Isle of Wight Council

Cowes to Gurnard Coastal Slope Stability Study

Ground Behaviour Assessment

August 2000

Halcrow Group Limited

Halcrow

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Contents Amendment Record

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1	0	Draft	16/08/00	RM.
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Acknowledgements

This report has been prepared by:

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Mr E.M. Lee - Coastal Geomorphological Partnership, University of Newcastle

Professor D. Brunsden - Consultant

The study was commissioned by:

Mr R.G. McInnes - Centre for the Coastal Environment, Isle of Wight Council

The contributions of Halcrow staff, Council officers, consultees and local residents are gratefully acknowledged.

Contents

1 Scope of Study

In February 2000, the Centre for the Coastal Environment of the Isle of Wight Council commissioned Halcrow Group Limited to carry out a coastal slope stability study at Cowes and Gurnard (letter dated 21 February 2000, ref CM36/2-RMcI/J)

The Terms of Reference were set out in a letter from the Council dated 12 January 2000 (ref RGM/CLT).

This Report is submitted in fulfilment of those Terms of Reference. Halcrow Group Ltd has prepared it in association with Professor D Brunsden (Consultant) and the Mr E M Lee (Coastal Geomorphology Partnership, University of Newcastle).

The main objective of the study is to provide general guidance and information on ground stability conditions along the coastal frontage from Market Hill, in central Cowes, west to Gurnard Marsh, and north of Baring Road located along and above the coastal slopes. Specifically, the study brief required the preparation of a series of geomorphological, ground behaviour and planning guidance maps following the format of an earlier landslip potential study at Ventnor on the south coast of the Isle of Wight. The series of maps are intended to assist decision-making by informing the planning process as well as provide a basis for assessing the requirements for stability investigations and reports in support of future development proposals in the study area.

The study brief specified the following tasks:

1. A review of readily accessible information sources, including published literature, technical reports, geological and topographic maps and plans, and historical prints and photographs.

2. Interviews with the Isle of Wight Council Coastal Manager, Planning and Building Control Managers, and up to four local consulting engineers and surveyors.

3. Engineering geomorphological mapping and survey of damage due to ground movement in accordance with the approach adopted for the Ventnor study.

2 Introduction and Approach

2.1 *Study Area Description*

The north-facing coastal slopes extending from Cowes to Gurnard are the most northerly landmass of the Isle of Wight (Figure 1). The coastal slopes form a prominent headland separating the Medina River and Estuary from the western Solent. The headland is characterised by a plateau forming the higher ground above gently sloping coastal cliffs of varying height up to 35m. The limit of the study area is shown in Figure 2, an area of about 100ha extending along the coast from Market Hill, Cowes, to Gurnard Marshes, and by up to 0.6 km inland of the shoreline.

The character of the coastal slopes within the study area varies along the shoreline. From Market Hill to the Royal Yacht Squadron, Cowes, steep estuary slopes up to 20m above Ordnance Datum form the northwest shore of the Medina River (Plate 1). From the Royal Yacht Squadron to Egypt Point and beyond to Gurnard Green, the coastal slopes rise gently to 35m above Ordnance Datum (Plate 2). A stream valley intersects the shoreline at Gurnard Green, beyond which steep coastal slopes known as Gurnard Cliffs extend to Gurnard Marshes at the western edge of the study area. Gurnard Cliffs vary in height up to 35m above Ordnance Datum (Plate 3).

The coastal slopes between Cowes and Egypt Point have, historically, been extensively developed for residential, leisure and retail purposes. Initially, development was focused at Cowes on the more accessible gently sloping ground. As the demand and opportunities for development sites increased, developed spread further west towards Gurnard. Other sites have been redeveloped with multi-storey flats or detached homes. The spread of development has, in places, occurred on steeper ground of marginal stability. This has led to an apparent increase in the number of reported problems of ground instability. The problems have been heightened in recent years as a result of several slope failures caused by construction activities.

2.2 *Approach*

The conflict between development and unstable land is not unique to the area. A review of landsliding in Great Britain (Geomorphological Services Ltd., 1986-1987) identified around 8,800 recorded landslides, many of which are located on the coast, including the north coast of the Isle of Wight[1]. Since 1984, central and local government has carried out extensive research to assess the significance and consequences of unstable land in Great Britain. Lee, Jones and Brunsden (2000) provide a summary of the research, from which several key conclusions were drawn:

- There is a legacy of ancient landslides formed during past climatic conditions, i.e. many problems of ground instability are related to inadvertent reactivation of pre-existing landslides or failed ground.

- Coastal cliff recession is an intermittent process, with periods of little or no erosion separated by rapid and occasionally dramatic landslides, which may remove large sections of cliff in a single event.

- The impact of human activity which can have a significant effect on cliff stability, both at the site and on adjacent slopes.

As part of this research, the Department of the Environment (now the Department of the Environment, Transport and the Regions), South Wight Borough Council and subsequently the Isle of Wight Council, commissioned a series of studies[2] to develop an approach for landslip potential assessment. The main objective of these studies was to identify, collect and test appropriate levels of earth science information in support of planning and development decisions on unstable land. This research provided the background to the preparation of planning policy guidance (PPG14; Department of the Environment 1990, 1996), and associated guidance for the investigation and management of landslides in Great Britain aimed at planners and developers (Clark, Lee and Moore 1996).

Central to the approach developed by these studies is the need to:

- Determine the nature and extent of unstable ground/landslide problems;

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[1] A landslide distribution map of Southern Britain was presented in the Ventnor report prepared for the former South Wight Borough Council (Moore, Lee and Clark 1995)

[2] Geomorphological Services Ltd (1986-1987); Halcrow, Sir William & Partners (1988); Lee and Moore (1991); Moore, Lee and Clark (1995)

- Understand the past behaviour of unstable areas;

- Formulate a range of management strategies to reduce the impact of future ground instability.

The landslip potential approach, which uses detailed desk study and field mapping techniques is appropriate for the Cowes to Gurnard study area, and has been applied according to the scope and programme specified by the brief.

The ground behaviour assessment and landslide models presented in this report are inferences made from the available information and field mapping. It is recognised that without detailed sub-surface ground investigations the landslide models should be regarded as provisional. The approach provides a framework for understanding general planning and development control principles. It also assists in identifying key uncertainties and areas where sub-surface investigation is most needed.

2.3 *Information Sources*

Various information sources have been utilised during this study, including technical reports, maps and image records (Table 1). Further details are presented in Appendix A.

Table 1: Summary of Information Sources

Information	**Date**	**Source**
Topographic maps, 1:2500 scale	1939 – 1973	Ordnance Survey
Image records including photographs, aerial photographs and postcards	1892 – 1936	County Records Office
Geological maps, memoirs and records	1856 – 2000	British Geological Survey
Coast Protection at Gurnard – Preliminary Study	2000	Posford Duvivier
Isle of Wight Coast Shoreline Management Plan, Volume 2: Management Strategy	1997	Halcrow
Report on sea wall between Egypt Point and Gurnard	1990	Posford Duvivier
Site investigation reports	1988 – 2000	Local Engineers

2.4 *Consultations*

In preparing this Report, the following were consulted:

Isle of Wight Council, Coastal Manager
Isle of Wight Council, Building Control
Isle of Wight Council, Planning Department
Isle of Wight Council, Highways Department
Isle of Wight County Records Office
British Geological Survey
Southern Water Services Limited
Southern Electric
British Telecom
Transco
Robert Cowan Associates Ltd
Tari Willis Associates
G J Banks (I.W.) Ltd

3 Development History

The history of Cowes and Gurnard is described by McInnes (1974) from which the following account is summarised.

Prior to the 16th century little is known of the history of Cowes except that it was a port where some shipbuilding was undertaken. By the 18th century the shipbuilding industry was well established and naval vessels were built along with other ocean craft. During the 19th century, Cowes became popular as a centre for bathing and sailing and the Royal Yacht Club was formed in 1817. As the Royal Yacht Club grew in importance, so did Cowes. Development of the waterfront was haphazard and little attention was paid to public health and sewerage at the time. Today, Cowes is the world's leading yachting centre and Cowes week is the culmination of the yachting calendar, attracting many seasonal visitors to the town.

Gurnard is located to the west of Cowes seafront and comprises mainly bungalows, chalets and holiday accommodation. The coastal slopes at Gurnard have attractive views of The Solent and the Hampshire mainland. The resort attracts seasonal visitors but the settlement largely comprises private homes.

3.1 *Housing and Infrastructure*

A more accurate picture of the age and extent of development within the study area can be traced from past editions of the Ordnance Survey maps (Appendix A). From an assessment of these, the development of housing and infrastructure within the study area may be divided into three main phases, shown in Figure 2. Phase 1 includes development prior to 1897 and is concentrated at Cowes in a narrow band adjacent to the coast and along Queens Road. Phase 2, from 1897 to 1939, comprises a large area of development at Gurnard and along Solent View Road. Phase 3, includes mainly post 1939 development, which was concentrated at Gurnard Heights and along Baring Road. Two large areas remain undeveloped, at Gurnard Cliff and above Prince's Esplanade.

3.2 *Coastal Protection*

Although a port has existed at Cowes since at least the 16th century there is little information on the history of the coastal defences. Those that are visible today date from the 1930's onwards and are described in the 'Isle of Wight Coast

Shoreline Management Plan, Volume 2: Management Strategy' (Halcrow, 1997). The study area is within three Shoreline Management Plan units, as follows:

- West of Gurnard to Egypt Point
  "Around Gurnard Bay up to Egypt Point there are a series of block, masonry and concrete walls which vary in age, dating from 1970 through to 1995. The differences in age reflect the varying condition of the walls. The oldest defences are two short sections of wall, which have crest heights of 2.2m and 2.5m, with a number of rock groynes, which have provided superficial protection and require regular reconstruction. The most recently completed scheme takes the form of a new concrete seawall, with toe piling around Egypt Point, of over 1km in length alongside the coast between Gurnard and just beyond Egypt Point. The shingle shore is typically eroding and at a low level. The Isle of Wight Council owns and maintains defences covering over 85% of this section of coast. The remainder are the responsibility of private owners."

- Egypt Point to Cowes Castle
  "The unit starts with a short section of new wall with toe piling. The remainder is mainly a concrete wall, which has either an apron or a ridged shingle beach in front. The defences have crest heights from 2.1m to 2.4m, and are generally in poor to bad state of repair. These defences are fronted by a highly stable shingle beach."

- Cowes Harbour
  "The defences on the west side of the River Medina are privately owned masonry walls with a substantial amount of steel and timber piling fronting extensive marina facilities and quays. The defences are generally in a poor to bad state of repair. The crest levels vary from 2.2m to 2.6m."

Plates 1 – 8 illustrate the various types, age and condition of the coastal defences within the study area.

4 Slope Stability Review

To assess the scale of ground movement related problems in the Cowes and Gurnard area, a slope stability review has been carried out comprising an assessment of the reported history of ground movement rates and events and their impacts on development.

4.1 *The History of Ground Movement*

The history of ground movement has been evaluated from the information sources available to this study (see Section 2.3). From these it may be concluded that there is very little quantitative information with respect to past ground movement within the study area. Appendix A provides details of a review of photographs and reports that make reference to previous landslip events and reported ground movement. In summary, these include:

- Gurnard Cliffs; mudslide activity apparent in 1892.
- Gurnard Cliffs; significant landslides occurred here in the mid 1930s and 1980s, the latter reportedly causing the loss of 14m of the seaward edge of private gardens.
- Gurnard Bay; slumping of the green is apparent on old photograph dated 1934.
- Between Egypt Point and Gurnard it was reported there was movement of the sea wall of about 3m due to landslip.

4.2 *The Impacts of Ground Movement*

Various sources of information have been used to assess the impacts of ground movement, as follows:

- Isle of Wight building control records.
- Isle of Wight planning records.
- Local knowledge: accounts of local residents, engineers and surveyors.
- Systematic survey of damage due to ground movement, carried out by Halcrow for this study.

The systematic survey of damage due to ground movement was carried out in accordance with the approach used in the Ventnor study (Moore, Lee and Clark 1995). The survey was restricted to observations of external damage to buildings, walls and roads that could be directly linked to ground movement (i.e. the convergence of ground cracks/settlement with structures showing visible signs of damage). The survey classified damage caused by ground movement on a five-fold severity scale from negligible to severe based on increased levels of damage and by inference, costs of repair (Table 2). Illustrations of the nature and severity of damage observed in the study area are presented in Appendix B.

Table 2: Damage Survey Classification

Damage Intensity	Description
Negligible	Hairline cracks to buildings, walls and roads with no appreciable lipping or separation.
Slight	Occasional cracks. Distortion, separation or relative settlement apparent. Small fragments of debris may occasionally fall onto roads and structures causing only light damage. Repair not urgent.
Moderate	Widespread cracks. Settlement may cause slight tilt to walls and fractures to structural members and service pipes.
Serious	Extensive cracking. Settlement may cause open cracks and considerable distortion to structures. Walls out of plumb and road surfaces may be affected by settlement. Parts of roads and structures may be covered with landslide debris from above, repairs urgent to safeguard the future use of buildings, walls and roads.
Severe	Extensive cracking. Settlement may cause rotation or slewing of the ground. Gross distortion to buildings, walls and roads. Repairs will require partial or complete rebuilding and may not be feasible. Severe movements leading to the abandonment of the site or area.

