SANDY LANE BEACH REGENERATION AND MARINE CONSERVATION PROJECT

Environmental Impact Assessment (EIA) Report

REPORT FOR PUBLIC CONSULTATION (APRIL 2016)

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This EIA Document

This document represents the formal submission of the clients (Beach Regeneration incorporated – BRI) Environmental Impact Assessment (EIA) for the proposed project. This document represents an amalgamation of an initial Draft EIA (submitted in October 2015 to the Government of Barbados) in addition to an Addendum (December 2015) to the previous Draft submission for the proposed project.

The EIA (now complete and subject to a public consultation phase in April 2016) includes updates to key sections of the EIA as proposed by the Town and Country Development Planning Office (TCDPO) throughout the duration of this process (since December 2014) to enable the regulatory authorities, and the public, to enable a transparent decision to be made on this proposal. Separate appendices are produced to help support this EIA submission with specific technical and supporting detail.

This document has been produced to embrace requests for additional field data and modelling work proposed by TCDPO (see below) plus any correspondence received from key stakeholders (notably only the Ministry of Transport and Works on 3 December 2015) and from this, to update design related issues and impacts (as appropriate) within the EIA formally submitted to TCDPO in October 2015.

The project proposer (BRI) has also addressed the key points raised by TCDPO in their letters to BRI on 3 March 2016 and on 8 May 2015 (Ref. No. 1976/12/2014C), the latter setting our 12 clear Recommendations. These points are now updated and are considered and developed.

EIA Addendum (December 2015) BRI Response to TCDPO Requested information
Point 1 – Shoreline Morphological Response Report
A separate Appendix (5g) has been produced and entitled “Shoreline Morphological Response Report”. This is now updated to include all additional numerical modelling exercises completed to date and additional baseline data collection studies that have embarked since June 2015 (beach profile monitoring programme) plus the new ADCP deployment exercise which was undertaken during the fall of August-September 2015.
Point 2 – Construction Methodology
BRI confirm that this has been developed in more detail within Section 4 of the EIA using results from the physical and numerical modelling analysis as appropriate (Appendix 5g).
Point 3 and 4 – Sediment Source Analysis
The project has undertaken a thorough analysis and assessment of beach and marine sediments (plus inland quarry sourced sands). All sediment samples from Sandy Lane Bay have been tested by the Barbados National Standards Institute (BNSI) laboratories for particle size and density analysis. BRI confirm that no marine sources of sand are to be used for either filling the NESs or be used for beach replenishment. Details of the appropriateness of the proposed source sediment materials are clearly discussed in Sections 4, 5, 6 and 9. Appendices 5c, d and e present the sedimentological work carried out by the project.
Point 5 and 6 – Beach Profile Work
BRI have initiated a detailed monthly survey of the beach (commenced in June 2015) to complement the initial topographic exercise undertaken in November 2014 (the latter was already presented to TCDPO as part of our letter submission to them on 3 March 2015). Details of the newly proposed beach profile locations (which coincide where possible with existing profiles historically captured by CZMU) are presented in Appendix 5f. The analysis of historic beach profile data (CZMU and third party profiles from Beachlands is discussed in Section 5 and presented in more detail within Appendix 5g which has subsequently been updated with new field data as requested by TCDPO.
Point 7 – Additional Wave Data Collection
BRI have procured the deployment of an additional ACDP to capture real time summer season wave and current conditions over a 4-6 week period (undertaken during August/September 2015). This information has been used to determine sediment movement within Sandy Lane Bay for a typical ‘summer’ event.
Point 8 – Sediment Donor Sites
BRI confirm that no marine “sediment donor” sites are being proposed as part of this project. This point is

discussed within Section 4 of the EIA. The proposed quantity of land based material needed for the project has been referred to in Point 12.
Point 9 - Marine Ecological Assessment Report (Quantitative Assessment)
BRI can confirm that the initial Marine Ecological Assessment Report is presented in Appendix 5l and a supporting updated report (presenting marine ecological details of each proposed NES footprint is presented) is included as a specific Appendix 5m.
Point 10 – Marine Habitat Map and GA "footprint"
A GIS marine habitat map, showing proposed NES locations and dimensions relative to the location of sensitive marine ecosystems, is presented in Section 5.3.3 (Figures 5.25 and 5.26). The GA (Appendix 5g Annex F) show the dimensions of the structures in more detail.
Point 11 – Potential Impacts and Environmental Management Plan (EMP)
BRI can confirm that the EIA (Section 6.3.3 – Impacts) assesses potential impacts to sensitive marine habitats at each stage of the proposed development and corresponding mitigation measures (where required) are listed in Section 10. A separate Environmental Management Plan (EMP) is now completed (Section 11) that incorporates all new baseline studies and modelling work recently completed. This section now outlines the approach towards operationalising the Environmental Monitoring Plan as part of the engineering works to ensure total compliance to environmental permits granted by TCDPO.
Point 12 – Integrity of Geotextile Containers
Appendices 6a and 6b have been prepared to demonstrate the structural integrity and success of the soft engineering approach using examples from around the world (using examples in West Java (Indonesia), Kerala and Australia). A separate Appendix 6d is also included to outline the findings and outcomes of the Coastal Habitat Research Permit application to assess the filling and placement aspects of the structures (executed during September 2015). Appendix 9b is also prepared to justify the selection and use of geotextile sand containers for this project in Barbados waters.

1 INTRODUCTION

1.1 Overview

A new beach rehabilitation and marine conservation project is being proposed for Sandy Lane Bay and adjacent headland areas. Beach Regeneration Incorporated (BRI) is applying to the Town and Country Development Planning Office (TCDPO) for planning permission (application number 1976/12/2014C) to construct a beach rehabilitation scheme (Appendix 1a). The project is being proposed for Sandy Lane Bay and immediate adjacent headland areas (north and immediate headland to the south only) within St James Parish. The project's purpose is to address the worsening beach erosion issues that face the bay and the economic impact that inaction may bring to local business, stakeholders and communities alike.

The scheme is being sensitively designed to provide multiple benefits to the area (as the area falls within the Folkestone Marine Reserve), notably through improved coastal protection for important economic assets, marine habitat rehabilitation and improved park demarcation buoys and beach management procedures, including improved signage and safety parameters.

Its intended outcome shall therefore include improved coastal protection, rehabilitation of marine habitats and improved beach access along the immediate headlands of Sandy Lane Bay (from Sunset Reef to Leigh House) for visitors and Barbadians alike.

The proposal has the following intended outcomes:

- To restore a beach at Sunset Reef that has been eroded over the last ten years and to provide an enhanced beach width in front of Sandy Lane Hotel. This shall involve construction of 3 nearshore engineering structures (NESs) to retain the beach material;
- Safer access to and from the water for beach users with reduced beach slopes, particularly at Sandy Lane Hotel where residents and visitors have experienced difficulty in exiting the water.
- To avoid negative impact on the local surfing reef by avoiding any NES construction within the vicinity of the natural surf reef area;
- General improvement of beach access along the shoreline as follows:
    - Northern area (currently no access north from Landfall property); and
    - Southern area (currently difficult access at Leigh House).
- Restoration of coastal habitats through the use of appropriate and environmentally sensitive materials, coral transplantation (as appropriate) and from this the future establishment of a coral nursery in partnership with the Folkestone Marine Park.

Specific details of the project are as follows:

- Area of the site is 120,000m^2 / 5.3 ha; *(NB: this is an approximate bounding rectangular area around the works themselves; taking the wider site area (e.g. Beachlands to One Sandy Lane is approx. 750,000-800,000m^2)).*
- Length of frontage = 450m;
- Distance offshore of the nearshore engineering structure (NES) = approx. 100m;
- Gross floor area (including beach recharge and NES's) = 38,000m^2 / 370,000ft^2
- Gross roof area = n/a

The building materials needed to construct the proposed development are as follows:

- Beach recharge (circa 37,000m^3) using land derived quarry sand from Lears Quarry;

- Nearshore engineering structures (NES), consisting of Submerged Terrafix Soft Rock© 'sand containers' and rock armour with spatial "footprint" areal extent as follows;
  - Area of NES1 = 1,500m^2 / 11,150 ft^2; (consisting of rock).
  - Area of NES2 = 1,600m^2 / 12,000 ft^2; (consisting of Terrafix Soft Rock©)
  - Area of NES3 = 1,600m^2 / 13,000 ft^2; (consisting of Terrafix Soft Rock©).

1.2 Proposed Location

1.2.4 Island of Barbados

Barbados is the most easterly island in the Caribbean island chain, situated south of Saint Lucia, east of St Vincent, and north of Trinidad. The island is 23 kilometres (km) (14 miles) at the widest point, 34km long, and has an area of 432 square km. Barbados' coastline is 92km in length. Most of the island is made up of soft marine deposits of coral limestone that give way in the north-eastern part of the island to a terrain of clays and sandstones. Although the island has been described as flat with low elevation, it in fact rises from west to east in a series of gentle terraces to its highest point of about 1100 feet at Mount Hillaby in St. Andrew. The terrain dips in St. George to form the St. George Valley, separating the main limestone terraces from a lower limestone ridge in the Christ Church area. The coastal zone (the focal area of this project application) is also central to the social and recreational lives of Barbadians, attracting more than one million people to beaches every year (CZMU 2010).

1.2.5 Proposed Project Area

The project area is located in the Parish of St. James, about 7km south of Speightstown. It also falls within the Folkestone Marine Park (FMPR) jurisdictional boundary area with the project area situated within the water sports zone of the FMPR (see Figure 1.1 and associated inset map).

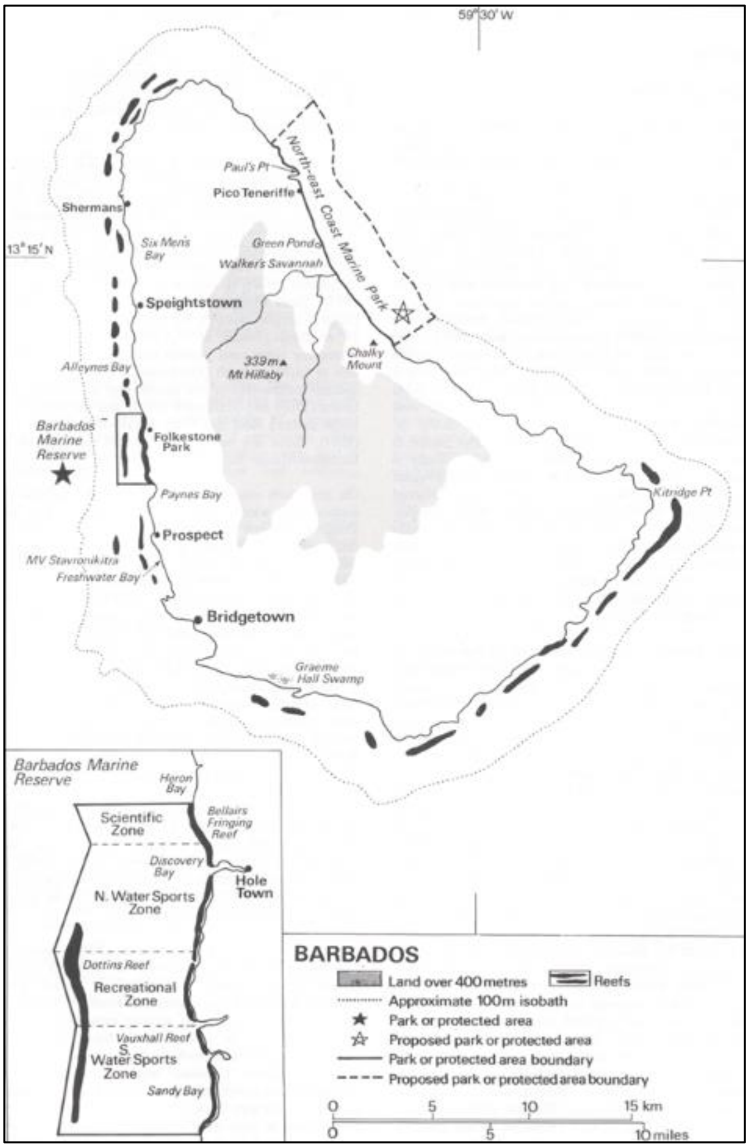

Figure 1.1: Map of Barbados and Folkestone Park Marine Reserve

The proposed project area occupies land and seabed directly adjacent to Sandy Lane Hotel and neighboring beachfront. However, the proposed "intervention" area itself is approximately 450m in linear length. A local wave model has been built within Sandy Lane Bay to investigate the baseline scenario (without structures) and wider effects of the proposed scheme. This local model area extends for a distance of approximately 1km north-south. A wider-area model has also been built to look at changes in wave parameters as a result of the scheme, extending south into Paynes Bay. This wider area model extends for a distance of approximately 1.7km north-south.

Land use in the vicinity of the project area is essentially touristic and residential. It is also low lying, being approximately 2m above sea level. The project construction is proposed to take place from mean high water (MHW) seawards to a depth corresponding to approximately the -4m Lamont Datum contour. Consequently, land use and existing infrastructure (residential and tourist accommodation, transport networks, utilities etc) will not be impacted upon or altered as a consequence of this project.

1.3 Project Proposal

The project area is located in the parish of St James on the west coast of Barbados in what is considered the island's premier tourism zone. The project area is physically bounded by two headlands, one in the vicinity of Sunset Reef in the north and the other in the vicinity of Leigh House in the south. This approximately 700m length of coastline has been divided into two "Units" that have been defined to make the identification of potential intervention measures easier to clarify and differentiate the study area (see Figure 1.2):

- Unit 1 – Sunset Reef to Landfall; and
- Unit 2 – Sandy Lane Bay – Landmark to Leigh House.

The design of Unit 1 is to provide a beach and achieve improved beach access for all states of the tide, for a length of approximately 200m. The northern extent of the salient proposed in this area will tie into the southern boundary of Club Barbados the southern extent will tie into the beach in the northern part of Sandy Lane Bay.

The new beach will be achieved through:

- One emergent rock breakwater (approx. 80m long, placed 100m from the shore); and
- Beach renourishment.

The breakwater is known as Nearshore Engineering Structure 1 (NES-1). The rational for using emergent rock is given in Section 4. The desired effect of the structure will be to encourage accretion of beach material in it's lee thereby increasing beach width to form a beach at Sunset Reef, effectively returning a beach and associated access to an area where the beach has eroded to a point where there is currently no beach present.

In addition, beach renourishment material of similar characteristics to the existing beach material will be added to the beach. The renourishment material will be profiled to create a natural beach slope down to the water. The addition of sand to the beach will help replace material that has been lost in previous years.

The design for Unit 2 is to provide an enhanced beach in front of Sandy Lane Hotel, for a length of approximately 500m, through the use of:

- Two submerged geotextile sand container (GSC) breakwaters within Sandy Lane Bay (approx. 80m long, placed 100m from the shore); and
- Beach renourishment.

The breakwaters are known as Nearshore Engineering Structures 2 and 3 (NES-2 and NES-3). Due to project requirements the EcoReef units are not included in the design at this stage; this may follow later (to be designed by others). Beach access in this central part of the study area is not the driver behind the design. The design requirement for this unit is to address the erosion of the beach crest at the hotel, which is a key concern for the client as it is limiting the available space for residents to enjoy the beach front to the hotel.

The design will aim to encourage accretion of beach material in the lee of the structures thereby increasing beach width within Sandy Lane Bay. Any natural accretion of beach material will be supplemented by an initial renourishment of suitable beach material in the lee of the structures. The physical characteristics of the renourishment material will be a close match to the existing beach material.

