The Coastal Geomorphology of North Cornwall: St. Ives Head to Trevose Head.

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A review of the scenery and coastal geomorphology of north Cornwall between St. Ives and Trevose Head, an area in the potential shadow of the proposed Wave Hub wave farm. This report comes ahead of the Wave Hub's proposed installation offshore of St. Ives in early 2009, and is made as part of the WHISSP (Wave Hub Impact on Seabed and Shoreline Processes) project at the University of Plymouth. A special emphasis is given to the character and physical attributes of the fifty-three individual beaches and coves in the study area, as well as the physical coastal processes in the region.

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Overview

1.1 The 'Wave Hub' and WHISSP

On the 6th December 2007 the UK Secretary of State for Environment, Food and Rural Affairs permitted the South West of England Regional Development Agency (SWRDA) to provide the necessary infrastructure to support and encourage developers of wave energy converters (WECs) to trial clusters of renewable energy devices in a so-called 'wave-farm' called the 'Wave Hub' [SWRDA, 2008]. The proposed location is 20km northwest of St. Ives in north Cornwall, in 50-60m water depth [South West of England Regional Development Agency, 2006]. It will be able to generate 20 megawatts of electricity over a deployment area of 4×2 kilometres (see Figures 1.1 and 1.2), feeding to an electricity substation located behind the dunes at Hayle [South West of England Regional Development Agency, 2006]. It represents the world's first large scale wave farm, supporting up to 30 wave energy devices, expected to be operational in 2009 [SWRDA, 2008].

A modelling study carried out by South West of England Regional Development Agency [2006] suggested that the Wave Hub would cause between 3 and 5% reduction to wave height between Gwithian and Newquay, as well as minor changes to surface tidal currents and offshore bed elevations. However, due to the inherent uncertainty behind such coastal modelling approaches in this hydrodynamic data-poor region, the WHISSP (Wave Hub Impact on Seabed and Shoreline Processes) project has been commissioned at the University of Plymouth to model and monitor the impact on the sea bed and shoreline of devices deployed in the Wave Hub project [UoP, 2008]. One of the key areas for concern regarding Wave Hub is an estimated wave height attenuation and tidal current modification in the lee of the Hub, and the associated impact on sedimentation, beach topography and beach state. A particular focus of WHISSP will therefore be on those popular recreational beaches in the hub's shadow. While the extend of the shadow cannot be known until the WEC devices are installed, the maximum likely extend is the stretch of north Cornwall between St. Ives and Trevose (see Figure 1.2), which is therefore the subject of this manuscript.

This report details fifty-three individual beaches and coves in the study area, which have been selected based on their area (≥ 1000 m^2). For each, a brief description of their character, physiography and physical attributes is given, based on the analysis of maps and secondary literature. The major beaches in the area, some fifteen in total, have also been sampled for their sediment and the results of particle size and carbonate analyses are given. Where available,

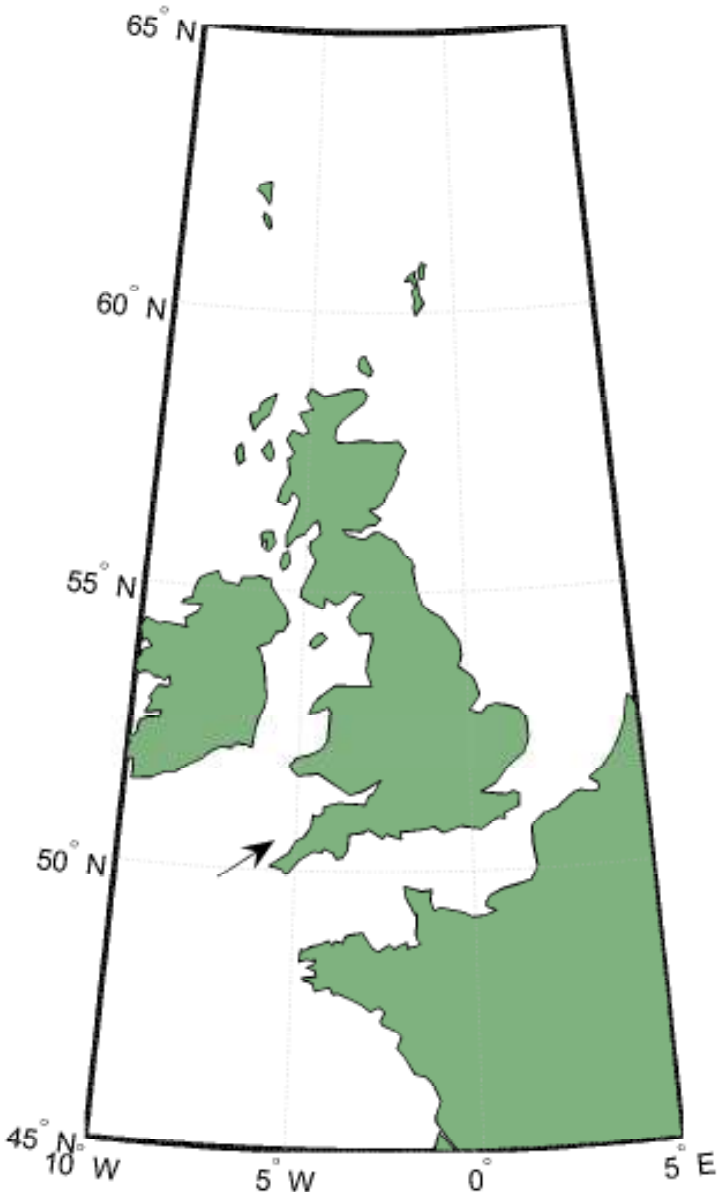

Figure 1.1 *The proposed location of the wave hub site is marked with an arrow.*

panoramic photos, beach profiles and digital elevation models are presented, based on recent surveys. Finally, these fifteen major beaches have been classified under a morphodynamic classification scheme.

1.2 Physiography and Geology

No other English county has as long a coastline as Cornwall. The stretch of coast between St. Ives Head and Trevose Head is relatively straight, with high cliffs and rocky headlands and a high proportion of coastal sand dunes. The geology in this part of north Cornwall has been classified as resistant and as having a 'high average resistance' by Clayton and Shamoon [1998], being composed of sandstones, shales, conglomerates, (Old Red Sandstone) slates and limestones which are Devonian (345–395 Ma BP) in age. This relative resistance is aided by the fact that cornwall was not glaciated under any Pleistocene glaciation, therefore there is no cover of weathered glacial material. The primary control on the evolution and behaviour of this stretch of coastline is the resistant nature of the geology [Halcrow, 2002]. The geology of the western section between St Ives and Newquay is dominated by the Porthtowan formation which consists of slates interbedded with sandstones and siltstones. This outcrops at Black Cliff near Hayle, and again north-east past Godrevy Point, and between Porthtowan and Perranporth. This formation has undergone metamorphic modification at St Agnes Head and Cligga Head [Bird, 1998]. The geology east of Newquay is dominated by the Trevose Slates, composed of slates with thin bands of limestone and volcanics, common between Bedruthan Steps and Trevose Head. The geology around Pentire Point is unique in that it is made up of Devonian pillow lavas and intruded volcanic lithologies [Bird, 1998]. These Devonian rocks vary considerably in hardness locally: the bays such as St Ives and Constantine are the result of relatively weak geology, and the many smaller coves have developed along minor faults in the rocks. The form and height of the cliffs is governed to a certain extent by being erosion platforms of Tertiary age.

Between 80ka BP and 120ka BP the sea level in Cornwall was 2–3m above its present position, and between 80ka BP and 6ka BP the sea level was lower than it is today. At the Last Glacial Maximum (LGM) the Cornish sea level was at least 120m lower than its present level [Bird, 1998; Scourse and Furze, 1999]. The mean sea level has been approximately stable since 6ka BP. North Cornwall is undergoing subsidence following the Lateglacial and Holocene deglaciation of the British Isles, at a rate of -1.1 mm a^1 [Shennan and Horton, 2002; UKCIP, 2006], recently revised down to -0.5 mm a^1 [DEFRA, 2006] based on new evidence by Gehrels [2006]. Whilst not glaciated during the Pleistocene (between 2 million and 10,000 years old), the landscape of north Cornwall is dominated by Pleistocene periglacial deposits, which locally can be important sources of sediment in the coastal system. Such sediments may be broadly classified into raised beach deposits, and head deposits. The raised beach deposits (found near Godrevy on the eastern side of St Ives Bay and Fistral near Newquay) were termed the Godrevy Formation by Scourse and Furze [1999] and were laid down 120,000 years ago during the high sea level phase of the Ipswichian interglacial. Their survival gives some indication of cliff recession rates, which must have been slow on these sections of coast. The Godrevy Formation is described in more detail by Campbell [1998]. Head deposits are extensive and consist of unconsolidated and poorly sorted mixtures of locally-derived rocks and sands/muds, formed by freeze-thaw and slumping/solifluction during glacial periods between 75ka BP and 25ka BP [Scourse and Furze, 1999]. In some locations, submerged forests may be found which

Figure 1.2 *WHISSP study area (scale 1:230220)*

are relict from past low sea levels (e.g. Portreath and Constantine).

Periglacial deposits are variable in nature, being composed of varying proportions of sands, gravels, boulders and muds. This explains some of the intra-beach sedimentary variability along this stretch of coastline. Measurable rates of coastal erosion are generally only found where the head deposits covering the bedrock are relatively unconsolidated [Halcrow, 2002].The diverse scenery of sandy beaches and dunes is also influenced heavily by local rivers (e.g. Perranporth and Porth Towan) and high and low cliffs of varying lithology, into which erosional features such as stacks, arches and hanging valleys have been cut. The study area has a large proportion of hindshore sand dunes compared with the national average. These dunes, such as at Phillack to Gwithian Towans, Godrevy Towans, Penhale and Holywell, develop to some considerable distance inland above beaches develop in sediment-rich areas under strong onshore winds. Gravel and boulders is present in smaller coves and fluvially-dominated systems such as Porthtowan, Porth Joke and Mawgan Porth, but in largely insignificant quantities [JNCC, 2008]. Well developed gravel and boulder ridges are absent from the study area.

The WHISSP beaches are characterised by low erosion rates (relative stability) due to high inputs of sediment from offshore. This makes the beach material unusually high in carbonate (up to 90%), especially since mineralgic contributions from local cliffs are relatively small. They are characterised by large tidal ranges and significant wave heights, thus large redistributions of material during storms and a strong seasonal component to beach change. On nearly all of the WHISSP beaches, dominant controls are also played by some combination of intertidal rock outcrops (for example constraining rip channels at high tide) and streams which discharge directly into the beach. For any given beach, exchanges of material on/offshore are likely to be more significant than exchanges alongshore.

1.3 Wave and tidal regime

The spring tidal range of the study area is of the order 5–6m [UKHO, 2003], and the 10% exceedance significant wave height of 2.5–3m [Draper, 1991; NERC, 1998], characterised by a mixture of Atlatic swell and locally-generated fetch-limited sea. This is amongst the strongest wave action in UK coastal waters. Tidal currents (Figure 1.3) are generally weak ($\leq\approx$ 0.75m/s) except locally around headlands (such as Godrevy Head). The co-range lines are seen in Figure 1.4.

A recent study [Millar et al., 2007] modelled the likely sensitivity of the wave climate to the proposed Wave Hub wave farm, concluding that the likely effects will be small. Table 1.1 reproduces some of the findings for wave height reduction associated with various transmission scenarios at different beaches along the study area (zero transmission refers to total wave absorption and is included purely for reference - note that a 90% transmission is a likely figure). This study concluded that at 90% transmission the average reduction in significant wave height was of the order 1cm, and that the stretch of the coast most likely to be affected was between Godrevy Head at the east of St Ives Bay and Towan Head to the west of Newquay Bay.

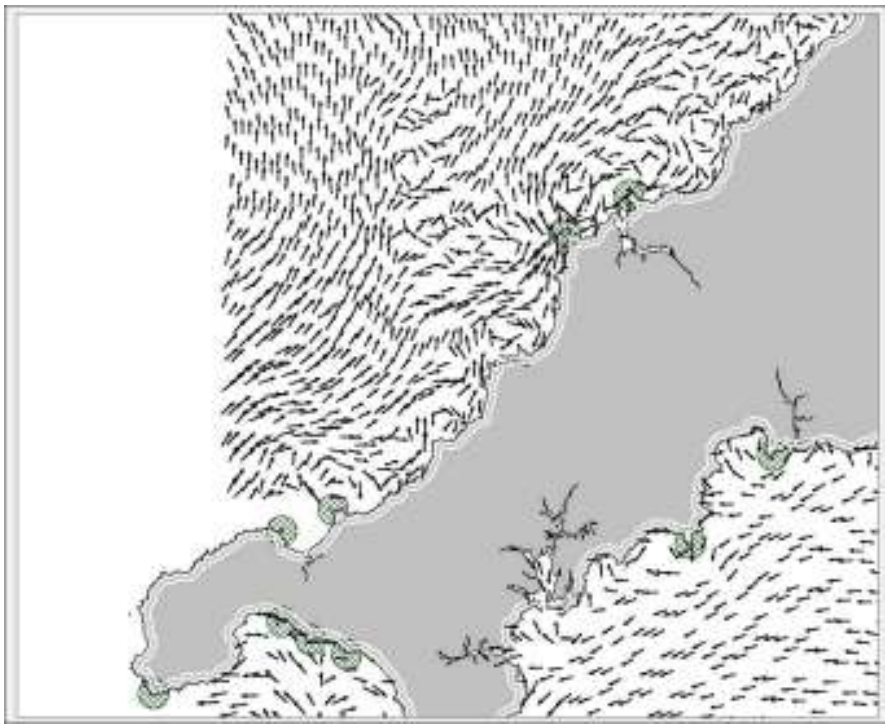

Figure 1.3 *Tidal residuals within the study area, according to Halcrow [2002]. Arrow size is relative to magnitude of the tidal flux. Map extent is 100km.*

Table 1.1 *Summary of the model findings of Millar et al. [2007]*

Location	Parameter	0% energy transmission	90% energy transmission
Gwithian	Max. $\Delta H_s/H_s$ (%)	11.72	1.08
	Av. $\Delta H_s/H_s$ (%)	3.44	0.36
Porth Towan	Max. $\Delta H_s/H_s$ (%)	9.18	0.97
	Av. $\Delta H_s/H_s$ (%)	4.68	0.47
Perranporth	Max. $\Delta H_s/H_s$ (%)	17.26	1.63
	Av. $\Delta H_s/H_s$ (%)	6.57	0.65
Fistral	Max. $\Delta H_s/H_s$ (%)	11.19	1.06
	Av. $\Delta H_s/H_s$ (%)	3.96	0.38
Newquay	Max. $\Delta H_s/H_s$ (%)	7.25	0.88
	Av. $\Delta H_s/H_s$ (%)	1.19	0.12
Watergate	Max. $\Delta H_s/H_s$ (%)	8.34	0.79
	Av. $\Delta H_s/H_s$ (%)	1.90	0.19
Constantine	Max. $\Delta H_s/H_s$ (%)	9.65	1.15
	Av. $\Delta H_s/H_s$ (%)	1.72	0.18

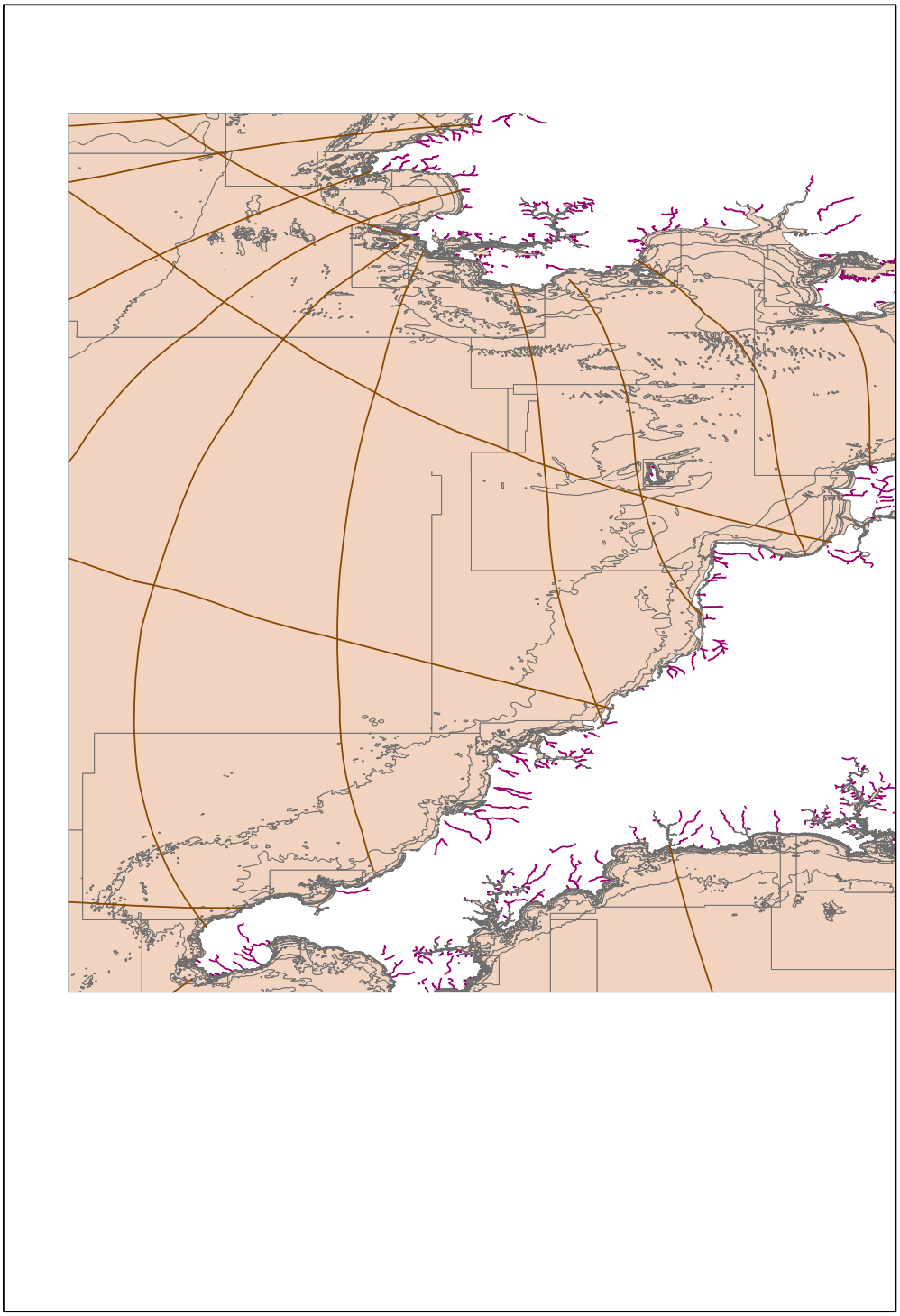

Figure 1.4 *Main rivers and tidal co-range lines in the WHISSP area. Source: Marine Digimap.*

1.4 Sediment and sediment transport

A numerical modelling study by Pingree and Griffiths [1979] suggested that the north coast of Cornwall undergoes net north-westerly sediment transport under prevailing westerly/south-westerly waves. It would appear, however, that there is a discrepancy in this well-supported point of view and evidence of bedform symmetry [Stride, 1963] which would suggest the opposite. Waves cause strong seasonal onshore/offshore movements of sediment at the shore [Scott et al., 2007], however there is thought to be limited movement in deeper water due to the low volume of sediment available, and the pattern on inlets and headlands [Halcrow, 2002]. According to Halcrow [2002], wave-induced currents are considerably more important than tide-induced currents in nearshore sediment transport affecting beaches. Based on what limited information there is on nearshore sediment circulation patterns in the study area, it is thought that sand stays close to the coast with its movement driven by south-westerly swell and north/easterly wind waves during storms.

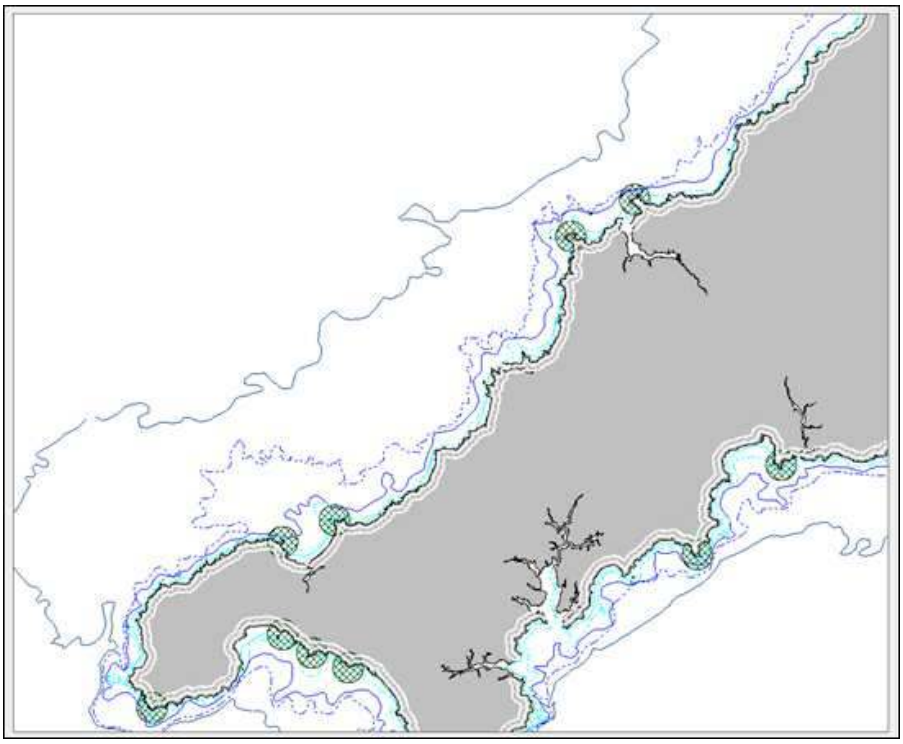

Figure 1.5 *Bathymetric overview of the study area, according to Halcrow [2002]. The -5, -10, -20, -30, -50m depth contours are shown. Map extent is 100km.*

The seabed slopes quickly to the -50m bathymetric contour offshore (Figures 1.5 and 1.6), after which it flattens considerably to the inner continental shelf at about 1m/km. The bathymetry is relatively uncomplicated, being approximately parallel to shore until approximately -60m. Offshore, the bedrock consists of slates and sandstones of Devonian and

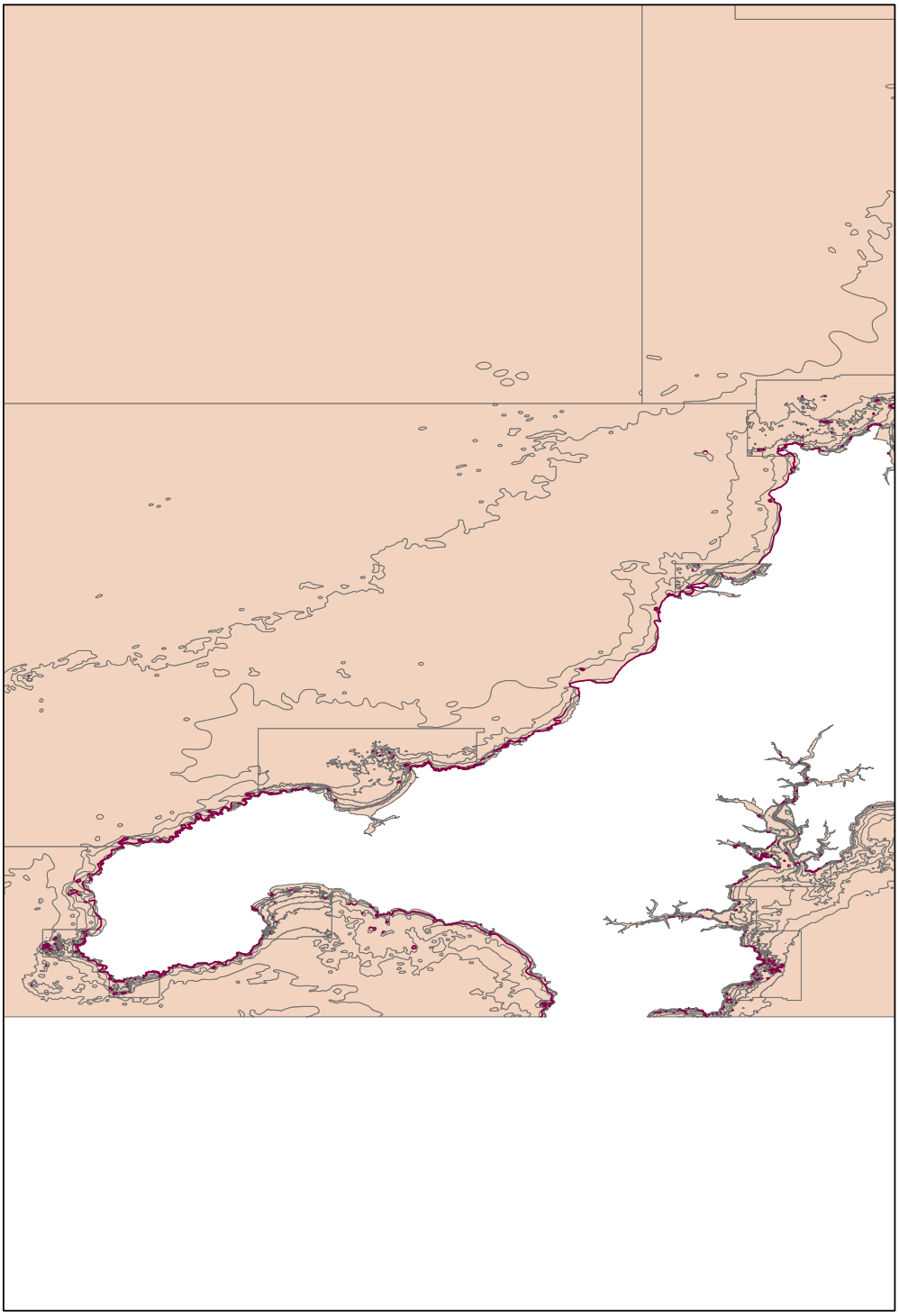

Figure 1.6 *Bathymetric contours of the WHISSP area. Source: Marine Digimap.*

Carboniferous age. In places, submerged cliffs and valleys formed during Pleistocene glacial periods when sea levels were lower occur, covered by a thin ($\leq$1m) layer of sand and gravel of Quaternary age. The reason for the sparse sedimentary covering offshore is probably because of the lack of terrestrial sediment supply from glacial weathering, as well as the relatively resistant bedrocks. Ancient fluvial channels have been detected offshore but are probably of minor hydrodynamic importance [Halcrow, 2002]. There is limited seismic seabed composition data available for this stretch of coast.

The carbonate content of the beaches of the study area is unusually high, up to 80% [Goudie, 1990; Halcrow, 2002] to the west of the study area at St Ives. This material is sourced largely from offshore from the calcareous shells and cases of marine bryozoa and echinoid [Halcrow, 2002], broken up and driven onshore by large waves. North Cornwall has a long history of mining activity, which has supplied a significant proportion of muds and fine sands to the coastal system (Figure 1.7). Old mining sites such as around St Ives and St Agnes contain sediments rich in minerals such as tin, copper, lead, iron and antimony [JNCC, 2008]. The majority of beaches in the study area are influenced by rivers which discharge directly into the beaches, which affect the local sedmentary makeup as well as drainage and the position and size of rip channels. The influence of these rivers on the coast is poorly studied.

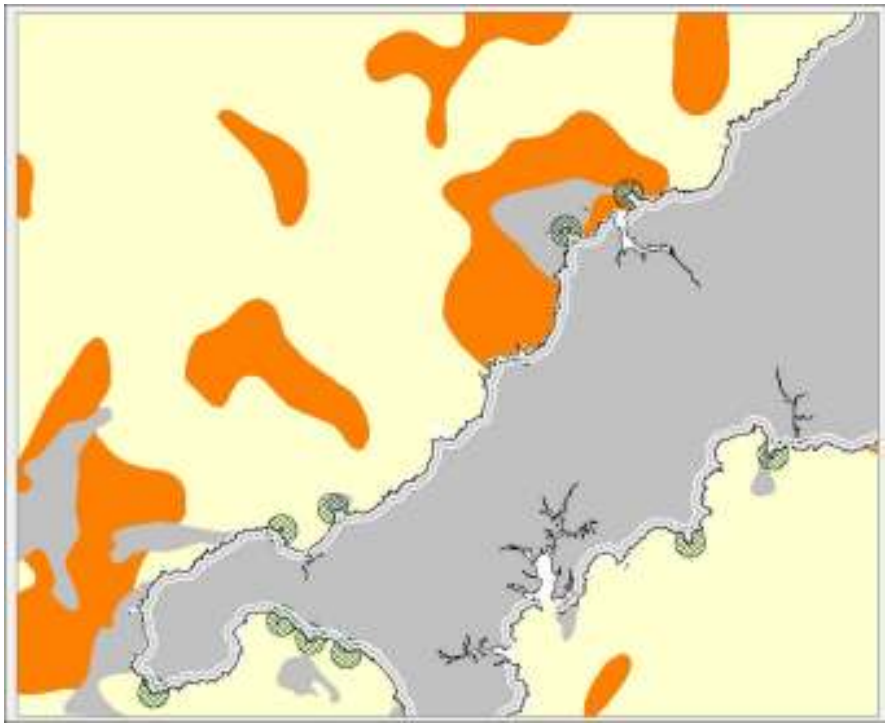

Figure 1.7 *Overview of the seabed sediments in the study area, according to Halcrow [2002]. Darkest shading is bedrock, intermediate is gravel, and light shading is sand. Map extent is 100km, and the information has largely been gathered from the British Geological Survey of 1987.*

1.5 Morphodynamic classification of WHISSP beaches

The main WHISSP beaches have been classified according to the classification scheme of Scott [in prep] which is specifically designed for macrotidal beaches of the UK. Reflective beaches are steep and have a reflective energy regime of plunging/surging breakers throughout a tidal cycle. Dissipative beaches have shallow slopes and tend to attenuate rather than reflect energy through spilling breakers in a wide surf zone. Consequently, relatively little energy reaches the shoreline. Intermediate beaches lie somewhere between reflective and dissipative beaches and tend to be morphologically more complicated or 'three-dimensional' (varying alongshore). Figures 1.8 and 1.9 provide a detailed explanation of the classification scheme used.

Table 1.2 *Beaches in the study area classified according to a morphodynamic classification scheme*

Beach	Type	Sub-type		Morphology
		HW	LW	
Porthmeor	Intermediate	Reflective	Intermediate	Low tide terrace + bar/rip
Carbis	Dissipative	Dissipative	Dissipative	Non-barred dissipative
Hayle	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Gwithian	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Portreath	Intermediate	Reflective	Intermediate	Low tide terrace + bar/rip
Porthtowan	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Chapelporth	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Crantock	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Fistral	Intermediate	Reflective	Intermediate	Low tide terrace + bar/rip
Towan	Dissipative	Dissipative	Dissipative	Non-barred dissipative
Watergate	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Porthcothan	Dissipative	Intermediate	Intermediate	Low tide bar/rip
Constantine	Intermediate	Intermediate	Intermediate	Low tide terrace + bar/rip
Boobys	Intermediate	Intermediate	Intermediate	Low tide terrace + bar/rip

1.6 Human Intervention and Shoreline Management

The entire stretch from Lands End to Trevose Head comprises one subcell (b - St Ives Head to Hartland Point) of management unit 7 (Lands End to Hartland Point) in the Shoreline Management Plan (SMP - see Figure 1.3) for the UK [Motyka and Brampton, 1993; Cooper et al., 2002], under the responsibility of the Cornwall and Isles of Scilly Coastal Authorities Group, a consortium composed of Cornwall County Council, English Nature, the Environment Agency, and Caradon, Carrick, Isles of Scilly, Kerrier, Penwith, North Cornwall, and Restormel District Councils. Table 1.4 contains a summary of present shoreline management activities, which collectively amounts to not a great deal of hard defences compared to many other regions of England and Wales.

