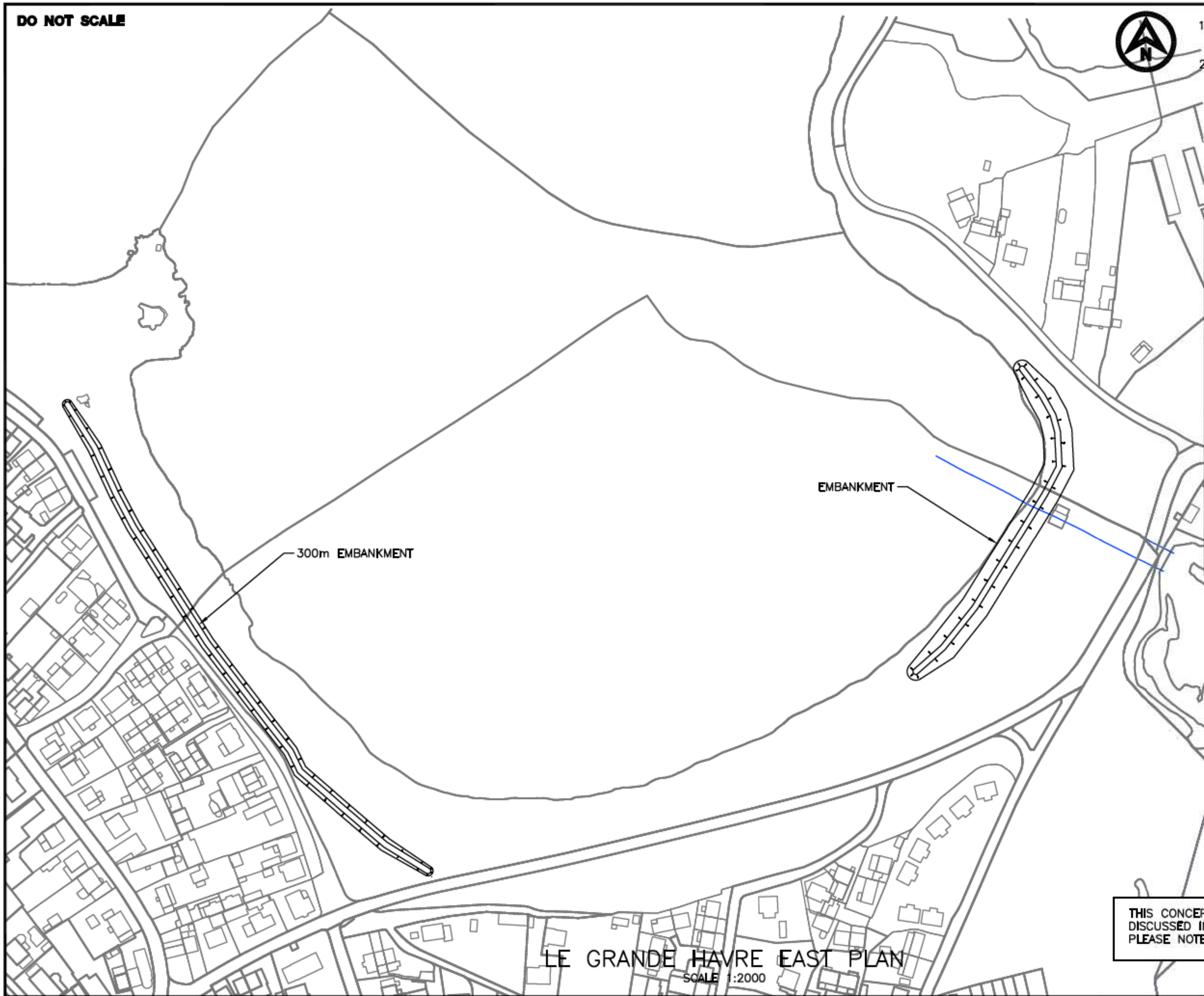
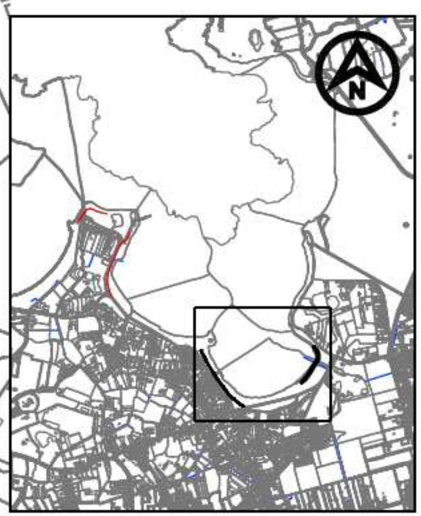
Job No. 9W2890	DATE FEB'11	SCALE AS SHOWN
ACAD Ref. 9W2890-3001	CHECKED BO	PASSED PW
DRAWN GG	DRG No. 9W2890-3001	REV APP.F

DO NOT SCALE

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES RELATIVE TO GUERNSEY DATUM UNLESS NOTED OTHERWISE.





