Ventnor Options Study

Ventnor Options Study: Future Schemes Report

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List of Abbreviations

BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
EA	Environment Agency
EIA	Environmental Impact Assessment
FBC	Full Business Case
FCERM	Flooding and Coastal Erosion Risk Management
FCERM-AG	Flood Defence Grant in Aid Funding – Appraisal Guidance
FDGiA	Flood Defence Grant in Aid Funding
FSR	Future Schemes Report
GI	Ground Investigation
GiA	Grant in Aid
GPR	Ground Penetrating Radar
H&S	Health and Safety
HRA	Habitats Regulation Assessment
IBCR	Incremental Benefit Cost Ratio
IWC	Isle of Wight Council
IROPI	Imperative Reasons of Overriding Public Interest
LRU	Landslide Reactivation Unit
LPRG	Large Projects Review Group
MMO	Marine Management Organisation
NAI	No Active Intervention
OB	Optimism Bias
OM	Outcome Measures
pOBC	Preliminary Outline Business Case
PV	Present Value
QRA	Quantitative Risk Assessment
SAC	Special Area of Conservation
SI	Site Investigation
SMP	Shoreline Management Plan
SOR	Statement of Requirements
SSSI	Site of Special Scientific Interest

Executive Summary

Ventnor and Bonchurch are located in the Undercliff on the south coast of the Isle of Wight, a complex pre-existing deep landslide system that is subject to land instability caused by coastal erosion and excess groundwater levels. The developed frontage is protected by various coastal defences, some of which are nearing the end of their serviceable lives and require repair or replacement. Without coastal defences, and slope stability measures, the Undercliff landslide system will become more active with predicted increased winter rainfall and accelerated rates of toe erosion causing widespread ground movement, landslide reactivation and asset damage in Ventnor and Bonchurch.

As part of appraisals required to develop future schemes to reduce risk and seek government funding for replacement coastal defences, Jacobs (previously CH2M) was commissioned by Isle of Wight Council to provide an initial appraisal and scheme identification study for Ventnor and Bonchurch. This Future Schemes Report is the hub of this study to identify how the 'Hold the Line' shoreline management policy for the Ventnor and Bonchurch frontage can be implemented. The objective of the report is to provide a start-to-finish account of the strategic level options assessment and identify priority future schemes for coastal defence and slope stability at Ventnor and Bonchurch. It uses the hazard and consequence models developed in the Technical Report (Appendix 1) as its basis and feeds results and information into the Preliminary Outline Business Case (pOBC) (Appendix 7) and non-technical summary (Appendix 6).

The Future Scheme Report develops the economically viable coastal defence and slope stability options identified in the Technical Report (Appendix 1) through partnership funding appraisal to identify the best value for money in schemes that are technically robust, environmentally acceptable, economically justified and in full accordance with the latest FCERM Appraisal Guidance. The report mirrors the content and structure of the pOBC and comprises the following key elements:

- **The case for change:** Rationale for replacement coastal defences and slope stabilisation measures.

  The primary case for change is to prevent loss of life and injury, and wide-spread damage to property and infrastructure which could threaten the viability of Ventnor in its current location. A significant landslide reactivation could directly impact the entire 7,000 population of Ventnor, either through loss of property, or loss of access routes into the town, or from the severance of services. In addition, Ventnor and Bonchurch are identified as regeneration areas where, due to areas of economic decline, support will be given by the current Isle of Wight Core Strategy and future initiatives to proposals which maintain and support the sustainability of the town.

- **Options appraisal Stage 1:** Economic assessment which appraises engineering issues and strategic solutions at the Defence Unit level.

  This assessment shows that there are coastal defences at Ventnor and Wheelers Bay in a poor state of repair that require urgent replacement and that slope stabilisation measures in the form of drainage wells are needed to mitigate landsliding. The Options Appraisal Stage 1 also shows that there are viable strategic engineering solutions for replacement coastal structures and a drainage scheme.

- **Options appraisal Stage 2:** Economic assessment which appraises engineering issues and strategic solutions at the Landslide Reactivation Unit (LRU) level (which uses geomorphological assessment to define landslide extents) using Cost Benefit Analysis (CBA) to identify preferred, economically and technically feasible options.

  This element is provided in full in the Technical Report (Appendix 1). It details the quantitative risk assessment (QRA) of ground movement, landslide hazard and consequence scenarios, and a cost benefit analysis (CBA) of maintaining and replacing coastal defences and slope stabilisation measures over the next 100 years. To do this the QRA and CBA compare the risk profiles and economic benefits the 'do nothing' option, which results in a significant increase in risk once the residual life of the existing coastal measures are exceeded, with the 'do minimum' option, which results in limited intervention and risk mitigation, and the 'improve' options, which involve coastal protection and deep cliff drainage measures, and results in a reduction of the likelihood of damaging events.

The Options appraisal Stage 2 demonstrates, that at a strategic level, there are economically viable schemes comprising deep drainage and various new and upgraded coastal defences for defined areas.

- **Options appraisal Stage 3:** Detailed economic assessment of the preferred, economically and technically feasible Priority Scheme and Partnership Funding (PF) calculations.

  This assessment identifies a package of preferred options from Stage 2, and shows that by grouping these options there is an economically deliverable programme of capital works at Ventnor Park, Central Ventnor and Wheelers Bay. A partnership funding score of 87% demonstrates that this grouped package of works delivers a strong economic case for a priority scheme seeking Grant in Aid (GiA) funding during future funding cycles. At Castle Cove, Bonchurch East and Bonchurch West maintenance has been identified as the most beneficial form of coastal management until the current defences reach the end of their serviceable lives and need replacing. At this point the cost benefit balance switches to favour replacement structures and any future scheme could be delivered in these LRUs as a fresh FDGiA submission, separate to the benefits from Ventnor Park, Central Ventnor and Wheelers Bay, although partnership funding is also likely to be required in this neighbouring area.

- **Preferred capital schemes and maintenance:** This element identifies the preferred capital schemes and maintenance options in each of the 7 LRUs. It also provides the principles behind the Priority Coastal and Drainage Scheme proposed for Ventnor Park, Central Ventnor and Wheelers Bay, i.e. the importance of combining the coastal defence improvements with drainage relief wells to deliver a considerable improvement in the stability of the Undercliff in the long-term, both protecting the coastal defence assets from future landslide damage, and by extending the stabilising effects of the combined coastal defences drainage solution up to 1km inland. This benefits all assets, services and the community occupying the areas protected by the scheme.

- **GiA and partnership funding options:** This element presents the financial case and funding options. It shows that the proposed scheme for Ventnor Park, Central Ventnor and Wheelers Bay is in a strong financial position at this strategic stage. The overall scheme cash costs of £32,043k will be largely financed by £25,274k (present value costs) of FDGiA 'Grant in Aid' funding. Although the potential shortfall in funding of £4,199k (cash cost) needs to be financed by the Isle of Wight Council and through partnership funding contributions there is significant opportunity to rationalise the scheme costs and increase benefits to reduce this shortfall. The damages due to landslide risk provide a robust baseline for the economics but additional monetised benefits can be considered at scheme appraisal stage such as additional flooding benefits (these will be small in comparison to the erosion benefits), tourism benefits and other intangible benefits etc.
- **Environmental considerations for preferred schemes:** The only potentially significant environmental constraint relating to the priority scheme proposed is at Wheelers Bay where the rock armour presently protecting part of the frontage overlaps the South Wight Maritime SAC. Although it is therefore likely that in this area the replacement structure footprint will impinge on the SAC boundary, there are mitigating factors which would likely result in a scheme that would gain the necessary consents.

1. Introduction

1.1 Overview

The town of Ventnor and Bonchurch village are situated in the Undercliff, an extensive coastal cliff and landslide complex with significant urban development where approximately 7,000 people live. The site (on the south coast of the Isle of Wight) covers a 4 km section of the eastern Undercliff, comprising the steepest and most developed part of the landslide complex (Figure 3). Coastal defences at the toe of the Undercliff help prevent landslide reactivation that would otherwise occur if erosion was not controlled. Beyond the limits of the coastal defences active toe erosion, cliff recession and landsliding are evident.

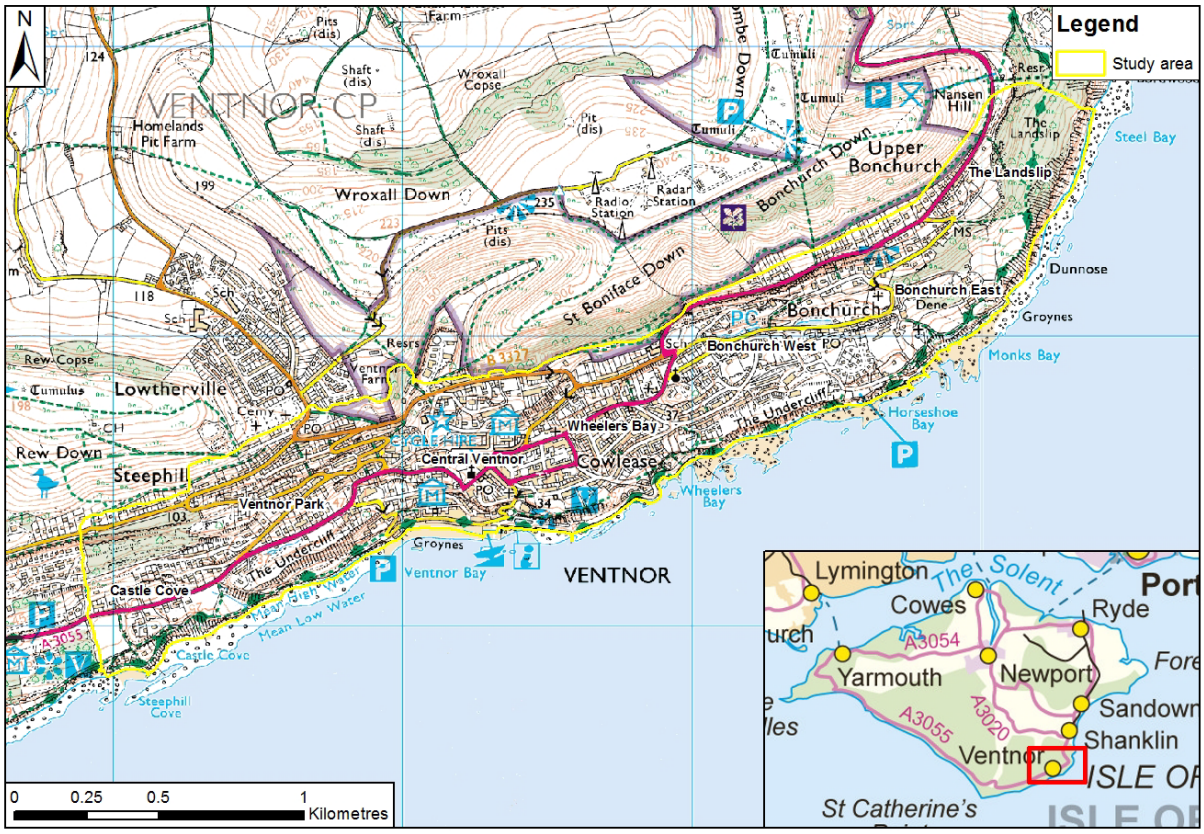


Figure 1. Site location map. Credit: OS © Crown copyright (2017).

Despite the toe protection afforded by the coastal defences, the Undercliff at Ventnor and Bonchurch is subject to slope instability including progressive deep-seated ground movement and occasional landslides due to the effects of coastal erosion, rainfall and groundwater. As a result of urban occupation and land use, the cumulative impact and associated cost to the coastal defence assets, roads, property, businesses and services has been substantial.

The Isle of Wight Council (IWC) has taken a major role in addressing coastal erosion and cliff instability. Important elements of their strategy over a number of years has included various coastal defences and slope stabilisation measures, site investigation, ground stability monitoring and ad hoc repairs to property and infrastructure. However, because many of the coastal defence structures are ageing, and over the next century climate change and relative sea level rise are expected to result in an increase in coastal erosion and cliff instability, a more efficient and coordinated plan of coastal management is required to mitigate the increasing risk.

This Future Schemes Report develops the economically viable and technically feasible coastal defence and drainage schemes identified in the Technical Report (Appendix 1), including Partnership Funding appraisal in accordance with the requirements of the latest FCERM and HM Treasury Guidance. The objective is to identify

the spending profile and programme of works required for the preferred schemes to be developed, with the next national funding cycle due to begin in 2021.

The report forms a key element of the overarching assessment aimed at identifying technically robust and economically viable coastal protection and cliff management options to reduce coastal instability risk at Ventnor and Bonchurch.

In summary, the overarching assessment comprises the following elements:

1. **Structures assessment:** provides the baseline condition and residual life of the existing coastal defences.
2. **Technical report**: provides the baseline condition of coastal landsliding in the Undercliff, quantitative risk assessment and cost benefit analysis of mitigation options.
3. **Future schemes report**: provides option selection and forward proposals/spending profile for priority schemes with a robust case for seeking grant in aid GiA funding during future funding cycles.
4. **Non-technical summary**: provides a non-technical summary of the above.

The work has been carried out between 2017-2019 in full accordance with all relevant and latest national flood and coastal erosion risk management guidance.

1.2 Report objectives

This Future Schemes Report is the hub of the Ventnor Options Assessment. Its objective is to provide a start-to-finish account of the strategic level options assessment and priority scheme identification for coastal defence and slope stability schemes at Ventnor and Bonchurch. It uses the Technical Report (Appendix 1) as its basis (e.g. the hazard and consequence models) and feeds results and information into the Preliminary Outline Business Case (pOBC) (Appendix 7) and non-technical summary (Appendix 6).

1.3 Scope

The scope of the Future Schemes Report has been delivered in accordance with requirements f, g, h, i, j, k, l and m set out in Section 3 of the Technical Specification and Scope produced by IWC, and extension tasks (site walkover to review a drainage solution to stability with Eddie Bromhead and statements of requirements for proposed schemes) agreed with IWC in March 2018. The scope is split into the following elements:

- **The case for change:** Rationale for replacement coastal defences and drainage.
- **Options appraisal Stage 1:** Economic assessment which appraises engineering issues and strategic solutions at the Defence Unit level.
- **Options appraisal Stage 2:** Economic assessment which appraises engineering issues and strategic solutions at the Landslide Reactivation Unit (LRU) level using Cost Benefit Analysis (CBA) to identify preferred, economically and technically feasible options. There are 7 LRUs along the 4km study area.
- **Options appraisal Stage 3:** Detailed economic assessment of the preferred, economically and technically feasible Priority Schemes, including PF calculations.
- **Preferred capital schemes and maintenance:** Summary of preferred capital and maintenance options by LRU, and identification of the priority scheme.
- **Appraisal costs:** Detailed assessment of appraisal, design and OBC costs (e.g. ground investigation, appraisals, design and construction supervision) for schemes carried forward.
- **Statement of Requirements:** Statement of requirements for ground investigation, monitoring and analysis required for the preferred coastal and drainage schemes to be progressed.

- **GiA and Partnership Funding:** Identification of any funding shortfall and assessment of Partnership Funding options.
- **Environmental considerations:** Assessment of environmental considerations specific to the preferred coastal defence and drainage schemes.
- **Programme:** Project delivery programme, planning consents and risk management.
- **Planning Note:** Note on the planning implications (including constraints and opportunities, and drawings) of the preferred schemes and provision of an outline programme for planning applications.
- **Preliminary Outline Business Case**: Provision of a draft pOBC which considers all currently available data and identifies what additional information is required.

1.4 Technical report summary

1.4.1 Objective and content

The Technical Report (Appendix 1) synthesizes all available information to provide a robust but flexible (to account for changes brought online though future appraisal results) technical and economic basis for identifying viable future schemes. It provides a strategic level assessment of coastal management options for Ventnor and Bonchurch to achieve the 'Hold the Line' Shoreline management Plan policy approach. The land instability hazards, their consequences and the reduction in risk achievable via various schemes are captured and the locations which will provide the most viable schemes identified, within a coordinated approach.

The Technical Report comprises a quantitative risk assessment (QRA) of landslide hazard and consequence scenarios, and a cost benefit analysis (CBA) of maintaining and replacing the coastal defences at Ventnor and Bonchurch. It divides the Ventnor and Bonchurch frontage into Landslide Reactivation Units (LRUs) based on the Undercliff landslide geomorphology (Figure 2). These units provide a fundamental geospatial framework for the evaluation of risk and identification of viable scheme options.

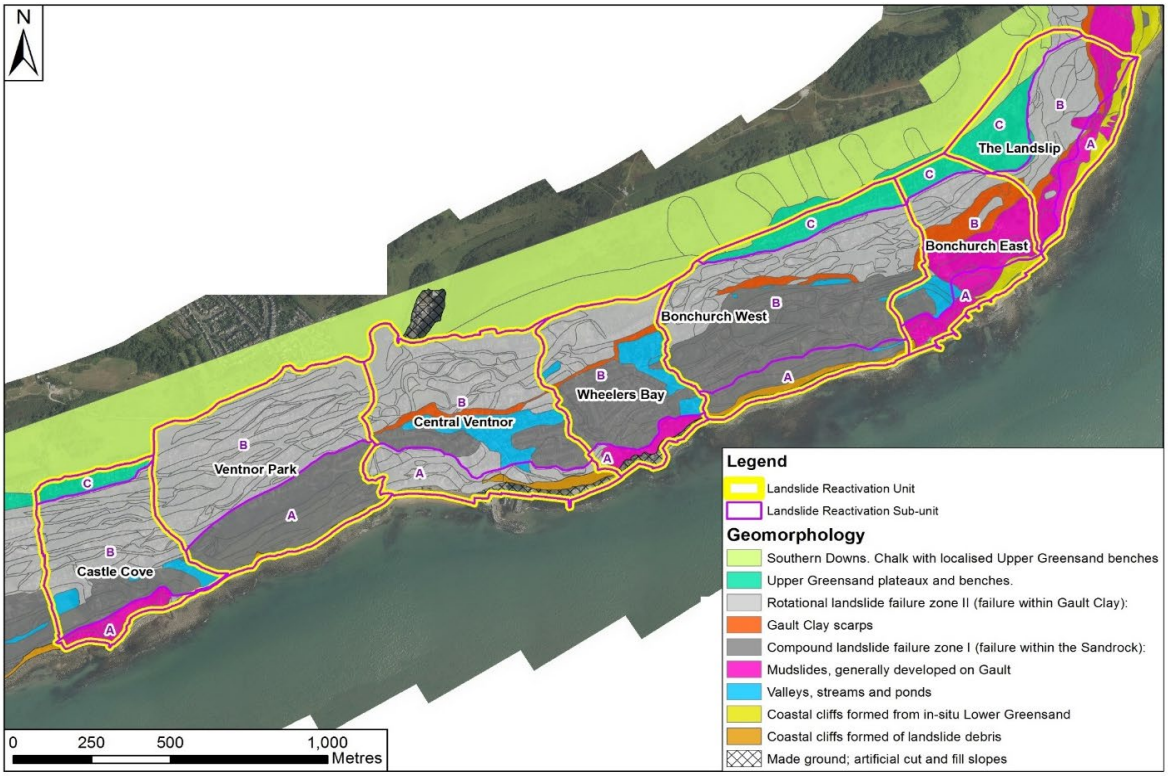


Figure 2, Geomorphology and landslide reactivation units

The Technical Report forms a key element of the overarching assessment aimed at identifying technically robust and economically viable coastal protection and cliff management options to reduce coastal instability risk at Ventnor and Bonchurch.

The QRA and CBA compares the risk profile of 3 future coastal and slope management approaches, 'no active intervention', 'with present management' and 'with project' (this option includes various engineering schemes). As shown in Figure 3, the objective of the 'with project' option is to significantly reduce risk via the implementation of appropriate schemes.

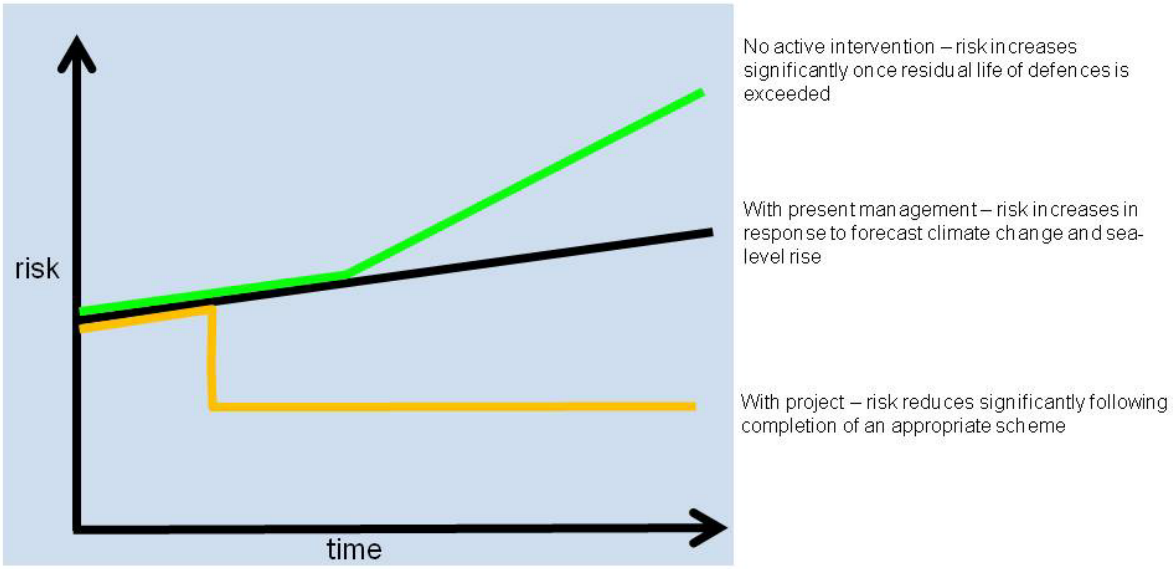


Figure 3 Future risk profiles for each management option

1.4.2 Results

The Technical Report (Appendix 1) demonstrated that at a strategic level over the next 100 years, there are economically viable schemes in the Landslide Reactivation Units (LRUs) with high total asset values and/ or where at least one of the coastal defences is in very poor condition (Ventnor Park, Central Ventnor and Wheelers Bay and Castle Cove). Schemes at Bonchurch West and Bonchurch East, targeted at failing assets are potentially viable but will likely require significant partnership funding to proceed. There is unlikely to be a viable scheme at the area historically known as 'The Landslip' at the easternmost edge of the study area, although the consequences of landslide recession breaching the A3055 will have significant future local and political implications.

Significantly, the Technical Report also demonstrated the importance of combining coastal defences with drainage because landslides at Ventnor and Bonchurch are driven by toe erosion, rainfall and groundwater. Without the ageing coastal defences in place, the system would change behaviour and toe erosion will cause widespread landslide reactivation under the town and this has the potential to cause significant asset damage. Even with the coastal defences preventing toe erosion, significant historical damage to coastal defence assets as well as property, services and infrastructure has been caused by ground movement due to the effects of rainfall on groundwater pressures. The QRA and CBA clearly show that effective coastal management and landslide remediation at Ventnor and Bonchurch requires solutions that deal with both coastal erosion and rainfall-groundwater triggers of ground instability.

As such, it is recommended that future management options and schemes must combine deep drainage with coastal defences to provide the most beneficial and cost-efficient strategy to implement the SMP 'Hold The Line' policy at Ventnor and Bonchurch. Failure to take this approach could result in wasteful use of funding if, for example, a new coastal defence asset was built and this was damaged by ground movement or a landslide because rainfall triggered instability hadn't been dealt with.

The CBA data, methods and results detailed in the Technical Report are summarised in Section 3.2 as part of the 3-stage options selection detailed in this FSR.

1.5 FSR Approach

The primary objective of this assessment is to identify preferred priority schemes and management options for the frontage at Ventnor and Bonchurch. The QRA and CBA in the Technical Report (Appendix 1) provides a robust account of the costs and benefits of the various options via a comprehensive assessment of the hazards, consequences and scheme costs. As such, following provision of the case for change in Section 2, Section 3 provides a summary of the economically and technically feasible coastal defences and drainage options (solutions) identified in the CBA.

PF scores are then calculated for the options and CBUs which achieved the best CBA scores and where priority schemes are required. These areas relate to assets which have or are close to reaching the end of their serviceable live and where property and other asset values are highest. This approach identifies areas which are likely to achieve the highest levels of scheme funding to be taken forward for further consideration which includes a detailed assessment of scheme costs (e.g. appraisal, design and OBC costs) and benefits (e.g. the number of properties protected under OM3). The results of this have been used to update the PF calculator to provide a best estimate PF score and the most robust case of the preferred schemes.

Areas where it is clear that the funding gap will be extremely large due to poor CBA results have not been assessed to the same level of detail. In these cases alternative management and maintenance approaches have been identified.

2. The case for change (strategic case)

2.1 Strategic context

The problem and the need for intervention is fully detailed in the Technical Report (Appendix 1) and summarised in business case format in the draft preliminary Outline Business Case (pOBC) (Appendix 7). These documents describe how the landslide risk is directly related to the continued protection of the toe of the complex cliff. This protection takes the form of shoreline coastal protection measures (hard engineering), which should be maintained to prevent loss of slope support and unlocking of the deep landslide system. In addition, deep drainage is required to reduce land instability and ground movement, driven by the effects of excess rainfall and groundwater, to protect assets throughout the coastal slope including the coastal defences themselves.

GiA funding granted 20 years ago to a scheme for part of Wheelers Bay demonstrates an important precedent for understanding and dealing with coastal protection at locations which experience the dual threat of coastal erosion and instability. Indeed, this example is used in the EA's national guidance on 'Assessment of Coastal Erosion and Landsliding for the Funding of Coastal Risk Management Projects' (EA, 2010). The case study concludes by saying: 'Basis for grant in aid – a full consideration of cliff instability and erosion processes in a holistic manner identified major risks linked fundamentally with the sea.'

The pOBC (Appendix 7) summarises the continual risk from land movements throughout Ventnor. This can be continuous small-scale creep resulting in widespread minor damage, through to the lower frequency of a catastrophic landslide event, which could feasibly destroy large areas of Ventnor and threaten the future of the town in its current location. The technical mechanisms for these hazards are detailed in the QRA in the Technical Report (Appendix 1) and the risk of damage is assessed through the QRA process. The OBC summarises the consequences of "doing nothing" (Appendix 7, Section 2.6) and the QRA details these risks and their consequences (Appendix 1, Section 4).

2.2 The case for change

The Isle of Wight Core Strategy (adopted 2012) identifies Ventnor as an important hub (the largest town on the south coast) and, it was identified as a regeneration area due to its ongoing economic decline. The Strategy states that support will be given to proposals which maintain and support the sustainability of Ventnor. In recent years, investment and confidence in Ventnor has grown. The new draft Island Planning Strategy (consulted upon in February 2019) continues to highlight the importance of effective management of risks and ensuring development is sustainable in this area.

The Isle of Wight Shoreline Management Plan (SMP) (IWC, December 2010) defines a Hold the Line policy for the full developed Ventnor frontage for all epochs (up to 2105), Policy Unit 4A.2. The exception is the "Landslip" Landslide Reactivation Unit (LRU), located at the far east of the study area (SMP Policy Unit PU4A.1). This single frontage has a policy of No Active Intervention (NAI) for all epochs. There are no existing defences at this location. Similarly, to the west of the Study area the relatively undeveloped and undefended coast of the Undercliff will continue to evolve naturally. The focus of this report is future risk reduction along the highly developed coastal town and frontage from Monks Bay to Steephill Cove, which is vulnerable to coastal erosion and coastal landslide reactivation, especially with regard to the predicted impacts of climate change of rising sea level and increasing winter rainfall.

2.3 Objectives

The main overarching objective is to provide coastal erosion and flood risk benefits to existing properties and the area as a whole. The majority of the funding for a future risk reduction scheme will come from FDGiA, which is justified as the scheme protects local communities and makes them flood resilient over the longer term by mitigating the impacts of deteriorating coastal defence assets, sea level rise and excess groundwater on pre-existing coastal landslide units.

The investment objectives of the project are:

- Establish a preferred option that provides a consistent SoP throughout Ventnor which is resilient/adaptive to climate change;
- Deliver OM3s which contribute to the Environment Agency's corporate commitment (target: 791 properties by 2027 i.e. 791 OM3s. NB, this is a proportion of the 2,911 total number of properties which would have risk reduced by a priority scheme proposed);
- Deliver the project in an efficient manner that results in project cost savings (target: 10% saving at FBC stage); and
- Seek and secure partnership funding to achieve an adjusted partnership funding score of more than 100%.

Further objectives essential for sound investment decision-making require working with key partners and the local community to develop an acceptable, least cost, technically suitable, environmentally best, long term solution. As well as protecting homes and the community, the scheme will also:

- Contribute to the protection of natural resources and the conservation or enhancement of the environment
- Minimise and mitigate the adverse impacts and safety and environmental risks that may result from the project.

2.4 Current strategic arrangements

The current measures to manage the probability and consequences of coastal erosion and landslides is described in detail in the Technical Report (Appendix 1) supported by the Defence Appraisal (Appendix 10 of Appendix 1).

All of the Ventnor and Bonchurch frontage is at risk from coastal erosion and landslides. In line with the Hold the Line SMP policy for the majority of the frontage, the coastline is protected by near continual coastal defence measures. These measures of varying ages include seawalls, revetments, breakwaters, managed beaches and beach control structures (groynes). In addition, there are a number of small cliff and landslide stabilisation measures such as slope drainage, slope re-profiling, and structural measures. The historical investment to manage the risk has been significant, which is attributable to the high value of the built assets and investment in the town.

2.5 Main benefits

The Do Nothing scenario will result in the following:

- Failure of existing coastal defences, leading to severance of public coastal access
- Erosion of the cliff toe and loss of slope support leading to localised landslides
- Unloading and removal of bulk weight at the toe of the cliff, increasing likelihood of deep landslide movements
- Deep-seated movement of lower-tier landslide blocks, causing loss of support to the upper-tier landslide blocks, and leading to severe land instability on a large scale
- Damage to property, infrastructure, the extent and severity of which will increase over time
- Increased risk to life as property and infrastructure is damaged and destroyed
- Loss of access due to breaching of the main roads into Ventnor contributing to economic decline of the town and potential future abandonment of the town

Do Nothing damages are detailed in the Section 4.3 of the Technical Report (Appendix 1). Over the 100-year appraisal period nearly 4,000 properties are at risk, and in a conservative assessment, Do Nothing could lead to total PV damages of £455 million (or £1.7bn in cash cost), or the loss of the equivalent of 2,288 properties. These property damages are distributed along the Ventnor/Bonchurch frontage as defined in Table 1.

Table 1. Do Nothing damages over 100-years appraisal period for the LRUs

Landslide Reactivation Units (LRU)	Number of residential and non-residential properties at risk of damage in LRU	Total Damage, £ (cash cost, undiscounted)	Total Damage, £ (PV, discounted)	Equivalent residential and non-residential property numbers written-off (over 100 years)	Potential OM3s over 59 year benefit period
Castle Cove	156	162,769,727	34,959,027	79	30
Ventnor Park	552	284,748,482	76,391,515	412	217
Central Ventnor	1,412	605,442,322	172,483,747	740	268
Wheelers Bay	947	477,401,224	132,905,507	633	306
Bonchurch West	606	118,637,645	25,414,667	333	181
Bonchurch East	128	39,400,345	11,048,343	67	22
The Landslip	77	6,271,091	1,564,651	23	2
Total	**3,878**	**1,694,670,838**	**454,767,456**	**2,288**	**1,027**

A scheme to reduce the coastal defence failure probability and causes of landslide ground movement would stabilise the landslide system and significantly reduce the risk of adverse damage and losses described in the 'Do Nothing' scenario. Outcome Measures would be limited to erosion damages (OM3), for which an improved scheme for all LRUs would contribute an equivalent of 1,027 properties (if sufficient funding was available).

3. Options appraisal and economic appraisal (economic case)

The objective of this section is to identify the preferred option (e.g. capital scheme, maintenance, do nothing) for each part of the frontage at Ventnor and Bonchurch via a phased appraisal of options (Cost Benefit Analysis then Partnership Funding calculations) in accordance with the requirements of the latest FCERM and HM Treasury Guidance.

The options appraisal, economic appraisal and options selection comprises three stages to represent the complexity of the full Ventnor frontage:

- **Stage 1: Individual coastal asset option identification** – Costs are defined for options to maintain and improve each coastal asset (Defence Unit). Failure probabilities for options at each asset are identified but this is not translated into damages. No Cost Benefit Analysis (CBA) has been undertaken at this stage.
- **Stage 2: Grouping of coastal and drainage options for each Landslide Reactivation Unit (LRU)** – This groups similar coastal asset management options from Stage 1 at LRU level. For each LRU, the economic assessment takes the combined costs for the individual coastal defence assets and drainage costs. The damages are derived by identifying the weakest link, or asset in the poorest condition, from all the coastal assets in a LRU for a given option. The failure probabilities are linked through to a QRA model for each LRU. A CBA is undertaken for each LRU to identify a preferred overall management option for each LRU.
- **Stage 3: Grouping of LRU options to identify a package of priority works** – This identifies a package of preferred options from Stage 2, grouping them so that there is an economically deliverable programme of works. A CBA is undertaken for the grouped package of works to identify the economic case for delivery of the package of priority works.

Stages 1 and 2 are described in more detail in Section 3 of this report and in the Technical Report (Appendix 1).

3.1 Summary of Stage 1 (Defence Unit level) options appraisal and economic assessment

This level of economic assessment looks at the costs associated with options at a coastal defence asset level i.e. it appraises engineering issues and solutions at the Defence Unit level.

3.1.1 Options

The various coastal Defence Units (frontages) covering the study frontage are defined within the Shoreline Management Plan (SMP, 2010). The Defence Units are defined by individual defence IDs e.g. IW30 / 001. Each shoreline Defence Unit incorporates various engineering assets for that frontage, including the shoreline structures (seawalls, revetments), beach control structures (groynes), offshore structures (breakwaters) and set-back defence elements (set back flood walls/gabions etc) associated with providing the standard of protection for the given frontage.

The Defence Appraisal (Appendix 10 of Appendix 1) is used to identify the engineering assets within each Defence Unit that are below standard or vulnerable to various failure modes. The Defence Appraisal defines the probability of failure from various failure mechanisms. The representative summary failure probability for the Defence Unit is used to generate the damages (see below).

In response to the deficiencies in the coastal assets identified and detailed in the Defence Appraisal assessment, a number of engineering options have been considered to reduce the risk of failure. This is a relatively high-level strategic assessment only and a fully detailed long list and short list appraisal would be required at the appraisal stage. The options considered for each Defence Unit are as follows:

- The **Do Nothing** (No Active Intervention) option is used as a baseline against which all other options are appraised.

- The **Do Minimum** management option has no capital works associated with it. Such options would not improve the standard of protection to a consistent or acceptable standard (where needed), but may serve to maintain a given standard, but the risk of failure will increase over time. This option reflects the level of maintenance that is typically currently undertaken along each frontage, based on data supplied by the IWC for recent years
- Multiple **Improve** options have been identified in long list form to maintain and improve the engineering assets to prevent erosion of the shoreline and the risk of landslide reactivation. These represent engineering options to reduce the probability of failure (improve the standard of protection) for a given defence. These are presented as **Improve 1**, **Improve 2**, **Improve 3** etc.

The options identified above are presented in tabular form for each Defence Unit in Appendix 8 of the Technical Report (Appendix 1). A full scheme-level options appraisal would be required at Outline Business Case stage and has been costed for in the following chapters of this report. This would include reconsidering and reconfirming the long list of options, the identification of a short list of options (where various standards of protection could be considered alongside a range of engineering solutions) and the identification of the preferred option through the outline design process. To date the costing has assumed that defences will be upgraded to provide a consistent SoP that is likely to be around a 1 in 200 standard (inclusive of climate change impacts over its design life). The most cost-effective consistent SoP would be identified during the early design stages at OBC stage.. The short-listing process would use results from surveys (geotechnical site investigation, topographic survey, environmental surveys etc), coastal processes assessment and analysis.

This strategic review of engineering options for the Defence Units (Appendix 8 of Appendix 1) identifies engineering options for the Do Minimum and Improve options introduced above. In summary it provides the following for each Defence Unit:

- The ID, description, frontage length and condition grade (which links to the Defence Appraisal in Appendix 10 of Appendix 1);
- A brief written description of the proposed engineering works;
- Identification on whether a given option is taken forward to the Stage 2 options assessment (refer to Section 3.2.1). This section also describes how Improve 1, 2, 3 etc. from Stage 1 translate to Improve A, B, C etc options in Stage 2. Engineering judgement has been used to take the most viable engineering option for a given frontage through to Stage 2 (this would need further consideration at scheme appraisal stage).
- The proposed interventions timing within the appraisal period (used for the Stage 2 CBA);
- The basis for the costing (refer to Section 3.1.2);
- The initial failure probability (following the intervention for the improve options), which is used for the benefits assessment in Stage 2 (refer to Section 3.2.3);
- The incremental failure probability expressed as a percentage representing the ongoing deterioration of assets over time, which is used for the benefits assessment in Stage 2 (refer to Section 3.2.3);
- General notes relating to the Defence Unit; and
- Links to geomorphology.

Further detail is included in the Technical Report (Appendix 1).