JNCC [2008] have designated a number of GCRs (Geological Conservation Review sites) in a number of SSSIs (Sites of Special Scientific Interest) in the study area. In fact, most of the study area comprises one GCR or another (see Table 1.5). These are areas of geological interest which require special protection, mintenance, appreciation and research.

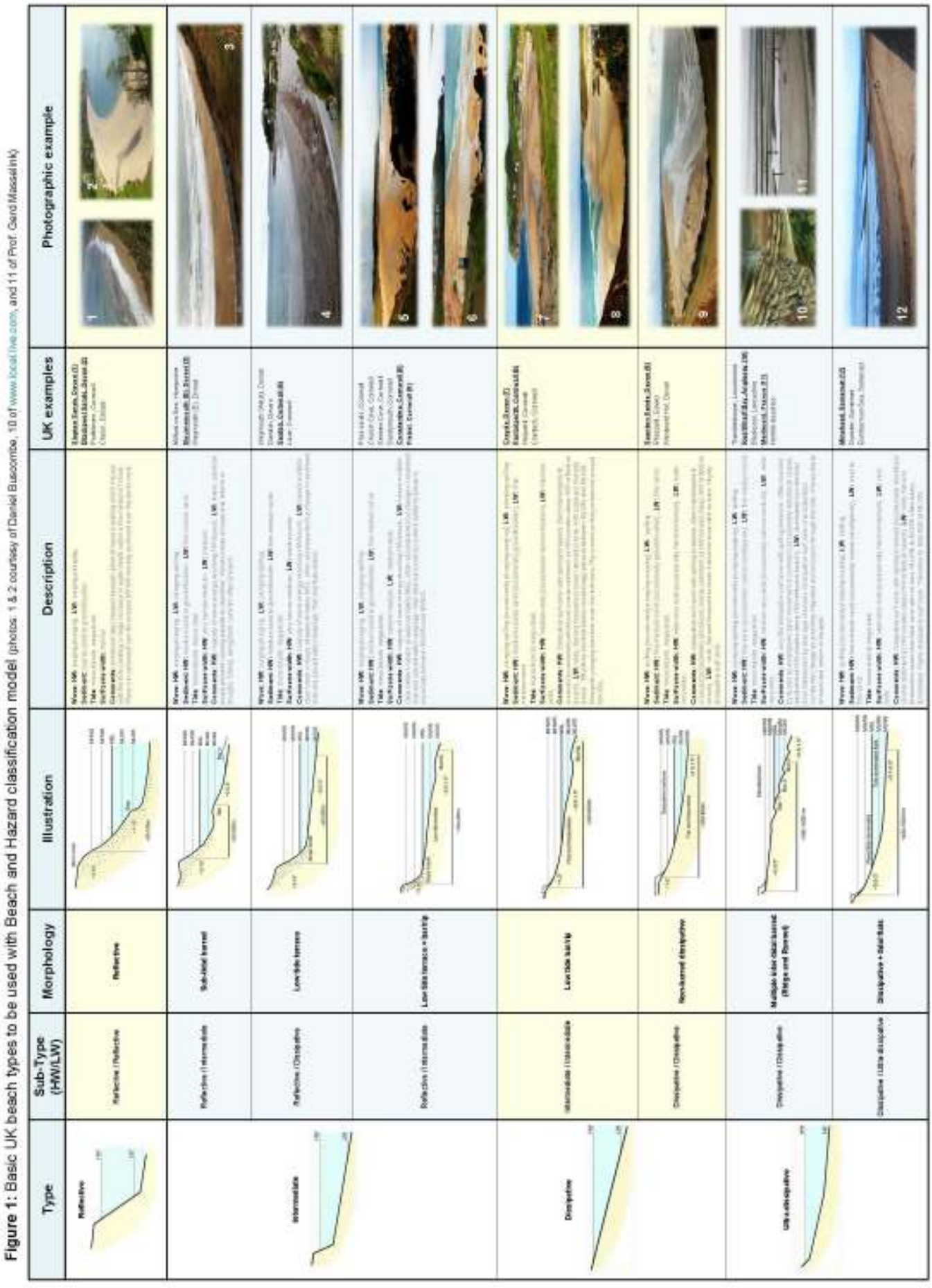

Figure 1.8 *Morphodynamic classification of beach types (from Scott [in prep]) I: type and description.*

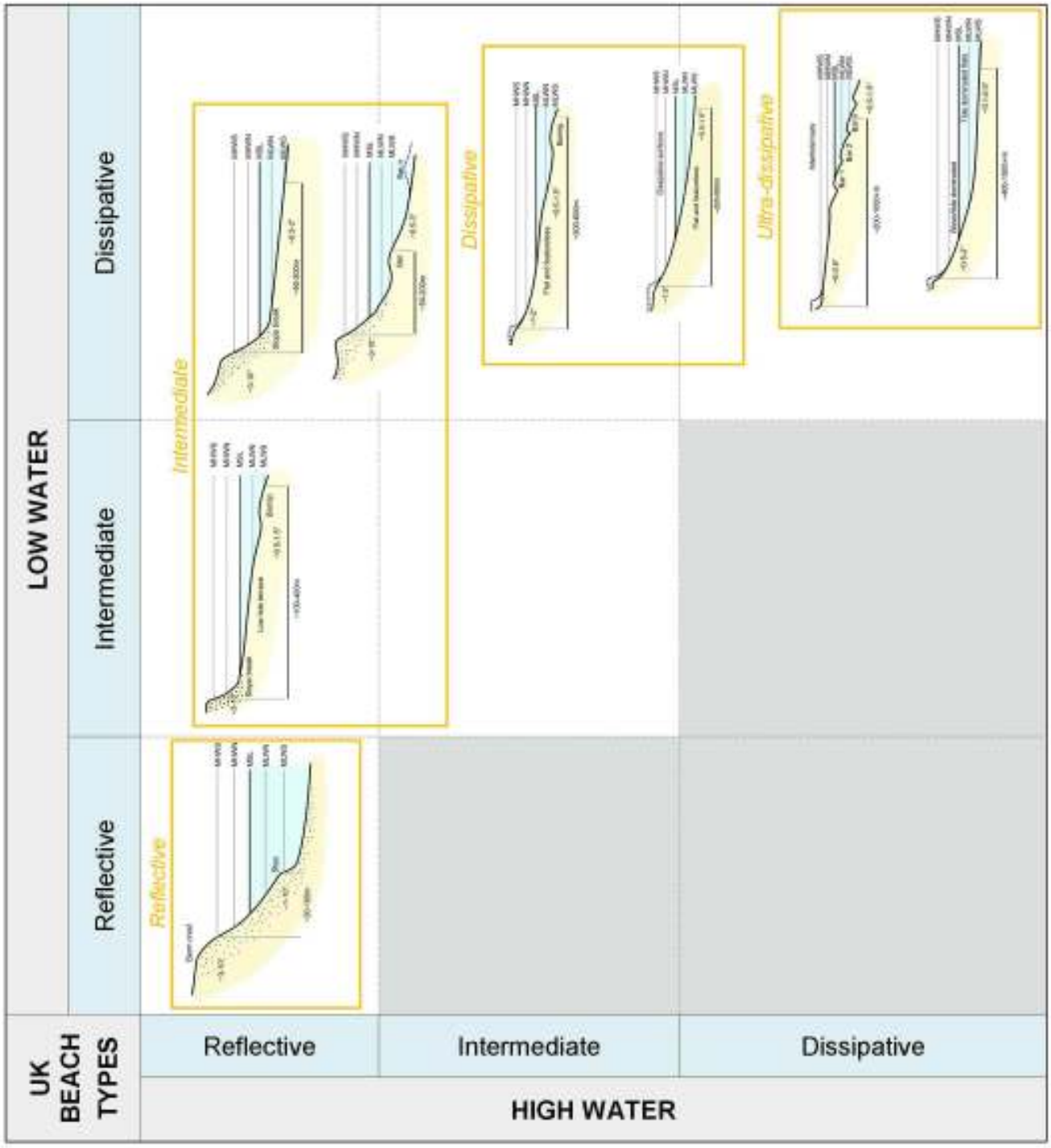

Figure 1.9 *Morphodynamic classification of beach types (from Scott [in prep]) II: conceptual matrix of beach types.*

Table 1.3 *Halcrow [2002] divisions for SMP Cell 7b (St Ives Head to Hartland Point)*

SBS (Shoreline Behaviour Statement)	LSRS (Local Scale Shoreline Response)
St Ives Bay (St Ives Head to Godrevy Point)	St Ives Carbis Bay to Godrevy
Godrevy Point to Pentire Point	Godrevy Point to Perranporth Perranporth to Towan Head Towan Head to Trevose Head Trevose Head to Pentire Point
Pentire Point to Hartland Point	Pentire Point to Widemouth Bay Widemouth Bay to Crooklets Crooklets to Hartland Point

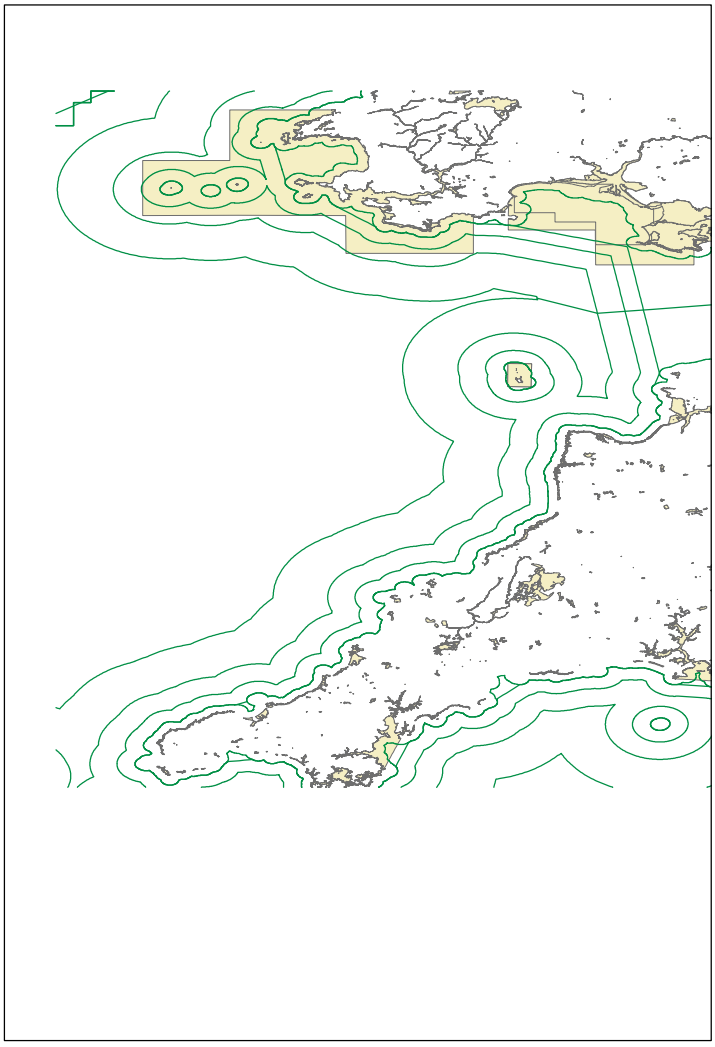

Figure 1.10 *Protected areas and national limits. Source: Marine Digimap.*

Table 1.4 *Summary of present shoreline management activities*

Beach	Management
Porthmeor	
Porth Gwidden	stone gabion
Harbour Sand	sea wall; harbour pier
Porth Minster	sea wall
Carbis Bay	sea wall
Porth kidney and Hayle	estuary dredging; sluicing
Phillack	dune management; sand extraction
Upton Towans	dune management; sand extraction
Gwithian Towans	dune management; gravel-sand bund
Godrevy Cove	
Mutton Cove	
Fishing Cove	
Hudder Fown	
Hell's Mouth	
Hudder Cove	
Basset's Cove	
Porth-cadjack Cove	
Western Cove	
Portreath	sea wall; harbour pier
Gooden Heane Cove	
Sally's Bottom	
Porth Towan	sea wall; river training
Chapel Porth	sea wall; river training
Trevaunance Cove	sea wall
Grean Island	
Hanover Cove	
Perranporth	sea wall; river training
Hoblyn's Cove	
Holywell	dune management
Porth Joke	
Crantock	dune management
Fistral	sea wall; stone gabion; harbour
Towan	beach de-watering system; harbour
Tolcarne	
Lusty Glaze	
Porth	sea wall; river training
Whipsiderry	
Watergate	sea wall; gabion
Stem Cove	
Beacon Cove	
Mawgan Porth	sea wall; gabion
Trerathick Cove	
Whitestone Cove	
Bedruthan Steps	
Diggory's Island	
Pentire Steps	
The Saddle	
Porth Mear	
Porthcothan Bay	
Fox Cove	
Pepper Cove	
Treyarnon Bay	
Constantine Bay	dune management
Booby's Bay	sea wall

Table 1.5 *GCR Sites between St Ives Head and Trevose Head [JNCC, 2008].*

SSS1	GCR	Grid Reference
Aire Point to Carrick Du	Porthmeor Cove	SW425376
Bedruthan Steps	Bedruthan Steps	SW849696
Godrevy Head to St Agnes	Godrevy	SW581428
	Godrevy Point and Strap Rocks	SW579415
	Wheal Coates	SW698499
Gwithian to Mexico Towans	Upton and Gwithian Towans	SW575406
Harbour Cove	Harbour Cove	SW914768
Penhale Dunes	Cotty's Point, Perranporth	SW758549
	Gravel Hill Mine	SW764575
	Perran Beach to Holywell Bay	SW760591
Pentire Peninsula	Pentire Head	SW933796
	Pentire Point - Rumps Point	SW931804
	Polzeath to Pentire Point	SW931799
St Agnes Beacon	St Agnes Beacon Pits	SW705510
Trevaunance Cove	Trevaunance Cove	SW723517
Trevone Bay	Marble Cliff	SW890763
	Pentonwarra Cliff	SW890760
	Porthmissen Bridge	SW892765
	Trevone Bay	SW889763
Trevose Head and Constantine Bay	Booby's Head to Trevose Head	SW857751
	Dinas Head to Trevose Head	SW849764

Coastal erosion is limited compared with the east and south-east coasts of England. Cliff recession is occuring at such a slow rate it is difficult to measure, however sand dune erosion is an increasing concern [JNCC, 2008; Halcrow, 2002]. The risk of coastal flooding is greatest when a storm surge amplifies the spring high tide. Portreath and Perranporth are considered to be at greatest risk from coastal flooding [JNCC, 2008].

Cell	Site	Foreshore	Backshore	Map Dates
St. Ives Bay	w103	widening	short	1889, 1908, 1938, 1963, 1989, 2000
	w104	no change	no change	1908, 1963
	w105	long	widening	1889, 1908, 1938, 1963, 1979, 1989, 2000
	w106	long	no change	1908, 1963, 2000
Godrevy to Pentire Point	w107	no change	no change	1908, 1963, 2000
	w108	widening	no change	1888, 1908, 1963, 1982, 2000
	w109	widening	no change	1908, 1963, 2000
	w110	widening	long	1888, 1908, 1963, 1982, 2000
	w111	widening	no change	1908, 2000
	w112	no change	widening	1908, 1963, 2000
	w113	long	widening	1908, 1963, 2000
	w114	long	widening	1908, 1963, 2000
	w115	long	widening	1888, 1908, 1933, 1963, 1976, 2000
	w116	long	long	1888, 1908, 1933, 1963, 1973, 1993, 2000
	w117	widening	widening	1907, 1963, 2000
	w118	long	widening	1907, 1963, 2000
	w119	widening	widening	1888, 1907, 1963, 1974, 2000
	w120	widening	short	1888, 1907, 1933, 1963, 1974, 2000
	w121	widening	long	1888, 1907, 1933, 1963, 1974, 1983, 2000
	w122	long	short-medium	1888, 1907, 1933, 1963, 1974, 1983, 2000
	w123	widening	widening	1888, 1907, 1983, 2000
	w124	long	no change	1888, 1907, 1933, 1963, 1974, 1983, 2000
	w125	long	short-medium	1888, 1907, 1933, 1963, 1974, 1983, 2000
	w126	long	widening	1888, 1908, 1963, 1976, 2000
	w127	long	widening	1888, 1907, 1933, 1963, 1976, 2000
	w128	long	widening	1907, 1963, 2000
	w129	long	widening	1888, 1907, 1933, 1978, 2000
	w130	long	widening	1888, 1907, 1963, 1978, 2000
	w131	no change	no change	1907, 1962, 2000
	w132	long	no change	1907, 1962, 2000

Table 1.6 *Halcrow [2002] shoreline trend analysis, from historical map analysis.*
'No change' refers to zero mean rate of shoreline change. 'Widening' refers to a positive mean rate of shoreline change. 'Long' refers to the projected life of an eroding shoreline being ≥100 years. 'Short' refers to the projected life of an eroding shoreline being ≤20 years. 'Short-medium' refers to the projected life of an eroding shoreline being 20-50 years.

Location	Behaviour	Height (mOD)	Engineering	Materials	Failure	Activity	Supply Potential
Porthmeor Beach	Simple cliffs	20	Cliff stabilisation, Toe protection	1,9	1	Inactive	3m
Porthminster Beach	Simple cliffs	30	Cliff stabilisation, Toe protection	1,9	1,4	Marginally stable	3m
Porthminster Point to Hayle	Simple cliffs	40	None	9	1,4ds	Marginally stable	3c
Black Cliff, Phillack	Simple cliffs	30	None	9	1,2,4ds	Marginally stable	3c
Gwithian	Simple cliffs	15	None	4,9	1,4ds	Active	2m
Godrevy Point to Portreath	Simple cliffs	80	None	7,9	1,2,4rs	Active	1c
Portreath to Porthtowan	Simple cliffs	75	None	7,9	1,2,4rs	Active	1c
St Agnes Head	Simple cliffs	90	None	9	1,2	Marginally stable	3c
Travellas	Simple cliffs	85	None	7,9	1,2,4rs	Active	1c
Perranporth	Simple cliffs	80	None	9	1,2	Marginally stable	3c
Penhale to Pentire	Simple cliffs	40	None	9	1,2,4ds	Marginally stable	3c
Newquay	Simple cliffs	40	None	9	1,2	Marginally stable	3c
Whipsiderry to Treyarnon	Simple cliffs	60	None	7,9	1,2,4ds	Active	1c
Constantine Bay	Simple cliffs	20	None	9	1,2	Marginally stable	3c
Trevose Head	Simple cliffs	70	None	9	1,2	Marginally stable	3c

Table 1.7 *Cliff classification. Data modified from Halcrow [2002], from video and map analysis.*
Materials are classified as follows: 1. Weak superficial deposits (WSD); 2. WSD over jointed weak rock (JWR); 3. Stiff clays (SC); 4. Weak sandy strata (WSS); 5. SC over WSS; 6. SC overlain by hard caprock; 7. Jointed weak rock (JWR); 8. Weak rock (chalk); 9. Hard rock.
Failure mechanisms are classified as follows: 1. Erosion; 2. Falls; 3. Flows; 4. Slides; sr. single rotational; mr. multi rotational; md. mudslide; ds. debris slide
Sediment supply potential is classified as: 1. High; 2. Medium; 3. Low; f. fine; m. medium; c. coarse.

Location	Sensitivity	Recession Potential	Recession Frequency	Uncertainty	Notes
Porthmeor Beach	Low	5	1	Moderate	Cliffs regraded and protected for development
Porthminster Beach	Medium	5,8	1,3	Moderate	Cliffs engineered for road access and development
Porthminster Point to Hayle	Low	5,8	1,3	High	Degraded coastal slopes above rock sea cliff
Black Cliff, Phillack	Low	5,8	1,3	High	
Gwithian	Medium	4,8	1,2	High	
Godrevy Point to Portreath	Medium	4,7	1,3	High	Large rockslides apparent 2001
Portreath to Porthtowan	Medium	4,7	1,3	High	Large rockslides apparent 2001
St Agnes Head	Low	5,8	1,2	High	Degraded slopes above rock sea cliff; quarry/mining works
Travellas	Medium	4,7	1,3	High	Large rockslides apparent 2001; quarry/mining works
Perranporth	Low	5,8	1,2	High	Degraded slopes above rock sea cliff; quarry/mining works
Penhale to Pentire	Low	5,8	1,2	High	Cliffs obscured by blown sand in places
Newquay	Low	5,8	1,3	High	
Whipsiderry to Treyarnon	Medium	4,7	1,3	High	Large rockslides apparent 2001
Constantine Bay	Low	5,8	1,2	High	

Table 1.8 *Future behaviour of cliffs. Data modified from Halcrow [2002], from video and map analysis.*
Recession potential (annual erosion rate) is classified thus: 1. Very high ≥2m/yr; 2. High 1-2m/yr; 3. Medium 0.5-1m/yr; 4. Low 0.1-0.5m/yr; 5. Very low ¡0.1m/yr; 6. High ¿50m (¿1ha); 7. Medium 10-50m (0.2-1ha); 8. Low ¡10m (¡0.2ha)
Recession (event) frequency is classified thus: 1. ≤1 year (erosion); 2. 1-10 years; 3. 10-100 years; 4. 100-250 years; 5. 250-1000+ years.

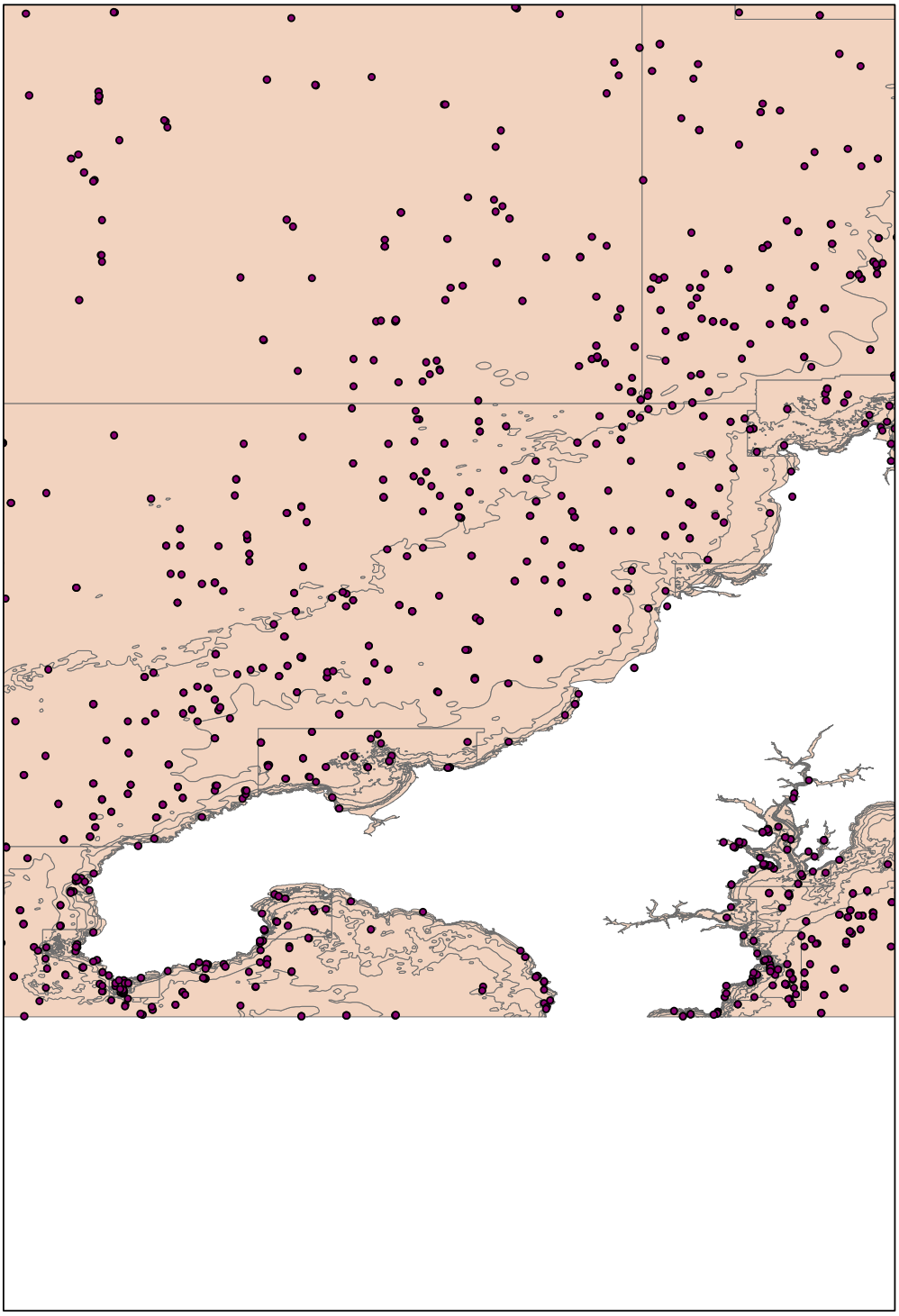

Figure 1.11 *Locations of wrecked ships in the WHISSP study area. Source: Marine Digimap.*

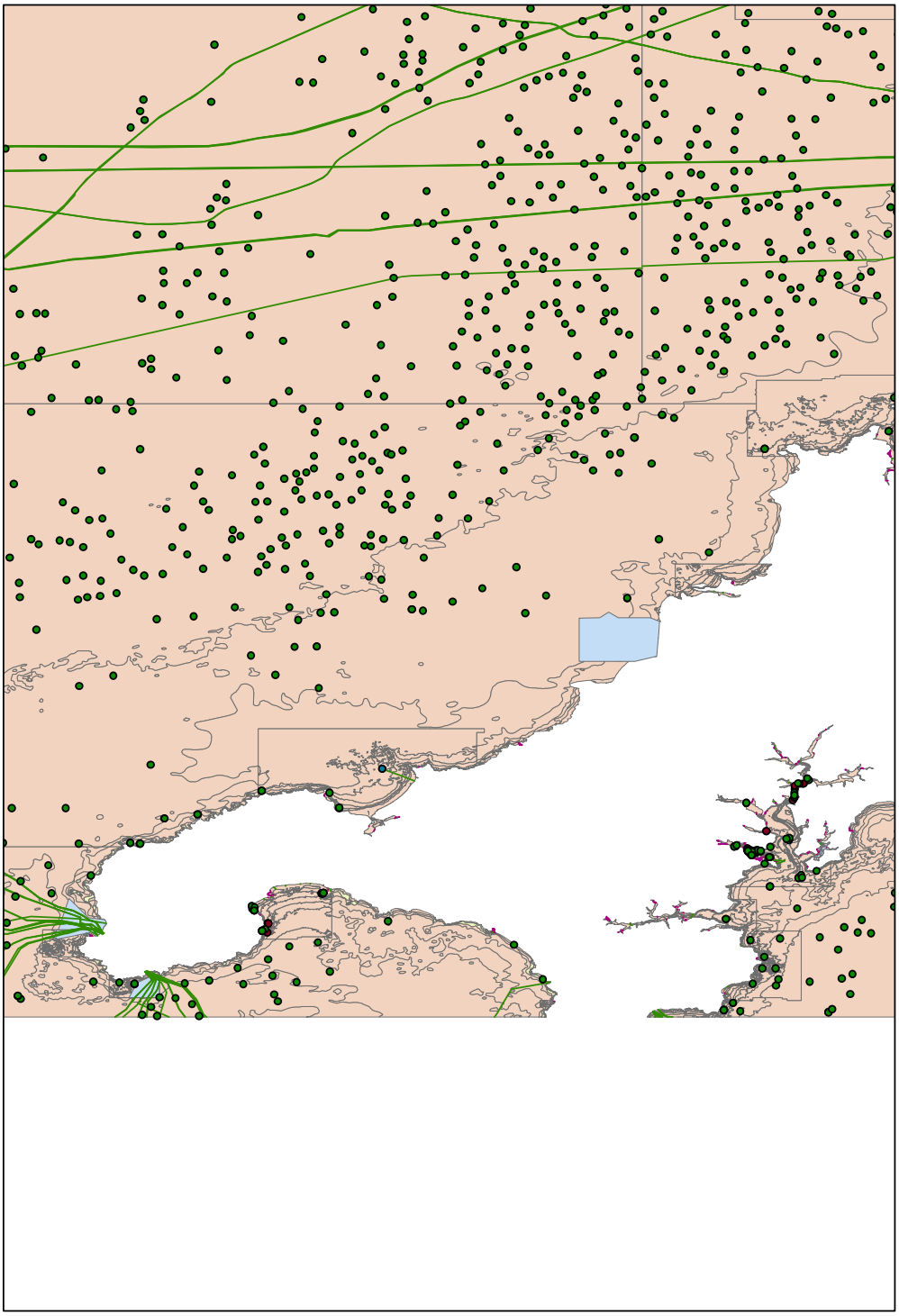

Figure 1.12 *Locations of construction, obstructions and installations in the WHISSP study area. Source: Marine Digimap.*

Chapter 2

St Ives Head to Godrevy Head

Figure 2.1 *St Ives Head to Godrevy Head (scale 1:38794)*

The stretch of coast between St Ives and Godrevy contains 10 beaches, comprising a total area of 2,802,500 m^2. St Ives Bay, 20 square kilometres in area and 7km at its widest extent, is a major sediment sink, with the beaches, dunes and Hayle estuary storing regionally important volumes of sand. This is a 'closed' sedimentary system with little/no input of sediment from adjacent stretches of coastline. This means that sediment eroded from local sources such as raised-beach deposits and sand dunes, is likely to remain within individual embayments and undergo periodic redistribution within the Bay [Halcrow, 2002]. Between Hayle and Godrevy there is potential for north-eastward sediment transport, however there is little evidence of sediment accumulating against Godrevy Head [Halcrow, 2002].

St Ives Bay has formed where the sea has cut in lee of relatively resistant granite rocks which make up the cliffs between St Ives Head and Lands End. In St Ives Bay the geology becomes Devonian silty slates, mudstones, sandstones and limestones. Godrevy Point and

Navax Point are possibly more resistant to erosion due to bands of sandstones in the slates [Halcrow, 2002]. There are limited amounts (less than 1m thick) of sand offshore in the Bay although these are not thought to have a strong interaction with shoreline sediments [Halcrow, 2002]. St Ives Bay is sheltered from the dominant south-westerly/westerly waves. Most of the beaches are swash-aligned to waves with roughly equal movement in either direction, although there is a tendency for longshore drift to deflect the north-oriented low-water harbour channel to the east. There is uncertainty over the exact nature of sediment movements within the Bay, particularly the alongshore movements which are likely to be most important for shorelines and beach plan shapes [Halcrow, 2002]. The beaches would be expected to retain their overall shape because of continual inputs of carbonate material from marine organisms, with possibly some additional material from the erosion of cliff heads and slopes. Local dune erosion in the un-sheltered section between Carbis and Godrevy would be expected to continue during storms.