The advantage of the systematic damage survey is that it provides complete coverage of the study area. The building control, planning section and local records are generally biased to the more serious or obvious damage cases but nevertheless provide an important record that may be used for comparison. The latter records also provide additional detailed information on ground conditions and the nature of damage in some cases.

The systematic damage survey has been analysed to provide an indication of the scale of damage due to ground movement affecting pre- and post-1900 development. The results are summarised in Table 3. The occurrence of negligible and slight damage was found to be widespread throughout the study area. These records have been excluded from the analysis as they are considered to reflect damage associated with the settlement/subsidence of clay soils rather than landslip. Section 5.3 provides further background on the causes of slope instability.

Table 3: Damage Survey Results

Damage Records	**Damage Class**	**No. of Records**	**Developed Area (ha)**	**Damage Density (No./ha)**
All records				
Pre 1900 development	Moderate	21	22	0.95
	Serious	10		0.46
	Severe	5		0.23
Post 1900 development	Moderate	40	63	0.63
	Serious	25		0.4
	Severe	9		0.14
Damage Records	**Damage Class**	**No. of Records**	**Number of Buildings**	**Buildings Affected (%)**
Buildings only				
Pre 1900 development	Moderate	7	266	2.6
	Serious	1		0.4
	Severe	0		0
Post 1900 development	Moderate	11	375	2.9
	Serious	12		3.2
	Severe	0		0

The impacts of moderate and serious damage to buildings, walls and roads indicates slightly higher incidence for pre 1900 development, which might be expected given the greater age and density of development at Cowes. The impacts on buildings have been separately shown which indicates a higher incidence of moderate to serious damage to post 1900 development. This probably reflects variation in the design of post 1900 buildings, which tend to be less substantial than earlier 'Victorian' buildings, and the spread of development onto marginally stable slopes.

Figure 2 presents the distribution of damage throughout the study area, which shows marked concentrations of moderate to severe damage. These concentrations appear linked to landslide areas at Gurnard Cliff, the area above Prince's Esplanade and the Cliff Road area (see Section 5.2.2). Other damage appears more widespread although there are notable linear distributions of damage above and at the base of the coastal slopes.

Review of the Isle of Wight Council Building Control and Planning records indicates a number of areas where ground stability is known to be an issue. These are summarised in Table 4.

Table 4: Reported Areas where Ground Stability is an Issue

Location	Description
Solent View Road	Known stability problems. Some properties have been underpinned.
Stanhope Drive	Localised ground movement caused by slope oversteepening.
Castle Road	Hummocky ground possibly caused by superficial movement. There are constant groundwater seepages in this area.
Worsley Road	Cliff recession resulted in the road being diverted to the north-east towards Shore Road.
Battery Road	Landslips have affected private gardens at the crest of the coastal slopes.
Baring Road	Groundwater from the golf course near Egypt Hill has been a problem in the past. A number of properties have been underpinned along Baring Road.
Cliff Road	Recent problems of ground movement possibly caused by construction activities. There are numerous indications of ground movement. Deep-seated slip suspected. Properties have been underpinned in this area.
Queen's Road	Shrink and swell behaviour of clays caused by seasonal drainage is a problem.
Pinetree Close	New development encountered foundation and settlement problems soon after construction, possibly related to settlement of fill.
Prince's Esplanade	Area subject to heave and soil creep. New development has been designed with reinforced strip foundations to account for potential ground movement.
Trinity Church Lane	Area subject to past ground movement. New development was designed to account for potential ground movement.
Egypt Esplanade	Ground movement experienced in the area around the Gas Valve Compound. The sea wall has been affected.
Lammas Close	Settlement has occurred above the coastal slopes. Some properties have been underpinned.
Shore Path	Known instability problems. Some properties underpinned.
Woodvale	Some properties have had structural repairs and underpinning. The sea wall has been damaged and repaired on occasions.

5 Coastal Slope Development

5.1 *Geology*

Details of the geology of the study area have been obtained from a number of sources, as follows:

- British Geological Survey (BGS) County Series Maps (1:10,560 scale);
- BGS Old Series One Inch Maps (1:63,360 scale);
- BGS Memoir 'A short Account of the Geology of the Isle of Wight';
- Institute of Geological Sciences British Regional Geology, The Hampshire Basin and Adjoining Areas (Melville and Freshney 1982);
- BGS Borehole Records (8 No total);
- Bird (1997) The Shaping of the Isle of Wight;
- Site investigation records and accounts of local engineers and surveyors;
- Field Observations by this Study.

5.1.1 *Solid and Superficial Geology*

The geological formations of the study area comprise sedimentary rocks of Tertiary and more recent age (Table 5). They consist of deposits that were laid down on the seabed, in estuaries and on deltas, and in lakes and lagoons. They include clays, silts, sands, limestones and gravels. The various formations were originally deposited in more or less horizontal strata, but have since been tilted and folded, forming structures that were then dissected by erosion to produce the present landscape.

The solid strata to be found in the study area are summarised in Figures 3 and 4 along with their approximate thickness. They include the Osborne Member and Bembridge Formations, comprising Bembridge Limestone and Bembridge Marls, overlain by superficial Plateau Gravel.

Table 5 Geological Age of Study Area

Period		Age (years)	Epoch
Quaternary		10,000	Holocene (recent)
		2 M	Pleistocene
Tertiary	Eocene	5 M	Pliocene
		23 M	Miocene
		36 M	Oligocene
	Palaeocene		Eocene
		53 M	Palaeogene

Note: refer to Figure 3 for geological formations

The oldest stratum, the **Osborne Member**, is 22 to 23m thick in the north of the Isle of Wight. The unit consists of brackish and freshwater clays and marls, some highly coloured red and green, and discontinuous bands of concretionary limestone, shells and fish beds. The strata outcrop at the base of the coastal slopes, where they have been exposed by coastal erosion in places (Plate 9) and extend below sea level.

The **Bembridge Limestone** is about 5 to 8m thick, thinning to the west. They comprise massive beds of pale limestone with intercalated greenish clays. The limestones outcrop at the base of the coastal slopes, typically above sea level (Figure 4). They are jointed and may have been displaced by slope instability where they are encountered within 5m of the ground surface. The limestone, albeit thin, provides a relatively coherent stratum within otherwise incoherent clay strata.

The **Bembridge Marls** are about 20 to 37m thick. At their base there is a 3m thick bed of sand packed with fossil oysters. This represents the second of two marine incursions, although more estuarine than marine in character. The succeeding Marls represent a regime of brackish lagoons and of floodplain lakes and marshes. The marls show various phases of deposition, following periods of river erosion, with deposits becoming finer-grained upwards. The clays are mottled grey-green and contain abundant shell fragments.

The youngest deposits, superficial **Plateau Gravel**, are found on the higher ground above the coastal slopes. The gravels comprise sub-angular and well-rounded flint and chert gravel in an orange earthy matrix. The deposits were derived from past erosion of the Chalk and Upper Greensand strata that outcrop in the central and southern parts of the Island. The Plateau Gravel was formed under conditions of repeated freezing and thawing resulting in sludge or solifluction of the parent materials. Plateau Gravel is well exposed at the crest of the coastal slopes in the study area, and may be found in the debris of landslides that have developed.

Other superficial deposits in the area include alluvial deposits associated with stream valleys and colluvium or landslide debris associated with coastal landslides derived in recent geological time (i.e. Holocene).

5.1.2 *Structure*

The solid formations described above were disturbed during a major phase of folding that took place in Miocene times. The tectonic warping produced a gently undulating lowland on the younger Palaeocene and Eocene rocks of the northern part of the island, with a very steep (70°-90°) northwards dip of the Chalk and Greensand rocks of the Central Downs, as shown in Figure 4.

There is uncertainty regarding the dip of strata across the study area. Bird (1997) indicates a general dip of strata for the northern part of the Isle of Wight to the south. The BGS Old Series Map of the Cowes area indicates a southerly (landward) dip of strata up to 10° along Queen's Road. The available borehole data indicates extensive disturbance of strata (i.e. Bembridge Limestone), possibly due to coastal instability or cambering (down-warping) of strata, from which reliable estimates of bedding inclination is not possible. From the available data it is only possible to conclude there is likely to be a southern component of dip for *in situ* strata.

5.2 *Geomorphology*

Geomorphology is the study of landforms and the processes which shape them. An understanding of the relationships between landforms and geological formations is a fundamental aspect of such studies. It is necessary to realise that some landforms have been shaped gradually by weathering and erosion over many thousands of years, and may be regarded as relict landforms, a legacy of past climates and processes. Others have developed in more recent times, such as coastal landslides, as a result of contemporary erosion by the sea and extreme rainfall or storm conditions.

5.2.1 *Landform Development*

The development of the landforms of the 'Isle of Wight' from late Miocene to early Holocene (Table 5) was marked by rapid erosion and lowering of the uplifted (folded) landscape that was created by the major earth-movements in Miocene times (White 1921). At this time the Isle of Wight was connected to the mainland via the Purbeck ridge, to the west.

The predominant drainage of the 'Isle of Wight' to the north contributed to the catchment of a major river, known as the Solent River. The Solent River is believed to have been a continuation of the Dorset Frome, which followed an eastward course through Poole Harbour, Bournemouth Bay, the Solent and Spithead. The sea breached the former chalk ridge that once extended to Purbeck during the late Pleistocene (Bird 1997). Consequently, the contemporary coastal landforms of the northern coast of the Isle of Wight date back to this period, whilst those relict landforms that have remained largely unaffected by the recent incursion of the sea into the Solent, owe their existence as much to fluvial processes and valley slope development associated with the former Solent River.

Over the past 6,000 years, sea level has remained relatively stable (Bird 1997). The drowned valley mouths, such as the Medina Estuary and Gurnard Marsh, have been partially infilled with Holocene sediment brought down by the rivers and washed in from the sea to form valley terraces, intertidal mudflats and salt marshes.

It seems therefore, that the coastal slopes within the study area would have largely formed during the early part of the Holocene as a result of the post ice age rapid rise in sea-levels, erosion of the soft rock cliffs by the sea promoting cliff failures and coastal landsliding.

Although now subject to wave attack, the cliff line is characterised by low-angled clay slopes that, in places, appear to be relatively close to their ultimate angle of stability. Experience elsewhere (e.g. on naturally abandoned cliffs of London Clay in Essex and Kent; Hutchinson, 1967; Hutchinson and Gostelow 1976) suggests that such slopes would have experienced "free degradation" for many thousands of years, in the absence of basal erosion. A number of explanations of the development of the coastal landforms in the study area can be put forward, as follows:

- The cliff line was created during a period of slightly higher sea-level in the Holocene, and was abandoned by the relative sea-level fall;

- The cliff line was created during the Holocene but became protected at the toe by an extensive, wide sand/shingle beach, preventing further basal erosion and, hence, allowing the "free degradation" process to proceed;

- The cliff line was created by river erosion during the Holocene;

- The cliff line was created during a period of higher sea level in a previous interglacial period and was abandoned by the sea-level fall.

5.2.2 *Geomorphology Map*

A geomorphological map of the study area has been produced (Drawing A), which summarises the surface morphology (shape) of the coastal slopes and surrounding features. The map shows the relative positions of the main geomorphological units that occur in the area, and identifies the nature and extent of individual landslide units.

It is noted that it is not possible to confidently model landslide mechanisms throughout the study area without extensive sub-surface investigation. However, the spatial pattern of surface features, such as broad benches, steep slopes and cliffs, give vital clues about the extent and behaviour of landslides and their mechanisms of failure. In this way, the geomorphology map identifies a number of different landslide forms and their inter-relationships.

The geomorphological map is the product of extensive field mapping[3] supported by an interpretation of aerial photography and available geological information of the area. The following main features are identified on the Geomorphology Map and described below:

- Plateau
- Estuary Slopes of the Medina
- Valley-side slopes
- Degraded Coastal Slopes

[3] Geomorphological field mapping comprised a detailed tape and clinometer (slope angle) survey of accessible areas, including private land where permission was granted.

- Coastal Mudslides
- Deep-Seated Coastal Landslides

The **Plateau** forms the higher ground above the estuary and coastal slopes, varying in elevation above 20m and 35m above Ordnance Datum, respectively. Immediately above the estuary and coastal slopes the Plateau is gently sloping (up to 7°) towards the coast. Further inland, the Plateau is flatter with slope gradients of 1 or 2°. Streams such as Gurnard Luck and the stream by Gurnard Green, have dissected the Plateau in places. The Plateau is characterised by a cover of free-draining Plateau Gravel (see Section 5.1.1), which collects surface water over a wide catchment area. Groundwater seepages from the Plateau Gravel at the crest of the estuary and coastal slopes are common.