It should be noted that there are limited coastal defence methods/options due to the relatively exposed alignment of the frontage and nature of the site. Most Defence Units are likely to require a robust shoreline defence located at the toe of the cliff to protect the mostly continual promenade and coastal cliffs cut into the toe of the landslide complex. Typical methods proposed for this are **rock armour revetment, concrete revetment and concrete seawall**. Options to increase the beach width through the provision of beach control structures

such as groynes are unlikely to be viable for much of the frontage but may be viable alongside shoreline parallel structures. Breakwaters may be viable but are unlikely to be cost effective and are likely to adversely impact on offshore environmental designations and features. Shoreline parallel structures will also provide additional toe weight to the base of the cliff, bringing further slope stabilisation benefits.

3.1.2 Costs

The Technical Report (Appendix 1) outlines the basis of the cost estimates for the various short-listed options on a Defence Unit basis.

There are no costs associated with the Do Nothing scenario. It is assumed that costs for closing footpaths and signage (managing H&S) would be covered by existing council budgets.

The cost estimates for the Do Minimum option are considered as annual costs, which links typical annual expenditures on these frontages.

The cost estimates for the Improve options are based on contractor priced or outturn construction prices for similar, recent UK coastal engineering schemes. Typically, these contractor-costed schemes have been broken down to provide a typical cost per metre length of frontage for the types of interventions proposed for Ventnor (scaled up or down to reflect where required). The cost estimates for the more active maintenance components such as beach recycling and rock placement at the toe of structures have been assessed by assuming a quantity of material (for beach recycling) or a length of frontage covered (for toe rock) and taking unit costs from similar recent priced schemes. These costs include for contractor's preliminaries and profit (typically totalling 30%).

Optimism bias is included in Stage 2. Refer to Section 3.2.2 for more information.

3.1.3 Benefits

Landslide reactivation could occur if any one of the coastal defences fails in a given LRU. Hence, it is not possible to separate the damages for a single coastal defence asset.

The probability of failure of a given defence has been identified for the various options described above. This is used do derive the benefits in Stage 2.

3.1.4 CBA

Not undertaken at this Stage as benefits are considered as a single LRU in Stage 2.

3.2 Summary of Stage 2 (Landslide Reactivation Unit level) options appraisal and economic assessment.

This level of economic assessment looks at the costs associated with options at LRU level i.e. it groups various options from the Defence Unit level (Stage 1) and considers suite of engineering options that would be required to deliver benefits for a given landslide reactivation unit (LRU). This level also considers the drainage works options within the LRU. There are seven LRUs across the 4km frontage, as shown in Figure 2.

3.2.1 Options

The identified LRUs do not link directly to the single Defence Units appraised under Stage 1. The links between the two (LRU Stage 2 and Defence Unit Stage 1) are summarised in Table 2. There can be a number of coastal defence assets (structures) within each Defence Unit.

Table 2. Links between LRUs and Defence Units

Landslide Reactivation Units (LRU)	Defence Unit(s)							
Castle Cove	36/001	36/002	36/003	36/004	36/005	36/006	36/007	36/008
Ventnor Park	35/002	35/003	35/004	35/005				
Central Ventnor	33/002	34/001	34/002	34/003	34/004	35/001		
Wheelers Bay	32/001	32/002	32/003	33/001				
Bonchurch West	31/002 (part)							
Bonchurch East	30/001	30/002	30/003	31/001	31/002 (part)			
The Landslip	No coastal defences in landslide unit							

The Stage 2 LRU level options are groupings of the Defence Unit options within each LRU:

- The **Do Nothing** (No Active Intervention) option is used as a baseline against which all other options are appraised.
- The **Do Minimum** management option has no capital works associated with it. Such options would not improve the standard of protection to a consistent or acceptable standard (where needed), but may serve to maintain a given standard, but the risk of failure will increase over time. This option reflects the level of maintenance that is typically currently undertaken along each frontage, based on data supplied by the Isle of Wight Council for recent years
- Multiple **Improve** options have been identified. These represent management options to improve the standard of protection:
    - **Improve option A** considers the initial replacement of all failing engineering assets (structures), plus drainage. All engineering assets are then subject to an active and aggressive maintenance regime, but such measures would take place largely on a reactive basis, typically as emergency capital works. This may involve placing rock at the toe of a structure before it becomes critically exposed, or more active local beach recycling. This asset management option seeks to maximise the residual life of the asset.
    - **Improve options B and C** seek to uniformly improve the protection to a 0.005% (1 in 200 year) standard of protection for the Defence Unit, replacing assets as required under a full capital works and maintenance programme, plus drainage. Engineering judgement has been used for this strategic level assessment to identify the engineering measures required and the most viable option to progress. Options B and C represent two such representative engineering options (concepts) to consider for the strategic economic case (for some assets only one option, Option B, has been identified). Option C typically brings the programme forward for future capital schemes identified in Improve B. A full options appraisal stage would be required where an economically viable priority scheme is identified within the strategic programme of works for a given frontage.

Further details on the coastal defence options are included in the Technical Report (Appendix 1). It should be noted that (as detailed in section 3.1.1) there are limited coastal options/methods of coastal defence which are suitable, due to the relatively exposed alignment of the frontage and nature of the site (i.e. the combined risks of aggressive coastal erosion and local incipient, shallow and ongoing, deep-seated slope stability issue negate the effectiveness, and therefore viability, of many typical coastal defence solutions).

The proposed drainage comprises a network of boreholes which reduce groundwater pressure on a landslide shear surface by removing water from the system. The wells will be designed based on the ground investigation and monotiling described in Section 6. Further details of the proposed drainage is provided in Section 5.2 of the Technical Report (Jacobs, 2019)

3.2.2 Costs

Capital and Maintenance Costs

The coastal costs are aggregated for the suite of engineering schemes identified at the Defence Unit level in Stage 1 i.e. the overall LRU cost for each option is the summation of all the relevant Defence Unit option costs in a given LRU. These costs over the 100-year appraisal period are presented in Appendix 9 of the Technical Report (Appendix 1) and are summarised in Table 3 below (excludes optimism bias).

The timing of the coastal interventions at each Defence Unit is based on the point at which the defence is expected to degrade to such a point that the risk of failure becomes unacceptable. Refer to Section 5.3 of the Technical Report for more info.

The deep drainage costs for each LRU are presented in Section 5.2.5 of the Technical Report and are summarised in Table 3 below.

The cost of maintaining the drainage wells is included in the costs for coastal maintenance in Section 5.3.2 of Appendix 1. Drainage maintenance cost isn't reported separately because there is significant cost uncertainty relating to the type of drainage deployed, the local ground conditions and how quickly ground movement can be arrested. As such, any figures quoted could later be misleading. The cost associated with the maintenance of drainage is significantly less than coastal maintenance such as beach recharge/recycling, structural repairs and the import of rock. By proposing a healthy budget for a robust regime of coastal maintenance, provision has been made for maintaining the drainage wells.

Table 3. Estimated cash cost of coastal interventions, coastal maintenance, drainage and total combined costs by LRU (over 100 years) for all options.

Landslide Reactivation Unit	Expenditure Type	Estimated cash costs (not discounted) of options (£) over 100 years*				
		Do Nothing	Do Minimum	Improve A	Improve B	Improve C
Castle Cove	Drainage	-	-	£2,362,000	£2,362,000	£2,362,000
	Coastal	-	-	-	£3,067,000	£3,067,000
	Maintenance	-	£800,000	£1,334,000	£957,000	£814,000
	Total	**-**	**£800,000**	**£3,696,000**	**£6,386,000**	**£6,243,000**
Ventnor Park	Drainage		-	£3,542,000	£3,542,000	£3,542,000
	Coastal	-	-	-	£3,517,000	£3,517,000
	Maintenance	-	£600,000	£1,113,000	£625,000	£530,000
	Total	**-**	**£600,000**	**£4,655,000**	**£7,684,000**	**£7,589,000**
Central Ventnor	Drainage		-	£3,542,000	£3,542,000	£3,542,000
	Coastal	-	-	£3,801,000	£8,041,000	£8,041,000
	Maintenance	-	£1,400,000	£2,100,000	£1,511,000	£1,511,000
	Total	**-**	**£1,400,000**	**£9,443,000**	**£13,094,000**	**£13,094,000**
Wheelers Bay	Drainage		-	£2,362,000	£2,362,000	£2,362,000
	Coastal	-	-	£3,202,000	£7,658,000	£7,713,000
	Maintenance	-	£1,100,000	£799,000	£627,000	£599,000
	Total	**-**	**£1,100,000**	**£6,363,000**	**£10,646,000**	**£10,674,000**
Bonchurch West	Drainage		-	£3,542,000	£3,542,000	£3,542,000
	Coastal	-	-	-	£14,250,000	£14,250,000
	Maintenance	-	£400,000	£900,000	£609,000	£492,000
	Total	**-**	**£400,000**	**£4,442,000**	**£18,401,000**	**£18,284,000**

Landslide Reactivation Unit	Expenditure Type	Estimated cash costs (not discounted) of options (£) over 100 years*				
		Do Nothing	Do Minimum	Improve A	Improve B	Improve C
Bonchurch East	Drainage		-	£2,362,000	£2,362,000	£2,362,000
	Coastal	-	-	-	£6,311,000	£7,019,000
	Maintenance	-	£1,000,000	£2,179,000	£1,123,000	£960,000
	Total	**-**	**£1,000,000**	**£4,541,000**	**£9,795,000**	**£10,340,000**
The Landslip	Drainage		-	£738,000	£738,000	£738,000
	Coastal	-	-	-	£4,685,000	£4,685,000
	Maintenance	-	£50,000	£270,000	£150,000	£250,000
	Total	**-**	**£50,000**	**£1,008,000**	**£5,572,000**	**£5,672,000**

*Values have been rounded to the nearest thousand. Values do not include optimism bias or appraisal and design costs.

Appraisal, design, consenting and construction supervision costs

The costs outlined in Section 5 of this report have been used in the economic assessment for the package of initial priority schemes at Wheelers Bay, Central Ventnor and Ventnor Park (the costs have been apportioned to the three LRUs for these initial works). For the capital works in other LRUs and for future schemes, the appraisal/design/supervision costs have been conservatively assumed as 20% of the capital costs.

Optimism Bias

In line with the appraisal guidance a 60% optimism bias has been applied to all capital and appraisal costs to reflect the strategic level of the options/cost assessment.

A 19% optimism bias has been applied for all maintenance costs. This reflects the mix of maintenance costs within the economic cost profile. The maintenance costs comprise regular (annual), lower value maintenance costs mixed with infrequent, more significant coastal asset repairs. The annual maintenance costs are in part drawn from current maintenance costs, so a 0% optimism bias would be appropriate. The infrequent, higher value maintenance costs are drawn from high level cost estimates, so these should be subjected to a 60% optimism bias. An overall 19% Optimism bias was determined by looking at the relative mix of annual maintenance costs to one off more significant repairs (refer to Table 4).

Table 4 Deriving optimism bias for maintenance costs over 100 years, in terms of cash cost

	Ventnor Park	Central Ventnor	Wheelers Bay	Combined
Total maintenance costs (comprising annual, smaller value maintenance and large, less frequent maintenance events)	£625,000	£1,510,500	£626,500	£2,762,000
Annual maintenance only (no optimism bias required)	£515,000	£962,000	£416,000	£1,893,000
Large maintenance only (without optimism bias)	£110,000	£548,500	£210,500	£869,000
% Large maintenance	18%	36%	34%	31%
Large maintenance only (with 60% optimism bias applied)	£176,000	£877,600	£336,800	£1,390,400
Total maintenance costs inclusive of Optimism Bias	£691,000	£1,839,600	£752,800	£3,283,400

	Ventnor Park	Central Ventnor	Wheelers Bay	Combined
Overall optimism bias % (using 0% on annual and 60% on large)	10%	22%	20%	19%

3.2.3 Benefits

Benefits from preventing landslide reactivation are considered at this LRU level. Benefits include damage avoided to property (residential and commercial), tourism, transport (highways and footpaths), traffic disruption, utilities and services and emergency response.

Damages for the more significant landslide reactivations scenarios have been assessed using the highest probability of failure of a given defence within a LRU (the “weakest link”) for a given option described above. The defence with the highest residual probability of failure for a given year (within a given LRU) is used to generate damages. This complex quantitative risk assessment (QRA) is described in detail in the Technical Report (Appendix 1).

Development of the QRA in this study has involved detailed analysis of the following cliff behaviour and consequence parameters:

- the full extent of the cliffs, landslides, systems and processes
- the types of contemporary ground movement
- the frequency of landslide events
- the causes of landslides, including antecedent rainfall, groundwater and coastal erosion
- the predicted impacts of climate change including sea level rise and increasing winter rainfall
- the impact of ground movement in built up areas
- the extent, condition and economic value of the assets at risk
- the vulnerability of buildings, infrastructure and services to cliff instability and ground movement (Appendix 1, Section 4.3)
- the cost and impact on risk reduction of all feasible future coastal defence and cliff stability management/engineering options.

The economic damages are linked to the various landslide reactivation scenarios within the QRA. The output from the QRA is a series of damages for each of the options (Do Nothing, Do Minimum and Improve A, B & C).

3.2.4 CBA background

This section provides a summary of the cost benefit analysis detailed in Section 6 of the Technical Report (Appendix 1) which assesses the economic viability of the various coastal erosion and landslide mitigation options put forward in Section 5 of the Technical Report. The cost benefit of each option has been tested in full accordance with all relevant requirements and latest national and latest FCERM and HM Treasury Guidance using the Environment Agency’s “Supporting Spreadsheet to the Economic Appraisal for a Flood or Coastal Erosion Risk Management Project” (based on older Defra Project Appraisal Guidance (PAG) spreadsheet, corrected and updated to reflect the new FCERM-AG). The full life cycle cost of each option has been compared to the reduction in PV damages benefit.

3.2.5 CBA method and calculations

The aim of the cost benefit analysis is to identify where strategic level priority schemes have a robust case for Grant in Aid (GiA) funding. The CBA achieves this by calculating a ratio of the total expected cost of the range of management and engineering options against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

In the first part of this analysis, the results are expressed as a single number known as the benefit cost ratio (BCR). If this number is less than 1, the cost of the scheme outweighs the benefits; if the number is greater than

1 it shows the beneficial return of investment i.e. a BCR of 2 means for every £1 spent on engineering £2 of benefit is realised.

To enable selection of options which provide the greatest amount of protection but not necessarily the highest BCR, the second part of this analysis expresses results as an incremental benefit cost ratio IBCR. The procedure works by considering progressively higher-protection options. At each stage, a higher-protection option is accepted in preference to a lower-protection option if the incremental benefit–cost ratio is greater than a specified critical value.

The benefit of a scheme is the reduction in risk, expressed in monetary terms, compared to the 'no active intervention' case. The costs include all the costs incurred during the investigation, planning and design, construction and implementation of the scheme. Both benefits and costs are considered over the appraisal period of 100 years and related to Present Value by discounting in accordance with HM Treasury guidance.

3.2.6 CBA results

The CBA results (presented in Table 5) demonstrate that the existing coastal and cliff stabilisation schemes and practices (do minimum) adopted at Ventnor and Bonchurch have moderately reduced economic risk across the study site. However, the risks could be reduced significantly further by improving the overall stability of the Undercliff through deep drainage and improved coastal protection measures. In summary:

- The Improve B option (deep drainage and new and upgraded coastal defences) is the preferred option at Castle Cove, Ventnor Park, Central Ventnor and Wheelers Bay where the greatest value of assets are protected and/ or at least one of the coastal defences is in very poor condition.
- The Improve A option (drainage and coastal schemes targeted at failing assets and maintenance elsewhere) is the preferred option at Bonchurch West and Bonchurch East where more moderate assets values are protected.
- At a strategic level over 100 years there are economically viable schemes at Castle Cove, Ventnor Park, Central Ventnor and Wheelers Bay.
- At a strategic level over 100 years there are potentially economically viable schemes at Bonchurch West and Bonchurch East.
- There is unlikely to be an economically viable scheme at The Landslip due to the relatively low asset values protected. However, it is noted that the A3055 coastal road forms part of the Island's strategic road network linking the Undercliff with Shanklin and is at risk of breaching in the future from landslide reactivation and recession landward of the Devil's Chimney.

Table 5 Benefit Cost Ratio (BCR) and Incremental Benefit Cost Ratio (IBCR) for each LRU (preferred options in bold)

Landslide Reactivation Unit	Economic Parameter	Benefit Cost ratio (BCR) and Incremental Benefit Cost Ratio (IBCR) for each LRU option over 100 years			
		Do Minimum	**Improve A** (drainage, targeted new coastal defences and maintenance)	**Improve B** (drainage and new and improved coastal defences)	**Improve C** (drainage and early intervention new and improved coastal defences)
Castle Cove	BCR	3.8	5.7	**5.3**	4.7
	IBCR		5.8	**3.4**	0.4
Ventnor Park	BCR	6.3	7.7	**8.2**	7.8
	IBCR		7.7	**11.0**	0.0
	BCR	1.1	9.4	**9.8**	N/A

Landslide Reactivation Unit	Economic Parameter	Benefit Cost ratio (BCR) and Incremental Benefit Cost Ratio (IBCR) for each LRU option over 100 years			
		Do Minimum	**Improve A** (drainage, targeted new coastal defences and maintenance)	**Improve B** (drainage and new and improved coastal defences)	**Improve C** (drainage and early intervention new and improved coastal defences)
Central Ventnor	IBCR		9.8	**14.8**	N/A
Wheelers Bay	BCR	1.0	8.7	**7.7**	7.5
	IBCR		9.0	**4.5**	4.1
Bonchurch West	BCR	8.9	**2.8**	2.0	1.5
	IBCR		**2.6**	0.3	0.0
Bonchurch East	BCR	0.8	**1.5**	1.1	0.9
	IBCR		**1.6**	0.3	0.3
The Landslip	BCR	0.0	0.3	0.2	0.1
	IBCR		0.4	0.1	0.0

NB the preferred option for The Landslip is 'Do Nothing'.

The preferred options for each LRU are listed individually, but each LRU is also influenced by its neighbours in terms of slope stability and coastal processes, so it is essential to consider management actions across the study area in a coordinated way.

3.2.7 Outcome Measures and Partnership Funding Scores

The economically preferred options for each LRU (refer to Section 3.2.6) have been assessed using Defra's Partnership Funding Calculator. Each LRU has been assessed on the assumption that it is delivered as a single package of works. This is an acceptable approach as the benefits are largely limited to within a single landslide unit i.e. there will not be any significant overlapping benefits to consider. By considering each LRU, this is considered to be a strategic approach to managing the risk.

As per guidance, the benefits period for the partnership funding calculation has been capped to the point at which the next significant capital investment is required (>20% of the initial scheme capital costs). This doesn't imply that the capital schemes will be rebuilt, rather that other defences in the LRU at the end of their serviceable life will require rebuild. For Ventnor Park, Central Ventnor and Wheelers Bay, this is 59 years. For Castle Cove, Bonchurch West, Bonchurch West and the Landslip the benefits period is 99 years.

The outputs from the LRU level partnership funding calculations are presented in Table 6. For completeness, The Landslip has been included in table 6 assuming Improve A option benefits and costs, despite no active intervention (NAI) being the preferred economic solution.

Table 6 Partnership Funding outputs for the LRUs where interventions have been considered.

Contributions to Outcome Measures (OM)	Castle Cove	Ventnor Park	Central Ventnor	Wheelers Bay	Bon-church West	Bon-church East	The Landslip
OM1: Economic Benefit							
Present Value (PV) Benefits, £k	25,866	50,230	110,795	77,429	16,174	6,874	420
Present Value (PV) Costs, £k	4,785	6,251	11,829	10,969	5,674	4,304	1,200
Scheme Benefit/Cost Ratio (>5 in bold)	5.41	8.04	9.37	7.06	2.85	1.60	0.35
Potential contributing FDGiA from OM1, £k	1,362	2,144	5,343	3,361	505	296	18
OM2: Households better protected against flood risk (Nr)							
Properties (No).	0	0	0	0	0	0	0
OM3: Households better protected against coastal erosion							
20% most deprived areas (Nr)	0	0	215	92	0	0	0
21-40% most deprived areas (Nr)	0	22	54	214	181	22	2
60% least deprived areas (Nr)	30	195	0	0	0	0	0
Potential contributing FDGiA from OM3, £k	269	2,445	6,142	5,840	2,125	464	29
OM4: Statutory environmental obligations met							
OM4 contributions	0	0	0	0	0	0	0
Partnership Funding calculation							
Raw Partnership Funding Score (>50% in bold)	34%	**73%**	**97%**	**84%**	46%	18%	4%
Potential contributing FDGiA towards scheme, £k	1,631	4,588	11,485	9,201	2,630	760	47
External PV Contribution or saving required to achieve an Adjusted Score of 100%, £k	2,929	1,601	330	1,738	2,876	2,943	1,073
Benefit Period, years	**99**	**59**	**59**	**59**	**99**	**99**	**99**

Contributions to Outcome Measures (OM)	Castle Cove	Ventnor Park	Central Ventnor	Wheelers Bay	Bon-church West	Bon-church East	The Landslip
Economically preferred option used for PF calculation	Improve B	Improve B	Improve B	Improve B	Improve A	Improve A	Improve A

The initial PF% score for Ventnor Park, Central Ventnor and Wheelers Bay are all in excess of 70%, which presents a very positive basis for which to promote a scheme. These LRUs cover all priority coastal works where defences are in a very poor/failed state.

Castle Cove has a BCR greater than 5 but the initial PF% score is only 34% (the contributing OM3s are only 30 properties). This would require a significant partnership funding element of approximately £1.6m to allow this option to be viable. There are no urgent coastal defence works in this LRU, but deep drainage works would prove beneficial should additional contributions be forthcoming.

Bonchurch West has a low BCR of 2.8, but with 181 potential OM3s, the PF% is 46%. Again, this would require a significant partnership funding element of approximately £2.6m to allow this option to be viable. As with Castle Cove, there are no urgent coastal defence works in this LRU, but deep drainage works would prove beneficial should additional contributions be forthcoming.

It should be noted that the OM3s identified represent the total damage avoided cost as an equivalent number of properties. The number of properties that will have improved protection against landslide are greater than the OM3s identified. For example, at Ventnor Park, Central Ventnor and Wheelers Bay, the total number of properties that will have improved protection would be 2069 residential and 842 non-residential properties, compared against the 791 OM3s identified.

3.2.8 Options to take forward to Stage 3

There are economically viable schemes comprising deep drainage and new and upgraded coastal defences (Improve B) in the landslide reactivation units (LRUs) with high total asset values (Ventnor Park, Central Ventnor and Wheelers Bay). These LRUs have been identified to be taken forward to Stage 3 as this produces the most robust cost model for a programme that will meet partnership funding requirements. These LRU's cover all of the most urgent coastal works identified through the Defence Appraisal (see Appendix 10 of Appendix 1).

Improve B at Castle Cove has a relatively robust and positive cost benefit, but inclusion of this LRU in the priority package of works in Stage 3 would result in a dilution of the benefits and an increased requirement for third party contributions. There are no urgent priority coastal works in this LRU. Should cost savings be identified at the appraisal stage, or if significant third-party contributions be forthcoming, the inclusion of the drainage works for Castle Cove should be considered within the priority package of works.

Schemes at Bonchurch West and Bonchurch East comprising drainage and coastal schemes targeted at failing assets (Improve A) are potentially viable but will likely require significant partnership funding to proceed. Schemes at these frontages are unlikely to be economically in the near term but changes in funding provision/rules and may make schemes viable in the future. In addition, as the coastal defences at Bonchurch West and Bonchurch East reach the end of their serviceable lives the risk profile of the LRU, and therefore scheme benefits, increases so that schemes will become economically viable in the medium to long term.

There is unlikely to be a viable scheme at 'The Landslip' in the east of the area where 'No Active Intervention' will continue, although the consequences of breaching the A3055, due to landsliding retreating upslope in due course, will have significant local and political impact.

3.3 Stage 3 (package of priority works) economic assessment and option selection for the business case

This level of economic assessment combines preferred options from Stage 2, but it only considers LRUs where there is a strong economic case identified at Stage 1. This appraisal represents a package of works that would be carried through and delivered under a single business case (which will bring efficiencies). By considering these engineering interventions together under a single business case (with shared costs and benefits) this ensures that a "strategic approach has been taken to avoid double counting of benefits" (Quote taken from PF Calculator which is posed as a question requiring a Y or N answer).

3.3.1 Options

As detailed in Section 3.2, the following LRU options have a robust BCR/iBCR and have been packaged together for further consideration:

- Ventnor Park – Improve B has a BCR of 8.2 and an iBCR of 11.0 over Improve A
- Central Ventnor – Improve B has a BCR of 9.8 and an iBCR of 14.8 over Improve A
- Wheelers Bay – Improve B has a BCR of 7.7 and an iBCR of 4.5 over Improve A

The works that have been identified as being required in the short term are packaged as the 'Priority Package of Works'. These comprise the following elements (with capital cash costs exclusive of optimism bias):

1) **Ventnor Park - Deep drainage wells (approx. £3,542k) – Installed in Year 5 following monitoring**
2) **Ventnor Park (IW35/003) - Rebuild encasement with drainage and increased rock revetment levels (approx. £137k) – Constructed in Year 3 at earliest point in funding cycle**
3) **Central Ventnor - Deep drainage wells (approx. £3,542k) – Installed in Year 5 following monitoring**
4) **Central Ventnor (IW33/002) - Replace structure with new 181m rock revetment with concrete upper seawall (approx. £3,801k) – Constructed in Year 3 at earliest point in funding cycle**
5) **Wheelers Bay - Deep drainage wells (approx. £2,362k) – Installed in Year 5 following monitoring**
6) **Wheelers Bay (IW32/001) - Replace structure with new 133m rock revetment with concrete upper seawall (approx. £2,793k) – Constructed in Year 3 at earliest point in funding cycle**
7) **Wheelers Bay (IW33/001) - Landslide drainage to reduce susceptibility to landslides and replace toe with new sheet piles and rock revetment to add toe support over 119m (approx. £1,747k) – Constructed in Year 3 at earliest point in funding cycle**

The total of the priority works listed above is £17,925,000 (cash cost).

The economic appraisal over 100-years includes the priority works above and all other future maintenance, capital and rebuild costs associated with the Improve B option at these three LRUs.

3.3.2 Costs

The costs for this assessment over the 100-year appraisal period are simply the aggregated costs for the various LRU options from Stage 2 for Ventnor Park, Central Ventnor and Wheelers Bay (refer to Table 7). The optimism bias allowances are as per Stage 2 (see Section 3.2.2).

Table 7 PV costs over appraisal period for combined option (includes capital, maintenance, appraisal and design costs, and optimism bias)

Option	PV costs over 100-yr appraisal period, PVc (£k)
Do Nothing	0
Do Minimum	1,100
Improve A	27,190
Improve B	32,048
Improve C	32,893

3.3.3 Benefits

The benefits for this assessment are the aggregated LRU benefits from Stage 2. As there are no overlapping benefits between the various LRU's, there is no risk of double-counting benefits.

3.3.4 CBA

The Cost-Benefit Analysis for the combined LRU proposal over the 100yr appraisal period is summarised in Table 8 below.

Table 8 CBA for combined scheme at Ventnor Park, Central Ventnor and Wheelers Bay

Option	PV Costs (£k)	PV Benefits (£k)	Average BCR	Incremental BCR (IBCR)	Option for IBCR
Do Nothing	0	0			
Do Minimum	1,100	2,293	2.1		
Improve A	27,190	238,137	**8.8**	9.0	DM
Improve B	32,048	277,889	8.7	**8.2**	A
Improve C	32,893	280,123	8.5	2.6	B

Improve A has the highest Benefit-cost Ratio of 8.8 but using the Decision Rules, Improve B is justified due to the IBCR of 8.2. Improve C is not justified as the iBCR is below 3.0. **Improve B is the economically preferred option.**

3.3.5 Outcome Measures and Partnership Funding Scores

Applying the benefits, costs and property protected over the 59-year benefits period into the Partnership Funding calculator provides the outputs summarised in Table 9. The Partnership Funding calculator for the priority scheme is provided in Appendix 4.

Table 9 Partnership Funding calculator inputs and results for the combined scheme at Ventnor Park, Central Ventnor and Wheelers Bay (over Benefits Period)

Contributions to Outcome Measures (OM)	OMs
OM1: Economic Benefit	
- Present Value (PV) Benefits	£238,453,791
- Present Value (PV) Costs	£29,048,976
- Scheme Benefit to Cost Ratio	8.21
Potential contributing FDGiA from OM1	£10,847,885
OM2: Households better protected against flood risk (Nr)	
Properties (No).	0
OM3: Households better protected against coastal erosion	
- 20% most deprived areas	307
- 21-40% most deprived areas	289
- 60% least deprived areas	195
Potential contributing FDGiA from OM3	£14,426,421
OM4: Statutory environmental obligations met	
OM4 contributions	0
Partnership Funding calculation	
Raw Partnership Funding Score	87%
Potential contributing FDGiA towards scheme	£25,274,306
External PV Contribution or saving required to achieve an Adjusted Score of 100%	£3,653,431
Benefit Period	59 years
Economically preferred option used for PF calculation	Improve B

A raw PR% of 87% is considered very robust in comparison to other nationwide schemes. The economics potentially generate £25.3m of funding, leaving a shortfall of only £3.7m (PV), or £4.2m (cash cost). Section 7 considers the funding sources and constraints in more detail for the package of priority works.

3.3.6 Sensitivity tests

To check that the preferred schemes are robust against uncertainties, sensitivity tests have been carried out on scheme costs, by varying optimism bias, and appraisal costs required at OBC and FBC, by comparing the lower, best and upper cost estimates (see Section 5 for breakdown of appraisal cost estimates).

Table 10 shows that reducing Optimism Bias to 30% pushes the PF score to over 100%, meaning the scheme would not require an external funding contribution. It also shows that even when Optimism Bias is increased to 90% the PF score is still relatively high at 75%.

Table 11 shows that varying the appraisal costs has a relatively small impact on the PF scores and external funding contributions required. This is because the appraisal costs are a relatively small component of the overall capital expenditure on a scheme. This table includes appraisal and detailed design costs which are found in Section 5 Appraisal costs and detailed design costs.

Table 10 Partnership Funding sensitivity tests on scheme capital costs (over Benefits Period using optimism bias)

Contributions to Outcome Measures (OM)	30% OB	60% OB (as used in economics/PF calculations)	90% OB
Present Value (PV) Costs (including capital, maintenance, and appraisal and design costs)	£24,368,821	£29,048,976	£33,729,130
Scheme Benefit to Cost Ratio	9.79	8.21	7.07
Raw Partnership Funding Score	104%	87%	75%
PV potential Local Levy Contributions	£0	£500,000	£500,000
PV potential IWC Contributions	£0	£1,500,000	£1,500,000
Additional External Contribution or saving required (PV) to achieve an Adjusted Score of 100%:	£0	£1,653,431	£6,220,943
Total contributions (PV) required to achieve Adjusted Score of 100%:	£0	£3,653,431	8,220,943

Table 11 Partnership Funding sensitivity tests on scheme appraisal costs via lower, best and upper cost estimates

Contributions to Outcome Measures (OM)	LOWER	BEST (as used in economics/PF calculations)	UPPER
Present Value (PV) Costs (including capital, maintenance, and appraisal and design costs)	£28,506,653	£29,048,976	£30,007,453
Scheme Benefit to Cost Ratio	8.36	8.21	7.95
Raw Partnership Funding Score	89%	87%	84%
PV Local Levy Contributions	£500,000	£500,000	£500,000
PV IWC Contributions	£1,500,000	£1,500,000	£1,500,000
Additional External Contribution or saving required to achieve an Adjusted Score of 100%:	£1,126,552	£1,653,431	£2,585,978
Total contributions (PV) required to achieve Adjusted Score of 100%:	£3,126,552	£3,653,431	£4,585,978

3.3.7 Variance from the standard appraisal guidance and OM3

To deal with the unique circumstances of the Undercliff at Ventnor and Bonchurch, it has been necessary to build a bespoke QRA to model the various hazard scenarios and their consequences. Qualifying benefits under OM3 relate to the reduction in direct damages to residential properties caused by eroding coastlines. At Ventnor and Bonchurch coastal erosion has far wider reaching consequences than would normally be expected of simple eroding cliffs because the Undercliff landslide complex extends up to 500 m landward of the shoreline and encompasses the majority of the built-up area.

As such, the QRA developed in the Technical Report (Appendix 1) doesn't consider the linear coastal erosion recession model used in OM3, rather the annual damages caused by cliff instability and erosion throughout the entire Undercliff, from the shoreline to the Undercliff headscarp. The QRA uses a probabilistic approach to modelling landslide hazards and the benefits of controlling coastal erosion and groundwater and acknowledges the fundamental link between cliff instability and erosion by the sea that is required to be considered for grant in aid under the Coast Protection Act 1949. This approach is wholly consistent with the EA guidance (FCERM-AG,

2010) and other complex coastal cliff stabilisation schemes at Castlehaven, Lyme Regis Phases II & III, East Cliff Phase IV, Fairlight Cove and Scarborough Spa.

Section 4.1.1 of the Technical Report details the divergence and rational for the divergence from standard Outcome Measures 3 (OM3) Appraisal Guidance.

The number of properties protected under OM3 has been calculated as follows:

- Damage caused by the lower severity and more frequent landslide scenarios 1 and 2 is not included as the minor damage to property is deemed not to accumulate to property write-off i.e. would result in repairs only. This does not contribute to OM3s.

- For the less frequent, but more severe scenarios 3, 4 and 5, landslide damage will result in written off property over time. However, not all properties impacted would result in write off in a single event. To define the total number of properties contributing to OM3, the total damage to all impacted properties over the benefits period (59 years) is divided by the average property value in the LRU. This calculation considers the probabilities of various scenarios occurring and the resultant damage. In practice, hazard scenario 5 would likely destroy property in a single event but this has been treated probabilistically.

For more information on the landslide scenarios, the probabilistic assumptions and the damage calculations, refer to the Technical Report.

4. Preferred capital schemes and maintenance (preferred option)

Below, Section 4.1 details the preferred capital schemes and maintenance options in each of the 7 LRUs. Section 4.2 focuses on the principles behind the coastal and drainage schemes proposed for Ventnor Park, Central Ventnor and Wheelers Bay, which together form the priority works. Section 4.3 provides details and costs for annual and ad-hoc maintenance proposed throughout the frontage.

4.1 Preferred options for all LRUs

A summary of the preferred capital and maintenance works for each of the LRUs over 100 years is outlined in Table 12.

For Ventnor Park, Central Ventnor and Wheelers Bay, the proposals in Table 12 are the priority package of works outlined by the Stage 3 economic assessment (Section 3.3). The main capital works for the proposed priority scheme of works is identified by bold text.

The capital and maintenance proposals identified for Castle Cove are for the economically preferred Improve B option. However, this LRU has been discounted from the priority scheme as it will adversely impact on the overall scheme affordability as it does not bring sufficient benefits. Improve B has been included for Castle Cove as at this option may be appropriate in the future as a stand-alone scheme. This may become increasingly viable as coastal defence capital works are required at the point at which one of the coastal defences reaches the end of its serviceable life and has to be replaced.

The proposals for Bonchurch West and East are Improve A, which represents a pro-active maintenance approach funded by IWC. As with Castle Cove, maintenance will continue until a future funding cycle where the continued deterioration of assets will improve CBA and PF score until the point that a scheme is warranted. Any future scheme could be delivered in these LRUs as a fresh FDGiA submission, separate to the benefits from the neighbouring Ventnor Park, Central Ventnor and Wheelers Bay LRUs used in the Priority Scheme. Partnership funding is also likely to be required in this area.

For details of the proposed works, refer to the Technical Report and its appendices. Section 5.2 of the Technical Report (Appendix 1) provides the objectives of drainage, different drainage options (pumped, syphon and relief wells), the cost estimates, the timing of interventions and the post-drainage landslide probabilities. Section 5.3 of the Technical Report identifies the coastal defence options, costs, proposed timing of the defence interventions, the links between the coastal structures and the landslide reactivation risk pre and post scheme.