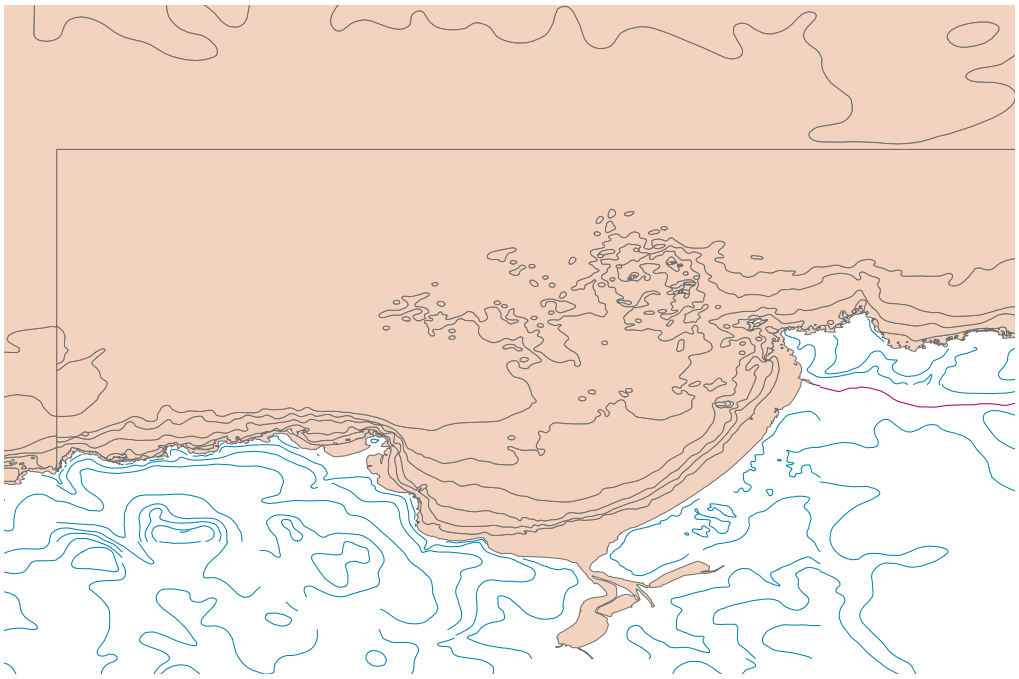

Figure 2.2 *Bathymetry of St Ives Bay. Source: Marine Digimap*

2.1 Porthmeor

'The Island' headland separates Porthmeor to the west, and Porth Gwidden, Harbour Sand and Porth Minster to the east. These are wide sand beaches composed of carbonate material. Porthmeor (SW515410) is one of the most popular surfing beaches in Cornwall. The rocky headlands separating the beaches in this part of St Ives Bay are composed of dolerite and gabbro, and the beaches are backed by cliffs and head deposits [Halcrow, 2002].

Table 2.1 *Porthmeor Beach - Physical Attributes*

Easting (m)	151629
Northing (m)	40968
Latitude	50°12'53.72" N
Longitude	5°28'58.87" W
Local authority	Penwith Council
Management Unit	Porthmeor 7A2-02
MSR (m)	5.77
Length (m)	550
LW Length (m)	550
Width (m)	200
Area (m^2)	110000
Angle (^{o})	350
Angle Code	NNW
Morphological Classification	Open coast beach.
Sediment Classification	High water sand and rock; low water sand.

Table 2.2 *Porthmeor Beach - Sediment Attributes (08/11/2007)*

	Lower	Upper
Mean (ψ)	-2.55 (0.17 mm)	-3.11 (0.11 mm)
Sorting (ψ)	0.35 (0.78 mm)	0.24 (0.85 mm)
Skewness	0.23	0.24
Mean fall vel (cm/s)	5.85	8.62
D_{50} (Hallermeier equation, mm)	0.43	0.61
$CaCO_3$ %	77.14 $\pm$ 0.61	n/a

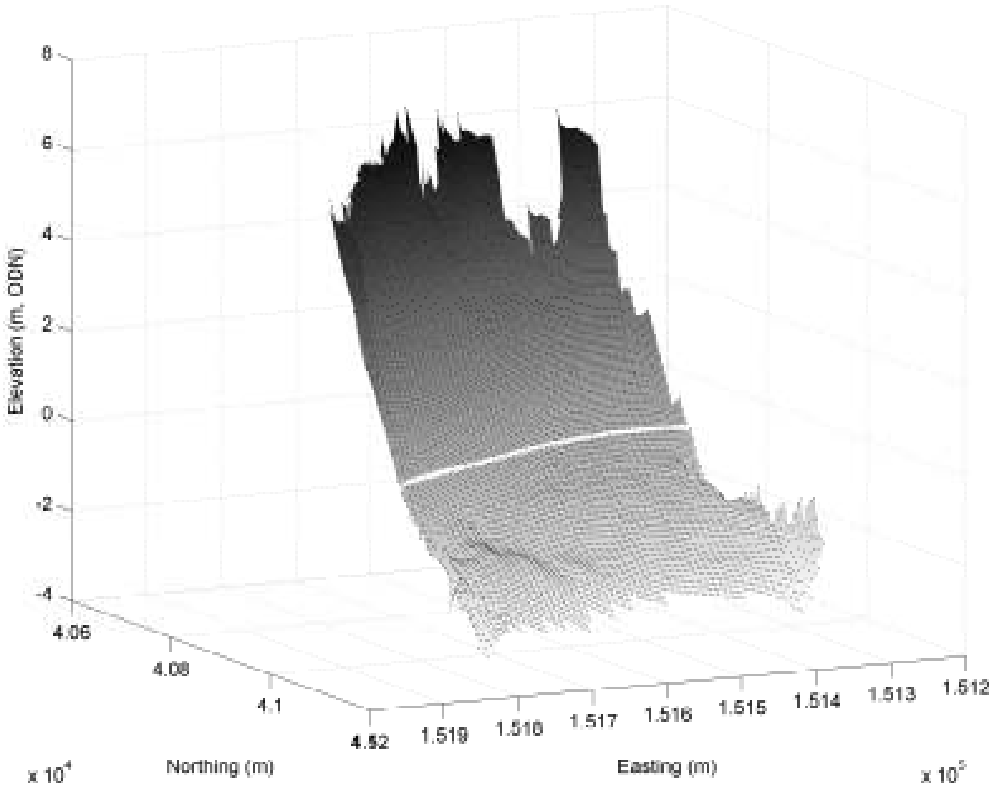

Figure 2.3 *Digital Elevation Model of Porthmeor Beach, 2007. Elevations in m (ODN) —0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

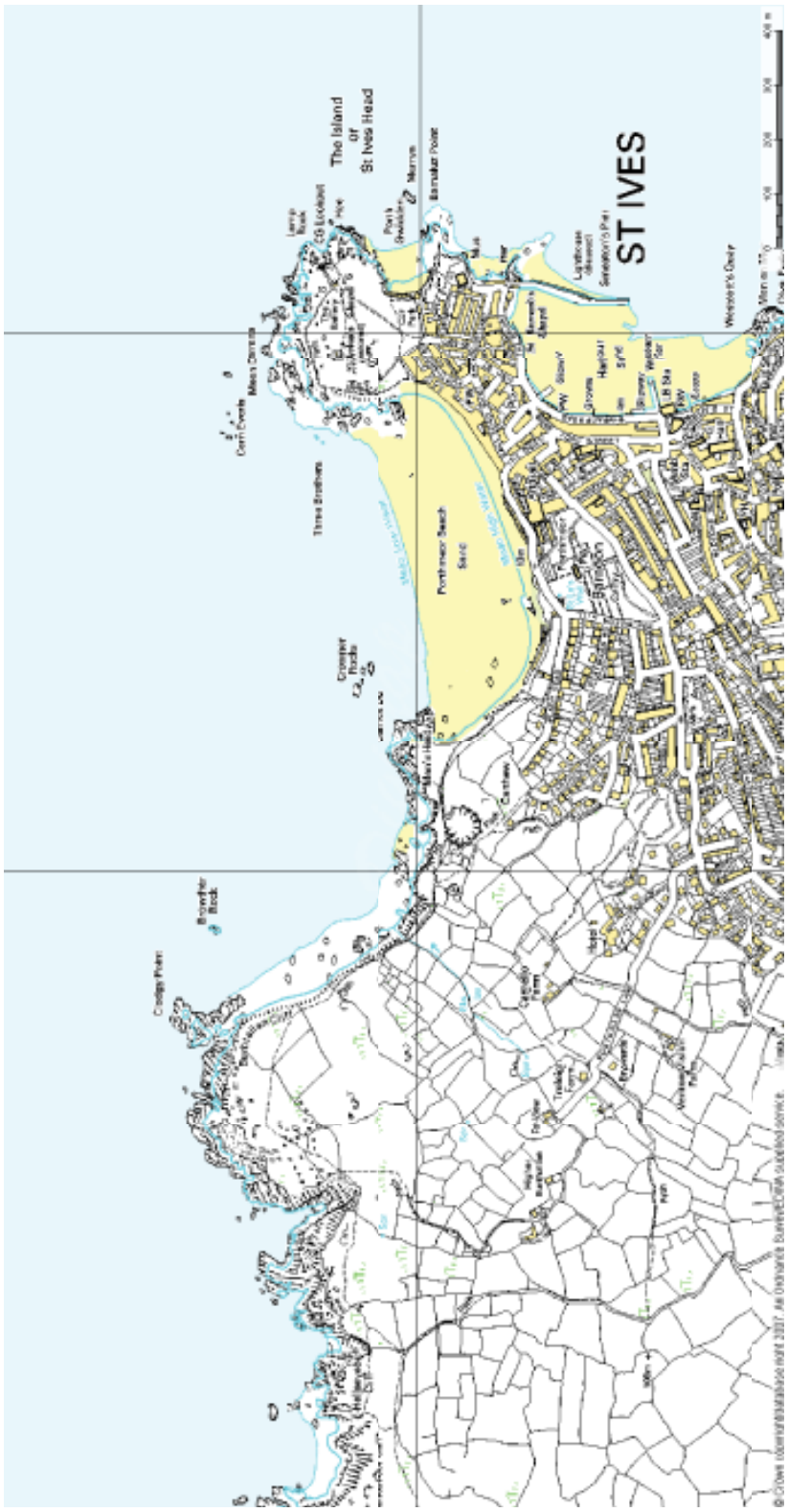

Figure 2.4 *Porthmeor Beach (scale 1:7831)*

2.2 Porth Gwidden

A sheltered sandy cove (SW52204110) backed by stone walkways. The composition of beach sediments indicates that shell material is the primary source of sand, with carbonate contents up to 80%. The remaining proportion is accounted for by inputs from the erosion of cliffs adjacent to and backing sections of beach.

Table 2.3 *Porth Gwidden Beach - Physical Attributes*

Easting (m)	152129
Northing (m)	41052
Latitude	50^o13'1.77" N
Longitude	5^o28'34.21" W
Local authority	Penwith Council
Management Unit	St Ives 7A2-04
MSR (m)	5.77
Length (m)	100
LW Length (m)	100
Width (m)	100
Area (m^2)	10000
Angle (^{o})	80
Angle Code	ENE; relatively sheltered
Morphological Classification	Open coast beach.
Sediment Classification	High water sand and rock; low water sand.

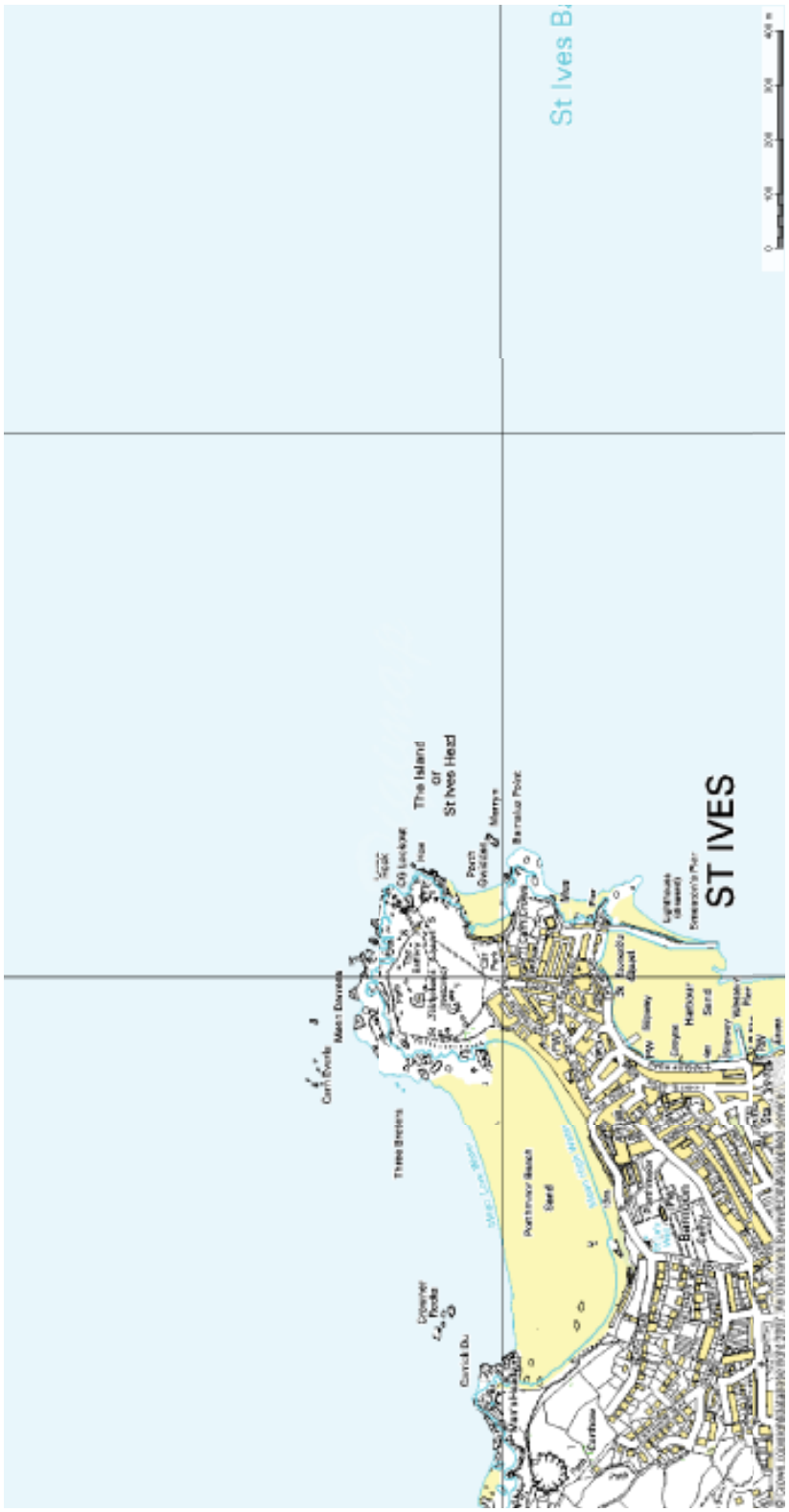

Figure 2.5 *Porth Gwidden Beach (scale 1:7831)*

2.3 Harbour Sand

St Ives Harbour Beach is a small sandy beach in centre of St Ives beside the harbour and sheltered by the harbour wall (Smeaton Pier, built in 1770). There are numerous hard defences around St Ives including seawalls and harbour piers, which act to trap a large volume of sediment within and adjacent to the harbour. Seawalls run continuously behind Porthmeor, Porth Gwidden and Harbour beaches, and in the central portions of Porth Minster and Carbis Bay. Sand accumulating against the back of Porthmeor beach is annually re-profiled to lower parts of the beach. This practice possibly prevents the formation of supra-tidal dune systems [Halcrow, 2002]. The harbour is one of the few places between Lands End and Newquay where trailer-bourne boats can be launched.

Table 2.4 *Harbour Sand Beach - Physical Attributes*

Easting (m)	152005
Northing (m)	40610
Latitude	50°12'49.77" N
Longitude	5°28'42.36" W
Local authority	Penwith Council
Management Unit	St Ives 7A2-04
MSR (m)	5.77
Length (m)	400
LW Length (m)	400
Width (m)	150
Area (m^2)	60000
Angle (°)	110
Angle Code	ESE; relatively sheltered
Morphological Classification	Open coast beach with breakwaters and groyne.
Sediment Classification	High water sand and rock; low water sand.

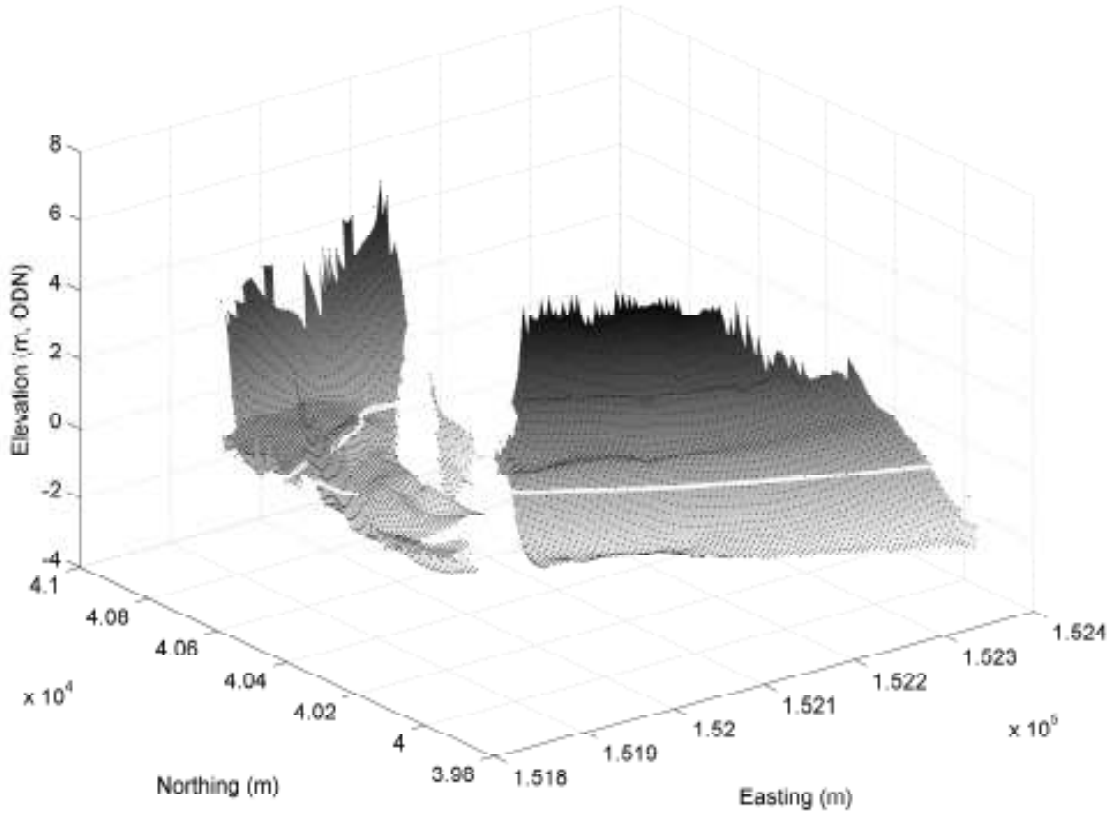

Figure 2.6 *Digital Elevation Model of St Ives Harbour Beach, 2007. Elevations in m (ODN) —0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

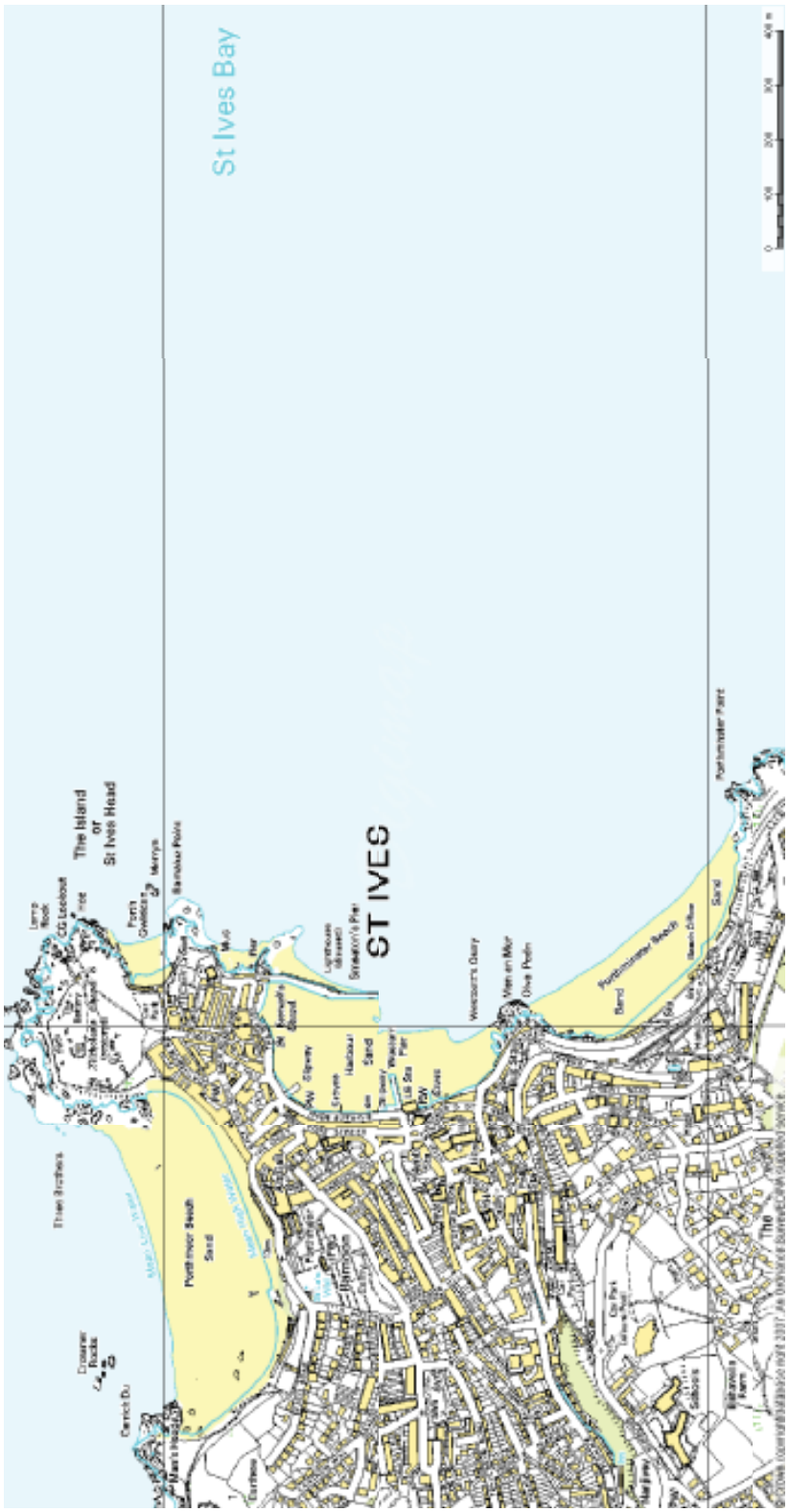

Figure 2.7 *Harbour Sand Beach (scale 1:7831)*

2.4 Porth Minster

This gently sloping sheltered beach (SW522402) has a mild microclimate, and is popular with families.

Table 2.5 *Porth Minster Beach - Physical Attributes*

Easting (m)	152146
Northing (m)	40094
Latitude	50°12'31.92" N
Longitude	5°28'32.50" W
Local authority	Penwith Council
Management Unit	St Ives 7A2-04
MSR (m)	5.77
Length (m)	600
LW Length (m)	600
Width (m)	100
Area (m^2)	60000
Angle (^{o})	50
Angle Code	NE; relatively sheltered
Morphological Classification	Open coast beach.
Sediment Classification	High water sand and rock; low water sand.

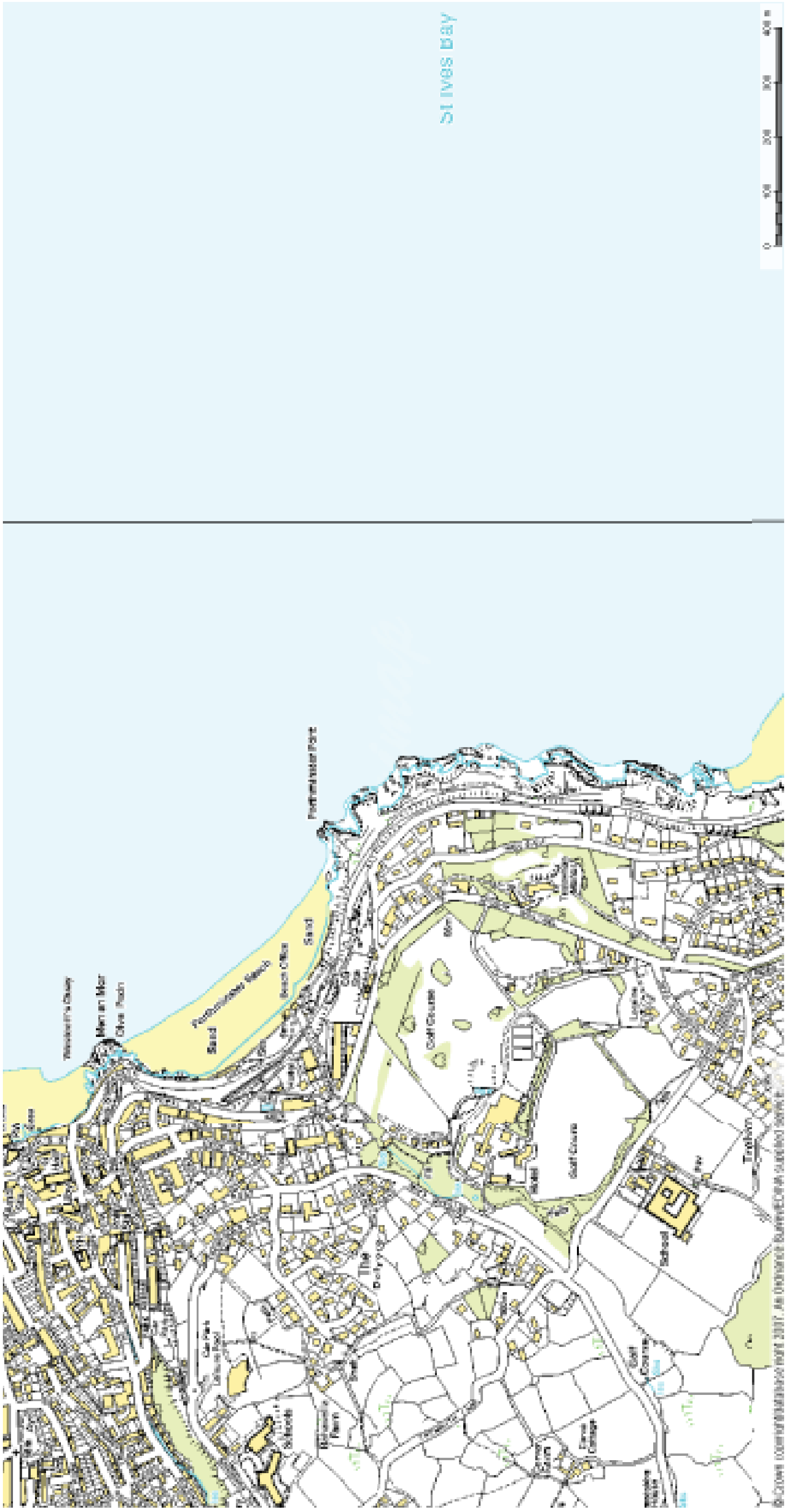

Figure 2.8 *Porthminster Beach (scale 1:7831)*

2.5 Carbis Bay

This family-orientated beach (SW52803890) is privately owned by the Carbis Bay Hotel, approximately 2 miles from St Ives. The beach is protected both by it's aspect and the large tree covered cliffs, which is rare on the exposed north Cornish coast. From Carbis Bay to Godrevy Point the coastline is composed entirely of sedimentary rocks with Devonian slates, which form a relatively low-relief shoreline.

Table 2.6 *Carbis Bay Beach - Physical Attributes*

Easting (m)	152925
Northing (m)	38934
Latitude	50°11'55.16" N
Longitude	5°27'53.69" W
Local authority	Penwith Council
Management Unit	West of Porth Kidney 7A2-05
MSR (m)	5.81
Length (m)	1000
LW Length (m)	1000
Width (m)	150
Area (m^2)	150000
Angle (^{o})	20
Angle Code	NNE; relatively sheltered
Morphological Classification	Open coast beach.
Sediment Classification	High water sand; low water sand.

Table 2.7 *Carbis Bay Beach - Sediment Attributes (08/11/2007)*

	Lower	Upper
Mean (ψ)	-2.33 (0.20 mm)	-2.27 (0.21 mm)
Sorting (ψ)	0.38 (0.77 mm)	0.34 (0.79 mm)
Skewness	0.3	0.24
Mean fall vel (cm/s)	5.01	4.81
D_{50} (Hallermeier equation, mm)	0.38	0.36
$CaCO_3$ %	72.22 $\pm$ 5.18	n/a

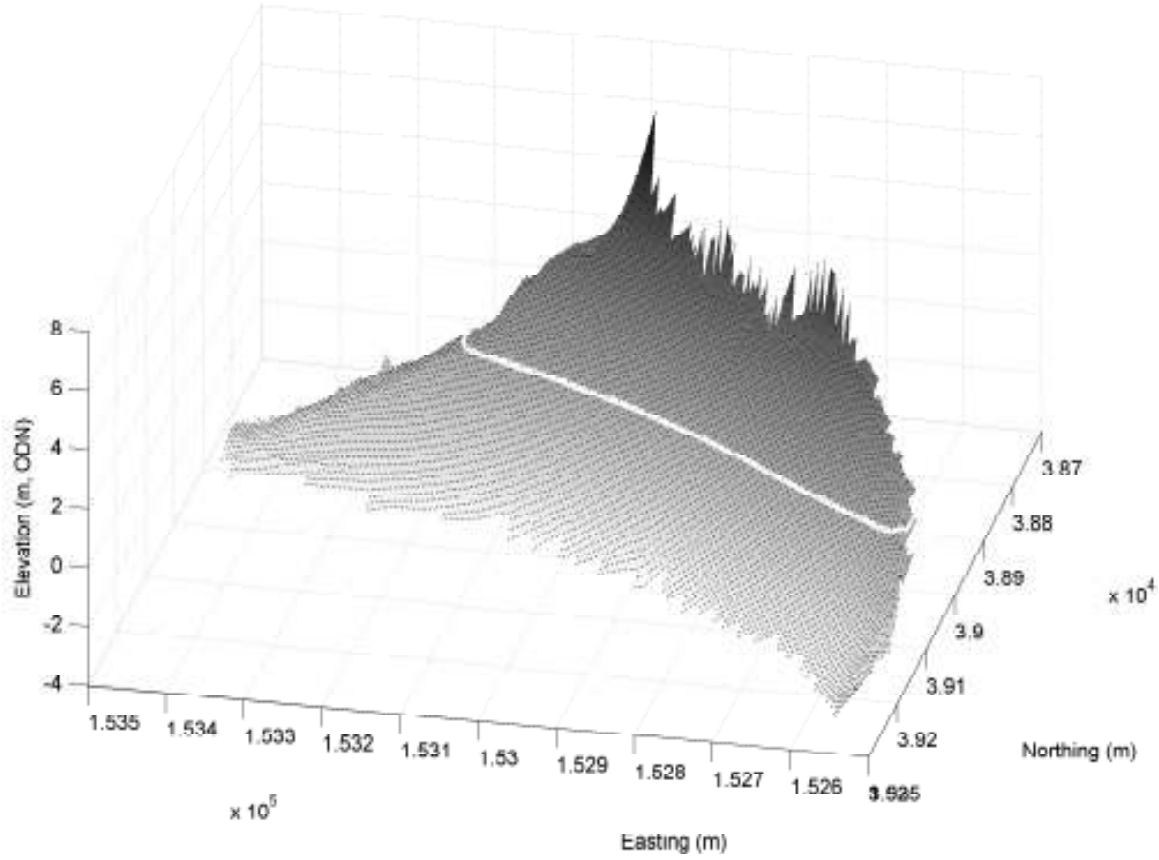

Figure 2.9 *Digital Elevation Model of Carbis Bay Beach, 2007. Elevations in m (ODN) —0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

Figure 2.10 *Carbis Beach at low tide.*

Figure 2.11 *Carbis Bay or Barrepta Cove Beach (scale 1:7831)*

2.6 Porth Kidney Sands and Hayle Estuary

Porth Kidney is a large sandy beach in front of the sand dunes of Lelant and adjacent to the mouth of the Hayle estuary. The Hayle is a small estuary formed from the valleys of the Rivers Hayle, St. Erth and Angarrack, which join at the harbour head and which have become infilled following their inundation by post-glacial sea-level rise. The Hayle river is of Tertiary age, and is thought to have been deepened and modified by periglacial meltwater. Hayle estuary has been infilled with sediment to such a level that its tidal prism is very small and has little direct impact upon the adjacent open coast [Halcrow, 2002]. Indeed, up to 34m of alluvium lies on the bed of the river Hayle, siltation caused by the deposition of fines from tin mining centres. Ebb-tidal dominance ensures that sand is transported into Hayle estuary, deposited as a bank at the mouth of the harbour [Bird, 1998]. This bank is actively extracted to aid navigation, and some is carried into the entrance channel from where it may be flushed back to the shoreline by the strong ebb tide [Halcrow, 2002]. Further upstream, sparse saltmarshes have grown in the muddy sediment south of Lelant [Bird, 1998]. Hayle estuary is regarded as an international quality bird-watching spot: sightings include Avocets, Ospreys and a host of wading birds. Hayle estuary has been heavily modified by various walls and sluices, however it is unlikely that this has significantly reduced its interaction with the open coast. Sand is also removed from a bank at the mouth of the harbour to aid navigation [Halcrow, 2002].