The **Estuary Slopes** of the Medina extend from Market Hill to the Royal Yacht Squadron, Cowes. They are around 20m in height and extend from the Esplanade sea wall to Castle Road above. The Estuary Slopes have been extensively developed in the past for residential and retail purposes, and associated access roads and services. The natural form of the slopes has been largely altered or obscured by development which has typically involved construction of cut and fill platforms. The majority of cuttings are supported by retaining walls of various age and construction. At the base of the estuary slopes, there is a noticeable platform or terrace that is used as the Parade car park. Although this terrace is made-ground it is considered that the feature represents an area of possible reclaimed salt marsh.

The **Valley-Side Slopes** are associated with past and present incision of two north-flowing streams, one of which drains through the developed area of Gurnard, with an outlet by Gurnard Green, and the other being Gurnard Luck, which flows into Gurnard Marsh. The valley slopes are cut into the Plateau Gravel and underlying Bembridge Marls and have characteristic upper and lower valley slope forms. The upper valley slopes are subdued, gently sloping (up to 7°) and probably represent relict valley slopes when stream levels were much higher than today.

The lower valley slopes are steeper (up to 20°) and associated with contemporary incision/erosion by the streams. The lower valley slopes are locally unstable due to the steepness of the slopes cut in weak Bembridge Marls coupled with high groundwater levels.

The **Degraded Coastal Slopes** form the most northerly coastal slopes of the Isle of Wight, extending from the Royal Yacht Squadron, Cowes, to beyond Egypt Point. They extend from the Esplanade upslope in a series of shallow benches and scarp slopes to a height of 35m above Ordnance Datum. The slopes are formed of Bembridge Marl with Bembridge Limestone outcropping at the base of the slopes with Osborne Marls beneath. The coastal slopes are protected at their base by a sea wall. They are characteristically subdued with the benches gently inclined at gradients of 2-12° with intervening scarp slopes typically less than 20°. There are features of slope instability in localised areas, comprising heave, tension cracks and lobate features consistent with shallow translational mudslide phenomena[4]. Available borehole records in the area indicate peat deposits/buried palaeosols about 5m below ground level, which provides evidence of burial of vegetation and soils possibly by mudslides. Given the degraded, subdued nature of these coastal slopes, it seems unlikely they were formed by coastal erosion prior to the construction of coastal defences. It is possible therefore, that the degraded coastal slopes are relict valley-side slopes of the former Solent River (refer to Section 5.2.1). They are marginally stable and sensitive to reactivation caused by changes to the slope geometry and hydrogeology, either artificially by man or through natural processes such as erosion and extreme rainfall events.

Coastal Mudslides have been observed and mapped in mostly undeveloped areas above Egypt Esplanade and on Gurnard Cliff. They are contemporary landforms influenced by current coastal erosion and groundwater conditions. They are developed within the Bembridge Marls and are characterised by scarp slopes up to 20°, and shallow benches typically less than 10°. The mudslides appear generally shallow (i.e. < 5m deep) and both lobate and elongate forms are apparent. The coastal mudslides are probably seasonally active in response to high groundwater levels during the winter. There is much evidence of widespread seepage, ponding and surface drainage in these areas.

Deep-Seated Coastal Landslides have been identified at three main locations within the study area. These include Gurnard Cliff, Prince's Esplanade and Cliff

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[4] Mudslides are a form of mass movement in which masses of softened argillaceous, silty or very fine sandy debris advance chiefly by sliding on discrete boundary shear surfaces in relatively slow moving, lobate and elongate forms.

Road. The Cliff Road and Prince's Esplanade landslides are protected by sea walls. The Gurnard Cliff Landslide is partly protected by a sea wall west of Gurnard Sailing Club (Plate 6). The Prince's Esplanade and Gurnard Cliff landslides have former rubbish tips located beneath their rear scarps. The tips were used from Victorian times until the 1970s, with rubbish being end-tipped onto the landslides over the rear scarp or coastal cliff edge.

The deep-seated coastal landslides are contemporary landforms influenced by current coastal erosion and groundwater conditions. They are developed in the Bembridge Marls, Bembridge Limestone and underlying Osborne Marls, with depths of failure possibly up to 20m below surface, extending below sea level. The landslides comprise linear benches with gradients typically less than 5°, separated by scarp slopes with gradients of 15-25°; the benches are locally tilted backwards with ponding and soft ground accumulated to the rear and sides of the benches, a characteristic of deep-seated rotational and translational landslides. The landslides are probably subject to imperceptible creep, although the cumulative displacement over time can be significant (i.e. 3m displacement of the sea wall has previously been reported). Such movement causes progressive settlement and shearing of the ground, resulting in cracking, ground heave and associated damage (see Section 6).

5.3 *The Causes of Slope Instability*

It is evident from the geology and geomorphology of the Cowes to Gurnard area that ground movement related problems are related to two key factors, namely:

- The presence of weak clay subsoil;
- The presence of relict landslides.

Ground movement and landslides occur when the force of gravity exceeds the strength of the slope materials[5]. In these circumstances, the displacement of slope materials occurs to restore the balance between the destabilising forces and the resisting forces (i.e. the shear strength of soils) along the surface of rupture (shear surface). Therefore, a landslide may be regarded as a process that changes a slope from an unstable to a more stable state. In cases where pre-formed shear surfaces

[5] The shear strength of the Bembridge Marls and Osborne Marls is low. Borehole records in the area indicate many slickensided (sheared) surfaces within these units and residual strength parameters as low as $c'_r = 0$ and $\phi'_r = 7°$

exist (as for relict landslides), ground movement will be greatest along such surfaces. For clay slopes unaffected by landslip, ground movement may occur as surface creep, settlement, subsidence and ground heave. Such features of instability are common on clay soils subject to shrink and swell behaviour through seasonal wetting and drying of the soils and the effects of tree roots.

A distinction needs to be made between subsidence (i.e. vertical movement) of clay soils, which is a wider problem in Britain, and settlement (i.e. horizontal and vertical movement) of slopes. This study is restricted to consideration of slope instability caused by landslides and the settlement of clay slopes.

The causes of slope instability have been well documented by others (i.e. Jones and Lee 1994; Moore, Lee and Clark 1995). Such studies separate the causes of slope instability into two categories, namely:

- **Preparatory factors** which work to make the slope increasingly susceptible to failure without actually initiating it;

- **Triggering factors** which initiate movement.

When considering the actual cause of landsliding this relative simplicity gives way to complexity, as there is a great diversity of causal factors. In broad terms, however, they may be divided into **internal causes** that lead to a reduction in shear strength and **external causes** which lead to an increase in shear resistance (Table 6). The more important of these factors that have had a significant influence on the historical and recent development of coastal slope instability at Cowes have been:

- The removal of lateral and underlying support and oversteepening of slopes by fluvial and coastal processes;

- The inherent low shear strength of the clay soils;

- High groundwater levels and pore water pressures arising from extreme rainfall events;

- The influence of development and construction, including formation of cut and fill platforms, disturbance of natural drainage, and surcharging of groundwater levels;

- The long-term trend for rising sea levels and increased rainfall caused by global warming.

Table 6 Causes of Slope Instability

Internal Causes	External Causes
Materials: • Soils subject to strength loss on contact with water or as a result of stress relief (strain softening) • Cohesive soils which are subject to strength loss or gain due to weathering • Soils with discontinuities characterised by low shear strength such as bedding planes, faults, joints etc.,	**Removal of lateral support:** • Undercutting by water (waves and stream incision) • Washing out of soil (groundwater) • Man-made cuts and excavations
Weathering: • Physical and chemical weathering of soils causing loss of strength (cohesion or friction)	**Increased loading:** • Natural accumulations of water, snow, talus • Man-made pressures (e.g. fill, tips, buildings)
Pore-water pressure: • High pore-water pressures causing a reduction in shear strength. Such effects are most severe during wet periods or intense rainstorms.	**Transient Effects:** • Earthquakes • Traffic vibrations

6 Ground Behaviour Assessment

6.1 *Introduction*

Ground behaviour assessment, as the term suggests, is a method used to define landslide hazard potential based on an understanding of the ground behaviour conditions and the impacts of past ground movement. The method was developed for the landslip potential study at Ventnor (Lee and Moore 1991 and Moore, Lee and Clark 1995) and has been successfully applied elsewhere (Moore, Clark and Lee 1995 and Rendel Geotechnics 1997). The method is appropriate for the Cowes to Gurnard study area where the ground conditions and impacts of ground movement are variable across the site.

The ground behaviour assessment is based on the following information:

- The stability review (Section 4), which summarises past records of ground movement and the damage survey carried out as part of this study;
- An understanding of coastal slope development (Section 5), which includes the geology and structure of the study area, the geomorphological map prepared for this study, and consideration of the causes of ground movement.

The geomorphological assessment of the inter-relationships between the relict landslide features and the nature of contemporary ground movement provides a framework for understanding the ground behaviour of the coastal slopes, which is presented on the Ground Behaviour Map (Drawing B).

The remainder of this section presents the results of the ground behaviour assessment, which includes consideration of the types of ground movements that can be expected, and an explanation of the Ground Behaviour Map and Cliff Behaviour Models (Figure 5).

6.2 *Types of Contemporary Ground Movement*

The nature of ground movements in the Cowes to Gurnard area can be divided into two distinct groups, namely:

- Sub-surface movements associated with the progressive creep of deep-seated landslides;

- Surface or superficial slope movements arising from the erosion or failure of steep slopes, the differential movement and settlement of clay slopes, and compression or ground heave.

The impact of sub-surface movements is restricted to the areas of deep-seated landslides identified on the Geomorphological Map (Drawing A) at Gurnard Cliff, above Prince's Esplanade and above Queen's Road. Little is known about the rates of subsurface movement, although the sea wall at Gurnard is reported to have been bodily displaced by up to 3m in the past (the time period of this report is unknown). Evidence of crack damage to buildings, walls and roads indicates that annual rates of movement in these areas of up to 10mm can be expected. With reference to Table 4, sub-surface creep of deep-seated landslides may partly explain areas of known instability at Woodvale and Cliff Road.

Throughout the study area, contemporary problems arising from ground movement tend to result almost entirely from superficial movements. The nature of these is summarised in Table 7. The nature and significance of superficial ground movements varies across the study area, with different coastal slopes and landslide systems characterised by different problems. The relative risks in the area can be determined by comparing the types of ground movement hazard with the pattern of existing development and services.

The pattern of damage to buildings, walls and roads within the Cowes to Gurnard area is related to the various forms of ground movement. There appears to be a strong relationship between the types of ground movement that can be expected in different geomorphological units across the study area. Each geomorphological unit or landslide feature has its own characteristic range of stress conditions which will affect buildings, walls and roads, producing a characteristic type and distribution of damage.

For example, the concentration of severe damage at Gurnard Cliff has resulted from coastal mudslides, comprising undermining and recession of the cliff top, active settlement of the cliffs and translational movement of debris to the foreshore. Outward displacement and heave of mudslide lobes at the base of the coastal cliffs has promoted the destruction of coastal defences along this section.

The nature of ground movement in the area above Prince's Esplanade and Egypt Esplanade is somewhat different, and comprises differential settlement of deep-seated landslide blocks. This has caused widespread damage to development due to differential shear and crack damage, tilt of structures and ground heave at the toe of the slope, the latter possibly exacerbated by the passive restraint of the existing sea wall. Similar ground movement related problems are apparent in the area around Cliff Road.

Table 7 Types of Superficial Ground Movement

Type	Description
1	**Coastal Mudslides** (lobate and elongate forms): seasonally active in response to winter rainfall. Ground movement may comprise differential settlement along head-scarps and side-scarps and translational ground movement. Outward displacement and heave may occur at the toe due to accumulation of mudslide debris lobes. Ground movements of several metres or more can occur in one season.
2	**Sea Cliffs**: low sea cliffs formed in weak rocks subject to falls, slides and erosion due to active undercutting by waves and slope degradation/ weathering processes. Cliff falls are rapid and may occur without warning. Fresh scars and cliff fall debris may be observed after events.
3	**Deep-seated Landslides**: active differential settlement of landslide blocks due to deep-seated rotational and translational movements. Ground movements are imperceptible and progressive comprising shear, tension, torsion, compression and heave. Ground heave may be exacerbated due to passive support of structures at the toe of the landslides, such as sea walls. Annual rates of movement of several cm can be expected.
4	**Degraded coastal slopes**: relict marginally stable slopes with little apparent evidence of contemporary ground movement. The soft clay slopes have been over-steepened by fluvial/marine processes and will have been subject to slope instability in the past. The slopes are subject to periodic localised creep and small landslides, particularly associated with poor drainage.
5	**Cliff Top Settlement and Recession**: tension cracks and scarps developed above steep coastal slopes and cliffs due to progressive failure of the rear-scarp. Occasional landslips at the crest of the coastal slopes may lead to recession of the cliff top by up to 10m or more in a single event. Imperceptible and progressive settlement of the cliff top is an indicator of possible impending landslip and recession potential.
6	**Valley-slope Instability**: creep of gently sloping valley-sides formed in soft clays leading to imperceptible and progressive settlement and heave in places. Occasional localised shallow mudslides may develop on steep slopes associated with high groundwater levels and toe erosion.
7	**Soft Ground**: level soft ground areas subject to imperceptible and progressive shrink/swell behaviour associated with saturated soils.