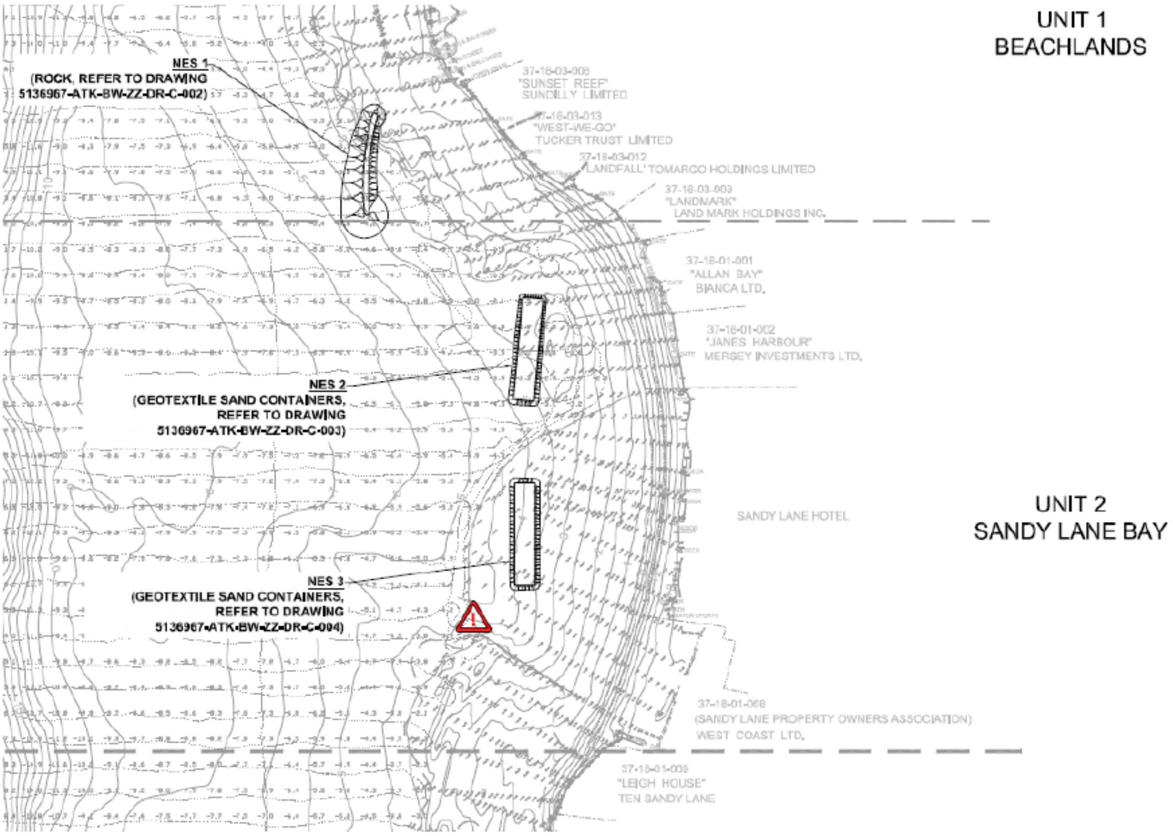

Figure 1.2: Project Proposed Area and Location of the 3 Nearshore Engineering Structures (NES)

1.3.4 Project Phases

Some project baseline assessment work phases have been undertaken, over a number of years, prior to this proposal application. The Phase titles are as follows:

- **Phase 1**: The Scoping Study (Blades *et al* 2012);
- **Phase 2**: The Baseline Assessment and Project Proposal Development (2013);
- **Phase 3**: The Preliminary Design (initial component) completed in March 2014;
- **Phase 4:** The Final Design (this application);
- **Phase5**: Implementation of beach stabilisation and marine conservation measures (engineering contract to be prepared);
- **Phase 6**: Management and Maintenance (planned to commence in 2016).

The initial stakeholder assessment exercise carried out (Blades *et al* 2012 – see Appendix 1b) derived a consensus among the stakeholders and property owners (from Beachlands in the north to One Sandy Lane to the south) that the extent of the beach along this frontage has decreased in width over recent years and this situation has impacted, and will continue to impact the continuity of their beach tourism related businesses. All property owners acknowledge the short term influence that the winter north and south swells can have along this coastal stretch, moving beach sands from one end of the bay to the other, leaving behind a shoreline that is stripped of sand. However, it was agreed (Blades *et al* 2012) that all stakeholders believe the longer term trend of beach erosion is getting worse each year. This was reported on as part of Phase 1.

Following the initial work by Blades *et al* (2012), the CARIBSAVE Partnership and WS Atkins International Ltd (Atkins) were contracted to provide advice on engineering details (Phases 2 and 3). The goal of the study was therefore to assess measures that could be taken to improve the shoreline, while also considering the health of the nearshore reefs and how these may influence the beaches and shoreline. Phase 3 also involved a detailed option appraisal exercise which is reflected upon and updated in Section 9 of this EIA document.

1.4 Application and Approval Process

1.4.4 The Planning Process

The planning procedure followed by BRI reflects current legislative and regulatory practice which is required for any development application in Barbados. The TCDPO has the mandate to regulate and approve new and expanded developments including those on Crown Lands (coastal and marine lands). The Government of Barbados (GoB) has introduced guidelines for the types of developments requiring an environmental impact assessment (EIA) and the related studies that are required as part of the EIA for planning approval. Coastal engineering schemes are included in the list of projects that trigger an EIA.

As part of the planning approvals process for projects requiring an EIA, the TCDPO establishes a committee of relevant agencies to provide a review of and comment on the project. In advance of the EIA, the proponent submits a Terms of Reference (TOR) document to TCDPO for approval of the work scope to be completed. Upon completion of the EIA, the proponent is required to submit the report to TCDPO. The report is circulated to the various government agencies for comment. The EIA process also requires that the applicant conduct a public information session to present the project to the public and the results of the EIA. (***NB: This is to take place during April 2016 upon completion of additional baseline data capture that has been requested by the statutory authorities and subsequent additional re-runs of numerical coastal models).***

1.4.5 The BRI Approach

Following a meeting held between Sandy Lane Hotel representatives, BRI, representatives from the Ministries of Environment, Tourism and Finance and a separate meeting with the Coastal Zone Management Unit (CZMU) on 26 and 27 November 2014 respectively, it was confirmed that BRI would lead the planning application consultation and the appropriate submissions would be made. BRI submitted an application (No. 3262/11/04C) for planning approvals to the TCDPO in December 2014 (see Appendix 1a), in addition, an EIA Terms of Reference (ToR) was also submitted to the Town and Country Planning Office (see Appendix 1c), for the attention of the Chief Town Planner (CTP) on 11 December 2014. These TOR were subsequently commented upon by TCDPO on 8 May 2015. A formal response to these comments is presented in Appendix 1d.

1.5 Project Justification

1.5.1 Client requirements

The following principles were agreed that set the framework for the project’s design and approach.

- “Hold” the current property lines (2014);
- Restore a walkable beach to the projects “intervention” area (approximately 500m in linear length) for all users;
- Avoid any “visible” structures where possible;
- Avoid any use of rock where possible;
- Protect and enhance the coral reefs.

1.5.2 Strategic Project Benefits and Added Value

The proposed project is designed to be sensitive towards consideration that Barbados is currently addressing the need for risk resilient coastal management through the implementation of the Coastal Risk Assessment and Management Programme. This is because latest predictions indicate that climate change is likely to increase the frequency and severity of natural hazards and disasters in Barbados and thus has the potential to affect shoreline stability, the health of coastal and marine ecosystems, the tourism industry and coastal flood risk to private properties within the Coastal Management Area (CMA) of Barbados in general. For example, according to data from the CZMU, the 100-year coastal flood model predicts that 6,000 residences along the south and west coasts and 70% of west coast hotels would be affected by the event (CZMU 2010). In addition, coral bleaching, the intensification of beach erosion and the encroachment of mangroves and lagoons as a consequence of poor land management, pollution and sea level rise could have serious implications for future development, recreational activities and livelihood security in the coastal zone. For example, 80% of Barbados' fringing reefs are reported as seriously degraded. Bank reefs have also decreased in their coral cover from 37% to 23% over the past decade. Likewise, shoreline erosion rates are estimated at 15 meters/100 years (CARIBSAVE 2012).

Vulnerability to sea level rise is most evident in Christ Church and Saint James Parishes. It has been calculated that this climate change related sea level rise accounts for 89% of the predicted land loss (CARIBSAVE 2012). Consequently, there is an emerging awareness of the risks that are being presented (as a consequence of climate change) to approximately 50% of the population of Barbados (267,000) and 95% of the tourism related infrastructure that is concentrated in or near the coastal zone[1]. With tourism accounting directly and indirectly for approximately 39% of GDP in 2008 and 50% of total export earnings and employing up to 44% of the labour force, losses to coastal ecosystems services and the public and private infrastructure that depend on them represent significant threats to the resilience of the economy (Barbados National Assessment Report 2010). The economic impact of climate change on the coastal zone is very significant as it has exposed assets that will reach an estimated to US$4.7 billion in 2020 under an A2 scenario in 2020 with a maximum of US$44 billion for 2100 under a B2 scenario[2].

The proposed project is therefore being designed to pay due cognisance to the current climate change adaptation efforts in Barbados, and makes use of a combination of policy, hard engineering coastal protection and active seaward advance via land claim. The adaptation benefits of this approach do provide an indicator of the reduced vulnerability associated with the measures and structures that the GoB has undertaken in regards to climate change. With adaptation there is a residual vulnerability which cannot be adapted away. However, with appropriate adaptation it has been shown that the vulnerability of the Barbados economy, especially that within the coastal zone, can be reduced.[3]

With specific reference to this project proposal, Sandy Lane Bay including its contained built assets and related socio-economic activities, relies heavily on a healthy and resilient coastal zone for its economic sustainability. Consequently, the adaptation strategy for this part of the Barbadian coast (especially the high tourist Parish of St James) cannot consider the progressive abandonment of land, infrastructure and its associated coastal defence structures. This strategic option is not viable for the GoB due to land constraints and the type of tourism product that the west coast of Barbados offers. Instead, what has to be considered must include the consideration of alternative strategic options and engineering techniques that offer (where possible) "soft" solutions that also introduce multiple benefits or "added value" outcomes such as improved longitudinal beach access along the coast.

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[1] http://www.iadb.org/en/news/webstories/2013-03-04/coastal-infrastructure-in-barbados,10326.html
[2] A2 and B2 scenarios are from the Special Report on Emission Scenarios (SRES) for the period 2010 to 2100 and as detailed by the Intergovernmental Panel on Climate Change (IPCC). See http://www.eclac.org/publicaciones/xml/7/45297/LCARL.326.pdf.
[3] http://www.eclac.org/publicaciones/xml/7/45297/LCARL.326.pdf

For Barbados (and especially on the vulnerable west coast including the parish of St. James) sea-level rise and storm surge are likely to have a threefold impact:

- Accelerate land loss,
- Indirectly impact on tourism expenditure (reduction) and
- Increase maintenance and coastal defence improvement (rebuilding) costs.

In 2009, the CARIBSAVE Partnership (CARIBSAVE 2009) conducted sea-level rise and coastal vulnerability assessments for Holetown, an area on the west coast of Barbados, heavily developed for tourism. The results revealed that approximately 80% of all beach areas in Holetown would be affected by a 2 m mean sea-level rise scenario, while a rise of 3.5 m would result in 100% of beach areas being affected. All major resorts in the Holetown area were vulnerable to structural flooding by a 3.5 m flood scenario. The permanent or temporary loss and relocation of these major private sector run resorts would affect the livelihoods of thousands of employees. The hotels and apartments in Barbados, especially those with the capacity to accommodate 50 or more guests, are generally located within the coastal zone. There are no private beaches in Barbados so all beaches are in fact open to the public at all times. Since these beaches are within the 1 in 100 inundation zone defined setback line, this places them at risk of severe erosion and possible complete loss associated with future sea level rise and storm surges.The vulnerability of Sandy Lane Hotel to the effects of climate change has significant implications (CARIBSAVE 2012). The results are shown in Figure 1.3 and are summarised below:

- A 3.5m flood scenario would result in over total loss of over 18,411.4 sq.m of beach area with an additional loss of 14,059 sq.m of land area. (CARIBSAVE 2012). (Table 1.1 below).

- A 0.5m SLR would result in a 36.78% inundation of the highly valued Sandy Lane beach whereas under a 3m SLR, significant tourism infrastructure would be at risk (CARIBSAVE 2012). (Table 1.2 below).

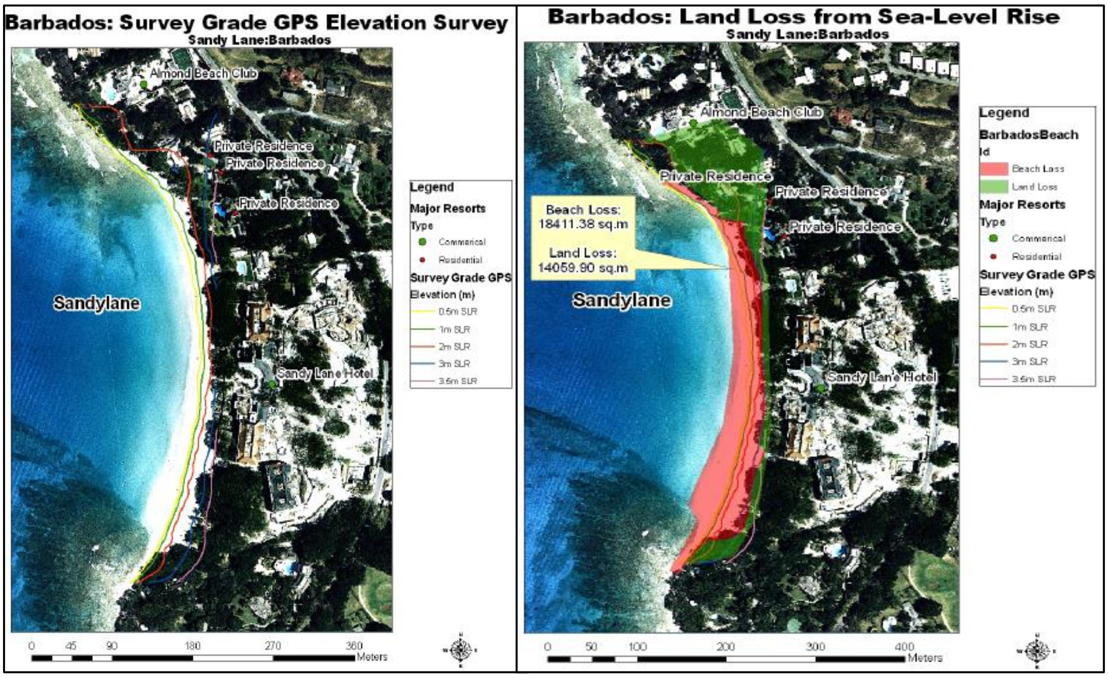

Figure 1.3: Sea Level Rise Flooding Impacts and Total Land Loss - Sandy Lane Bay, Barbados (CARIBSAVE, 2012)

Based on projections for the Caribbean and Barbados, quantitative estimates of land and commercial properties at risk of loss (within Sandy Lane Bay), from rising sea level and storm surge, is included in Tables 1.1, 1.2 and 1.3.