Table 2.8 *Porth Kidney Beach - Physical Attributes*

Easting (m)	154315
Northing (m)	38616
Latitude	50°11'41.52" N
Longitude	5°26'39.78" W
Local authority	Penwith Council
Management Unit	Hayle 7A1-06
MSR (m)	5.81
Length (m)	1350
LW Length (m)	6450
Width (m)	500
Area (m^2)	675000
Angle (^{o})	0
Angle Code	NNE
Morphological Classification	Open coast beach with high cliff.
Sediment Classification	High water rock and sand; low water sand.

Table 2.9 *Porth Kidney Beach - Sediment Attributes (08/11/2007)*

	Lower	Upper
Mean (ψ)	-2.13 (0.23 mm)	-2.19 (0.22 mm)
Sorting (ψ)	0.45 (0.73 mm)	0.31 (0.80 mm)
Skewness	0.15	0.20
Mean fall vel (cm/s)	4.38	4.57
D_{50} (Hallermeier equation, mm)	0.33	0.35
$CaCO_3$ %	62.86 $\pm$ 0.64	n/a

In 1985, the D_{50} at Porth Kidney was 0.35 mm [Goudie, 1990], compared with 0.33 –0.35 in 2007 (Table 2.2). The $CaCO_3$ content in 1985 was 56.8% [Goudie, 1990], and in 2007 it was 62%.

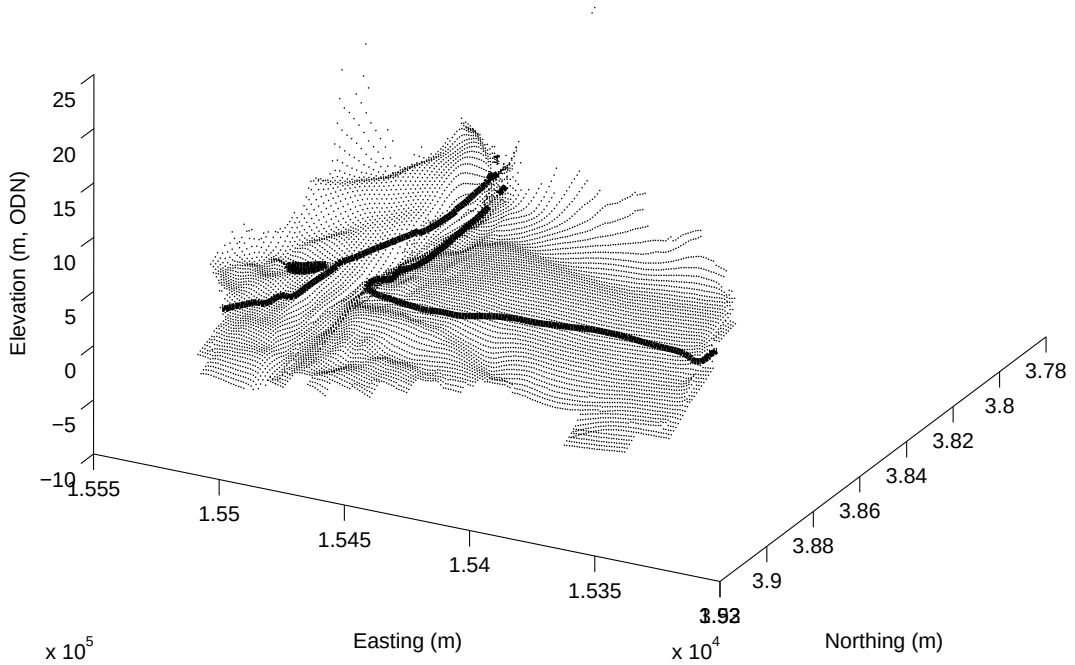

Figure 2.12 *Digital Elevation Model of Hayle, 2007. Elevations in m (ODN) —0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

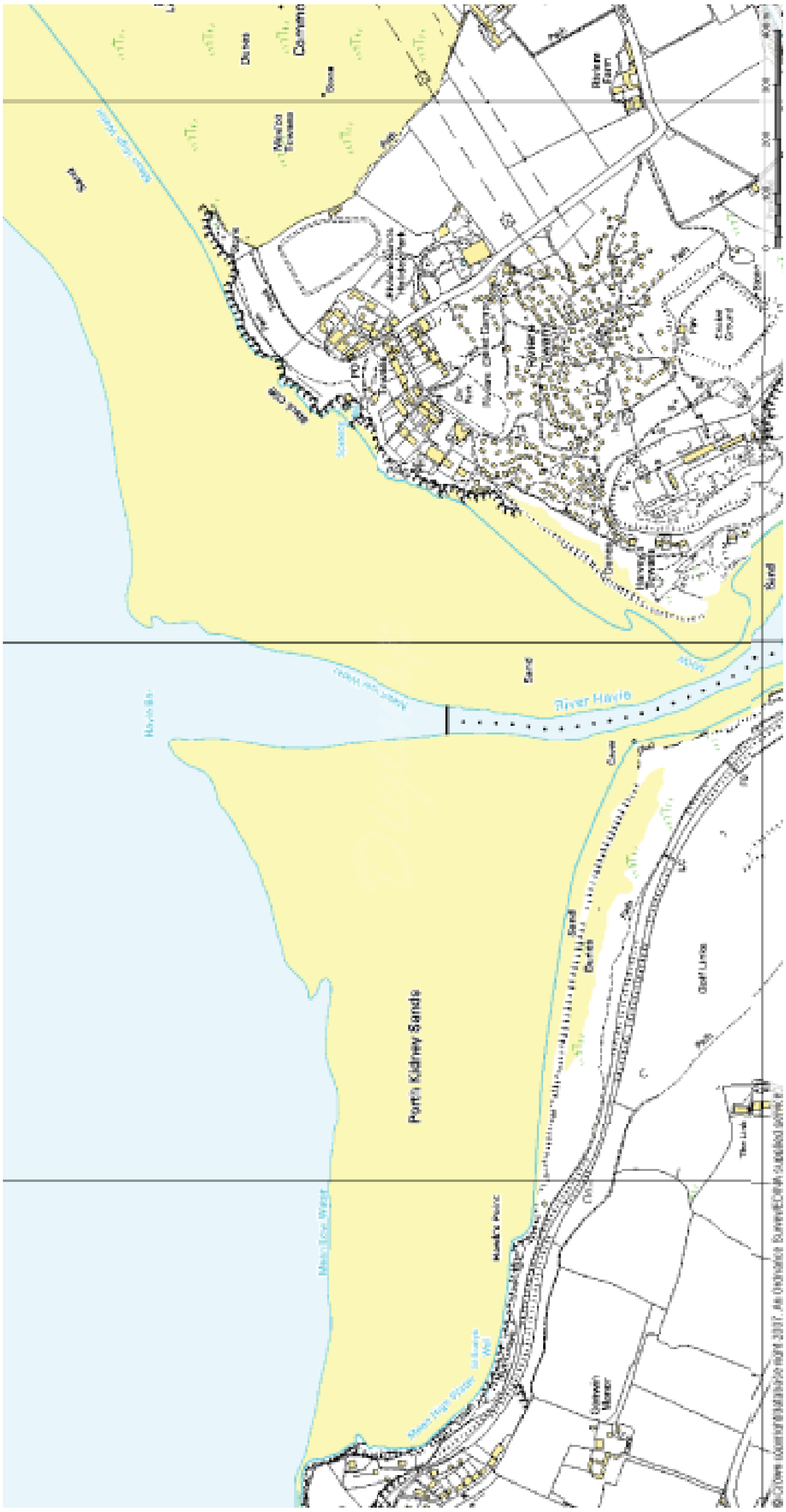

Figure 2.13 *Porth Kidney or Hayle Beach (scale 1:7831)*

2.7 Phillack Towans

The dune system east of Hayle extends some 3km and over 1km inland, known as the 'Phillack/Hayle (SW554388) , Upton, and Gwithian Towans', banked to heights of over 60m. The dunes overlie cliffs of bedrock and head or raised-beach deposits, and in some places even old mine waste [Halcrow, 2002]. Blown sand also covers parts of the western side of Godrevy Point at the northern end of St Ives Bay [Halcrow, 2002]. There has been only limited research at this site [Steers, 1964; Balchin, 1954; Hosking and Ong, 1963]. Black Cliff is an outcrop of the Porthtowan Formation [Bird, 1998], which are steep sandstones. The beach and dunes are carbonate-rich because they are primarily composed of shell material, and have varying patterns of erosion and accretion. The beach sands contain both tin and other heavy metals which have preseumably been carried to the beach from streams [Hosking and Ong, 1963]. This site is unusual within the UK because there are few sites where erosional forms are being exposed by the removal of dunes. As dunes to the south have been eroded they have exposed former cliffs, caves and stacks [May and Hansom, 2003].

Table 2.10 *Phillack Towans Beach and Dunes - Physical Attributes*

Easting (m)	155685
Northing (m)	39223
Latitude	50^o12'6.97" N
Longitude	5^o25'21.86" W
Local authority	Penwith Council
Management Unit	Godrevy 7A2-07
MSR (m)	5.84
Length (m)	2050
LW Length (m)	2050
Width (m)	350
Area (m^2)	717500
Angle (^{o})	330
Angle Code	NNW
Morphological Classification	Open coast beach with high dunes.
Sediment Classification	High water sand; low water sand.

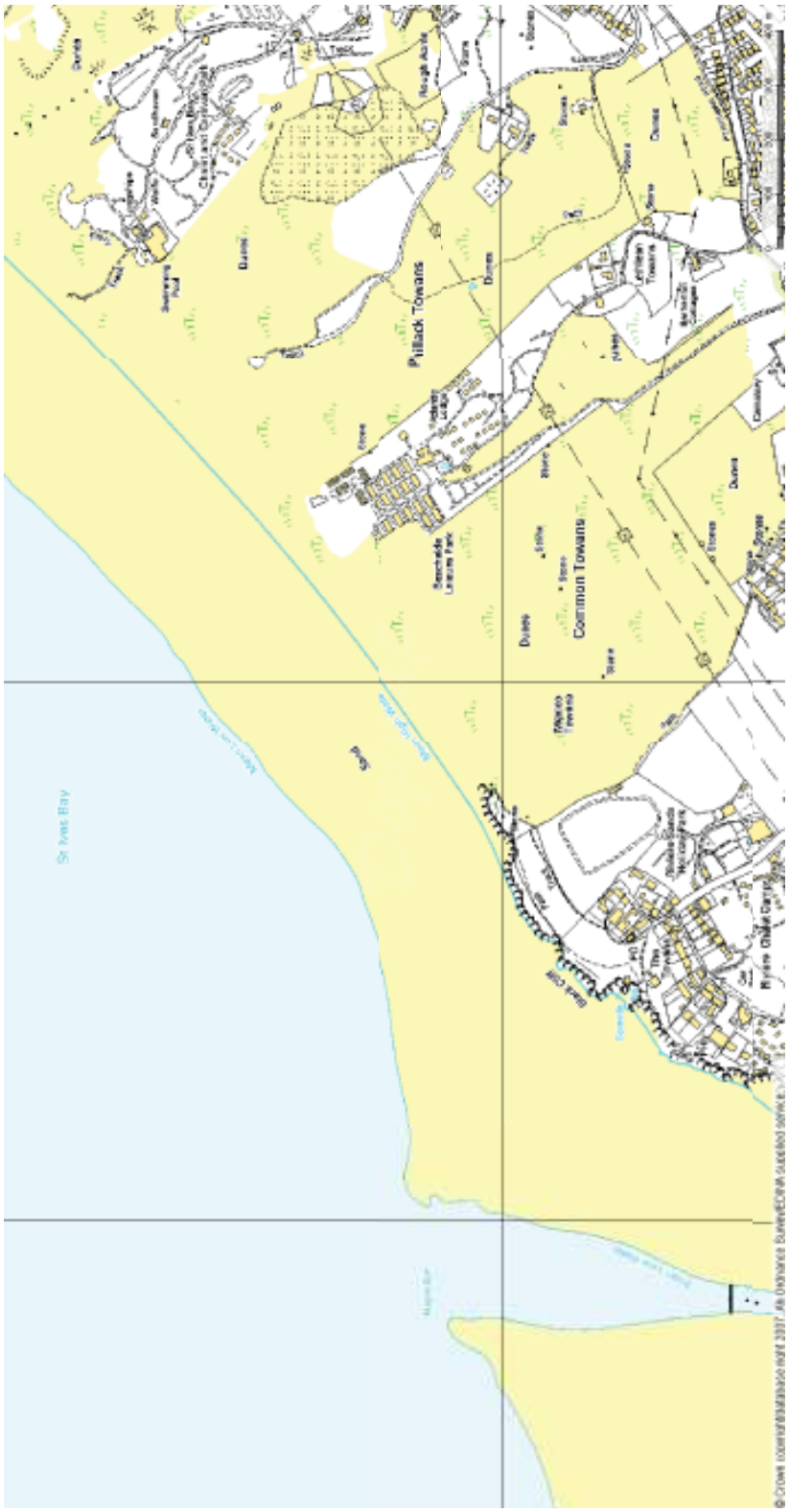

Figure 2.14 *Phillack Towans (scale 1:7831)*

2.8 Upton or 'Mexico' Towans

There has been significant extraction of sand from the dunes northeast of Hayle, in particular Mexico Towans (to the south) and Upton Towans (to the north) where the dunes have been almost entirely removed and a bund has been constructed across the back of the beach to prevent inundation [Halcrow, 2002]. The dunes are dissected by blowouts [Bird, 1998].

Table 2.11 *Upton Towans Beach and Dunes - Physical Attributes*

Easting (m)	156838
Northing (m)	40193
Latitude	50°12'40.62" N
Longitude	5° 24'25.53" W
Local authority	Penwith Council
Management Unit	Godrevy 7A2-07
MSR (m)	5.86
Length (m)	1400
LW Length (m)	1400
Width (m)	30
Area (m^2)	420000
Angle (^{o})	31
Angle Code	NW
Morphological Classification	Open coast beach with high dunes.
Sediment Classification	High water sand; low water sand.

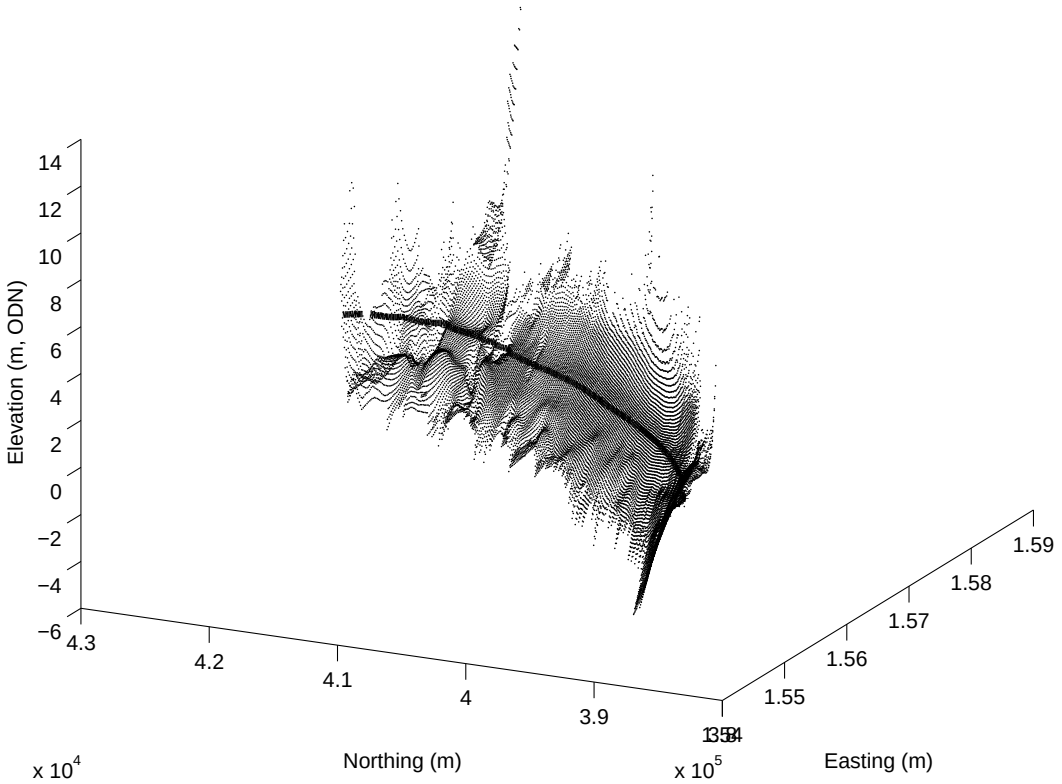

Figure 2.15 *Digital Elevation Model of Hayle to Gwithian, 2007. Elevations in m (ODN) —0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

Figure 2.16 *Upton Towans (scale 1:7831)*

2.9 Gwithian Towans

Gwithian (SW581417) is a sandy bay interspersed with rocks, popular with surfers. This Geological Conservation Review (GCR) and Blue Flag site is formed at its southern end by active climbing dunes which reach over 25m in height [May and Hansom, 2003]. Gwithian village was named after the obscure St. Gwthian, who was patron saint of good fortune on the sea. A fifth century church and the relics of St. Gwithian were uncovered on the beach itself in the last century but reclaimed by the sand. The beach also covers the remains of a Bronze Age farm [Steers, 1964]. Through Gwithian Towans runs the Red River, named after oxidised tin residues from the tin mines around Reduth and Camborne. Nowadays it is running clear, however it is in fact still heavily contaminated. The fact that Gwithian Towans rests high on head deposits which themselves rest on fossiled dunes suggests that dunes have existed at this site for tens of thousands of years [Bird, 1998].

Table 2.12 *Gwithian Towans Beach and Dunes - Physical Attributes*

Easting (m)	157660
Northing (m)	41373
Latitude	50°13'17.84" N
Longitude	5°23'53.03" W
Local authority	Penwith Council
Management Unit	Godrevy 7A2-07
MSR (m)	5.87
Length (m)	1500
LW Length (m)	1500
Width (m)	300
Area (m^2)	450000
Angle (^{o})	295
Angle Code	WNW
Morphological Classification	Open coast beach with high dunes.
Sediment Classification	High water sand; low water sand.

Table 2.13 *Gwithian Beach - Sediment Attributes (08/11/2007)*

	Lower	Upper
Mean (ψ)	-1.70 (0.31 mm)	-1.80 (0.29 mm)
Sorting (ψ)	0.44 (0.74 mm)	0.39 (0.76 mm)
Skewness	0.25	0.23
Mean fall vel (cm/s)	3.25	3.48
D_{50} (Hallermeier equation, mm)	0.25	0.27
$CaCO_3$ %	38.25 ± 15.20	n/a

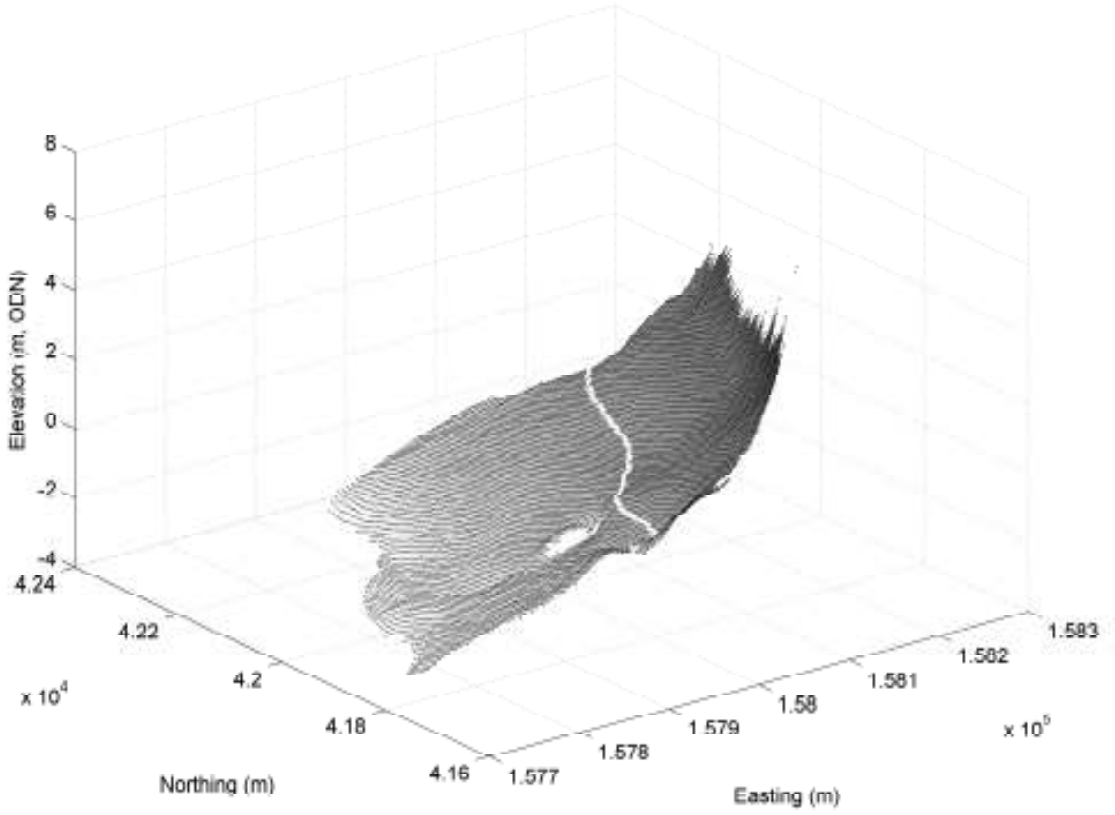

Figure 2.17 *Digital Elevation Model of Gwithian Beach, 11/02/2008. Elevations in m (ODN) —0 ODN (MSL) marked.*

Figure 2.18 *Gwithian Towans (scale 1:7831)*

2.10 Godrevy Cove

The coastline here, 4 miles from Hayle, is run by the National Trust. Navax Point hosts Godrevy Lighthouse 50 miles offshore, built in 1859 and immortalised by Virginia Woolfe's novel *To The Lighthouse*. In the summer, porpoises are frequent visitors to the rather strong tidal currents that sweep around the headland. The dunes at Gwithian undergoing erosion are gradually replaced at the shoreline by a small rock cliff upon which they rest. This cliff reaches about 20 m in height south of Peter's Point before declining towards 15 m around Strap Rocks. Between Peter's Point and the northern boundary of the site (SW 530 417), the cliff is broken by small coves, stacks and caves associated with lines of weakness in the Lower Devonian rocks [May and Hansom, 2003]. At Godrevy Point the sand has been cemented to form a porous sandstone called beachstone.

Table 2.14 *Godrevy Cove - Physical Attributes*

Easting (m)	158082
Northing (m)	42476
Latitude	50°13'45.12" N
Longitude	5°23'27.58" W
Local authority	Penwith Council
Management Unit	Godrevy 7A2-07
MSR (m)	5.88
Length (m)	150
LW Length (m)	150
Width (m)	100
Area (m^2)	150000
Angle (^{o})	240
Angle Code	WSW
Morphological Classification	Open coast beach with dunes and low cliffs.
Sediment Classification	High water rock and sand; low water sand.

Figure 2.19 *Godrevy Beach at low tide*

Figure 2.20 *Godrevy Cove (scale 1:7831)*

Chapter 3

Godrevy Head to St. Agnes Head

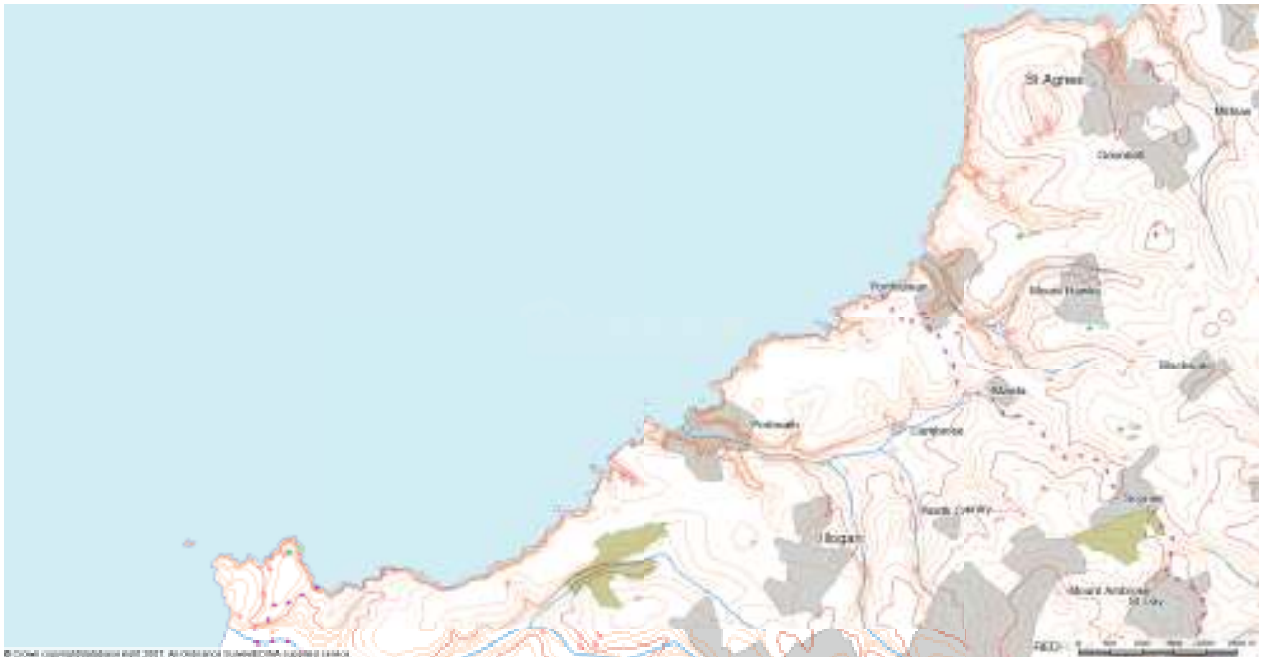

Figure 3.1 *Godrevy Head to St. Agnes Head (scale 1:55358)*

The stretch of coast between Godrevy and St Agnes contains 13 beaches, comprising a total area of 826,250 m^2. The primary control on this stretch of coastline is the resistant geology, which is overlain by a blanket of head deposits. Where the coast is dissected with coves and beaches, small streams discharge through the beach. Beach sediments, which are high in carbonate, are rapidly redistributed offshore during storms. The stretch of coast contains many steep-sided coves cut into the slates and sandstones of the Porthtowan formation, rising to over 90m at St Agnes Beacon.

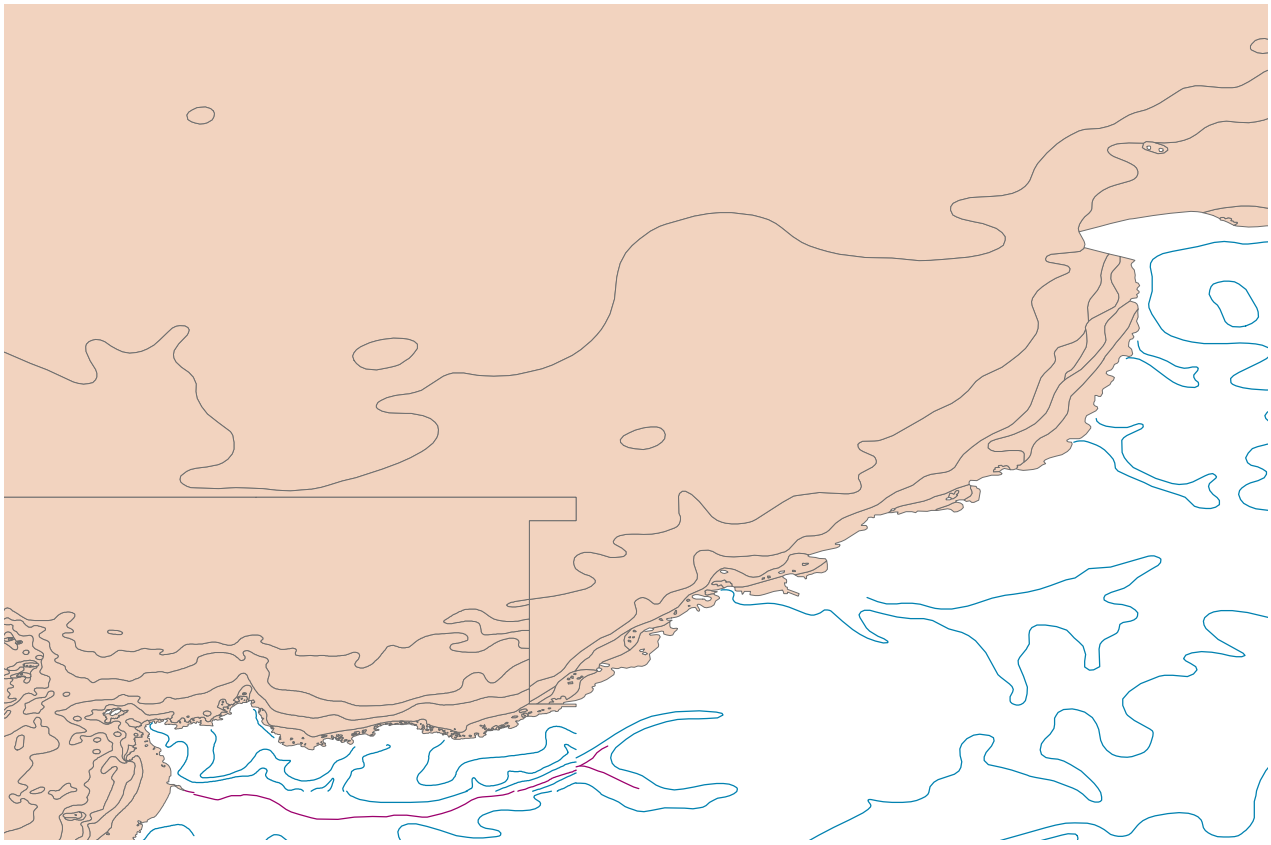

Figure 3.2 *Bathymetry of Godrevy to St Agnes. Source: Marine Digimap*

3.1 Mutton Cove

Table 3.1 *Mutton Cove - Physical Attributes*

Easting (m)	158398
Northing (m)	43340
Latitude	50^o14'25.49" N
Longitude	5^o23'20.06" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.89
Length (m)	150
LW Length (m)	150
Width (m)	50
Area (m^2)	75000
Angle (^{o})	0
Angle Code	NNE
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock, gravel and sand; intertidal gravel and sand

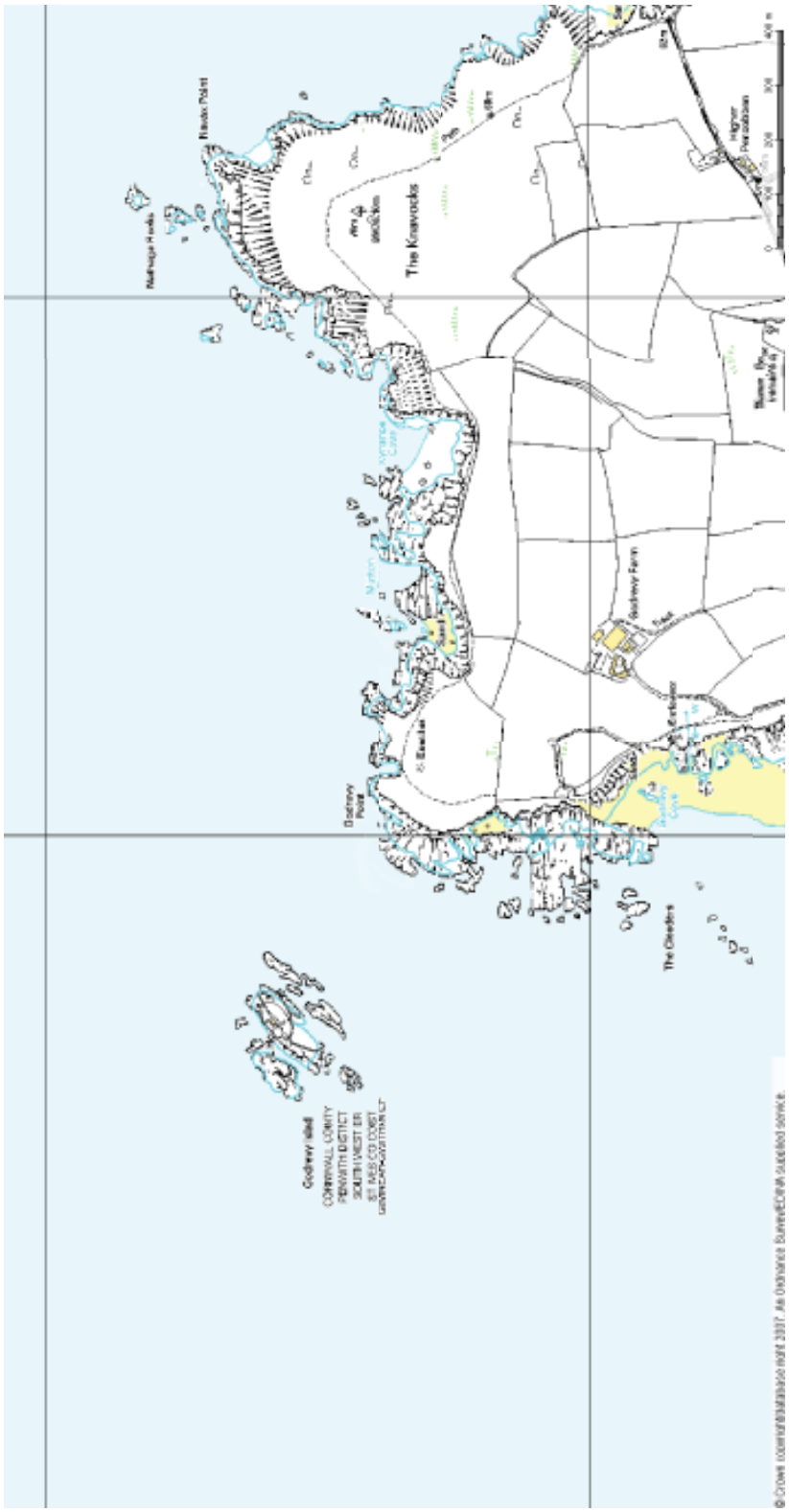

Figure 3.3 *Mutton Cove (scale 1:7831)*

3.2 Fishing Cove

Table 3.2 *Fishing Cove - Physical Attributes*

Easting (m)	159645
Northing (m)	42939
Latitude	50°14'13.14" N
Longitude	5°22'22.37" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.9
Length (m)	100
LW Length (m)	100
Width (m)	50
Area (m^2)	5000
Angle (^{o})	30; relatively sheletered
Angle Code	NE
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock-gravel; low tide gravel

3.3 Hudder Down

The cliffs of Hudder Down are low and even, with large clasts at the bottom the result of historic landslides.