Table 12 Type and year of each of the preferred stability and coastal defence interventions

LRU	Preferred option	Summary of coastal defence works	Coastal schemes and management strategy by asset	Slope stabilisation strategy
Castle Cove	Improve B (Improve A may be the only affordable option in the short term)	*Monitor, undertake repairs to seawall/rock structures and plan capital works prior to coastal structure failure. Placement of additional toe rock when seawall toe vulnerable. Localised beach recharge.*	IW36/001 - Monitor, patch/local repairs, repair rock if movement (assumed every 20yrs) and rebuild/strengthen revetment, seawall and gabions (Yr 60). IW36/ 002 - Monitor and repair rock if movement (assumed every 20yrs) and rebuild/strengthen groyne (Yr 60). IW36/003 - Monitor, patch/local repairs, repair rock if movement (assumed every 20yrs), rebuild/strengthen wall and rock structure and recharge with beach material (Yr 60). IW36/004 - Monitor, with repairs to concrete seawall and reposition and/or top up rock if movement (assumed every 20yrs), rebuild/strengthen wall and rock and recharge with beach material (yr 60). IW36/005 - Monitor and repair rock if movement (assumed every 20yrs) and rebuild/strengthen groyne and wall (Yr 60). IW36/006 & 007 - Monitor, with local repairs to seawalls as required and reposition and/or top up toe rock if movement/required (assumed every 20yrs) and rebuild wall with rock at toe (Yr 60). IW36/008 - Monitor, with local repairs to seawalls as required and reposition and/or top up toe rock if movement/required (assumed every 20yrs) and rebuild wall and revetment at end of serviceable life (Yr 60).	Pumped well drainage in the body of the landslide at the point at which one of the coastal defences reaches the end of its serviceable life and has to be replaced. As well as protecting property this scheme will prolong the lifespan of present and future coastal protection assets which is, in part, reliant on achieving slope stability.
Ventnor Park	Improve B	*Monitor, undertake repairs to seawall/rock structures and plan capital works prior to coastal structure failure. Placement of additional toe rock when seawall toe vulnerable. Localised wall drainage improvements.*	IW35/002 - Monitor with minor repairs, place additional rock in front of sections of wall that become vulnerable and rock repairs every 20yrs and then strengthening to structures at end of serviceable life (assumed yr60). **IW35/003 - Rebuild encasement with drainage and increased rock revetment levels as priority capital scheme** (Year 3 of the priority scheme). IW35/004 - Monitor with repairs to seawall rendering, additional rock added to the revetment as required, assume every 20yrs and rebuild seawall with increased rock revetment level (assumed yr60). IW35/005 - Monitor, re-position and/or top up rock if movement every 20yrs and rebuild/ strengthen groynes and increased rock revetment levels in yr60.	**Pumped and relief well drainage interventions at or close to the slope toe** from year 5 of the priority scheme when PV damages peak for rainfall triggered instability*. As well as protecting property this scheme will prolong the lifespan of present and future coastal protection assets which is, in part, reliant on achieving slope stability.
Central Ventnor	Improve B	***Priority capital works** for new revetment/ seawall. Monitor, undertake repairs to seawall/rock structures and plan capital works prior to coastal structure failure. Localised beach recycling.*	**IW33/002 - Replace structure with new rock revetment with concrete upper seawall as priority capital scheme** (Year 3 of the priority scheme) and pro-actively maintain. IW34/001, 002 & 003 - Monitor with minor repairs and rock repairs every 20yrs and significant repairs/strengthening to structures at end of serviceable life (assumed yr60). IW34/004 & IW35/001 - Monitor with minor repairs, reactive beach recycling on average every 10yrs, concrete repairs every 20yrs and strengthening to structures at end of serviceable life (assumed yr60).	

Wheelers Bay	Improve B	***Priority capital works*** *for new revetment/ seawall. Monitor, undertake repairs to seawall/rock structures and plan capital works prior to coastal structure failure. Placement of additional toe rock when seawall toe vulnerable.*	**IW32/001 - Replace structure with new rock revetment with concrete upper seawall as priority capital scheme** (Year 3 of the priority scheme) and pro-actively maintain. IW32/002 & 003 - Monitor, patch seawall repairs and rock repairs every 20yrs. IW33/001 - **Landslide drainage to reduce susceptibility to landslides and replace toe with new sheet piles and rock revetment to add toe support as priority capital scheme** (Year 3 of the priority scheme)**.**	
Bonchurch West	Improve A	*Monitor, undertake repairs and bring in additional toe rock as required.*	IW31/002- Monitor, patch repairs and extend and replace toe rock as required (assumed every 10-years). Rock will increasingly become more important in providing standard of protection as volumes increase over time.	
Bonchurch East	Improve A	*Monitor, undertake repairs and bring in additional toe rock as required. Localised beach recycling.*	IW30/001: Monitor, patch repairs, top up with additional rock (1-week of rock works every 10yrs for toe rock and 1-week rock works on groyne every 20-yrs). IW30/002 & 003 - Monitor, patch repairs to seawall, shingle recycling and shingle recharge/rock repairs every 20yrs. IW31/001 & 002- Monitor, patch repairs and extend and replace toe rock as required (assumed every 10-years)	

*Note: A drainage scheme is not currently assessed as affordable for Bonchurch West and East, where coastal defence maintenance is expected to continue, but the drainage approach is recommended for future consideration for this frontage, especially following further investigation into this method in the priority scheme for the more densely-developed neighbouring central Ventnor LRUs (Ventnor Park, Central Ventnor and Wheelers Bay first), and dependent on future funding availability.

4.2 Priority scheme

4.2.1 Introduction

As demonstrated in the Technical Report (Appendix 1), the principle behind combining coastal defences and drainage is that effective coastal management and landslide risk reduction at Ventnor requires solutions that deals with the primary causes of failure, coastal erosion and rainfall-groundwater. Without the coastal defences in place, toe erosion would cause a rapid decline in stability and widespread reactivation of the Undercliff landslide system, and potential significant damage to development and assets. With coastal defences preventing toe erosion, historical damage to coastal defence assets as well as property, services and infrastructure has been caused by ground movement due to the effects of rainfall and groundwater. Thus, alleviation of groundwater pressures together with coastal defence improvements will have the greatest beneficial effect in reducing coastal instability risk.

There is a good local example of this approach. In 2004, at Castlehaven in the Undercliff (6km to the east of the present study area of the town of Ventnor), cliff protection and slope drainage measures were used to prevent toe erosion and reduce groundwater levels/ pressures to improve slope stability. The Phase IV East Cliff scheme at Lyme Regis is another good example (Appendix 1, Section 5.2).

This section details the principles, assumptions, and limitations of the preferred coastal and drainage schemes proposed. Scheme maps showing the location and extent of the works are provided in Appendix 10.

4.2.2 Priority scheme objectives

Objectives of the priority coastal defence and drainage scheme are as follows:

- Combine coastal defence improvements with drainage relief wells to deliver a considerable improvement in the stability of the Undercliff in the long-term, both protecting the coastal defence assets

from future landslide damage, and by extending the stabilising effects of the combined coastal defences drainage solution up to 1km inland. This benefits all assets, services and the community occupying the Undercliff.

- Secure the long-term future of the town against coastal erosion and landsliding in one of the most unstable geological settings in the UK.
- To produce an innovative scheme design based on a deep understanding of the geomorphology, geology and natural processes, with enhanced environmental and amenity benefits.
- To reconcile technical requirements to counter coastal erosion and instability with major environmental constraints pertaining to geology, geomorphology and wildlife.
- To successfully balance the technical requirements of the project, the needs of the local community and environmental issues.

4.2.3 Coastal defences

This section provides details of, and the principle behind, the replacement coastal defence structures which are proposed as part of the preferred scheme at Ventnor Park, Central Ventnor and Wheelers Bay.

The structures listed below (photos are provided in Table 13) have all be identified and mapped in the Scheme Maps (Appendix 10) as being in poor condition and in need of urgent replacement.

Asset IW 35/003 at Ventnor Park comprises a seawall with toe encasement and rock armour revetment. The plan is to rebuild the structure's encasement and add drainage to prevent groundwater flows damaging the structure and reduce groundwater levels to stabilise a local shallow failure currently impacting the structure. The level of the rock revetment would also be increased. The work is a priority capital scheme in year 3. As well as remediate the local shallow landslide the new structure will dissipate the wave action and decrease significantly the effects of sea erosion to the cliff material and improve the standard of protection against flooding to 1 in 200 years. This will protect against toe erosion and instability triggered by loss of toe support.

Asset IW 33/002 at Central Ventnor currently comprises a 181 m long concrete sea wall with steel sheet piled toe, wide toe apron and sloping revetment face above stepped base of crest. The plan is to replace structure with new rock revetment with concrete upper seawall as priority capital scheme in year 3. The new structure will dissipate the wave action and decrease significantly the effects of sea erosion to the cliff material and improve the standard of protection against flooding to 1 in 200 years. This will protect against toe erosion and instability triggered by loss of toe support.

Asset IW 32/001 at Wheelers Bay currently comprises a 133 m long rock revetment, concrete steps, sheet piled toe to concrete sea wall, with wide apron. The plan is to replace the structure with new rock revetment with concrete upper seawall as priority capital scheme in year 3. The new structure will dissipate the wave action and decrease significantly the effects of sea erosion to the cliff material and improve the standard of protection against flooding to 1 in 200 years. This will protect against toe erosion and instability triggered by loss of toe support.

Asset IW 33/001 at Wheelers Bay currently comprises a 119 m long concrete wall with Tetrapods and toe piling. The plan is to change the structure to a sheet pile and rock revetment and add drainage to prevent groundwater flows damaging the structure and reduce groundwater levels to stabilise a local shallow failure. The new structure will dissipate the wave action and decrease significantly the effects of sea erosion to the cliff material and improve the standard of protection against flooding to 1 in 200 years. This will protect against toe erosion and instability triggered by loss of toe support.

Table 13. Photographs of the coastal defence measures to be replaced as part of the priority scheme.

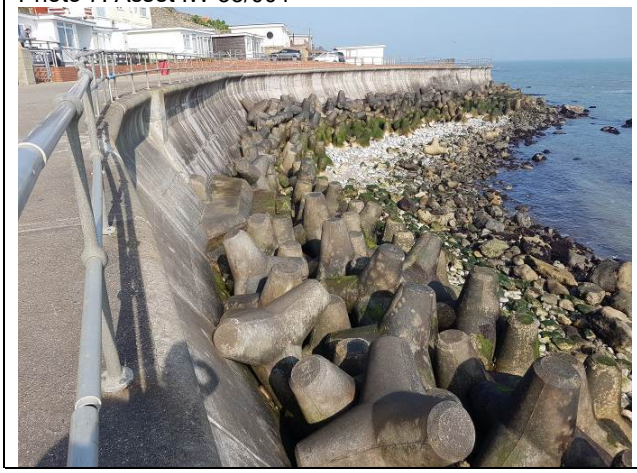
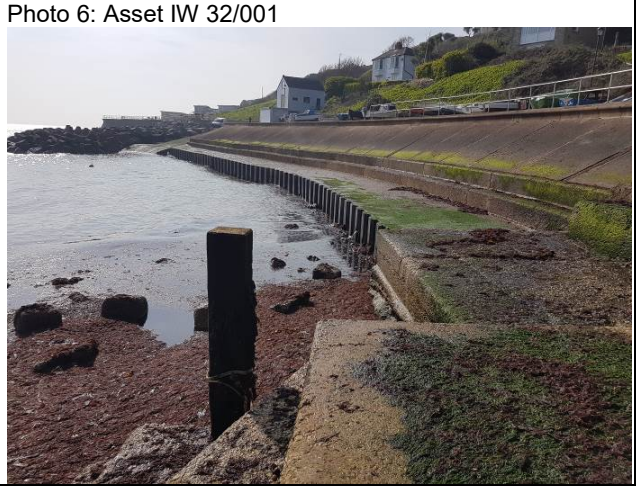
Photo 1: Asset IW 35/003 	Photo 2: Asset IW 35/003 
Photo 3: Asset IW 33/002 	Photo 4: Asset IW 33/002 
Photo 7: Asset IW 33/001 	Photo 8: Asset IW 33/001 

Photo 5: Asset IW 32/001

Photo 6: Asset IW 32/001



4.2.4 Drainage

Due to the Undercliff landslide system extending some distance offshore, with basal shear surfaces up to 40 m below the coastal defences and because toe erosion is currently prevented by coastal protection, a significant proportion of the landslide risk at Ventnor and Bonchurch is driven by rainfall and groundwater. As such, to safeguard the design life of the coastal defences and secure their effectiveness in upholding the frontage SMP policy of Hold the Line, existing or proposed coast protection measures require complementary works in the form of drainage wells to protect them from damage caused by deep-seated displacement of the Undercliff.

A large component of the progressive movement of the lower-tier deep-seated landslide blocks is controlled by groundwater pressures developed on basal shear surfaces in the Lower Greensand Sandrock (bed 2d). Deep drainage to relieve of groundwater pressures could achieve significant improvement in the stability of the lower-tier landslide blocks, which in turn would arrest retrogressive movement and failure of the upper-tier landslide blocks above the Gault Formation. In time the system would self-stabilise as a result of the immobile lower tier exerting passive support to the upper tier.

There are a number of different options for deep drainage using vertical wells, which refers to the installation of boreholes provided with a permeable liner at the level at which de-watering is required (in this case the Sandrock 2c at depths of between -5m OD and -40m OD). The wells reduce groundwater pressure on a landslide shear surface by removing water from the system through a variety of methods. Each well will have a zone of influence around it where groundwater is drawn down around the well in a cone of depression, the radius and characteristics of which will depend upon the permeability of the surrounding material and the nature and distribution of discontinuities such as joints. Wells are designed to drawdown water pressures by a specific amount to ensure an adequate factor of safety and improvement of landslide stability. The aim of this would be ensuring that winter groundwater levels are kept at or below normal summer groundwater levels, so that the triggering of landslide movements which typically occur during the winter or early spring does not take place.

Due to the inherent variability in ground conditions, and mass permeability in particular, within the Undercliff landslide systems, the effectiveness, longevity and maintenance requirements of each well can only be estimated on the basis of detailed ground investigation and pumping tests. The actual performance needs to be confirmed through the monitoring of groundwater pressures around the well in a series of separate observation wells. As each well has a limited radius of influence and in order for them to be effective as a stabilisation measure, wells need to be installed in groups, often closely spaced and in lines with each well being less than 10 m away from its neighbours. In the case of Ventnor, the wells will be located along the 1.6 km of the frontage, at elevations as low as practicably possible (to minimise their depth and therefore cost, and maximise the potential for water levels to be lowered through released artesian pressure, alongside the potential for pumping, to be determined).

There are a variety of different wells which are suitable for different hydrogeological and slope stability conditions. The proposed detailed ground investigation and monitoring will be used to gauge rate of ground movement and provide parameters for stability analysis and hydrogeological modelling. This in turn will be used

to select the most appropriate well systems (or combinations of well systems) and to predict if ground displacements can be arrested before the wells sever and stop working.

Section 5.2 of the Technical Report (Appendix 1) details the various potential well drainage options which will be explored during the monitoring and ground investigation proposed in Section 6.

4.2.5 Scheme appraisal and programme principles.

The Priority Scheme is proposed to be undertaken over a period of 6 years, with the first 2 years to commission and undertake a ground investigation and monitoring, leading to detailed design in year 3 and construction of the coastal defence works in year 4. This would be followed by design and construction of the deep drainage in year 6. This two-staged approach has been chosen to allow maximum time to gather monitoring information and carry out drainage modelling and design, and to avoid the disruption of simultaneous construction projects. The requirements of these future stages are outlined below in Sections 5, 6 and 9 of this report. Also, the environmental implications of the Priority Scheme are summarised in Section 8. The funding required for this Priority Scheme is discussed in Section 7 of this report.

4.3 Future maintenance costs

Table 12 highlights the more significant maintenance requirements. In addition, there is an allowance in the scheme economic case for annual small repairs. Together, these maintenance obligations would require funding by the Local Authority or other sources, with the frequency and scale of the repairs dependent on the availability of funding. The proposed maintenance schedule is considered to represent a precautionary and pro-active approach to maintaining these coastal assets to extend the serviceable life of these assets. This will minimise the risk of failure (through multiple failure modes) and accelerated wear. Such measures will minimise wave overtopping, which will minimise risks to the public and protect the hinterland from damage.

In practice, funding availability may force IWC to adopt a more reactive maintenance schedule (as currently).

4.3.1 Annual maintenance

The economic case currently proposes in excess of £20k per annum for maintenance for the priority scheme frontage (Ventnor Park, Central Ventnor and Wheelers Bay). This represents the costs of monitoring and repairing all of these assets as follows:

- Monitoring movement of structures and beach levels (some of this may be funded through the Regional Coastal Monitoring Programme)
- Detailed visual inspection of the assets (coastal defence and drainage) and reporting
- Includes an allowance for less regular intrusive surveys (steel and concrete testing etc) and non-intrusive investigations (GPR surveys for voids etc)
- Localised repairs to cracks, surfaces, access steps etc
- Localised movement of beach material to maintain design beach profiles
- Replacement of shorter design life elements e.g. concrete wall joint sealant
- Clearance of sediment from drainage and replacement of drainage filters
- Public safety audits and signage (permanent and temporary for works)
- Office and contract administration for all maintenance and repair works

Some of the above may currently be covered by other council budgets. An average annual cost has assumed to cover all of the above, but in reality, the cost profile will vary from year to year. It is important to demonstrate that these costs have been included when seeking for approval for capital works funding.

4.3.2 Ad hoc maintenance

Allowance has been included for more significant maintenance works, which occur infrequently. Such maintenance would not be considered major enough to comprise capital works, hence would be unlikely to be funded through FDGiA. Examples of such works are as follows:

- Import or re-distribution of existing rock to protect toes of seawalls that have become exposed
- Import of beach material to increase the bulk of a beach following sustained losses
- Localised re-building/repairs of existing rock structures that have been damages (using existing materials)
- More significant concrete repairs or strengthening works
- Re-surfacing/rendering of structures

Assumptions for the above requirements for each LRU are summarised in Table 12 and detailed in the Technical Report (Appendix 1). As per the annual maintenance, the timing and magnitude of the above repairs will likely be dictated by funding availability within IWC. In practice, is may not prove viable to maintain these structures in the optimal way and maintenance spends may veer towards more reactive measures as emergency works.

5. Appraisal costs (to OBC) and detailed design costs (to FBC)

This section outlines indicative costs for taking the Priority Scheme through the scheme appraisal stage, through to consenting, detailed design and construction supervision. The costs have been split up to Outline Business Case (OBC) Stage and the future Full Business Case (FBC)/construction stage.

The costs are for delivering the package of priority schemes at Wheelers Bay, Ventnor Park and Central Ventnor (coastal and deep drainage schemes) only. These costs have been estimated based on similar and recent design and appraisal projects for UK coastal works, adjusted as required to reflect the requirements at Ventnor.

5.1 Site investigation, outline design and appraisal costs (to OBC)

Table 14 provides a cash cost estimate for developing the scheme to Outline Business Case (OBC) stage for the scheme of priority works. The overall costs for developing this business case ranges between £0.78m to £1.16m. This includes an allowance for the detailed geotechnical site investigation required as part of developing the OBC to inform the design. The Statement of Requirements (Appendix 3) provides a detailed breakdown of the ground investigation and monitoring costs required.

Further information on the ground investigation is provided in Chapter 6.

Note: Tables 14 and 15 provide an upper and lower estimate of costs based on Jacobs experience of delivering similar inputs/schemes. A range of costs is provided to give an indication of the potential variability of these inputs. The mid-point of these costs is used for the economic assessment.

Table 14. Site investigation, outline design and appraisal costs (cash cost)

Category	Task	Lower estimate, £	Upper estimate, £	Notes
Specialist survey or investigations	Topographic survey (traditional and laser scan) [1]	20,000	30,000	Covers priority coastal and drainage scheme locations and ground levels for GI hole locations. Assume bathymetric survey not required (available through CCO)
	Ground Penetrating Radar (GPR) survey[1]	4,000	6,000	To identify voids under structures
	Services searches, interpretation and ground survey to confirm (where required)	3,000	5,000	
	As built information/survey	2,000	4,000	
	Procurement of geotechnical GI	2,000	5,000	Assumes assisting the Client only
	Geotechnical ground investigation (survey, lab testing and factual report) [1]	350,000	550,000	Refer to detailed breakdown in Appendix 3 (lower estimate - £250,000 to upper estimate £400,000 for drainage; and lower estimate £100,000 to upper estimate £150,000 for coastal defence)
	Ground monitoring over 2 years and factual reporting[1]	125,000	160,000	Refer to detailed breakdown in Appendix 3).
	Ground stability assessment and modelling	100,000	120,000	Assessment of hydrogeology and instability for drainage design using the GI and monitoring results
Design and technical appraisal for outline design	Data gathering and review	2,000	3,000	Assume relatively limited info available
	Geotechnical Interpretive report	12,000	20,000	This is to include review and incorporation of existing GI

Category	Task	Lower estimate, £	Upper estimate, £	Notes
	Develop ground models and identify drainage network options	20,000	30,000	Identification of most effective drainage options based on the specialist surveys results
	Detailed condition inspection and report of coastal intervention locations	2,000	3,000	Concentrating on structures at intervention points only
	Coastal processes study	5,000	10,000	Study to inform toe levels for design
	Procure ECI and liaison regarding outline construction costs and buildability	3,000	6,000	Contractor with drainage and coastal experience.
	Identify long list and workshop	3,000	6,000	Develop long list of engineering solutions for each intervention
	Agree short list and workshop	2,000	4,000	With ECI considering technical merits, env and economic merits
	Identify preferred option (design and SoP)	2,000	6,000	Identify preferred option, design life, maintenance requirements and SoP
	Outline design (analysis, review, workshop and drawings)	15,000	25,000	Engineering design to outline level suitable for ECI costing*
Mathematical Modelling	Define coastal conditions for design (wave and hydrodynamic modelling)	20,000	30,000	Scope depends on what models are available and what datasets they use (to inform detailed design as well)
	Modelling the influence of groundwater on stability	20,000	30,000	Refer to Section 5.2 in Appendix 1 for details
	Modelling the influence of drainage on groundwater and stability	15,000	20,000	Refer to Section 5.2 in Appendix 1 for details
Economic appraisal	Confirm costs of short list (incl. maint), benefits from QRA, other benefits and CBA/PF	2,000	4,000	Assumes current QRA is used for benefits assessment. Costing provided by ECI
Consultation	Stakeholder consultation (does not include planning/MMO license)	4,000	6,000	Statutory and non-statutory consultees. Assumes covered in two workshops.
	Partnership funding meetings and approvals	2,000	5,000	Assuming a few potential funding sources only
	Public consultation	3,000	5,000	Single consultation for OBC only
	Landowner meetings	1,000	2,000	Assumes client will undertake most landowner consultation, but some technical back up required
OBC reporting	Draft OBC document, review and issue	5,000	8,000	Including appendices
	Present to LPRG and respond to questions for approval	2,000	10,000	Wide range as may enquire more appraisal, modelling, consultation etc
Environmental assessment	Collate environmental baseline information	1,000	1,000	Collation and review of existing information only.
	Phase 1 habitat surveys and reporting	5,000	7,000	Assumes no specific species surveys required, just high-level Phase 1 Habitat Survey to low water and reporting.
	Environmental screening and scoping	1,000	2,000	Letters accompanied by scheme summary note issued to MMO and Council's EIA screening officer.
	Environmental reporting	3,000	5,000	Full EIA and planning/MMO at detailed design phase
Project management	All PM including meetings	10,000	15,000	
Expenses		10,000	15,000	
TOTAL Ground Investigation and monitoring costs		**475,000**	**710,000**	

Category	Task	Lower estimate, £	Upper estimate, £	Notes
TOTAL OBC phase (excluding GI)		**301,000**	**448,000**	
TOTAL OBC phase (including GI)		**776,000**	**1,158,000**	

Totals and notes on the table above:

The cost of the work outlined above (Scheme costs to OBC stage including ground investigation and monitoring) ranges from a lower estimate £776k to an upper estimate £1.158m, so the average estimated cost for this stage of the work is £967k. In more detail:

[1] The items labelled '1' above on *Site Investigation and Survey* combine to a lower estimate cost of £499k and an upper estimate cost of £746k, therefore an average cost of £623k (cash cost) is reported in Table 15 below.
All other costs listed above in Table 13, minus items [1], combine to a lower cost estimate of £277k and an upper cost estimate of £412k, therefore an average cost of £345k (cash cost) is reported in Table 15 below for *project development costs from OBC to FBC*.

5.2 Detailed design, consenting phase (to FBC) and construction supervision costs

Table 15 identifies a high-level cost for developing the Full Business Case (FBC) for the scheme of priority works ranging between £0.86m to £1.41m. This includes an allowance for site supervision costs during the works. Chapter 9 provides a full programme of works which includes the various OBC and FBC elements.

Table 15. Detailed design, consenting phase and construction supervision costs (cash costs)

Category	Task	Lower estimate, £	Upper estimate, £	Notes
Specialist survey or investigations	Topographic survey	0	0	Assume all covered at OBC stage
	Geotechnical ground investigation	0	0	Assume all covered at OBC stage
Design and technical appraisal for outline design	Data gathering and review	2,000	3,000	Assume relatively limited info available
	Detailed groundwater modelling	20,000	40,000	These tasks model the influence the chosen drainage design on groundwater, porewater pressure and slope stability (Factor of Safety)
	Detailed design of drainage wells	20,000	50,000	
	Detailed design of MEICA for drainage wells	20,000	50,000	
	Geotechnical analysis for coastal structures	8,000	12,000	Settlement, global stability, seepage etc
	Detailed design of coastal structures (analysis, review, workshop and drawings)	100,000	150,000	Coastal and structural engineering to detailed design level
	Construction drawings and specifications	30,000	50,000	
	Design criteria report and Final Design Report	10,000	15,000	
Mathematical Modelling	Define coastal conditions for design (wave and hydrodynamic modelling)	0	0	Assume all covered at OBC stage
Economic appraisal	Update OBC costs using tendered prices and final QRA/PF for FBC	1,000	2,000	

Category	Task	Lower estimate, £	Upper estimate, £	Notes
Consultation	Stakeholder consultation (does not include planning/MMO license)	2,000	3,000	Statutory and non-statutory consultees. Assumes covered in one workshops.
	Confirm Partnership Funding with meeting	1,000	2,000	Reconfirming OBC assumptions only
	Public consultation	3,000	5,000	One consultations to accompany planning
	Landowner meetings	1,000	2,000	Assumes client will undertake most landowner consultation, but some technical back up required
	Planning process	25,000	100,000	Assumes consultant takes the lead for planning. Wide cost estimate to account for impact of environmental designation at IW33 / 01, which might, for example, necessitate redesign
	MMO consultation and license	4,000	6,000	Assumes consultant takes the lead for license
	Temporary footpath and road diversion orders	5,000	15,000	Costs for identifying diversions required, applications, liaison and reporting/drawings.
Contract Docs	Pre-Construction Information	2,000	4,000	
	Draft documents	7,000	10,000	Contract docs compiling only, works Information covered in detailed design task
	Assist Client in tender review	3,000	5,000	
FBC reporting	Draft FBC document, review and issue	2,000	4,000	Including appendices. Assumes LPRG approval of OBC, so most comments will have been responded to at OBC stage
	Present to LPRG and respond to questions for approval	1,000	2,000	Assumes LPRG approval of the OBC, so most comments by LPRG/stakeholders will have been resolved previously
Environmental assessment	LPA/MMO screening and scoping	1,000	2,000	
	Environmental Statement to accompany planning/MMO and HRA Stage 1 and 2	40,000	80,000	Full EIA for planning/MMO
	Allowance for ecological survey	5,000	20,000	Lump sum to cover multiple surveys (yet to be confirmed)
Construction supervision	Site supervisor and Ecological Clerk of Works[1]	224,000	336,000	Assumes 12month construction period covered by full time experienced supervisor and part time ECoW

Category	Task	Lower estimate, £	Upper estimate, £	Notes
	Design office support to supervision[1]	30,000	45,000	Assumes 12month construction period with 10hrs per week office support on average
	Vibration monitoring[1]	15,000	50,000	Installation of drainage well only
	Health and Safety File[1]	10,000	20,000	Inclusive of As Built info and Operations and Maintenance manual
	Site supervision of deep drainage well installation [1]	80,000	100,000	Part time supervision required
	Other consultant fees and contract administration [2]	140,000	160,000	ECC PM/cost consultant
Project management	All PM including meetings	20,000	30,000	For the design/supervision contract only
Expenses		25,000	40,000	
TOTAL DETAILED DESIGN, FBC AND CONSTRUCTION SUPERVISION		**857,000**	**1,413,000**	

Note: For the economic assessment, an average of the upper and lower costs was assumed. The upper and lower costs have been assessed as economic sensitivity tests in Section 3.3.6.

Totals and notes on the table above:

The cost of the work outlined above (Scheme costs from OBC to FBC, including construction supervision) ranges from a lower cost estimate £857k to an upper cost estimate £1.413m, so the average estimated cost for this stage of the work is £1.135m. In more detail:

[1] The items labelled '1' above on *Site Supervision* combine to a lower estimate cost of £359k and an upper estimate cost of £551k, therefore an average cost of £455k (cash cost) is reported in Table 15 below.
[2] The item labelled '2' above on *Other consultant costs for contract administration* has a lower estimate cost of £140k and an upper estimate cost of £160k, therefore an average cost of £150k (cash cost) is reported in Table 15 below.
All other costs listed above in Table 14, minus items [1] and [2], combine to a lower cost estimate of £358k and an upper cost estimate of £702k, therefore an average cost of £530k (cash cost) is reported in Table 15 below for *project development costs from OBC to FBC*.

5.3 Summary of appraisal, Site Investigation, design and construction supervision costs

Excluding site investigation (SI), construction supervision and capital scheme costs, the OBC and FBC phase costs total £1.15m (conservatively using the upper estimate). This represents 4% of the predicted £28.7m capital costs of the priority works (initial capital cash costs of £17,925k plus 60% optimism bias). Inclusive of SI, detailed design and construction supervision this increases to £2.56m, representing 9% of the capital costs.

Local authority (Isle of Wight Council) information and support will also be required throughout these OBC and FBC stages.

The costs outlined above have been used in the economic assessment for the three priority scheme LRUs (the costs have been apportioned to the three LRUs for these initial works).

For the capital works in other non-priority LRUs and for future schemes in all LRUs, all non-constriction costs (appraisal, design, supervision, project management etc) have been conservatively assumed as 20% of the capital costs for the coastal works and 10% for the drainage works.

6. Statement of requirements for the geotechnical investigations for coastal and drainage schemes

The Ventnor Undercliff Options Study has identified coastal defence improvements and deep drainage via relief wells as preferred options to secure the future stability of the Ventnor and Bonchurch urban coastal frontage.

To design an effective deep drainage scheme, more information is required to better define surface and sub-surface movement rates, hydrogeology regime (including groundwater pressures and levels), landslide stability and recession models, and their causal-response relationships. This will identify the potential benefits of deep drainage and the impact on the long-term stability of the Undercliff.

In addition to standard detailed geotechnical information to inform design of replacement coastal defences, more information is required to better define the slope stability and hydrogeology regime of the Undercliff.

The work activities provided in summary below, and in detail in Appendix 2 and Appendix 3, evaluate the suitability of installing relief wells to stabilise the Undercliff, and define the requirements for ground investigation and monitoring needed to support the proposed costal defence and drainage schemes. Costs for these items are provided in Chapter 5 and Appendix 3.

6.1 Activity 1: Site walkover with Prof. Eddie Bromhead to review feasibility of deep drainage

There is presently no control over the excess groundwater pressures which trigger ground movement and episodic landslides at Ventnor and Bonchurch. There is compelling evidence showing a strong relationship between antecedent effective rainfall, groundwater pressures, and ground movement acceleration in the Undercliff (Moore et al. 2010; Carey et al. 2014). Consequently, the control of groundwater pressures, specifically to keep them below the threshold at which slope instability can be triggered, in combination with coastal defence improvements, has great potential to deliver a significant reduction in land instability risk in the Undercliff.

The technical note provided in Appendix 2 reviews the feasibility, advantages and challenges of a deep drainage scheme, comprising relief wells. The review was carried out during a site visit with the purpose to solicit the views of Prof Eddie Bromhead and others present about the merits of deep drainage options to stabilise the lower-tier landslides of the Undercliff, as well as early identification of issues that will need to be addressed to support the design and installation of relief drainage wells along the alignment of coastal defences.

The site visit took place on 31st January 2018 and was attended by Prof Eddie Bromhead, Prof Roger Moore, Ross Fitzgerald, Claire Czarnomski, Jenny Jakeways and Peter Marsden.

In summary, Prof Eddie Bromhead was impressed with the work done to refine the ground models at the site. He notes that the concept of local deep drainage to relieve confined water pressures in the Sandrock Formation at the coastal margin has great merit, and the programme of investigation required to prove scheme feasibility a necessary task. Prof Eddie Bromhead also highlights the most important questions which ground investigation and monitoring will need to answer:

- What are the magnitude and distribution of artesian water pressures in Sandrock 2d at the sea cliff location (preliminary hydraulic modelling by Prof Eddie Bromhead demonstrates that there is potential for high artesian pressures at sea level)?
- What is the permeability of Sandrock 2d?
- What is the level of water pressure reduction that can be achieved via drainage and whether this is enough to lock in place the landslide system?

6.2 Activity 2: Data requirements for deep drainage and replacement coastal defence assets

A combined deep drainage and replacement coastal defence scheme provides the most effective protection against coastal erosion and slope instability at Ventnor and Bonchurch. For drainage to be successful, a

comprehensive understanding of the relative contributions of surface water drainage and the subsurface hydrogeology regime to groundwater levels and pressures is essential. This requires investment and time to carry out drainage surveys, hydrogeological ground investigations and trials, and analytical modelling to support selection of options and design of a preferred drainage solution. The design of robust replacement coastal defences also requires information on subsurface hydrogeological and geotechnical conditions.

The presentation and accompanying tables provided in Appendix 3 sets out a statement of requirements (SoR), and outline scope, and the costs for ground investigation and monitoring required for the design and construction of the proposed, priority coastal and deep drainage schemes identified at Wheelers Bay, Central Ventnor and Ventnor Park. The SoRs are based upon the best available data.

The aim for the various ground investigation/monitoring/appraisals is to be pragmatic. The recommendations are focused where information is needed and provide an appropriate and safety-focused basis on which to proceed scheme design. The costs, based on a leading GI contractor's current rates, are provided in Appendix 3 and Table 13 of this report, and are input into the Partnership Funding calculations in Section 3.3.5 and the pOBC. The GI and monitoring are to be delivered as part of a scheme and the costs included within each viable scheme's costs.

All existing knowledge has been used to build the ground models in Appendix 3 (these were first developed in Section 3 of the Technical Report provided as Appendix 1). The proposed ground investigation is designed to build on this knowledge, specifically to:

- Develop and extend the ground model and understanding of ground conditions established in previous work.
- Monitor ground movement and groundwater pressures and levels.
- Define landslide mechanisms and controls.
- Identify the location and depth of ground movements.
- Define geotechnical parameters for coastal and drainage scheme design and construction.

The outline scope contained in the SoR document comprises:

- Ground model sections from the geomorphological mapping and existing GI information
- Recommendations for exploratory hole type, location, depth, samples, in-situ and lab tests, instrumentation, monitoring and other appraisals.
- Consideration of access constraints.
- Explanatory notes on the objectives of each exploratory hole and general recommendations for the investigation.
- Estimates on the cost of the required monitoring, ground investigation and analysis, required to support the coastal defence and drainage schemes.

7. GiA and partnership funding options (financial case)

7.1 Financial summary for the Priority Scheme

Table 16 summarises the costs (present value, whole life and project cost for approval) for the scheme delivery at Ventnor Park, Central Ventnor and Wheelers Bay. The costs have been built up from the costs outlined in Section 3 and Section 5. The total cost for scheme delivery is £32,043k, which includes for the scheme development costs (appraisal, reporting, site investigation) and capital construction costs (inclusive of 60% optimism bias and site supervision). Future maintenance costs are not included within the project cost for Outline Business Case (OBC) approval.

Table 16. Cost summary for priority scheme

Project Summary (£k)	PV cost for economic appraisal	100-yr whole life cost (cash cost)	Project cost (approval) (cash cost)
Project development costs			
Project start to OBC approval	323	345	345
OBC to FBC approval	497	530	530
Post approval project costs			
Other consultant costs for contract administration	141	150	150
SI & Survey	584	623	623
Construction	15,601	17,925	17,925
Site Supervision	427	455	455
Optimism Bias of initial project costs (60%)	10,543	12,016	12,016
Future Costs – Future capital costs	1,816	12,885	
Future Costs – Operation & Maintenance	863	2,763	
Optimism Bias of future capital costs (60%)	1,090	7,731	
Optimism Bias of future maintenance costs (19%)	164	525	
Total	**32,048**	**55,946**	**32,043**

The cash costs (non-discounted) summarised in Table 16 are distributed over the scheme delivery programme as detailed in Table 17. These timings align with the timings assumed in the economic assessment.

Table 17. Cash cost summary for priority scheme

Project Summary £k	Yr 0 (21/22)	Yr 1 (22/23)	Yr 2 (23/24)	Yr 3 (24/25)	Yr 4 (25/26)	Yr 5 (26/27)	Yr 6 + (27/28 +)	Total
Consultant costs	172	172	530					875
Site investigation costs	326	296						623
Site supervision and other consultant costs for contract administration				515		90		605
Initial investment (Capital cost)				8,478		9,446		17,925
Risk contingency (Appraisal and initial capital costs) *	299	281	318	5,396	0	5,722	0	12,016
Project sub total	**798**	**750**	**848**	**14,389**	**0**	**15,258**	**0**	**32,043**
Future costs (Revenue cost)	37	37	37	19	24	24	23,726	23,904
Project Total	**834**	**786**	**885**	**14,408**	**24**	**15,282**	**23,726**	**55,946**

Note: Should funding be identified to progress the OBC earlier, the overall programme for works could be brought forward.
*For simplicity applied at Year 3.

7.2 Funding sources

The overall scheme cash costs of £32,043k will be largely financed by FDGiA 'Grant in Aid' funding (£25,474k PV costs or £27,844k cash costs),(refer to Section 3.3.5). This leaves a potential shortfall in funding of £4,199k (cash costs), which needs to be financed through Partnership Funding to unlock the maximum FDGiA contribution. In practice this maximum FDGiA may not be available in full and additional contributions may need to be found. This section considers the options for generating these additional partnership funding contributions, should there still be a shortfall in funding at appraisal stage.