Other types of ground movement appear related to the settlement and recession of steep scarp slopes and in particular cliff top areas above the coastal landslides and estuary slopes. The problems encountered along Worsley Road, Battery Road, Pinetree Close, Lammas Close and Castle Road (see Table 4) can mostly be explained as a result of the imperceptible and progressive settlement of the cliff top. Periodic slips of the scarp crests have been recorded, resulting in recession of 14m in a single event. Tension cracks and differential settlement above the cliff top are apparent in some locations. Also, drainage of groundwater from the Plateau Gravel has possibly exacerbated settlement rates as a result of seepage erosion (loss of fine soils) from within the Gravels close to the cliff edge, particularly along Castle Road and the stream head embayment near Egypt Hill (see Drawing A).

The degraded coastal slopes at Egypt Hill, Stanhope Drive, Queen's Road and Trinity Church Lane, are reported to have ground movement related problems and these appear mostly related to periodic localised instability of scarp slopes and ground heave towards the toe of the coastal slope.

As Table 7 indicates, ground movement can also be expected on the valley-side slopes associated with two streams at Gurnard Green and Gurnard Luck. These slopes are subject to superficial settlement and creep, and in localised places shallow mudslides have developed resulting in tension and settlement at the crest and ground heave at the toe of the mudslide. Ground movement problems such as these have been encountered along Solent View Road and along the valley-side slopes in Gurnard.

It is noteworthy that some damage has been recorded in areas away from the coastal and valley slopes, such as along Baring Road. Such problems do not appear related to slope instability and are probably related to ground subsidence caused by shrink and swell behaviour of the clay soils and overlying Plateau Gravel.

6.3 *Ground Behaviour Map*

The approach used in the production of the ground behaviour map (Drawing B) involved the assessment of landslide activity within contrasting geomorphological units. The map identifies four distinct cliff behaviour units or coastal landslides. The contemporary processes and impacts of ground movement in these areas can be expected to be somewhat different, as explained in the legend.

Other ground behaviour units are also identified, which include the valley-side slopes, estuary slopes and plateau. Although these areas are not characterised by large-scale landslides, ground movements can be expected as explained in the legend. A cliff-top settlement zone has been defined to account for the potential settlement and recession of the cliff-top. The landward boundary is arbitrarily defined in places, 50m parallel the cliff edge, in the absence of an obvious geomorphological boundary.

The map demonstrates that the potential problems vary from place to place according to the geomorphological setting, and this has been used as the basis for the Planning Guidance Map (see Section 7).

6.4 *Cliff Behaviour Models*

The four cliff behaviour models shown on Drawing B are reproduced in Figure 5. The models are based on the geomorphology map (Drawing A) and the limited geological and geotechnical information available to this study for key sections through each coastal landslide. They provide general indications of landslide geometry, sub-surface geology and the likely mode and mechanisms of failure. It is noted that in the absence of detailed sub-surface ground investigation the cliff behaviour models should be regarded as preliminary. Key points to note for each section are as follows:

- **Model A: Prince's Green**, characterised by relict degraded shallow landslides (mudslides) within the Bembridge Marls. The slopes are highly degraded with gently sloping benches less than 12° and scarp slopes less than 25°. The scarp and bench morphology indicates strong lithological control on the mechanism of landsliding. The slopes appear reasonably well drained except in localised areas. Borehole evidence indicates that the Bembridge Limestone is at or slightly lower than sea level. The *in situ* dip of strata is to the south, which is not favourable for deep-seated bedding failures. Therefore, the mechanism of failure is most likely translational comprising mudsliding. Several zones of failure may be identified. The depth of landslide deposits in Zone I can be expected to be about 5m, given that there is evidence of buried organic material and peat deposits revealed by several boreholes. The depth of landslide deposits in Zone II can be expected to be slightly deeper with a basal shear surface within the Bembridge Marls.

- **Model B: Cliff Road**, characterised by an active deep-seated landslide developed at two levels within Bembridge Marls. Slope gradients are similar to Model A, although recent ground movements on the upper slopes have resulted in local steepening and a characteristic sharp slope morphology. Drainage in the area is poor with much evidence of ground water seepages from the upper slopes and Plateau area. The *in situ* dip of strata is to the south with the Bembridge Limestone outcropping at or slightly below sea level. The mechanism of failure is predominantly translational although localised rotational failure is possible. The depth of landslide deposits is uncertain but can be expected to be up to 10m in places. The depth of failure in Zone I possibly coincides with the outcrop of the Bembridge Limestone. Given the apparent southerly dip of *in situ* strata, the bedding probably does not facilitate the occurrence of deep-seated failure, although cambering or down warping of strata to the north (as a result of valley-bulging or unloading of coastal slopes) may have contributed to instability along this coastal section.

- **Model C: Prince's Esplanade,** characterised by active deep-seated landsliding developed within Bembridge Marls. The markedly linear landslide benches have consistent gradients of about 5° seaward, with the rear scarp up to 23°. Drainage is generally poor with large areas of ponding and soft ground to the rear of the landslide benches. The *in situ* dip of strata is to the south with the Bembridge Limestone outcropping at or slightly below sea level. The geomorphology and available borehole data indicates failure at a consistent depth, coincident with the Bembridge Limestone. The depth of failure can be expected to be up to 15m in places. Given the apparent southerly dip of *in situ* strata, the bedding probably does not facilitate the occurrence of deep-seated failure, although cambering or down warping of strata to the north (as a result of valley-bulging or unloading of coastal slopes) may have contributed to instability along this coastal section.

- **Model D: Gurnard Cliff**, characterised by active deep-seated landslide developed within Bembridge and Osborne Marls. The landslide bench has a gradient of about 4° seaward and a rear scarp up to 27°. Drainage is poor with a large area of ponding, soft ground and stream flow to the rear of the landslide bench. The *in situ* dip of strata is to the south with the Bembridge Limestone outcropping at or slightly below sea level. In comparison with Model C, there is a narrow upper tier (Zone II) of predominantly shallow rotational slides with a lower degraded translation landslide (Zone I) up to 15-20m deep, with a basal shear surface probably within the Osborne Marls. Given the apparent southerly dip of *in situ* strata, the bedding probably does not facilitate the occurrence of deep-seated failure, although cambering or down warping of strata to the north (as a result of valley-bulging or unloading of coastal slopes) may have contributed to instability along this coastal section.

7 Planning Guidance

7.1 *Introduction*

One of the objectives of this study is to develop an appropriate planning response to the land instability problems within the area. The assessment of ground behaviour indicates that existing property in unstable areas will probably continue to experience damage due to ground movement. The Planning Guidance Map (Drawing C) is based on the assessment of ground behaviour and the variability in stability conditions across the study area. Guidance is provided on development plan policy and the control of development in areas subject to land instability. The map categorises the area according to the degree of impact which slope stability considerations might have on development proposals. Five categories have been distinguished, as follows:

- Area suitable for development
- Area likely to be suitable for development
- Area likely to be suitable for development with appropriate mitigation and stabilisation measures
- Area unlikely to be suitable for development
- Area unsuitable for development

In actively unstable areas, ground movement will affect new development; such areas should be avoided. Less unstable areas may be successfully developed, provided that the developer carries out appropriate mitigation and stabilisation measures. In areas subject to land instability, developers and homeowners must accept a higher level of commercial risk than would be expected in normal circumstances (provided that the risk is not associated with a significant safety risk). It is important in such cases, that prospective purchasers are made aware of the potential risks, along with their legal responsibilities with regard to safeguarding their property and neighbouring land from instability

These broad conclusions provide the framework for the development of planning procedures for the area that take account of the information now available on land instability problems. The overall objective of the guidance that follows is based on 'Planning Policy Guidance: Development on Unstable Land' (PPG14)[6], which is:

- *to ensure that development is suitable and that the possible physical constraints on the use of land are properly accounted for at all stages of planning. Although in some cases the appropriate response might be to prevent the development of land that is unsuitable, the principal objective of the guidance is to encourage the full and effective use of land in an acceptable and appropriate manner.*

The planning guidance takes account of similar studies undertaken in the Isle of Wight Undercliff (Lee and Moore, 1991; Moore, Lee and Clark 1995) and elsewhere in Great Britain (Halcrow 1988; Clark, Lee and Moore 1996; Thompson *et al.* 1996).

7.2 *Development Plan Policies*

Policy G7 'Development on Unstable Land' included in the Unitary Development Plan applies to the Cowes to Gurnard coastal frontage. The policy states:

"Development of areas of known or possible land instability will only be permitted where the Council is satisfied that the site can be developed and used safely and not add to the instability of the site or adjoining land and the stabilisation measures are environmentally acceptable. Planning applications for development should be accompanied by a suitably qualified engineer's report detailing how the development is to be carried out and what mitigating measures are to be used."

With regard to the instability problems in the Cowes-Gurnard area, development proposals in areas susceptible to land instability will be subject to the development control procedures shown on the Planning Guidance Map (Drawing C). The Planning Guidance Map identifies areas where particular development controls will apply. The planning guidance map and accompanying advice should be taken into account in all applications for development.

Applications for developments which have no material effect on stability (e.g. minor developments and applications involving change of use only) will not normally be subject to these procedures, unless the change of use significantly worsens the consequences of any instability.

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[6] Department of the Environment (1990, 1996)

7.3 *Development Plan: Allocation of Land*

When setting out proposals for the development and use of land, and allocating land for specific purposes, the local planning authority should use the information presented in this Report as the basis for establishing whether, in general terms, potential sites can be safely developed. Issues that should be considered include:

- the level of risk at the site, taking particular account of the consequences of any instability;
- the coastal protection needs associated with particular land uses or types of development;
- the nature and scale of any stabilisation measures that would be acceptable at the site.

7.4 *Development Control*

The local planning authority should take land instability into account when dealing with all planning applications within the area. The results of this study should provide background information to assist making planning decisions, although specialist advice may be needed in certain circumstances.

The recommended procedures are set out below, and summarised in Figure 6.

1. *Pre-application Stage;* the procedures for dealing with land instability problems need to be widely publicised to inform potential developers of the necessary requirements before they make a planning submission. This might involve:
    - Publication of clear policies and explanatory text within the development plan;
    - Publication of a Supplementary Planning Guidance note on land instability issues;
    - Pre-application discussions between planning control officers, building control surveyors and potential developers;
    - Provision of a guidance note for applicants with the planning application form;
    - Inclusion of specific questions on the planning application form to alert applicants to the land instability issues.

2. *On Receipt of Application;* the Planning Department should decide whether or not land instability is a matter for consideration. This will depend on:

- The nature and scale of the proposed development;
- Its location with respect to the zones shown on the Planning Guidance Map.

Developments that might be considered sufficiently minor in scale and character to be exempt from these procedures are listed in Table 8.

Table 8 Possible Exemptions from the Instability Development Control Procedures

Suggested exemptions include:
• All developments in areas where ground stability does not impose a constraint on development • Developments limited to changes of use, or external appearance etc. provided that the change of use does not significantly worsen the consequences of any instability • Single storey small extensions and minor structures (e.g. signs, fences, etc.), which satisfy the following criteria: – there is no material change to the ground loadings either by excavation or filling – groundwater flows are not affected – surface run-off is not restricted and is discharged by means which do not degrade stability – existing retaining walls are not removed

3. *Development Control Requirements;* the applicant should be informed by letter of the development control requirements and a copy of this letter should be sent to Building Control.

   For developments which require planning permission, but which are exempt from these requirements, an advisory note should be issued, drawing the applicant's attention to the possible risk of land instability and consequent liabilities, and also the requirements that are likely to be imposed by Building Control.

   In all other cases it is recommended that the applicant should be required to submit a Stability Report prepared by a Competent Person (see Section 7.5).

   The responsibility for the stability and safe development of the site rests with the developer (and his/her specialist advisors), and it is recommended that a

Stability Declaration Form (see Appendix C) accompanies the Stability Report, to be completed by the author(s) of the Stability Report.

In order to avoid putting applicants to unnecessary expense (especially in those situations where factors other than potential land instability may lead to a refusal of planning consent), applicants need not be required to fulfil all of the development control requirements prior to submitting their application. Pre-application discussions between the developer and planning department will assist in identifying specific requirements for proposals at an early stage, and should be encouraged.

4. *Determination Process*; a number of options are available:

- *Applications submitted without a Stability Report*; it is normal practice to first consider whether the proposal meets other planning criteria. If not and the application is likely to be refused on other grounds, it would not be necessary to request a Stability Report.

  Where the proposal is not refused on other grounds, and is not exempt from the instability development control procedures, it will be necessary to recommend that a Stability Report must be provided before it can be determined.