Table 3.3 *Hudder Down - Physical Attributes*

Easting (m)	159884
Northing (m)	42861
Latitude	50°14'13.01" N
Longitude	5°21'58.91" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.9
Length (m)	50
LW Length (m)	50
Width (m)	25
Area (m^2)	1250
Angle (^{o})	345
Angle Code	NNW
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock-gravel; low tide gravel

3.4 Hell's Mouth

Hell's Mouth is a steep-sided cove cut into the slates and sandstones of the Porthtowan Formation [Bird, 1998].

Table 3.4 *Hell's Mouth - Physical Attributes*

Easting (m)	160327
Northing (m)	42967
Latitude	50°14'13.83" N
Longitude	5°21'43.27" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.9
Length (m)	100
LW Length (m)	100
Width (m)	100
Area (m^2)	10000
Angle (^{o})	345
Angle Code	NNW
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock-gravel; low tide gravel

3.5 Hudder Cove

Table 3.5 *Hudder Cove - Physical Attributes*

Easting (m)	160568
Northing (m)	43086
Latitude	50°14'18.97" N
Longitude	5°21'30.55" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.9
Length (m)	100
LW Length (m)	50
Width (m)	100
Area (m^2)	5000
Angle (^{o})	345
Angle Code	NNW
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock-gravel; low tide gravel

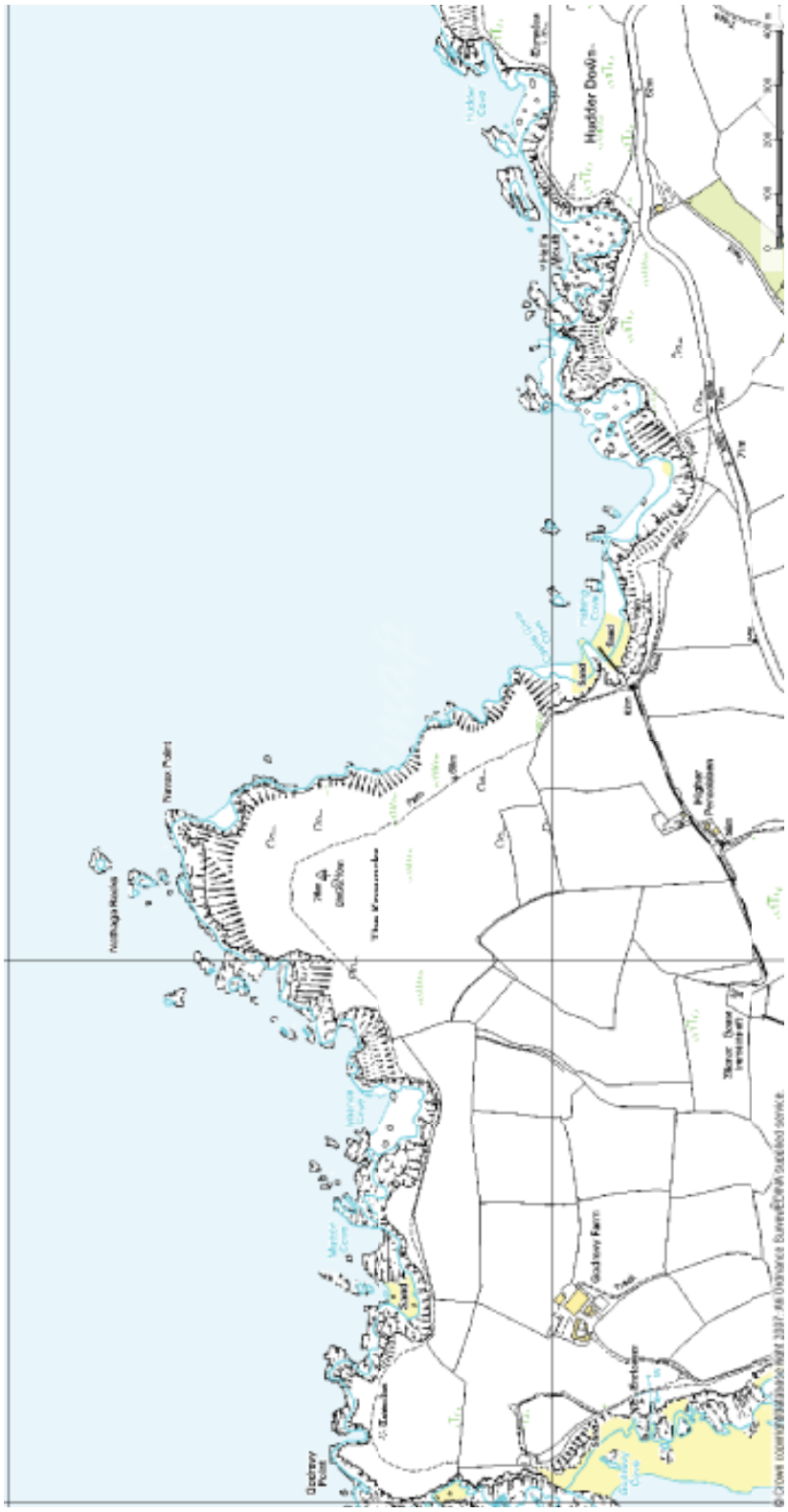

Figure 3.4 *Fishing Cove to Hudder Cove (scale 1:7831)*

3.6 Basset's Cove

The large beach at Basset's Cove is fed by sediments from the local steep and disintegrating cliffs, which are composed of quartz-veined sandstones and slates [Bird, 1998]. Basset Cove is the main beach of a long strip of National Trust owned land which runs between Godrevy Point to Portreath. Nearby is Ralph's Cupboard, a deep shaft formed from the collapse of a cave and named after a smuggler who used the cleft for storing contraband [Automobile Association, 1984]. It is also said to be the home of the giant Wrath, whose legend has it that he waded out to sea to devour passing ships.

Table 3.6 *Basset's Cove - Physical Attributes*

Easting (m)	163755
Northing (m)	44212
Latitude	50*o*14'59.07" N
Longitude	5^{o}18'52.51" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.94
Length (m)	250
LW Length (m)	250
Width (m)	100
Area (m^2)	25000
Angle (^{o})	320
Angle Code	NW
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock-gravel; low tide gravel

3.7 Porth-Cadjack Cove

Table 3.7 *Porth-Cadjack Cove - Physical Attributes*

Easting (m)	164045
Northing (m)	44732
Latitude	50°15'17.44" N
Longitude	5°18'37.08" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.95
Length (m)	150
LW Length (m)	150
Width (m)	100
Area (m^2)	15000
Angle (^{o})	320
Angle Code	NW
Morphological Classification	open coast high cliff
Sediment Classification	High-water rock-gravel; low tide gravel

Figure 3.5 *Basset's Cove to Porth-Cadjack Cove (scale 1:7831)*

3.8 Western Cove

Table 3.8 *Western Cove - Physical Attributes*

Easting (m)	164606
Northing (m)	45245
Latitude	50°15'37.44" N
Longitude	5°18'12.22" W
Local authority	Kerrier Council
Management Unit	West of Portreath 7A3-01
MSR (m)	5.95
Length (m)	250
LW Length (m)	250
Width (m)	100
Area (m^2)	25000
Angle (^{o})	320
Angle Code	NW
Morphological Classification	open coast high cliff
Sediment Classification	High-water boulders and sand; low tide sand and gravel

Figure 3.6 *Western Cove (scale 1:7831)*

3.9 Portreath

A mostly sand with a little gravel beach (SW653455) set in a steep valley about 4 miles from Redruth and 12 miles from Truro. To the western end of the beach are high cliffs on one side and the pier and car park on the other, with a stream running down the middle. Another smaller cove which is seperated by the high tide. The other end of the beach is bounded by a granite wall which protects the narrow harbour. The sands are marine, but the gravels are washed in by the river. It is popular with families and was once a busy port, importing coal and exporting copper but now only sheltering the occasional fishing boat. A submerged forest is sometimes exposed by storms [Bird, 1998]. A hollow and dangerous wave breaks off the pier, and alongside there is an emerged gravel beach cemented by black manganese [Bird, 1998]. The first pier at Portreath was built in 1706, and from then it evolved into a thriving harbour serving local tin and copper mines. It's importance is underlined by the fact that in 1809 it became the terminus of a horse-powered tramroad [Automobile Association, 1984].

Table 3.9 *Portreath - Physical Attributes*

Easting (m)	165245
Northing (m)	45435
Latitude	50°15'42.70" N
Longitude	5°17'36.53" W
Local authority	Kerrier Council
Management Unit	Portreath 7A3-02
MSR (m)	5.95
Length (m)	450
LW Length (m)	450
Width (m)	150
Area (m^2)	67500
Angle (^{o})	345
Angle Code	NNW
Morphological Classification	open coast beach with harbour
Sediment Classification	High-water rock and sand; low tide sand

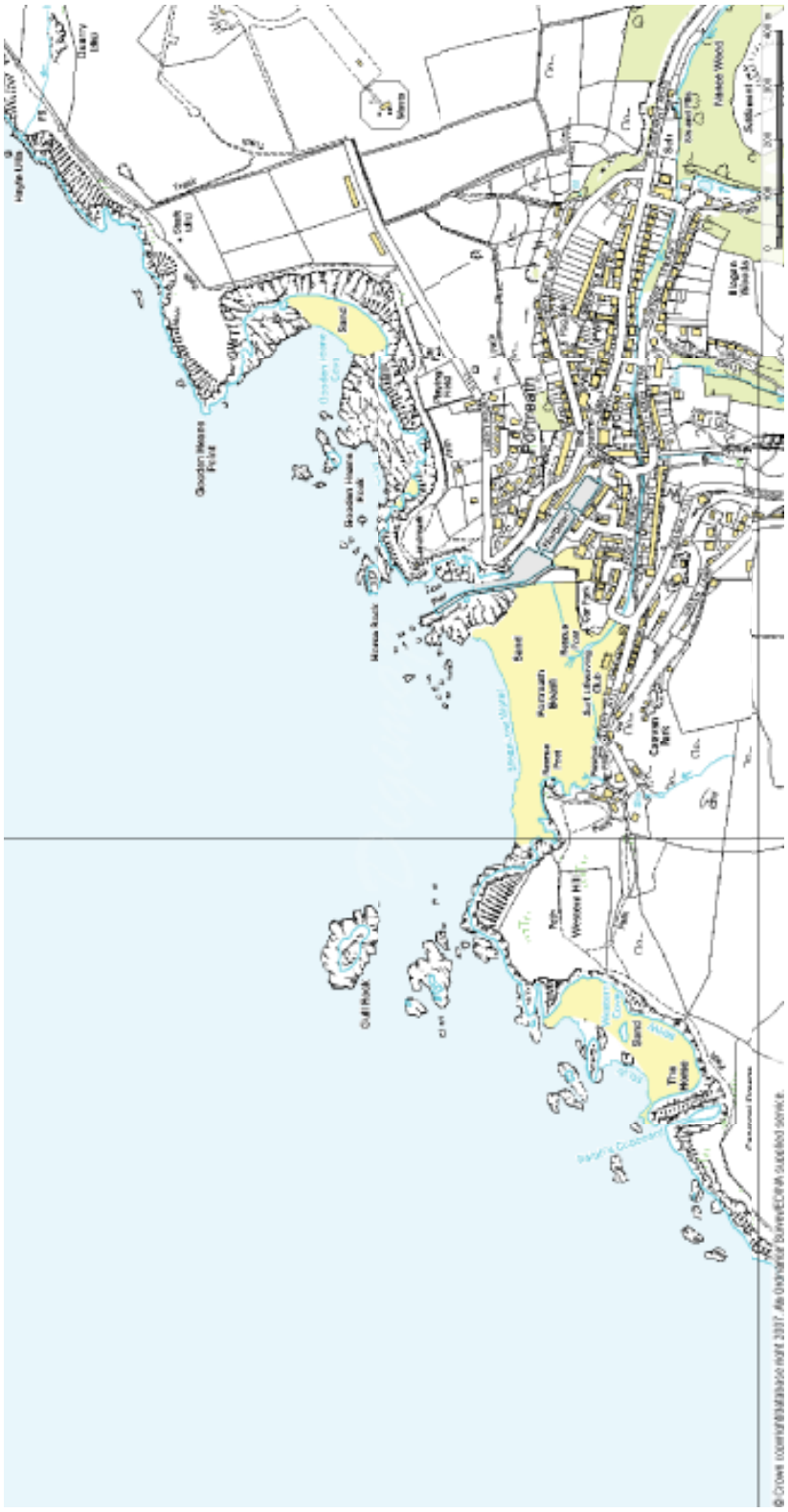

Figure 3.7 *Portreath Beach (scale 1:7831)*

3.10 Gooden Heane Cove

Table 3.10 *Gooden Heane Cove - Physical Attributes*

Easting (m)	165934
Northing (m)	45815
Latitude	50º15'55.37" N
Longitude	5º17'4.62" W
Local authority	Carrick Council
Management Unit	East of Portreath 7A3-03
MSR (m)	5.97
Length (m)	250
LW Length (m)	250
Width (m)	50
Area (m^2)	12500
Angle (^{o})	300
Angle Code	NW
Morphological Classification	open coast barrier high cliff
Sediment Classification	high tide rock-sand, low tide sand

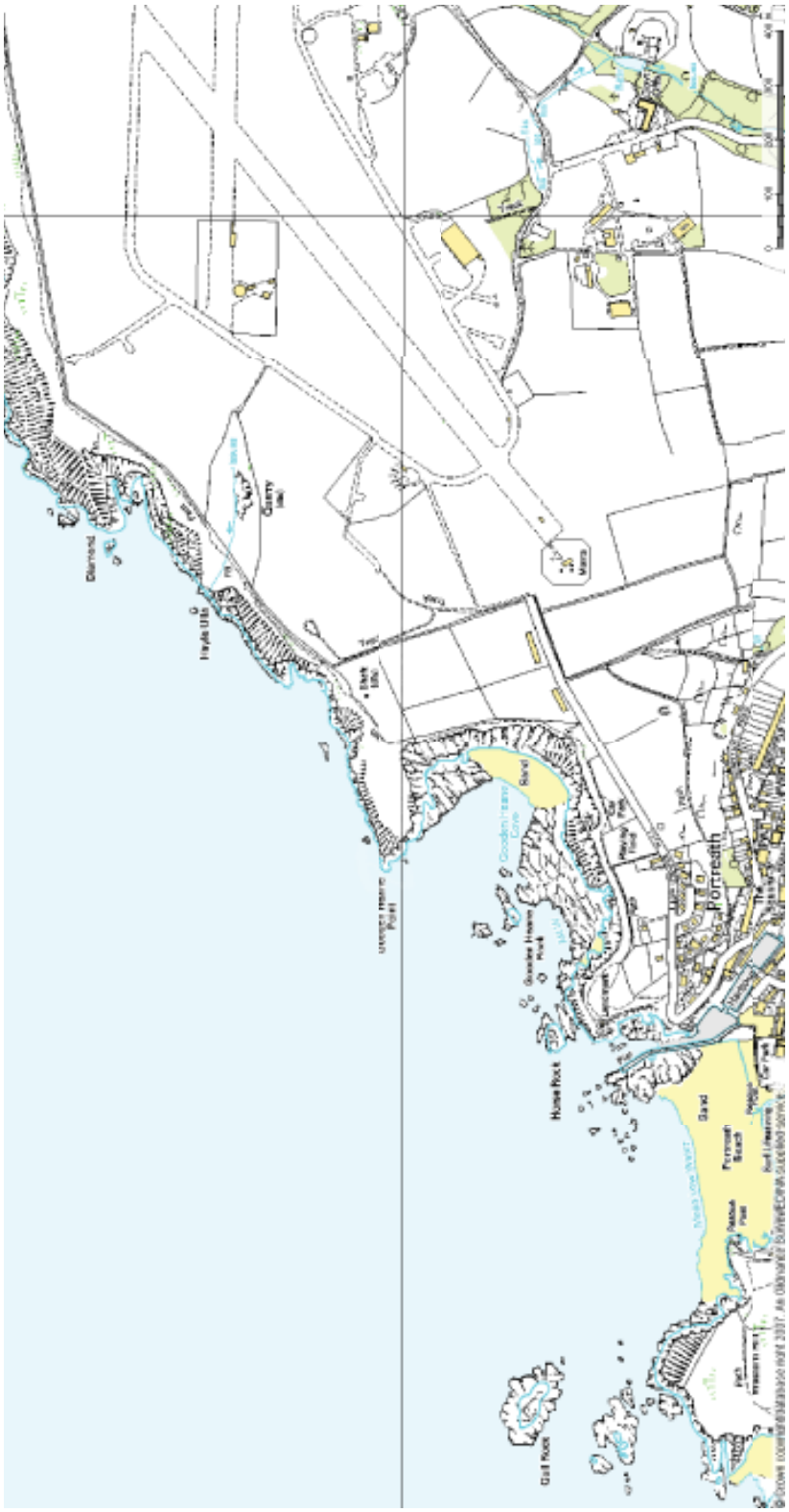

Figure 3.9 *Gooden Heane Cove (scale 1:7831)*

3.11 Sally's Bottom

Table 3.11 *Sally's Bottom - Physical Attributes*

Easting (m)	167742
Northing (m)	47066
Latitude	50º16'18.94" N
Longitude	5º16'40.69" W
Local authority	Carrick Council
Management Unit	East of Portreath 7A3-03
MSR (m)	5.99
Length (m)	450
LW Length (m)	450
Width (m)	100
Area (m^2)	45000
Angle (º)	310
Angle Code	NW
Morphological Classification	open coast barrier high cliff
Sediment Classification	high tide rock-sand, low tide sand

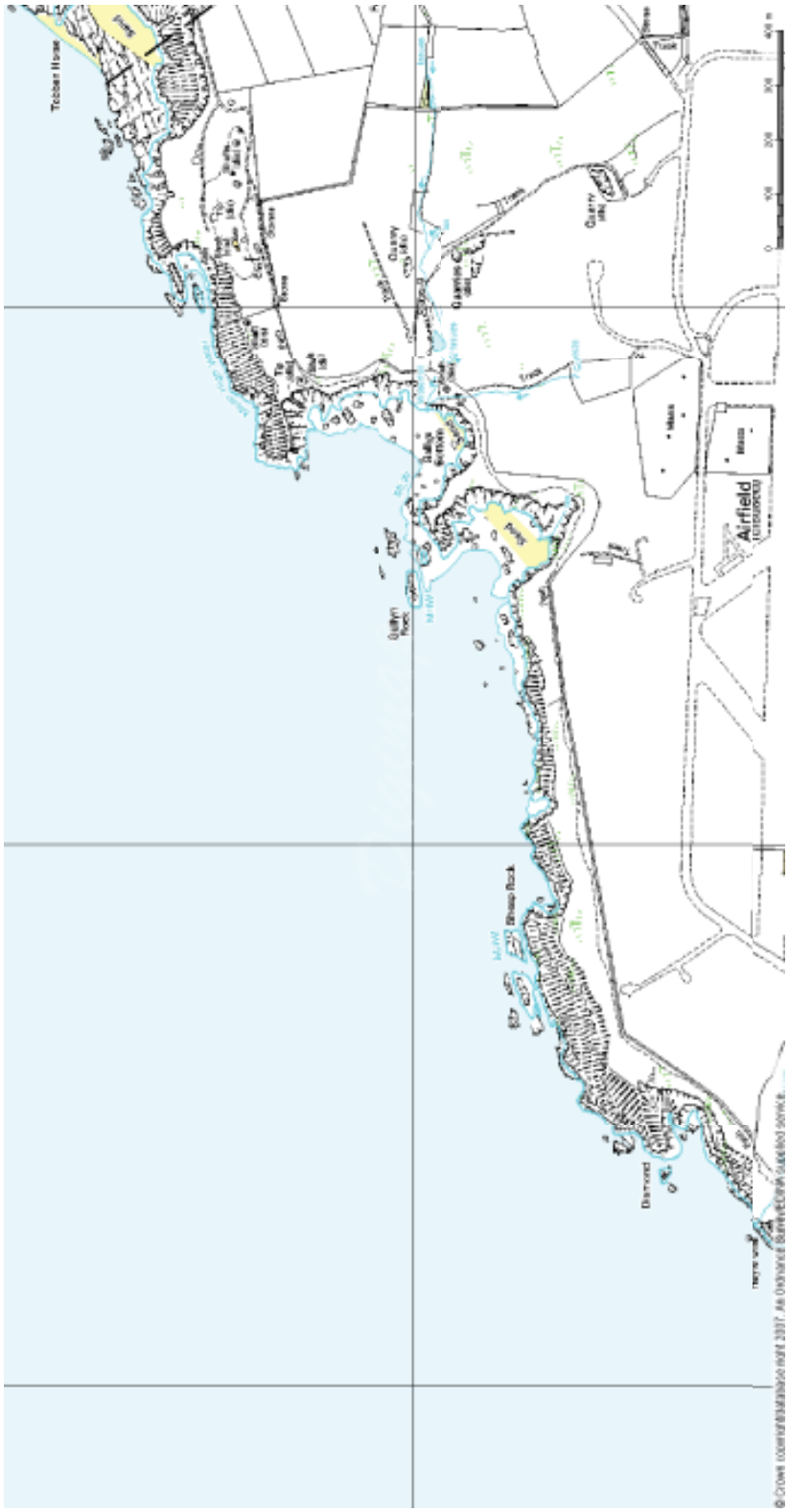

Figure 3.10 *Sally's Bottom (scale 1:7831)*

3.12 Porth Towan

Porthtowan (SW69134809) is a sandy beach flanked by steep cliffs within an Area of Outstanding Natural Beauty (AONB), 9 miles from Truro and 15 miles from Newquay. Porthtowan stands at the mouth of a deeply-incised valley composed of slopes heavily modified by previous mining activity [Bird, 1998], especially old tin and copper mines. The head deposits in the cliffs show evidence of periglacial processes such as freeze-thaw. Porthtowan is popular with surfers, canoeists and families.

Table 3.12 *Porth Towan - Physical Attributes*

Easting (m)	168904
Northing (m)	48206
Latitude	50°17'12.92" N
Longitude	5°14'35.16" W
Local authority	Carrick Council
Management Unit	Porth Towan 7A3-04
MSR (m)	6.0
Length (m)	1250
LW Length (m)	2350
Width (m)	300
Area (m^2)	375000
Angle (°)	300
Angle Code	NW
Morphological Classification	open coast beach with low dunes
Sediment Classification	high tide gravel and sand, low tide sand

Table 3.13 *Porth Towan Beach - Sediment Attributes (08/11/2007)*

	Lower	Upper
Mean (ψ)	-2.33 (0.20 mm)	-2.46 (0.18 mm)
Sorting (ψ)	0.28 (0.82 mm)	0.22 (0.86 mm)
Skewness	0.37	0.14
Mean fall vel (cm/s)	5.03	5.52
D_{50} (Hallermeier equation, mm)	0.38	0.41
$CaCO_3$ %	55.70 ± 6.48	n/a

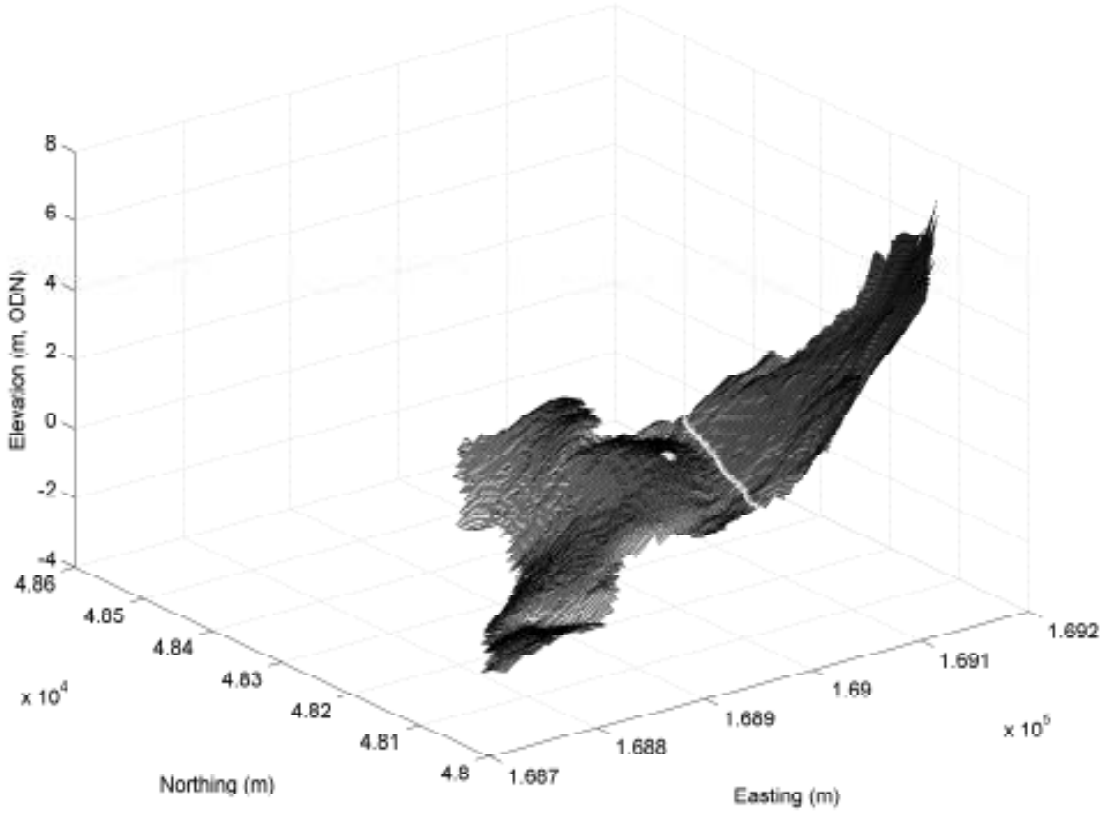

Figure 3.11 *Digital Elevation Model of Porth Towan Beach, 10/02/2008. Elevations in m (ODN) - 0 ODN (MSL) marked.*

Figure 3.12 *Porth Towan Beach at low tide*

Figure 3.13 *Porth Towan Beach (scale 1:7831)*

3.13 Chapel Porth

A west facing beach (SW697495) 12 miles from Newquay and 9 miles from Redruth. It is owned by the National Trust, and is backed by high cliffs at north and south ends composed of Porthtowan slates and grits overlain by very sandy head deposits. Chapel Porth, which gets its name from an ancient chapel which once stood here, connects with Porthtowan at spring low tide. The famous Wheal Coates engine house, active in the nineteenth century but recently restored, overlooks the beach from the clifftop.