It should be noted that the scheme is in the very early stages of development and there is significant opportunity to rationalise the scheme costs to reduce this shortfall. Similarly, there will the opportunity to increase benefits. The damages due to landslide risk provide a robust baseline for the economics but additional monetised benefits can be considered at scheme appraisal stage such as additional flooding benefits (these will be small in comparison to the erosion benefits), tourism benefits and other intangible benefits etc.

Note, that the overall scheme cash cost of £32,043k (exclusive of maintenance) varies with the overall scheme present value cost £29,049k (exclusive of maintenance) presented in Section 3.3.5 (both costs are over the Benefits Period inclusive of Optimism Bias). Similarly, the shortfall in funding as a cash cost is £4,199k and the shortfall as a present value cost is £3,653k.

In the sections below, the potential funding commitments of the Isle of Wight Council (Unitary Authority) are considered, and then other potential sources of partnership funding are reviewed and outlined.

7.2.1 Potential contributions from IWC

The Isle of Wight Council (IWC) are responsible for maintenance of defences in Ventnor. IWC currently funds ongoing maintenance works. Hence, maintenance costs associated with the preferred option have at this early stage been assumed to be funded by the Council, although future maintenance funding availability will be dependent on future budgets.

IWC will be financially and reputationally exposed to the risk of failures of any of the coastal defences and any subsequent major landslips. Indeed, land instability risk should be included on the council's risk register. This

provides a basis for which the Council may be able to justify further contributions for the capital works, especially as the capital works will reduce the Council's potential risk exposure should any of the existing defences fail and new structures will reduce the need for expensive emergency works on these structures. .

The funding options for the Council for the coastal defences along the frontage at the Ventnor Park, Central Ventnor and Wheelers Bay LRUs (Landslide Reactivation Units) are as follows:

1. Continue with business as usual with the current annual spend by IWC on reactive maintenance works. Note: This is not a viable option for future maintenance as it doesn't keep pace with incipient ground movement or the effects of climate change and doesn't consider that some of the coastal defences are moving beyond serviceability. This option is very close to a 'Do Nothing' scenario under which risk is increasing.
2. As above but followed by emergency repairs and then more permanent repairs after the failure of defences (once they have reached the end of their serviceable life). Allowing the existing defences to fail carries a significant risk of triggering a major landslide and associated adverse impacts that will require emergency works and remediation that will to cost more than planned intervention i.e. Option 3.
3. Council to fund (with Partnership Funding contributions sought from other beneficiaries of the project) the funding shortfall for the preferred coastal defence and deep drainage (combined) Scheme (Section 3.3.5). The Scheme will result in reduced future maintenance commitments compared to responding to ad hoc defence failure in Options 1 and 2 above.

These options are investigated in more detail below. The funding comparison is over 59-years, which covers the benefits period for the proposed full scheme option.

7.2.1.1 Options and assumptions

As summarised above, three future coastal defence scenarios have been considered. Assumptions have been made about the timing of future interventions and the input costs. Table 18 below lists the three scenarios, the costs and assumptions made for each scenario and provides a commentary on their impact on risk exposure:

Table 18 Risk exposure to IWC from different management options

Option	Input costs	Timing of interventions	Risk implications
Reactive maintenance	• This option is based on the actual average spend on maintenance for each LRU. • This was calculated based on data provided in the Undercliff Maintenance Costs record between 2009-2016	• A 20% annual increase to the original maintenance spend was applied, assuming that average spend would increase over time • It models the likely spend by the IWC over the 59-years, but does not factor in any emergency works in response to larger failures to the coastal assets nor the elevated risk profile generated by this approach	• This approach isn't realistic because it ignores the fact that the community is left exposed to a rising risk profile brought about by not dealing further with instability, reducing coastal defence asset serviceability and increasing risk of geohazards due to climate change and sea level rise
Reactive maintenance, temporary and permanent emergency repairs	• This option is based on the reactive maintenance spend (outline above) plus temporary then permanent emergency repairs • Temporary repairs are costed at 50% of the capital cost of a full scheme (coastal elements only) • Permanent repairs are costed at 150% of the	• It is assumed the worst-condition elements of the current coastal defence assets will degrade then fail 10 years after their serviceable life elapses in year 3 • Therefore, in year 13 it is assumed a significant failure in the coastal asset will occur, requiring temporary emergency repairs • It is assumed that the temporary works will require a more	• This approach isn't realistic because it ignores the fact that the community is left exposed to a rising risk profile by doing nothing further to address the risk of a failure until after a failure has occurred. It also does not deal with the risk of instability increasing due to the impacts of

Option	Input costs	Timing of interventions	Risk implications
	capital cost of a full scheme (coastal elements only) • Optimism bias has not been applied Note: This is considered a conservative assessment of costs. Emergency works can be considerably more expensive than well planned, proactive schemes. The cost of rebuilding, rehousing, legal and reputational damage are also considerations not included in the comparison.	substantial permanent repair after 15 years, in year 28. • Reactive maintenance costs continue across this time • All calculated capital costs exclude drainage costs as it would not be possible to input the proposed drainage scheme reactively	increasing winter rainfall and sea level rise.
Proposed full scheme	• This is the funding shortfall which is required in order to potentially receive national FDGiA funding for the combined coastal defence and deep drainage scheme. • This figure for a required LA/local contribution could be reduced if other local funding contributions could be secured, e.g. from Local Levy, utilities, and other public and private contributions • Drainage, maintenance and appraisal/design costs are all included within the proposed full scheme as presented in the Future Schemes Report	• Capital spend on permanent repair works to coastal assets proposed to occur in years 3-9 (from 2024/25 onwards).	• This option actively seeks to reduce risk exposure by tackling instability though replacing ageing coastal defences and installing deep drainage. It also takes account of defence serviceability, the assets protected (in Ventnor town) and the impact of climate change

7.2.1.2 Key inputs

Table 19 shows the key monetary inputs to the funding comparison.

Table 19 Monetary inputs for the funding comparison

Cash Costs	Ventnor Park unit	Central Ventnor unit	Wheelers Bay unit	Totals
Current maintenance per annum on the current coastal defences	£1,311	£1,358	£3,168	£5,837
Proposed scheme capital on coastal defences (excluding drainage*, and excluding optimism bias)	£137,000	£3,801,000	£4,540,000	£8,478,000
Temporary emergency repairs capital (to coastal defences)	£68,630	£1,900,500	£2,270,000	£4,239,130
Permanent emergency repairs capital (to coastal defences)	£205,880	£5,701,500	£6,810,000	£12,717,380

*Note: The combined scheme costs including deep drainage are stated earlier in this paper, see section 3.3.1.

7.2.1.3 Funding comparison

Figure 4 shows the funding for the three options. In the case of the proposed schemes, the figure relates to the funding shortfall for which the Council would potentially be responsible. It illustrates that overall the emergency repair approach results in a 6.5 times higher bill for the Council than bridging the funding shortfall required to enable FDGiA funding of a full scheme (note that this is not a comparison of the overall cost of retrospective actions against the overall cost of a scheme, the majority centrally funded, against, which would give a ratio of approximately 3:1).

Perhaps even more important than the clear economic benefit of the proposed scheme is its positive impact on risk exposure (refer to the QRA in Section 4 of the Technical Report in Appendix 1). The present reactive maintenance regime largely ignores the fact that the community is left exposed to a rising risk profile by not dealing fully with instability, reducing coastal defence asset serviceability and increasing risk of geohazards due to climate change and sea level rise. The emergency works are little better as only seek to address these risks following the failure of coastal defences, by which time assets have been exposed to instability triggered by toe erosion, with the increasing future potential for landside reactivation under the town.

Please note the current reactive maintenance option provides a baseline spending profile, extrapolating current costs but not accounting for any significant failures in the current coastal assets.

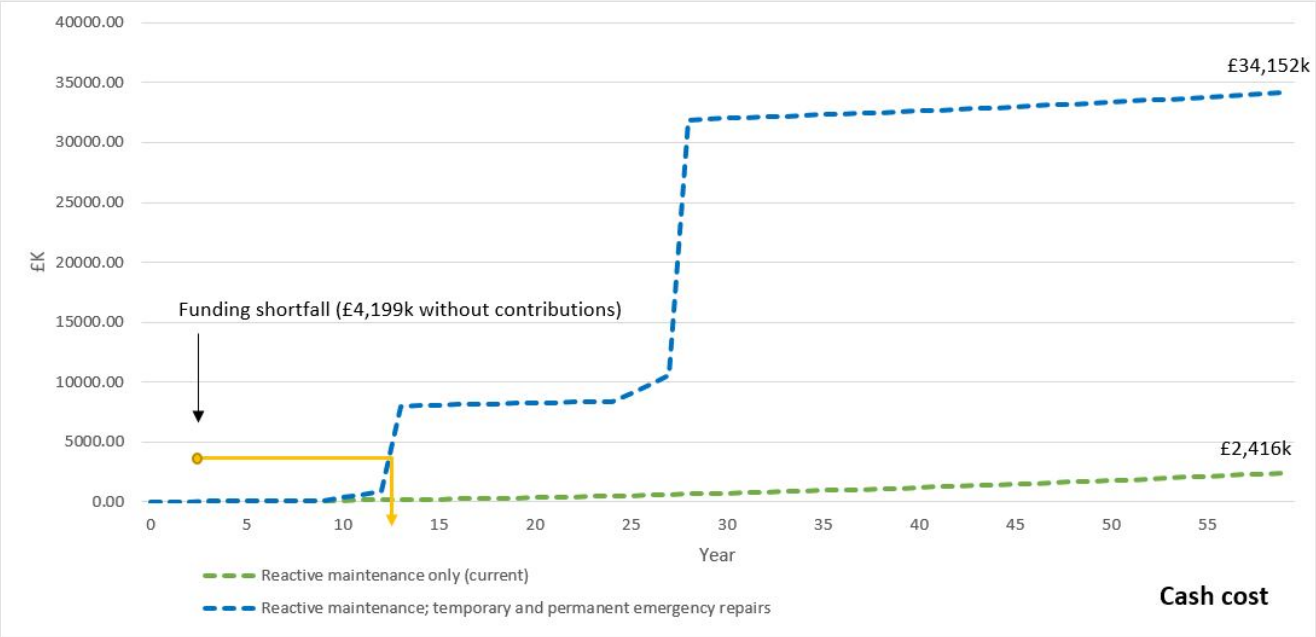


Figure 4 Funding of management options (cash costs). It is assumed the worst-condition elements of the current coastal defence assets will degrade then fail 10 years after their serviceable life elapses in year 3 so that in year 13 it is assumed a significant failure in the coastal asset will occur, requiring temporary emergency repairs. It is assumed that the temporary works will require a more substantial permanent repair after 15 years, in year 28. The funding shortfall is the cash cost without subtracting contributions from potential local levy and IWC. Maintenance following the construction of the Priority Scheme will be required, information on this can be found in Section 4.3

Given the justification above for the Council to contribute to the Scheme, it is considered likely that there will be some contribution from the Council towards the capital costs of the scheme. For this strategic assessment, it has been assumed that the Council will contribute £1.7m or more towards the £4.2m funding gap for the priority capital works and pay for all future maintenance costs, which will include a combination of small and large-scale maintenance of the coastal scheme elements, as detailed in the Appendix 9 of the Technical Report (see Appendix 1) and summarised in Table 16. Future capital costs (replacement of structures at the end of their serviceable life) would be expected to be paid through future FDGiA.

7.2.2 Potential partnership funding sources

The following sections consider additional potential sources of partnership funding that could be sought to help provide funding for the Priority Scheme.

7.2.2.1 Local Levy

Contributions from Local Levy should be sought, but the anticipated value of the contribution is currently unknown. A potential PV contribution of £0.5m has been assumed at this stage. It is recommended that local levy allocation is agreed during options appraisal.

7.2.2.2 Potential contributions from others/

The funding shortfall will need to be met by larger contributions from IWC (assumed £1.5m PV or more at this stage) and the RFCC Local Levy (assumed £0.5m PV at this stage) or secured from other beneficiaries (LEP, utilities, local businesses etc). The shortfall of partnership PV funding at this strategic level has been identified as £3.7m. This only represents 10% of the appraisal and capital costs of the priority works over the first 5-years.

7.2.3 Funding options and establishment of a stakeholder group

This study has identified the need for partnership funding contributions to be sought to finance the capital works outlined. The approach could include securing one-off capital payments from commercial beneficiaries of the project or implementing methods to generate revenue. A partnership approach from all major authorities and key beneficiaries should be considered which could include (but not be limited to): Isle of Wight Council, Ventnor Town Council, utility companies and significant businesses and landowners.

These authorities could be brought together under a Memorandum of Understanding to find a solution which could include the formulation of a stakeholder group, led by IWC. A landslide management committee previously existed in Ventnor. Although this group has not met in recent years, re-establishing this group could be the ideal solution to exploring funding solutions.

The primary role of this group would be to consider all methods of securing investment/revenue. These could include:

- Utilising existing council funds outside of flood and erosion risk management budgets (e.g. council regeneration funds were secured for FCERM projects in Weston Super Mare and Littlehampton)
- Securing contributions from utility service providers and major landowners, justified by the scheme benefits to their assets (e.g. recent South West Water contribution at Lyme Regis)
- Seeking Local Enterprise Partnership (LEP) funding (if applicable) to support the Ventnor area economy, community and essential access to the town, for engineering scheme(s) to reduce future landslide risk. The unique characteristics and landscape of the area provides both the economic opportunity and the threat, which needs to be carefully managed, to avoid loss of confidence and to promote appropriate growth.
- Levying local businesses, for example through the establishment of a Business Improvement District aimed at providing funding for erosion defences (a similar arrangement was recently introduced in Sheffield)
- Funding derived from future development in the area (e.g. Section 106/Community Infrastructure Levy)
- Tourism-related funding (e.g. implementation of a voluntary, or mandatory, tourism levy in Ventnor or across the Isle of Wight)
- Precepts on properties in Ventnor (as recently implemented following the 2009 floods in Cockermouth, where the project team organised a referendum in the town and residents voted to pay additional council tax in order to help fund the scheme)

- Other methods of attracting government investment beyond FCRM GiA (e.g. recent funding made available from the Department of Education for increasing flood protection to academy schools or additional Defra funding)
- Grants (e.g. Coastal Communities Fund, Heritage Lottery)

Considering the likely and substantial requirement for funding any solution could require several of these options to be implemented. A further role of any group could be raising the profile of the project, coastal erosion and landslides to the community to increase the likelihood of some of the more contentious financing streams above being acceptable to the community, although care is needed on how future risks are presented.

Jacobs have assisted other clients to establish similar governance groups in other areas such as for the River Thames Scheme and have provided support to projects across the country, which has included producing funding strategies, financial modelling, creating negotiation material and undertaking beneficiary assessments.

Alongside securing partnership funding, efficiencies during scheme planning and delivery should be sought and will be expected to be secured as part of any grant in aid funding provision. At Cockermouth, CH2M/Jacobs identified over £1m of efficiencies through the detailed design phase, which ultimately achieved the 100% partnership funding threshold.

7.3 Overall affordability

The proposed scheme for Ventnor Park, Central Ventnor and Wheelers Bay is in a strong financial position at this strategic stage and there is significant opportunity to reduce the funding shortfall at the appraisal stage. The overall affordability of the scheme over the lifetime is presented in Table 20.

Table 20 Funding profile (cash costs)

CIP funding profile (£k)	Yr 0 (21/22)	Yr 1 (22/23)	Yr 2 (23/24)	Yr 3 (24/25)	Yr 4 (25/26)	Yr 5 (26/27)	Yr 6 + (27/28+)	Total
FCRM-GiA (Grant in Aid)	798	750	848	12,423		13,025		27,844
IWC*				807		917		1,724
Local Levy*				269		306		575
Additional third-party funding to be identified*				890		1,011		1,900
Sub Total (capital funding)	**798**	**750**	**848**	**14,389**	**0**	**15,258**	**0**	**32,043**
IWC Funded Maintenance (over 100-years)	37	37	37	19	24	24	3,109	**3,287****
Future capital costs (over 100-years)							20,617	**20,617 ***
Totals	**834**	**786**	**885**	**14,408**	**24**	**15,282**	**23,726**	**55,946**

* nb. PV contributions identified in the PF calculator have been converted from PV costs to cash costs in this table through applying the discount factor for the Yr 3 and Yr 5 costs. The remainder of the cash contribution is from FDGiA (which is only identified as a PV cost in the PF calculator).
** nb. including 19% optimism bias
*** nb. including 60% optimism bias

7.3.1 Recommendations for ensuring scheme affordability

At the appraisal stage it is recommended that the following tasks are undertaken:

- Develop the option designs to improve on the cost certainty and reduce optimism bias
- Appraise additional benefits, for example utility and tourism benefits which are calculated according to good practice but are possibly underestimated in this assessment, which could be refined with improved information provided by the companies involved.
- Further consider damage assessment. For example, consider how the potential breaching of the A3055 road to Shanklin and Sandown can be used to increase the benefits. Such an approach was successfully applied at West Bay where the no active intervention damages included the costs of routing a new road to properties that would be expected to be cut off.
- Plan a co-ordinated approach to securing additional partnership funding. It is recommended that the various authorities and stakeholders are brought together under a Project Board.

7.4 Major factors influencing PF %

To provide the IWC with an understanding of where appraisal efforts and the exploration of additional information is best focused to enhance PF scoring across the Ventnor and Bonchurch frontage, the list below details the major factors influencing the PF score (in rough order with greatest influence at the top):

a. Property values
b. Scheme costs
c. Number of properties under OM3
d. Other asset values (e.g. services)
e. Pre-scheme hazard scenario probabilities (severity of the problem)
f. Post-scheme hazard scenario probabilities (effectiveness of solution)
g. Climate change
h. Appraisals and design etc. costs
i. Maintenance

The list can roughly be split where factors a to f have a far greater influence on PF % than factors g to i.

Note that the PF score will continue to develop as the project moves through the business case phases. Further enhancing costing and PF % based on the OBC appraisals will lean heavily on improved estimates on the following factors:

a. Scheme costs via ground investigation and monitoring results (see Section 6.2),
d. Obtaining other asset values (e.g. services) via information from the service providers and business owners, possibly though a stakeholder group (see Section 7.2.3),
f. Post-scheme hazard scenario probabilities (effectiveness of solution) via ground investigation and monitoring results (see Section 6.2), and,
h. Appraisals and design etc. costs via ground investigation and monitoring results (see Section 6.2).

Ground investigation and monitoring undertaken during OBC will enhance cost estimates on factors a, f and h, and ultimately PF accuracy, by providing detailed, location-specific information.

8. Environmental considerations for preferred schemes

8.1 Considerations for all works

Flood and Coastal Erosion Management works at Ventnor, including all preferred schemes and maintenance outlined in Section 4, may include activities within areas which may be sensitive to construction activities (Figure 5). Any proposed coastal defence and drainage works, or maintenance should consider, and comply as appropriate with, the requirements of the following designations and features:

- The South Wight Maritime Special Area of Conservation (SAC);
- Isle of Wight Downs Special Area of Conservation (SAC);
- Compton Chine to Steephill Cove Site of Special Scientific Interest (SSSI)
- Ventnor Downs Site of Special Scientific Interest (SSSI)
- Ventnor Conservation Area
- Solent & Dorset Special Protection Area (pSPA) (downdrift of site)
- Bembridge and Sandown Bay Marine Conservation Zone (rMCZ) (downdrift of site)
- Isle of Wight Area of Outstanding Natural Beauty
- Tennyson Heritage Coast (to the west of Ventnor);
- Historic environment (Numerous Listed Buildings and archaeological sites);
- Public Rights of Way (Isle of Wight Coastal Path).

The key designations which may have an influence on the scheme are provided in detail in Appendix 3 of the Ventnor Options Study Technical Report (Appendix 1).

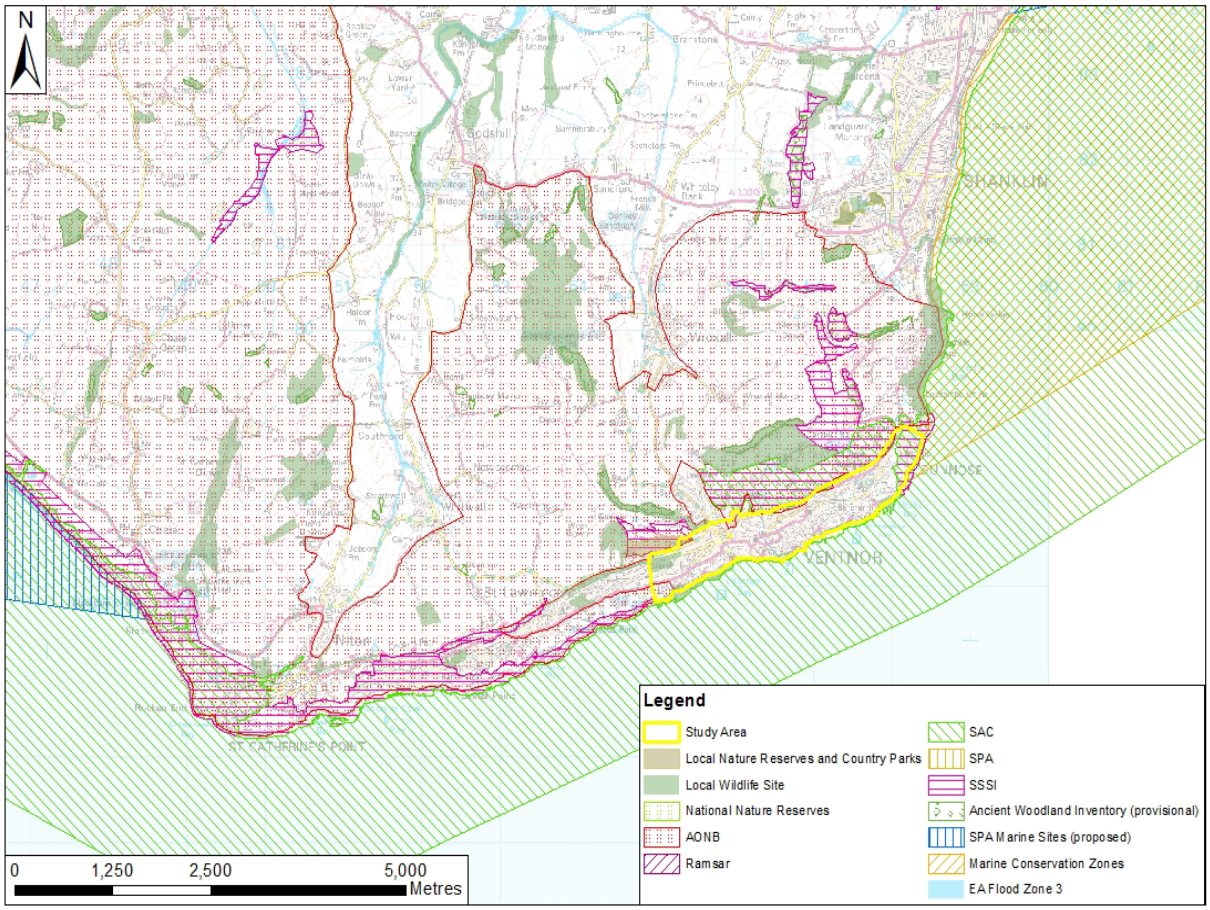


Figure 5 Key environmental designations at Ventnor

(Source: Defra - MagicMap, Available online at: http://magic.defra.gov.uk/MagicMap.aspx)

8.2 Specific considerations at Wheelers Bay

The South Wight Maritime Special Area of Conservation (SAC) is located offshore all along the Ventnor and Bonchurch frontage (and along much of the south coast of the Isle of Wight), with the boundary of the designated site usually extending from the low water mark seawards, which will require consideration in future Scheme design.

For approximately 170 metres near Wheelers Bay, the SAC boundary is closer to the shore and the current defence line, and within this area there are also some works proposed to upgrade the coastal defences as part of the Priority Scheme. The rock armour presently protecting part of the frontage at Wheelers Bay overlaps the South Wight Maritime SAC by up to 15m width. It is therefore likely that in this area the replacement structure footprint will impinge on the SAC boundary. As such, this section provides specific environmental considerations for the proposed schemes at Wheelers Bay. Figure 6 shows the potential interaction of replacement structure and the SAC and Table 21 summarises the environmental considerations.

Figure 6 Overlap of the Maritime SAC and coastal structures at Wheelers Bay

Table 21 Environmental considerations for the proposed schemes at Wheelers Bay

Asset	LRU	Environmental designation	Potential impact on designation
IW 32 / 001 - Replace structure with new rock revetment with concrete upper seawall	Wheelers Bay	South Wight Maritime SAC protecting habitats in subtidal reefs and areas of large boulders that extend into the intertidal zone.	The rock armour presently protecting the western end of the asset overlaps the SAC by up to 15m. The seawall is set back from the SAC by 10m. As such it is possible that the replacement structure footprint will overlap the SAC boundary
IW33/001 - Landslide drainage to reduce susceptibility to landslides and replace toe with new sheet piles and rock revetment to add toe support	Wheelers Bay		The tetrapods presently protecting this asset overlap the SAC by up to 7m and, in places, the seawall meets the SAC boundary. As such it is very likely that the replacement structure footprint will overlap the SAC boundary

The design and therefore footprint of the replacement structures at Wheelers Bay will not be known until GI, monitoring and other appraisals have been completed and analysed at the OBC stage (see Section 6). To account for this uncertainty, a robust budget for environmental appraisals (up to and including HRA Stage 2),

design and construction, based on experience at similar sites, such as Lyme Regis, Fairlight and West Bay, has been built into the CBA, PF and OBC costs. These allow for design and construction of a robust solution that accounts for potentially unfavourable ground conditions and for local incipient ground movement. While a new steel sheet piled toe and extensive rock revetment to provide additional toe protection/weight have been provisioned for in this assessment, the solution hinges on reducing/eliminating movement on the deep failure through the deep drainage scheme proposed in this report. Both the coastal and drainage elements require specific ground investigation before detailed design can be considered and structure footprints defined.

Although there is an apparent overlap of the Maritime SAC and the rock armour in the east and tetrapods in the west at Wheelers Bay this may not present a problem for the following reasons:

- There is a rational argument that the SAC boundary is arbitrary as it follows the low water mark. This supposition is supported by the fact that the designation protects subtidal reefs which are a small distance offshore rather than aligned to the low water mark or present defence limit. An assessment of extent and distribution of the reefs/features of interest could show that the SAC boundary could be moved seaward, eliminating the overlap. A preliminary assessment of the bathymetry and aerial imagery has been undertaken for this assessment. It shows that the reefs extend in places into the intertidal zone but cannot identify conclusively if they overlap the rock armour. If necessary (i.e. if the proposed scheme does overlap the SAC boundary), this would require a detailed assessment at the OBC stage.

- Because there is already a significant structure in place, any replacement is very unlikely to have a significant impact on net loss of habitat or nearshore sediment transport which otherwise could potentially bury the reef and necessitate compensatory habitat.

- Both the rock armour (2000) and the tetrapods (1991) were installed before the SAC designation was put in place (2005) so that these structures are now ‘inadvertently’ part of the designation. Despite installation prior to the designation, neither structure is mentioned in the SAC citation, so that there would seem to be no clear argument to prevent their replacement, particularly if the rock were to be locally removed and replaced with no net loss of habitat.

If it transpires that new structures impinge on the SAC, an Environmental Impact Assessment (EIA) and a Habitats Regulation Assessment (HRA) would need to be undertaken. The HRA is a 4-stage process. Stage 1 during OBC would consider whether there are likely significant impacts of the works. If these are found, Stage 2 would look more closely at the potential impacts with the aim of demonstrating that there is no significant detrimental effect, or that mitigation can be identified for any unfavourable effect.

As the current foreshore appears to be either tetrapods or loose rock/small debris there would likely be little/no overall impact on the SAC. This is where most schemes pass the HRA and there is no need to go to Stage 3 or 4. If Stage 3 is necessary then an Imperative Reasons of Overriding Public Interest (IROPI) application will be required to progress the scheme. This can be a slow process where the option selection is scrutinised. However, the schemes proposed here make a very strong safety case (which is the cornerstone of IROPI) because there is an overriding public interest in preventing activation of the landslide below at Ventnor and Bonchurch. The biggest risks in this process is that compensatory reef habitat may have to be found and that IROPI can have significant impacts on programme. These potential impacts are impossible to estimate at this stage so have not been factored into the budget for environmental appraisals in Section 5.

In summary, the presence of the SAC at this location may not be a significant issue. If it is an issue, it will be necessary to fully consider and investigate, and achieve consent through the HRA process which is not unusual. At West Bay, Jacobs obtained consent to build a rock revetment fully within the SAC through a Stage 2 HRA by demonstrating there is no overall impact on the SAC.

The ‘Hold the line’ Shoreline Management Plan policy set at this location in 2010 was part of the SMP strategic level assessments which included an IROPI case considering Island-wide impacts passed in 2011. This issue will now require further consideration at Scheme level.

9. Programme, consents and risk management

9.1 Programme

A project delivery programme is presented in Appendix 9 The key milestones are as follows:

- Spring 2019: Submit Priority Scheme to the pipeline in the national Programme Refresh, seeking indicative allocations from 2021/22 onwards (for a 6 year Scheme).
- Through 2019-20: Discuss and advance the Scheme with decision-makers and stakeholders, seeking funding contributions; whilst also securing indicative future GiA allocations
- 2020-21: Prepare and submit FCERM7 (or earlier if funds are available earlier); whilst also obtaining the required funding contributions
- *Start of 2021:* Agree funding release with EA through FCERM7 approval (ready to commence Scheme from March 2021 onwards, or earlier if funds are available earlier).
- *May 2021:* Appoint consultant for OBC (including outline design)
- *Aug to Sept 2021:* GI site works
- *Dec 2021:* Agree Short List of options
- *June 2022:* Identification of preferred option
- *Nov 2022:* Submit OBC (following completion of outline design)
- ***Feb 2023:* OBC approval**
- *May 2023:* Appoint consultant for FBC (including detailed design)
- *Aug 2023:* Public consultation
- *Oct 2023:* Submit planning application
- *Jan 2024:* Completion of detailed design
- *Mar 2024:* Submit FBC (following receipt of planning permission)
- ***Jun 2024:* FBC approval**
- *Jul 2024:* Award construction contract
- *Sept 2024 to Aug 2025:* Construction of coastal defence works
- *Jan 2027 to Aug 2027:* Construction of drainage wells
- ***Sep 2027:* Completion.**

9.2 Planning

The programme outlined above considers the submission of a full planning application once the detailed design has been substantially complete. There would be the opportunity to submit an earlier application on completion of the main general arrangement drawings. A pre-application could also be considered.

A note on the planning implications of the proposed scheme and way forward is included as Appendix 5. The planning note should be accompanied by the non-technical summary (Appendix 6) for decision makers and the public as an appendix to the planning note.

9.3 Other consents

A marine licence would need to be obtained through the MMO. The coastal defences are likely to require significant volumes of good quality rock, for which transport by sea is likely to prove the most viable delivery method (delivered to an offshore anchor location via a large barge and transhipped to a shuttle barge for delivery to shore). Given the environmental sensitivities along the frontage, this is likely to require an Appropriate Assessment through the Habitats Regulations Assessment. Early screening and scoping with MMO and early dialogue with Natural England would manage these consenting risks. There is a risk that IROPI would be required but this risk would be carefully mitigated throughout the design and environmental appraisal stages.

Other than planning consent and the marine licence, other approvals required could comprise (but not be limited to) Environmental Permit (from the Environment Agency for works to a flood defence), Temporary Public Rights of Way Closures/Diversions and protected species consents (unknown at this stage if/what required).

9.4 Risk Management

There are significant economic and health and safety risks to the IWC and the local community associated with not progressing any improvement works at Ventnor. There are also risks associated with delivering the schemes at Ventnor. Many of these project delivery risks are typical of most similar schemes and these risks should not be a barrier to moving forward.

9.4.1 Risks of not progressing a scheme

- **Risks to the community:**

  - **Asset damage** (re. Appendix 1, Section 4.3.3) – this comprises repairs to regular small landslide movements and more significant infrequent events. The most significant scenarios could result in property write off. Asset damage and loss includes impacts to residential and non-residential property, transport links such as roads and footpaths and utilities and services.

  - **Injury/death/wellbeing** – the level of these risks relates to the magnitude and frequency of ground movements. Building collapse, services severance and severance/collapse of transportation infrastructure could all lead to serious injury or death. Smaller ground movements would frequently result in trips as steps and footways move. In addition, living with the constant fear of injury or financial exposure could have negative wellbeing impacts.

    Although the risk of injury is possible, and loss of life possible but very unlikely, they have not been quantified in the QRA. This is because the FCERM and HM Treasury Guidance requires all damages and losses to be presented in financial terms and the value associated with injury and, in particular death, is subjective and very difficult to define. In addition, any conclusions regarding these factors would have to recommend complete avoidance or mitigation because the loss on even a single life is intolerable. Although the effects of instability and landsliding, such as loss of homes or access to transport links, will affect the wellbeing of the community, they are also very difficult to present in economic terms so have not been included in the QRA;

  - **Reduction in property value** – Where the direct effects of instability and landsliding become more visible they can have a negative effect on property value and property investment, particularly where damage is caused. Properties which avoid damage from landslides will also be affected due to devaluation of damaged neighboring properties and infrastructure and due to increased risk exposure in unstable areas

  - **Rising cost insurance and inability to insure** – it will become increasingly difficult/expensive to insure property and other assets in the town should local claims against damage increase due to

ground movements. It is also possible that residents may have trouble finding insurance in areas effected by significant/persistent ground instability problems.

- **Disruption to transport** (re. Appendix 1, Section 4.3.2) – Transport disruption could mean that journey times and costs are increased significantly due to diversions caused by landslides. This issue is of particular significant at Ventnor and Bonchurch where losing one of the remaining two key road links to the rest of the Island could impose significant increases, exemplified when Undercliff Drive (to the west of the study area) was lost due to landslides. In worst case scenarios landsliding could isolate the community if incoming roads are closed.

- **Disruption to services** (re. Appendix 1, Section 4.3.3) – Disruption to services could pose significant problems for residents and businesses that loose access to power, heating, lighting or water.

- **Impacts on local economy -** The impacts of landsliding and instability, including those listed immediately above (e.g. damage and disruption to transport and services) would have a detrimental effect on the local economy. For example, tourism (dealt with in Section 4.3.2 of the Technical Report in Appendix 1) would suffer if tourists felt the area was unsafe to visit or if damage to roads prevented access.

- **Hamper to regeneration and other outside investment in improvements -** The presence/ threat of landslides and instability would discourage investment in regeneration and other local improvements. Investors would likely seek lower risk opportunities at alternative locations.

- **Risks to the IWC / asset owner:**

  - **Asset damage and loss** (re. Appendix 1, Section 4.3.2) - Without suitable intervention the IWC and other asset owners (e.g. utilities owners) will be increasingly financially exposed to the risk of asset damage and loss. There are also further risks regarding the maintenance of existing and potential new assets which are listed in section 9.4.2 below.

  - **Expensive emergency repairs to coastal defences** (see the funding comparison in Section 7.2.1) – failure of coastal assets and subsequent slope instability could result in emergency works which are much more expensive (by an order of magnitude) than bridging the currently estimated funding shortfall required to enable FDGiA funding of a full scheme.

  - **Reputational risk** (potential negligence in the face of coastal risks) – Without suitable intervention the IWC will be reputationally exposed to the risk of failures of any of the coastal defences and any subsequent major landslips. Despite a widespread understanding that council budgets are continually stretched, IWC would likely be seen as being the responsible party. This could amount to a significant risk in the event of a large landslide following the failure of a poorly maintained/performing coastal defence.

The mitigation to all of the above risks is to pursue combined coastal and drainage improvement schemes (where technically and financially feasible) and maintain protection measures to manage the risk.

9.4.2 Risks to scheme delivery

There are always many risks to consider for scheme delivery. These risks should be appraised at OBC through a risk workshop to identify the risks, plan mitigations and to cost the residual potential impacts to ensure that an adequate risk budget is set. The risk budget at this strategic level assessment is considered as part of the Optimism Bias allowance. A few of the more major risks are considered below.

- **Risks to the funding solution proposed**:

  - **Funding shortfall** – typically partnership funding is required to top up national Flood Defence Grant in Aid (FDGiA) for flood and erosion risk management schemes. This strategic plan has been developed in order to identify the most viable cost model for delivering improved risk management

measures for Ventnor, but there will likely be a shortfall that will need to be addressed. The mitigation for this risk is to seek alternative funding from amongst those suggested in Section 7.2.

- **Maintenance** – there is the risk of insufficient availability of funding for maintenance of the existing and the potential new coastal defence and deep drainage assets, in both normal operations and in the event of land movement affecting the system functioning.