Table 1.1: Sandy Lane Bay – Total Land and Commercial Property Loss from Sea Level Rise (CARIBSAVE, 2012)

Type of Area	Total Loss (sq. meters)
Land Loss	14,059.90
Beach Loss	18,411.38

Table 1.2: Sandy Lane Bay – Percentages of Beach Area Lost from Sea Level Rise (CARIBSAVE, 2012)

SLR Scenario	Beach Area Lost (m^2)	Percentage of Beach Area Lost
0.5 meters	6,772.67	36.78%
1.0 meters	1,55278	46.31%
2.0 meters	12,113.94	65.79%
3.0 meters	16,989.18	92.27%
3.5 meters	18,411.38	100.00%

Table 1.3: Sandy Lane Bay – Impacts on Residential and Commercial Property from Sea Level Rise (CARIBSAVE, 2012)

Name	SLR Scenario (Meters)	Impacts
Sandy Lane Hotel	3	100% Beach by 3 m
Private Residence	3	100% Beach loss
Private Residence	1,2,3	100% Beach loss 1m
Private Residence	3	100% Beach loss
Almond Beach Club	1,2,3	100% Beach loss by 1m Scenario, Building Flooding by 2 m

In addition to the above issues, BRI are also very aware of the national situation regarding the delivery of the IADB donor funded Coastal Investment Programme (CIP) (2002-2009***)*** and the importance of introducing risk resilience into coastal engineering (ongoing Coastal Risk Management Programme – CRMP).

By December 2009, (at a final cost of US$30.3 million), GoB had successfully implemented three coastal infrastructure projects in addition to carrying out a number of capacity-building activities. The crowning achievement of the CIP was the construction of a 1.2 km boardwalk at both Holetown and along the Worthing frontage, revetment and headlands project that stands out as a “best practice” in coastal resource management in the Caribbean. In all, the three projects successfully provide a total of 2km of protected shoreline and provide a combined total of four kilometres of continuous, safe access to the coast. The upcoming IADB funded interventions (BA-L1014 and BA-T1025) are expected to build on the experience gained from cooperating with the CZMU on managing risks and undertaking coastal zone management practices (Figure 1.4).

Figure 1.4 Some of the key success results from IADB support to ICZM in Barbados since 1994 (Source: http://www.iadb.org/en/news/webstories/2013-03-04/coastal-infrastructure-in-barbados/10326.html)

The CIP has invested heavily on coastal engineering works around the island, though the highest percentage of work has occurred predominantly on the Caribbean coast (south and west coasts). The objective of the CIP was to ensure a healthy environment and continued economic development of Barbados through improved management and conservation of the coastal zone. The specific objectives of the CIP are set out below (Table 1.4), though it is clear that the attention was on addressing present day issues and challenges as opposed to planning to manage future climate risk.

Table 1.4: Objectives of the CIP (2002-2009)

Objective
1. To create and/or enhance the amenity value of beaches for local and tourist use through the implementation of shoreline stabilization and erosion control projects.
2. To restore and protect affected ecosystems through the implementation of coastal infrastructure recovery projects.
3. To encourage safe and increased access to the waterfront through coastal access improvement projects.
4. To upgrade capabilities and support the process of innovating coastal management, through the implementation of institutional strengthening activities for CMZU and the Ministry of Physical Development and Environment (MPE).

BRI therefore have taken into consideration within their project design, the growing need for the views of local and visitor communities to be embraced in decision making regarding the protection of the coastline and the use of its resources. For example, the construction of a 1 km long boardwalk between Rockley and Coconut Court on the southern coast of Barbados is not only a tourist attraction, it also provides safe public access to beaches and has increased beach width by nearly 20 meters in some areas. The six-to-twelve-foot deep boardwalk and its related engineering infrastructure were designed to connect beaches, prevent erosion and protect the coast from winds in excess of 170 km/hr. The approach, through the very admission of the CZMU, has been almost exclusively an engineered "hold the line" strategy, but this is understandable and acceptable given the circumstances (economic driver to sustain tourism on the Caribbean coast). It also appears to have been implemented in a robust and sustainable way (subject to monitoring any significant upstream and downstream impacts of engineered interventions).

For these reasons, and mindful of GoB policy and CZMU interventions on adjacent lengths of coast in St James, the project is being designed to support this national position by deriving an innovative approach towards integrating coastal protection needs, improved longitudinal beach access and marine conservation (see Section 4 for Project details). The project will bring significant "added value" benefits. Through this project the Sandy Lane Bay will:

- Be more resilient to storm surge waves (hurricanes and winter swell events);

- Have more stable beaches with less drastic winter erosion and quicker recovery;
- Beach users will have more convenient lateral access along the beach, particularly during erosion events;
- Have new benthic habitat for corals and fish which (among other factors) are critical for marine biodiversity conservation, through the installation of the 3 NES's.

It also conforms to the policies of the National Physical Development Plan (NPDP 2003) in the following ways:

1. *Strategic environmental policies* that seek to protect the environment, specifically:
    a. To conserve and manage natural resources for valued ecological functions and to provide an improved quality of life for the residents and future generations of Barbados; and
    b. To advance public awareness and appreciation of the essential linkages between the environment, quality of life and sustainable development.
2. *The Integrated Coastal Zone Management Plan* for the West Coast of Barbados, which provides a basis for the CZMU's review of development applications on the West Coast of the island, by "enhancing environmental quality and promoting and enabling economic development" by "seeking compatibility between economic activity and environmental interests at the coast."
3. *Resource extraction* will be carefully managed to ensure the impact is minimized.
4. *Natural Heritage Conservation Areas (Marine*) will be carefully managed to prevent damage to habitats and a reduction in species to aid in preserving Barbados' near-shore marine system which is one of its "most important natural resources and provides major tourist and recreational attraction for the island."
5. *Coastal Landscape Protection Zone* by safeguarding remaining sections of undeveloped coastline outside the National Park.
6. *Access to and from Highways* will minimize disruptions to vehicular and pedestrian traffic.
7. *Holetown Community Plan* by contributing to the vision of the town *"to improve the quality of life for all"* specifically through contributing to the goal of strengthening Holetown's base through the identified objectives of: *enhancing existing employment opportunities; and expanding retail facilities and amenities.*

1.6 Report Organisation

This report consists of the following sections:

Section 1: Introduction. This section provides a brief Project overview and purpose and explains the context under which the EIA is being submitted.

Section 2: Legislative and Regulatory Overview. This section provides an overview of all policies and legislation that exist in Barbados that may be applicable to this proposed Project.

Section 3: Approach and Environmental Assessment Methodology. This section describes how the environmental assessment has been conducted, including social impacts and public consultation outreach.

Section 4: Project Description. This section provides a more detailed summary of the facilities and activities that are encompassed in the Project to help identify possible interactions with the environment.

Section 5: Climatic, Environmental and Socio-economic Project Baseline. This section describes the current environmental and socio-economic baseline conditions of the Project Area.

Section 6: Significant Environmental Effects. This section specifies the potential effects and significance of these effects during the construction and operational phases.

Section 7: Cumulative Effects Assessment. This section specifies the effects of this project with other projects in the same geographic area (St James Parish).

Section 8: Social Impact Assessment. This section describes the effects of the project on the socio-economic environment and the program of public and agency consultation to obtain input to the study.

Section 9: Mitigation Measures. This section presents a list of mitigation methods to be implemented into the Project activities and design, and recommendations.

Section 10: Environmental Monitoring Plan. This section outlines all environmental monitoring approaches recommended to ensure the project is environmentally sustainable and addresses the methods identified in Section 9.

Section 11: References. Lists references used in the preparation of the report.

2 LEGISLATIVE AND REGULATORY FRAMEWORK

2.1 Review of Relevant Legislation and Policies

There are approximately 37 main pieces of legislation in Barbados which deal with land use and building issues. Of these 37 statutes, 62% may be classified as environmental in nature, 27% as related to land use and 1% as related to building. Generally, while most are not exclusive to the coastal zone of Barbados, all are indirectly applicable to the coast in varying degrees. The most directly relevant legislation (Coastal Management Zone Act 1998 – see Section 2.1.2) used by the CZMU to manage the Coastal Management Area (CMA) is set out in more detail within the following sub-sections and also in Appendix 2a.

2.1.1 Town and Country Planning Act - TCPA (1985)

The TCDPO oversees land development. Environmental protection is covered by the Town and Country Planning Act (TCPA), and the Coastal Zone Management Act (CZMA). For new developments the TCPA Planning Control stipulates the requirements for, "building, engineering, mining, or other operations." This includes material changes to land use, or land subdivision. Except for development in the coastal zone management area, planning permission may be granted through a development order for an area of the country by the Chief Town Planner (CTP). Planning permission by a development order may be granted unconditionally or subject to specified conditions and limitations, especially if part or all of the development or use of land is in a coastal zone management area.

The Town and Country Planning Act (TCPA - CAP. 240) and in its subsidiary legislation, Town and Country Planning Development Order, 1972 regulates all lands within the limits of the territorial waters of Barbados and would therefore include all coastal and marine development within the 200 nautical mile territorial limits. The Town and Country Planning Act, Cap. 240, defines development as *"The carrying out of building, engineering, mining or other operations in, on, over or under any land, the making of any material change in use of any buildings, or other land or the subdivision of land"*.

The legislation relating to environmental protection for new and expanded developments includes a number of acts in addition to the provisions under the TCPA that control and mitigate adverse effects on coastal and heritage resources and in sites of natural scenic beauty. Specific criteria relating to air emissions, warm water discharge and water quality changes allowed by new developments are determined under the *TCPA*, which allows the CTP to request information to assist in assessing an application for a new development. The planning objectives and policies of the Government of Barbados are described within the National Physical Development Plan (Draft) - Amended 2003 (see Section 2.2).

The Act defines coastal setback lines for construction and establishes all planning requirements for development. The CZMU have produced a specific guide manual on planning applications in the coastal zone, and all necessary information is included within that document (CZMU 2010 – see CZM Act 1998 below).

2.1.2 Coastal Zone Management Act No. 394 (1998)

The CZMA provides a comprehensive, statutory basis for CZM and planning in Barbados. It seeks to coordinate and update the existing, fragmented statutes relevant to coastal management, and makes provision for the protection of coral and other marine reserves, the creation of marine reserves and the identification of critical areas of concern not covered by current legislation. The Act has mandated the creation of a Coastal Zone Management Policy that comprises policies, strategies and standards for coastal structures, environmental impact assessments (EIA), beach use and beach access among others. This is encompassed in an over-arching goal of the CZMU and in turn the Government of Barbados (GoB) to practice on-going CZM. Although the CZMA does require all Authorities to have regard to the management plan, it is not clear how any contradictions will be dealt with, in particular the TCPA (1985). With specific reference to the protection of coral reefs (Article 27), the Act is able to prescribe a fine of BBD$300/square meter of coral that is damaged or even imprisonment for 5 years or both.

2.1.3 Draft Environmental Management Act

The Environmental Management Act is not yet enshrined in law. However, elements of the Act are being implemented nationally. Specific reference to the CZMA (1998) is made within this legislation along with promoting sustainable development principles through the EIA process. This is viewed as a comprehensive law which will seek to address local environmental management issues.

2.1.4 Marine Pollution Control Act (1998)

The Marine Pollution Control Act' makes provision for the prevention, reduction and control of pollution of the marine environment in Barbados from whatever source. It will regulate all discharges that may impact negatively on the marine environment. A series of standards have been set for a full range of pollutants and dischargers must meet those standards or face penalties up to $200,000 and 5 years in jail. The MPCA is applicable to discharges that occur inland as well as on the coast. Initially, each discharge will be assessed for compliance and if the existing system does not comply with the standards, the discharger must enter into a flexibility agreement with Environmental Protection Department (EPD). This agreement will be monitored through a self-policing scheme and confirmed with spot checks by EPD Marine Pollution Control Inspectors. Dischargers must report any spills and engage in waste minimisation activities.

2.1.5 Tourism Development Act, Cap. 341:

This Act encourages the sustainable development of the tourism industry by providing duty-free and income tax concessions. Reference to the coast is not specific and importantly, there appears to be a total lack of reference to environmental impact, risk and climate change throughout the Act.

2.1.6 Emergency Management Act (2006)

Disaster Emergency Management (DEM) is administered under the Emergency Management Act, Cap 160A (2006) thereby providing a Government institution for the development and coordination of the national Emergency Management Programme in Barbados. An overall capacity needs assessment of the Department of Emergency Management to carry out its mandate is being finalized. The Ministry of Home Affairs as the civil protection agency responsible for DRR, is piloting an initiative aimed at reforming the Community Emergency Management Programme to provide for new institutional governance, administrative and operational mechanism. The existing District Emergency Organisations (DEOs) will be reformed and rebranded to encourage greater participation by civil society.

2.1.7 Fisheries Act (1993)

Based on the OECS harmonized legislation, the Fisheries Act covers formulating and reviewing fisheries management and supporting development. It also specifies conservation measures such as prohibiting use of any explosive, poison or other noxious substance; closed seasons and gear restrictions. The Act gives the Minister the authority to create new regulations for the management of fisheries as and when necessary.

2.1.8 Fisheries (Management) Regulations (1998)

The Regulations include management measures to restrict capture of juvenile fish and other marine species, prohibiting the capture of endangered or threatened marine species and regulating harvest of specific species via a permitting system.

2.1.9 Marine Areas (Preservation and Enhancement) Act (1976)

This defines management of marine reserves – this allows for the design of restricted areas in any part of marine areas of Barbados for purposes of preservation of natural beauty, conservation of fauna and flora, etc. Land control agreements may be entered into by the National Conservation Commission (NCC – see below for NCC Act and the Barbados Marine Reserve Regulations 1981).

2.1.10 Marine Areas (Preservation and Enhancement – Barbados Marine Reserve Regulations - 1981)

There is currently only 1 legislated marine reserve on the island: the Barbados Folkestone Park and Marine Reserve, although it is estimated that only 6% of Barbados reefs are within the Reserve (Burke and Maidens 2004). The reserve was established in 1981 via the Designation of Restricted Areas Order and the Marine Areas under the Preservation and Enhancement Act of 1976 (the Barbados Marine Reserve Regulation). The reserve is a no-take zone that covers approximately 11% of the west coast of Barbados (2.1 sq km) and has 4 different zoning designations (scientific, northern water sports zone, recreational, southern water sports zone). The reserve is actively managed by the National Conservation Commission with enforcement support from the Marine Police and Coast Guard (National Conservation Commission 2011).

2.1.11 National Conservation Commission Act

The National Conservation Commission Act establishes the National Conservation Commission (NCC) which has as one of its main functions to conserve the natural beauty of Barbados; to control and develop public parks, public gardens, beaches and caves; to provide advice on the removal of coral from the ocean bed; and to regulate commercial activities in public parks, gardens, caves, and on beaches.

2.1.12 Occupational Health and Safety at Work Act (2005) Cap. 356

The Occupational Health and Safety at Work Act provides prescriptive standards of safety and health in the workplace that are consistent with those of other jurisdictions. The owner is responsible for providing a safe workplace and worker protection for hazardous tasks. Workers are expected to report any unsafe procedures to their supervisor and conduct their duties in a safe manner.

2.1.13 Shipping Act (1994)

The Shipping Act, which came into effect during 1994, provides a comprehensive scheme for the registration of ships under the Barbados flag and regulation of ships so registered. The Act generally covers all Barbados registered ships whoever the owners may be, but in certain matters distinguishes between Barbados owned ships and foreign ships, also governing activities of ships registered elsewhere when they are operating within Barbados territorial waters.

2.1.4 Draft Recreational Diving Operations Regulations (1998)

This Regulation is part of the above mentioned Shipping Act (1994). The proposed regulations govern operations of dive operations for hire in Barbados. Regulation 8(3) of the Shipping (Watersports) Regulations, 2004 states that: - *'Notwithstanding anything in these Regulations, a person may hire a speedboat, not exceeding 4 meters in length, for pleasure and may drive that speedboat without being the holder of a driving licence or learner's permit; but he shall have been instructed in its use and operation by a licenced driver being allowed to operate the speedboat'*

2.1.5 Designation of Carlisle Bay and the Rockley Breakwater as Protected Areas

These areas have been designated largely through stakeholder public consultation. It is hopeful that a Protected Area is established during 2015. This area falls outside of the proposed development location, however, provides the potential for future sites to be set up to complement the existing legally established Folkestone Marine Park.