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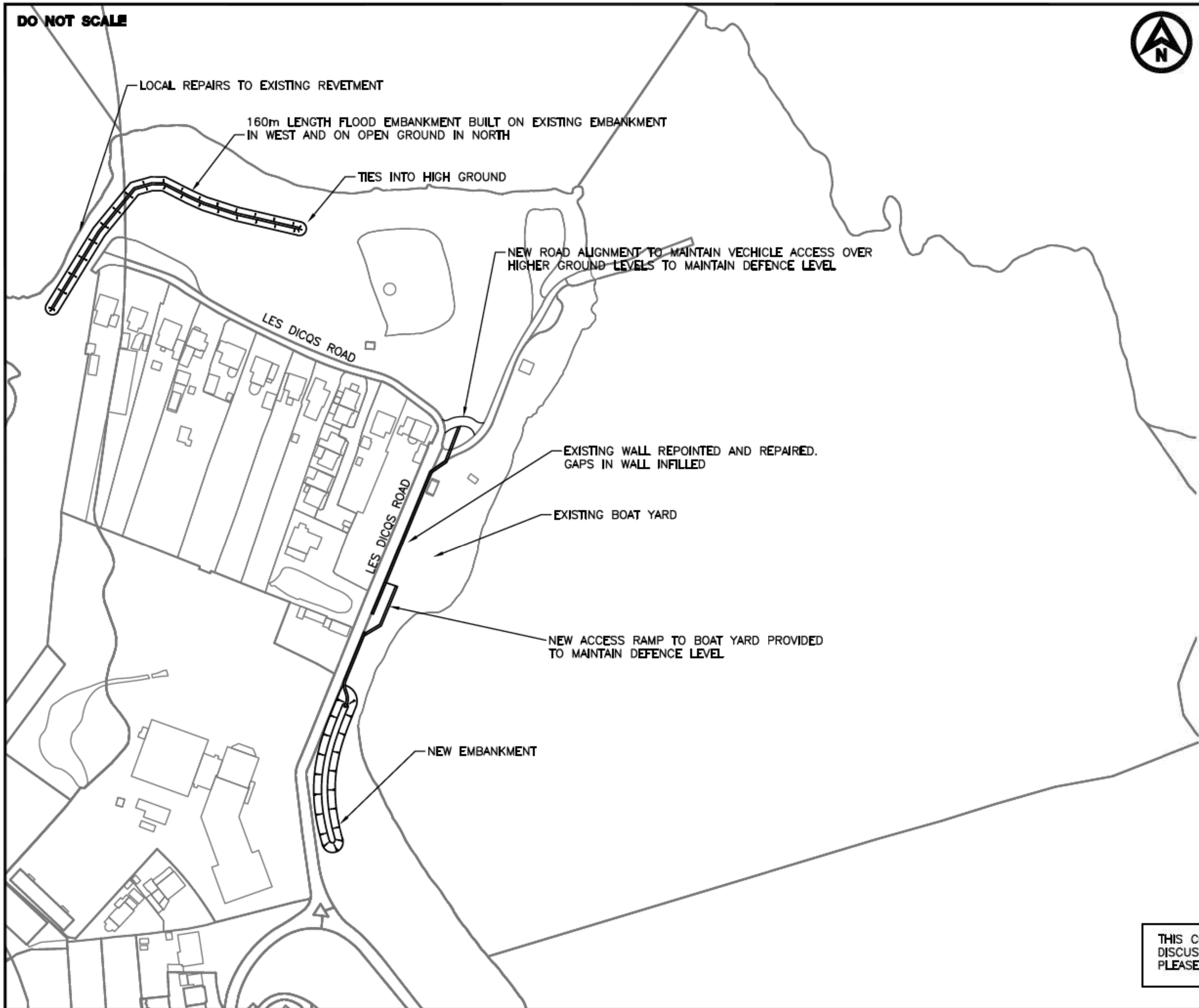
LE GRANDE HAVRE EAST PLAN
SCALE 1:2000