- **Risks to the scheme approach chosen**:

  - **Scheme viability** (e.g. solution proved not to be feasible during appraisal) – It is possible, though unlikely, that appraisals such as ground investigation and monitoring undertaken during OBC provide evidence that an element of the proposed scheme is not technically viable. This is quite normal, however, the information gathered during OBC is also likely to provide insight into alternative viable options. This is part of the continual options appraisal and value engineering process. The application of 60% optimism bias on the construction costs provides some financial contingency should more expensive alternative options be required. It is considered low risk that it will not be possible to identify viable coastal defence solutions as there are not considered to be any overriding technical issues where defences have been identified as being in a poor condition. If no viable solution is found, IWC wouldn't be left to pick up the bill as OBC costs are recouped. In addition, IWC would have been seen to have been taking action to reduce risk in the event of a damaging landslide (i.e. it wouldn't be the responsibility of IWC that a technically viable and fundable option could not be developed). The mitigation is to allocate sufficient budget for a full options appraisal and supporting site investigation and analysis at outline design phase. If a deep drainage solution is implemented to reduce ground movement and reduce risks, the longevity of the system would depend on by how much the landslide system stability is increased and if or when any further movement sheared one or more of the drainage boreholes. What happens then should also be an issue for consideration in future risk management as the scheme is developed, including the implications of ceasing maintenance on any existing or new assets.

  - **Intolerable environmental constraints** – following an initial assessment of the environmental constraints, the risk of not being able to find appropriate technical solutions are considered low. The mitigation is to undertake detailed screening and scoping at the outset of the OBC phase and feed this into the options appraisal and EIA process.

  - **Stakeholder/public objection** – the risk of stakeholder/public resistance to a proposed scheme at Ventnor is considered low. The mitigation would be to engage widely with stakeholders and the public thorough the appraisal, design and construction stages.

  - **Consenting** – planning permission is likely to be required and a MMO Marine Licence will be required. The single biggest risk to these approvals is likely to be gaining Habitats Regulation Assessment (HRA) approval through Natural England due to the environmental designations. An Appropriate Assessment is likely to be required but it is considered relatively low risk that IROPI would be required. If it is required, there will be a strong case for its approval, but this may add significant programme risk. The mitigation would be for early screening and scoping through the MMO and the local planning authority and early engagement with Natural England.

  - **Access for construction** – access for delivery of material and for construction plant may well prove problematic due to the varied topography. This has been considered in the proposed ground investigation (see Appendix 3) but requires ongoing consideration as the Scheme develops. There are likely to be workable solutions, but this may increase the price of construction. The mitigation is to include for 60% optimism bias to accommodate such risks.

9.4.3 Residual Risks

The priority coastal and drainage scheme proposed for Ventnor Park, Central Ventnor and Wheelers Bay (which combines coastal defence improvements with drainage relief wells) is anticipated to deliver a considerable improvement in the stability of the Undercliff in the long-term, both by protecting the coastal defence assets from future landslide damage and by extending the stabilising effects of the combined coastal defences and drainage solution up to 1km inland. This will benefit all assets, services and the community occupying the areas protected

by the schemes. However, not all risk can be prevented. The scheme will reduce the probability of landslide reactivation, not eliminate it. The potential for and likelihood of residual damages at different scales is recognised, and is reflected in the cost-benefit analysis in this study, which includes the damages avoided by implementing the scheme.

10. Preliminary Outline Business Case (pOBC)

The information contained in this report (and its appendices) has been translated to the RMA business case template (Five Case Model). This draft Preliminary Outline Business Case (OBC) presents the information available at this early, strategic assessment phase.

This OBC template has been populated to varying levels of completeness. To quickly identify where further work is required, and where information will likely need to be superseded at options appraisal stage, a colour coding system has been used for the chapter headings as follows:

- Sections in green highlights can be completed at this stage, but should be reviewed at the scheme appraisal stage
- Sections in blue highlight have some information that can be presented at this stage, but would need additional info at the scheme appraisal stage
- Sections in pink highlight have some indicative information included based on the current work, but this would need to be superseded at scheme appraisal stage
- Sections in red highlight have no information available at this time from this stage of the project and would have to be completed at scheme appraisal stage

The working draft pOBC document is included in Appendix 7.

11. Conclusions

The Future Scheme Report develops the economically viable coastal defence and slope stability options identified in the Technical Report (Appendix 1) through Partnership Funding appraisal. Like the technical report it has demonstrated the importance of future management options and schemes combining deep drainage with coastal defences to provide the most beneficial and cost-efficient strategy to implement the SMP 'Hold The Line' policy at Ventnor and Bonchurch and to minimise the risk of coastal erosion and landsliding.

The assessment shows that there is an economically justified, environmentally acceptable and technically feasible scheme at Ventnor Park, Central Ventnor and Wheelers Bay, where there are the greatest total asset values to protect and coastal defences are reaching the end of their serviceable lives. The combined priority scheme proposed, comprising deep drainage and various new and upgraded coastal defences, scores partnership funding of 87% so delivers a strong economic case for seeking future national Grant in Aid (GiA) funding..

The priority coastal and drainage scheme proposed for Ventnor Park, Central Ventnor and Wheelers Bay (which combines coastal defence improvements with drainage relief wells) is anticipated to deliver a considerable improvement in the stability of the Undercliff in the long-term, both protecting the coastal defence assets from future landslide damage, and by extending the stabilising effects of the combined coastal defences drainage solution up to 1km inland. This will benefit all assets, services and the community occupying the areas protected by the schemes.

The overall scheme cash costs of £32,043k will be largely financed by £25,274k (present value costs) of national FDGiA 'Grant in Aid' funding (assessed under the present system). Although the potential shortfall in funding of £4,199k (cash cost) will need to be financed by the Isle of Wight Council and through partnership funding, this assessment has identified a number of possible funding sources and that there is significant opportunity to rationalise the scheme costs and increase benefits to reduce this shortfall.

At Castle Cove, Bonchurch East, Bonchurch West and the Landslip, maintenance has been identified as the most beneficial form of coastal management until the current defences reach the end of their serviceable lives and need replacing. At this point the cost benefit balance switches to favour replacement structures and any future scheme could be delivered in these LRUs as a fresh FDGiA submission, also likely to require local partnership funding contributions, and separate from the benefits for Ventnor Park, Central Ventnor and Wheelers Bay in the first priority scheme.

12. References

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Appendix 1 – Technical Report

Appendix 2 – Site walkover with Prof. Eddie Bromhead to review feasibility of deep drainage

Ventnor Options Appraisal: Drainage Relief Wells; Expert's Site Visit and Report

Prepared for
Isle of Wight Council

Date: 07/06/2019

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Contents

Introduction

1.1 Background

Coastal land instability risk in the Undercliff is controlled by two principal factors:

- Loss of support through coastal erosion, and
- Excess groundwater pressures triggering ground movement and episodic landslides

Maintenance and improvements to the coastal defences across the frontage at Ventnor and Bonchurch will mitigate future coastal erosion and loss of support by holding the defence line in its current position. Foreshore erosion may still occur seaward of the coastal defences causing some loss of support, albeit the rate of down wearing is low and, therefore, relatively insignificant compared to other factors.

There is presently no control of excess groundwater pressures triggering ground movement and episodic landslides. There is compelling evidence to show there is a strong relationship between antecedent effective rainfall, groundwater pressures, and ground movement acceleration in the Undercliff (Moore et al. 2010; Carey et al. 2014). Consequently, the control of groundwater pressures in combination with coastal defence improvements, has great potential to deliver significant reduction in land instability risk in the Undercliff.

Drainage is an effective measure to stabilise slopes and landslides; it is rarely adopted in isolation and is most often used in combination with other slope stabilisation measures. For drainage to be successful, a good understanding of the relative contributions of surface water drainage and the subsurface hydrogeology regime to groundwater levels and pressures is essential. This requires investment and time to carry out drainage surveys, hydrogeological ground investigations and trials, and analytical modelling to support selection of options and design of a preferred drainage solution.

1.2 Previous work

The local geology of a combination of relatively permeable and impermeable layers dipping seawards and consequent historical ground movement (of rotational and translational landslides and mudslides) has created the complex of south-facing terraces, scarp slopes and sea cliffs forming the Ventnor Undercliff landslide complex underlying the town of Ventnor and it's surrounding villages.

Previous work carried out at Ventnor by Halcrow (2002 and 2006) considerably advanced understanding of the hydrogeological regime of the Undercliff, specifically the relative influence of aquifers above the impermeable Gault Formation and below the impermeable Sandrock 2d layer (Moore et al. 2010), in which landslide slip surfaces occur.

The upper aquifer above the Gault is unconfined and drains surface water infiltrating the Southern Downs watershed under hydrostatic conditions, feeding a number of well-known springs and ponds (e.g. Bonchurch pond) at mid-level within the Undercliff. The springs and ponds are drained by streams which convey surface water to the shoreline. This is essentially an effective natural surface water drainage system that has evolved over time albeit modified in some locations to accommodate development and amenity (e.g. Ventnor Park).

The lower aquifer below the Gault is confined and has the potential to generate significant artesian groundwater pressures at the base of the Undercliff, reducing its stability, and causing ground movement. The source of groundwater feeding the lower aquifer is the central vale of the Isle of Wight where the Lower Greensand Sandrock strata outcrop at surface (60-100 mAOD). These strata dip to the

south-south-east and are gently folded - forming the St Lawrence syncline - so that under gravity, groundwater drains beneath the Southern Downs to the Undercliff, where the strata are confined by the overlying impermeable Gault and base of the landslides in Sandrock bed 2d, some 20-40m below sea level. Drainage of this aquifer is impeded and probably occurs offshore, giving rise to a potentially significant artesian pressure head of up to 60m at the shoreline. Artesian groundwater pressures have been confirmed in several locations where boreholes have been drilled deep enough into these strata.

1.3 Combined coastal defence and deep drainage solution

The instability and progressive movement seaward of the lower-tier deep-seated landslide blocks are controlled by groundwater pressures developed on basal shear surfaces in the Lower Greensand Sandrock e.g. bed 2d. Relief of artesian groundwater pressures on the basal shear surface could achieve significant improvement in the stability of the lower-tier landslide blocks, which in turn would arrest retrogressive movement and failure of the upper-tier landslide blocks above the Gault Formation.

Combining coastal defence improvements with drainage relief wells along the shoreline could deliver a considerable improvement in the stability of the Undercliff in the long-term, both protecting the coastal defence assets from future landslide damage, and by extending the stabilising effects of the combined coastal defences drainage solution up to 1km inland, benefitting all assets, services and the community occupying the Undercliff.

1.4 Purpose of site visit

The purpose of the site visit was to solicit the views of Prof. Eddie Bromhead and others present about the merits of deep drainage options to stabilise the lower-tier landslides of the Undercliff, as well as early identification of issues that will need to be addressed to support the design and installation of relief drainage wells along the alignment of coastal defences.

The site visit took place on 31st January 2018 and was attended by Prof Eddie Bromhead, Prof Roger Moore, Ross Fitzgerald, Claire Czarnomski, Jenny Jakeways and Peter Marsden. The weather was overcast with occasional showers, sunny spells and moderate winds.

Site visit report

2.1 Prof Bromhead site visit report

I was very impressed by the work done to refine knowledge of the fold system that runs through the Undercliff, and to hear that the changes in the landslide system reflect the changes in the elevation of critical sequences relative to sea level. I am completely in accord with the idea that the groundwater in the landslide system can be divided into two subsystems: above and below the Gault, with little or no connection between them; the sub-Gault system being fed from outcrops inland of the Downs, and perhaps finding an outlet offshore, in which case the postulated existence of artesian pressures at the coast would be likely. I think that the experience of artesian flows from the SWA borehole in Steephill Road (A3055) is good evidence. I think it might be worth consulting records of the borehole near the Terminus Hotel, which you will find in Martin Chandler's thesis, as that certainly penetrated the Gault Clay. It might provide some evidence of water levels and extraction rates possible from the lower strata at another location south of the Downs.

The concept of local deep drainage to relieve confined water pressures in the Sandrock Formation exclusively at the coastal margin seems to me to have great merit, and the programme of investigation seems to me to be a worthwhile exercise.

Returning to some of the observations I made in the field, the investigation needs to answer several questions, not least are there artesian water pressures in the Sandrock at the sea cliff location that can be readily relieved, and if so, what are their magnitude and distribution?

Drainage concentrated at the coastal margin has several advantages, notably that unlike drainage in the upper groundwater system with the varied geology in the landslide system above the Gault it is unlikely to cause severe differential settlement of the surface. However, what is proposed is to 'pin' the slip surface in a clay member of the Sandrock, thus transferring shear to underlying strata. On reflection, they are probably strong enough, having survived the higher stresses prior to formation of the shear surface necessary to induce it, and also benefitting from the drainage effect and increase of effective stress, and therefore also increasing in strength. That does mean relieving pressures in all the sand members of the Sandrock. In my files I have strength data on some parts of the Sandrock – I will find this and forward it.

The improvement in stability overall is a function of how much water pressure reduction can be achieved, but as this is local to the coast, the remainder of the landslide system landward of the major effect will require adjustments in stresses and deformations, which may be a slower process than arresting movements in the coastal margin. There is also a question of how rapidly drainage and relief of water pressures in the sand members can take effect on the shear surface which is in a clay member. Calculations for this will require parameters from field and laboratory tests but are very feasible once the parameters are available.

The reconnaissance demonstrated that there were many locations where investigations could be undertaken, but with some shorter stretches where access was impractical. It seemed to me nevertheless that a comprehensive investigation scheme was highly practical. Certainly, the permeability of the Sandrock will turn out to be an important factor, which needs to be evaluated in field tests and as far as possible in the laboratory. I will remind you that the Sandrock is a 'locked sand' and that it may require special drilling techniques (see Figure 1). We used polymer additives when working at St Catherine's Point.

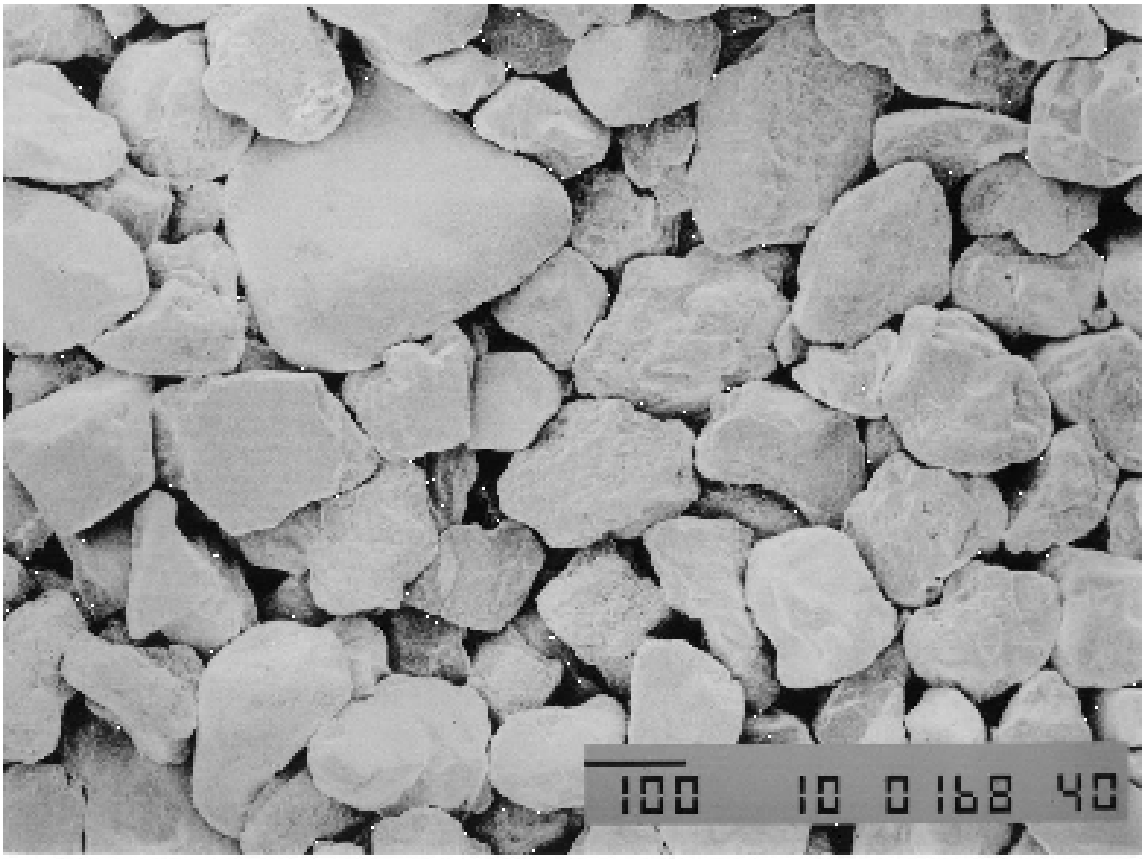

Figure 1. SEM photo of the Sandrock

2.2 Prof Bromhead groundwater flow model and insights

I have given some thought to the water flows from the outcrop of the Sandrock N. of the Downs, and think that this can be simple to model as the stratum does not vary greatly in thickness and is mostly a confined aquifer. Any connection to the phreatic system above the Gault in the Downs is a complicating factor, and any connection in the Undercliff another, but if it outcrops offshore, the plan shape and position of that outcrop would be very important in determining any artesian behaviour.

I looked in my archives and found a finite element mesh that I could use to get an idea of where water might flow from and to in the confined Sandrock aquifer. Without attempting to model the Sandrock outcrop round the Downs, but just to get a feeling, I took a square region, and represented the top half with a potential rising to the 'North'. I set the boundary potential around the 'Southern' half of the mesh to simulate some sort of an underwater outcrop with the hydraulic potential being sea level.

The equipotential lines deflected seawards at the coastal margin, which in my book indicates some artesian pressures relative to sea level.

The other point is that the flow out from the mesh takes place where the Sandrock outcrops near the coast. The velocities are very small in the southern half of the mesh, which probably means that it doesn't matter what shape it is, and indeed, whether the downdip extremity of the Sandrock outcrops at all. The sides have to outcrop where they come down to the shore.

The interesting thing is that in the West, the outcrop is under Rocken End! It makes me look at the stream that disgorges into Watershoot Bay with new eyes, as I'd always felt it came out of the phreatic water body on top of the Gault underneath Gore Cliff, whereas it might be leaking out of the Sandrock.

In the East, the corresponding point is somewhere near the end of Shore Road where we stopped and Roger discussed the end of any sites for relief wells and/or investigation boreholes. That marks the end of a debris apron, but not the end of the ridge. That would put the end somewhere between East Dene and the Winterbourne Hotel in Bonchurch.

The maximum artesian pressure under the beach can't be enough to lift off the overlying strata, but that could still be a lot. Hence my suggestion of modelling the confined aquifer with the correct geometry. In addition, it would be sensible to just test the level of artesian pressure it with one borehole somewhere?

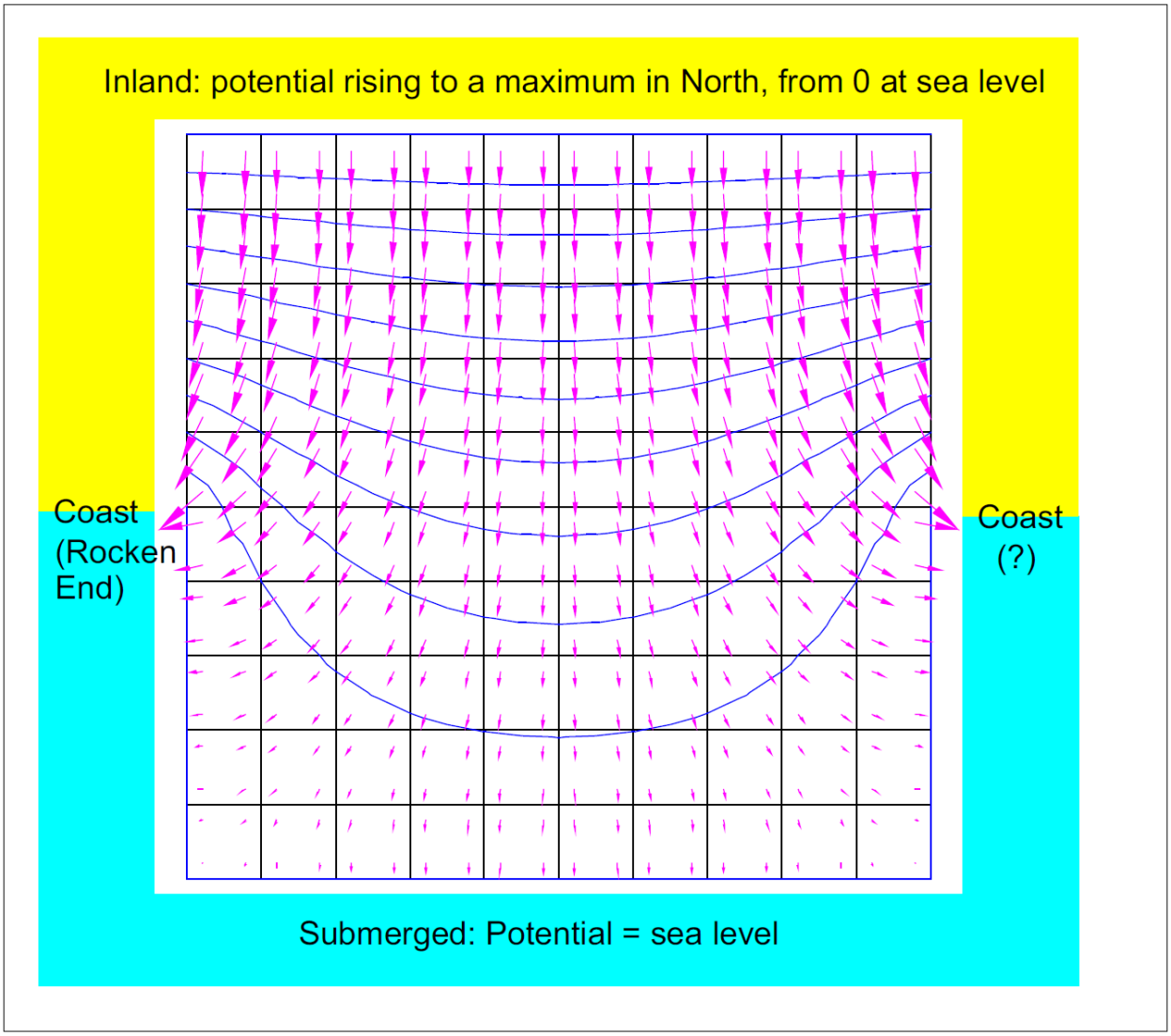

Figure 2. Finite element mesh model showing potential artesian pressures at sea level

2.3 References

Halcrow Group Ltd (2002). Bonchurch Landslide of March 2001: Preliminary Interpretative Report. Technical Report to the Isle of Wight Council.

Halcrow Group Ltd (2006). Ventnor Undercliff, Isle of Wight, Coastal Instability Risk: Interpretative Report and Quantitative Risk Analysis. Technical Report to the Isle of Wight Council.

Moore R, Carey JM & McInnes RG (2010). Landslide behaviour and climate change: predictable consequences for the Ventnor Undercliff, Isle of Wight. Quarterly Journal of Engineering Geology and Hydrogeology, Vol. 43, pp447-460.

Appendix 3 – Statement of Requirements for deep drainage and replacement coastal defence assets

Ventnor Options Assessment

Statement of requirements for ground investigation and monitoring needed for replacement coastal defences and deep drainage at Ventnor

07/06/2019

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Prepared for

Isle of Wight Council

Date: 08/02/2019

This document has been amended and approved as follows:

Revision	Date	Description	Created by	Reviewed by	Approved by
0	08/02/2019	For issue	Andrea Perrone and Ross Fitzgerald	Ross Fitzgerald Claire Czarnomski	Roger Moore
1	07/06/2019	Updates to client comments	Andrea Perrone and Ross Fitzgerald	Ross Fitzgerald Claire Czarnomski	Roger Moore

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Introduction

As part of appraisals required for gaining government funding for replacement coastal defences, Jacobs (previously CH2M) has undertaken an assessment of coastal management options for Ventnor and Bonchurch to identify the range of technically feasible and economically viable schemes in accordance with the latest FCERM Appraisal Guidance. The assessment demonstrates that effective coastal cliff management at Ventnor requires solutions that prevent coastal erosion and excess groundwater levels which drive instability.

This slide pack sets out a statement of requirements, an outline scope, and the costs for ground investigation (GI) and monitoring required for the design and construction of the proposed priority coastal and deep drainage schemes identified at Wheelers Bay, Central Ventnor and Ventnor Park. **The aim of these investigations is to**:

- Develop and extend the ground model and understanding of ground conditions established in previous work.
- Monitor ground movement and groundwater pressures and levels for the scheme design, building on the existing monitoring network data.
- Define landslide mechanisms and controls.
- Identify the location and depth of any ground movements.
- Define geotechnical parameters for coastal and drainage scheme design and construction.

The outline scope contained in this document comprises:

- Ground model sections from the geomorphological mapping and existing GI information.
- Recommendations for exploratory hole type, location, depth, samples, in-situ and lab tests, instrumentation, monitoring and other appraisals.
- Consideration of access constraints.
- Explanatory notes on the objectives of each exploratory hole and general recommendations for the investigation.
- Estimates on the cost of the required monitoring, ground investigation and analysis required to support the coastal defence and drainage schemes.

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Outline Scope

Annex 1 provides the outline scope for each exploratory hole of the GI and the monitoring. It details the location, objective, drilled depth, installations, in situ tests, samples, lab tests, ground model tested, access and special recommendations. The cost (provided on slide 20) of the ground investigation detailed in Appendix 1 has been estimated using a current Bill of Quantities from a major GI contractor and is input into the costs detailed in the Future Schemes Report and the Outline Business Case. The Bill of Quantities cannot be shared.

Slides 5 and 6 of this slide pack provide the ground investigation layout required for *drainage* design. Slides 7 to 9 provide the ground model cross-sections that these intrusive works aim to test and calibrate. Slides 10 to 13 provide the ground investigation layout required for *coastal defence* design.

Below are general recommendations which are applicable to the GI as a whole.

- **Ground investigation must be flexible:** The outline scope for GI provided in this document is appropriate for the information available on 08/02/2019. It is important that the GI can be adapted to any new information and, once in progress, adjusted based on the results of each preceding borehole or test.
- **Experienced supervision required:** This will enable good decision making when adapting the GI to ground conditions observed in preceding boreholes. This will ensure that the GI obtains the required information as efficiently as is possible.
- **Core logging:** Detailed core logging with specialist interpretation should be used to develop the ground model, identify marker beds, slip surfaces, structure, laminations, bedding, remoulding, dip angle and to correlate between boreholes. The logging system guidance on slide 17 should be used to guide core logging.
- **Gamma logging:** Gamma logging should be used to assist in identifying marker beds, slip surfaces, dip angle and to correlate between boreholes. The gamma logging guidance on slide 19 should be used.
- **Existing borehole information:** The location of available existing borehole information has been taken into account when planning this outline GI scope. These datasets have been used to create ground models presented herein.

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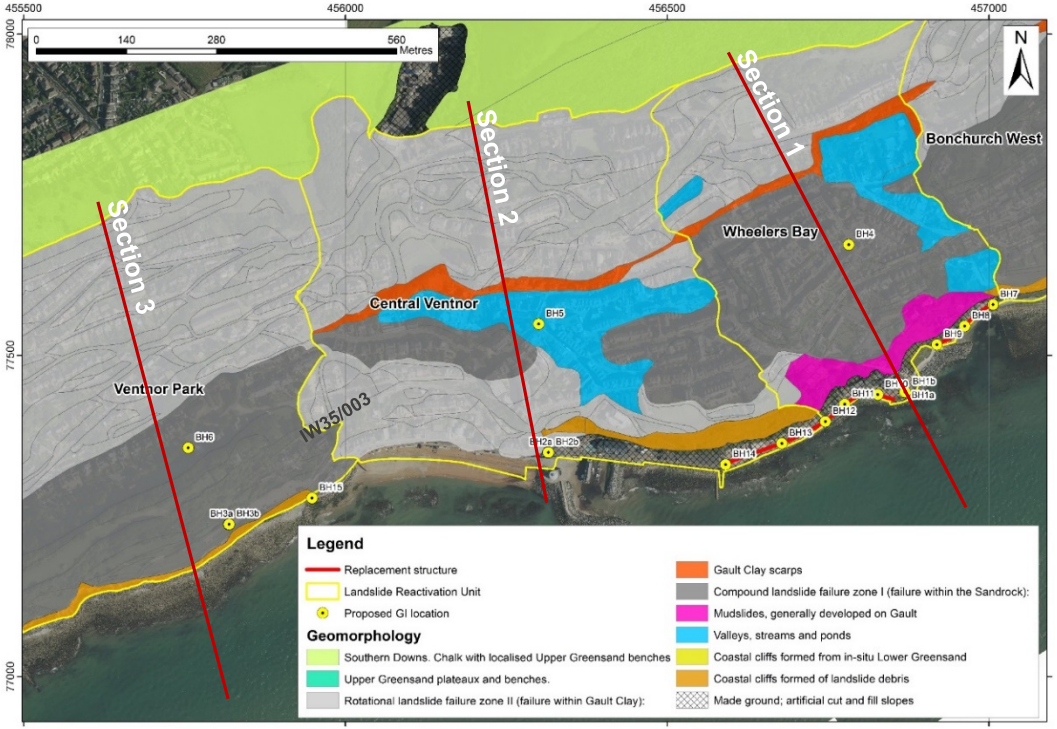
Site map and borehole locations for drainage design and coastal defence design

- A total of 18 ground investigation locations are proposed, utilising a variety of methods, instrumentation and depths (see Annex 1 for details).
- These locations are sited mainly along the coastline but also include 3 sites upslope.
- 9 boreholes will inform the drainage solution (ranging from approx. 40-85 m deep),
- 9 boreholes will inform the coastal defence design (to approx. 15 m deep



Boreholes 1a and b, 2 a and b, 3 a and b and 4-6 are for drainage design, boreholes 7-16 are for coastal defence design.

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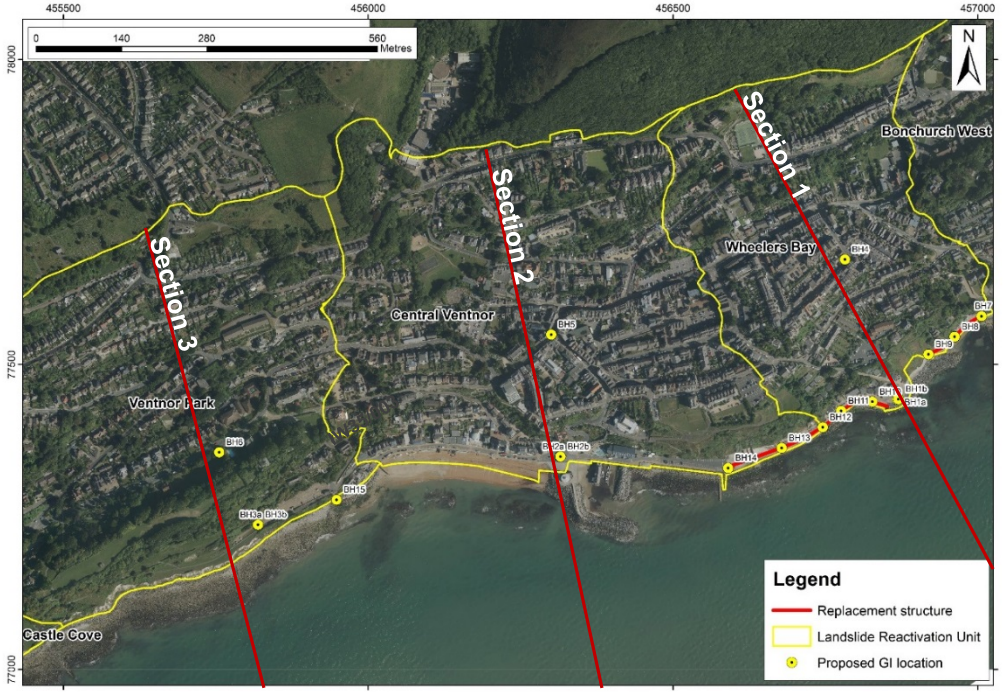
Site map and borehole locations for drainage design

- Priority drainage schemes with the aim of reducing ground water pressures in the Sandrock 2C unit are proposed at Ventnor Park, Central Ventnor and Wheelers Bay.
- The distribution and depth of the boreholes are planned to investigate landslide geometry and mechanisms.
- Surface profile data for the sections in slides 7-9 are extracted from the 2015 LiDAR data.
- The distribution of inclinometer installations (Boreholes 1a, 2a, 3a, 4, 5 and 6) is designed to measure the ground movement depths, rates and directions in relation to key morphological features and the coastal defences.
- The distribution of piezometer installations (Boreholes 1b, 2b, 3b) is designed to understand groundwater conditions and its influence on slope stability.
- The side by side boreholes along the frontage should be as close to the seawall (i.e. close to proposed drainage location) as possible, with a target depth into unit 2c. The first hole will be continuously sampled for in-situ tests, traditional and gamma logging, lab samples and inclinometer to inform the ground model, the second open hole for piezometers to assess ground water.
- The mid-slope open hole boreholes are planned close to the rear of the lower landslide tier, with a target depth into unit 2c. Inclinometers and gamma logging are planned to inform the ground model.