Table 3.14 *Chapel Porth - Physical Attributes*

Easting (m)	169586
Northing (m)	49598
Latitude	50^o18'1.92" N
Longitude	5^o14'6.95" W
Local authority	Carrick Council
Management Unit	North of Porth Towan 7A3-05
MSR (m)	6.03
Length (m)	1100
LW Length (m)	1100
Width (m)	150
Area (m^2)	165000
Angle (^{o})	290
Angle Code	WNW
Morphological Classification	open coast beach
Sediment Classification	high tide boulder, gravel and sand, low tide sand

Table 3.15 *Chapel Porth Beach - Sediment Attributes (15/07/2007)*

	Lower	Middle	Upper
Mean (ψ)	-2.64 (0.16 mm)	-2.48 (0.18 mm)	-2.48 (0.18 mm)
Sorting (ψ)	0.26 (0.84 mm)	0.22 (0.86 mm)	0.26 (0.83 mm)
Skewness	0.15	0.24	0.24
Mean fall vel (cm/s)	6.24	5.57	5.58
D_{50} (Hallermeier equation, mm)	0.46	0.41	0.41
$CaCO_3$ %	53.14 $\pm$ 0.77	n/a	n/a

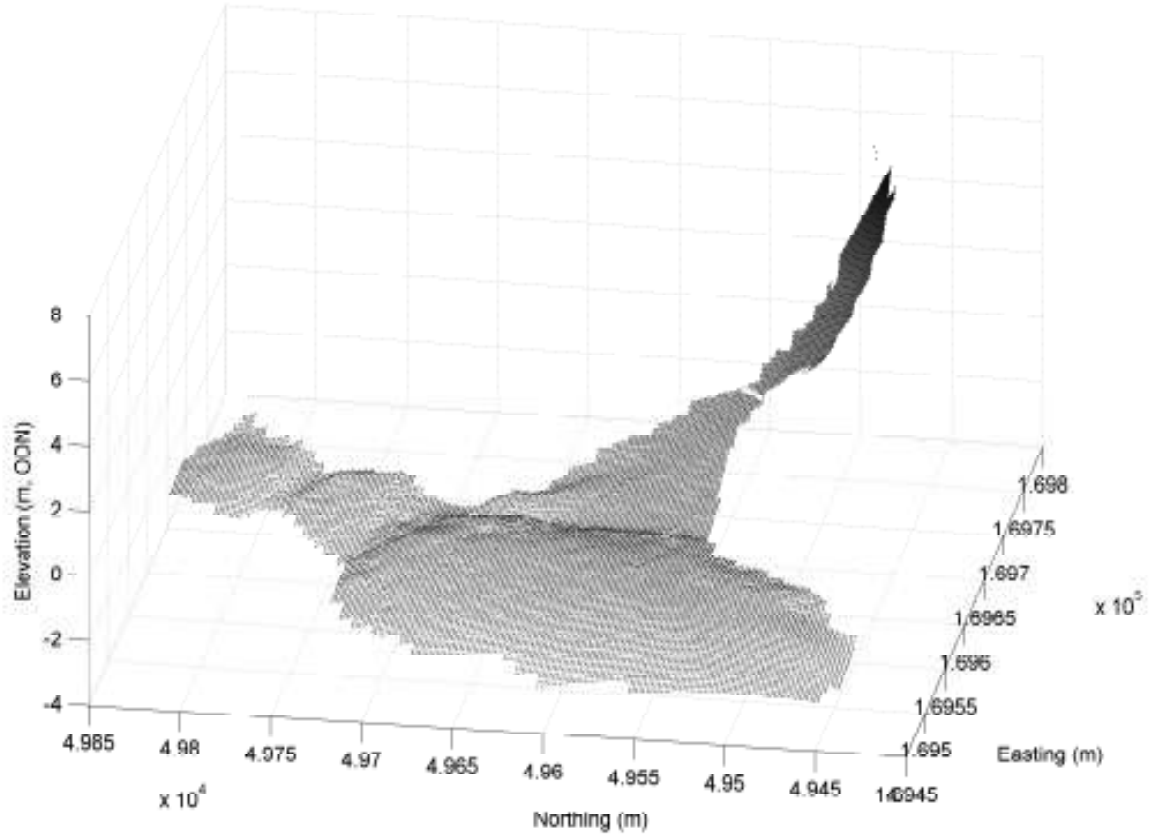

Figure 3.14 *Digital Elevation Model of Chapel Porth Beach, 09/02/2008. Elevations in m (ODN) - 0 ODN (MSL) marked.*

Figure 3.15 *Chapel Porth Beach at low tide.*

Figure 3.16 *Chapel Porth Beach (scale 1:7831)*

Chapter 4

St Agnes Head to Penhale Head

Figure 4.1 *St. Agnes Head to Penhale Head (scale 1:55358)*

The 6 beaches along the coast between St Agnes and Penhale, comprising a total area of 1,418,750 m^2, are exposed pocket beaches where storm-driven changes can result in large changes in beach morphology over very short timescales.

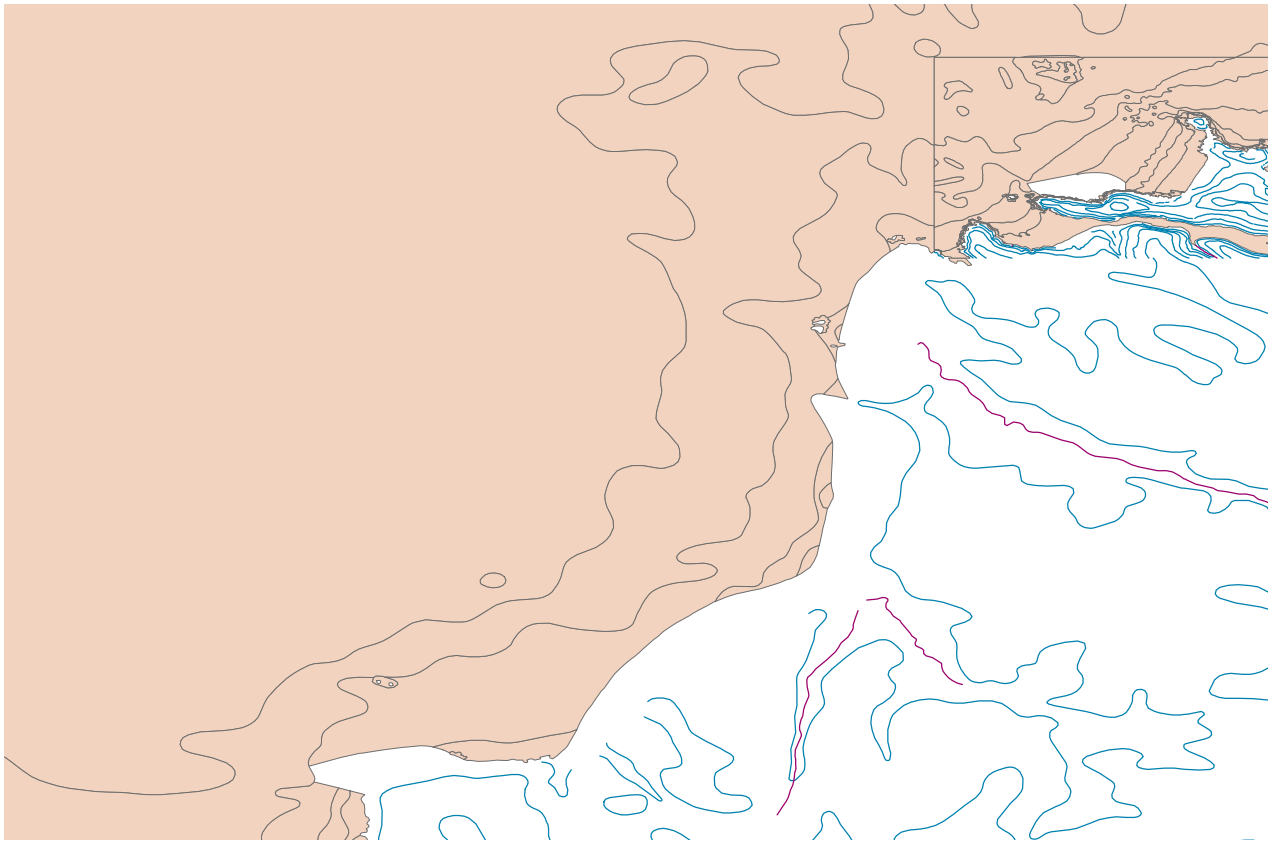

Figure 4.2 *Bathymetry of St Agnes to Porthcothan. Source: Marine Digimap*

4.1 Trevaunance Cove

Trevaunance cove (SW723517) at the mouth of a valley near St Agnes, is completely covered at high tide. It is enclosed on both sides by cliffs, rocks and an old harbour wall. St Agnes is the home of environmental campaign group Surfers Against Sewage. Trevaunance Cove is also home to a RNLI lifeboat launch station. The beach material is locally sourced, such as sands from St Agnes Beacon and gravels from quarried cliffs. The site has a varied history of successive harbours being built and destroyed, due to St Agnes once being a very important mining centre. A path may be taken to St Agnes Beacon, a 629 ft hill summit owned by the National Trust which was once used to light beacons to warn of the approach of the Spanish Armada [Automobile Association, 1984].

Table 4.1 *Trevaunance Cove - Physical Attributes*

Easting (m)	172154
Northing (m)	51730
Latitude	50°19'13.37" N
Longitude	5°12'4.12" W
Local authority	Carrick Council
Management Unit	Trevaunance 7A3-06
MSR (m)	6.03
Length (m)	300
LW Length (m)	300
Width (m)	100
Area (m^2)	30000
Angle (°)	345
Angle Code	NNW
Morphological Classification	open coast beach
Sediment Classification	high tide gravel and sand, low tide sand

Figure 4.3 *Trevaunance Cove Beach at low tide*

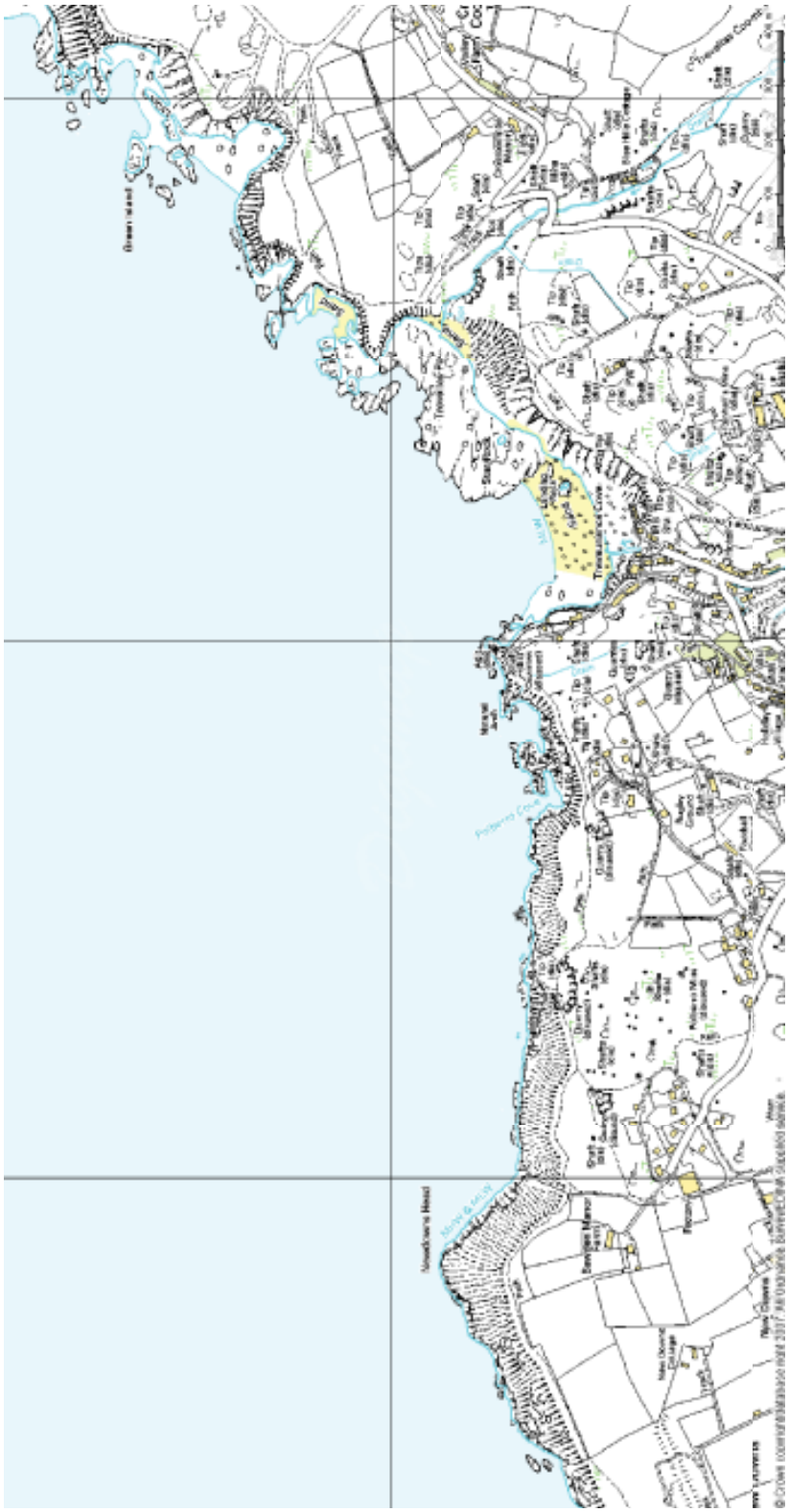

Figure 4.4 *Trevaunance Cove and Grean Island (scale 1:7831)*

4.2 Grean Island

Table 4.2 *Grean Island - Physical Attributes*

Easting (m)	172863
Northing (m)	52334
Latitude	50^{o}19'30.53" N
Longitude	5^{o}11'51.00" W
Local authority	Carrick Council
Management Unit	East Of Trevaunance 7A3-07
MSR (m)	6.06
Length (m)	350
LW Length (m)	350
Width (m)	25
Area (m^2)	8750
Angle (^{o})	320
Angle Code	NW
Morphological Classification	open coast shore platform with high cliff
Sediment Classification	high tide rock, low tide boulders

4.3 Hanover Cove

South past Cligga Point is Hanover Cove (SW738531), where head and rock has collapsed dramatically into the sea. Here, the wreck of the Hanover lies with most of the treasure reputedly onboard still not recovered...

Table 4.3 *Hanover Cove - Physical Attributes*

Easting (m)	173686
Northing (m)	53121
Latitude	50^o20'4.69" N
Longitude	5^o10'52.78" W
Local authority	Carrick Council
Management Unit	East Of Trevaunance 7A3-07
MSR (m)	6.08
Length (m)	500
LW Length (m)	500
Width (m)	50
Area (m^2)	25000
Angle (^{o})	270
Angle Code	WNW
Morphological Classification	open coast shore platform with high cliff
Sediment Classification	high tide rock, low tide boulders

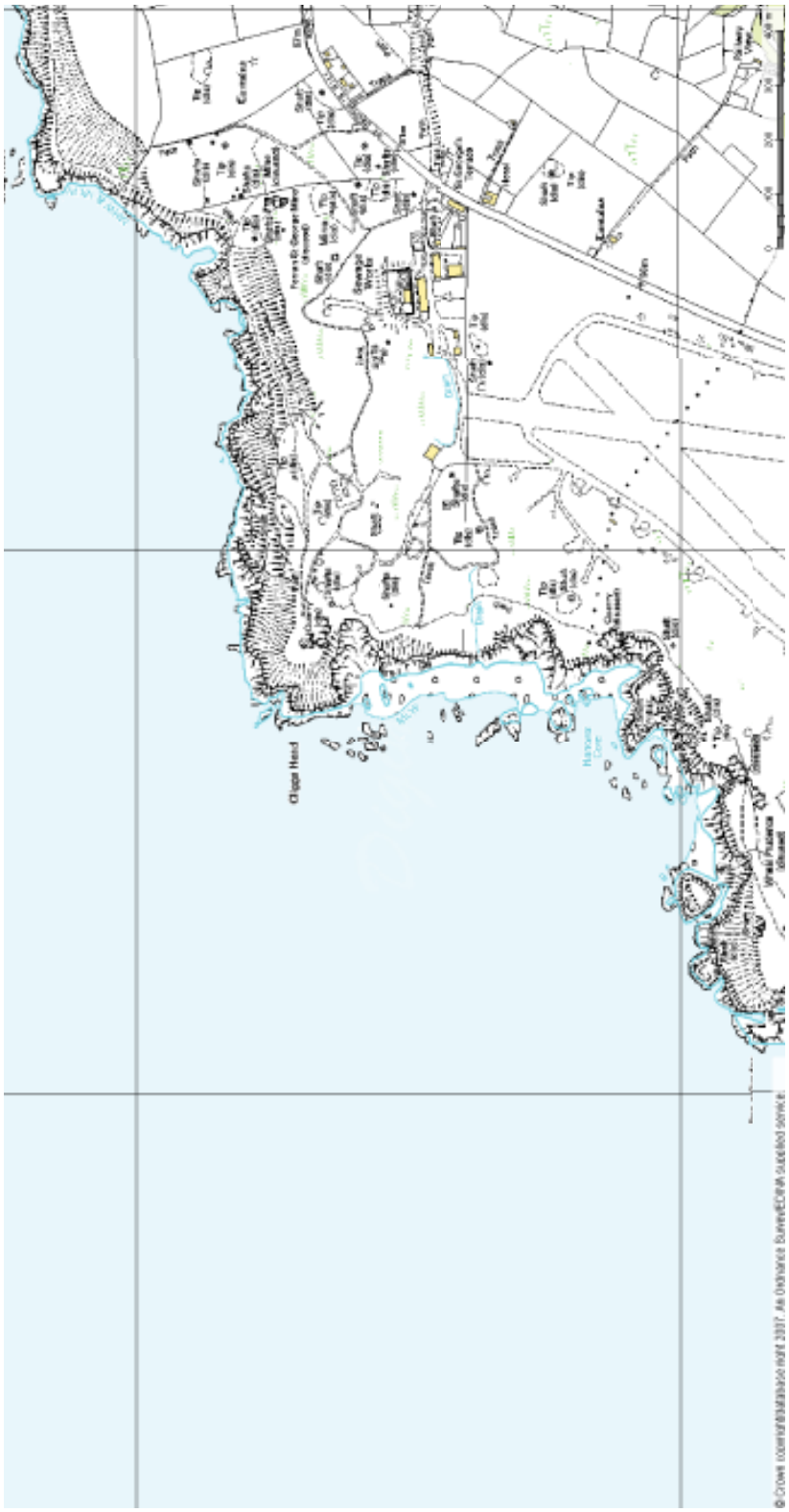

Figure 4.5 *Hanover Cove (scale 1:7831)*

4.4 Perranporth Beach

The beach (SW757548), which extends for 2 miles from Droskyn to Liggar Point, is 10 miles from Truro and 8 miles from Newquay, is popular with surfers and families. It is backed by a dune system that includes St. Piran's Cross and the ruins of St. Piran's Oratory, so-called because Perran Bay is reputed to be the landing place of St Piran, the patron saint of Cornish Tinners. Piran was a Celtic monk on a millstone [Automobile Association, 1984]. The Oratory of St. Piran was built in the seventh century, it was an important early Celtic monastery and a place of pilgrimage in the Middle Ages and was said to contain the relics of St. Piran. It became submerged by drifting sands in the 11th century and had to be abandoned. It emerged during a storm in 1835. A second church of St. Piran was built on higher ground in 1150, but unfortunately suffered a similar fate in 1608. Exhumed by excavation in 1835 and 1910, a Celtic cross on the cliffs marks its former position. According to popular legend, the sand in the dunes north of Perranporth at Penhale Sands conceal a 'lost city' called Langarrow [Steers, 1964]. A submerged forest has been found at the mouth of the Bolingey river [Bird, 1998] which runs to the west of Chapel Rock.

Table 4.4 *Perranporth Beach - Physical Attributes*

Easting (m)	175819
Northing (m)	56035
Latitude	50°21'23.95" N
Longitude	5° 9'20.92" W
Local authority	Carrick Council
Management Unit	Perran 7A3-09
MSR (m)	6.15
Length (m)	3500
LW Length (m)	3500
Width (m)	300
Area (m^2)	1050000
Angle (°)	285
Angle Code	WNW
Morphological Classification	open coast beach with high dunes
Sediment Classification	high tide sand, low tide sand

In 1985, the D_{50} at Perranporth was 0.26 mm [Goudie, 1990], compared with 0.25 –0.35 in 2007 (Table 4.5). The $CaCO_3$ content in 1985 was 52.88% [Goudie, 1990] and in 2007 was 44%.

Table 4.5 *Perranporth Beach - Sediment Attributes (15/08/2007)*

	Lower	Middle	Upper
Mean (ψ)	-2.21 (0.22 mm)	-1.98 (0.25 mm)	-1.71 (0.31 mm)
Sorting (ψ)	0.37 (0.77 mm)	0.34 (0.79 mm)	0.34 (0.79 mm)
Skewness	0.14	0.19	0.25
Mean fall vel (cm/s)	4.63	3.95	3.27
D_{50} (Hallermeier equation, mm)	0.35	0.30	0.25
$CaCO_3$ %	43.80 $\pm$ 8.80	n/a	n/a

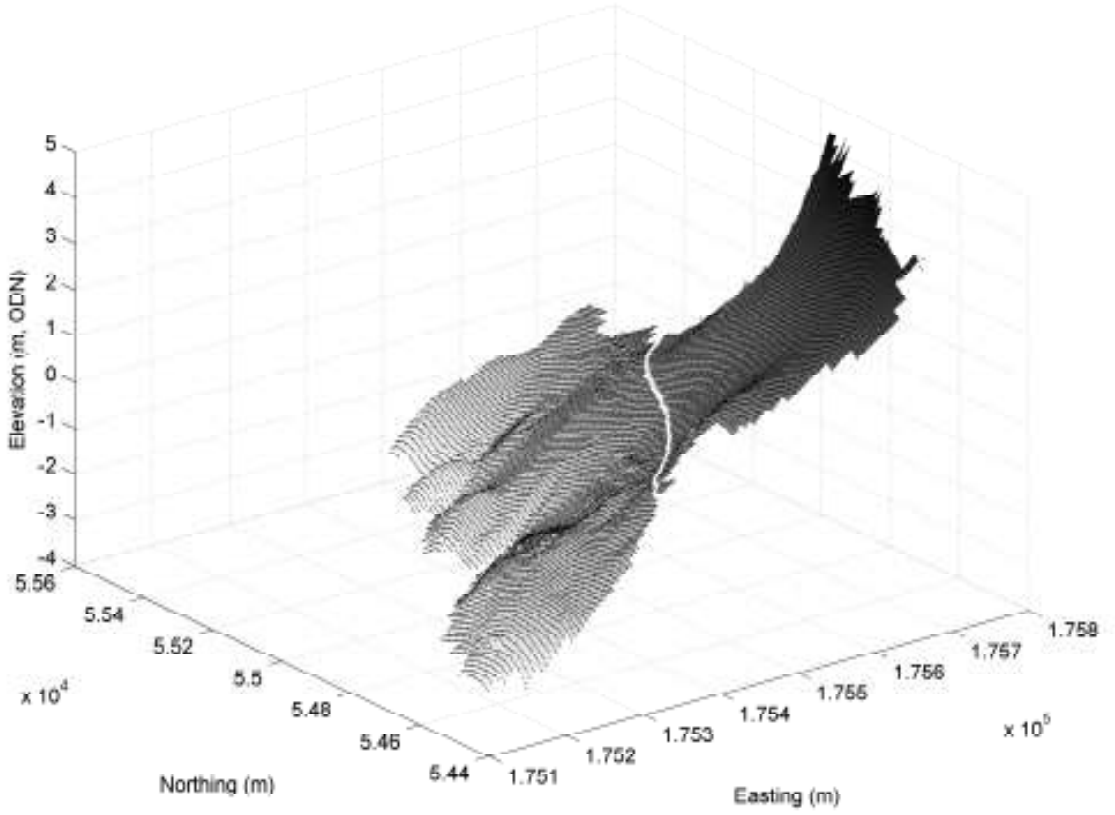

Figure 4.6 *Digital Elevation Model of Perranporth Beach, 08/02/2008. Elevations in m (ODN) —0 ODN (MSL) marked.*

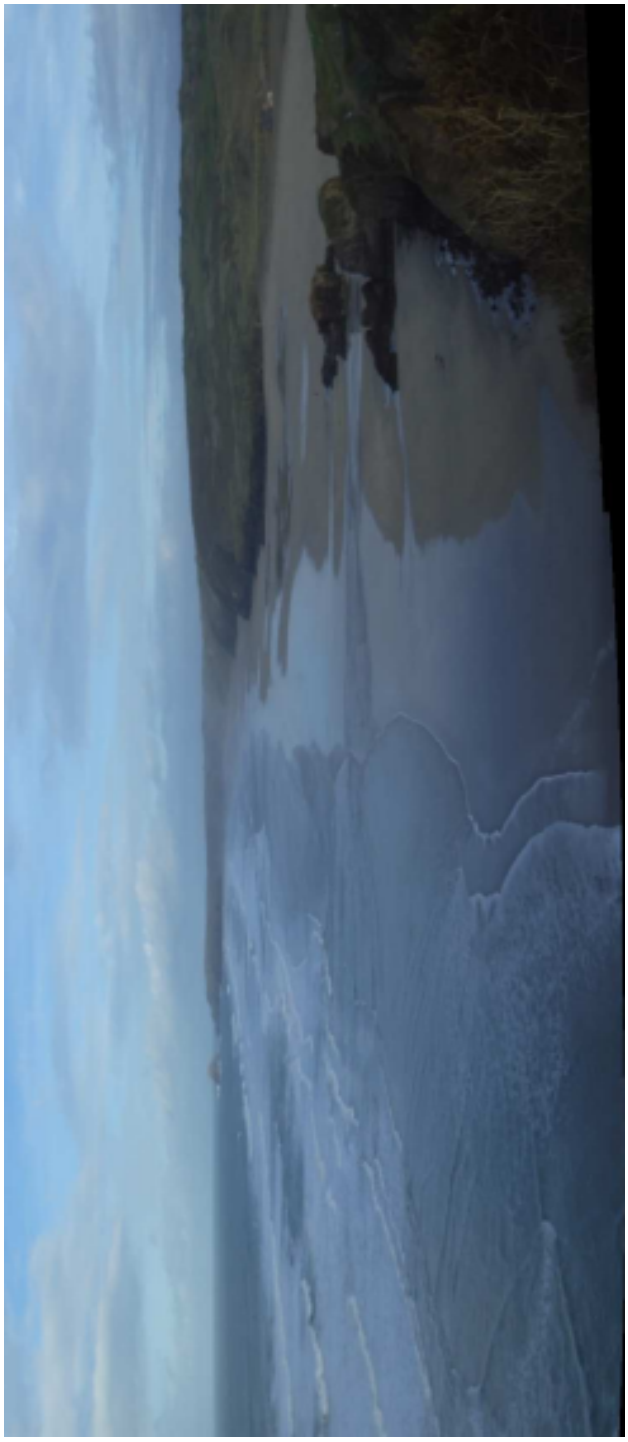

Figure 4.7 *Perranporth Beach at low tide*

Figure 4.8 *Perran Sands/South Perranporth (scale 1:7831)*

Figure 4.9 *Central Perranporth (scale 1:7831)*

Figure 4.10 *North Perranporth (scale 1:7831)*

4.5 Hoblyn's Cove

Table 4.6 *Hoblyn's Cove - Physical Attributes*

Easting (m)	176107
Northing (m)	58243
Latitude	50°22'53.11" N
Longitude	5° 9'0.19" W
Local authority	Carrick Council
Management Unit	South of Holywell 7A3-10
MSR (m)	6.2
Length (m)	50
LW Length (m)	50
Width (m)	100
Area (m^2)	5000
Angle (°)	270
Angle Code	WNW
Morphological Classification	open coast beach with high cliffs
Sediment Classification	high tide boulder and sand, low tide boulders and rock

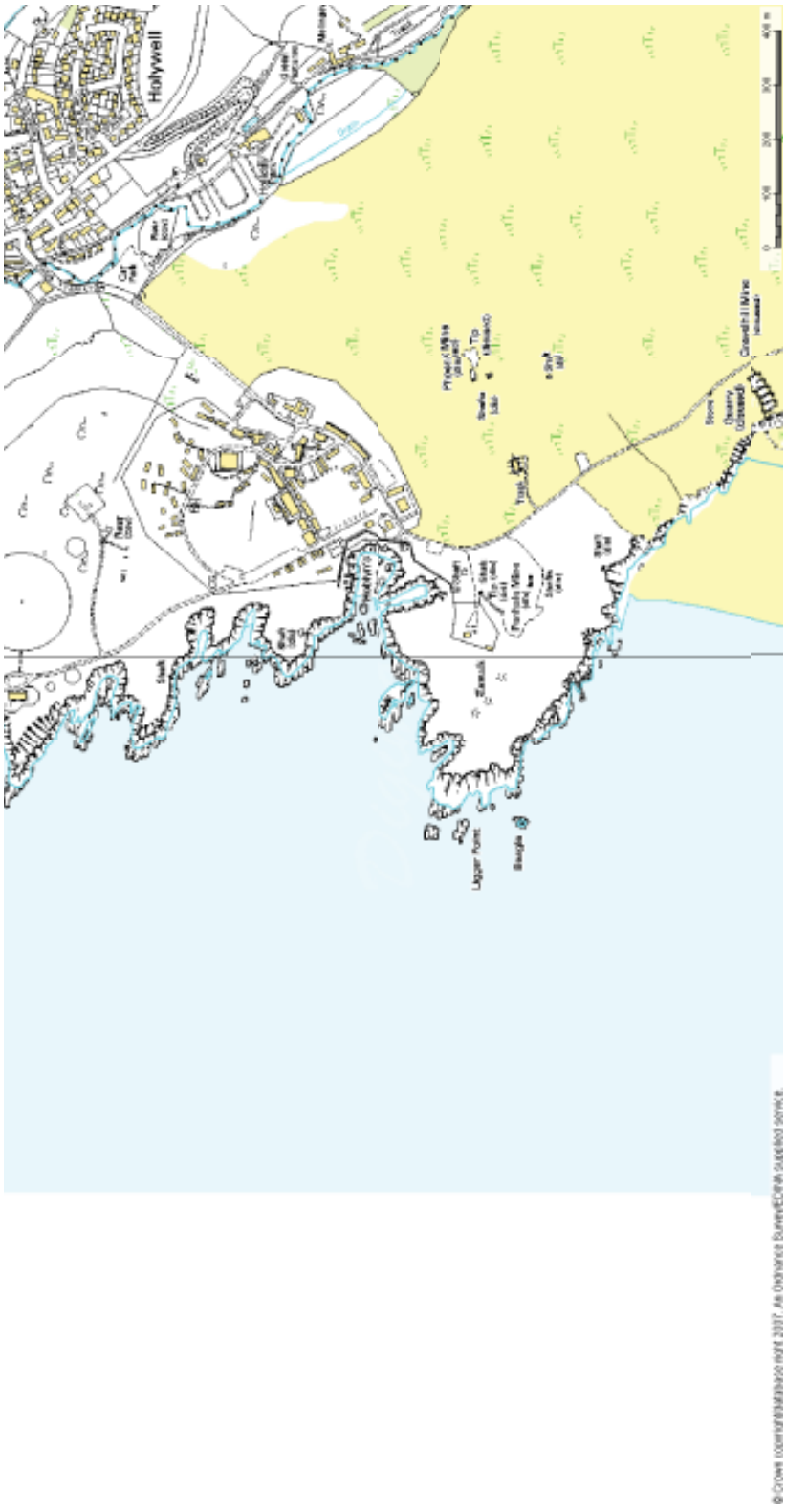

Figure 4.11 *Hoblyn's Cove (scale 1:7831)*

4.6 Holywell Beach

The beach (SW76505950), 16 miles from Truro and 6 miles from Newquay, is set within a bay and is backed by high sand dunes similar to Perran sands. A broad but shallow river draining the Cubert valley enters the beach alongside slaty rock outcrops at the southern end.