TITLE: LE GRANDE HAVRE GENERAL ARRANGEMENT OF CLOSURE EMBANKMENTS	PROJECT: GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING — HASKONING UK LTD, COASTAL AND RIVERS DIVISION, Stratus House, Emperor Way, Exeter, EX1 3QS; +44 (0)1392 447999 Telephone; +44 (0)1392 446148 Fax; info@exeter.royalhaskoning.com E-mail; www.royalhaskoning.com Internet

Job No. 9W2890	DATE FEB'11	SCALE 1:2000
ACAD Ref. 9W2890–4001	CHECKED BO	PASSED PW
DRAWN GG	DRG No. 9W2890–4001	REV APP.F



1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES RELATIVE TO GUERNSEY DATUM UNLESS NOTED OTHERWISE.

SITE LOCATION PLAN
SCALE 1:25000

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TITLE GENERAL ARRANGEMENT OF WORKS TO ROUSSE HEADLAND, STRATEGIC OPTION 1	PROJECT GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING — HASKONING UK LTD COASTAL AND RIVERS DIVISION	Job No. 9W2890	DATE FEB'11	SCALE 1:2000
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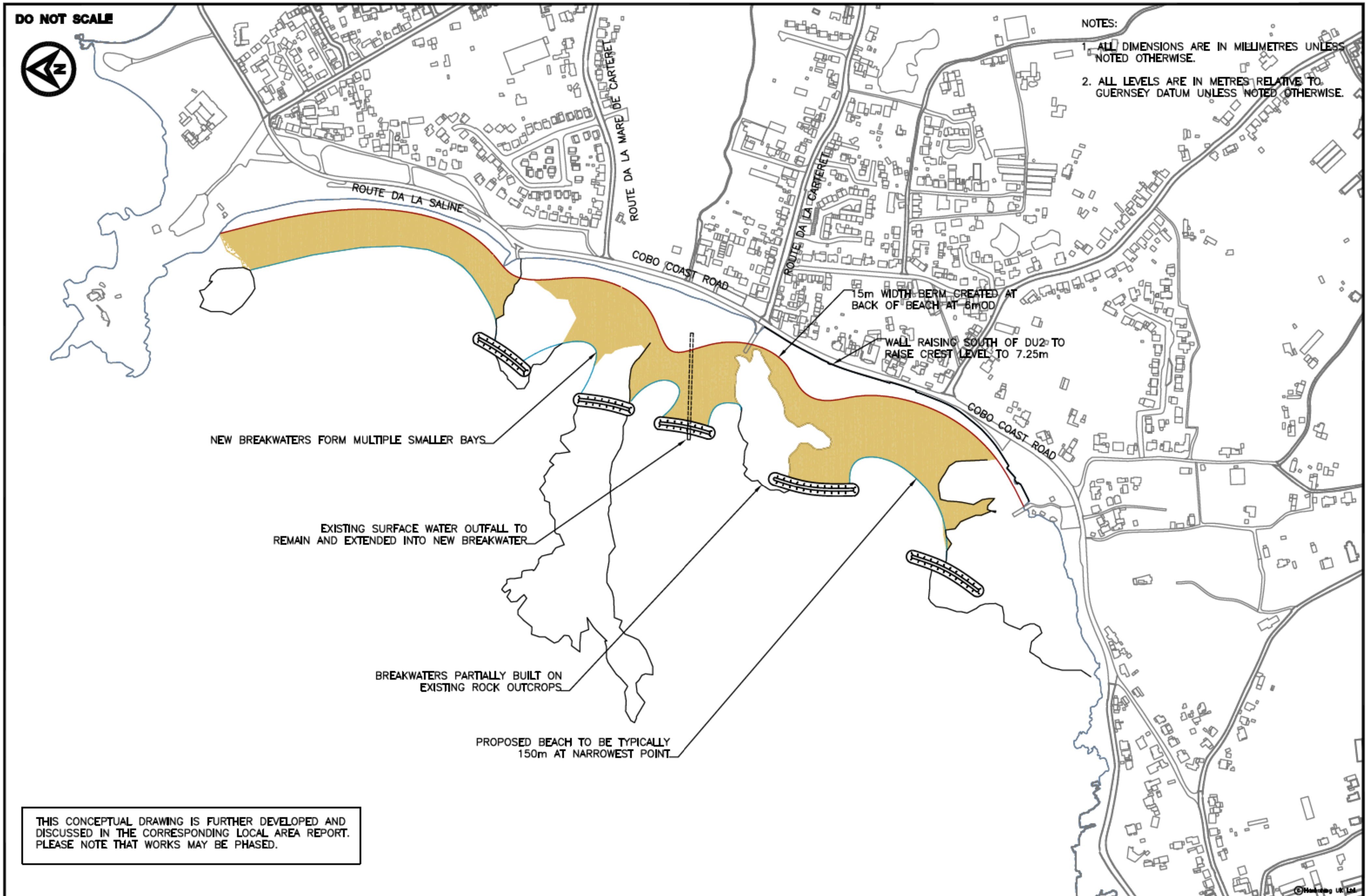