Boreholes 1a and b, 2 a and b, 3 a and b and 4-6 are for drainage design, boreholes 7-16 are for coastal defence design. The sections, shown in profile on slides 7-9, indicate the proposed depth of the boreholes in relation to the landslide shear surfaces

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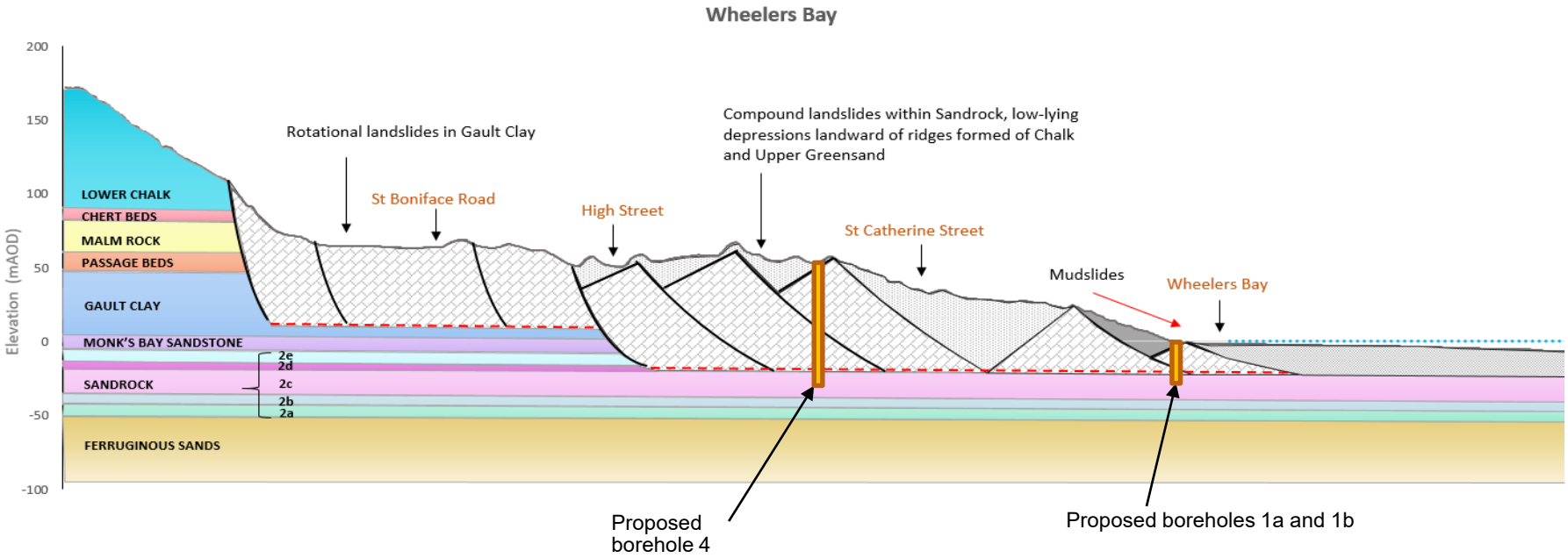
Section 1: Ground model through Wheelers Bay showing proposed borehole locations



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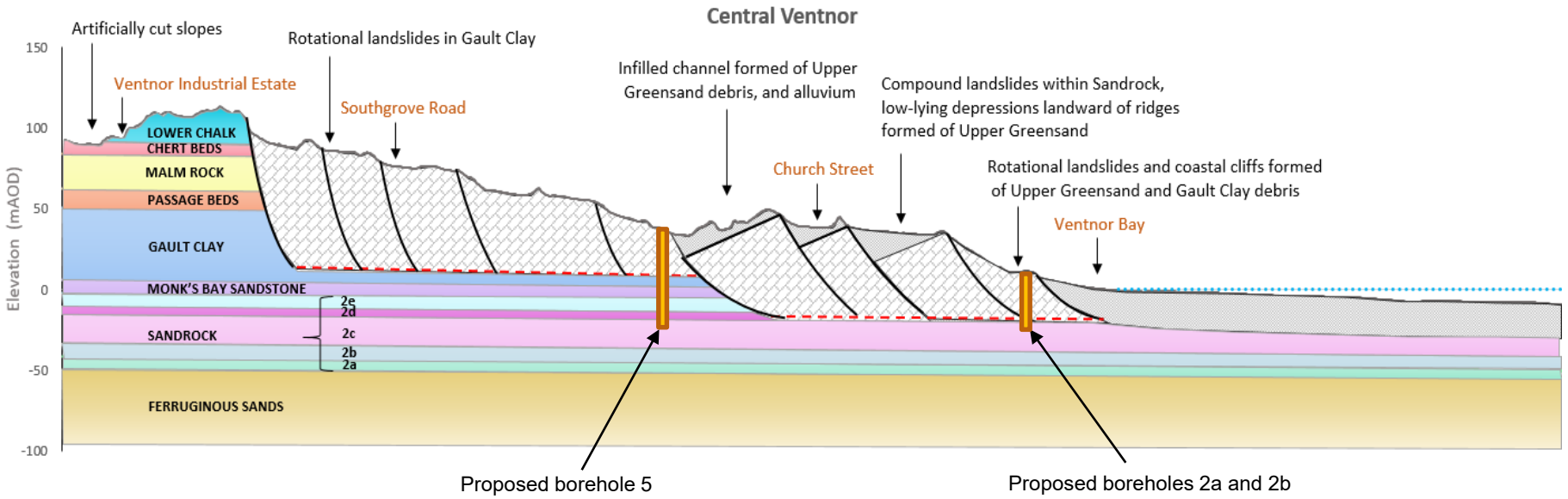
Section 2: Ground model through Central Ventnor showing proposed borehole locations



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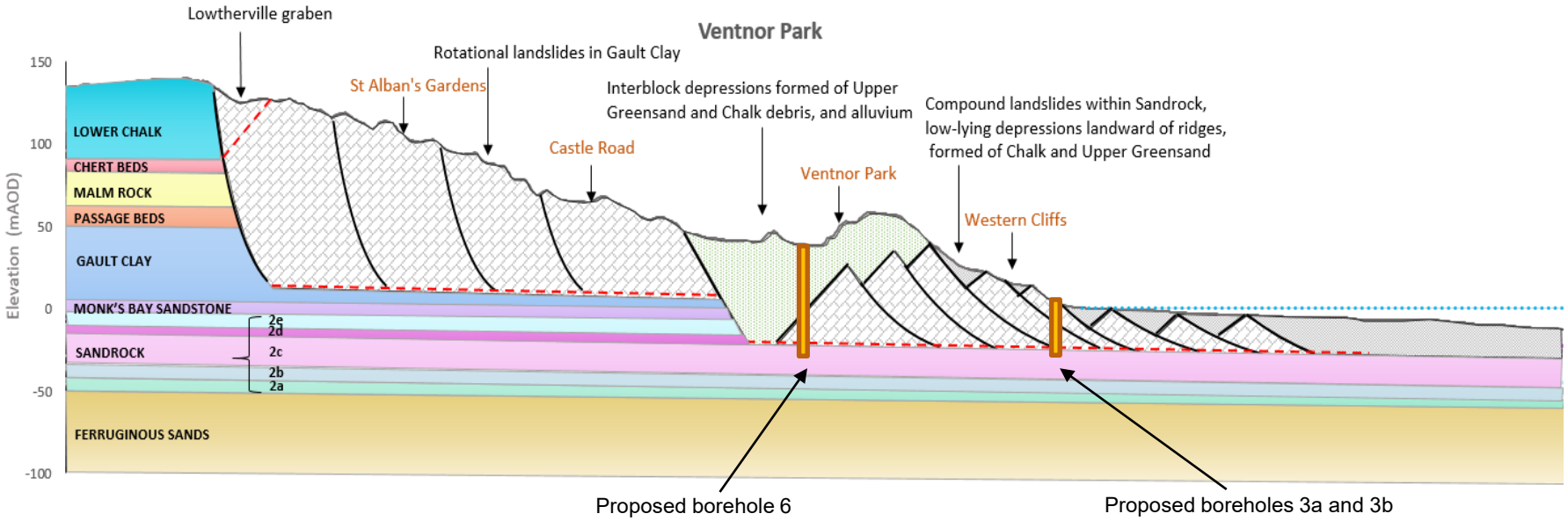
Section 3: Ground model through Ventnor Park showing proposed borehole locations



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Wheelers Bay: Asset replacement IW 32 / 001

- Asset IW 32/ 001 protects 110m section of eastern Wheelers Bay.
- The objective is to replace current structure, which is in poor conduction, with a new rock revetment with concrete upper seawall
- The 3 boreholes are located a the middle and ends of the structure to maximise coverage of the investigation.

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Wheelers Bay: Asset replacement IW 33 / 001

- Asset IW 33/ 001 protects 119m section of western Wheelers Bay.
- The objective is to provide drainage to reduce susceptibility to local shallow landsliding (note, this is different to the Undercliff-wide deep-seated landslide which the deep drainage mitigation targets) affecting the existing structure and replace toe with new sheet piles and rock revetment to add toe support.

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Central Ventnor: Asset replacement IW 33 / 002

- Asset IW 33/ 002 protects 181m section of Eastern Cliffs at Central Ventnor.
- The objective is to replace current structure, which is in poor conduction, with a new rock revetment with concrete upper seawall

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Ventnor Park: Asset rebuild IW 35 / 003

- Asset IW 35 / 003 protects 12m section of Western Cliffs at Ventnor Park .
- The objective is to rebuild the encasement with drainage and provide increased rock revetment levels.

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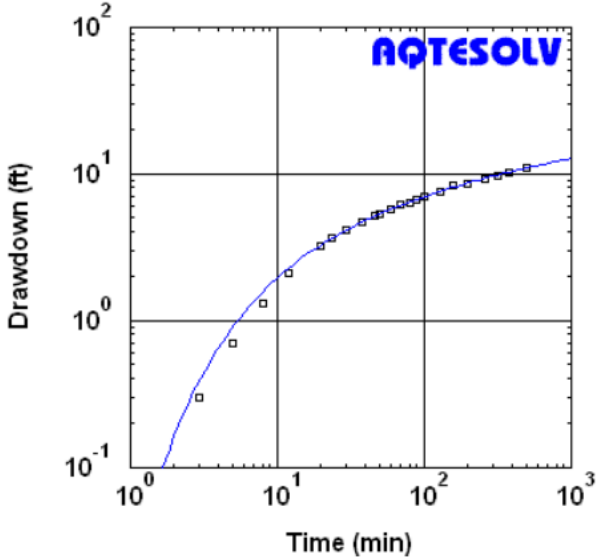
In-situ permeability tests

The following hydraulic tests should be undertaken because they provide critical information on ground water levels and pressures for the design of deep drainage.

- Variable/ falling head and pumping tests are required to measure soil and rock permeability and to understand the groundwater regime and response to drainage and drawdown.
- Due to slow ground water response to recharge the tests should be undertaken over a period of 1 year.
- Real-time automatic monitoring of ground response to recharge of a boreholes 1a, 2a and 3a should be undertaken in adjacent boreholes 1b, 2b and 3b to define drawdown.
- Note that the drillers logs will be important for identifying ground water under artesian pressures in the slope. Water should backfill boreholes in areas experiencing high pressures.



Estimation of aquifer drawdown collected in an observation well during a constant-rate pumping test

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Instrumentation: Inclinometers

- Inclinometers should be installed in boreholes 1a, 2a, 3a, 4, 5 and 6 to measure ground displacements at depth.
- Inclinometers datasets will return information on the depth, rate and vector of ground movement.
- The data obtained from inclinometers will be used to inform the ground model (e.g. identifying movement along shear surfaces) and parameters for slope stability calculations.

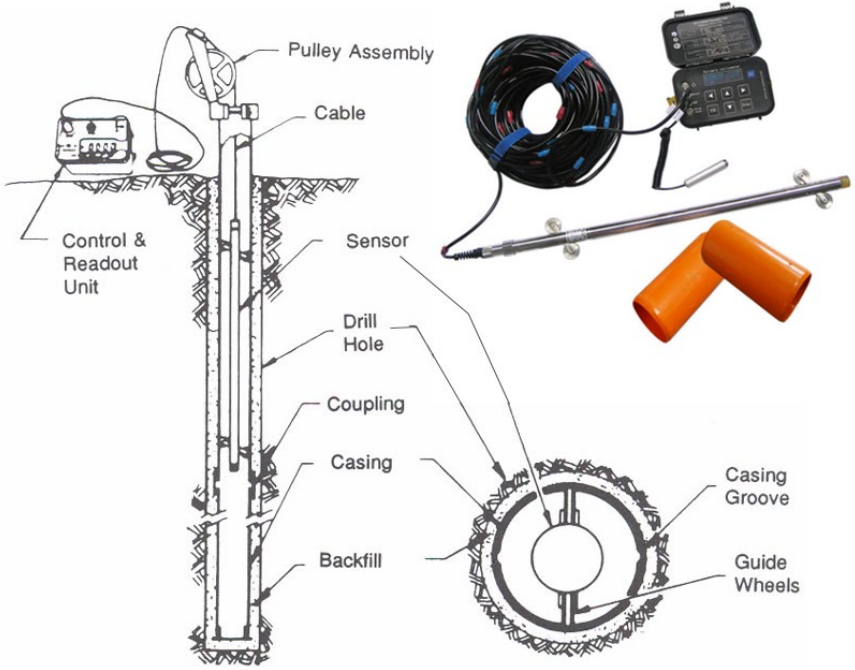

Image and schematic of a typical inclinometer

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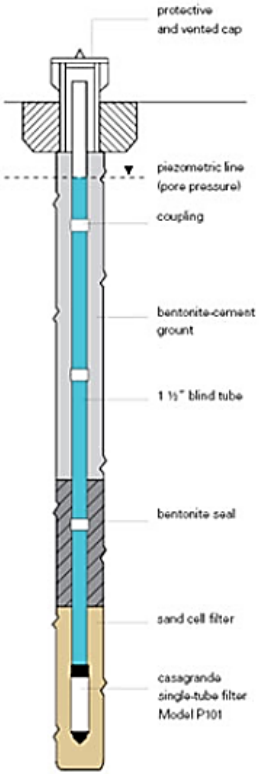
Instrumentation: Piezometers

- Standpipe piezometers fitted with Casagrande filter tips measure the pressure of groundwater at specified depths in boreholes.
- Water pressures will be measured in groundwater response zones in the upper aquifer and lower Sandrock 2c aquifer in boreholes 1b, 2b and 3b. For the slope stability assessment, these groundwater response zones provide pore water pressures in the basal shears of the landslide.
- The data obtained from piezometers will be used to determine parameters for slope stability calculations and to understand how much water will need to be removed to achieve stability for the deep drainage design.

Typical standpipe piezometer with Casagrande tip



Schematic of a typical standpipe piezometer

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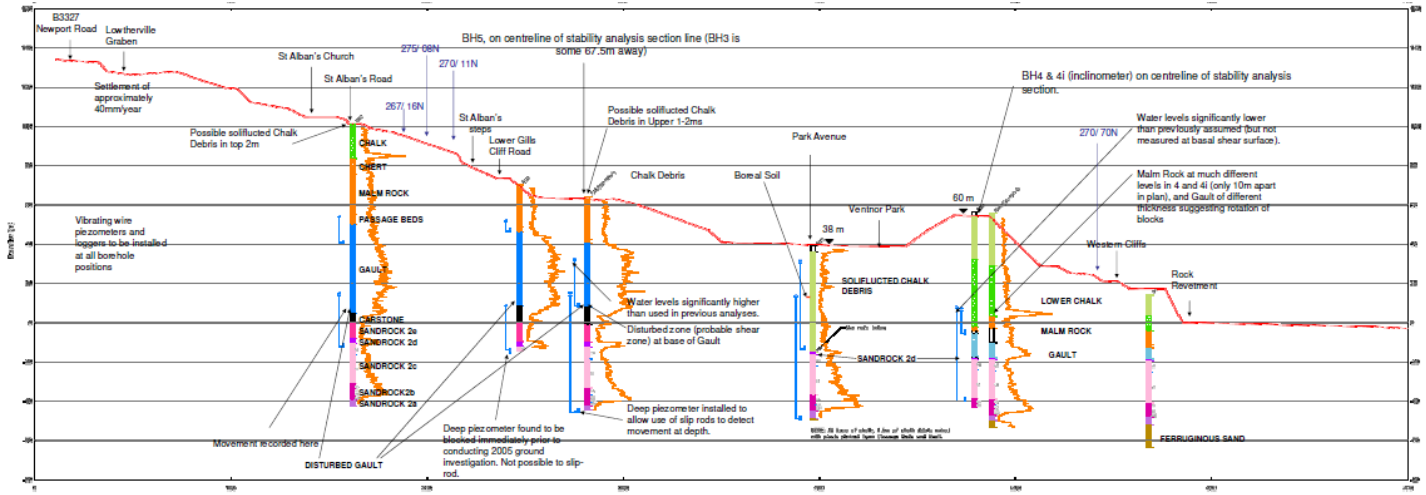
Core Logging Guidance

The objective of core logging is to develop the ground models by identifying and recording in detail the material properties and structure of the sediments and features (e.g. shear surfaces) encountered.

Logging requirements:

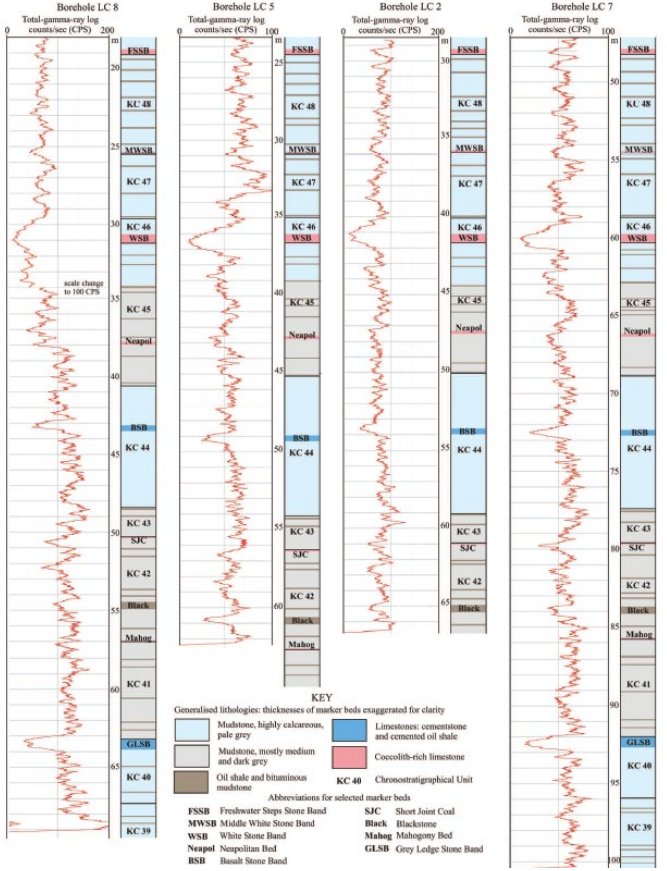
1. Rotary boreholes 1a, 2a and 3a should be continuous coring or sampling to their full depth.
2. Regular inspection of cores or samples in the field by an engineer expert in the identification of shear surfaces is required to allow initial interpretation (particularly of shear surfaces) and if necessary modification of the remaining GI.
3. Detailed logging and interpretation of samples including description and identification of slip surfaces, structure, laminations, bedding, remoulding, and dip angle. These data are vital for the development of the ground model.
4. If any fossils are encountered retain the specimen and record their depths to enable identification as stratigraphic markers if necessary.

Results from earlier Ventnor ground investigation used to make the current ground model



Gamma Logging

- Gamma logging should be undertaken in boreholes 1a, 2a, 3a, 4, 5 and 6.
- Natural gamma logging is a geophysical down-hole logging method carried out in open or cased boreholes to provide information on lithology or for the identification and correlation between boreholes of marker beds.
- It measures naturally-occurring gamma radiation to characterise the rock or sediment in a borehole. Different types of rock emit different amounts and different spectra of natural gamma radiation. Gamma logging should be used to identify principal marker beds and slip surfaces via variations in gamma radiation signal and dip angles and landslide geometry via correlation between boreholes.
- The gamma logs should also be used to determine hydrogeology and permeability and feed data into the stability modelling.
- Gamma logs of difference should be prepared to identify zones of disturbed ground. This is achieved by subtracting one gamma log from a neighbouring log. Any remaining spikes in gamma signal denote areas of disturbed ground indicative of landsliding.
- The distribution of gamma logging has been planned to provide optimal updates to the ground model via identification of the difference beds and shear surfaces. Those planned by the seawall inform the ground model in the vicinity of the proposed drainage and those half way up the slope complete the picture of the lower landslide tier which requires drainage for stability.
- The downhole geophysics will require separate visits on completion of each borehole. It is recommended that a lump sum is agreed with the GI contractor to have the equipment on standby for each test.



Above left: typical gamma ray logger; Above: Identification of marker beds in Kimmeridge Clay and correlation between cores with gamma logs. From Gallois, 2010.

Monitoring requirements and cost

In order to generate the data required for design of a deep drainage schemes the following monitoring is required:

- There are large areas not covered by in situ or dGPS monitoring that should be addressed to advance the ground model to the standards required to support the landslide stabilisation. Add 100 pins to the permanent ground marker network (PGM) and carry out bi-annual dGPS surveys to measure ground displacement over a periods of at least 2 years.
- Upgrade the existing slope monitoring network in Ventnor and Bonchurch including: Semi-automatic weather station at Ventnor Park; Manually read inclinometers and piezometers in Ventnor (2002 & 2005 GI); Semi-automatic recording of VW piezometers at the Winter Gardens; Semi-automatic recording settlement cell and crack meter at Bath Road; Semi-automatic recording settlement cells and crack meters at Lowtherville Graben
- Install automatic logging of groundwater in boreholes over a 1 year period due to slow ground water response to recharge. The variable and falling head and pumping tests require real-time automatic monitoring of ground response.
- Bi-annual monitoring of the borehole inclinometers is required over at least 2 years to provide data on the ground model, shear surfaces and displacement rates required for deep drainage design.
- Installation and bi-annual monitoring of surface tiltmeters, settlement cells and crackmeters over at least 2 years to provide data on the ground model, shear surfaces and displacement movements rates required for deep drainage design.

Monitoring	Duration	Lower cost estimate	Upper cost estimate
Install additional PGM network (100 pins) and carry out bi-annual dGPS surveys	2 years	£5,000.00	£7,000.00
Overhaul existing network of sensors in boreholes and bi-annual monitoring	2 years	£20,000.00	£25,000.00
Install automatic logging of groundwater in BHs	1 year	£25,000.00	£32,000.00
Inclinometers in BHs and bi-annual monitoring	2 years	£50,000.00	£64,000.00
Surface tiltmeters, settlement cells and crackmeters	2 years	£25,000.00	£32,000.00
	TOTAL	**£125,000.00**	**£160,000.00**

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Ground investigation costs

- The tables below provide the summary best and upper estimate totals to complete the deep drainage and coastal defence ground investigations detailed in this document. The majority of uncertainty in the cost estimates is driven by unknown ground conditions. If, for example, the rotary drilling is slowed by particularly hard ground the cost of keeping the rotary rig and operators on site increases the overall GI cost rapidly. These costs are used in the Future Schemes Report costs and OBC costs.

Drainage ground investigation:

GI line item	Lower estimate cost	Upper estimate cost
General items, provisional services and additional items	£ 15,000.00	£ 24,000.00
Rotary drilling	£ 75,000.00	£ 120,000.00
Pitting and trenching	£ 4,000.00	£ 6,400.00
Sampling and monitoring during intrusive investigation	£ 6,000.00	£ 9,600.00
Geophysical testing	£ 12,000.00	£ 19,200.00
In situ testing	£ 15,000.00	£ 24,000.00
Instrumentation	£ 18,000.00	£ 28,800.00
Installation monitoring and sampling	£ 4,000.00	£ 6,400.00
Geotechnical laboratory testing	£ 40,000.00	£ 64,000.00
Geoenvironmental laboratory testing	£ 6,000.00	£ 9,600.00
Factual report	£ 15,000.00	£ 24,000.00
Interpretive report (this is consultant not a GI contractor cost)	£ 15,000.00	£ 24,000.00
Ground modelling (this is consultant not a GI contractor cost)	£ 25,000.00	£ 40,000.00
Total:	**£ 250,000.00**	**£ 400,000.00**

Coastal defence ground investigation:

GI line item	Lower estimate cost	Upper estimate cost
General items, provisional services and additional items	£ 8,000.00	£ 12,000.00
Rotary drilling	£ 22,000.00	£ 33,000.00
Pitting and trenching	£ 2,000.00	£ 3,000.00
Sampling and monitoring during intrusive investigation	£ 2,000.00	£ 3,000.00
In situ testing	£ 8,500.00	£ 12,750.00
Instrumentation	£ 6,000.00	£ 9,000.00
Installation monitoring and sampling	£ 3,000.00	£ 4,500.00
Geotechnical laboratory testing	£ 7,000.00	£ 10,500.00
Geoenvironmental laboratory testing	£ 1,500.00	£ 2,250.00
Factual report	£ 10,000.00	£ 15,000.00
Interpretive report (this is consultant not a GI contractor cost)	£ 10,000.00	£ 15,000.00
Ground modelling (this is consultant not a GI contractor cost)	£ 20,000.00	£ 30,000.00
Total:	**£ 100,000.00**	**£ 150,000.00**

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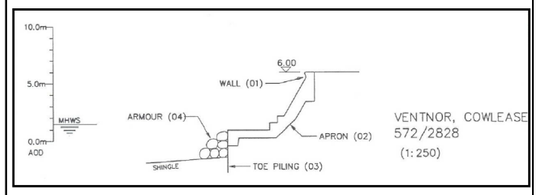
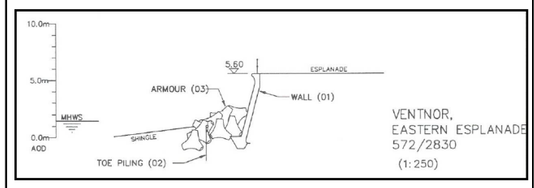
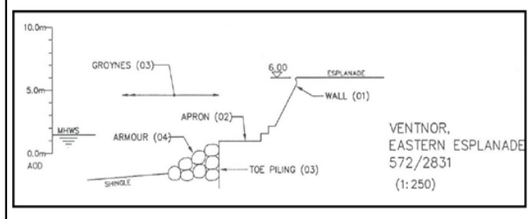
Annex 1: Outline scope for Ground investigation

Outline scope for deep drainage ground investigation

Borehole number	LRU	Rig	Borehole Coordinates	Drilled depth (m OD)	Installations	In situ tests	Samples	Lab tests	Objectives	Ground Model	Location	Rig and Access	Special Recommendations
			Borehole locations, drilled depths and installation depths are subject to verification by the supervising engineer based on the ground conditions encountered										
1a	**Wheelers Bay**	Rotary continuous sampling	456869.858 77443.143	-35m OD or at least into the Sandrock 2C. Start height 6m OD. Borehole depth 41m	Inclinometer to full depth of hole	Shear Vane, Hand vane and pocket penetrometer. Pumping test with real-time automatic monitoring response (drawdown) in b borehole.	Continuous sampling rotary core to define stratigraphy and identify shear surfaces. Regular inspection of cores in the field by the engineer to allow initial interpretation and if necessary modification of the remaining GI	Index tests, permeability, shear strength, particle size and particle density in 2d	Inform the ground model and obtain information on controls on landsliding. Locate the Gault and possible 2d shear surface and depth to 2c Gauge the rate of any movement. Gauge how long it might take for boreholes to shear (drainage to stop working)	Lower tier rotational landslides in in Sandrock 2d. Shear surface is thought up to -30m OD with the interface between 2d and 2c just below this depth	An area of private land landward of the promenade provides the most suitable working platform for the rig. The disadvantage of this position is that the borehole would be passing through fill rather than natural slope materials in upper part of the borehole so would not be informing the ground model from the surface. The ground surface is at approximately 6m OD so the borehole would need to be approximately 41m deep to pass through the possible shear surface in 2d and reach 2c	A rotary rig with sufficient power to reach -35m OD in Sandrock and stiff clay that can access and operate at the selected borehole location. Rigs should be used according to materials to provide the best possible samples. Access, measured using GIS, is via a 4.5m wide road to the east and the working area is approximately min 8m wide by 20m. Access restrictions should be checked on site with respect to the particular rig proposed.	The borehole should be open hole through the fill beneath the promenade and below this continuous sampled. Detailed core logging required to identify stratigraphy and shear surfaces and Gamma logging to correlate marker beds in the Clay and Sandrock and any slip surfaces between boreholes
1b	**Wheelers Bay**	Rotary open hole	456868.164 77442.614	-35m OD or at least into the Sandrock 2C. Start height 6m OD. Borehole depth 41m	2* piezometers (approximately -10m OD in upper aquafer and -35m OD in 2c lower aquafer)	Variable and falling head permeability tests over one year (due to slow ground water response to recharge)	na	na	Measure pore water pressures, ground water response to recharge and artesian head				The borehole should be open hole throughout
2a	**Central Ventnor**	Rotary continuous sampling	456314.573 77348.962	-45m OD or at least into the Sandrock 2C. Start height 6m OD. Borehole depth 51m	Inclinometer to full depth of hole	Shear Vane, Hand vane and pocket penetrometer. Pumping test with real-time automatic monitoring response (drawdown) in b borehole.	Continuous sampling rotary core to define stratigraphy and identify shear surfaces. Regular inspection of cores in the field by the engineer to allow initial interpretation and if necessary modification of the remaining GI	Index tests, permeability, shear strength, particle size and particle density in 2d	Inform the ground model and obtain information on controls on landsliding. Locate the Gault and possible 2d shear surface and depth to 2c Gauge the rate of any movement. Gauge how long it might take for boreholes to shear (drainage to stop working)	Lower tier rotational landslides in in Sandrock 2d. Shear surface is thought up to -40m OD with the interface between 2d and 2c just below this depth	An area of promenade and council owned parking provides the most suitable working platform for the rig. The ground surface is at approximately 6m OD so the borehole would need to be approximately 51m deep to pass through the possible shear surface in 2d and reach 2c	A rotary rig with sufficient power to reach -40m OD in Sandrock and stiff clay that can access and operate at the selected borehole location. Rigs should be used according to materials to provide the best possible samples. Access is via the Esplanade and the working area is approximately min 8m wide by 10m. Access restrictions should be checked on site with respect to the particular rig proposed.	The borehole should be open hole through the fill beneath the promenade and below this continuous sampled. Detailed core logging required to identify stratigraphy and shear surfaces and Gamma logging to correlate marker beds in the Clay and Sandrock and any slip surfaces between boreholes
2b	**Central Ventnor**	Rotary open hole	456315.419 77348.962	-45m OD or at least into the Sandrock 2C. Start height 6m OD. Borehole depth 51m	2* piezometers (approximately -12.5m OD in upper aquafer and 45m OD in 2c lower aquafer)	Variable and falling head permeability tests over one year (due to slow ground water response to recharge)	na	na	Measure pore water pressures, ground water response to recharge and artesian head				The borehole should be open hole throughout
3a	**Ventnor Park**	Rotary continuous sampling	45588.12 77279.02	-35m OD or at least into the Sandrock 2C. Start height 15m OD. Borehole depth 50m	Inclinometer to full depth of hole	Shear Vane, Hand vane and pocket penetrometer. Pumping test with real-time automatic monitoring response (drawdown) in b borehole.	Continuous sampling rotary core to define stratigraphy and identify shear surfaces. Regular inspection of cores in the field by the engineer to allow initial interpretation and if necessary modification of the remaining GI	Index tests, permeability, shear strength, particle size and particle density in 2d	Inform the ground model and obtain information on controls on landsliding. Locate the Gault and possible 2d shear surface and depth to 2c Gauge the rate of any movement. Gauge how long it might take for boreholes to shear (drainage to stop working)	Lower tier rotational landslides in in Sandrock 2d. Shear surface is thought up to -30m OD with the interface between 2d and 2c just below this depth	The council owned parking in the southeast of Ventnor Park provides the most suitable working platform for the rig close to the coast. The ground surface is at approximately 15m OD so the borehole would need to be approximately 50m deep to pass through the possible shear surface in 2d and reach 2c	A rotary rig with sufficient power to reach -35m OD in Sandrock and stiff clay that can access and operate at the selected borehole location. Rigs should be used according to materials to provide the best possible samples. Access, measured using GIS, is via a 4.5m wide pinch point in the promenade to the east and the working area is approximately min 4m wide by 10m. Access restrictions should be checked on site with respect to the particular rig proposed.	The borehole should be open hole through the fill beneath the promenade and below this continuous sampled. Detailed core logging required to identify stratigraphy and shear surfaces and Gamma logging to correlate marker beds in the Clay and Sandrock and any slip surfaces between boreholes
3b	**Ventnor Park**	Rotary open hole	45888.823 7729261	-35m OD or at least into the Sandrock 2C. Start height 15m OD. Borehole depth 50m	2* piezometers (approximately -15m OD in upper aquafer and -35m OD in 2c lower aquafer)	Variable and falling head permeability tests over one year (due to slow ground water response to recharge)	na	na	Measure pore water pressures, ground water response to recharge and artesian head				The borehole should be open hole throughout
4	**Wheelers Bay**	Rotary open hole	456782.159, 77672.13	Down to 2c at approximately -35m OD. Start height 50m OD Borehole depth 85m	Inclinometer to full depth of hole	na	na	na	Inform the ground model and obtain information on controls on landsliding. Locate the 2d shear surface and depth to 2c Gauge the rate of any movement. Gauge how long it might take for boreholes to shear (drainage to stop)	Lower tier rotational landslides in in Sandrock 2d. Shear surface is thought up to -15m OD with the interface between 2d and 2c just below this depth	Roadside on the landward edge of the lower landslide tier	Access via the main road network. Half of the road will have to be closed while rig in-situ	The borehole should be open hole throughout. Gamma logging is required to correlate marker beds in the Clay and Sandrock and any slip surfaces between boreholes
5	**Central Ventnor**	Rotary open hole	456300.398 77548.853	Down to 2c at approximately 45m OD. Start height 34m OD Borehole depth 79m	Inclinometer to full depth of hole	na	na	na	Inform the ground model and obtain information on controls on landsliding. Locate the 2d shear surface and depth to 2c Gauge the rate of any movement. Gauge how long it might take for boreholes to shear (drainage to stop)	Lower tier rotational landslides in in Sandrock 2d. Shear surface is thought up to -30m OD with the interface between 2d and 2c just below this depth	Roadside on the landward edge of the lower landslide tier	Access via the main road network. Half of the road will have to be closed while rig in-situ	The borehole should be open hole throughout. Gamma logging is required to correlate marker beds in the Clay and Sandrock and any slip surfaces between boreholes
6	**Ventnor Park**	Rotary open hole	455755.785 77356.079	Down to 2c at approximately -35m OD. Start height 38m OD Borehole depth 73m	Inclinometer to full depth of hole	na	na	na	Inform the ground model and obtain information on controls on landsliding. Locate the 2d shear surface and depth to 2c Gauge the rate of any movement. Gauge how long it might take for boreholes to shear (drainage to stop)	Lower tier rotational landslides in in Sandrock 2d. Shear surface is thought up to -40m OD with the interface between 2d and 2c just below this depth	Landward edge of Ventnor Park close to the landward edge of the lower landslide tier	Access via the main road network	The borehole should be open hole throughout. Gamma logging is required to correlate marker beds in the Clay and Sandrock and any slip surfaces between boreholes

Outline scope for coastal defence ground investigation

Borehole number	LRU	Rig	Borehole Coordinates	Drilled depth (m OD)	Installation	In situ tests	Samples	Lab tests	Objectives	Ground Model	Location	Rig and Access	Special Recommendations	Asset ID	Existing Structure Description	Replacement structure Description
			Borehole locations, drilled depths and installation depths are subject to verification by the supervising engineer based on the ground conditions encountered													
7, 8, 9	**Wheelers Bay**	Rotary	457006.24 77578.5; 456962.16 77545.7; 456918.62 77515.88	-10	-	Permeability - seepage analysis under variable hydraulic conditions	High quality continuous cored rotary samples from core logging and bulk samples for geotechnical lab tests	PSD and Atterberg Limits - erosion resistance and correlation with material strength RQD (correlation with Strength, cu, phi') Particle density and bulk density - Unit weight (load on wall) Triaxial with pore pressure measurements and without (effective stress and total stress cu, c', phi'), point load test (cu) - design Oedometer - Settlement calculations	Inform the ground model (soil layers thickness, identification and classification) and provide geotechnical parameters to support the design of replacement steel sheet piled sea wall structure. In particular to define the strength and stiffness of natural soils and any man-placed fills.	This asset sits on the lower tier of the landslide complex where compound failure within Sandrock comprising large blocks of failed Chalk and Upper Greensand and infilled depressions and mudslides. Whilst coastal defences are in place and preventing toe erosion landslide failures are primarily driven by rainfall inducing movement along the basal shear surfaces. The basal shear surface in the Sandrock lies well below the depth of planned defence replacements up to approximately 30m below sea level along this frontage.	Promenade	Accessible via car park at eastern end of Eastern Esplanade. Partial Promenade closure required	all the cores need to be photographed as soon as possible before they degrade, dry or are damaged by handling. Expert Engineer supervising the GI, able to identify which section of the core to be used for which test.	**IW 32 / 001**	Rock revetment, concrete steps, sheet piled toe to concrete sea wall, with wide apron. Stepped toe to sloping concrete revetment of Length=133 m, crest level =4.1mOD. Concrete decking. 	Replace
10, 11	**Wheelers Bay**	Rotary	456826.82 77438.36	-10	Inclinometer	Permeability - seepage analysis under variable hydraulic conditions	High quality continuous cored rotary samples for core logging and geotechnical lab tests	PSD and Atterberg Limits - erosion resistance and correlation with material strength RQD (correlation with Strength, cu, phi') Particle density and bulk density - Unit weight (load on wall) Drained Triaxial (effective stress and total stress) and direct shear (c', phi'), point load test (cu) - design Oedometer - Settlement calculations	The defence appraisal noted that ground movement at this location has resulted in displacement of the seawall. Inform the ground model (shear surfaces, and soil layers thickness, identification and classification) and provide geotechnical parameters to support the design of replacement steel sheet piled sea wall structure. In particular to define the strength and stiffness of natural soils and any man-placed fills.	This asset sits on the lower tier of the landslide complex where compound failure within Sandrock comprising large blocks of failed Chalk and Upper Greensand and infilled depressions and mudslides. Whilst coastal defences are in place and preventing toe erosion landslide failures are primarily driven by rainfall inducing movement along the basal shear surface in the Sandrock lies well below the depth of planned defence replacements up to approximately 30m below sea level along this frontage, shallow ground movement has damaged the seawall st this location.	Promenade	Accessible from Wheelers bay road.	all the cores need to be photographed as soon as possible before they degrade, dry or are damaged by handling. Expert Engineer supervising the GI, able to identify which section of the core to be used for which test.	**IW 33 / 001**	Concrete wall with Tetrapods at base of the wall Length=119m Crest=5.6mOD 	"change" to Sheet pile and rock revetment
12, 13, 14	**Central Ventnor**	Rotary	456745.53 77396.53; 456678.33 77363.74; 456590.71 77329.6	-10	Piezometer	Permeability - seepage analysis under variable hydraulic conditions	High quality continuous cored rotary samples for core logging and geotechnical lab tests	PSD and Atterberg Limits & Classification- erosion resistance and correlation with material strength RQD (correlation with Strength, cu, phi') Particle density and bulk density - Unit weight (load on wall) Drained Triaxial (effective stress and total stress) and direct shear (c', phi'), point load test (cu) - design Oedometer - Settlement calculations	Inform the ground model (soil layers thickness, identification and classification) and provide geotechnical parameters to support the design of replacement steel sheet piled sea wall structure. In particular to define the strength and stiffness of natural soils and any man-placed fills.	The assets sit on the lower tier of the landslide complex which comprises of compound failure within Sandrock, comprising of large blocks of failed Chalk and Upper Greensand, infilled depressions and mudslides on the coastal slopes. Whilst coastal defences are in place and preventing toe erosion Landslide failures are primarily driven by rainfall inducing movement along the basal shear surfaces. The basal shear surface in the Sandrock lies well below the depth of planned defence replacements up to approximately 40m below sea level along this frontage.	Promenade	Accessible from the public road but gate closing the costal path, from Ocean Blue Quay, Eastern Esplanade side. On the other side structure is accessible from Wheelers Bay Road	all the cores need to be photographed as soon as possible before they degrade, dry or are damaged by handling. Expert Engineer supervising the GI, able to identify which section of the core to be used for which test.	**IW 33 / 002**	Rock revetment, concrete steps. Concrete sea wall with steel sheet piled toe, wide toe apron and sloping revetment face above stepped base of crest Length=181m and Crest=6 mOD 	Replace
15	**Ventnor Park**	Rotary	455948.16 77279.06	-10	-	Permeability - seepage analysis under variable hydraulic conditions	High quality continuous cored rotary samples from core logging and bulk samples for geotechnical lab tests	PSD and Atterberg Limits - erosion resistance and correlation with material strength RQD (correlation with Strength, cu, phi') Particle density and bulk density - Unit weight (load on wall) Drained Triaxial (effective stress and total stress) and direct shear (c', phi'), point load test (cu) - design Oedometer - Settlement calculations	Inform the ground model (soil layers thickness, identification and classification) and provide geotechnical parameters to support the design of replacement structure. In particular to define the strength and stiffness of natural soils and any man-placed fills.	The assets sit on the lower tier of the landslide complex which comprises of compound failure within Sandrock, comprising of large blocks of failed Chalk and Upper Greensand, infilled depressions and mudslides on the coastal slopes. Whilst coastal defences are in place and preventing toe erosion Landslide failures are primarily driven by rainfall inducing movement along the basal shear surfaces. The basal shear surface in the Sandrock lies well below the depth of planned defence replacements up to approximately 40m below sea level along this frontage.	Below western end of Ventnor park carpark	Due to significant challenges with access a terrier rotary rig will need craned in from the road above or over the seawall from the rear of the Spyglass Inn.	all the cores need to be photographed as soon as possible before they degrade, dry or are damaged by handling. Expert Engineer supervising the GI, able to identify which section of the core to be used for which test.	**IW 35 / 003**	Not available	Replace

Appendix 4 – PF Calculator for Priority Scheme

FCRM Partnership Funding Calculator for Flood and Coastal Erosion Risk Management Grant in Aid (FCRM GiA)
Version 8 January 2014

Project Name	Ventnor Priority Scheme (Coastal Works and Deep Drainage)
Unique Project Number	TBC

All figures are in £'s
Figures in Blue to be entered onto Medium Term Plan

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Key

Input cells
Calculated cells

SUMMARY: prospect of FCRM GiA funding

		Scheme Benefit to Cost Ratio:	**8.21** to 1
		Effective return to taxpayer:	**9.75** to 1
Raw Partnership Funding Score	**87%** (1)	*Effective return on contributions:*	**65.27** to 1
External Contribution or saving required to achieve an Adjusted Score of 100%	**3,653,431** (2)		
Adjusted Partnership Funding Score (PF)	**100%** (3)		
PV FCERM GiA towards the up-front costs of this scheme (PV Cost for Approval)	**24,462,514** (4)		

Cell (2) shows the minimum amount of contributions and/or reductions in scheme cost that are required to raise the Adjusted PF Score to at least 100%. Further increases on this will improve this scheme's chances of an FCRM GiA allocation in the desired year. Planned savings and contributions should be entered into cells(9,10,12) and cells(14-17). See NOTE below.