Other partially relevant (coastal zone) related legislation includes the following:

- ✓ Marine Boundaries and Jurisdiction Act (1978): Defines waters of Exclusive Economic Zone (EEZ) and establishes marine boundaries and jurisdiction for Barbados. It amends the Barbados Territorial Waters Act (1977) that defined territorial and internal waters.
- ✓ Defence Act (1979): Multi-purpose surveillance in EEZ and territorial waters.
- ✓ Shipping Act (1994): Registration and inspection of large vessels.
- ✓ The existing Soil Conservation Act is used as the driving force for implementing structural and non-structural disaster-mitigation efforts. Measures include, for example, the relocation of communities in flood-prone and landslide areas (UNISDR, 2011a).

2.2 The Regulatory Process for Coastal Issues

The CZMU has responsibility for the management of all developments that can have a direct or indirect impact on the coastline of Barbados (CZMU, 2010). In this regard, the CZMU acts as the key development advisors to the TCPDO, which is the absolute authority for granting permission for all developments on the island. For the purpose of management of the coastline of Barbados the CMA on the west (Caribbean) coast is defined by the landward boundary of the main coastal road or the limit of the predicted 100m storm surge flooding, whichever is further inland. The CMA is divided into eight (8) sub-areas to facilitate the execution of the mandate of the CZMU (Figure 2.1).

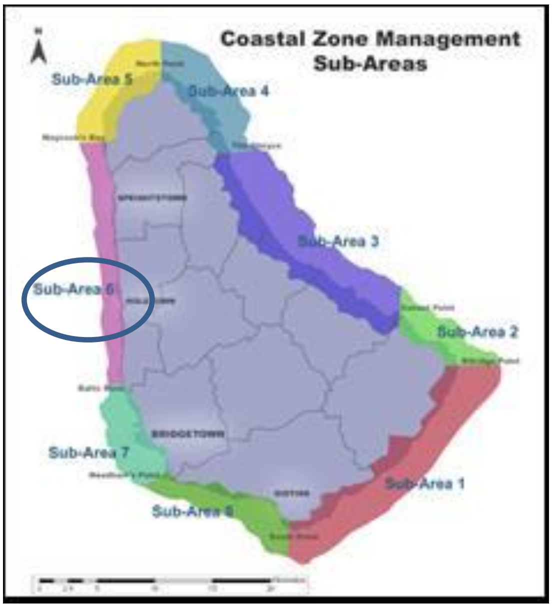

Figure 2.1: Location of Sandy Lane Bay within Sub Area 6 (CMA) (Taken from CZMU 1998)

The CZMA (1998) covers the management of coastal resources and activities that could impact them. A key part of the act is the protection of the beaches, beach vegetation and coral reef surrounding Barbados. The MPCA (1998) controls the release of pollutants to the sea and provides the government with the mandate to investigate pollution sources and to require monitoring by the discharger. The Act makes it an offence to release any pollutant in violation of the applicable standards and requirements. End of pipe waste water standards have been developed that include waste water treatment plants.

The proposed project by BRI, which falls in the CZMU's designated coastal sub-area 6 (see Figure 2.1), would constitute a development for which permission has to be granted by the TCPDO in consultation with the CZMU. The regulatory processes to be completed from application submission to completion of development are outlined in Figure 2.2.

The construction of coastal engineering structures (jetties/groynes/breakwaters/revetments/sea walls) is assessed by the CZMU in order to advise the TCPDO on the granting of permission to develop the coastline. Furthermore, the application for coastal development triggers a series of legally required consultations with Government Ministries, knowledgeable persons and/or bodies such as the Ministry of Transport and Works, the Ministry of Health and the Ministry of the Environment, Water Resources and Drainage. Other agencies consulted include the Ministry of Agriculture (Soil Conservation Unit – regarding the stability of land within the Scotland District area; Fisheries Division - regarding fisheries and aquaculture/mariculture projects) the Barbados Water Authority and the Ministry of Tourism (CZMU, 2010).

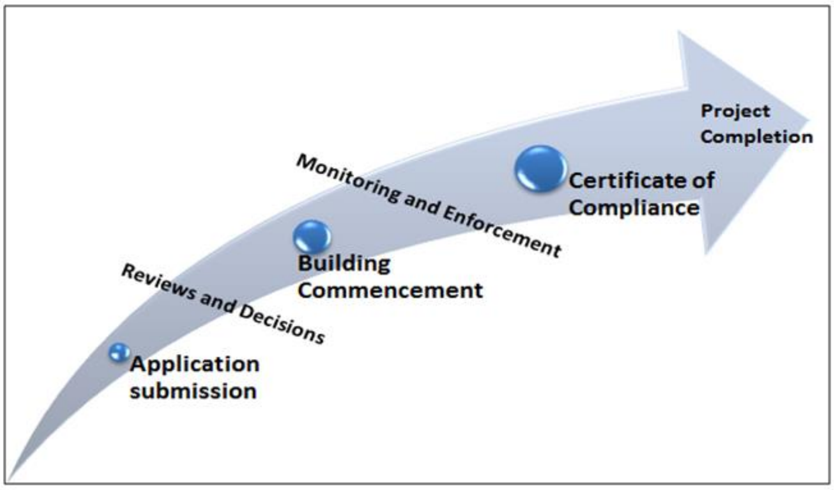

Figure 2.2: Regulatory processes for completion of project

On fulfilment of the requirement for application assessment by the developer, the various agencies, with CZMU taking the lead for coastal projects, conduct reviews based on a list of 15 criteria and areas of expertise ranging from setbacks, access to and along coastal roads, beach management, coastal engineering, conservation or coastal ecosystems and wildlife, coastal development proposed, resource extraction, water quality implications and global and regional coastal change. The reviews and assessments carried out by the CZMU and other bodies will inform the decision of the TCPDO on whether to grant permission for the proposed development, or to impose conditions upon the permission. These can include the requirement for further studies, in particular environmental and social impact assessments, specific engineering details, models, designs and/or alteration or suitable options to the structure and designs proposed. Approval can also be granted with conditionality such as the need for an environmental management plan and environmental monitoring to act as early warning systems that may be deemed necessary to help mitigate against unpredicted impacts.

The Physical Development Plan (PDP – 2003 – currently being updated in 2016) is a key document as it describes the government's vision for development and sets out principles to guide policies and approval of new developments. The plan contributes to sustainable development through the establishment of policies on general environmental planning, coastal zone management and control of development in natural hazard lands. It aims to manage the natural environment and resources to ensure the best use of their aesthetic, educational, ecological, recreational, and economic benefits. It protects the physical environment by establishing:

1. general environmental planning policies which apply to all land use designations throughout the island;
2. policies respecting development in the Coastal Zone Management Plan areas and to control development in natural hazard lands including gullies, escarpments, coastal and other erosion areas and flood prone lands.

The PDP provides the following guiding principles for planning policies and the approval of new developments:

1. the efficient use of land, resources and finances of the nation;
2. the promotion of social equity, health and safety for all residents;
3. the conservation, protection and enhancement of environmental and man-made resources;
4. provide a settlement structure that maintains and creates vibrant and safe places for people to live, work and play; and
5. the management of growth so that it occurs in an orderly fashion while ensuring that environmental features and agricultural lands are maintained

The Coastal Zone Management Plans for the Atlantic and Caribbean Coasts (produced in 1998 by Halcrow though pending update into 2016) reflect the overarching planning principles set out in the PDP (see Figure 2.3).

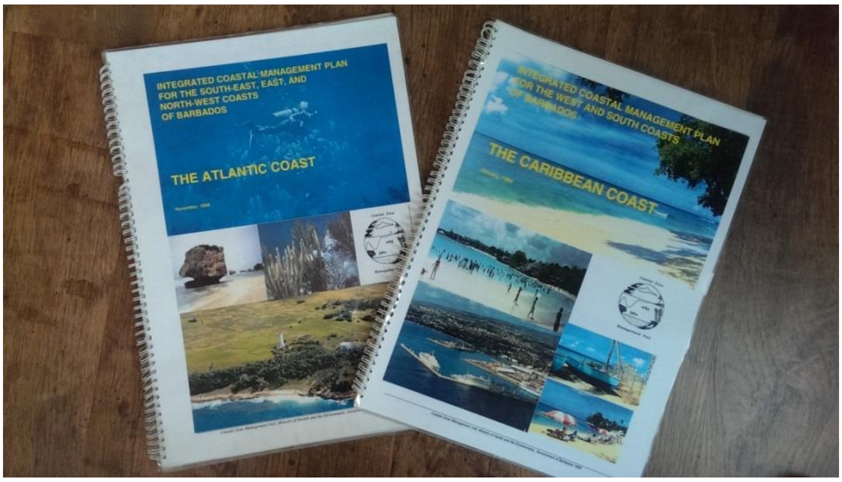

Figure 2.3: Barbados Coastal Zone Management Plans (1998)

2.3 EIA Procedures in Barbados

2.3.4 EIA Guidance

In recent years, the TCDPO has published two key guidance documents which are intended to provide further clarification and instruction to planning applicants with regard to the EIA process. These guidance documents are: (1) The Applicant's Handbook and Guide to Town Planning (TCDPO, 2002); and (2) the Environmental Impact Assessment Guidelines for the Preparation of Terms of Reference (TOR) and Environmental Impact Assessment (TCDPO, 2005). The following presents an overview of each of these guidance documents.

2.3.4.1 The Applicant's Handbook and Guide to Town Planning

The Applicant's Handbook and Guide to Town Planning (herein referred to as the "Handbook") was produced by the TCDPO in November, 2002. According to two governmental employees, the Handbook was prepared in order to help applicants and consultants to comply with and better understand the application approval process. The Handbook is a 62 page-long document which outlines the various stages and requirements pertaining to applications for new developments under the relevant sections of the TCPA, including application fees, forms, information requirements and requirements pertaining to EIA.

The Handbook states that the CTP is guided by the policies outlined in the National Physical Development Plan in his/her assessment of planning applications (TCDPO, 2002:2). The types of developments that are required to submit an EIA under the Handbook are directly comparable to those identified under the draft 1998 NPDP, as presented in Figure 2.4.

Types of developments required to submit an EIA in Barbados:

1. Special industry
    a. A chemical or petroleum manufacturing plant other than a plan for the manufacturing of pharmaceutical drugs;
    b. A desalination plant;
    c. An electricity generating plant;
    d. A cement plant or other plant for the burning of lime or bricks;
    e. Any other industry where the process is potentially obnoxious or dangerous to health and amenity by reason of excessive smell, fumes, smoke, dust, grit, ash, noise or vibration;
2. Waste management facilities other than facilities for initial sorting or processing of source separated dry recyclables;
3. Waste disposal sites;
4. Golf courses;
5. Uses within:
    a. Natural Heritage Conservation Areas;
    b. The National Park Forest Area;
    c. Agricultural Areas
6. Mining operations including quarries and sand mines;
7. Applications for initial construction of, or expansions to, major transportation infrastructure including highways, airports, seaports, wharves, marinas or jetties;
8. Sewage treatment facilities;
9. Crematoria and funeral parlours;
10. Amusement parks.

(Source: MHLE, 1998)

Figure 2.4 Types of Development Requiring an EIA in Barbados (TCDPO 2002)

Whilst there is no specific mention specifically of coastal development structures, it has to be assumed that Development 7 (above in Figure 2.4) covers this specific issue. The Handbook also provides guidelines for the preparation of the TOR for an EIA, and the Handbook identifies the public consultation requirements associated with EIA in Barbados. Guidance with respect to public consultation also clearly states:

"The applicant/developer also has to hold a public meeting in close proximity to the site and residents within a 300 metre radius should be notified in writing and by public advertisement (e.g. radio, newspaper) of the date and time of the meeting and the place/s were copies of the document may be obtained for perusal. The applicant/developer has to make the EIA document available for public scrutiny a minimum of twenty-eight (28) days prior to the public meeting (TCDPO, 2002:22)".

Also of relevance is the Handbook's description of the TCDPO's ability to attach conditions to an approval of a development. Under the TCPA, the CTP is authorized to grant application approvals subject to conditions deemed necessary to control and limit proposals in order to achieve a satisfactory form of development (TCDPO, 2002). According to the Handbook, Section 21 of the TCPA stipulates that the CTP should *'endeavour to give a decision within two (2) months of the date of the application'* (TCDPO, 2002:48). In the event that the CTP fails to issue a decision within this time limit, the applicant may request that the application be referred to the Minister of Economic Affairs (i.e. the Prime Minister) to render a decision on the application (TCDPO, 2002).

2.3.4.2 The Environmental Impact Assessment Guidelines for the Preparation of Terms of Reference (TOR) and Environmental Impact Assessment

The EIA is initiated after the Terms of Reference (ToR) for the project are agreed upon with the TCDPO. The contents of the EIA ToR are required to include the following broad categories:

1. an outline of the environmental issues and the disciplines required for studying the issues;
2. a list of the government and other agencies that appear to have an interest in the application. A consultation program is also included; and
3. a proposed program for consultation with the local public.

The steps involved in completing the EIA following the approval of the ToR for the scope of the study include, gathering of data, consulting with the public and interested agencies, and completion of the EIA document for circulation.

Upon approval of the ToR, the applicant then conducts an EIA, prepares an EIA report, holds a public town meeting following a 28 day-long period for public review of the EIA report, and then submits the EIA report to the TCDPO. The TCDPO then distributes the EIA report to the members of the EIA Review Panel for individual review. NB: According to several consultants involved in EIA production in Barbados, governmental employees and other interview participants, the EIA Review Panel often requires a lengthy period of time, typically up to several months, for review of an EIA report.

When the panel is satisfied that the EIA addresses the environmental impacts, approval is provided which may or may not include specific conditions. The CTP allows no development of the site without prior approval of the EIA.

2.3.5 Approval process, permits and conditions

Where the CTP has determined that a development application has merit and conforms to the policies of the NPDP, he/she may grant an approval for the development application, subject to any conditions which may have been recommended during the review process (TCDPO, 2002). Section 16 of the TCPA provides the legal basis for the CTP to attach conditions to an approval, and enables the CTP to grant permission subject to conditions as he/she deems suitable (GoB, 1972; TCDPO, 2002). According to the Handbook, the purpose of attaching conditions to a planning permission is to control and limit proposals in order to achieve a satisfactory form of development (TCDPO, 2002). The conditions must serve a useful planning purpose, must be reasonably related to the development, and must not be manifestly unreasonable (TCDPO, 2002). According to the Handbook (TCDPO, 2002), and of relevance to this application, the following are some of the types of conditions that may be attached to a planning permission:

- Regulations of the development or use of land or requirements for carrying out works on such land (e.g. ensuring adequate waste water treatment capacity for a development);
- Requirements for the completion of any development before a specified date;
- Maintenance conditions for developments that involve the continuing use of land (e.g. landscaping).

2.4 Climate Change Adaptation and Disaster Management

The GoB is pursuing a “Green Economy” framework for sustainable development, and it is expected that as part of this reconfiguration of the national economy, very strong links will be forged between environmental management, climate change adaptation (CCA) and disaster risk reduction (DRR), in order to achieve national goals for social and economic well-being. Thus all financial institutions are seeking to take into account CCA and DRR in their economic models[4].

At the physical planning stage, considerable vulnerability reduction is possible and must be achieved through the full integration of CCA and DRR into the existing system. To this end, Barbados produced its first national communication to the UNFCC in October 2001 led by the Ministry of Physical Development and Planning. This document recognised the importance of environmental management to sustainable development. The GoB focuses its adaption work on land preservation and protection. The strategies include:

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[4] http://www.preventionweb.net/files/31056_brb_NationalHFAprogress_2011-13.pdf

a) “do nothing” in under-developed locations on the east coast of the country. Allow the natural buffer action of the backshore areas to absorb high energy waves experienced on open coastal sections. Capital outlay is almost zero but the benefit is substantial.
b) 'Maintain' or 'hard options', inclusive of the building of revetments and sea walls, in highly developed coastal areas, for example Bridgetown.
c) “Control” or “soft options” which includes vegetation or re-vegetation of areas; vegetative matting on bluff faces to aid in bluff face stabilization; and enforcement of coastal related legislation specifically for the protection of some vegetation species and building setbacks, and the prevention beach sand mining.