- *Application submitted with a Stability Report*; the planning officer, in consultation with the Building Control Section and Coastal Manager, should view the Stability Report. The intention of this is to determine whether the Report meets the Council's requirements with regard to the assessment of instability issues (see Section 7.5) and the type of development involved. The report should specifically address the potential for instability at the site and on adjacent land that could affect, or be caused by, the development proposals during the lifetime of the scheme.

  The Council is under no obligation to comment on the Stability Report, but has a duty to ensure that a high standard of investigation and reporting is achieved and that the views of the Competent Person are adequately covered by Professional Indemnity insurance. This would be achieved primarily by reference to the Stability Declaration Form included within the report.

If the information in the Stability Report is either incomplete or insufficient in detail to aid determination, the planning officer should, in the first instance, refer it back to the applicant.

In some circumstances, such as the consideration of large-scale development proposals or high-risk sites, the planning officer may need to seek independent verification of the Stability Report. Appropriate specialists should do this.

If there is no response or an inadequate response to the request for additional information, the planning officer should recommend a refusal of planning permission on the grounds of insufficient information.

If the Stability Report and any subsequent reviews conclude that the development can proceed with or without appropriate mitigation and stabilisation measures then the planning officer may approve the application.

- *Post Determination*; copies of the Stability Report, design drawings and conditions should be forwarded to Building Control.

  The responsibility for safe development rests with the developer and their advisors, including the Competent Person. The developer should provide the Council with written assurance that full account has been taken of the stability report, design drawings and the terms of the planning permission. Any subsequent modifications to the designs or construction detail should be submitted to the Council prior to implementation.

7.5 ***Stability Reports***

Stability reports should be prepared by a Competent Person who should be able to demonstrate relevant specialist experience in the assessment and evaluation of slope stability (Halcrow, 1988). A Competent Person would normally be expected to be either a Chartered Engineer or Chartered Geologist with an appropriate length of experience in assessing the stability of natural slopes.

The local planning authority should maintain a list of persons and organisations that are considered capable of providing adequate reports. This list could then be made available to prospective developers wishing to engage a specialist. The developer should be advised of the advantage of obtaining such reports from persons or organisations that possess and maintain adequate professional indemnity insurance. This provision will promote a degree of commercial responsibility for the opinions expressed and will help to safeguard both the developer's and local planning authority's interests in the event of the development being damaged subsequently.

Before making a stability report, the Competent Person should undertake such inspections and investigations as are considered necessary to allow an opinion to be made on the stability of the proposed development site and its surrounding area. In order to satisfy the local planning authority the stability report should demonstrate:

- an adequate appreciation of ground and groundwater conditions and any other relevant factors influencing slope stability, based on desk studies, site reconnaissance and appropriate subsurface investigation, laboratory testing and monitoring;

- that the site is stable and has an adequate margin of stability or can be made so as part of the development works, for the foreseeable conditions which will operate at the site;

- that the site is not likely to be affected by reasonably foreseeable slope instability originating outside the site boundaries;

- that the development is not likely to result in slope instability or erosion of adjacent property.

In preparing the stability report, the Competent Person should consider all factors that might influence the stability of the site and surrounding area in relation to its suitability for the proposed development. The report should therefore contain:

- a factual record of the sources of information and investigations carried out;

- a description and engineering interpretation of the relevant ground and groundwater conditions;

- an account of any stability calculations; the geotechnical design parameters used should be clearly stated and justified

- conclusions on the stability of the site and the influence of the proposed development;

- recommendations for slope stabilisation measures, site inspections and monitoring.

Two levels of Stability Report are envisaged, reflecting the variations in severity of instability problems across the area:

Outline Stability Report, based on

- a desk study involving a review of available information relating to instability problems in and around the proposed development site and

- an inspection of the site and surrounding area to assess the geomorphological context of the proposed development and to identify any recent ground cracking or structural damage to property.

If appropriate, the Outline Stability Report may recommend that a Full Stability Report is undertaken.

Full Stability Report, covering

- the requirements of the Outline Stability Report (unless that has been separately undertaken)

- reports on such subsurface investigation (e.g. trial pitting, boreholes and groundwater monitoring) as are appropriate given the scale of the proposed development and the potential impact of any slope instability.

In order to ensure a comprehensive report, which can be readily assessed by the local planning authority, the report should follow a standard format where possible A proposed structure and contents for a Stability Report is given in Appendix C.

8 Management of Coastal Slope Instability

The role of human activity in initiating or reactivating many slope problems should not be underestimated. As experience in Ventnor has shown (e.g. McInnes and Lee *In Press*), in such circumstances many problems can be reduced if there is a programme of active landslide management (Figure 7).

A similar management strategy for the coastal slopes between Cowes and Gurnard should be implemented. The main objectives of such a strategy are to reduce the likelihood of future movement by controlling the factors that cause ground movement, and to limit the impact of future movement through the adoption of appropriate planning and building controls. A variety of approaches could be adopted to address the ground movement problems:

1. Improving ground conditions, notably through:

    a) Engineering measures to stabilise part or parts of the coastal slopes using earthworks, drainage, structural solutions or combinations thereof.

    b) Coastal protection measures. Here it is worth drawing attention to the key role of the existing coast protection structures in maintaining the current stability conditions along the Cowes-Gurnard coastline. Indeed, sustainable development within those areas affected by historic landsliding is dependent upon maintaining the condition and performance of the defence structures. Should the defences fail, or the standard of protection decline, then renewed cliff foot erosion will inevitably lead to a decline in stability and accelerated ground movement problems. In order to fully address the link between coastal defence and stability, it is recommended that a Coastal Defence Strategy Plan (Strategic Implementation Plan) be developed to identify sustainable options for providing the necessary defence infrastructure over the next 50 years. In this context, consideration should be given to past landform development (see Section 5.2.1) which raise important implications for cliff management, as follows:

        - Until relatively recently the cliff line was a relict feature i.e. one that was not being actively shaped by basal erosion. The Victorian coast protection works may have been put in place to defend the seafront infrastructure rather than to address a cliff retreat problem;

- The pre-defence behaviour will not provide a good analogy for the future behaviour of the cliff line. If the defences were removed basal erosion will result in the re-initiation of instability on the previously abandoned cliff line.

2. Preventing water leakage and control of water into the ground;

3. Control of construction activities;

4. Preventing unsuitable development through planning control and building control;

5. Improving building standards, e.g. through the development of codes of practice.

6. Encouraging repairs and maintenance (i.e. homeowners guide to good practice);

7. Monitoring ground movement and weather conditions at automatic and manual recording stations;

8. Raising professional and public awareness through displays and meetings.

Further detailed discussion of the range of landslide investigation and management options may be found in the various technical and summary reports produced for the Ventnor Landslip Potential Studies (see Lee and Moore, 1991 and Moore, Lee and Clark 1995), and national guidance published by the Department of the Environment in respect of PPG14 (Clark, Lee and Moore, 1996)

9 Conclusions and Recommendations

This study has involved a thorough review of the available information with particular reference to ground conditions, the history of past ground movements and their impacts. The study carried out field surveys of the geomorphology and damage due to ground movement, which has enabled an assessment of the scale and magnitude of ground instability throughout the study area.

The ground behaviour assessment and landslide models presented in this report are inferences made from the available information and field mapping. It is recognised that without detailed sub-surface ground investigations the landslide models should be regarded as provisional. The approach provides a framework for understanding general planning and development control principles. It also assists in identifying key uncertainties and areas where sub-surface investigation is most needed.

The ground behaviour map provides the basis for preparing guidance for future planning policy and development control that takes account of the different ground conditions that can be expected. The requirements for stability reports in support of future development proposals, outlined in this report, also account for the different ground conditions and their uncertainties.

The study has identified four distinct cliff behaviour units or coastal landslides characterised by different failure mechanisms, scale and magnitude of various types of ground movement. Other ground behaviour units have been identified, and although these are unaffected by landslides, localised problems of settlement and subsidence of the weak clay subsoil has been recognised, particularly in association with poor drainage.

The broad conclusion of the study is that past incidents of ground movement and the contemporary distribution of serious and severe damage to buildings, walls and roads is mostly related to the four cliff behaviour units. Ongoing ground movements in these areas can be expected to cause similar occurrences and distribution of damage in the future. It is notable that the damage survey identified a higher incidence of serious damage to post-1900 buildings. In order to safeguard existing and new development in these areas appropriate detailed investigations should be carried out for the purpose of identifying measures to mitigate potential ground movement related problems.

In some areas, such as Gurnard Cliff, development would be inappropriate due to land instability constraints, among other factors. In other areas, new development and redevelopment of sites may be feasible provided the advice presented in this report is taken into account and appropriate investigations and precautionary measures are implemented.

Specific recommendations arising from this study include:

1. This Report provides supplementary guidance to the Unitary Development Plan and Coastal Defence Policy for the Cowes to Gurnard frontage, which should be taken into account.

2. There is a need for a Coastal Strategy Study of the Cowes to Gurnard shoreline to review the current and future requirements of coastal protection measures over the next 50 years or so. This study could be carried out in the wider context of the north-west coast of the Isle of Wight. The study is important, as a decline in the current levels of coastal protection may lead to a significant increase in coastal slope instability in future years. A specific consideration along the Gurnard Cliff frontage is the safeguarding of cliff top properties from future cliff instability and recession.

3. There is a need for detailed subsurface ground investigation(s) to refine the preliminary cliff behaviour models. Such investigations should comprise deep boreholes (with continuous sampling), the installation of inclinometers and piezometers to monitor subsurface movement and groundwater levels, and laboratory testing of soils and rocks.

4. In respect of point 3, above, dating of buried organic matter should be carried out wherever possible, and related to other archaeological evidence, to improve the understanding of past landform development in the study area.

5. The study has highlighted the influence of groundwater drainage from the Plateau Gravels onto the coastal slopes, which promotes instability. Detailed hydrogeological investigations should be carried out to identify the main sources of groundwater and drainage pathways into the coastal landslides with a view to identifying drainage options. This would lead to recommendations for drainage design for future highway schemes and other developments.

6. The study highlights a number of cases of serious damage to buildings, walls and roads. A detailed survey of these should be carried out by appropriately

qualified structural surveyors and appropriate actions identified. The Council should maintain records of repeat inspections and actions for specific cases.

7. Discussions with the Planning Authority should be held regarding the suitability of development in landslide areas identified by this study.

8. Publication of supplementary planning guidance notes for distribution with planning application forms should be considered to raise awareness of the development control procedures for development on unstable land. The planning application form should include specific questions alerting applicants to the land stability issues.

9. Ongoing discussions with professional groups (such as insurers, local engineers, contractors, estate agents) and service industries should be held to exchange information on ground conditions within the area. This could be facilitated by an extension to the remit of the 'Ventnor Undercliff Landslide Management Technical Committee', to include Cowes to Gurnard.

10. The Ventnor Undercliff Landslide Management Technical Committee may co-opt appropriate representatives to assist implementation of a 'Coastal Slope Management Strategy for the Cowes to Gurnard Area'. The strategy should be formalised, setting out clear objectives, scope and responsibilities. The implementation of the strategy should be monitored to evaluate the socio-economic implications and effectiveness of decision-making.

11. A code of practice should be targeted at developers and contractors assisted by the European Union Life Project entitled 'Coastal Change Climate & Instability' (McInnes and Jakeways, *In press*), being led by the Council's Coastal Manager, which will be launched shortly.

12. Advice leaflets to developers and homeowners should be produced to disseminate the findings of this study with respect to ground behaviour conditions and management. This should include the effects of vegetation clearance with respect to the mitigation of potential slope instability.

13. The digital maps and data produced by this study should be incorporated into the Council's landslide geographic information system (GIS) for use in routine enquiries and information management.

Finally, there is no reason why there should not be confidence in the Cowes to Gurnard area from a building, insurance or financial development point of view providing sensible use is made of the information and advice presented in this report. It is important that further investigations and monitoring are carried out to enable periodic review of the ground behaviour conditions and planning guidance presented herein, particularly in respect of potential changes in sea level and climatic conditions that are predicted to occur from global warming in the near future.