1. Scheme details

Risk Management Authority type of asset maintainer	**LA** (5)	**Yes** (6)	Is evidence available that a Strategic Approach has been taken, and that double counting of benefits has been avoided ?
Duration of Benefits (years)	**59** (7)		
PV Whole-Life Benefits:	**238,453,791** (8)		

All costs and benefits must be on a Present Value (PV) Whole-Life basis over the Duration of Benefits period. Where Contributions are identified these should also be on a Present Value basis.

PV Costs	
PV Appraisal Costs	3,155,123 (9)
PV design & Construction Costs	24,960,823 (10)
Sub Total - PV Cost for Approval (appraisal,design,construction)	**28,115,945** (11)
PV Post-Construction Costs	933,031 (12)
PV Whole-Life Costs:	**29,048,976** (13)

The total value of any necessary contributions will depend on whether maintenance (ongoing costs) is funded through revenue FCRM GiA, or by other means.

NOTE: This scheme is to be maintained by an RMA other than the EA (ref cell 5). Capital FCRM GiA will fund the appropriate share of the up-front costs (cell 11) with any shortfall needing to be paid for via contributions identified in cells(14-17). Future ongoing costs (cell 12) and any contriubutions towards them are a matter for local agreement by the RMA and should NOT be included in cells(14-17). It is recommended that the RMA takes the opportunities created during scheme development to separately secure contributions towards future ongoing costs (cell12).

PV Contributions secured to date	
PV Local Levy secured to date	500,000 (14)
PV Public Contributions secured to date	1,500,000 (15)
PV Private Contributions secured to date	*1,653,431* (16)
PV Funding form other Environment Agency functions/sources secured to date	(17)
PV Total Contributions secured to date	3,653,431 (18)

2. Qualifying benefits under Outcome Measure 2: households better protected against flood risk

Number of households in:	Before			After			Change due to scheme		
20% most deprived areas			-		-		0	0	0
21-40% most deprived areas			-		-		0	0	0
60% least deprived areas			-		-		0	0	0
At:	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk	Moderate risk	Significant risk	Very significant risk
Annual damages avoided (£), compared with a household at low risk							150	600	1,350

Change in household damages, in:	Per year	Over lifetime of scheme	**Qual. benefits (discounted)**
20% most deprived areas	£ -	£ -	**OM2 (20%)** £ -
21-40% most deprived areas	£ -	£ -	**OM2 (21-40%)** £ -
60% least deprived areas	£ -	£ -	**OM2 (60%)** £ -

3. Qualifying benefits under Outcome Measure 3: households better protected against coastal erosion

Number of households in:	Before	
20% most deprived areas	155	151
21-40% most deprived areas	145	145
60% least deprived areas	103	92
	Long-term loss	Medium-term loss

Damages per household avoided:		
Annual damages avoided	£ 6,000	£ 6,000
Loss expected in	50	20 years
Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)	£ 1,184	£ 3,015
	Long-term loss	Medium-term loss

Change in household damages, in:	Year 1 loss avoided:	Over lifetime of scheme:	**Qual. benefits (discounted):**
20% most deprived areas	-£ 639,648	-£ 37,739,236	**OM3 (20%)** **£ 16,776,995**
21-40% most deprived areas	-£ 607,660	-£ 35,851,924	**OM3 (21-40%)** **£ 15,937,990**
60% least deprived areas	-£ 399,447	-£ 23,567,358	**OM3 (60%)** **£ 10,476,880**

4. Qualifying benefits under Outcome Measure 4: statutory environmental obligations met

Payments under:			Assumed benefits per unit:	**Qual. benefits (discounted):**
OM4a		Hectares of net water-dependent habitat created	£ 15,000	OM4a £ -
OM4b		Hectares of net intertidal habitat created	£ 50,000	OM4b £ -
OM4c		Kilometres of protected river improved	£ 80,000	OM4c £ -
				OM4 **£ -**

5. Qualifying benefits arising from the overall scheme, for entry into the Medium-Term Plan

OM, deprivation:		Qual. benefits:	Payment rate:	FCRM GiA contribution:
OM1		£ 195,261,926	5.56 p in the £1	£ 10,847,885
OM2	20% most	£ -	45.0	£ -
	21-40%	£ -	30.0	£ -
	Least 60%	£ -	20.0	£ -
OM3	20% most	£ 16,776,995	45.0	£ 7,549,648
	21-40%	£ 15,937,990	30.0	£ 4,781,397
	Least 60%	£ 10,476,880	20.0	£ 2,095,376
OM4		£ -	100.0	£ -
Total		£ 238,453,791		**£ 25,274,306**

Maximum for Outcomes delivered. The actual value any scheme is elligible for may be less.

Sensitivity Testing. *It is important that users of this calculator appreciate the implications on funding from changes to input data which may become necessary as the project develops and better information is available. Five typical tests are provided below. Users should consider how appropriate these are to their project, what other tests may be appropriate and how best to use the information with all those that may be involved in the project.*

	Raw Score	Contribution for 100% Score (£k)
As scenario above	87%	3,653,431
Sensitivity 1 - Change in PV Whole Life Cost (25% increase)	87%	4,566,788
Sensitivity 2 - Change in OM2 - 50% of households in Very Significant (Before) risk may already be in Significant Risk band	87%	3,653,431
Sensitivity 3 - Change in OM3 - 50% of households in Medium Term loss (Before) may already be in Long Term loss	78%	6,170,496
Sensitivity 4 - Increase Duration of Benefits by 25%	53%	13,243,720
Sensitivity 5 - Reduce Duration of Benefits by 25%	83%	4,901,386

END OF WORKSHEET

Appendix 5 – Planning Note

Ventnor Options Study

Ventnor Options Study: Planning Note

Document No. | 0

17th December 2019

Isle of Wight Council

Ventnor Options Study

Project No:	691614
Document Title:	Ventnor Options Study: Planning Note
Document No.:	Document No.
Revision:	1
Date:	17 December 2019
Client Name:	Isle of Wight Council
Client No:	Client Reference
Project Manager:	Ross Fitzgerald
Author:	Ross Fitzgerald
File Name:	Ventnor Options Study Planning Note 171219

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Document history and status

Revision	Date	Description	By	Review	Approved
0	25/10/2019	For issue	Ross Fitzgerald	Jon Denner	Roger Moore
1	17/12/2019	Incorporating client comments	Ross Fitzgerald	Jon Denner	Roger Moore

Contents

Figures

1. Introduction

Ventnor and Bonchurch are located on the Undercliff, a deep landslide system that is subject to land instability triggered by coastal erosion and excess rainfall and groundwater levels. The developed frontage is protected by various coastal defences, some of which are nearing the end of their serviceable life and require repair or replacement. Without coastal defences and slope stability measures, such as drainage, the Undercliff landslide system will become increasingly active, leading to widespread ground movement, landslide reactivation and asset damage. Climate change impacts such as increased rainfall and accelerated rates of toe erosion due to sea level rise and increased storminess will increase the rate and magnitude of this damage.

The Isle of Wight SMP (IWC, December 2010) recommends a 'Hold the Line' shoreline management policy for the Ventnor and Bonchurch frontage. Jacobs was commissioned by Isle of Wight Council (IWC) to provide an appraisal of future schemes to reduce coastal erosion and landslide risk in accordance with the strategic Hold the Line policy. This assessment is detailed in the Future Schemes Report (the main report to this Appendix), which identifies technically, environmentally and economically viable engineering solutions to manage this risk. The engineering intervention measures have been packaged as the Priority Scheme, which concentrates capital investment in areas of high risk and high asset value.

The Priority Scheme covers 1.6 km of coast from Ventnor Park in the west to Wheelers Bay in the east. The proposed scheme comprises replacement of several failing coastal defences and new deep drainage measures to provide slope stabilisation. The objective, location and principles of the various scheme elements are provided in detail in Section 4.2 of the Future Schemes Report (FSR), and in summary comprise:

- Replacement of a 5 m section of seawall, toe encasement and rock armour revetment with new encasement and localised slope drainage at the western cliffs, Ventnor Park.
- Replacement of a 181 m long section of concrete seawall and deteriorated steel sheet piled toe with a a new rock revetment and concrete upper seawall at Eastern Cliffs Ventnor.
- Replacement of a 119 m long section of concrete wall, Tetrapods and toe piling, with a sheet pile and rock revetment plus localised slope drainage at the western edge of Wheelers Bay
- Replacement of a 133 m long rock revetment, concrete steps, sheet piled toe and concrete sea wall with a new rock revetment with concrete upper seawall at the eastern edge of Wheelers Bay.
- New deep drainage, throughout the Ventnor Park, Central Ventnor and Wheelers Bay frontages, comprising of vertical wells located close to sea level.

This document provides an overview of current planning guidance at Ventnor and Bonchurch. It then details the implications (opportunities and constraints) of the guidance on the Priority Scheme.

It also explores the implications of the Priority Scheme on current planning policy and appropriate development at Ventnor and Bonchurch. The following two options are explored:

1. **Implementation of the proposed Priority Scheme**: Replacement of poor condition coastal defence assets and deep drainage slope stabilisation measures.
2. **Continuation of current practice**: Ad-hoc emergency repairs to coastal defences and no deep drainage slope stabilisation measures.

2. Information Sources

The following planning policy guidance, peer-reviewed journal papers and good practice guides have been used in developing this Planning Note.

- Department of the Environment (1990) Planning Policy Guidance Note 14: development on unstable land (PPG14). HMSO, London.
- Department of the Environment (1990) Planning Policy Guidance Note 14 Annexe 1: development on unstable land: landslides and planning. HMSO, London.
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- McInnes R and Jakeways J (2002) Managing ground instability in the Ventnor Undercliff, Isle of Wight, UK. p739-746, In: McInnes R and Jakeways J (eds.) Instability, Planning and Management: seeking solutions to ground movement problems. Proceedings of the international conference organised by the Centre for the Coastal Environment, Isle of Wight Council, and held in Ventnor, Isle of Wight, UK on 20-23rd May 2002.
- McInnes RG and Moore R (2014) Living with Ground Instability and Landslides – An International Good Practice Guide'. CH2MHILL.
- McInnes, R.G. and Moore, R., 2011. 'Cliff Instability and Erosion Management in Great Britain – A Good Practice Guide'. Halcrow.
- Moore R and McInnes R (2016) Ground instability and landslide management. Raising awareness and increasing capacity for change within affected societies, ISL Naples.

3. Overview of Planning Guidance

Government planning guidance states that coastal erosion and the stability of the ground, in so far as they affect land use, are material considerations that should be taken into account when drawing up development plans and deciding on planning applications (Communities and Local Government, 2019).

To spatially identify the areas within Ventnor and Bonchurch that may be appropriate for development, and to define the development constraints relative to land stability, Planning Guidance Maps were produced by Geomorphological Services Ltd (1991). Based on local differences in the geological/geomorphological setting and exposure to coastal erosion, the Planning Guidance Maps take account of the varied levels of ground instability and erosion risk to property and infrastructure throughout the Undercliff. These maps and supporting information are designed to provide guidance on how to treat different parts of the Undercliff for both formal planning and development control.

Figure 1 shows excerpts of the Planning Guidance Maps 1 and 2 plus the likely footprint of the of the Priority Scheme comprising replacement coastal defences and deep drainage wells. Although 28 years old, the Planning Guidance Maps remain an appropriate tool for setting out development proposals because the spatial pattern of instability and coastal erosion have not changed significantly, and the Hold the Line coastal management policy remains in place.

With the exception of the far western end of central Ventnor, the scheme elements at Central Ventnor and Wheeler Bay fall inside a coastal strip comprising the defences and esplanade access and amenity assets. These low-lying areas generally comprise coastal promenades and coastal defences immediately seaward of the base of the natural slope. This zone was deliberately not given a planning guidance rating. This is to enable IWC the opportunity to protect the areas landward, many of which are suitable for development, by replacing coastal structures as they reach the end of their serviceable lives. In addition, this zone is public open space, owned by IWC, that is reserved for the defences, amenity and access rather than for private development.

The new structures at Ventnor Park and Central Ventnor fall within an area of more natural slope, comprising cliff terraces with rock revetment at their toe. This area is designated on the local planning guidance maps as either being subject to significant planning constraints due to instability or as unsuitable for development due to the instability. The objective of these designations is to constrain private development on unsuitable ground rather the prevent implementation of coastal defences and slope stability measures, which would protect landward areas likely to be suitable for development such as Ventnor Park.

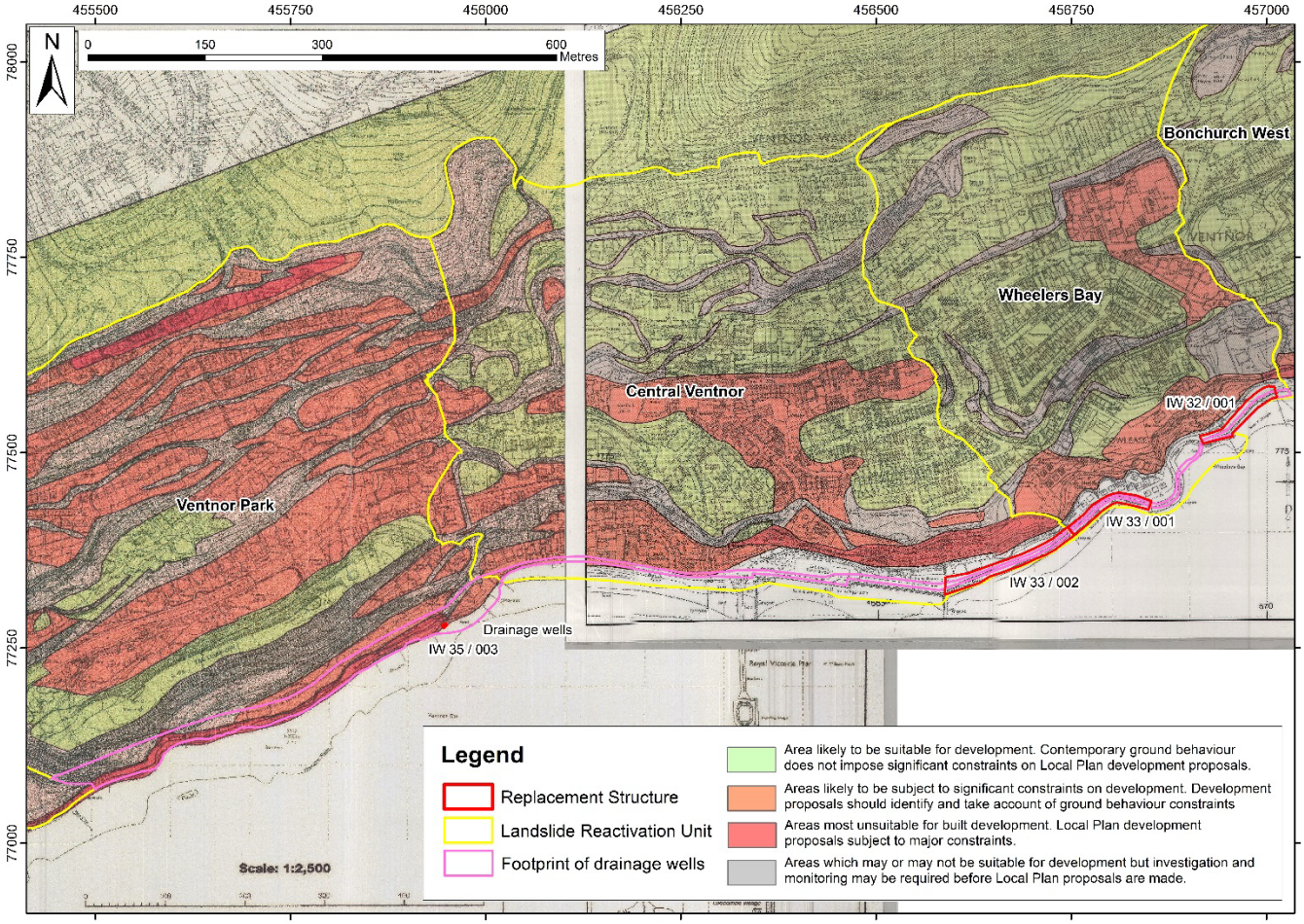

Figure 1: Undercliff Planning Guidance Map with extent of Priority Scheme replacement coastal structures and deep drainage.

4. Planning Application for the Priority Scheme

Ventnor is designated as a regeneration area which needs to contribute a sufficient supply of housing (80 units), additional retail, leisure and business uses and an improvement in accessibility by 2027. In order to achieve this development in accordance with planning guidance, the planning application (to be submitted Oct 2023) for the various Priority Scheme elements (shown in Figure 1) will need to demonstrate;

- **That the proposed development identifies and takes account of ground behaviour constraints and risks.** *The intention of the proposed scheme is to prevent coastal erosion and mitigate the ground behaviour constraints identified in the Planning Guidance Maps. Appraisals required for design and construction will need to demonstrate that the proposed scheme provides the required level of coastal protection and improvement in slope stability over the design life of the scheme. Without this the scheme will not be implemented.*
- **That the proposed development adheres to high standards of building construction, slope engineering and coastal protection measures so as not to cause adverse effects or transfer coastal change risks to other areas.** A*ppraisals will need to demonstrate that the proposed scheme will not generate unfavourable impacts in adjacent parts of the Undercliff. Without this the scheme will not be implemented.*
- **That the proposed development maintains the Hold the Line coastal management policy.** *Scheme appraisals will need to demonstrate that the required level of protection against coastal erosion and landsliding can be achieved without significantly advancing or retreating the line of the frontage.*
- **That the proposed development takes account of climate change and sea level rise.** *Scheme appraisals will need to demonstrate that the proposed coastal defence elements are robust against predicted rising sea levels and increased wave energy. The slope stabilisation elements will need to be demonstrably robust against predicted increases in winter rainfall and ground water levels. Adaptive management measures should be considered, e.g. defences which can be further raised in the future in accordance with the actual rate of sea level rise.*
- **That the proposed development is sustainable.** *Both the replacement coastal defences and deep drainage wells will need to use sustainable construction methods and materials that will perform as expected throughout their design lives, including allowing for planned maintenance.*
- **That the proposed development takes account of environmental constraints and adheres to the requirements of environmental designations.** *Appraisals such as a Habitats Regulation Assessment will need to demonstrate that the proposed scheme is able to satisfy all environmental requirements to gain the necessary consents. Environmental appraisals are required for Outline Business Case stage and consent is required before the planning application at Full Business Case stage. Section 8 of the Future Schemes Report covers potential environmental constraints relating to the specific scheme elements in detail. It identifies the South Wight Maritime SAC as the only constraint that is likely to be significant. This is because a short section of the current defence structure at the western end of Wheelers Bay coincides with the SAC boundary. At this stage, however, there is uncertainty whether there are any environmental impacts associated with the replacement coastal defences proposed. To account for this uncertainty, scheme costs estimates, put forward in the Future Schemes Report, include a robust budget for environmental appraisals (up to and including HRA Stage 2), design and construction.*
- **That the proposed development meets the approval of local stakeholders.** *The intention of the proposed scheme is to mitigate the adverse ground behaviour impacts on local stakeholders. Consultations with stakeholders will need to demonstrate the positive benefits and overcome any objections to the proposed scheme.*

5. Implications on Planning and Development: With Scheme

The primary benefit of the proposed Priority Scheme is to reduce the risk of coastal erosion, ground movement and landslides, thereby reducing the frequency and magnitude of damaging events (these benefits are captured in the Future Schemes Report). The scheme also provides a number of secondary benefits which are captured below in the *potential* implications of the 'with scheme' option on planning policy:

- **Potential to update the local planning guidance maps to reflect the reduced risk of coastal erosion and landsliding.** *Following a period of monitoring and assessment to demonstrate reduced levels of risk, the renewal of coastal defences and implementation of slope stabilisation drainage measures may increase the amount of land that can be considered suitable for regeneration and built development. The maps can then be updated accordingly. This will have positive benefits on the value of land and existing assets, and encourage investment in new property, business and infrastructure.*
- **Potential to implement planning policy that permits redevelopment or new development in areas previously considered of too high risk or increases the range of suitable development (including infrastructure and facilities)**. *As with the point above, this will encourage investment in new property, business and infrastructure, but will require monitoring and assessment to demonstrate reduced land instability risk.*
- **Opportunity to increase local understanding and awareness of how the risk of coastal erosion and land instability and the resultant damage is reduced by investment in a scheme.** *Added awareness of scheme benefits brings the opportunity for increased contributions towards current and future schemes for the wider area by stakeholders such as residents, local businesses and service providers.*
- **Potential to invest in monitoring to assess scheme performance.** *Monitoring ground movements and weather conditions using appropriate automatic or manual recording instruments enables assessment of scheme performance and lifespan, provides early warning of issues and can be fed into subsequent schemes.*
- **Use positive results of regeneration to leverage future schemes.** *The positive reactions of residents, business and media to increased slope stability will result in increased investment. Tourism and business revenues can be used to champion future schemes and outcomes at other coastal sites vulnerable to erosion and landsliding.*

6. Implications on Planning and Development: Without Scheme

Without the proposed scheme, the coastal defences will fail and expose Ventnor and Bonchurch to increased coastal erosion, ground movement and landsliding. This negative change is reflected below in the *potential* implications to future planning policy:

- **Update Planning Guidance Maps to reflect the increased risk of coastal erosion and landsliding**. *As the coastal defence assets fail and erosion and landsliding recommence and recess landward, more areas will become unsuitable for built development. To account for this the Planning Guidance Maps will need to be updated based on the monitoring and assessment of coastal and slope change.*
- **Implement planning policy that prevents redevelopment/new development and/or ensures that new development is only undertaken in low risk areas and does not cause adverse effects/ transfer coastal change risks to other areas.** *Future monitoring and appraisal of how, where and when ground conditions deteriorate due to coastal erosion and landsliding will be needed to ensure that planning policy remains effective at ensuring development is only undertaken in demonstrably low risk areas.*
- **Implement increasingly stringent planning and development controls that ensure the highest standards of building construction, slope engineering and protection measures**. *Where development is allowed, mitigating increasing risks of coastal erosion and landsliding will require strict implementation of the highest design and construction standards.*
- **Update the Hold the Line coastal management policy.** *Without the proposed renewal of defences and drainage, the Hold the Line policy will become unsustainable and will need to be contravened or updated as the frontage retreats.*
- **Invest in building local understanding and awareness of growing risk**. *Increased risk of property and infrastructure damage caused by coastal erosion and landsliding will require the IWC to invest in better informing the community, for example through public awareness campaigns.*
- **Implement an emergency early warning system and response plan.** *Increased risk of damaging events will require IWC to invest in monitoring ground movements and weather conditions to enable the development of a coastal change incident early warning system. The increased occurrence of damaging incidents will require development and implementation of emergency response plans.*
- **Potential for blight.** *Potential for reduced confidence in the area due to inaccurate and/or accurate perceptions of future risk, affecting the community, insurers, purchasers, developers, businesses etc.*
- **Prepare a relocation policy.** *Prepare a rollback policy for the relocation of residents, property, community facilities and infrastructure away from areas at risk e.g. define where residents are housed if their property becomes uninhabitable due to landslide damage and what happens when an important road is severely damaged by land instability.*
- **Demolition of properties made uninhabitable by landslide or erosion damage.** *Unsafe and uninhabitable buildings will need to be demolished to eliminate risks such as building collapse.*
- **Find land for relocation housing.** Potential to a*llocate and set aside in advance the land required to build new properties for the relocation of residents if land is not readily available or affordable.*
- **Deal with homeowners that are reluctant to leave unsafe properties and/or are unhappy about relocation away from areas of risk.** *Historically, some homeowners choose to stay put and face the increased risk of living in unsafe locations/properties rather than relocate to a safe location. In addition, relocations can lead to dealing with negative media coverage.*

- **Management of coastal defence structure residual life and failure:**
    - **Assess the future performance of damaged coastal defences.** *Without replacement, the condition of the coastal defences will deteriorate and necessitate assessment of their ongoing ability to provide some measure of protection against coastal erosion and landsliding.*
    - **Assess the impact of climate change.** *Sea level rise, enhanced wave energy and increased rainfall will necessitate further appraisal of the impacts of climate change on the performance of deteriorating coastal defences.*
    - **Remove derelict coastal defences and other abandoned structures**. *When structures become unserviceable, they may need to be removed to prevent secondary risks and restore natural processes.*
- **Implement managed realignment.** *A strategy of Managed Realignment (or No Active Intervention) may be required to manage future coastal change, work with natural processes in coastal management and maintain habitat.*
- **Risk to historical assets and plan how to preserve historical assets.** *As defences fail local historical assets may be at risk from erosion and landsliding. This will require plans which explore ways to conserve historical assets in situ and plans to record historical assets to preserve evidence/ knowledge for when they are lost to erosion and land instability.*
- **Potential to change environmental designations.** *Some environmental designations were created after the construction of current coastal defences so may, in part, be reliant upon the protection and service they provide. Without renewal of this service the designation may need to be changed or contravened.*

Further information on the costs of the not-pursuing a scheme can be found in The Ventnor Options Technical Report (Appendix 1 of the main report), for example' including the increased costs of maintaining the deteriorating defences and the increased costs of significant emergency repairs and response.

7. Outline Programme for Planning Application

Below is the proposed outline programme for planning application:

- *Nov 2022:* Submit early planning application once the preferred option has been identified at OBC stage
- *Oct 2023:* Submit planning application
- *Early 2024:* Receipt of planning permission
- *Mar 2024:* Submit Full Business Case

Please see the Programme provided in the Future Schemes Report for further information on the ground investigation, Outline Business Case, Full Business Case and construction phases of the Priority Scheme.

8. Conclusions

One planning application will be prepared and submitted in approx. October 2023 (at the FBC appraisal stage) detailing the proposed coast protection and landslide drainage Scheme, the aim of which is to prevent coastal erosion and landslide reactivation in the centre of the town of Ventnor (from Ventnor Park to Wheelers Bay).

Planning application for the Priority Scheme at Ventnor and Bonchurch will need to demonstrate that it:

- accounts for the ground behaviour risks,
- adheres to high standards of coastal defence and slope engineering,
- maintains the Hold the Line coastal management policy,
- accounts of climate change and sea level rise,
- is sustainable,
- is designed to minimise any potential impact on environmental designations and adheres to the requirements of the environment designations, and,
- is approved by local stakeholders.

The application will detail the locations of seawall improvement and reinforcement and the wider deep drainage scheme for boreholes. The constraints affecting this application have been considered and a potential constraint for further consideration in scheme development is managing any potential impact on the South Wight Maritime SAC.

Assessment and comparison of the implications on planning and development of the ‘with scheme’ and ‘without scheme’ options is one of contrast.

The ‘with scheme’ option provides a number of secondary benefits over and above the important reduction in risk and damage it generates. These relate to the opportunity to update planning guidance in a way that encourages investment and enhancement of property, infrastructure, services and the local economy.

Conversely, the ‘without scheme’ option would require the tightening of planning restrictions as risks increase, which adversely affects regeneration and improvement of Ventnor and Bonchurch. Unless alternative scheme proposals are pursued, ultimately this will lead to the need to deal with a number of negative consequences associated with updating planning and coastal management policy and relocating residents, business and services.

The opportunities presented by the ‘with scheme’ option should provide IWC with the confidence to progress with the appraisal, design and implementation of renewed coastal protection measures at Ventnor and Bonchurch.

9. References

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Communities and Local Government (2019). National Planning Policy Framework. [Online]. Department for Communities and Local Government, June 2019. Available from: https://www.gov.uk/government/publications/national-planning-policy- framework--2.

Geomorphological Services Ltd (1991) Undercliff, Isle of Wight, Planning Guidance Maps. Maps and supporting note to the Isle of Wight Council.

Isle of Wight Council (2010), Isle of Wight Shoreline Management Plan 2. Royal Haskoning and Isle of Wight Council for Isle of Wight Council.

Appendix 6 – Non Technical Summary

Ventnor Options Study

Ventnor Options Study: Non-Technical Summary

Document No. | 0

18th December 2019

Isle of Wight Council

Ventnor Options Study

Project No:	691614
Document Title:	Ventnor Options Study: Non-Technical Summary
Document No.:	Document No.
Revision:	1
Date:	18 December 2019
Client Name:	Isle of Wight Council
Client No:	Client Reference
Project Manager:	Ross Fitzgerald
Author:	Ross Fitzgerald
File Name:	Ventnor Options Study Non Technical Summary 181219

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Document history and status

Revision	Date	Description	By	Review	Approved
0	25/10/2019	For issue	Ross Fitzgerald	Jon Denner	Roger Moore
1	18/12/2019	Incorporating client comments	Ross Fitzgerald	Jon Denner	Roger Moore

Contents

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1. Introduction

Ventnor and Bonchurch are located on the Undercliff, a deep landslide system that is subject to land instability caused by coastal erosion and rainfall. The developed frontage is protected by various coastal defences, some of which are nearing the end of their serviceable lives and require repair or replacement. Without coastal defences, and slope stability measures, the Undercliff landslide system will become more active, with predicted increased winter rainfall and accelerated rates of toe erosion causing widespread ground movement, landslide reactivation and asset damage in Ventnor and Bonchurch.

Jacobs was commissioned by Isle of Wight Council (IWC) to provide an appraisal of future schemes which aim to reduce coastal erosion and landslide risk and seek government funding for replacement coastal defences. Presented in this document is a non-technical summary of this appraisal and of the technically and financially feasible scheme it identifies.

The summary is aimed at readers without technical knowledge of coastal erosion and ground instability or the cost-benefit of coastal and slope engineering. Alongside the main Options Assessment, its objective is to provide IWC with a decision-making tool for the management and prioritised investment in coastal defences and deep drainage measures which prevent coastal erosion and land instability and ensure the long-term viability of the frontage at Ventnor and Bonchurch.

To enable easy access to key information required to make funding and planning decisions, this summary is formed around a series of questions, such as why has an assessment of coastal defence and slope stability options been undertaken, and how much will the proposed scheme cost.

2. Non-Technical Summary

2.1 Why has an assessment of coastal defence and slope stability options been undertaken?

- The assessment has been undertaken to help develop, and seek government funding for, engineering schemes which reduce the risk of damage to property and infrastructure due to coastal erosion and ground instability.

- This risk exists because Ventnor and Bonchurch are located on a landslide system that is subject to land instability triggered by coastal erosion and rainfall. In the past, erosion and landslide risk have been reduced by coastal defences, however, some of these structures are nearing the end of their serviceable lives and require repair or replacement. Without renewal of these defences and implementation of slope stabilisation, the landslide system will become more active, exacerbated by the impacts of climate change. Predicted increased winter rainfall and coastal erosion have the potential to cause widespread landsliding and asset damage.

2.2 What area does this assessment cover?

- The assessment covers a 4 km section of the eastern Undercliff, comprising the steepest and most developed part of the landslide complex (Figure 1), where in the past the risks have been reduced by coastal defences and landslide management, and which requires careful consideration of how increasing risks will be managed in the future .

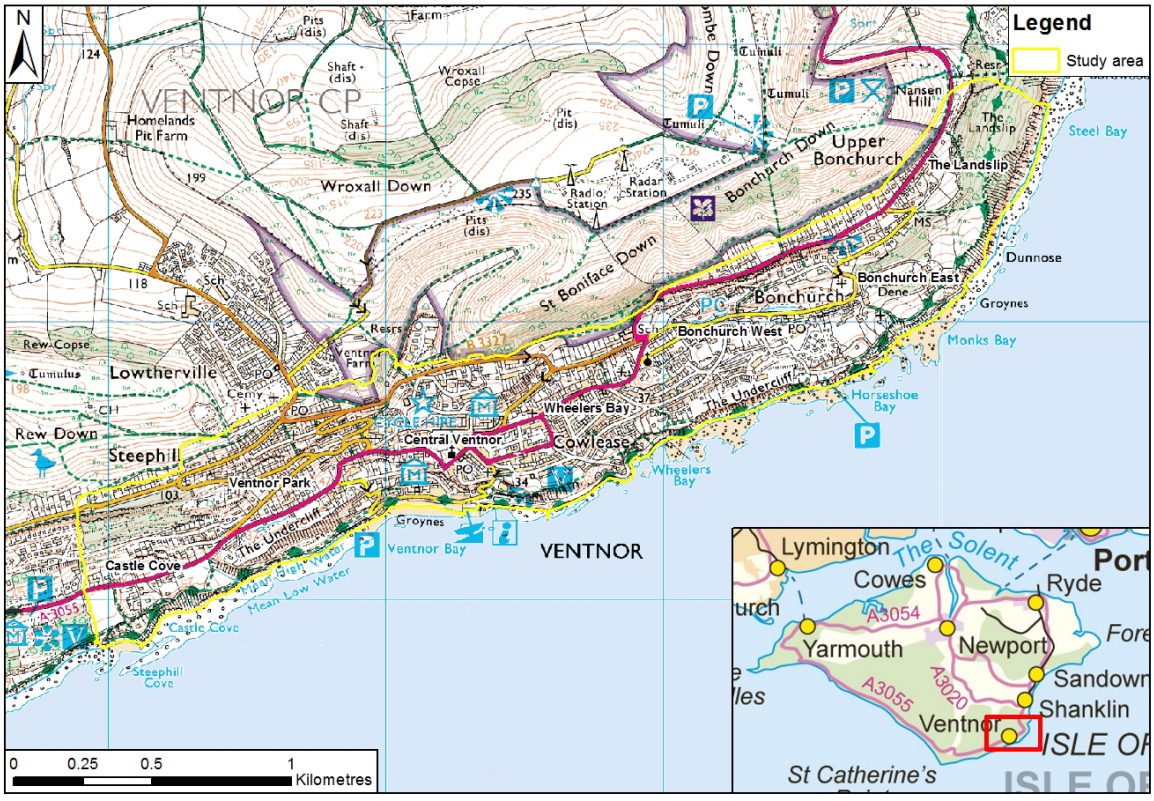


Figure 1. Site location map. Credit: OS © Crown copyright (2017).

2.3 What are the future risks in this area?

- Without intervention, the frequency and magnitude of damage to property and infrastructure caused by ground instability (landsliding) will increase throughout Ventnor and Bonchurch, with the effects extending from the sea front to the slope crest typically 500 metres inland from the coast.
- With increased frequency and intensity rainfall and rates of coastal erosion, previously marginally stable areas of the Undercliff will become unstable, and, in areas previously affected by ground movement or landslides, the frequency and rate of ground movement and landslides will increase.
- Likely impacts include damage to residential and non-residential property, infrastructure, utilities and services located on the terraces and slopes of the landslide complex, a decrease in tourism, loss of public amenity and erosion of health and wellbeing.

2.4 What does the Ventnor Options Assessment comprise?

The Ventnor Options Assessment comprises 3 reports:

1. **Structures assessment:** provides the baseline condition and remaining life of the existing coastal defences.
2. **Technical report:** provides the baseline understanding of current and future coastal erosion and landsliding, an assessment of the present and future cost of damage caused by coastal erosion and landsliding, and the cost and benefit (in terms of reduced damage to property and infrastructure) of investing in an engineering scheme which reduces risk.
3. **Future schemes report:** identifies the most technically and financially feasible and advantageous engineering solutions as a Priority Scheme (see 2.6) with a strong case for government funding.