Climate change vulnerabilities do not only impact coastal systems, coral reefs and fisheries but also agriculture, freshwater resources, human settlement/infrastructure[5] that fall outside of the direct remit of CZMU. Although the GoB has been involved in a number of national and regional projects addressing CCA it is unclear to what extent these have become inculcated into Government policy[6]. Despite the fact that the CZM Plans for the Caribbean and Atlantic coasts are used as *de facto* plans by both CZMU and Town Planning, there are significant gaps within them both (and hence the CZMU Policy Framework Strategic Plan which is now 14 years old) with regards to climate and disaster risk resilience on the coast. These are planned to be updated and revised based on recent data and new priorities by the CRMP (IADB Component 3). A new methodology for prioritizing coastal infrastructure projects that incorporate risk resilience should also be developed that incorporate concepts of DRM and CCA (IADB project Component 1).

In the coastal zone, disaster risk is now being considered in the approvals process for infrastructure development. The national architecture for disaster risk management, which includes the incorporation of key government ministries, departments, the private sector, national, regional and international stakeholders, non-Governmental Organisations (NGOs) and the community, constitutes the national platform for DRR through the multi-sectoral Emergency Management Advisory Council and its 16 Standing Committees. The National Mitigation Council has a framework for involvement in a wide cross-section of stakeholders. The active Standing Committee on Coastal Hazards is the only scientific Standing Committee and comprises representatives from both Government and private sector. The Committee is working with these multi-stakeholders in disaster risk reduction initiatives to reduce hazards along the coast, such as tsunamis, storm surge, winter swells, erosion, sea level rise and oil spills. The National Emergency Management System is administered by the Ministry of Home Affairs, Barbados’s civil protection ministry. The BRI project development being proposed seeks to introduce engineering approaches that shall enable the coast to become more resilient to climate change and disaster risk which has been experienced along the St James parish coast for the past 40 years (narrowing beach widths and deteriorating marine habitats etc). This shall be of benefit to all Barbadians by improving beach access along this stretch of St James Parish coast (which currently is not possible between Sunset Reef to One Sandy Lane).

[5] http://www.adaptationpartnership.org/resource/caribbean-current-and-planned-adaptation-action
[6] Op. Cit.

3 APPROACH AND EIA METHODOLOGY

3.1 Overview

The EIA (currently produced as a Draft for consultation) will (when finalised) be completed to meet the requirements as set out in the Environmental Impact Assessment Guidelines and Procedures for Barbados (1998). An Environmental Assessment (EA) is a complete process, which should begin at the earliest stages of planning and remain in force throughout the life of a project, moving through a series of stages:

1. Describing the project and establishing environmental baseline conditions;
2. Scoping the issues and establishing the boundaries of the assessment;
3. Assessing the potential environmental effects of the project, including residual and cumulative effects;
4. Identifying potential mitigation measures to eliminate or minimize potential adverse effects; and
5. Environmental management and monitoring plus an outline of any follow-up programs.

A summary of the EIA staged approach is set out in Figure 3.1.

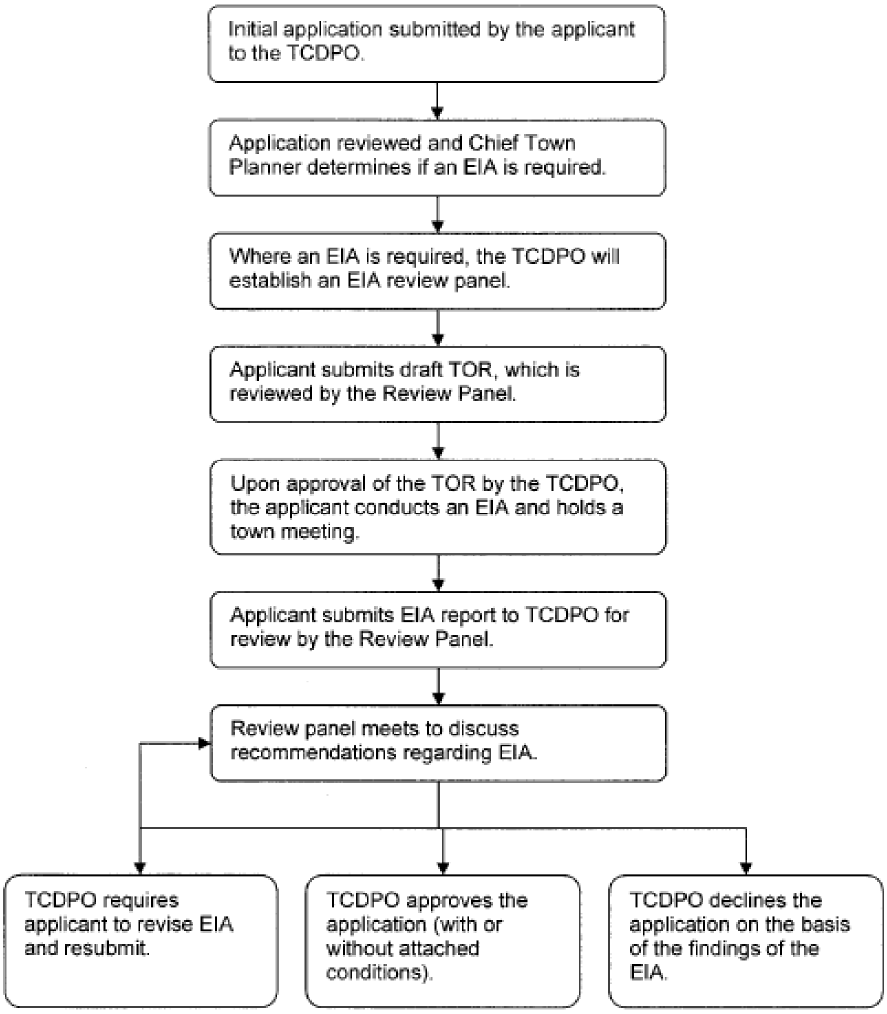

Figure 3.1 EIA Approach in Barbados (from TCDPO 2002)

3.2 Phased Approach to EIA Production

The work to complete the draft EIA was undertaken over a number of phases. Phase 1 involved the definition of the project components, collection of baseline data and information on the defined Project area. Phase 2 involved an effects assessment of the construction and operation of the proposed scheme.

The EIA is based on scientific, engineering, environmental and economic parameters, professional judgment, and consultation with the public, applicable government agencies, communities, interest groups and other stakeholders directly affected by the Project. The approach includes the following steps:

Phase 1 - Assembling Project Baseline Information (see Appendix 3a and Sections 4 and 5 of this EIA)

a. developing the Project description, including construction and operation activities; and
b. preparing a description of existing environmental conditions to assess the potential effects of the various Project activities on the environment and the potential effects of the environment on the Project.

Phase 2 - Issue Scoping (presented in the EIA ToR – Appendix 1c)

a. identify environmental and socio-economic issues during development of the study;
b. ensure that the concerns of the regulatory agencies involved in the Project review are identified;
c. take into consideration public concerns;
d. identify environmental issues or features that may be affected by the Project, by professionals in the field;
e. identify pathways between the environment and Project activities. Where pathways cannot be identified, the environment is deemed not to be affected by the Project and, therefore, is no longer considered as part of the analysis; and
f. ensure that alternatives that were identified are evaluated in the context of the proposed Project.

Phase 3 – Effects Assessment (presented in Section 6, 7 and 8 of this EIA)

The effects assessment considers the mitigation measures as provided in the report (Section 10). In order to be considered a significant adverse environmental effect, the assessment of these potential effects must determine that the effect is adverse and significant and likely (discussed in Section 3.5). The term 'cumulative environmental effect' (CEE) means the effect on the environment, which results from the effects of a project when combined with those of other past, existing and imminent projects and activities. These may occur over a certain period of time and distance.

Phase 4 - Environmental Protection Measures (presented in Section 9, 10 and 11 of this EIA)

The final phase is to define or describe the details of the environmental protection (or mitigation) measures that would be applied to the project for construction and operation of the facilities.

3.3 Baseline Data Collection

To provide accurate and scientific analysis of the potential environmental effects of the proposed Project on the environment, it is critical to have data that represents the state of the environment prior to developing the Project. This baseline data can then be used, in conjunction with the predicted Project outputs, to complete the environmental assessment for the Project. A summary of the baseline data collected for this project is clearly outlined in the EIA ToR (Appendix 1c) with specific survey information elaborated in more technical detail within Section 5 and the Appendix 3a.

3.4 Techniques used to Predict Environmental Effects

Methodologies used in the identification and assessment of effects may be specific to each discipline and can be grouped in the following categories:

1. Expert judgment based on:
   - Review of published literature ;
   - Review of unpublished reports and data from government agencies and departments, universities and research institutions, and other relevant projects;
2. Interviews with resource persons and knowledgeable individuals;

3. Use of models and extrapolation from datasets and trends;
4. Compilation of relevant statistical datasets;
5. Site visits and evaluations.

The details presented in Sections 5 to 11 of this EIA reflect an amalgam of all the above techniques and approaches used.

3.5 Determination of Significance

A common scale of reference for determining significance is required in order that the relative importance of various environmental effects can be compared. A definition of significance that is often applied for the assessment of environmental effects is:

"any change that the project may cause in the environment, including any effect of any such change on health and socio-economic conditions, on physical and cultural heritage, on the current use of lands and resources for traditional purposes, or on any structure, site or thing that is of historical, archaeological, paleontological or architectural significance".

A significant adverse environmental effect is defined as an effect that is adverse and significant and likely. Significance has been based on scientific determinations, social values, public concerns, and economic judgments. The significance of Project-induced changes is considered for all issues and is as determined based on the criteria set out in Table 3-1.

Table 3-1 Criteria to Determine Level of Significance when Determining Environmental Effects

Key Terms	Criteria
Adverse	Loss of rare or endangered species; Reductions in species diversity; Loss of critical/productive habitat; Transformation of natural landscapes; Toxic effects on human health; Reductions in the capacity of renewable resources to meet the needs of present and future generations; Loss of current use of lands and resources for traditional purposes; and Foreclosure of future resource use or production.
Significant	Magnitude; Geographic extent; Duration and frequency; Irreversibility; and Ecological context.
Likely	Probability of occurrence; and Scientific uncertainty.

Determination of significant environmental impacts (or relevance to this proposed scheme) is clearly presented in Section 6.

3.6 Cumulative Effects

The environmental effects of the Project in conjunction with other activities and other projects that have or will be carried out in the Project Area are also examined. The temporal boundaries are extended to include activities in the past, those that are under way in the area, and known projects planned outside of the time boundaries established for the Project. A review of other similar projects that have been operational for long durations (20 - 25 years) also provides insight into the potential cumulative effects of this Project. Details of cumulative effects are presented in detail within Section 7.

3.7 Mitigation

When significant adverse effects are likely, mitigation measures are required. Mitigation[7] in this context refers to the elimination, reduction or control of adverse environmental effects, including restitution through replacement, restoration, compensation, or any other means for any damage to the environment caused by such effects.

Mitigation measures proposed are consistent with the requirements of all relevant legislation, regulations, guidelines and policies, as well as management plans, specifications, and best management practices, where practical. Mitigation measures have been considered in a hierarchical manner with impact avoidance measures identified first, reduction measures second and compensation last.

Mitigation measures are also outlined for all key issues identified within the bio-physical and socio-economic environment. All proposed mitigation measures will be described in detail, including methods, timing and duration. Section 10 outlines the details associated with the mitigation measures being proposed as part of this proposed development.

3.8 Consultation Process

As part of the EIA process and the social impact assessment (SIA), consultations have been and will continue to be completed with the public and government agencies to ensure that all of the relevant issues are addressed within the report. Appendix 1b outlines the approach and indicative outcome of the original public consultation event that took place in 2013. Section 8 outlines the components of the consultation process that have been (and will be) undertaken as part of the Project development. A summary of the approaches to be adopted are presented below.

3.8.1 Regulatory Consultation

A critical component of the EIA process involves the consultation with the Barbados regulatory authorities. The consultation for this Project was initiated by the submission of a ToR Report for the EIA to the TCDPO (Appendix 1c). Subsequent consultations were, and continue to be held, with members of this committee, as well as other regulators, to review the proposed scope of work and responses to the comments, to describe the specific work plan for the baseline data collection program, and to obtain specific Project related information. Consultations have been arranged with the following agencies:

i. Town and Country Development Planning Office to confirm EIA scope;
ii. Barbados Water Authority to discuss water resources;
iii. CZMU regarding EIA scope and expectations;
iv. Environmental Protection Department regarding EIA scope and expectations;
v. Department of Transportation for traffic information during construction and operations;
vi. Barbados Museum on known historical resources;
vii. Ministry of Agriculture and Rural Development on rural development issues;
viii. Barbados National Trust on significant heritage features;
ix. Ministry of Tourism regarding tourism developments in area
x. National Conservation Commission (NCC) to discuss issues relating to coral reef health, protection and rehabilitation within FMP;

The ToR has been reviewed by the TCDPO with subsequent evidence of comment compliance by the applicant in letter which is outlined in Appendix 1d.

[7] Notably different from 'climate change mitigation'.

3.8.2 Stakeholder Engagement Plan

The Stakeholder Engagement Plan (SEP) provides information on the approach for engaging stakeholders (the Government of Barbados, organisations, private sector entities and the public) in the process of conducting an Environmental Impact Assessment of the proposed Sandy Lane Beach Rehabilitation and Marine Conservation project. Specifically, SEP has been elaborated for the marine engineering works proposed in the project area.

The SEP takes into the account national legislation, as well as the commitment of the project proposers to ensure that all stakeholder views are considered. The result of capturing these views is that the proposed project is guided accordingly and includes measures to be taken by the project proponent if necessary.

More detail is presented on the project SEP in Appendix 3b.

4 PROJECT DESCRIPTION

The design for Unit 2 (Landfall to Leigh House) is to provide an enhanced beach in front of Sandy Lane Hotel, for a length of approximately 300m. The new beach will be achieved through engineering intervention as follows (and also defined in Section 4.2):

- **<u>Two (2 No.) submerged geotextile 'sand container' structures</u>** in Sandy Lane Bay (approx. 80m long, placed 100m offshore). The crest elevation of the structures will be -0.37mLD; this is approximately 0.4m below Mean Low Low Water (MLLW). The structures will consist of NAUE Terrafix Soft Rock© 'sand containers'; and

- **<u>Beach nourishment</u>** to provide the beach salients in the northern part of the bay (at 'Allan Bay' and 'Jane's Harbour') and in front of Sandy Lane Hotel. It is not planned to recharge the beach south of the hotel. Modelling work has shown that the material placed to the north will benefit Leigh House with some material moving south and depositing at the back of the beach fronting the property boundary. The physical characteristics of the recharge will, where possible, match the existing beach material. There is approximately 37,000m^3 of beach recharge planned to be added within the bay (see Table 4.1 below).

4.1 Project Site Description and Infrastructure

4.1.4 Nearshore Engineering Structures & Beach Recharge

The primary component of the proposed approach is a series of 3 nearshore engineering structures (NES) approximately 80m in length and located approximately 100m from shore. Beach recharge will create salients landward of each structure through two separate recharge operations within Coastal Units 1 and 2. The NESs are been designed to reduce wave heights and thus retain the beach recharge along the project area frontage (see Figure 4.1 below as a concept image only). As a result, they will provide a degree of protection to the properties along the frontage and improve beach access and use.