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Figure 2 Main Phases of Development and Damage Records

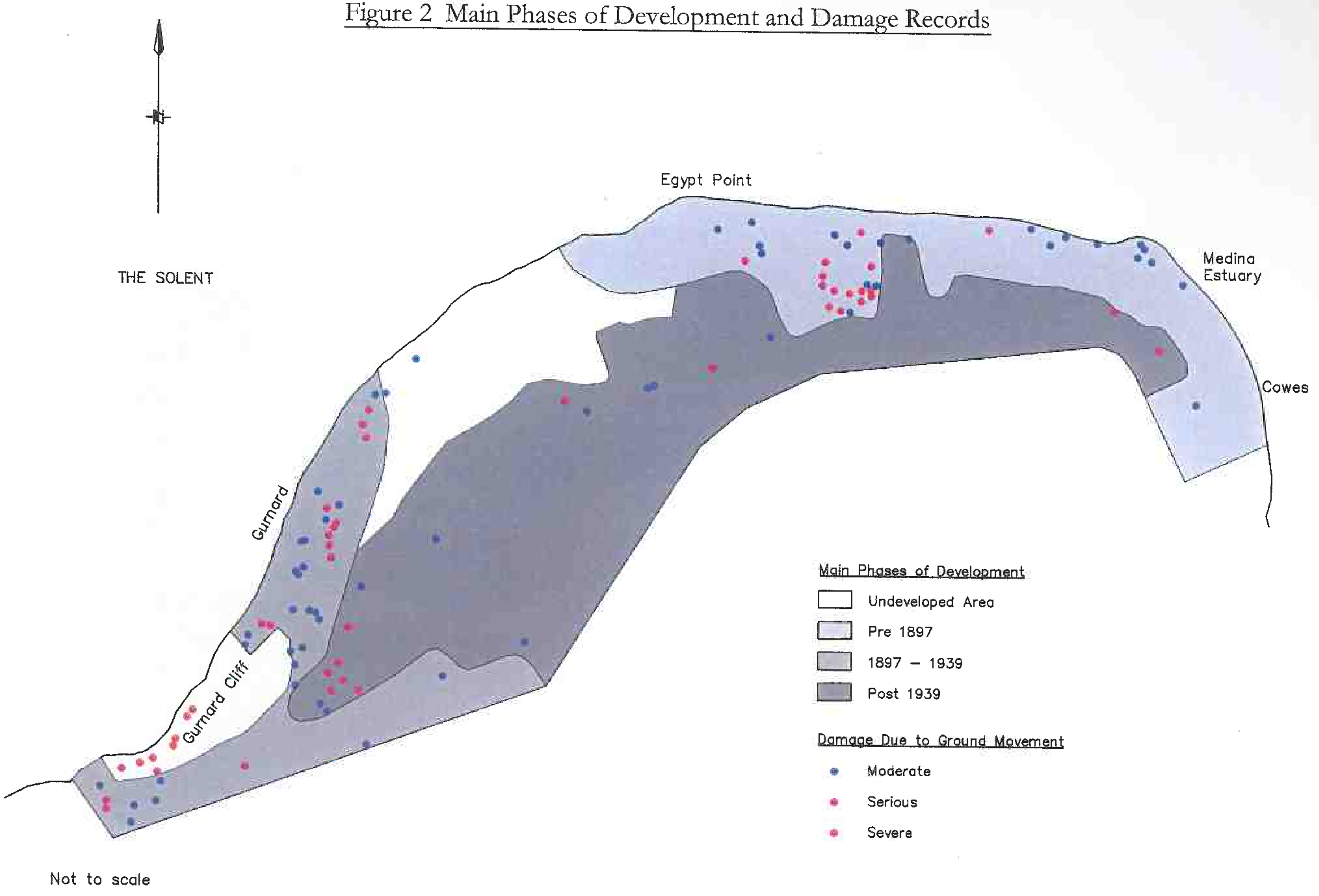

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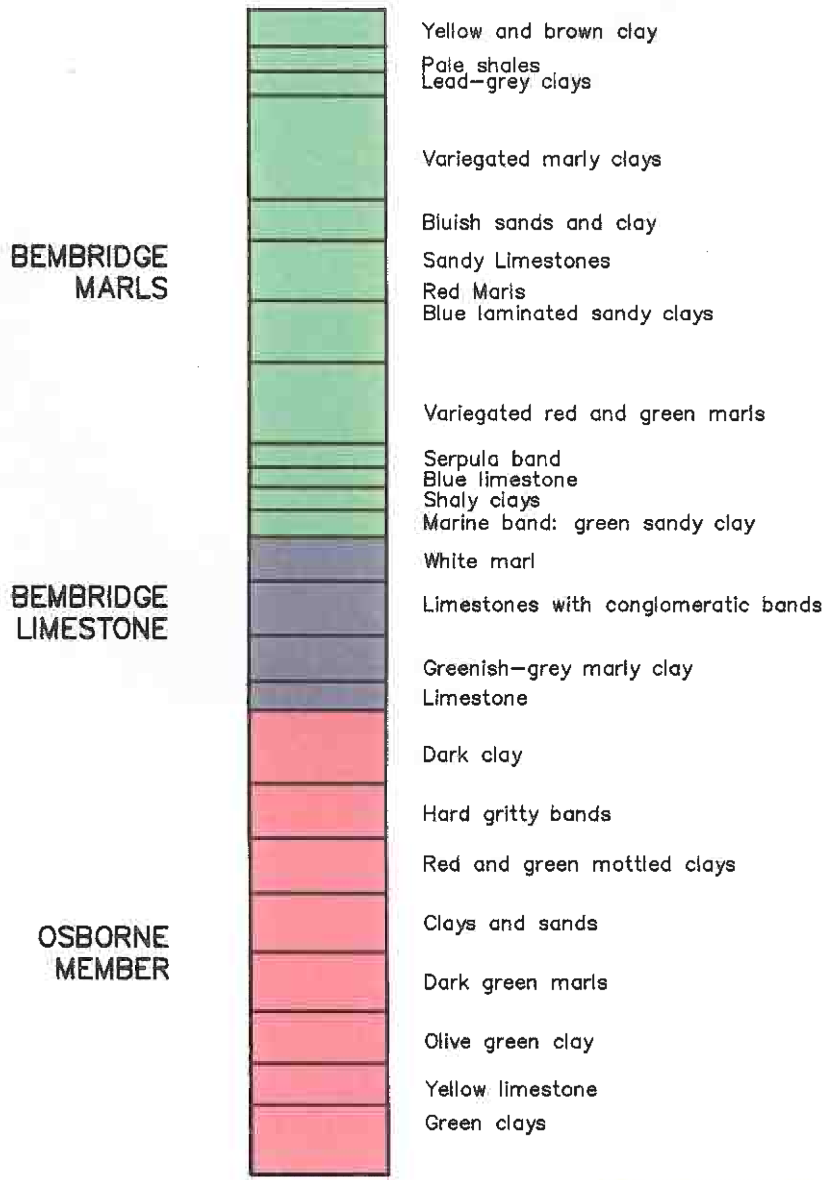
Figure 3 Geological Formations and Generalised Column

ERA	FORMATION	THICKNESS
Quaternary & Pliocene	Superficial Deposits (Plateau Gravel)	Various
Oligocene	Bembridge Marls	20 – 37m
	Bembridge Limestone	5 – 8m
	Osborne Member[1]	22 – 23m

Generalised Column[2]



Notes:

1 Osborne Member formerly known as the Osborne Beds (Melville and Freshney 1982)

2 After White (1921)

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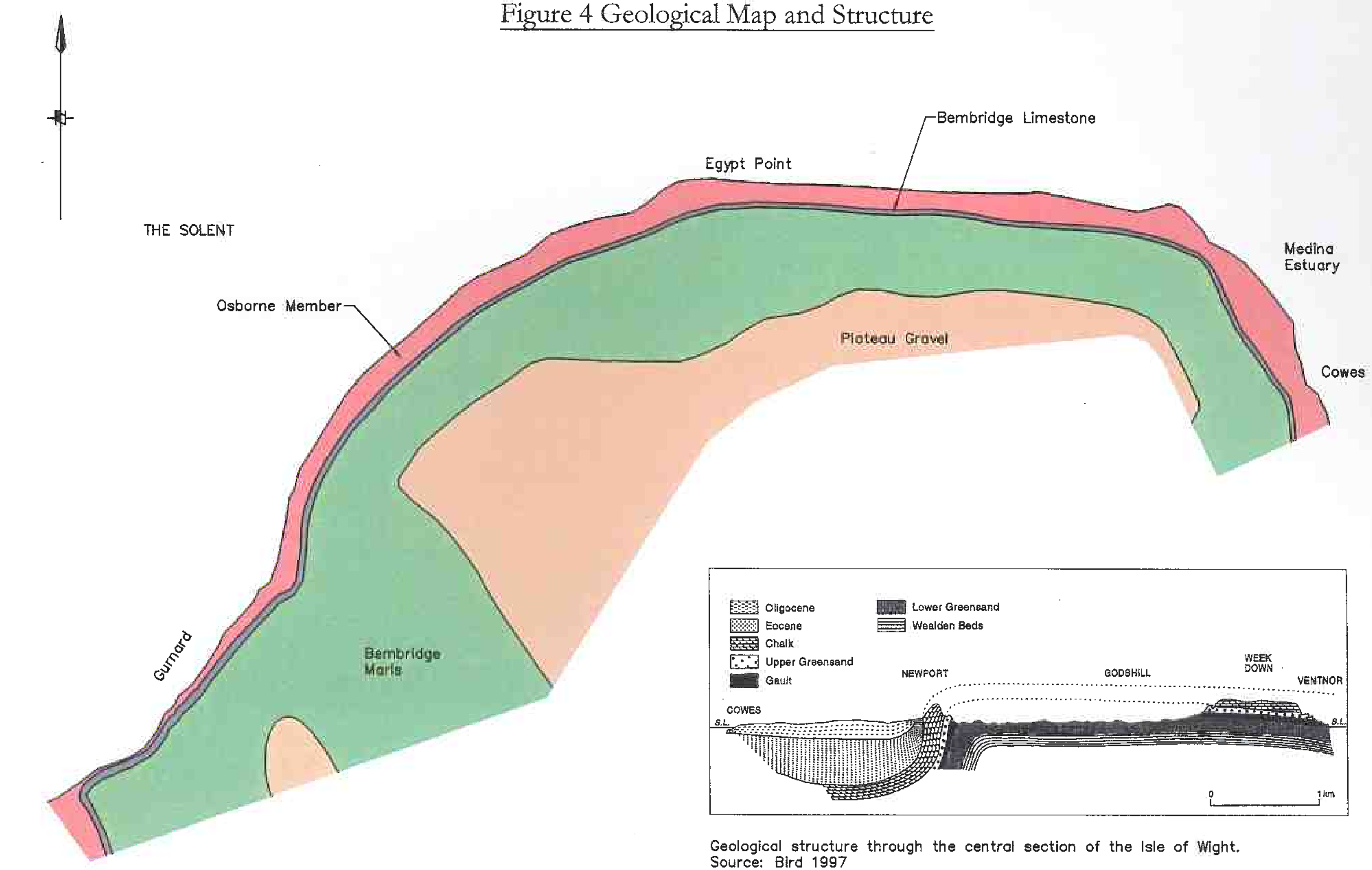
Figure 4 Geological Map and Structure



Geological structure through the central section of the Isle of Wight.
Source: Bird 1997

Not to scale

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Figure 5 Cliff Behaviour Models