Table 4.7 *Holywell Beach - Physical Attributes*

Easting (m)	176416
Northing (m)	59507
Latitude	50°23'34.65" N
Longitude	5° 8'48.30" W
Local authority	Carrick Council
Management Unit	Holywell 7A3-11
MSR (m)	6.25
Length (m)	1200
LW Length (m)	1200
Width (m)	250
Area (m^2)	300000
Angle (°)	305
Angle Code	NW
Morphological Classification	open coast beach with low dune
Sediment Classification	high tide sand, low tide sand

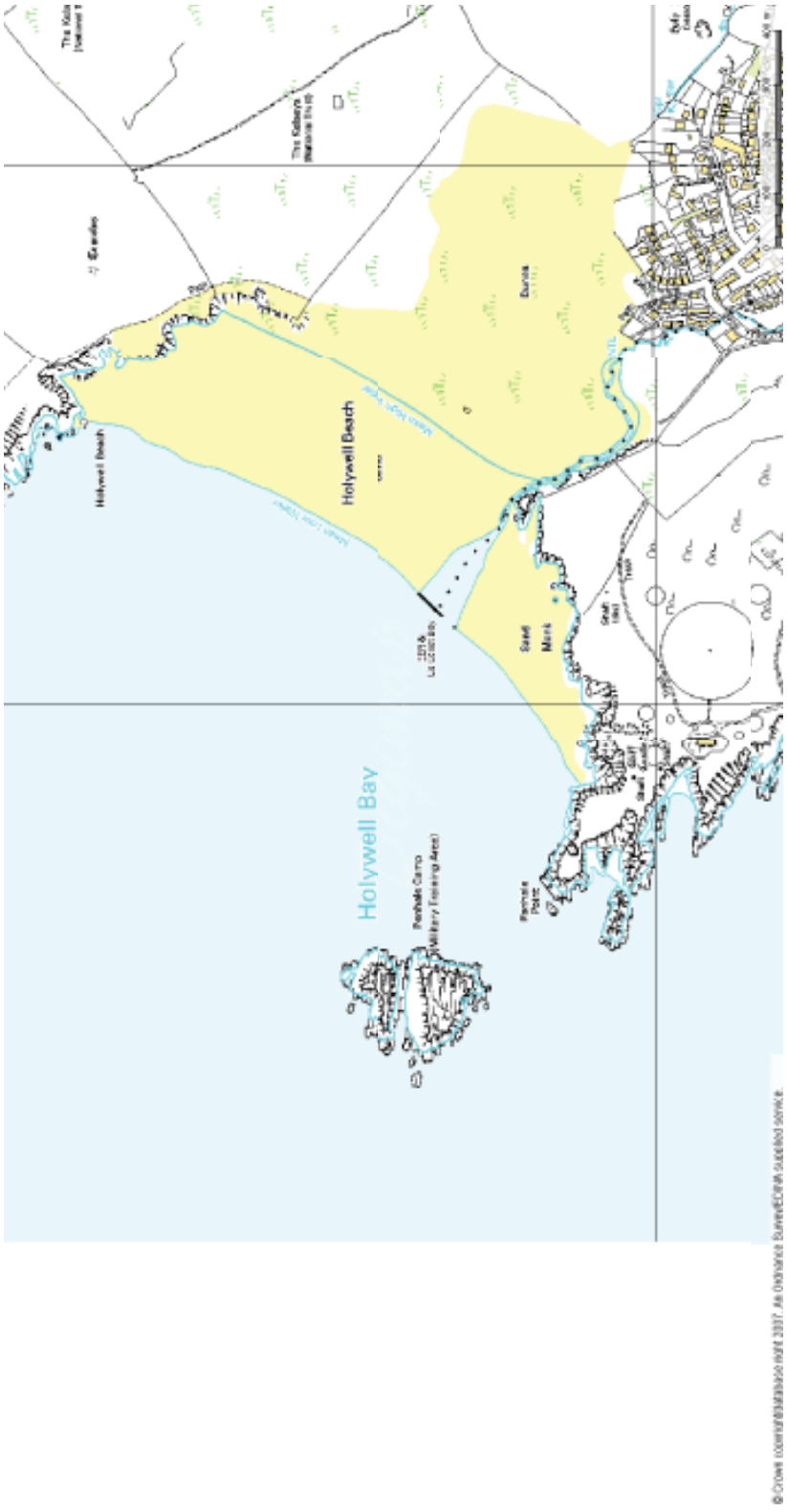

Figure 4.12 *Holywell Bay Beach (scale 1:7831)*

Chapter 5

Penhale Head to Porthcothan

Figure 5.1 *Penhale Head to Porthcothan (scale 1:67458)*

The stretch of coast between Penhale and Porthcothan is characterised by wide sandy beaches backed by sand dunes. It contains 19 beaches, comprising a total area of 2,875,000 m^2. The sands are very carbonate, together with some sediments derived locally.

5.1 Porth Joke

Porth Joke (SW77106060), a sandy beach owned by the National Trust, and flanked by dunes in a sheltered bay, is just south of Fistral Bay about 4 miles from Newquay, between Kelsey Head and West Pentire. It is accessed from the car park at West Pentire. The sand at Porth Joke is reputed to be rich in minerals which have been used as a natural fertiliser since an Act of Parliament during the reign of James II gave farmers permission to take sand from the beach. Seals breed on The Chick, a rocky island just off Kelsey Head [Automobile Association, 1984].

Table 5.1 *Porth Joke - Physical Attributes*

Easting (m)	177044
Northing (m)	60661
Latitude	50^{o}24'10.34" N
Longitude	5^o 8'14.53" W
Local authority	Restormel Council
Management Unit	North of Holywell 7A3-12
MSR (m)	6.3
Length (m)	250
LW Length (m)	250
Width (m)	400
Area (m^2)	100000
Angle (^{o})	335
Angle Code	NNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide gravel and sand, low tide sand

Figure 5.2 *Porth Joke Beach (scale 1:7831)*

5.2 Crantock Beach

Sheltered from the prevailing winds by Pentire Point West, across the Gannel Estuary 4 miles from Newquay is Crantock, a sandy beach (SW78406080) within east and west Pentire Headlands, backed by high grassy dunes to the northeast, and by steep cliffs to the southwest which are showing signs of erosion. The River Gannel enters the sea at the northern edge, which used to be very much larger than today making Crantock a navigable port. The Gannel is a long and narrow ria (drowned river valley) which is sandy in its lower course marked by large ripples and tidal pools, and muddy saltmarsh edge thereafter which has undergone some erosion.

Table 5.2 *Crantock Beach - Physical Attributes*

Easting (m)	178175
Northing (m)	61005
Latitude	50°24'25.26" N
Longitude	5° 7'18.90" W
Local authority	Restormel Council
Management Unit	West of Fistral 7A3-14
MSR (m)	6.33
Length (m)	700
LW Length (m)	700
Width (m)	400
Area (m^2)	280000
Angle (^{o})	320
Angle Code	NW
Morphological Classification	open coast beach with low dune
Sediment Classification	high tide rock and sand, low tide sand

Table 5.3 *Crantock Beach - Sediment Attributes (15/08/2007)*

	Lower	Upper
Mean (ψ)	-1.86 (0.28 mm)	-1.90 (0.27 mm)
Sorting (ψ)	0.42 (0.75 mm)	0.40 (0.76 mm)
Skewness	0.3	0.2
Mean fall vel (cm/s)	3.62	3.73
D_{50} (Hallermeier equation, mm)	0.28	0.29
$CaCO_3$ %	57.63 ± 2.96	n/a

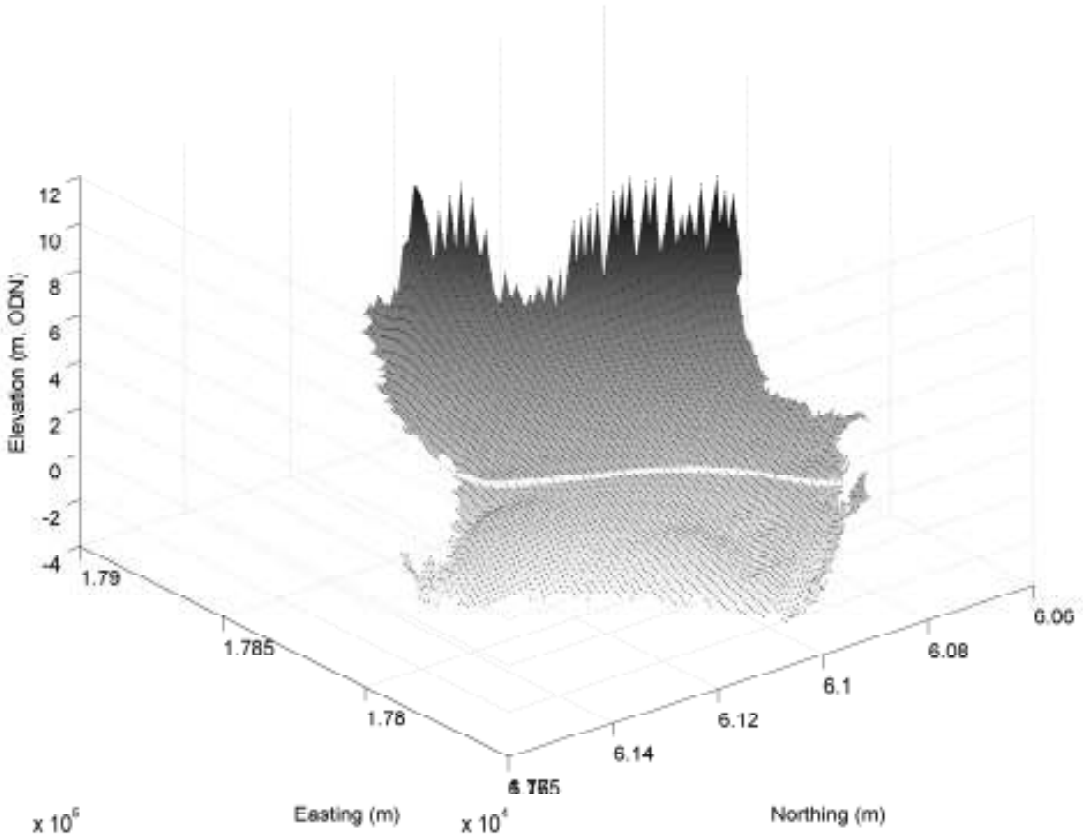

Figure 5.3 *Digital Elevation Model of Crantock Beach, 2007. Elevations in m (ODN) - 0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

Figure 5.4 *Crantock Beach at low tide.*

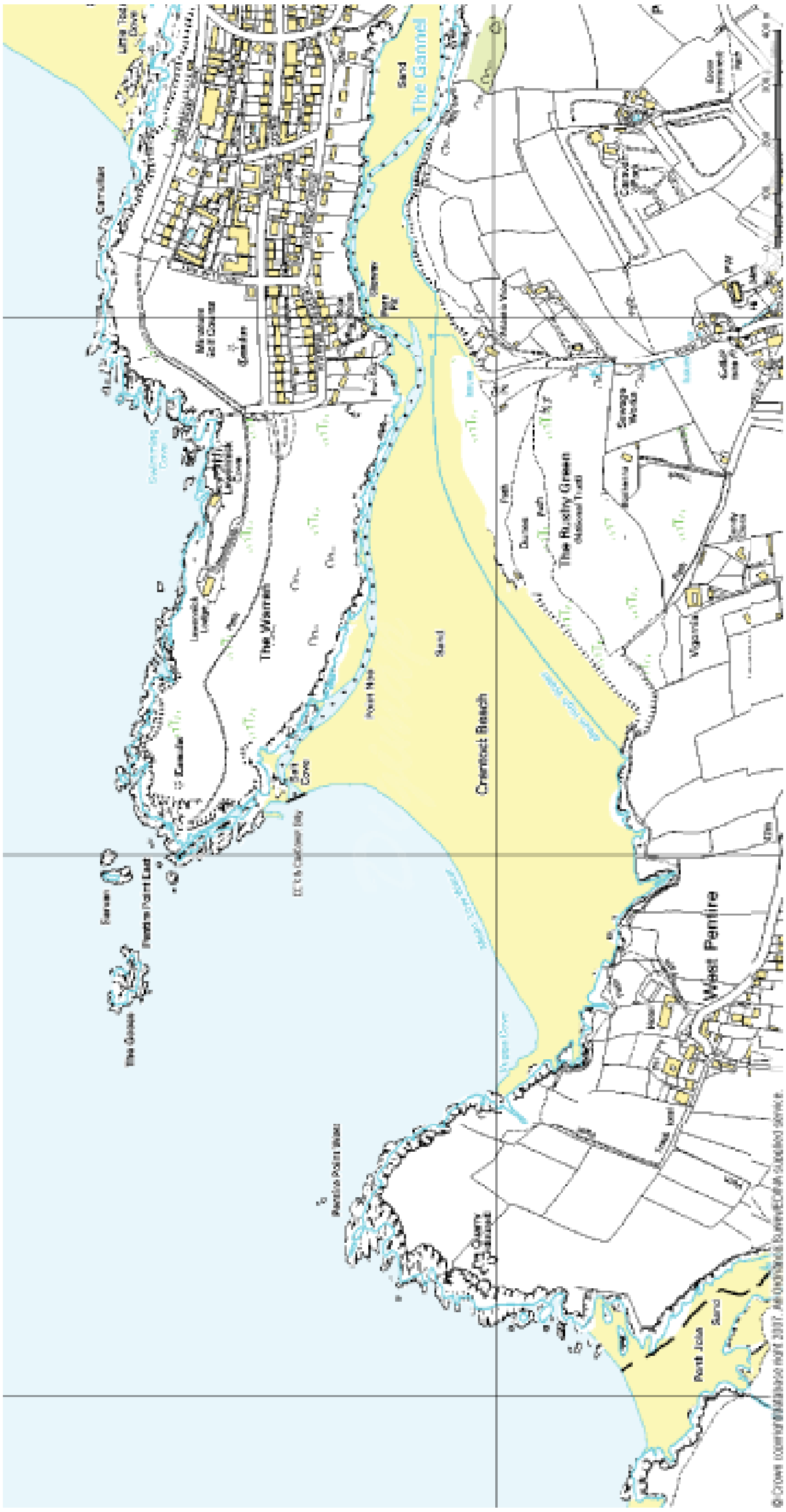

Figure 5.5 *Crantock Beach (scale 1:7831)*

5.3 Fistral beach

Fistral (SW79606230, commonly divided into North and South Fistral) is a Northwest-facing long sandy beach, 50 miles from Plymouth, backed by high cliffs. It dates to a harbour built in 1440, but a 'new quay' was added later. It is very popular with families and surfers because of the consistency of the waves. Fistral bay is cut into soft shales, and the beach contains shell fragments and some fragments of slate and quartz [Bird, 1998]. Fistral is famous for both its surf, and its emerged beaches and head deposits of Pleistocene age interspersed with erratics thought to have been deposited by ancient icebergs.

Table 5.4 *Fistral Beach - Physical Attributes*

Easting (m)	179745
Northing (m)	62103
Latitude	50º24'58.85" N
Longitude	5º 6'4.25" W
Local authority	Restormel Council
Management Unit	Fistral 7A3-15
MSR (m)	6.4
Length (m)	1200
LW Length (m)	1200
Width (m)	300
Area (m^2)	360000
Angle (^{o})	300
Angle Code	NW
Morphological Classification	open coast beach
Sediment Classification	high tide sand, low tide sand

Table 5.5 *Fistral Beach - Sediment Attributes (09/11/2007)*

	Lower	Upper
Mean (ψ)	-1.76 (0.30 mm)	-2.44 (0.18 mm)
Sorting (ψ)	0.44 (0.74 mm)	0.58 (0.67 mm)
Skewness	0.07	0.07
Mean fall vel (cm/s)	3.39	5.43
D_{50} (Hallermeier equation, mm)	0.26	0.40
$CaCO_3$ %	73.73 ± 9.21	n/a

In 1985, the D_{50} at Fistral was 0.56 mm [Goudie, 1990], compared with 0.26 –0.4 in 2007 (Table 4.5). The $CaCO_3$ content in 1985 was 76.85% [Goudie, 1990]

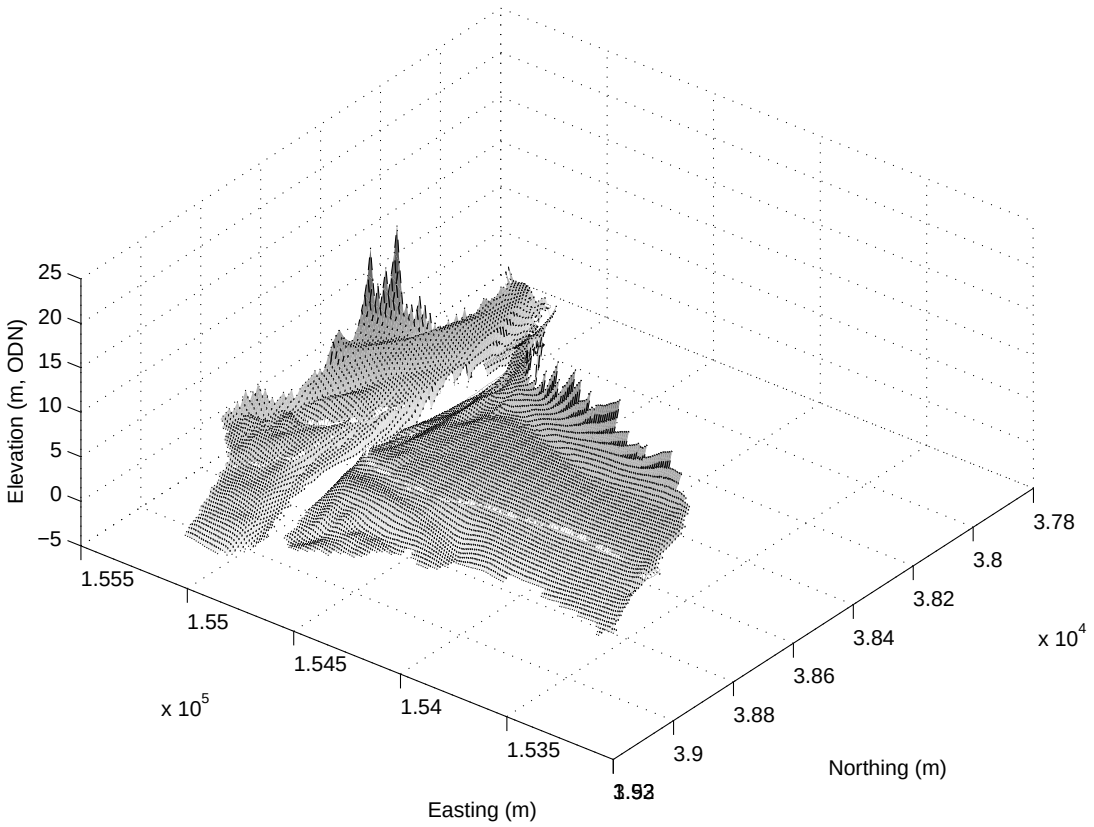

Figure 5.6 *Digital Elevation Model of Fistral Beach, 2007. Elevations in m (ODN) - 0 ODN (MSL) marked. Data courtesy of the Plymouth Coastal Observatory.*

Figure 5.7 *Fistral Beach at low tide.*

Figure 5.8 *Fistral Beach (scale 1:7831)*

5.4 Towan Beach

Towan (SW870329) is a high-tide gravel beach with many rocks and large areas of sand at low tide. The beach, backed by a sea wall, is completely tide washed. It has Newquay Harbour and the Island flanking two sides. In 1995 a dewatering system was installed in the attempt to halt beach erosion, which is thought to be exacerbated by poor drainage [Bird, 1998].

Table 5.6 *Towan Beach - Physical Attributes*

Easting (m)	180974 5
Northing (m)	61927
Latitude	50°24'56.42" N
Longitude	5° 5'4.56" W
Local authority	Restormel Council
Management Unit	North of Fistral 7A3-16
MSR (m)	6.4
Length (m)	850
LW Length (m)	2100
Width (m)	250
Area (m^2)	212500
Angle (^{o})	0
Angle Code	NNE
Morphological Classification	open coast beach with low cliff
Sediment Classification	high tide gravel and sand, low tide sand

Table 5.7 *Towan Beach - Sediment Attributes (09/11/2007)*

	Lower	Upper
Mean (ψ)	-1.69 (0.31 mm)	-1.67 (0.31 mm)
Sorting (ψ)	0.37 (0.77 mm)	0.34 (0.79 mm)
Skewness	0.24	0.27
Mean fall vel (cm/s)	3.22	3.18
D_{50} (Hallermeier equation, mm)	0.25	0.25
$CaCO_3$ %	58.06 $\pm$ 1.27	n/a

Figure 5.9 *Towan Beach at low tide.*

Figure 5.10 *Towan Beach (scale 1:7831)*

5.5 Tolcarne Beach

Tolcarne beach (SW81806215) is formed by a large expanse of sand backed by cliffs in a crescent shaped bay. It is popular with surfers, swimmers and families. Tolcarne is separated from Lusty Glaze by the Criggers, which is a rocky headland of limestone hardened to marble [Bird, 1998].

Table 5.8 *Tolcarne Beach - Physical Attributes*

Easting (m)	181551
Northing (m)	62110
Latitude	50°24'58.31" N
Longitude	5° 4'42.25" W
Local authority	Restormel Council
Management Unit	Newquay 7A3-17
MSR (m)	6.41
Length (m)	500
LW Length (m)	500
Width (m)	250
Area (m^2)	125000
Angle (°)	330
Angle Code	NNW
Morphological Classification	high tide gravel and sand, low tide sand
Sediment Classification	open coast beach with low cliff

5.6 Lusty Glaze

Lusty Glaze (SW82406255) is a privately owned beach and cove sheltered by 200ft cliffs

Table 5.9 *Lusty Glaze - Physical Attributes*

Easting (m)	182106
Northing (m)	62574
Latitude	50^{o}25'3.32" N
Longitude	5^o 4'26.46" W
Local authority	Restormel Council
Management Unit	Newquay 7A3-17
MSR (m)	6.41
Length (m)	600
LW Length (m)	600
Width (m)	250
Area (m^2)	150000
Angle (^{o})	310
Angle Code	NW
Morphological Classification	high tide gravel and sand, low tide sand
Sediment Classification	open coast beach with high cliff

Figure 5.11 *Tolcarne and Lusty Glaze (scale 1:7831)*

5.7 Porth Beach

Porth (SW82936275) is a narrow north west facing beach with a shallow incline. Easy access makes it popular with families. Porth Island to the east of the beach is the site of an Iron Age settlement, and is linked to the mainland by a footbridge [Marine Conservation Society, 2008; Bird, 1998]. It was a thriving port until the 19th century, in the latter days importing limestone from South Wales to apply to Cornwall's acidic granitic soil [Automobile Association, 1984]. On the north side a river runs past Trevelgue Head.

Table 5.10 *Porth Beach - Physical Attributes*

Easting (m)	182443
Northing (m)	62911
Latitude	50°25'29.24" N
Longitude	5° 3'32.02" W
Local authority	Restormel Council
Management Unit	Trevelgue 7A3-19
MSR (m)	6.41
Length (m)	150
LW Length (m)	150
Width (m)	650
Area (m^2)	97500
Angle (°)	295
Angle Code	WNW
Morphological Classification	open coast beach with low cliff
Sediment Classification	high tide gravel and sand, low tide sand

5.8 Whipsiderry Beach

A sandy cove, completely submerged at high tide, sheltered by high vertical cliffs. A path to Trevelgue Head passes a Bronze Age burial mound, as well as the remains of an Iron Age fortress [Automobile Association, 1984].

Table 5.11 *Whipsiderry Beach - Physical Attributes*

Easting (m)	183126
Northing (m)	63576
Latitude	50^{o}25'47.95" N
Longitude	5^o 3'20.8" W
Local authority	Restormel Council
Management Unit	Trevelgue 7A3-19
MSR (m)	6.42
Length (m)	700
LW Length (m)	3400
Width (m)	250
Area (m^2)	175000
Angle (^{o})	305
Angle Code	NW
Morphological Classification	open coast beach with low cliff
Sediment Classification	high tide sand, low tide sand

Figure 5.12 *Porth Beach and Whipsiderry (scale 1:7831)*

5.9 Watergate Beach

Watergate (SW84106490) is a long privately-owned Northwest-facing beach backed by the 80-90m crumbling cliffs of the St. Mawgan Plateau [Bird, 1998], about 3 miles from Newquay towards Padstow. It is set between the cliffs Trevlegue Head to the south and Stem Point in the north.

Table 5.12 *Watergate Beach - Physical Attributes*

Easting (m)	183920
Northing (m)	64962
Latitude	50°26'35.75" N
Longitude	5° 2'42.40" W
Local authority	Restormel Council
Management Unit	Trevelgue 7A3-19
MSR (m)	6.42
Length (m)	2550
LW Length (m)	2550
Width (m)	300
Area (m^2)	765000
Angle (°)	300
Angle Code	NW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide sand, low tide sand

Table 5.13 *Watergate Bay Beach - Sediment Attributes (09/11/2007)*

	Lower	Upper
Mean (ψ)	-1.77 (0.29 mm)	-1.87 (0.27 mm)
Sorting (ψ)	0.31 (0.81 mm)	0.37 (0.77 mm)
Skewness	0.19	0.24
Mean fall vel (cm/s)	3.40	3.64
D_{50} (Hallermeier equation, mm)	0.26	0.28
$CaCO_3$ %	44.52	n/a

Figure 5.13 *South Watergate or Tregurrian Beach (scale 1:7831)*

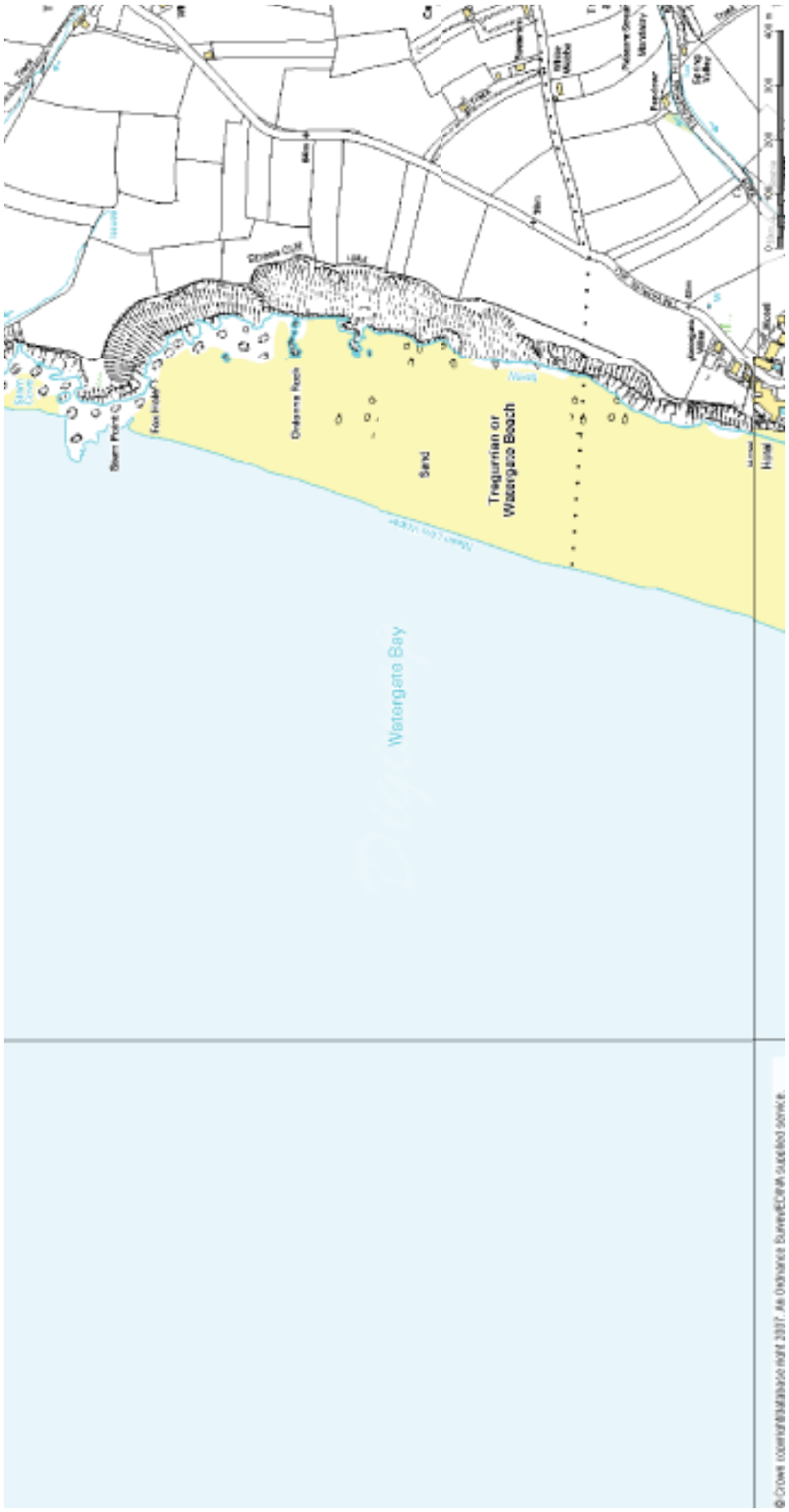

Figure 5.14 *North Watergate or Tregurrian Beach (scale 1:7831)*

5.10 Stem Cove

Table 5.14 *Stem Cove - Physical Attributes*

Easting (m)	184181
Northing (m)	66367
Latitude	50º27'33.87" N
Longitude	5º 2'19.94" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.42
Length (m)	150
LW Length (m)	150
Width (m)	100
Area (m^2)	15000
Angle (^{o})	280
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide boulders and sand, low tide sand

5.11 Beacon Cove

Table 5.15 *Beacon Cove - Physical Attributes*

Easting (m)	184314
Northing (m)	66683
Latitude	50º27'55.58" N
Longitude	5º 2'25.43" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.43
Length (m)	200
LW Length (m)	200
Width (m)	150
Area (m^2)	30000
Angle (º)	280
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide boulders and sand, low tide sand

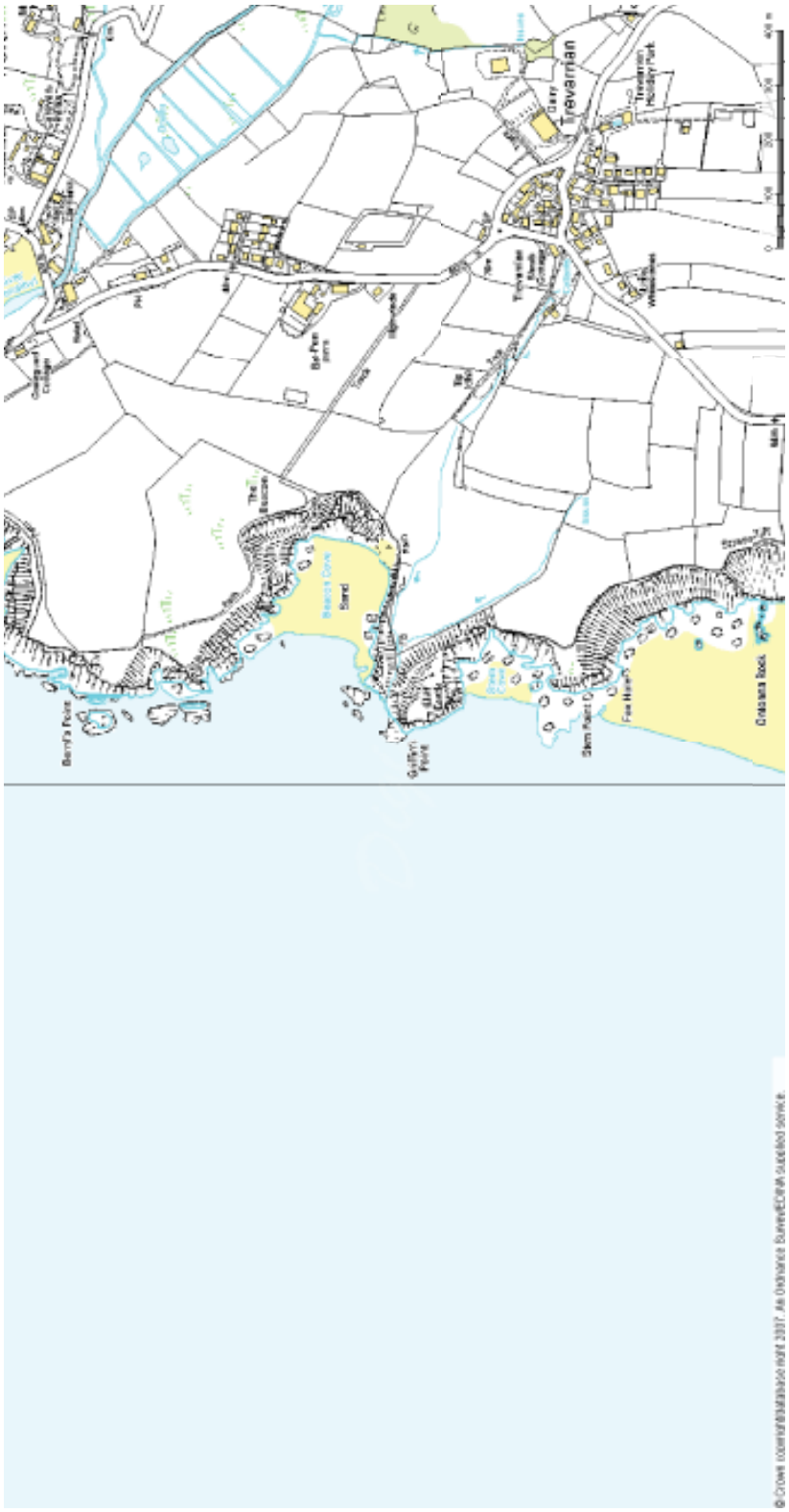

Figure 5.15 *Stem Cove and Beacon Cove(scale 1:7831)*

5.12 Mawgan Porth

A west-facing long flat sandy beach (SW848674) 7 miles from Newquay, with cliffs to the north and south, and a river on south side flowing into the sea at the mouth of the vale of Mawgan. At low tide a number of caves and coves are exposed. Behind Mawgan Porth is a low sea wall and some grassy dunes. The beach may be accessed via a clifftop path past Berryl's Point before dropping steeply down to Beacon Cove. The remains of a 5th century settlement are thought to be hidden by the dunes behind Mawgan Porth [Automobile Association, 1984].