Figure4.1. Aerial image visualization of the recommended option (left – before, right – after) ***(prepared February 2014 to demonstrate the concept only)***

In Unit 1, located offshore from Sunset Reef, NES 1 will be a rock structure with a crest elevation of +1.0mLD; this is equivalent to Highest Astronomical Tide (HAT). Modelling work undertaken to inform the scheme design and EIA has shown that an emergent structure is more effective at this location. This NES shall thereby be an emergent structure and will be constructed from rock (locally derived coralline rock boulder to form the core and armour) rather than geotextile sand containers. The structure cross-section will be formed from a coral stone and an armour layer (see Appendix 5g, Annex F for draft General Arrangement design).

Located offshore from 'Allan Bay' and 'Jane's Harbour' and Sandy Lane Hotel, NESs 2 and 3 will be submerged NESs formed from NAUE Terrafix Soft Rock© 'sand containers'. The base layer and core of the structures will be formed from smaller bags (R601's). The outer layer will comprised larger bags (RS1801's) of different lengths. The geotextile fabric of which the bags upper surface is constructed, includes a UV inhibitor that is applicable for the exposed site and high intensity UV of the Caribbean, to avoid degradation of the material. The crest elevation of the structures will be -0.37mLD; this is approximately 0.4m below Mean Low Low Water (MLLW) (see Appendix 5g, Annex F for draft General Arrangement design).

NESs 1-3 will have footprints of approximately 1,500m^2, 1,600m^2 and 1,600m^2 respectively, a total footprint of 4,700m^2. Each NES will be appropriately lit or marked with navigation aids, subject to confirmation of the specific requirements from the harbor master at the Port of Bridgetown.

In addition to the 3 NESs, approximately 37,000m^3 of sand will be added to the beach across the project area replacing sand that has been lost through erosion and restoring the width and height of the beach. The footprint of the 'new' beach will be circa 33,300m^2, encompassing the crest and slope over which the sand is spread. The height of beach above existing ground is estimated to be 2m. The recharged material will be profiled to create a natural beach slope down to the water.

Table 4.1 summarises the draft principal quantities for the engineering works. The bag type, quantities of each bag type and amount of fill, listed within Table 4.1 are subject to alteration prior to finalisation of NAUE's design.

NB: The exact design for NES1 will need to be finalised after discussions with local contractors in relation to available rock sizes and associated unit rate costs.

Table 4-1: Principal Quantities (by Coastal Unit)

	Coastal Unit 1	Coastal Unit 2	
	NES1	**NES2**	**NES3**
NAUE Secutex® Soft Rock 'sand containers'			
Levelling Layer: R601 Secutex® Soft Rock 601 Width/length: 1.45m x 2.38m	N/A	200	200
Crest Element: RS1801 Secutex® Soft Rock RS1801 Width/length: 5.60 x 16.50m (unfilled) / 15.9m (filled)	N/A	17	17
Slope Element: RS1801 Secutex® Soft Rock RS1801, Width/length: 5.60 x 10.0m (unfilled) / 9.55m (filled)	N/A	36	36
Rock			
Coral core (t)	1,500		
Coral armour (t)	10,000		
Fill Material			

Sand containers (m^3)		4,000	4,000
Beach Recharge (m^3)	6,000	31,000	

4.2 Project Activities

4.2.1 Access Issues

Access to the site for construction traffic shall be via both sea and by road. The sand for the beach nourishment programme (37,000m^3) will come from a land-based source at Lears Quarry.

Large construction equipment (12m^3 truck capacities) shall use existing road networks from Lears Quarry to Barbados Port (quarried sands) and from Lears Quarry direct to a storage area within the boundaries of Sandy Lane.

An estimated 3,000 truck movements will still be needed to transport the sands to either a designated solid stockpile area (close to Sandy Lane) prior to the beach fill operation or to transfer the material from the quarry to Barbados port. The temporary stockpile area is currently being defined by Sandy Lane in order to accumulate and accommodate an amount of sand that can be placed within a small amount of time during a temporary closure of the hotel (September 2016).

Road access from the stockpile area to the beach is yet to be determined as the exact location for the stockpile is yet to be confirmed and hence the traffic routes (proposed Traffic Management Plan) is to be finalised during early 2016. However, the stockpile area will be on the property of Sandy Lane Hotel.

Coralline rock (core material) shall be transported via road from Black Bess quarry to Barbados Port for subsequent transfer to Sandy Lane Bay via barge.

4.2.2 Nearshore Engineering Structure (NES) Construction

4.2.2.1 Pre-construction Planning

Prior to construction starting, notices to mariners and sea users that could be affected by the works will be published by the contractor, working with the harbourmaster. The contractor will also ensure permissions for anchoring in the construction area are in place.

A survey of the seabed at the project site will be carried out before construction. The site will be prepared so that there is no debris and the area within the footprint of the NESs is level and firm. In the case of protruding relic reef, where they lie in the footprint of a NES foundation, they shall be left in place and accommodated within the founding layer of each NES. Healthy coral colonies will be trans-located prior to construction. A description of the substrate within the footprint of each of the NESs is presented in Section 5.3.3.

Although considered part of the required construction activity, a description of the coral removal and transplantation process and the associated activities is described alongside the mitigation measures in Section 10.

Planning to reduce noise levels will be carefully considered as sand / water pumping from vessels onto the beach or to fill NES2 and 3 is likely to be the noisiest activity associated with the project. It is therefore advised that contractors search for the lowest noise plant and equipment possible and use encapsulation and screening wherever possible. This has been written into the works specification regarding decibel noise restrictions for plant, though it is appreciated that some noise would be inevitable.

Although estimated at this time, it is proposed that the contractor could mobilise with a "quiet start" from 8am. The period 8am to 10am is to be used for sealing up bags from the day before, setting out, lowering bags into position, including small bags if used etc. Noise during these works would only be from the use of the crane for handling bags etc. Pumping is therefore proposed to take place from 10am until 5pm (7 hour period) with a 1 hour period for demobilisation at the end of the day, which gives a 10 hour shift (8am to 6pm).

Although estimated at this time, it is preferred for work (NES filling and placement only) to start each day at Sunset Reef (northern limit of project area) in the morning and Sandy Lane Bay in the afternoon. This way the hotel guests would not be disturbed in the mornings. ***NB: the Geotube trial period (see Appendix 6d) was completed used to ascertain further confirmation from local contractors to assess if they shall "double-up" on plant and work on NES1 and NES2/3 in tandem. NES1 and NES2/3 have different construction methods, so there is a need to confirm plant required.***

4.2.2.2 NES Construction Approach

NES 1 will be composed of rock. Modelling work undertaken to inform the scheme design and EIA detail has shown that an emergent structure is more effective at this location. As an emergent structure will be more visible more often, it will be constructed from natural rock rather than geotextile sand containers (see Appendix 4a).

The bed level varies across the long-axis of the structure. The sea-bed is higher in the north of the Area of Interest (AoI) than the south. The structure comprises coral core and armour for the southern portion. As the bed level rises to the north, the space for any core underneath the armour disappears; the north section therefore shall comprise of armour stone alone (see Appendix 5g, Annex F for General Arrangement drawings).

The coral core rock will be loaded onto a barge for transportation to the construction site. Once on site, it will be positioned over the area of construction. A long-reach excavator on-board the barge will place the core rock to the levels and slopes shown on the construction drawings. The armour layer will then be placed upon the core rock, again to the correct slope and crest elevation.

No preparation of the sea bed is required prior to placement of the rock. The structure is essentially a seaward continuation of the natural reef in this location. From jet probe survey work completed to date by Marenco Ltd (see Appendix 5d and e), there is no sand material under the northern limit of the structure. For the southern portion of the structure, there is approximately 0.2-0.3m of sand above rock-head (see Appendix 5ei).

NESs 2 and 3 will be constructed of a mix of large and small sand filled geotextile bags. The geotextile bags shall be delivered to site in packaging that will protect the bags from ultra-violet light degradation. The labelling shall clearly identify the product supplied in accordance with BS EN 30320: 1993. Geotextile containers shall be protected at all times against physical or chemical damage and shall be kept in the wrappings provided by the manufacturer until required for use.

4.2.2.3 Beach Re-nourishment Engineering Approach

The beach nourishment material shall be sourced from Lears Quarry. The material shall not contain more than 2.5% of any other material, including shells, clay, silt or other material deemed unsuitable by the supervising engineer.

The existing beach material is medium/coarse sand with a median diameter (d50) of 0.6-0.7mm. The recharge material will be coarser sand with a d50 of approximately 1.2mm. Construction tolerances will be provided for the recharge material. Figure 4.2 illustrates the comparison between native beach grading and proposed recharge material and includes an indicative tolerance for the construction specification (see Appendix 5c for laboratory sediment analyses results).

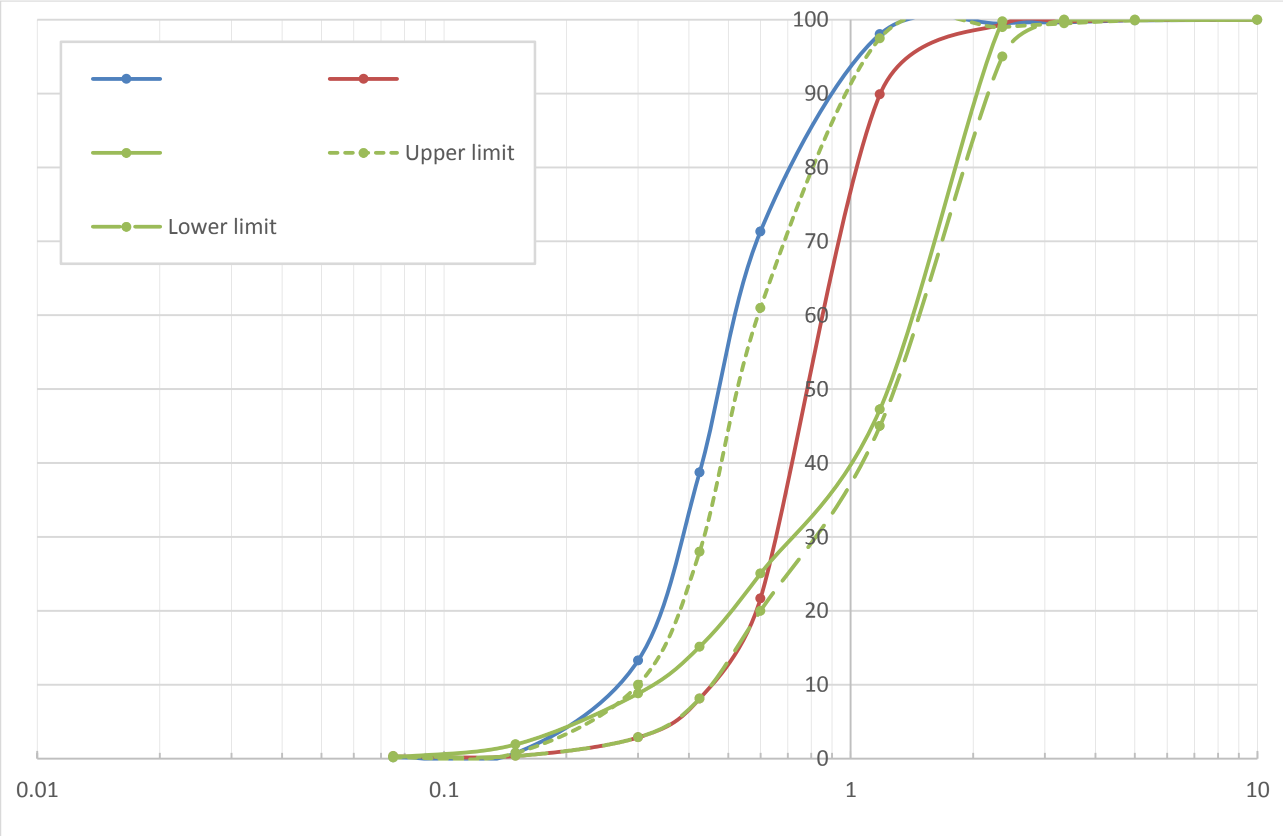

Figure 4.2: Beach PSD grading's

The control of the grade of the source material will be critically important in order to provide a design grade that does not contain an excess of fines or gravel material. This will entail some sample sieving and sampling of the material at the quarry.

Most of the material, unless otherwise instructed by the supervising engineer, shall be placed above the Mean Low Water (MLW) in accordance with the design drawings (see Appendix 4a and 4b).

Signs will be located around the site to provide contact details in the event of an emergency. This information will also be made available to the local police station.

4.3 Project Schedule

4.3.1 Construction Activity Programme

Most of the work is scheduled to be completed during the tourism low-season. Construction is planned to take place between 1 July 2016 and 30 September 2016, with the beach recharge operation taking place in the third week in September (w/c 7 or w/c 14 September 2016) within a maximum 10 day window in September 2016 whilst the hotel is temporarily closed in order to accommodate the works. Commencement of construction will be dependent on the overall planning approvals and the delivery of all plant, materials and machinery. The construction phase of the project will last approximately 3 months. This period is weather dependant and can be affected by storm swell events. A narrow hotel closure window of opportunity is also a constraint for beach related works.

During this construction time there will be some inconveniences to beach and sea users. The project team has and will continue to liaise with stakeholders to minimize disruption to business, home owners and beach access during this time.

4.3.2 Post Construction Activity Programme

Following completion of the works, all temporary access roads and structures shall be removed. All working and storage areas, the site compound and all other affected areas shall be reinstated to a condition not worse than existed prior to the works. The clean-up of the construction site is the final construction activity to be conducted. The clean-up crew will pick up debris, remove surplus materials and equipment, and clean or repair any damaged areas. Temporary buildings will be removed from site, and laydown areas restored.

5 CLIMATIC, ENVIRONMENTAL AND SOCIO-ECONOMIC PROJECT BASELINE

This section provides a description of the environmental setting for the proposed project area (i.e.: the proposed "intervention area" in addition to the modelled "project area" and includes those components of the environment potentially affected by the proposed Project. The description has been prepared from available information, discussions with government representatives and resource managers, relevant mapping, and information collected during field investigations, and provides information on environmental components that may potentially be affected by the Project, or which may influence or place constraints on the execution of Project-related activities. ***NB: Section 5.1 is written to address issues at a national level. The remaining sections are, where information allows, written to cover the project study area (or at least at the scale of St James Parish).***

5.1 Climatic and Atmospheric Conditions (including natural disaster hazards (National Focus)

5.1.1 Meteorological Conditions

Barbados is characterised by a tropical maritime climate which has two pronounced seasons: dry and wet. The wet season, which lasts from around June to October, is the fundamental source of potable water on the island. The amount available for use is heavily influenced by the island's geological structure and thereafter by the distribution system in place for water supply.

Annual rainfall averages 56 - 60 inches (142cm – 152cm) per year. Regardless of the substantial annual rainfall, most rivers in Barbados are dry due to the very permeable nature of the coral rock. Through gullies and sink-holes, water finds its way into underground water reservoirs which make up 98.6% of the public water supply. There are a large number of natural deep gullies across the island representing old coral reef formations. The gullies extend from the central upland region to the coastline, and form an integral part of the island's natural drainage system (GOB, 2000).

Temperatures show very little variation throughout the year, with day to night variations of approximately 8°C. The island has about 3,028 hours of sunshine per year, which represent 69.1% of the annual daylight hours. Winds are generally gentle to moderate, exceeding 5.7 m/s about 41% of the time, whereas the periods of calm or light variable winds amount to approximately 2%, on an annual basis. Wind direction and frequency data are summarized below in Table 5-1. The hourly wind directions are grouped into 16 classes, each corresponding to a 22.5-degree sector. One additional class corresponds to calm conditions when the wind speed was less than 0.5 m/s.[8]

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[8] Climatic data was available from the Caribbean Meteorological Institute (Husbands, St. James station, latitude 13o
09'N, longitude 59o 37'W). Wind data was also obtained from the Grantley Adams Airport in Bridgetown.