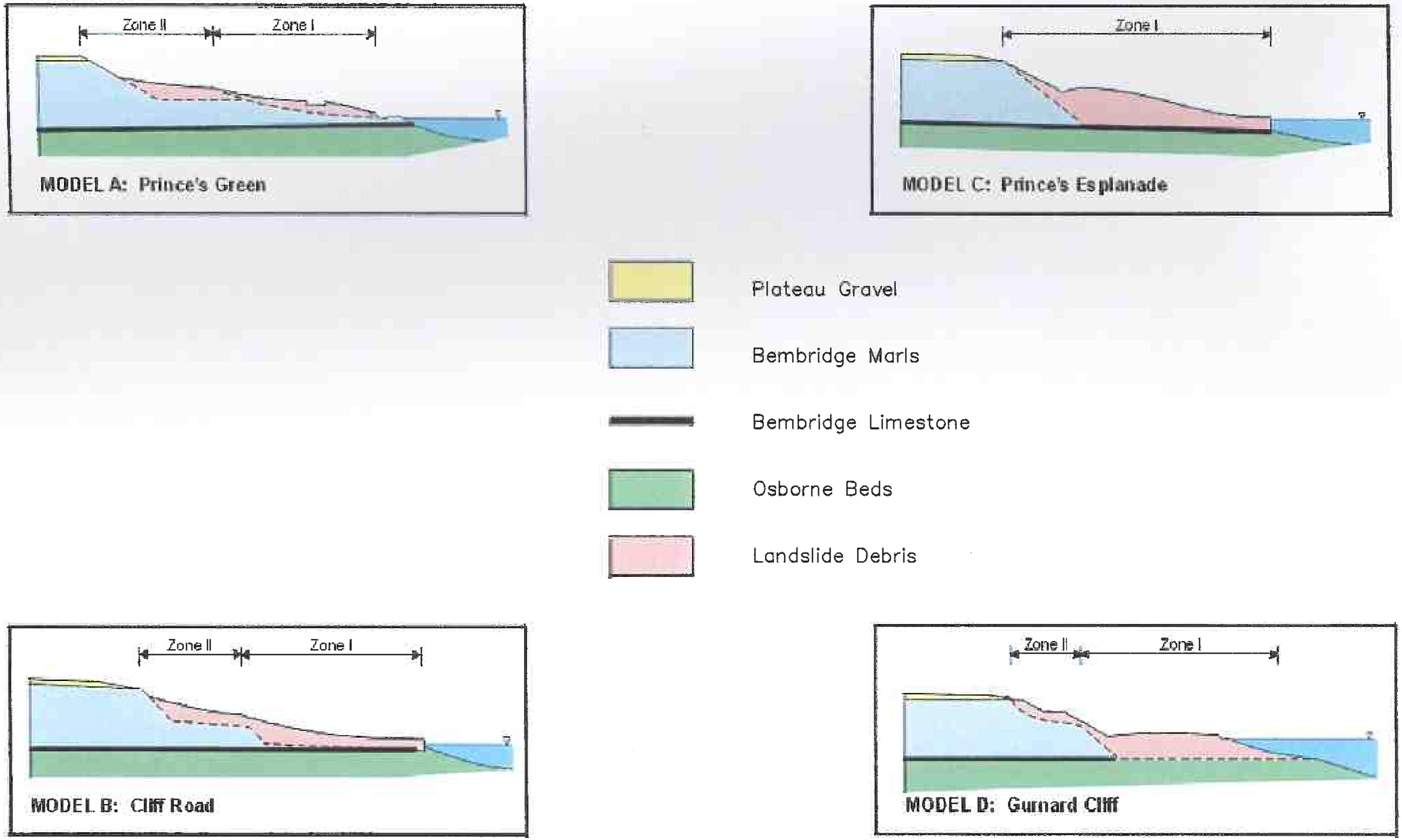

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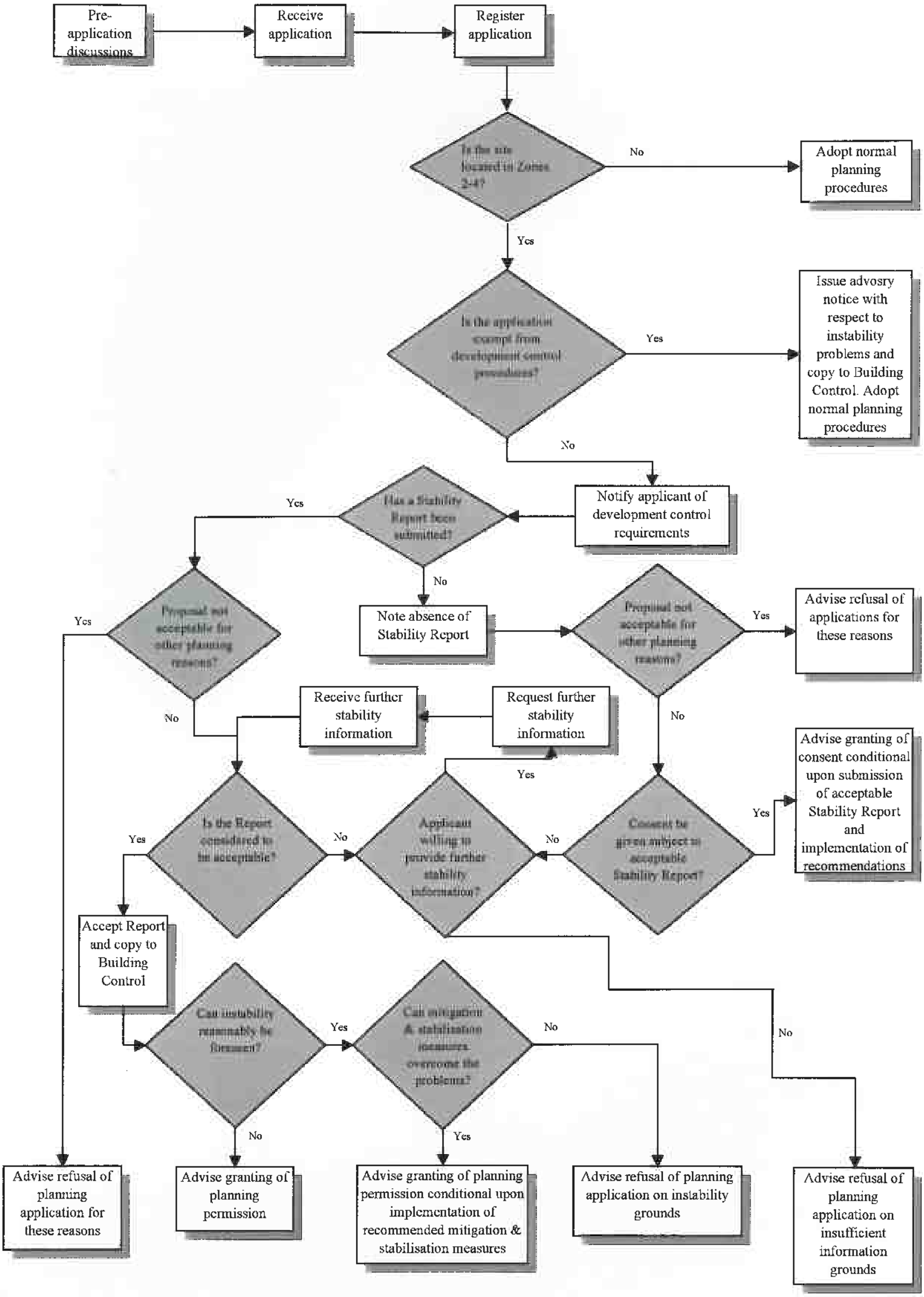
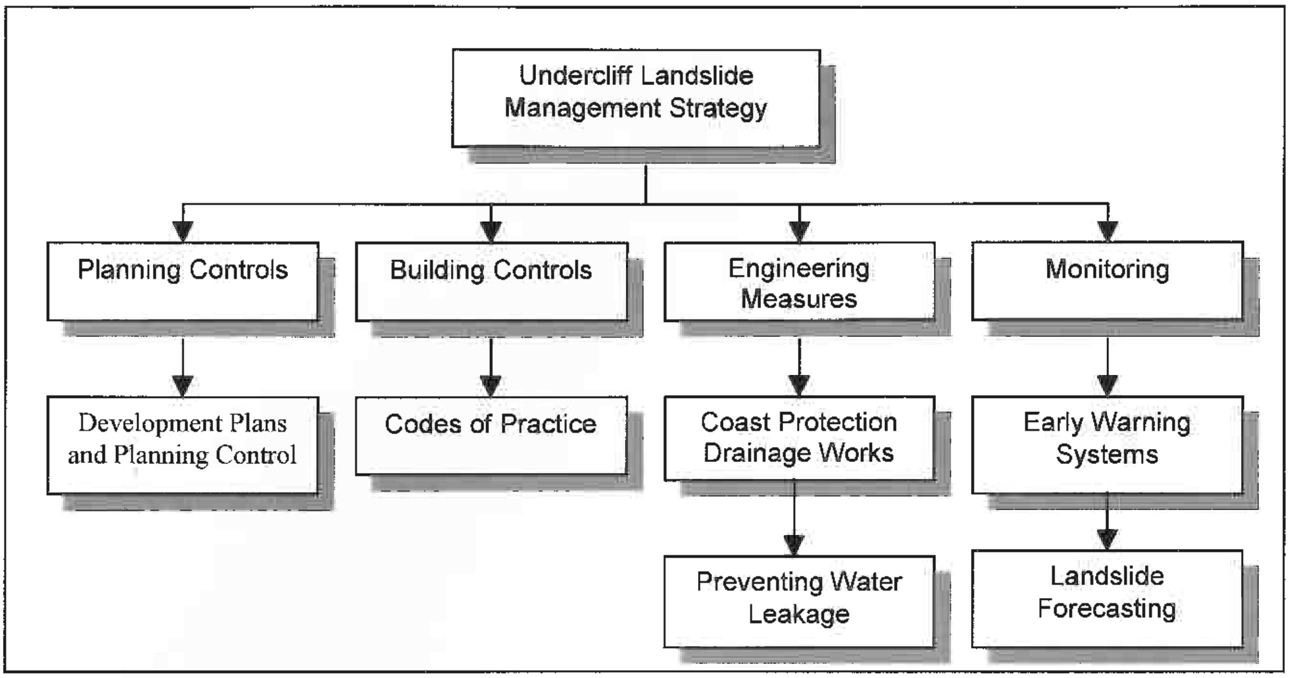
Figure 6 Instability Development Control Procedures



Note: modified after Thompson *et al.* 1996

Figure 7 The Undercliff Landslide Management Strategy



Source: Moore *et al.* 1995

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Plate 4 Private Coastal Defences at Gurnard Cliff

Plate 5 Collapsed Private Coastal Defences at Gurnard Cliff

Plate 6 Coastal Defences west of Gurnard Sailing Club

Plate 7 Sea Wall and Beach at Gurnard Green

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Plate 9 Osborne Marls Exposed at Gurnard Cliff

List of Drawings

A Appendix A

Information Sources

MAP REFERENCE LIST FOR DEVELOPMENT ASSESSMENT

Carried out as part of Cowes to Gurnard Ground Stability Study

Plan Number	Scale	Surveyed	Revised
Plan SZ 4896	1:2500	May-July, 1965	
Plan SZ 4996	1:2500	May-July, 1965	
Plan SZ 4795SW	1:1250	July 1965	
Plan SZ 4795NW	1:1250	July 1965	
Plan SZ 4796SE	1:1250	May 1965	1984
Plan SZ 4796	1:2500	May 1965	
Plan SZ 4895 NW	1:1250	Oct. 1965	Aug. 1973
Plan SZ 4795NE	1:1250	Oct. 1965	
Plan SZ 4895	1:2500	Oct.-Nov. 1965	
Plan SZ 4995	1:2500	Feb.-Jul. 1966	
90-2/XC.2/LXXXII.14 Revision of 1939	1:2500	1862-63	1939
82-14&14 Revision of 1939	1:2500	1863	1939
90-2/LXXXII.14 Edition of 1908	1:2500	1862-3	1907
90-2/XC.2/LXXXII.14 Second Edition 1898	1:2500	1862-3	1896
90-1/XC.1/LXXXII.13 First Edition 1862	1:2500	1862	1890
90-2/XC.2/LXXXII.14 Revision of 1939	1:2500	1862-3	1939
90-1/XC.1/LXXXII.13 Edition of 1908	1:2500	1862	1907
90-1/LXXXII.13 Revision of 1897	1:2500	1862	1896
90-1/XC.1/LXXXII.13 Revision of 1939	1:2500	1862	1939

All maps referred to are Ordnance Survey Maps.
Development Assessment carried out on March 6-8, 2000.

IMAGE RECORDS

Record of Images from County Records Office deemed to be of relevance to site of Cowes to Gurnard Ground Stability Study.

Photographs

GUR009 (1892)
View of Gurnard Cliffs from the West. Cliff appears only slightly vegetated with numerous bare patches suggesting potential erosion. No properties are visible along the base of the cliff. Bare scarps can be seen running along crest of cliffs. Form of low-lying debris appears lobate and suggests mudsliding activity.

GUR007 (1892)
View of Solent View Road from the West. Break in slope along the road clearly visible and can be seen to extend laterally towards the South. Shallower slopes on the northern side of Solent View Road are occupied/developed, whereas on the southern side the area is solely used for agricultural fields.

GUR008 (1913)
View of Gurnard and Solent View Road from the West. View extends across Gurnard Marsh. Break in slope within Solent View Road clearly observable. Few chalet properties present along base of Gurnard Cliffs. Cliffs are clearly visible and are covered by low shrub-like vegetation and few trees. Some areas only grassed.

Aerial Photographs

COW031A (No date) – Gurnard Esplanade showing cross Solent gas pumping terminal and part of Baring Road.
The gas site along the southern side of Princes Esplanade has clearly recently been constructed. The coastal slope extending along the area of pipeline appears heavily disturbed. Slope generally densely vegetated but does not extend further than the crest. Area has cearly been protected from development.
A seawall is visible along the northern side of Princes Esplanade. Solent View High School present.

COW033A (No date) – Prince's Esplanade from Gurnard, also show Woodvale and school.
Shows lower Gurnard along Princes Esplanade. Coastal slopes generally densely vegetated apart from recently disturbed terrain associated with the installation of the pipeline from the gas site. The slope between the gas reservoir and Princes Esplanade appears to have had some fill emplacements.
The area directly to the West of the gas site is currently being used as a caravan site. Area of coastal slope directly adjacent to this site appears to have had some tipping take place.

Other photographs reviewed but not considered to be relevant were:
COW013A – Looking West across Cowes, Gurard and the Solent.
COW025A – Gurnard Esplanade and bathing huts, Woodvale Road and part of Baring Road.
COW026A – Gurnard Bay looking eastwards over the whole of Cowes.
COW021A – View of Bettery Hill, Baring Road, Place Road, and Tuttons Hill from the North.

Postcards

Gurnard Bay, Cowes, Isle of Wight (1934)
Image shows lower Gurnard Bay site – Village Green area. The presently undeveloped green shows clear evidence of lobate slumping with some minor backscars visible. Coastal seawall also visible along the toe of the slope.

Bathing Beach, Near Cowes, Isle of Wight (1936)
Shows the Village Green area. The photo shows lobate slumping as well as some minor arcuate erosional features.

Gurnard Bay, near Cowes, Isle of Wight (No date)
Photo of seawall below Gurnard Cliffs. Wall appears in good condition apart from some minor undermining of footing. Beach extends a significant distance from the toe of the wall suggesting subsequent erosion when compared to present condition.

Details recorded on 9 March, 2000.