Table 5.16 *Mawgan Porth - Physical Attributes*

Easting (m)	184630
Northing (m)	67614
Latitude	50^o 28'2.61" N
Longitude	5^o 1'59.13" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.43
Length (m)	750
LW Length (m)	750
Width (m)	350
Area (m^2)	262500
Angle (^{o})	290
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide sand, low tide sand
D_{50} (mm)	0.29 [Goudie, 1990].
$CaCO_3$ %	61.04 [Goudie, 1990]

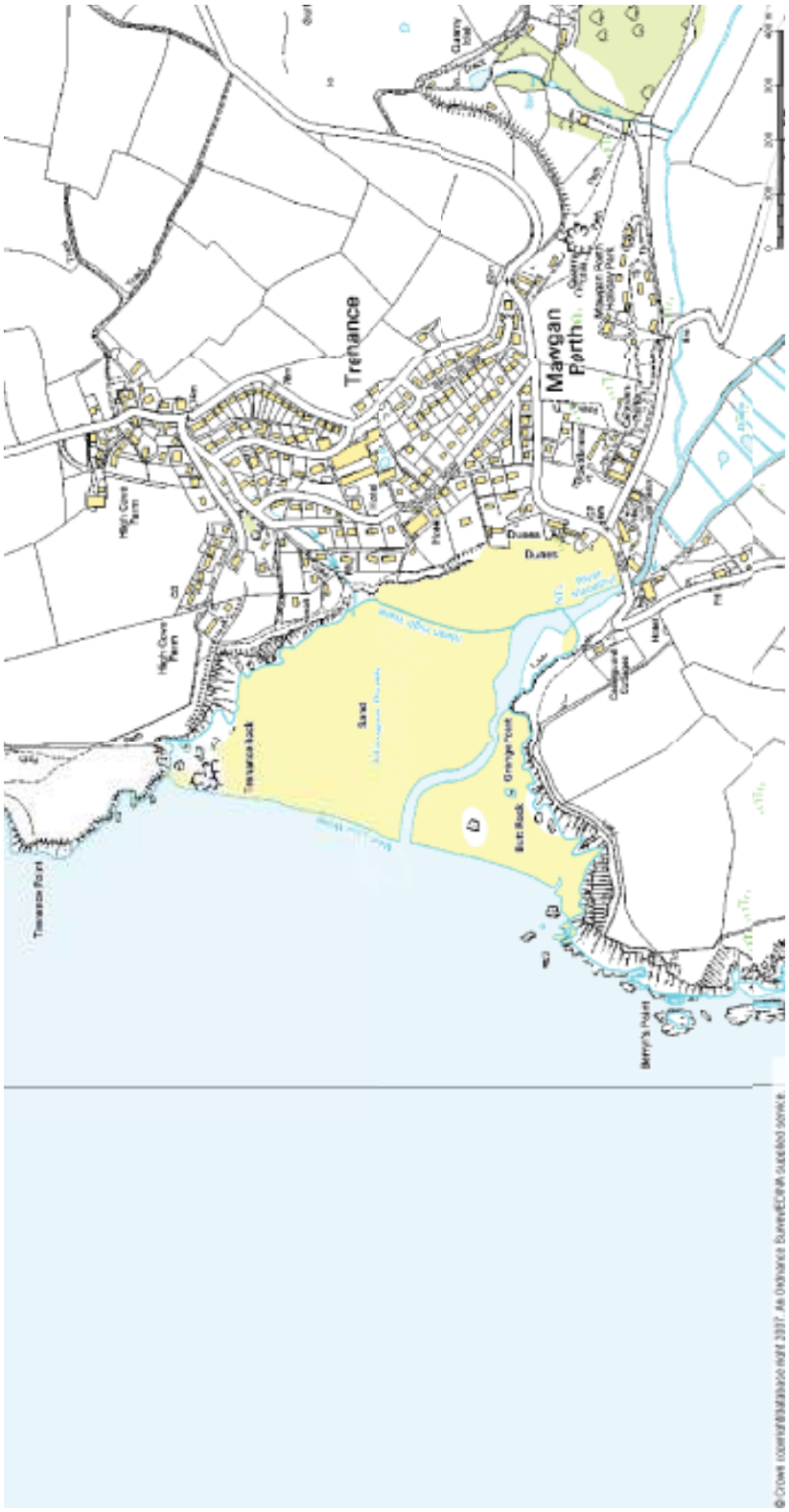

Figure 5.16 *Mawgan Porth Beach (scale 1:7831)*

5.13 Trerathick Cove

Table 5.17 *Trerathick Cove - Physical Attributes*

Easting (m)	184658
Northing (m)	68565
Latitude	50º28'35.98" N
Longitude	5º 2'10.21" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	200
LW Length (m)	200
Width (m)	100
Area (m^2)	20000
Angle (^{o})	270
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide rock and sand, low tide sand

5.14 Whitestone Cove

Table 5.18 *Whitestone Cove - Physical Attributes*

Easting (m)	184778
Northing (m)	69218
Latitude	50º28'53.14" N
Longitude	5º 2'7.22" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	350
LW Length (m)	1400
Width (m)	150
Area (m^2)	52500
Angle (^{o})	275
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide rock and sand, low tide sand

Figure 5.17 *Trerathick and Whitestone Coves (scale 1:7831)*

5.15 Bedruthan Steps or 'Pendarves'

A large sandy beach dwarfed by spectacular rock outcrops approximately 8 miles from Newquay, reached by a long flight of steps from a grassy clifftop. It gets it's name from the slate outcrops along the beach, and it is said that the outcrops were put there by Bedruthan, a giant, and used as them stepping stones. At low tide it is possible to walk from Bedruthan to Pendarves Island. Nearby are Carnewas cliffs owned by the National Trust, and looking west from here, views of Newquay bay. One rock is known as Queen Bess rock after its resemblance to Elizabeth I [Automobile Association, 1984].

Table 5.19 *Bedruthan Steps - Physical Attributes*

Easting (m)	184792
Northing (m)	69682
Latitude	50°28'59.37" N
Longitude	5° 2'2.32" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	650
LW Length (m)	650
Width (m)	200
Area (m^2)	130000
Angle (°)	270
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide rock and sand, low tide sand

Figure 5.18 *Bedruthan Steps Beach (scale 1:7831)*

5.16 Diggory's Island

Table 5.20 *Diggory's Island - Physical Attributes*

Easting (m)	184722
Northing (m)	70125
Latitude	50^{o}29'3.96" N
Longitude	5^o 2'8.50" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	250
LW Length (m)	250
Width (m)	200
Area (m^2)	50000
Angle (^{o})	260
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide rock and sand, low tide sand

5.17 Pentire Steps

Table 5.21 *Pentire Steps - Physical Attributes*

Easting (m)	184658
Northing (m)	70462
Latitude	50^{o}29'9.09" N
Longitude	5^o 1'59.40" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	100
LW Length (m)	100
Width (m)	150
Area (m^2)	15000
Angle (^{o})	260
Angle Code	WNW
Morphological Classification	open coast beach with high cliff
Sediment Classification	high tide rock and sand, low tide sand

5.18 The Saddle

Table 5.22 *The Saddle - Physical Attributes*

Easting (m)	184476
Northing (m)	70687
Latitude	50^{o}29'18.15" N
Longitude	5^o 2'0.45" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	100
LW Length (m)	100
Width (m)	100
Area (m^2)	10000
Angle (^{o})	230
Angle Code	SW
Morphological Classification	open coast shore platform with high cliff
Sediment Classification	high tide rock, low tide rock and sand

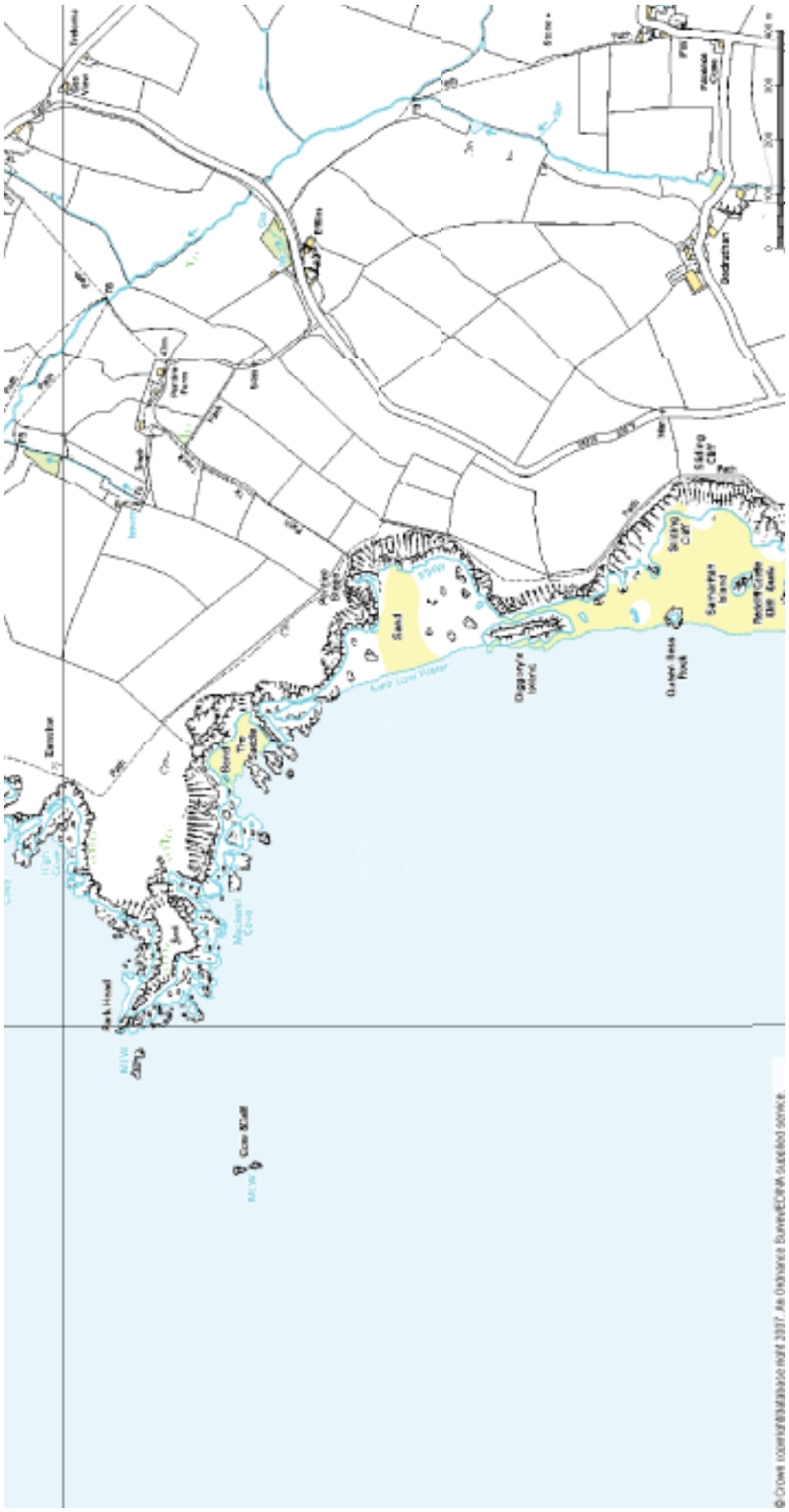

Figure 5.19 *Diggory's Island, Pentire Steps Beach and The Saddle (scale 1:7831)*

5.19 Porth Mear

Porth Mear occupies a wide valley mouth inlet, backed by eroding sand dunes [Bird, 1998]. It is a secluded cove or rock and coarse sand/gravel.

Table 5.23 *Porth Mear - Physical Attributes*

Easting (m)	184841
Northing (m)	71698
Latitude	50º30'27.84" N
Longitude	5º 2'4.46" W
Local authority	Restormel Council
Management Unit	North of Trenance 7A3-20
MSR (m)	6.44
Length (m)	250
LW Length (m)	250
Width (m)	100
Area (m^2)	25000
Angle (^{o})	330
Angle Code	NNW
Morphological Classification	open coast shore platform with high cliff
Sediment Classification	high tide rock, low tide rock and sand

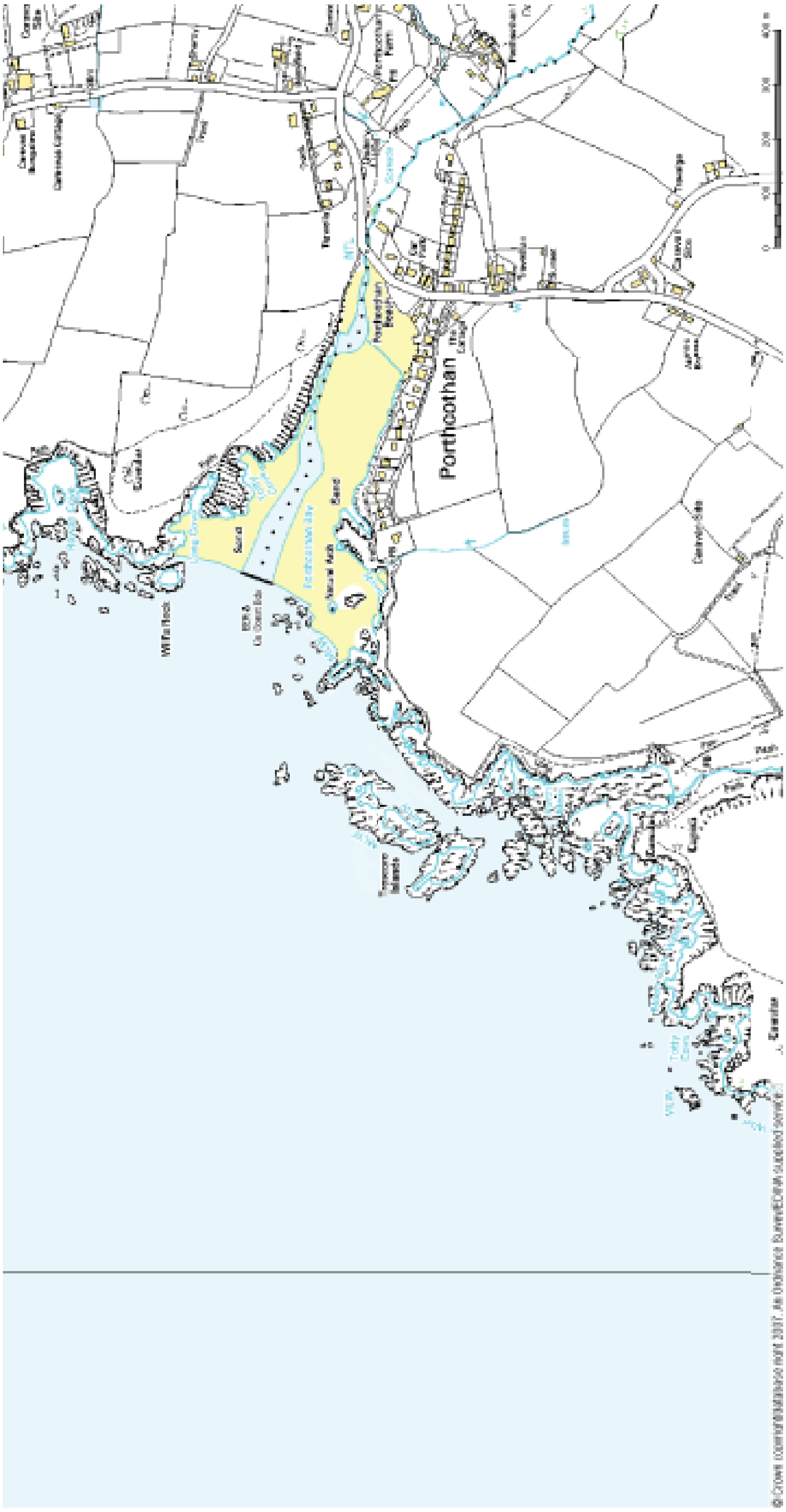

Figure 5.20 *Porth Mear and Porthcothan Beach (scale 1:7831)*

Chapter 6

Porthcothan to Trevose Head

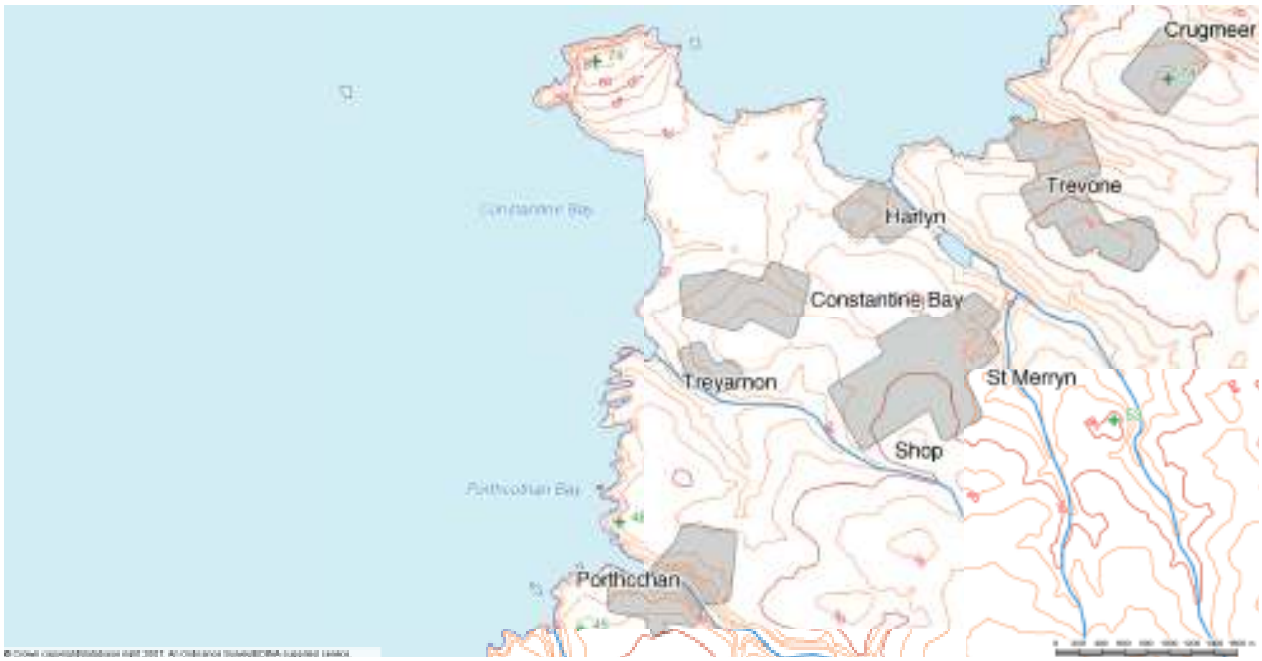

Figure 6.1 *Porthcothan to Trevose Head (scale 1:30747)*

The stretch of coast between Porthcothan and Trevose is dominated by cliff and platform morphology, but does contain 6 beaches comprising a total area of 307,500 m^2. The beaches are small embayments flanked by cliffs or low-lying land behind sand dunes, and all have streams flowing into them.

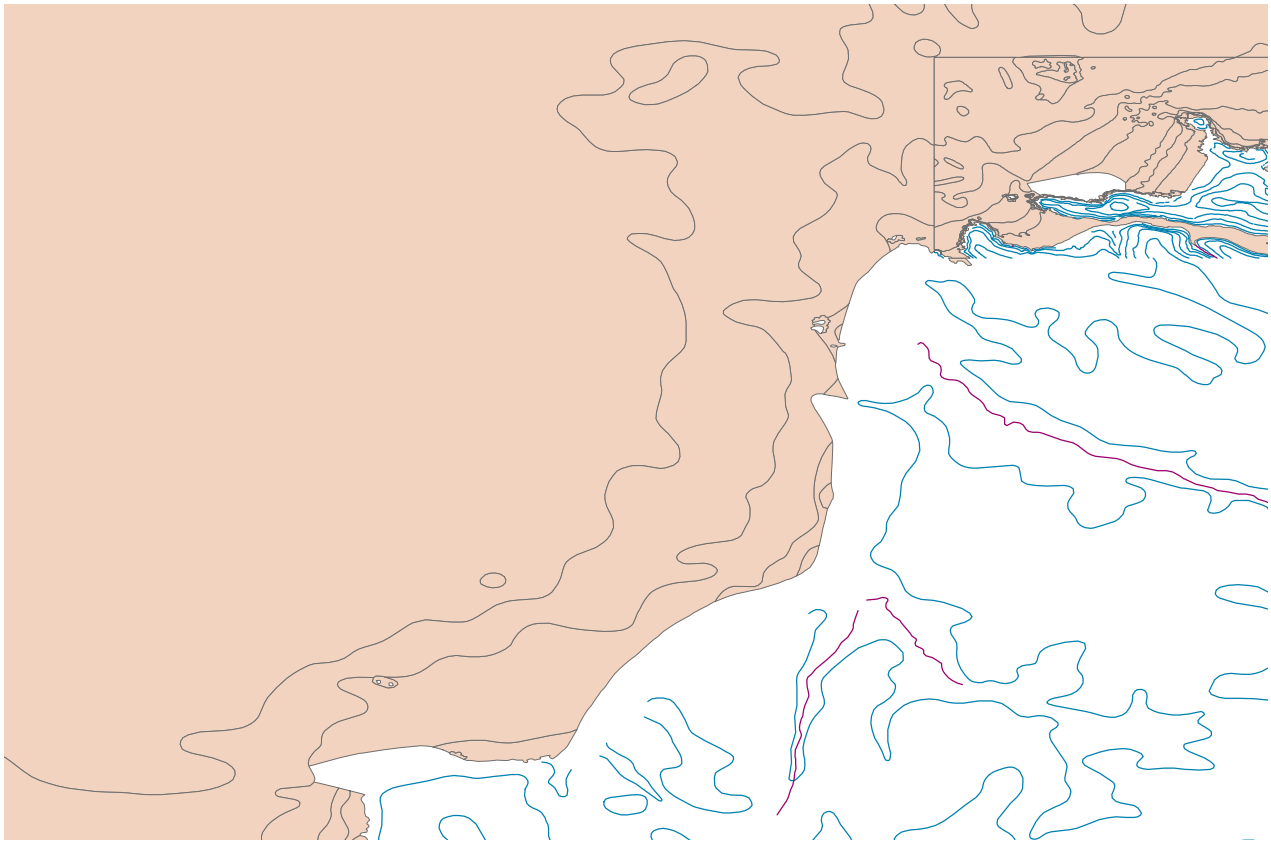

Figure 6.2 *Bathymetry of Porthcothan to Trevose. Source: Marine Digimap*

6.1 Porthcothan Bay

North-west facing long sandy cove (SW85707202), approximately 10 miles from Newquay, is popular with families, and surrounded by cliffs and backed by sheltering low sand dunes. Porthcothan is a long, narrow inlet with a stream flowing through it.

Table 6.1 *Porthcothan Beach - Physical Attributes*

Easting (m)	185382
Northing (m)	72204
Latitude	50º30'32.07" N
Longitude	5º 1'26.2" W
Local authority	North Cornwall Council
Management Unit	Porthcothan 7A3-21
MSR (m)	6.45
Length (m)	350
LW Length (m)	350
Width (m)	300
Area (m^2)	105000
Angle (^{o})	300
Angle Code	NW
Morphological Classification	open coast beach
Sediment Classification	high tide sand, low tide sand

Table 6.2 *Porthcothan Beach - Sediment Attributes (09/11/2007)*

	Lower	Upper
Mean (ψ)	-3.01 (0.12 mm)	-2.27 (0.21 mm)
Sorting (ψ)	0.31 (0.81 mm)	0.52 (0.70 mm)
Skewness	0.37	0.22
Mean fall vel (cm/s)	8.05	4.83
D_{50} (Hallermeier equation, mm)	0.58	0.36
$CaCO_3$ %	69.52	n/a

6.2 Fox Cove

Table 6.3 *Fox Cove - Physical Attributes*

Easting (m)	185453
Northing (m)	73276
Latitude	50º31'12.73" N
Longitude	5 1'34.27" W
Local authority	North Cornwall Council
Management Unit	North of Porthcothan 7A3-22
MSR (m)	6.45
Length (m)	100
LW Length (m)	100
Width (m)	150
Area (m^2)	15000
Angle (^{o})	245
Angle Code	WSW
Morphological Classification	open coast beach
Sediment Classification	high tide rock and sand, low tide sand

Figure 6.3 *Fox Cove (scale 1:7831)*

6.3 Pepper Cove

Table 6.4 *Pepper Cove - Physical Attributes*

Easting (m)	185544
Northing (m)	73681
Latitude	50^o 31'24.72" N
Longitude	5^o 1'36.27" W
Local authority	North Cornwall Council
Management Unit	North of Porthcothan 7A3-22
MSR (m)	6.46
Length (m)	50
LW Length (m)	50
Width (m)	100
Area (m^2)	5000
Angle (^{o})	245
Angle Code	WSW
Morphological Classification	open coast beach
Sediment Classification	high tide rock and sand, low tide sand

6.4 Treyarnon Bay

Low cliffs and a sandy beach washed by a stream. Treyarnon (SW85707390), in an Area of Outstanding Natural Beauty (AONB) next to Constantine Bay, has been termed "one of the most unspoilt beaches in North Cornwall" [Marine Conservation Society, 2008]. The cliffs above Treyarnon, on a clear day, offer some spectacular views to Trevose Head in the north and Newquay to the south.

Table 6.5 *Treyarnon Beach - Physical Attributes*

Easting (m)	185663
Northing (m)	74081
Latitude	50°31'32.43" N
Longitude	5° 1'23.6" W
Local authority	North Cornwall Council
Management Unit	North Constantine Bay 7A3-23
MSR (m)	6.46
Length (m)	250
LW Length (m)	250
Width (m)	300
Area (m^2)	7500
Angle (°)	270
Angle Code	WNW
Morphological Classification	open coast beach
Sediment Classification	high tide sand, low tide sand

Figure 6.4 *Pepper Cove and Treyarnon Beach (scale 1:7831)*

6.5 Constantine Bay

Constantine (SW85707480) is a gently curving west facing bay cut into shales, backed by large marram-covered dunes. It is bounded on either side by low headlands with rocky outcrops stretching seaward, and in the middle a stream flows out (controlled by a local golf course). There are remnants of a 3m raised beach [Bird, 1998], plus submerged forest deposits. Archealogically, the site is also very important with wrecked ships and bronze-age burial grounds in the headland between Constantine and Boobys bay. Fences and marram grass have been installed to prevent dune erosion. Dozens of rock pools are exposed at low tide on a wide rocky shelf.

Table 6.6 *Constantine Beach - Physical Attributes*

Easting (m)	185720
Northing (m)	74870
Latitude	50^o32'1.25" N
Longitude	5^o 1'22.54" W
Local authority	North Cornwall Council
Management Unit	North Constantine Bay 7A3-23
MSR (m)	6.46
Length (m)	250
LW Length (m)	250
Width (m)	300
Area (m^2)	75000
Angle (^{o})	270
Angle Code	WNW
Morphological Classification	open coast beach with low dune
Sediment Classification	high tide sand, low tide sand

Table 6.7 *Constantine Beach - Sediment Attributes (09/11/2007)*

	Lower	Upper
Mean (ψ)	-1.90 (0.27 mm)	-2.82 (0.14 mm)
Sorting (ψ)	0.39 (0.76 mm)	0.44 (0.74 mm)
Skewness	0.13	0.19
Mean fall vel (cm/s)	3.74	7.06
D_{50} (Hallermeier equation, mm)	0.29	0.51
$CaCO_3$ %	37.96 $\pm$ 4.72	

In 1985, the D_{50} at Constantine was 0.44 mm [Goudie, 1990], compared with 0.29 –0.51 in 2007 (Table 6.7). The $CaCO_3$ content in 1985 was 87.5% [Goudie, 1990], compared with 38% today.

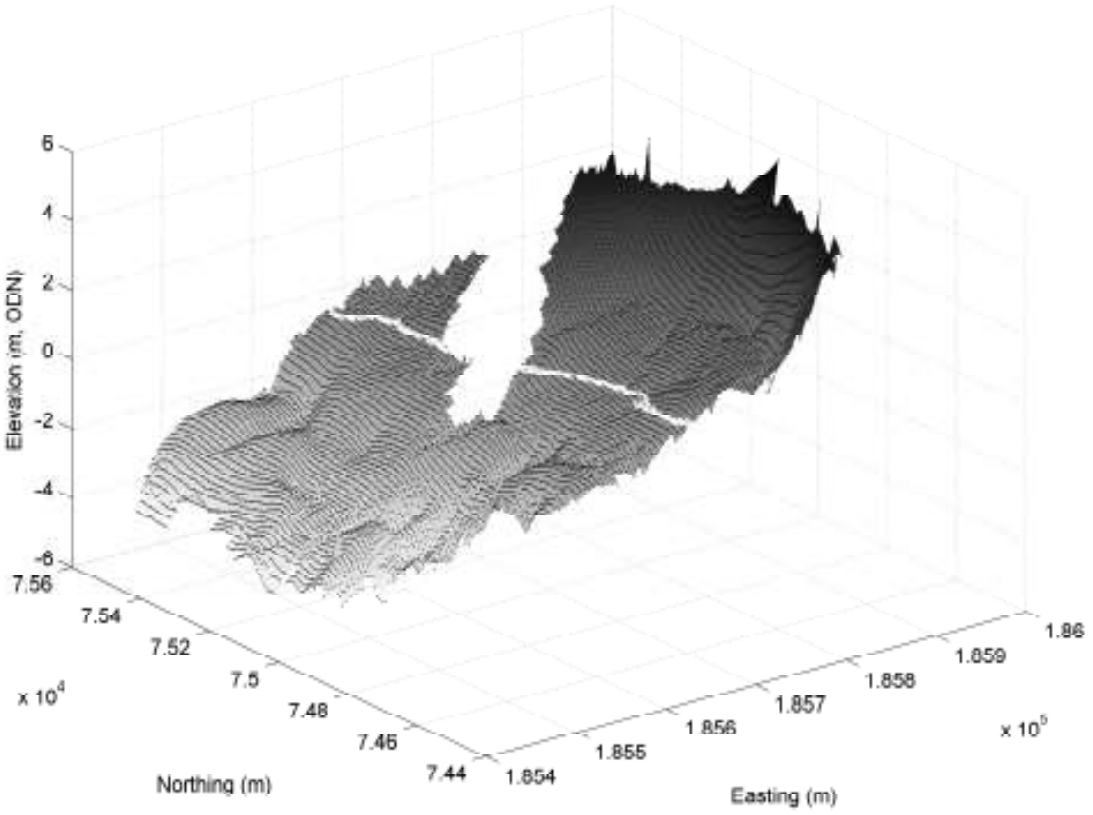

Figure 6.5 *Digital Elevation Model of Constantine Beach, summer 2006. Elevations in m (ODN) —0 ODN (MSL) marked.*

6.6 Booby's Bay

Boobys (SW856754), situated to the west of Trevose head near Padstow, connects with Constantine at low tide and is very popular with surfers

Table 6.8 *Booby's Beach - Physical Attributes*

Easting (m)	185628
Northing (m)	75383
Latitude	50°32'21.42" N
Longitude	5° 1'31.36" W
Local authority	North Cornwall Council
Management Unit	North Constantine Bay 7A3-23
MSR (m)	6.46
Length (m)	500
LW Length (m)	500
Width (m)	200
Area (m^2)	100000
Angle (^{o})	270
Angle Code	WNW
Morphological Classification	open coast beach with low cliff
Sediment Classification	high tide sand, low tide sand

Figure 6.6 *Constantine and Boobys Beaches at low tide.*

Figure 6.7 *Constantine and Boobys Beaches (scale 1:7831)*

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