Table 5.1: Frequency Distribution (counts) for 1999 Meteorological Data from Grantley Adams Airport

Direction		Wind Class (m/s)						Subtotal	Percent of Direction
(Compass)	(Degrees)	0.5-2.1	2.1-3.6	3.6-5.7	5.7-8.8	8.8-11.1	>=11.1		
N	**0**	83	53	27	5	0	0	168	1.9%
NNE	**22.5**	85	85	59	28	5	0	262	3.0%
NE	**45**	104	300	367	217	16	0	1004	11.5%
ENE	**67.5**	53	331	1193	1163	248	2	2990	34.1%
E	**90**	22	165	1101	1145	235	5	2673	30.5%
ESE	**112.5**	14	79	288	183	28	2	594	6.8%
SE	**135**	11	45	105	73	5	2	241	2.8%
SSE	**157.5**	6	35	36	30	1	0	108	1.2%
S	**180**	6	24	53	50	21	2	156	1.8%
SSW	**202.5**	4	18	24	35	10	0	91	1.0%
SW	**225**	3	12	13	22	4	1	55	0.6%
WSW	**247.5**	12	9	10	5	1	0	37	0.4%
W	**270**	17	9	22	21	5	0	74	0.8%
WNW	**292.5**	13	6	10	7	0	0	36	0.4%
NW	**315**	18	3	2	0	0	0	23	0.3%
NNW	**337.5**	43	26	5	0	0	0	74	0.8%
Subtotal		494	1200	3315	2984	579	14	8586	
Percent of Class		5.6%	13.7%	37.8%	34.1%	6.6%	0.2%		98%
Calms									174 (2%)
Missing Data									0
Total Counts									8760

The data clearly show the dominance of easterly winds. If the direction 45-112.5° (NE to ESE) are grouped, then the winds corresponding to this sector account for 82.9% of all wind directions. In other words, approximately 83% of the time the wind blows towards the west ±22.5°.

5.1.2 Natural Hazards

The island is on the southern edge of the West Indian hurricane zone, but apart from coastal damage experienced in 1998 due to ocean swells, it has not been affected by any major hurricane conditions since Hurricane Allen in 1980 (Government of Barbados, 2002). Therefore, compared to other Caribbean nations, Barbados is exposed to few natural hazards. Tropical depressions, tropical storms or hurricanes come close to Barbados on average every 3.07 years[9]. As part of the metocean study used to provide input conditions to the numerical and physical modelling, storm data from the Atlantic Ocean were obtained from the International Best Track Archive for Climate Stewardship (IBTrACS, Knapp at al 2010). This archive is hosted by the National Climatic Data Centre (a division of NOAA) and brings together all records of cyclone and hurricane tracks from around the world. The database was searched to find hurricanes and tropical storms passing within a radius of 300km of Barbados since 1969. 1969 was chosen as this is around the time that weather records became more comprehensive due to the use of meteorological satellites. A total of 47 storms were found to have approached within 300km of Barbados between 1969 and 2013. Including tropical storms, Barbados has been impacted 39 times in the last 41 years[10]. Table 5.2 summarises the main natural events that have occurred and their impact on the country[11].

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[9] http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=35160013
[10] http://www.hurricanecity.com/city/barbados.htm
[11] Op. Cit.

Table 5.2: Chronology of Tropical Storm Events in Barbados (Source: http://www.barbadosweather.org/PDF_Uploads/Can%20Barbados%20be%20Hit.pdf)

Natural Event Title	Date	Impact
Tropical Storm Chantel	2013	Minimal (WNW sustained winds of 50mph)
Hurricane Allen	1980	Destroyed 35 homes, damaged over 200 homes in St Andrew
Tropical depression	1970	Triggered massive floods in St. Michael and Bridgetown which became known as the 1970 floods
Hurricane Edith	1963	Passed within 50 miles but deposited 9 inches of rain on the island
Hurricane Janet	1955	35 people killed, destroyed 8,100 homes and left 20,000 homeless. Winds over 110 mph
Tropical storm #3	1949	deposited over 10 inches of rain in St. Thomas, St. George, St. Joseph, and St. John and five to six inches in northern parishes
Tropical storm #2	1901	1 person killed
Hurricane	1898	Strong hurricane passed south. 83 dead; 9 937 houses destroyed, 4 519 damaged; 50 000 homeless.
Tropical storm	1894	Passed north-west. Destroyed hundreds of homes; 18 fishermen missing.
Hurricane	1831	left damage at more than £2 million and about 1 525 dead,
Hurricane	1780	4 326 dead and over £1 million in damage (according to Commander-in-Chief Major General Vaughan).

The effects of hurricanes and tropical storms such as wind damage, inland flooding and coastal surges are of national concern. Latest NOAA data[12] has shown that the number of tropical storm systems within the Atlantic Ocean will increase over the next century. With the formation of these systems it is likely that the outer band of clouds will create the possibility of high intensity rainfall. The general climate circulation models have predicted an increase in the frequency of high intensity storms over the next 100 years. It is likely that there will be a reduction in the number of category 3 storms within a decade while that of categories 4 and 5 will increase. The general climate circulation models are predicting a decrease in rainfall for Barbados (UNDP[13]) of up to 15% by the year 2090. The proportion of total rainfall that falls in heavy events decreases in most model projections, changing by -26% to +10% by the 2090s.

Should a hurricane form to the east of the country, Bajan meteorological forecasters predict that there is a 90% probability that it will pass to the north of the island because of the Coriolis Effect. Due to the earth's anticlockwise rotation and the direction of the Trade Winds, air movement is deflected to the right in the northern hemisphere and to the left in the southern hemisphere. However, other factors such as a high

[12] http://www.aoml.noaa.gov/hrd/Storm_pages/Atl/ATLwind.dat
[13] http://country-profiles.geog.ox.ac.uk/index.html?country=Barbados&d1=Reports

pressure system can be one of the "steering currents" which causes the hurricane to travel along the periphery of the high pressure system and curve northwest when conditions permit.

Associated with changes in weather patterns, temperatures are predicted to rise between 1.4° to 3.2° (Figure 5.1). Significantly for Barbados and of importance to coral reefs with respect to shore line protection and the tourism industry, there is a predicted increase in ocean acidity of between 0.14 and 0.35pH units. The consequence of ocean acidification predictions is that by the middle of this century reefs may erode faster than can be rebuilt by new calcification growth rates.

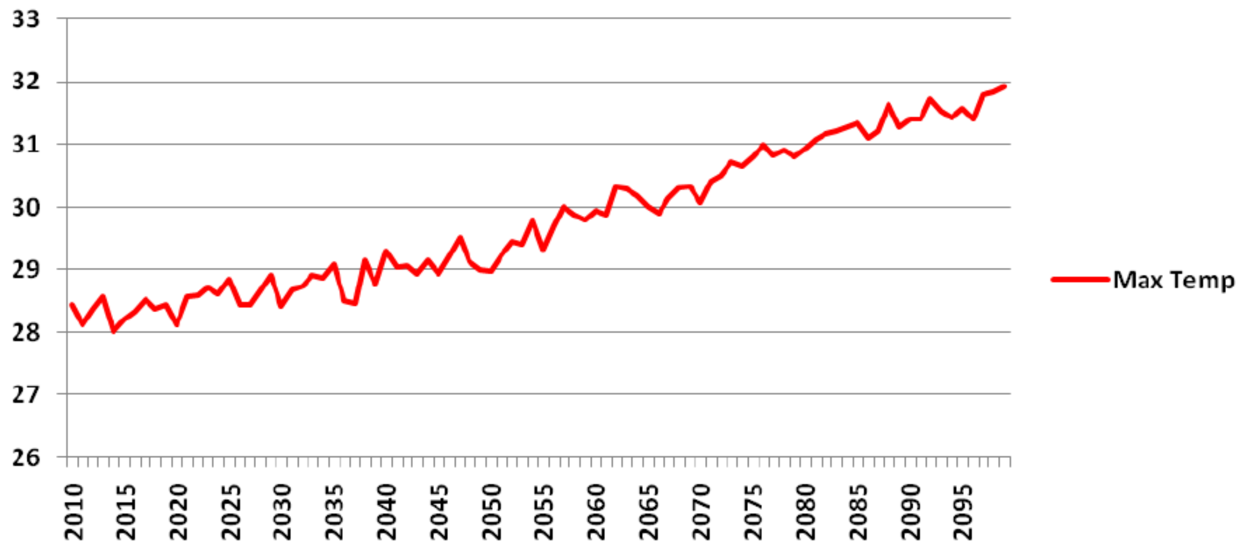


Figure 5.1 – Projected temperature rise in Barbados over the next 80years (Charlery and Nurse, Climate Studies group, Cave Hill, UWI (2012)

The active submarine volcano, *"Kick 'em Jenny"*, located 9 km northeast of Grenada, and about 260 km (100 miles) southwest of Barbados poses a potential threat of tsunamis and earthquakes. Historically Barbados has been impacted by nine (9) earthquakes and felt shocks between 1670 and 2000 (a return period of 36.67yrs).

5.2 Physical Environment

5.2.1 Topography and Bathymetry

Barbados is a comparatively flat island, rising in a series of terraced tablelands to Mount Hillaby at 336 m (1,104 ft) in the Parish of St. Andrew (Government of Barbados 2002). There are no permanent rivers in Barbados. There is 92 km of coastline that has an interesting diversity of land and seascapes and is a unique asset.

The proposed project area is characterized by a low lying hinterland without any special terrestrial designations. The project area is physically bounded by two headlands, one in the vicinity of Beachlands (Sunset Reef villa) in the north and the other in the vicinity of Leigh House villa in the south. In November 2014, a combined topographic and bathymetric survey of the project area was undertaken by Hart, Hutchinson & Field (HHF). Drawings of selected soundings, levels and derived contours have been presented on charts at an appropriate scale (see Figure 5.2). Detailed plots of the topographic and bathymetric survey results are presented in Appendices 5a and 5b.The collection of 1400m^2 of topographic beach data was programmed to coincide with the lowest possible tides in order to allow best access to the foreshore area. The topographical survey was undertaken such that the High Water Mark (HWM) can be established and agreed with the CZMU (as per the CZMU requirement that the submitted HWM has been surveyed within the last 2 years (CZMU Planning Handbook for Developers (2010); Section 3.2e)).

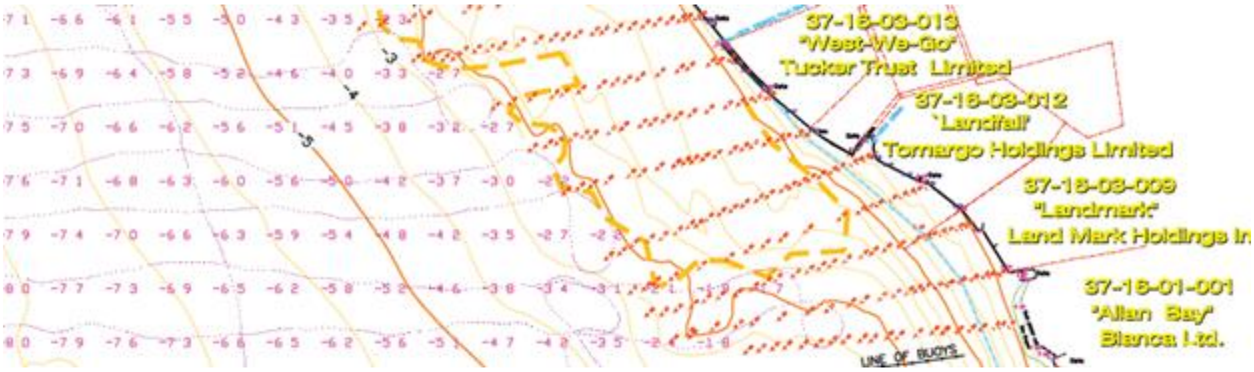


Figure 5.2 Sample output showing survey lines and bathymetric contour recordings

The offshore extent of the bathymetric survey area captured the -20m contour (to Lamont Datum, mLD) and extended approximately 400-600m from the shoreline as a result of the sinuous coastline. The survey area was therefore approximately 0.6km^2 (1.2km x 0.5km). The vertical accuracy of the bathymetric survey was set as being ± 10cm (Appendix 3a). The depth of area within which the engineering works will be located is shallow shelving down to a maximum bathymetric contour level of -4mLD.

5.2.2 Geology, Tectonic Uplift and Surficial Soils

Barbados is the top of a seamount that rises 300 m above sea level from the Barbados Ridge and was formed as an accreted wedge created by the movement eastwards of the Eastern Caribbean plate over the South American plate (RES 2003). The process continues with the leading edge now probably located 20 to 30 km west of Barbados (RES 2003). Eighty-six per cent (86%) of the island is capped by a coral limestone formation which gives the landscape a gently rolling topography, interrupted at points by deep gullies and a series of almost vertical cliffs that are old coral reef formations. In the remaining 14% of the island, the coral limestone cap has been completely eroded exposing the complex mix of impermeable clays underneath. This area (the Scotland District) is marked by highly rugged terrain compared to the rest of the island (GOB, 2000). Beneath the coral cap are oceanic beds consisting of marl and ash covering the "Wedge Cover Unit" comprised of mudstones, sandstones and marls that weather to form silty clay to sandy clay soils (RES 2004c). The most frequent soil type is fertile clay or clayey loam (RES 2003). The proposed project area is covered with a shallow veneer of clay soil derived from coralline limestone typical of the soils on Barbados. It sits within the predominant limestone part of the island, on the west coast.

Longitudinal "reefs" occur parallel to the coastline and are seen as a series of terraces extending inland; the oldest and highest terraces being about 700,000 years old, while the youngest adjacent to the coast are in the process of formation (Machel 1999). The average rate of tectonic uplift is about 0.4 m per 1,000 years, providing a rough measure for the ages of the various terraces and the amount of cementation of the coral that has occurred (RES 2003). Gullies are formed from the erosion of the limestone cap or the collapsed roofs of sinkholes, caverns and underground streams. These may follow cracks of tectonic origin within or below the coral cap (Machel 1999). The following information (taken from Speed *et al* 2012) presents the measured land uplift rates in Barbados. Site 52 (Sandy Lane) suggests an uplift estimate of 43cm in 1000 years (0.43mm yr uplift) (see Figure 5.3). A similar statistic is assumed to apply for the whole of the St James area.