Site Investigation, Ground Movement and Damage Records

Source	Date	Author	Findings
Report on sea wall between Egypt Point and Gurnard	December 12, 1990	Posford-Duvivier	"In addition to the attack by the sea the entire length of the sea wall appears to be subjected to varying degrees of ground movement. At the Egypt Point area this appears to be limited to the road and the promenade formation softening and squeezing the two upper rows of facing blocks and the coping seawards. This in turn is resulting in a gap opening up between the promenade surfacing and the coping blocks and permitting surface water and wave splash to enter and further aggravate the problem. Attempts have been made to seal this crack by forming a mortar fillet between the surfacing and the coping but further movement has taken place and nullified its effect."
Report on sea wall between Egypt Point and Gurnard	December 12, 1990	Posford-Duvivier	"The undulating longitudinal profile of the roadway and the numerous repairs to its surface suggest that it is subject to gradual ground movement. This movement does not appear to have any significant effect on the stability of the sea wall, possibly to its moving as one with the coastal slope. A study of aerial photographs of this section of the coast indicates that slip failures are present within the coastal slope, particularly over the section from chainage 400 to 1000 m. Further visual evidence of ground movement is also present at chainage 1000 m where the garden walls to Prince's cafe are broken into short misaligned sections. Resurvey wrk by the Ordnance Survey is reputed to have detected a seaward movement of the sea wall of 3.0 metres at Gurnard. Movement of this extent is unlikely to have occurred over a short period without there being more obvious signs of discontinuity and we therefore consider that the claim should be treated with caution until further evidence is obtained."
Report on sea wall between Egypt Point and Gurnard	December 12, 1990	Posford-Duvivier	"There are no apparent signs of foundation damage to the properties fronting Prince's Esplanade at Gurnard and it is thought likely that if movement is occurring this lower part of the slope and the Esplanade are moving very slowly as a block."
Report on sea wall between Egypt Point and Gurnard	December 12, 1990	Posford-Duvivier	"If it is considered necessary to investigate the movement of the clay slope promenade and foreshore it would be necessary to instigate a monitoring programme to survey and measure the movement at intervals over a period of two to three years."
Report on sea wall between Egypt Point and Gurnard	December 12, 1990	Posford-Duvivier	Location Plan 1:25 000 - Shows evidence of back scarps as seen on aerial photographs.
Slope stability assessment at 'Melody', Stanhope Drive, West Cowes, Isle of Wight	March 1, 1999	RSA Geotechnics Ltd.	"A standpipe piezometer was installed in the borehole to moniter the long-term groundwater level. The piezometer tip was installed at a depth of 6.3 m below ground level with a response zone between 6.6 and 5.8 and a bentonite seal from 5.8 to 5.3 m depth."

Slope stability assessment Stanhope Drive, West Cowes, Isle of Wight	March 1, 1999	RSA Geotechnics Ltd.	"To the west of 'Melody' the rear of Bat Tree Cottage was seen to be in some structural distress. The extension and the main house were seen to have window frames which were visually distorted and cracking of the wall was evident. To the rear of the extension the slope was heavily overgrown with shrubs and trees, and appeared to have been oversteepened although a retaining structure was not evident. The footpath on the slope immediately above the property was not horizontal, although this may have been constructed at this angle, it is more probably that it is an indication of localised slope instability due to oversteepening of the slope behind Bay Tree Cottage. This appeared to be a localised effect."
Slope stability assessment Stanhope Drive, West Cowes, Isle of Wight	March 1, 1999	RSA Geotechnics Ltd.	"The review of the available maps gave no indication of any slope instability during the last 137 years."
Report on Site Investigation Castle Road, Cowes, Isle of Wight	March 1, 1999	Sifeg Partnership	"Between the bowling green and the retaining wall along Castle Road the ground surface underneath the heavily overgrown part of the site, when cleared for erecting the boring rig, was found to be very hummocky, possibly due to superficial ground movements in the past."
Report on Site Investigation Castle Road, Cowes, Isle of Wight	March 1, 1999	Sifeg Partnership	"Groundwater monitored in the deep standpipe installed in the lower limestone bed in BH1 gave the water level as 10.75 m below ground level, or +12.5 m OD. It would appear that this lower limestone bed is not fully saturated. This may indicate that this lower limestone bed is in some way acting as a drainage channel for some of the groundwater in the overlying clay. Further mnitoring of the standpipes is recommended to better understand the groundwater conditions at the site."
Report on Site Investigation Castle Road, Cowes, Isle of Wight	March 1, 1999	Sifeg Partnership	Figure 1 - Shows numerous slickensided surfaces below 14.0 m within the 'Osborne Marls'.
Report on Site Investigation Castle Road, Cowes, Isle of Wight	March 1, 1999	Sifeg Partnership	Appendix B - Photographs (Site) - showing numerous defects observed in surrounding buildings.
Coast Protection at Gurnard - Preliminary Study	February 1, 2000	Posford-Duvivier	"The main coastal slope area between points B and E is approximately 400m long and is either undefended or now essentially unprotected by earlier defences, which are at or near the end of their useful life. No properties appear to be at immediate risk but progressive movement of the backscarp of the cliff slope due to erosion and landslips could affect some properties in Solent View Road in the long term."
Coast Protection at Gurnard - Preliminary Study	February 1, 2000	Posford-Duvivier	"The 70m of privately owned and constructed concrete sea wall fronting Shore Place protects the properties immediately behind. It also protects an earlier toe lobe which has stabilised the cliff slope. The useful life of the seawall is estimated to be between 5 and 10 years, after which the erosion of the toe lobe, loss of the properties and reactivation of the slip behind could all follow quite quickly. This is considered to be the most vulnerable area."

Coast Protection at Gurnard - Preliminary Study	February 1, 2000	Posford-Duvivier	"Over the major central section (B-E), the MHW line has moved very little despite successive slips and erosion of their toe lobes. The consequence f this has been a general steepening of the beach profile."
Coast Protection at Gurnard - Preliminary Study	February 1, 2000	Posford-Duvivier	"The same maps show that development of Solent View Road and Worsley Road commenced in the mid 19th Century with the majority of the properties, presently in place in these roads, Shore Road and Shore Path, established by 1939. A continuing history of slope instability is also indicated."
Coast Protection at Gurnard - Preliminary Study	February 1, 2000	Posford-Duvivier	"Gurnard Cliff has a history of instability. A significant landslide occurred during the mid 1930's and a more recent land slip, where a section of the wooded area of the coastal road spilled over the seawall onto the beach, occurred in the mid 1980's to the west of no. 44 Solent View Road. Mislips have occurred more recently but no details were recorded. Approximately 14m of level garden was reported as lost in the mid 1980's event but no trace of this can be detected between the 1965 and 1989 maps or the 1998 survey."
Coast Protection at Gurnard - Preliminary Study	February 1, 2000	Posford-Duvivier	"Instability of the coastal slope behind Shore Path may have been exacerbated as a result of dumping on an area at the top of the cliff to the west of Worsley Road and Winding Way. The residents noted that this area had been used as a dumping ground during Victorian times up until the 1970's. Worsley Road originally followed a northwesterly route towards the seafront, as a result of cliff top regression, the road was diverted in a northeasterly direction towards Shore Road. (This statement is not entirely substantiated by the Ordnance Survey Maps)."
Woodvale, Gurnard	2000	Halcrow	Site investigation records
Queen's Road, Cowes	1992-1993	Robert Cowan and Partners	Site investigation records
Queen's Road, Cowes	1988	Willis and Partners	Site investigation records
Queen's Road, Cowes	1998	Robert Cowan and Partners	Site investigation records
Gurnard	1997	Willis and Associates	Site investigation records
Stanhope Drive	1999	RSA Geotechnics Ltd.	Site investigation records
Woodvale, Gurnard	1997	Symonds Travers Morgan	Site investigation records
Shore Road, Gurnard	1999	Willis and Associates	Site investigation records
Castle Road, Cowes	1999	Sifeg Partnership	Site investigation records
Egypt Hill	1992 and 1999	HM Geotechnics	Site investigation records

B

Appendix B

Illustrations of the Nature and Severity of Damage Due to Ground Movement

Subsidence and crack damage of road pavement (moderate damage)

Subsidence and crack damage to the Parade, Cowes (moderate damage)

Crack damage to low boundary wall (moderate damage)


Forward tilt and heave of walls and outbuilding (serious damage)

Separation and outward displacement of podium (serious damage)

Separation of podium from main structure (serious damage)

Groundwater seepage and general decay of retaining wall (serious damage)

Crack damage and dislodgement of masonry blocks (serious damage)

Small failure of garden slope (severe damage)

Landslip (Dec. 1999) of private garden at crest of coastal slope (severe damage)

Old landslip (c1980s) of private garden at crest of coastal slope (severe damage)

C

Appendix C

Suggested Stability Report Format and Declaration Form

Suggested Structure and Content of Stability Reports

i. *Introduction*; a statement indicating for whom the work was done, the nature and scope of the investigation, its general location, its purpose and the period over which it was carried out.

ii. *Description of History*; a detailed description of the site based on the observations made by the Competent Person during his site review and reconnaissance. It should be referenced to a plan of the site showing national grid co-ordinates and to a scale no smaller than 1:2500.

iii. *Investigations*; information consulted during the course of the desk study should be referred to and listed as an appendix. Fieldwork should be described and full records of boreholes, trial pits or other exploratory methods included as an appendix and their locations shown on a plan. Site tests and laboratory tests and methods should be similarly described and their results included.

iv. *Ground Conditions*; descriptions of the ground conditions found during the investigation and an interpretation of their relevance to the stability of the site and surrounding area. Anomalies in any of the data collected should be pointed out. The following items should be discussed, where appropriate: geological conditions; hydrogeology; history of past events and ground movement rates; soil and rock properties; other factors e.g. coast protection.

v. *Evaluation of Stability;* the stability of the site and relevant adjacent area should be evaluated with respect to the proposed development and the assessment of ground conditions. Where stability calculations are carried out, the method of analysis should be stated. The stability calculations should demonstrate both the existing factors of safety and, where appropriate, the factors of safety that would be created by the proposed development and any associated stabilisation measures. It is expected that particular attention should be paid to the gradients of cut slopes and fills; drainage measures; retaining structures; failure mechanisms and the design criteria applied.

vi. *Conclusions and Recommendations*; the Competent Person should summarise the main conclusions of the investigation and list the recommendations to ensure both the long-term stability of the site (taking account of the anticipated life of the development) and also in the short term whilst construction proceeds. It is expected that particular reference will be made to matters such as: the avoidance of fills near the crest of steep slopes; restrictions on the depth of excavation at the toe of steep slopes; the maximum length of trenches excavated along the contours of steep slopes at any one time; avoidance of septic tanks and soakaways; provision of flexible jointed pipes capable of sustaining small movements without leakage; provision for free drainage of groundwater; minimising drainage diversions and their lining where site conditions require them.

STABILITY REPORT DECLARATION FORM

Site Name	Site Address	Development Control Area

Category	Question	Answer yes/no/?/na
A) Competent Person	• Has a Competent Person or Geotechnical Specialist prepared the report? • Does the Competent Person or Geotechnical Specialist operate a Quality System which meets the requirements of BS EN ISO9001? • Does the Competent Person or Geotechnical Specialist have a minimum of £1 M Professional Indemnity Insurance?	
B) Site History	• Has the site been affected by past ground instability? • Is the site located within or adjacent to any instability features?	
C) Site Inspection	• Has a detailed site inspection been carried out? • Does the site and adjacent land bear any geomorphological evidence of past or incipient ground instability? • Does the site or neighbouring property bear any evidence of structural damage or repairs that might be associated with ground instability?	
D) Geotechnical Desk Study	• Has the report 'Cowes to Gurnard Coastal Slope Stability Study' been consulted? • Have any previous ground investigation reports and/or borehole records from the site been consulted? • Is the information consulted and referred to sufficient to quantify the ground behaviour constraints, which could affect the stability of the site?	
E) Ground Investigation	• Has a ground investigation been carried out and have the results been submitted in support of this application? • Did the investigation identify the presence of sub-surface shear zones and low strength compressible soils at the site? • Is the information sufficient to quantify the ground behaviour constraints, which could affect the stability of the site?	
F) Stability Assessment	• Is the information in B,C,D and E (where applicable) adequate to assess the stability of the site and adjacent land? • Can ground instability reasonably be foreseen within or adjacent to the site within the design life of the proposed development, allowing for any deterioration of ground conditions caused by the development itself? • Can instability be reduced to a reasonable level through cost-effective mitigation and stabilisation measures that would be environmentally acceptable?	
G) Mitigation Measures	• Have mitigation measures been proposed with respect to ground instability issues? • Have these been designed to reduce the effects of actual or potential instability to a reasonable level? • Is it possible the mitigation measures may have an adverse effect on the stability of other, adjacent sites (for example by affecting groundwater drainage in the area)?	
H) Name, Qualifications and Signature of Person Responsible for the Stability Report	Full Name: Qualifications: Signature: Company Represented (if applicable):	

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