2.5 What do the Options Assessment results show?

- Ground instability and landsliding at Ventnor and Bonchurch are triggered by coastal erosion undermining the coastal cliffs and slopes and by rainfall increasing groundwater levels. Preventing and reducing these triggers lessens risk of asset damage.
- Without intervention, there is a high risk of defence failure instigating coastal erosion and slope instability which could cause widespread asset damage. This risk increases through time with the effects of climate change (see 2.16) and as more coastal defence assets are damaged and/or reach the end of their lives.
- There are technically viable and economically deliverable schemes in the Central Ventnor, Ventnor Park and Wheelers Bay areas, which are areas at the greatest risk coastal erosion and instability.
- The most beneficial and cost-efficient strategy is to combine targeted replacement coastal defences with additional slope stabilisation measures in areas of high risk into a Priority Scheme.
- The proposed Priority Scheme (see 2.6) prevents coastal erosion and landsliding by replacing the coastal defences which have reached the end of their serviceable lives and implementing slope stabilisation measures in the form of deep drainage.
- Deep drainage slope stabilisation addresses Environment Agency guidance requiring that new coastal defences have complementary slope stabilisation if they are at risk from ground instability and landslides.

- The proposed Priority Scheme has been assessed under Defra and the Environment Agency's present national funding system for prioritising coastal and flood defences schemes. A partnership funding score of 87% demonstrates that the Priority Scheme delivers a strong economic case for seeking significant national government funding. This is further explained in the sections below. The national 'partnership funding' system encourages those who benefit from a coastal protection or flooding scheme to contribute to its cost, and funding is prioritised nationally based on risk and outcomes, including on the number of residential properties better protected.

2.6 What does the Priority Scheme comprise?

The Priority Scheme comprises the replacement of the following poor condition coastal defences, together with deep-drainage through a series of boreholes along the Ventnor Park, Central Ventnor and Wheelers Bay coastline:

- **Defence Asset IW 35/003** at Ventnor Park comprises a seawall with toe encasement and rock armour revetment. The plan is to rebuild the structure's encasement and add localised adjacent slope drainage to prevent local groundwater flows damaging the structure.

- **Defence Asset IW 33/002** along Ventnor Eastern cliffs comprises a 181 m long section of concrete sea wall with deteriorated steel sheet piled toe, wide toe-apron and sloping revetment above stepped base. The plan is to replace the structure with new rock revetment with concrete upper seawall.

- **Defence Asset IW 33/001** at the western edge of Wheelers Bay currently comprises a 119 m long concrete wall with Tetrapods and toe piling. The plan is to change the structure to a sheet pile and rock revetment and add localised adjacent slope drainage to prevent groundwater flows damaging the structure.

- **Defence Asset IW 32/001** at the eastern edge of Wheelers Bay comprises a 133 m long rock revetment, concrete steps, sheet piled toe to concrete sea wall, with wide apron. The plan is to replace the structure with new rock revetment with concrete upper seawall.

- **Deep Drainage** throughout the Ventnor Park, Central Ventnor and Wheelers Bay frontages comprising vertical wells/boreholes which remove water from the landslide shear surface and improve slope stability. The wells will be located along 1.6 km of the frontage at elevations as close to sea level as practicably possible.

Maps showing the location and extent of the Priority Scheme are provided in Figure 2 and in detail in Appendix 10 of the main report. Table 1 shows photographs of the coastal defence measures to be replaced as part of the Priority Scheme.

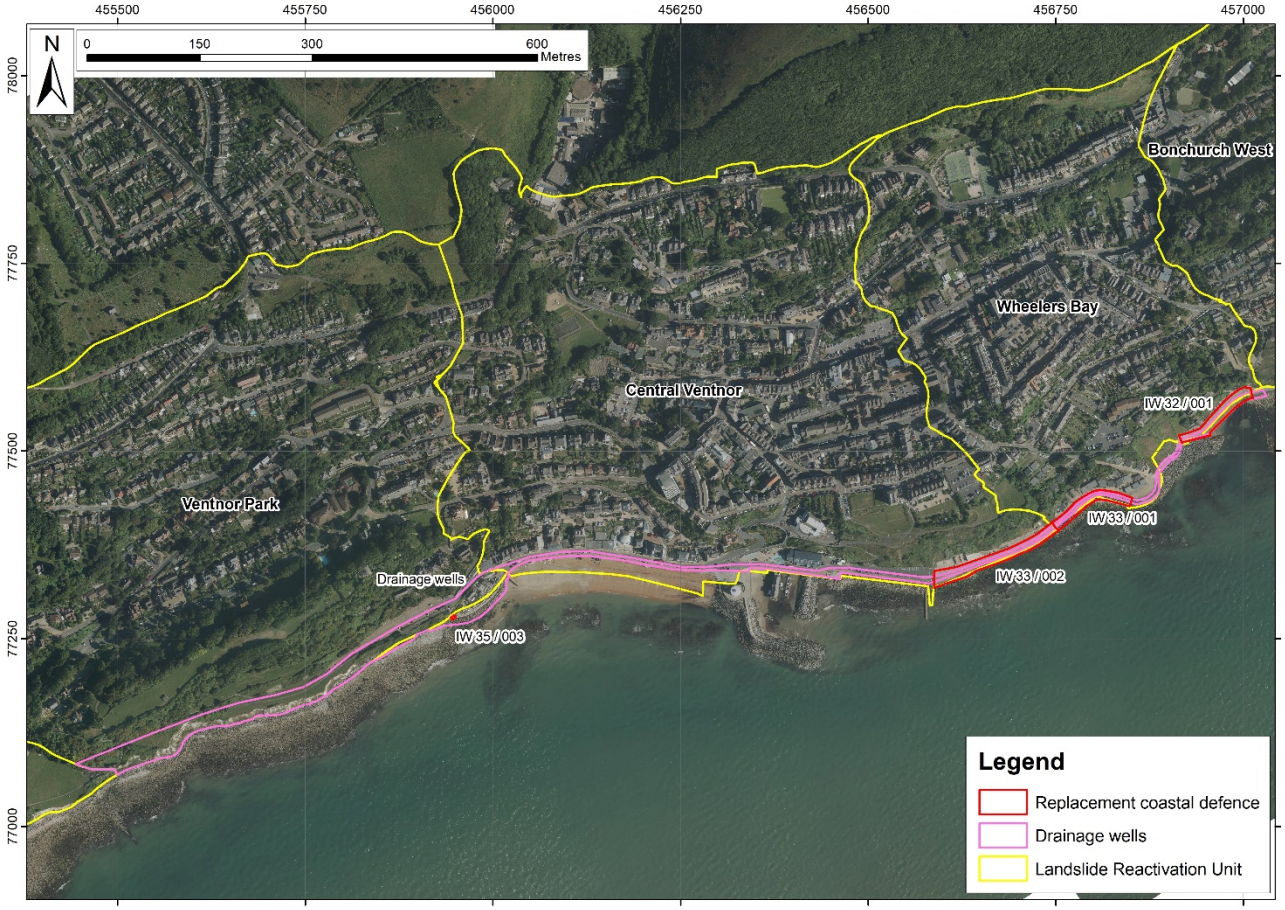


Figure 2. Footprint of the replacement coastal defences and drainage wells which make up the Priority Scheme.

Table 1. Photographs of the coastal defence measures to be replaced as part of the priority scheme.

Photo 1: Asset IW 35/003	Photo 2: Asset IW 35/003
	

Photo 3: Asset IW 33/002

Photo 4: Asset IW 33/002

Photo 7: Asset IW 33/001

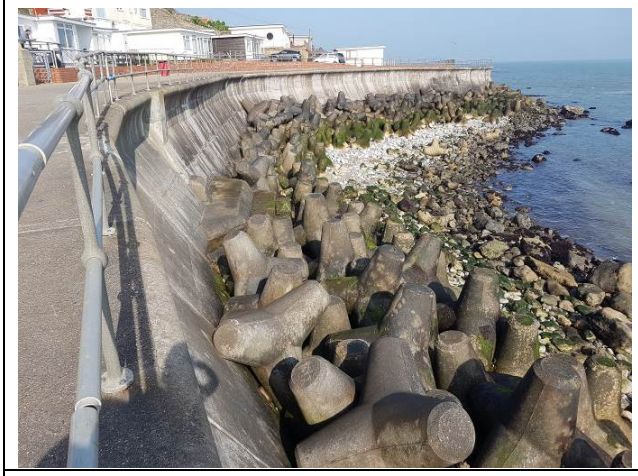


Photo 8: Asset IW 33/001

Photo 5: Asset IW 32/001

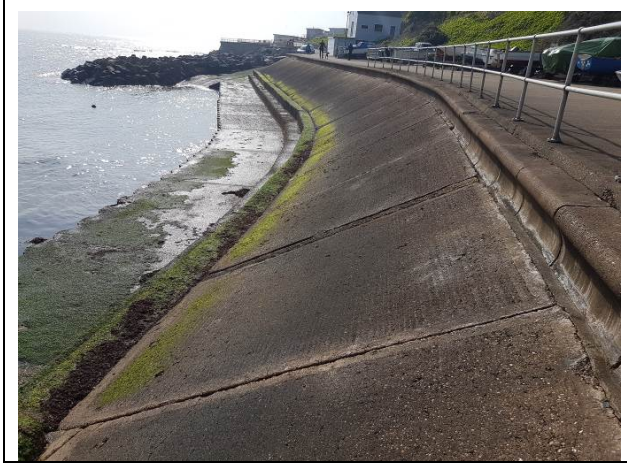


Photo 6: Asset IW 32/001

2.7 What are the benefits of the Priority Scheme?

- The objective of the Priority Scheme is to reduce the cost of damage caused by coastal erosion and landsliding to property (residential and commercial), tourism, transport (highways and footpaths),

utilities and services. The scheme will also reduce the likelihood of injury and prevent loss of public amenity and erosion of health and wellbeing,

- By reducing the risk of damaging events, the Priority Scheme produces £238.5m of Present Value Benefit (PV) over the 59-year design life of the proposed structures. PV benefits are future benefits expressed in present-day terms. They are used here as much of the damage avoided will happen in the future when the value of property and other assets will have changed.

- Although it cannot be formally accounted for in the Options Assessment (which focusses on protecting existing properties), Ventnor and Bonchurch could also expect increased future investment and economic growth.

2.8 Who will benefit from the Priority Scheme?

- The local community residents and businesses, utilities, service providers and IWC will benefit from reduced risk of damage and injury. Avoiding the cost of damage also increases property/asset values and investment in business, amenities and the visitor economy which will boost the local economy.

2.9 What are the Priority Scheme principles?

- The replacement coastal defence elements will prevent coastal erosion and improve the standard of protection against flooding/overtopping to a 1 in 200 years standard. Guarding against erosion and coastal retreat at the toe of the landslide complex will reduce significantly the potential for triggering ground instability and landslides. Some of the replacement defences will also be designed to remediate localised instability and groundwater flows which have damaged the existing structures.

- A large proportion of the landslide risk at Ventnor and Bonchurch is driven by rainfall and groundwater pressures developed on a deep shear surface in the Lower Greensand Sandrock (especially winter rainfall amounts). The proposed deep drainage will be designed to relieve of groundwater pressures to achieve a significant improvement in the slope stability, protecting both properties and infrastructure, and the new and assisting defences against ground movements.

2.10 How much will the Priority Scheme cost?

- The estimated PV cost of the scheme is £29m (£32m cash cost). PV cost is a future cost expressed in present-day terms. It is used here as the cost of investing in a scheme will be incurred in the future when the value of materials and labour etc. will have changed. The scheme is proposed to be developed over a period of approximately six years from in 2021/22 onwards (due to both risks and funding constraints).

2.11 Who will pay for the Priority Scheme?

- The options assessment shows that 87% of scheme funding could come from the central government. This is estimated to amount to £25.5m in ‘Grant in Aid’ funding (known as FCERM GiA, or Flood and Coastal Erosion Risk Management Grant in Aid).

2.12 How much funding will the local area/Isle of Wight Council have to find?

- There is currently a £3.6m PV funding shortfall (£4.2m cash cost). This will have to be met locally to ‘unlock’ the national funding. A combination of the following contributors can be investigated, and contributions sought. Their support is justified by the present cost of exposure to risk they currently experience and the future benefits to assets and economy they will experience:

- Utilising existing IWC funds outside of flood and erosion risk management budgets / capital funding bid(s).
- Securing contributions from utility service providers and major landowners.
- Local Enterprise Partnership (LEP) funding.
- Levying local businesses through the establishment of a Business Improvement District.
- Funding derived from future development in the area.
- Tourism-related funding (e.g. implementation of a tourism levy)
- Precepts on properties where residents can vote to pay additional council tax to help fund the scheme.
- Grants (e.g. Coastal Communities Fund, Heritage Lottery).

- At present, it is not possible to estimate what proportion of the 3.6m PV funding shortfall (£4.2m cash cost) will have to be found by IWC and the local area. This will depend on the number and size of contributions secured from the other sources listed above.
- Subsequent phases of appraisal and detailed design will provide the opportunity to rationalise the cost of the Priority Scheme for which generous budget estimates have been used in the Options Assessment. This may reduce the funding gap.

2.13 Over what time frame will the schemes be developed and constructed?

- The Priority Scheme is proposed to be undertaken from 2021 over a period of 6 years, with the first 2 years used to commission and undertake a ground investigation and monitoring, leading to detailed design in year 3 and construction of the coastal defence works in year 4. This would be followed by design and construction of the deep drainage in year 6.

2.14 How long will the new coastal defences and slope stabilisation measures last?

- All elements of the Priority Scheme will be designed to last for 60 years. This is standard for coastal engineering and has been used in the Options Assessment economic modelling.

2.15 What risks would remain?

- It is not possible to eliminate all risk. Although a successful scheme delivers a £238.5m reduction in damages caused by instability it will leave some residual risks of erosion and landsliding/ground movement. These are modelled as part of the Options Assessment.

2.16 Has climate change been taken into consideration?

The following predicted impacts of climate change have been considered:

- **Groundwater and increased winter rainfall.** Groundwater pressures in the Undercliff have a direct and profound effect on its stability by both imposing a destabilising force and by reducing strength along the landslide shear surface. Rainfall thresholds associated with historical instability and landsliding and climate change predictions have been used to estimate current and future likelihood of rainfall triggered landslide probabilities. With the increased frequency, intensity and amount of winter rainfall, previously

marginally stable areas of the Undercliff will become unstable, and, in areas previously affected by ground movement or landslides, the frequency and rate of ground movement and landslides will increase.

- **Coastal erosion and sea-level rise.** Undefended parts of the Undercliff frontage, which experience on average 0.4m/yr of coastal erosion due to wave action, provide a good indication of how the Ventnor and Bonchurch coastline would respond should the coastal defences fail. The removal of the slope toe in these areas increases slope angle and removes toe support and weighting, encouraging instability and landslides throughout the slope and terraces above. The Options Assessment has considered the potential impact of sea-level rise on the future stability of the Ventnor Undercliff. It estimates the current unprotected erosion rate will more than double to 0.91m/yr over the next 100 years and that, as a consequence, this significantly increases the likelihood of slope instability and landsliding.

2.17 What happens in areas of the frontage that don't presently qualify for scheme funding?

- In the Castle Cove, Bonchurch East and Bonchurch West areas, maintenance has been identified as the most beneficial form of coastal management. This is largely because the defences in these areas have not reached the end of their serviceable lives, so risk levels are lower than at Central Ventnor, Ventnor Park and Wheelers Bay.

- At the point when the existing coastal defences at Castle Cove, Bonchurch East and Bonchurch West reach the end of their lives, the cost-benefit balance switches to favour replacement structures and any future scheme could be delivered in these areas as a fresh scheme submission seeking a proportion of national 'Grant in Aid' funding, separate to the benefits from Ventnor Park, Central Ventnor and Wheelers Bay. However, it should be noted that, based on the current national funding rules, a significant proportion of 'partnership' / local funding would also be required for these areas, in which development is widespread but the density of development is not quite as high as in central Ventnor.

- In 'The Landslip' area to the east of Bonchurch, and the coastline to the west of Steephill Cove, the coast is currently undefended and naturally evolving. A policy of 'No Active Intervention' will continue along the shoreline in these areas.

2.18 What happens when other coastal defence assets fail in the future?

- The Options Assessment models the future failure of existing structures throughout the study area which have not reached the end of their serviceable lives and are not to be replaced as part of the Priority Scheme. As in Section 2.17, at the point when these existing defences reach the end of their lives, the cost-benefit balance switches to favour replacement structures and any future scheme could be delivered as a fresh FDGiA submission, separate to the benefits of earlier schemes.

2.19 Are there any environmental constraints?

- A review of environmental constraints on the Priority Scheme highlighted several considerations, one of which is a potential issue. This relates to the replacement defence at Wheelers Bay, which, depending on the final design footprint, may overlap with the South Wight Maritime Special Area of Conservation (SAC). Although this will need to be a careful consideration, the SAC is not thought to be a significant constraint at this stage due to the following:

  - the SAC boundary arbitrary follows the low water mark rather than the extent of the subtidal reef it protects,

- the rock armour (2000) and the tetrapods (1991) were installed before the SAC designation was put in place (2005) so that these structures are now 'inadvertently' part of the designation. Neither structure is mentioned in the SAC citation, so that there would seem to be potentially no clear argument to prevent their replacement, and,

- as there is a significant structure already in place, any replacement is unlikely to have an impact on loss of habitat.

- Detailed screening and scoping of environmental constraints has been costed for in the Options Assessment. This will be undertaken at OBC (Outline Business Case) stage when the replacement structure has been designed and potential impacts known. An Environmental Impact Assessment (EIA) and a Habitats Regulation Assessment (HRA) have been included in the Priority Scheme cost estimates.

2.20 Are there alternative scheme options?

- The exposed and unique nature of the Ventnor Undercliff site, which requires robust coastal defences combined with slope stabilisation, limits the range of viable solutions. Although alternative scheme designs have not been identified at this early stage, as part of the value engineering process ahead, the budgets proposed for appraisals, design and construction allow for the development and implementation of viable scheme alternatives as knowledge is increased.

2.21 What future maintenance will be needed, and how will it be funded?

- Maintenance will be required to maximise the lifespan of the proposed defences and drainage system.

- The Options Assessment details and costs an optimal and proactive maintenance regime. Maintenance is split into annual maintenance, such as beach recycling and clearance of sediment from drainage, and ad-hoc maintenance, such as the import of beach sediment and rock armour.

- Maintenance will cost £20k annually for all assets (old and new) in the Priority Scheme frontage (Ventnor Park, Central Ventnor and Wheelers Bay). An allowance for infrequent significant maintenance along the same frontage has also been made in the economics.

- As is the case presently, maintenance obligations would require funding by IWC, with the frequency and scale of the repairs dependent on the availability of funding. As such, in reality, a lower cost reactive maintenance regime may be adopted.

2.22 Are there any risks of the Priority Scheme not working?

- The risk of the proposed coastal defences not preventing erosion is very low, as there are not considered to be any overriding technical issues where defences have been identified as being in a poor condition.

- The effectiveness and longevity of the deep drainage will depend on by how much the landslide system stability is increased, and if or when any further movement has the potential to shear the drainage boreholes.

- The objective of appraisals undertaken during OBC is to demonstrate scheme viability to a high level of confidence so that solutions which carry too much risk are rejected.

- The information gathered during future appraisals is also likely to provide insight into any alternative viable scheme options which are not apparent with the current level of knowledge. A standard optimism

bias of 60% on the construction costs has been applied to provide financial contingency should more expensive alternative options be required.

- If no viable solution is found, IWC wouldn't be left to pick up the bill as appraisal costs during the first stages/years of the scheme are typically recouped. Also, IWC would have been seen to have been taking action to reduce risk in the event of a damaging landslide (i.e. it wouldn't be the responsibility of IWC that a technically viable and fundable option could not be developed). The mitigation provided in this Options Assessment is to allocate sufficient budget for a full options appraisal and supporting site investigation and analysis.

2.23 How urgent is the Priority Scheme?

- Very. The defences that require replacement have between 0-5 years of servable life remaining, are in poor condition and could fail at any time. Also, as per Environment Agency requirements, it is imperative to implement slope stabilisation immediately after construction of the defences to protect the new assets against damage caused by coastal instability.

2.24 How will scheme construction and operation impact the local community and business?

- All construction associated with the Priority Scheme will be undertaken at the base on the slope. While this will affect access and amenity along the promenade there will typically be no activities further up the slope or on any property.

- The coastal defences are direct replacements and drainage will be incorporated in the new defences so that, when complete, the scheme will not be noticeably different in extent and scale to the existing defences.

- The construction of the replacement coastal defences and then deep drainage will be undertaken separately in two stages to avoid the disruption of simultaneous construction projects.

2.25 What stage is the project at now and what happens next?

- This year (2019/20) the preliminary scheme proposal has been included in the EA's national Programme Refresh to help the national government understand the scale of future funding required for coastal and flooding schemes around the country beyond the end of the current national programme ending in 2021, and start the process of building a future pipeline of works. The intention would be to secure significant indicative allocations of national Grant in Aid funding in due course for a potential six-year scheme. This does not yet commit the Local Authority to the scheme and can be pursued alongside seeking the essential local partnership funding contribution that would be required to confirm the scheme, and as part of a process of reviewing and considering local priorities. During 2020 and 2021 (or earlier if funds are available earlier) the FCERM7 application (for approval of studies and strategies) will be prepared and submitted to seek the unlocking of the first national funds, alongside obtaining the local partnership funding contributions.

- Following this, from 2021/22, the scheme is proposed to be undertaken over a period of 6 years (through Outline Business Case and Full Business Case stages), with the first 2 years to commission and undertake a ground investigation and monitoring, leading to detailed design in year 3 and construction of the coastal defence works in year 4. This would be followed by design and construction of the deep drainage in year 6. This two-staged approach has been chosen to allow maximum time to gather monitoring information and carry out drainage modelling and design, and to avoid the disruption of simultaneous construction projects.

2.26 How can I suggest ideas of how to raise money?

- Please email coast@iow.gov.uk at the Isle of Wight Council with any ideas on how to raise funds, including and in addition to those put forward in Section 2.12. Thank you.

Appendix 7 – Preliminary Outline Business Case (pOBC)

Appendix 8 - PAFS form 29/01/2020

Appendix 8 PAFS form 29/01/2020

Data for entry into the PAFS system to bid for a Scheme:

Name:

- Ventnor coastal protection and slope stabilisation scheme.

Project type:

- Create a new flood or coastal erosion risk management asset, or improve the standard of service of an existing one.

Last financial year the project will spend funds:

- April 2026 to March 2027.

Location:

- SZ 56710 77367

Project benefit area:

- Shapefile created.

Important dates:

- Outline business case start date: April 2021
- Contract awarded: April 2023
- Start construction: April 2024
- Ready of service: March 2027

Funding sources and spending (cash costs):

Year	GIA	Not yet identified	Total (£)
2021 - 2022	£ 798,000	£ -	**£ 798,000**
2022 - 2023	£ 749,000	£ -	**£ 749,000**
2023 - 2024	£ 848,000	£ -	**£ 848,000**
2024 - 2025	£ 12,424,000	£ 1,966,000	**£ 14,390,000**
2025 - 2026	£ -	£ -	**£ -**
2026 - 2027	£ 13,025,000	£ 2,234,000	**£ 15,259,000**
Total (£)	**£ 27,844,000**	**£ 4,200,000**	**£ 32,044,000**

Earliest start:

The earliest date the project could start without impacting deliverability or outcomes is:

- April 2020

Risks and households benefitting:

Coastal erosion:

- Households affected by coastal erosion that benefit from the project (Nb. Houses built or converted after 1 January 2012 aren't included):

Financial year (April to March)	Households that will move to a lower flood risk category */erosion risk*	Of the households in column A, how many will be protected from loss within the next 20 years	Of the households in column B, how many are in the 20% most deprived areas
	A	B	C
2026 to 2027	791	388	151
Total	**791**	**388**	**151**

Standard of protection:
Length of time before coastal erosion affects the area that is likely to benefit from the project:
- 1 to 4 years

Length of time before coastal erosion affects the area, when the project is complete:
- 50 years or more

How the project will achieve its goals:
- The goal of the project is to maintain the Hold the Line policy and ensure an acceptable standard of coastal protection is provided over the next 100 years for the town of Ventnor, located on the largest coastal landslide complex in north-western Europe. This will be achieved by a implementing an economically, technically and environmentally justified scheme to replace ageing coastal defence structures and implement deep drainage. The scheme will help prevent accelerated rates of toe erosion causing loss of land, widespread ground movement, landslide reactivation and asset damage in Ventnor for 59 years. The scheme is expected to better protect 2,069 residential households (or 2,911 properties in total), all located on the landslide in the scheme area, but taking a precautionary approach at this early stage in the appraisal process only 791 homes are listed as full OM3s

Environmental benefits:
Surface water or groundwater the project is likely to protect or improve:
- 0 kilometres

Habitat the project is likely to protect or improve:
- 0 kilometres

River or priority river habitat the project is likely to protect or improve:
- 0 kilometres

Habitat of Principal Importance the project is likely to create:
- 0 kilometres

River the project is likely to open to fish and eel passage:
- 0 kilometres

Project urgency:
- The project is not urgent

Partnership funding calculator:
- Excel file provided (See Appendix 4 of the Future Schemes Report)

Additional information required:

Project Confidence Assessment:
Confidence in 'number' of homes:
- 2. Medium Low *(Definition: 'Initial modelling carried out')*

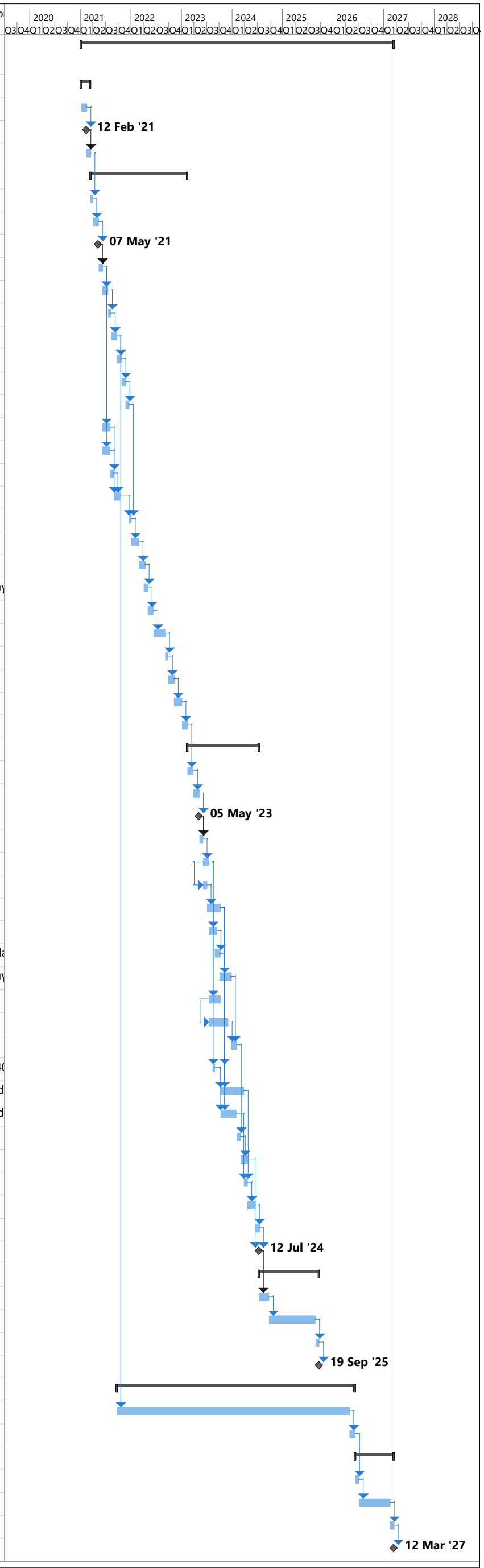
Confidence in Homes being delivered by specified gateway 4 date:
- 2. Medium Low *(Definition: 'Moderate concerns in delivery of specified homes numbers by specified gateway 4 date')*

Confidence in Securing partnership funding:
- 2. Medium Low *(Definition: 'Contributors not known and/or concerns over those identified. Optimistic a solution will be found; but not immediately obvious')*

Natural Flood Management considerations:
- Not applicable

Appendix 9 - Project delivery programme

ID	Task Name	Duration	Start	Finish	Predecesso
1	**Ventnor FCERM Package of Priority Works (Ventnor Park, Central Ventnor and Wheelers Bay)**	**1615 days**	**Mon 04/01/21**	**Fri 12/03/27**	
2	**Obtain Funding for OBC**	**50 days**	**Mon 04/01/21**	**Fri 12/03/21**	
3	Prepare FCERM7 and internal approvals	30 days	Mon 04/01/21	Fri 12/02/21	
4	Submit FCERM7	0 days	Fri 12/02/21	Fri 12/02/21	3
5	Agree funding with Environment Agency	20 days	Mon 15/02/21	Fri 12/03/21	4
6	**OBC**	**500 days**	**Mon 15/03/21**	**Fri 10/02/23**	
7	Detailed scope of works for consultant	10 days	Mon 15/03/21	Fri 26/03/21	5
8	Tendering Process	30 days	Mon 29/03/21	Fri 07/05/21	7
9	Appoint Consultant	0 days	Fri 07/05/21	Fri 07/05/21	8
10	Mobilisation and data review	20 days	Mon 10/05/21	Fri 04/06/21	9
11	Scope Ground Investigation	30 days	Mon 07/06/21	Fri 16/07/21	10
12	Mobilisation for GI	15 days	Mon 19/07/21	Fri 06/08/21	11
13	GI site works	30 days	Mon 09/08/21	Fri 17/09/21	12
14	GI lab testing and Factual Report	25 days	Mon 20/09/21	Fri 22/10/21	13
15	GI Interpretive Report	20 days	Mon 25/10/21	Fri 19/11/21	14
16	Develop ground models and drainage network options	20 days	Mon 22/11/21	Fri 17/12/21	15
17	Scope, procure and complete topo survey	40 days	Mon 07/06/21	Fri 30/07/21	10
18	Scope and undertake wave and hydrodynamic modelling	40 days	Mon 07/06/21	Fri 30/07/21	10
19	Coastal processes study	20 days	Mon 02/08/21	Fri 27/08/21	18
20	Identify and outline Long List of options	30 days	Mon 30/08/21	Fri 08/10/21	17,19
21	Agree Short List of options to progress	10 days	Mon 20/12/21	Fri 31/12/21	20,16
22	Preliminary design for Short List options	40 days	Mon 03/01/22	Fri 25/02/22	21
23	Pricing of Short List Options by ECI	30 days	Mon 28/02/22	Fri 08/04/22	22
24	Economic analysis	20 days	Mon 04/04/22	Fri 29/04/22	23FS-5 day
25	Identification of preferred option	30 days	Mon 02/05/22	Fri 10/06/22	24
26	Develop preferred option to outline design	60 days	Mon 13/06/22	Fri 02/09/22	25
27	Pricing of preferred option and risk budget	15 days	Mon 05/09/22	Fri 23/09/22	26
28	Draft OBC, review and issue	30 days	Mon 26/09/22	Fri 04/11/22	27
29	LPRG approval	40 days	Mon 07/11/22	Fri 30/12/22	28
30	Contingency	30 days	Mon 02/01/23	Fri 10/02/23	29
31	**Detailed Design and FBC**	**370 days**	**Mon 13/02/23**	**Fri 12/07/24**	
32	Detailed scope of works for consultant	30 days	Mon 13/02/23	Fri 24/03/23	30
33	Tendering Process	30 days	Mon 27/03/23	Fri 05/05/23	32
34	Appoint Consultant	0 days	Fri 05/05/23	Fri 05/05/23	33
35	Mobilisation and data review	20 days	Mon 08/05/23	Fri 02/06/23	34
36	Detailed scoping of works and Design Criteria Report	30 days	Mon 05/06/23	Fri 14/07/23	35
37	Detailed Scoping of EIA	20 days	Mon 05/06/23	Fri 30/06/23	36SS
38	Environmental Statement	70 days	Mon 03/07/23	Fri 06/10/23	37
39	Detailed groundwater modelling	40 days	Mon 17/07/23	Fri 08/09/23	36
40	Detailed design of drainage wells	30 days	Mon 28/08/23	Fri 06/10/23	39FS-10 da
41	Detailed design of MEICA for drainage wells	60 days	Mon 02/10/23	Fri 22/12/23	40FS-5 day
42	Geotechnical analysis for coastal structures	60 days	Mon 17/07/23	Fri 06/10/23	36
43	Detailed design of coastal structures	100 days	Mon 17/07/23	Fri 01/12/23	42SS
44	Construction drawings and specifications	30 days	Mon 25/12/23	Fri 02/02/24	43,41
45	Public consultation	10 days	Mon 14/08/23	Fri 25/08/23	36,38FS-4(
46	Submit planning application and obtain planning permission	24 wks	Mon 09/10/23	Fri 22/03/24	45FS+15 d
47	Submit for and obtain MMO License	16 wks	Mon 09/10/23	Fri 26/01/24	45FS+15 d
48	Contract documentation	20 days	Mon 05/02/24	Fri 01/03/24	44
49	Construction contract procurement	40 days	Mon 04/03/24	Fri 26/04/24	48
50	Draft FBC, review and issue	20 days	Mon 25/03/24	Fri 19/04/24	46,47
51	LPRG approval	40 days	Mon 22/04/24	Fri 14/06/24	50
52	Contingency	20 days	Mon 17/06/24	Fri 12/07/24	51
53	Award construction contract	0 days	Fri 12/07/24	Fri 12/07/24	52,49
54	**Construction of priority coastal defence works**	**310 days**	**Mon 15/07/24**	**Fri 19/09/25**	
55	Mobilisation	50 days	Mon 15/07/24	Fri 20/09/24	53
56	Construction of coastal defence works	12 mons	Mon 23/09/24	Fri 22/08/25	55
57	O&M Manual	20 days	Mon 25/08/25	Fri 19/09/25	56
58	Completion of construction contract for priority coastal works	0 days	Fri 19/09/25	Fri 19/09/25	57
59	**Groundwater monitoring**	**1230 days**	**Mon 20/09/21**	**Fri 05/06/26**	
60	Groundater monitoring and reporting	60 mons	Mon 20/09/21	Fri 24/04/26	13
61	Confirm groundwater modelling and design from detailed design	30 days	Mon 27/04/26	Fri 05/06/26	60
62	**Construction of priority drainage wells**	**200 days**	**Mon 08/06/26**	**Fri 12/03/27**	
63	Mobilisation	20 days	Mon 08/06/26	Fri 03/07/26	61
64	Construction of drainage wells	8 mons	Mon 06/07/26	Fri 12/02/27	63
65	O&M Manual	20 days	Mon 15/02/27	Fri 12/03/27	64
66	Completion of construction contract for priority drainage works	0 days	Fri 12/03/27	Fri 12/03/27	65



Project: Ventnor Indicative Sch
Date: Fri 07/06/19

Task	Inactive Task	Manual Summary Rollup	External Milestone
Split	Inactive Milestone	Manual Summary	Deadline
Milestone	Inactive Summary	Start-only	Progress
Summary	Manual Task	Finish-only	Manual Progress
Project Summary	Duration-only	External Tasks	

Appendix 10 - Scheme Maps

455500 455750 456000 456250 456500 456750 457000

78000 77750 77500 77250 77000

N

0 150 300 600 Metres

Bonchurch West

Wheelers Bay

Central Ventnor

Ventnor Park

IW 32 / 001

IW 33 / 001

IW 33 / 002

Drainage wells

IW 35 / 003

Legend

- Replacement coastal defence
- Drainage wells
- Landslide Reactivation Unit

456000
456250
456500
456750
77500
77250
N
0
75
150
300
Metres
Central Ventnor
Wheelers Bay
Ventnor Park
IW 35 / 003
Drainage wells
IW 33 / 001
IW 33 / 002

Central Ventnor

- Replacement coastal defence
- Footprint of drainage wells
- Landslide Reactivation Unit

Defence ID	IW 33 / 002
Current Condition	Very Poor
Residual Life	0 years
Crest Height (m)	6
Type	Steel sheet piling
Length (m)	181

455500

455750

456000

77250

77000

N

0 75 150 300 Metres

Central Ventnor

Ventnor Park

IW 35 / 003

VENTNOR

Drainage wells

Castle Cove

Ventnor Park

Replacement coastal defence

Footprint of drainage wells

Landslide Reactivation Unit

Defence ID	IW 35 / 003
Current Condition	Poor
Residual Life	5 to 7 years
Crest Height (m)	5.6
Type	Concrete wall
Length (m)	2

456750

457000

77500

N

0 30 60 120 Metres

Wheelers Bay

IW 32 / 001

Drainage wells

IW 33 / 001

Central Ventnor

IW 33 / 002

Wheelers Bay

- Replacement coastal defence
- Footprint of drainage wells
- Landslide Reactivation Unit

Defence ID	IW 33 / 001
Current Condition	Poor
Residual Life	5 to 7 years
Crest Height (m)	5.6
Type	Steel sheet piling
Length (m)	119

Defence ID	IW 32 / 001
Current Condition	Poor
Residual Life	5 to 10 years
Crest Height (m)	4.1
Type	Steel sheet piling
Length (m)	109