NOTES:

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE.
2. ALL LEVELS ARE IN METRES RELATIVE TO GUERNSEY DATUM UNLESS NOTED OTHERWISE.

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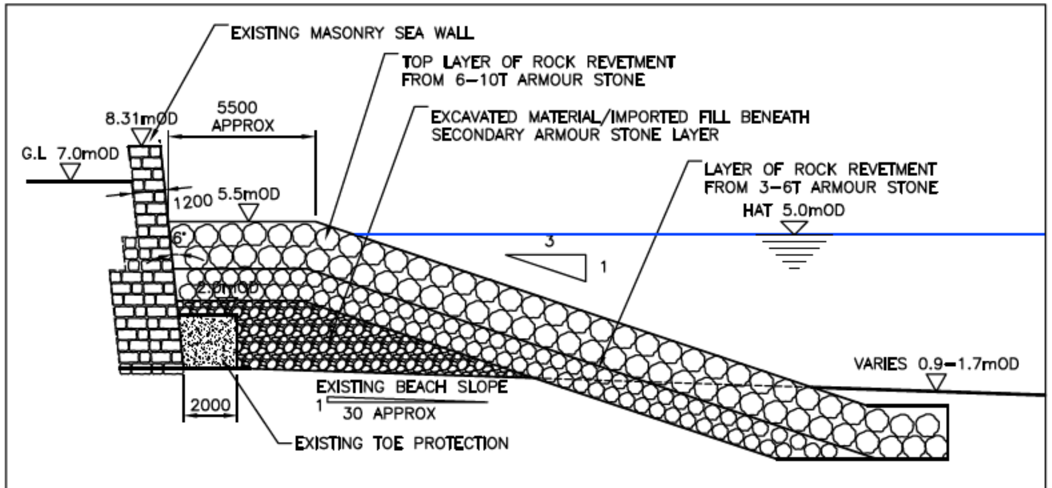
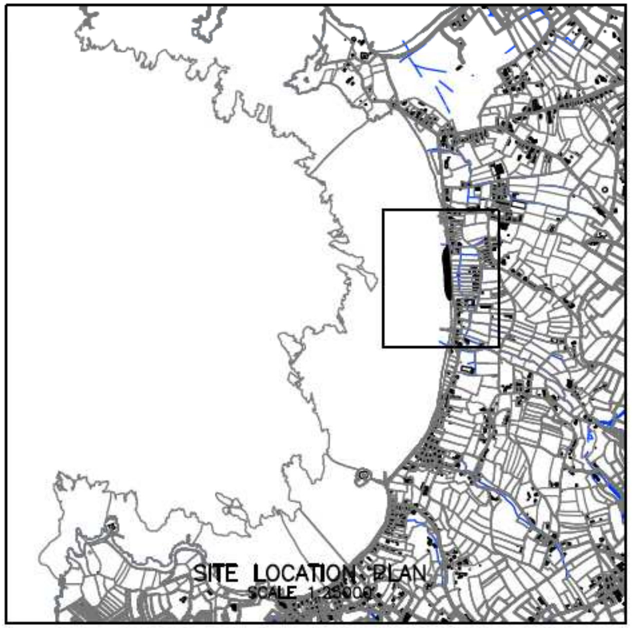
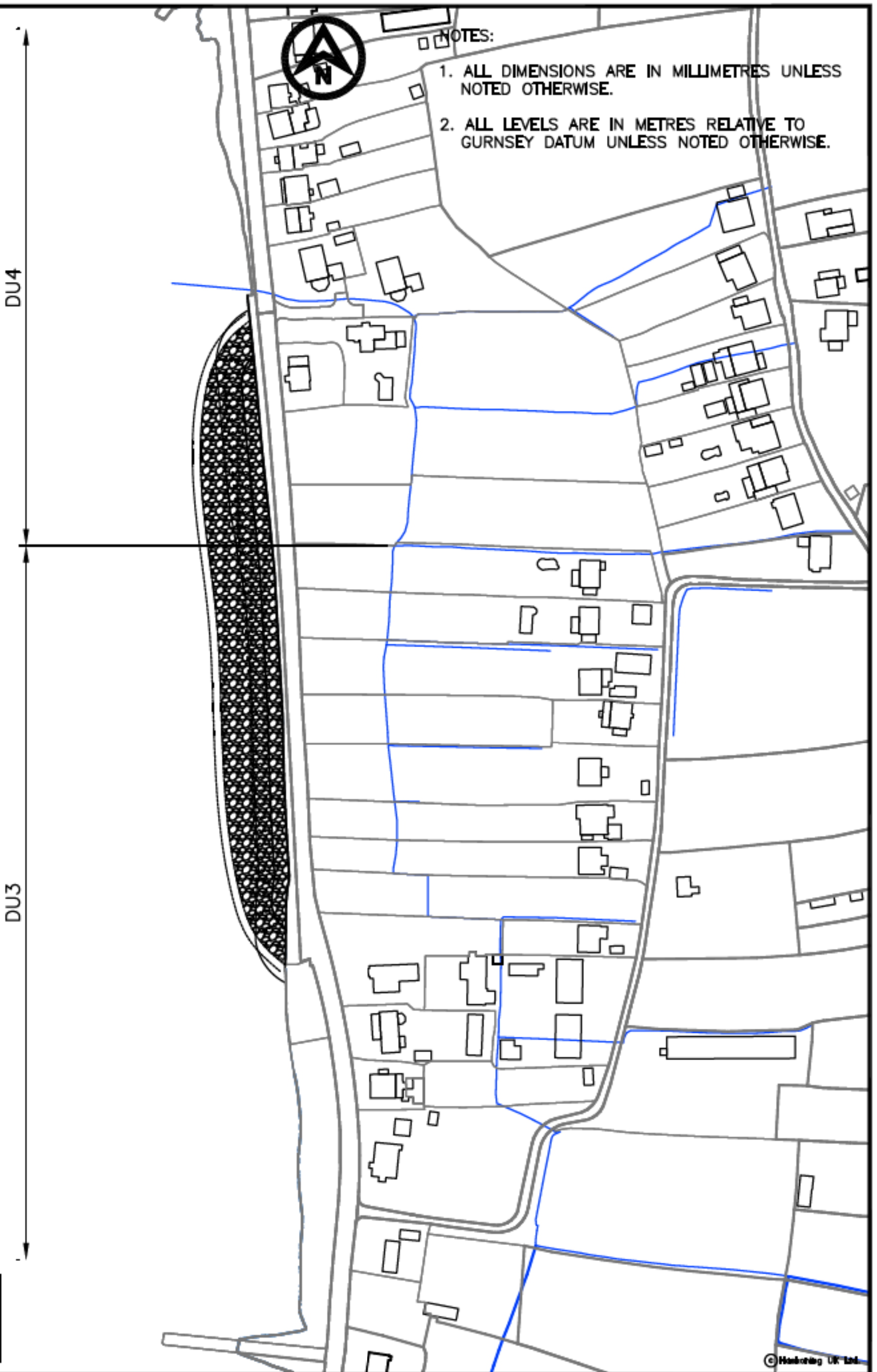
TITLE COBO BAY TYPICAL LAYOUT OF BREAKWATERS UNDER STRATEGIC OPTION 2	PROJECT GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING HASKONING UK LTD COASTAL AND RIVERS DIVISION	Job No. 9W2890	DATE FEB'11	SCALE 1:5000
			ACAD Ref. 9W2890–5001	CHECKED BO	PASSED PW
			DRAWN GG	DRG No. 9W2890–5001	REV APP.F

DO NOT SCALE



TYPICAL CROSS SECTION
SCALE 1:200





NOTES:

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TITLE ROCQUAINE BAY ROCK REVETMENT TOE PROTECTION OPTION 2	PROJECT GUERNSEY COASTAL DEFENCES FLOOD RISK ASSESSMENT STUDIES	ROYAL HASKONING HASKONING UK LTD COASTAL AND RIVERS DIVISION

Job No. 9W2890	DATE FEB'11	SCALE 1:2500
ACAD Ref. 9W2890–6001	CHECKED BO	PASSED PW
DRAWN GG	DRG No. 9W2890–6001	REV APP.F