Site #	Sht.	Locality	Elevation m/ ± m	Age (ky)	Z (m)	Marker	Rate (m/ky)
39	8	Brittons	28/1	102	-16	Vt-sa	0.43
40	8	Brittons	62/0.5	120	6	RHt-sa	0.38
41	8	Hasings	9/0.5	82	-21	Wt-sa	0.36
42	8	Harrison Coll.	12/1	102	-16	Vt-sa	0.27
43	8	Station Hill	16/1	102	-16	Vt-sa	0.31
44	8	Blackrock	20/1	82	-21	Wt-sa	0.49
45	8	Grazettes	32/1	102	-16	Vt-sa	0.47
46	8	Whitehall	62/1	120	6	RHt-sa	0.47
47	8	Cave Hill	70/1	120	6	RHt-sa	0.53
48	8	Cave Hill	38/0.5	102	-16	Vt-sa	0.53
49	8	Oxnards	62/2	120	6	RHt-sa	0.48
50	5	Holders	28/0.5	102	-16	Vt-sa	0.43
51	5	Holders	17/0.5	82	-21	Wt-sa	0.46
52	5	Sandy Lane	57/2	120	6	RHt-sa	0.43
53	5	Trents	19/2	102	-16	Vt-sa	0.34
54	3	St. Albans	20/2	102	-16	Vt-sa	0.35
55	3	Mullins	18/1	102	-16	Vt-sa	0.33
56	3	Heywoods	18/1	102	-16	Vt-sa	0.33
57	1	Colleton	18/1	102	-16	Vt-sa	0.33
58	1	Fryers Well	16/0.5	102	-16	Vt-sa	0.31
59	1	Greshie Bay	3/1	82	-21	Wt-sa	0.29
60	1	Stroud Bay	2/0.5	82	-21	Wt-sa	0.28
61	1	Stroud Pt.	25/2	127	6	coral	>0.16
62	1	Goulding Green	7/1	82	-21	Wt-sa	0.34
63	1	Touce Pt.	21/2	126	6	coral	>0.13
64	1	Sandy Hill	7/2	126	6	coral	>0.07
65	1	Hope	27/0.5	120	6	PCt-sa, degrad.	0.18
66	1	St. Clement	17/0.5	120	6	PCt-sa	0.10
67	2	Gays Cove	17/0.5	120	6	PCt-sa	0.10
68	2	Gays Cove	29/0.5	120	6	PCt-sa	0.19
69	2	Gays Cove	34/1	120	6	PCt-sa	0.23
70	4	Bathsheba	78/2	120***	6***	sa***	≥0.60
71	10	Shark Hole	6/2	120^^	6^^	degraded	≥0.00

Figure 5.3 Tectonic uplift in Barbados (taken from Speed et al 2012)

5.2.3 Hydrogeology and Groundwater Quality

In 1964, Barbados introduced the concept of "groundwater protection zones - GPZ". Five GPZs were defined on the basis of the travel time for bacteria, and restrictions were placed on development, in-ground sewage disposal systems, soakaway pits and quarrying (Klohn-Crippen, 1996). The highest level of protection is represented by Zone 1, which restricts new residential and industrial development, prohibits soakaway pits and quarrying. Zone 5 represents the lowest priority and provides no constraints to development. The proposed study area is located within Zone 5 (Figure 5.4 - Sandy Lane Bay identified by a red dot).

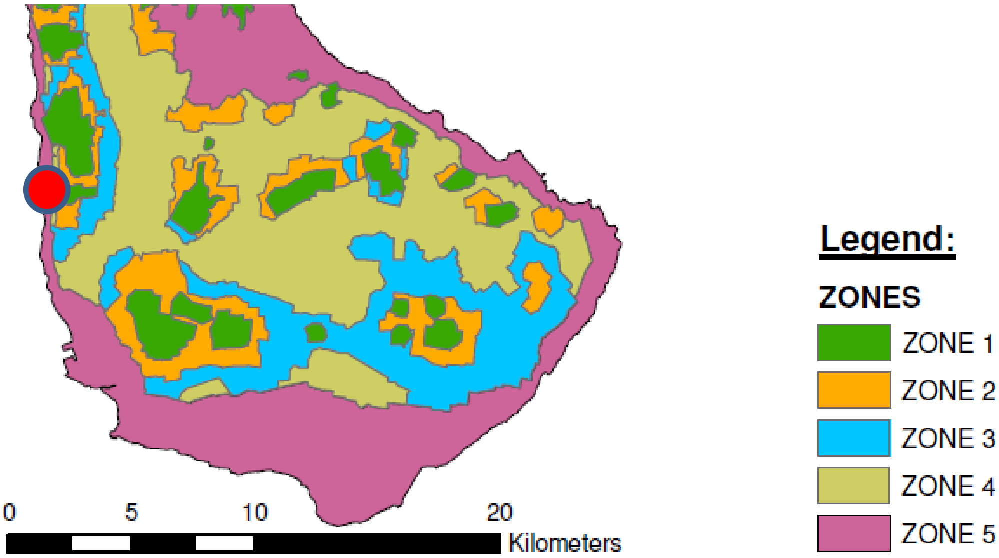


Figure 5.4 Groundwater Protection Zones in Barbados

The chemical quality of groundwater in Barbados is typical of water found in limestone formations. The major ions present in the water are calcium, magnesium, sodium, potassium, bicarbonate, chloride and sulphate. Total dissolved solids are generally in the range of 400 to 700 mg/L. In some areas, the impact of in-ground disposal of sewage and agricultural runoff has resulted in elevated concentrations of nitrate.

5.2.4 Sediments

5.2.4.1 Sediment Type, Size and Provenance

The primary sediment in the study area is made up of coarse to fine marine derived sand material overlaying the coral substrate. There are some exposed areas of coral and "coral rubble" as a direct consequence of recent and historic damage to the surrounding bank and fringing reef areas. Particle size distribution (PSD) data for Holetown was reported in Armstrong (2012).

A total of 14 samples were taken and analyzed within the Holetown area, including locations further south at Beachlands. Grain sizes (D_{50}, D_{75}, D_{90}) have been taken for six of the samples, indicating that the D_{50}, (the median grain size), is approximately 0.4mm, a fine sand material (see Appendix 5c).

New baseline data has been compiled for this study (Appendix 3a). Sampling and analysis of the sediments in Sandy Lane Bay has been undertaken to inform the development of the scheme and provide data on the physical and chemical properties of the sediment in the area.

In November 2014, several samples were collected for physical testing from locations stretching from Club Barbados in the north to Heronetta in the south. Figure 5.6 outlines the locations of samples collected. Locations S1-7 were taken on the beach at Sandy Lane Hotel. Samples S8 and S9 were taken from Lears Quarry and Black Bess Quarry respectively.

Sediment samples were analyzed by the Barbados National Standards Institute (BNSI) for particle density and were classified as being between coarse and fine grade grey to white sand or crushed sand. The mean particle density for the tested material was found to vary between 2.69 and 2.76 g/cm$^{3.}$ This data is included in Table 5.3.

Details of the BNSI laboratory tests are presented in Appendix 5c. A specific petrographic examination of fine aggregate sediments has been carried out for the Lears Quarry material, identified as the most suitable material for beach recharge and filling of the geotextile sand containers, since initiation and completion of the sediment sampling programme. This is shown in Figure 5.5.

In addition, physical testing of the Lears Quarry material was undertaken to assist in determining its geotechnical properties in order to assess the short and long term settlement of the proposed nearshore engineering structures (NES) and ensure appropriate selection of the geotextile fabric in order to avoid the fill material seeping through the pores within the material.

RESULTS OF ASTM C295

Weighted Percentages of Constituents of SL1 Fine Aggregate Sieve Fractions

CTL Project No.: 382183 | Report Date: April 29, 2015

Client: C.O. Williams Sand & Lime Ltd. | Sample Received: April 8, 2015

Project: Various Testing | Examined by: Casey Ricks

Constituent	No. 8 %	No. 16 %	No. 30 %	No. 50 %	No. 100 %	No. 200 %	Total
Limestone	0.2	27.0	26.0	20.8	16.9	7.4	**98**
Argillaceous Limestone	--	0.1	--	0.3	0.1	<0.1	**1**
Total	**0.2**	**27.1**	**26.0**	**21.0**	**17.0**	**7.4**	**99**
							1.2
							100

Notes:

1. "--" indicates constituent was not observed. "tr." indicates weighted percentage is less than 0.5.
2. Column and row summations may not equal reported totals due to rounding.
3. Results refer specifically to the sample submitted.
4. This report may not be reproduced except in its entirety.

Figure 5.5: Lears Quarry material (taken from CTL Group Laboratory assessment – April 2015)

Full results of the density tests and particle size distribution tests are included as Appendix 5c. Table 5.3 shows the median grain diameters for the samples collected together with the derived sorting coefficient, a measure of how widely graded the sediment sample is; the lower the value, the less the range of size within the sample. The existing beach and offshore material is a variety or fine, medium or coarse sand.

Table 5.3: Sediment density and particle size distribution results

Sample ID	Mean Particle Density (g/cm^3)	Median grain diameter, mm (d50)	Sorting Coefficient $(d84/d16)^{0.5}$
S1	2.73	0.53	2.35
S2	2.76	0.49	1.67
S3	2.72	0.23	1.34
S4	2.73	0.23	1.36
S5	2.75	0.84	2.06
S6	2.75	0.26	1.47
S7	2.76	0.72	2.58
S8 (Lears Quarry)	2.69	0.93	2.39
S9 (Black Bess Quarry)		0.42	3.13

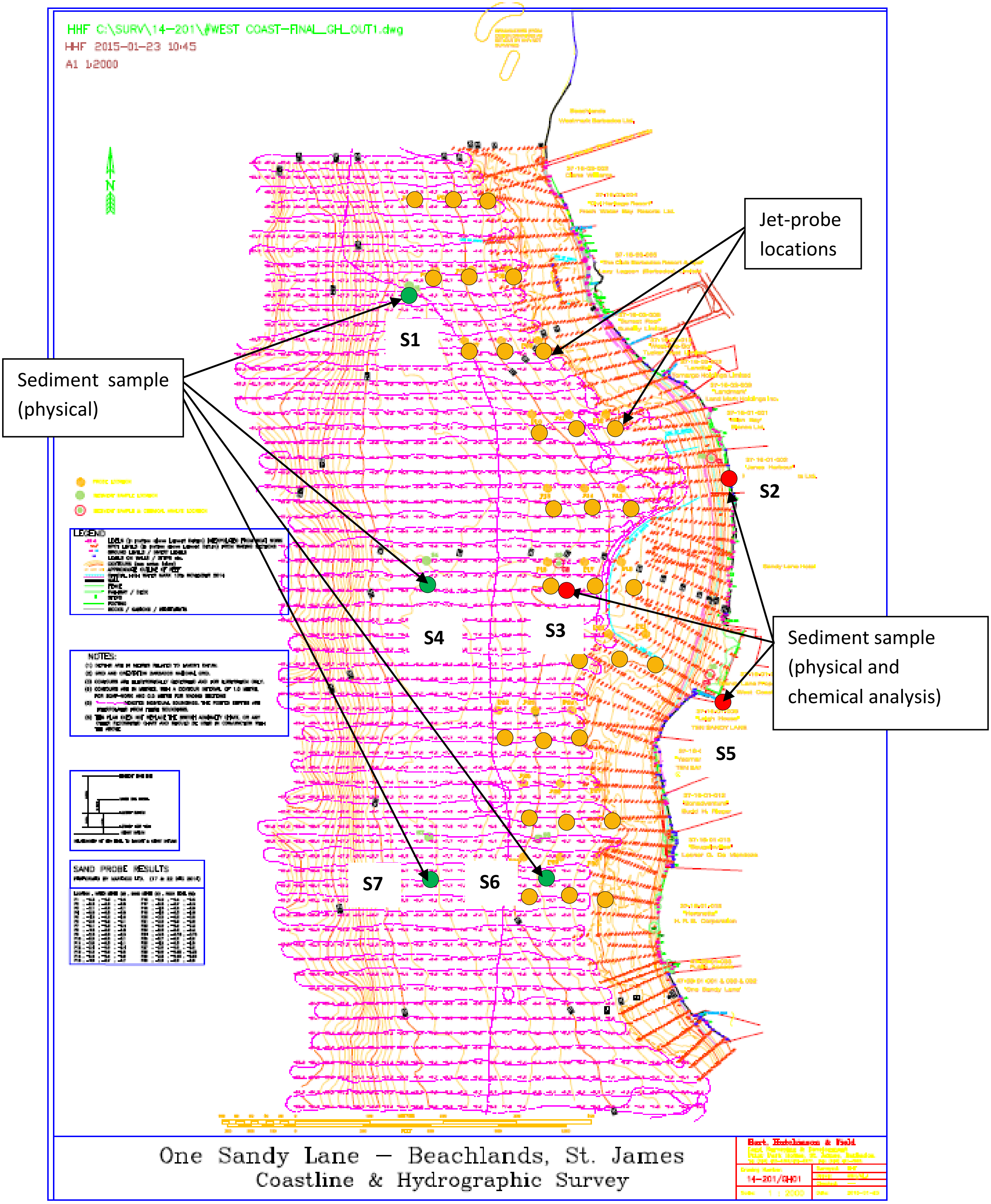


Figure 5.6: Sediment sample and jet-probe locations

5.2.4.2 Sediment Volumes – Offshore

Offshore jet-probing work was completed in December 2014 at several sites along the west-coast of Barbados. This was completed in order to understand the viability of these locations to provide material for the beach recharge operation. This work did establish one possible source of material offshore from Harrisons Point Lighthouse. A large sandy area close to Maycocks Bay was also found with sand depths of over 2.5m in approximately 45ft of water.

5.2.4.3 Sediment Depths – Inshore

Inshore jet-probing work was completed in December 2014 in order to gain some understanding of the depth of sand above the rock-head within the project area. This was completed in advance of the scheme design and confirmation of the location of the structures as currently given.

The area within which the samples were carried out was approximately 900m x 100m, and extended seaward for approximately 100m from the reef. Survey lines were run at 50m spacing intervals, both north-south and east-west. Thirty (30) jet-probes were completed. These locations are shown in Figure 5.6.

The jet-probe logs recorded a range of sand depths above the rock-head. In general the depth of sand is a thin layer, varying in depth between 0m (i.e. exposed coral) to 0.7m across the probe sites. This supports findings in previous papers where probe work has been undertaken to the north at Holetown (Armstrong, 2012). Full detail of the jet-probe work (December 2014) is presented in Appendix 5d.

Additional jet-probing work was undertaken in May 2015 within the footprint of NES 1 and NES2. NES3 was not surveyed due to the impact on beach users and swimmers at Sandy Lane Hotel. A full size copy of the plan and sampling stations is included in Appendix 5e.

5.1.4.1 Sediment Quality

Chemical analysis of sediment samples at eight locations was carried out to compare existing beach material with that of possible beach recharge materials, to ensure that contamination would not be introduced to the beach. Figure 5.6 outlines the sampling stations for the quality analysis work.

The project has undertaken over 25 quality analysis tests on samples taken at eight locations from the beach and inshore area. Samples taken have all been analysed for the following chemical contaminants / compounds: As, Hg, Cd, Cr, Cu, Ni, Pb, Zn, Organotins (TBT, DBT, MBT), PCB's (sum of ICES 7), PCB's (sum of 25 congeners), DDT, Dieldrin. All samples were preserved and submitted to the laboratory in labelled containers as recommended by Standard Methods for Examination of Water and Wastewater (SMEWW) Method 1060. Samples were submitted to Environmental Sciences Limited (ESL), Trinidad for analysis on 23 January 2015. Samples were analysed for contaminants (metals, organotins, polychlorinated biphenols and pesticides).

The contaminant testing results are presented in Figure 5.7. The full analytical report is contained in Appendix 5c.

ESL Sample No.	Client Sample ID	Organotins*			DDT*	Dieldrin*	PCB's*						
		DBT	TBT	MBT			1016	1221	1232	1242	1248	1254	1260
02/15 -1S	Sample 1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15 -2S	Sample 2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15 -3S	Sample 3	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15 -4S	Sample 4	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15 -5S	Sample 5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15 -6S	Sample 6	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15-7S	Sample 7	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
02/15-8S	Sample 8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

ESL Sample No.	Client Sample ID	Arsenic	Cadmium	Copper	Chromium	Lead	Nickel	Zinc
02/15 -1S	Sample 1	BDL	BDL	BDL	BDL	4.2	BDL	BDL
02/15 -2S	Sample 2	BDL	BDL	BDL	BDL	4.2	BDL	BDL
02/15 -3S	Sample 3	BDL	BDL	BDL	BDL	3.8	BDL	BDL
02/15 -4S	Sample 4	BDL	BDL	BDL	BDL	3.3	BDL	BDL
02/15 -5S	Sample 5	BDL	BDL	BDL	BDL	3.8	BDL	BDL
02/15 -6S	Sample 6	BDL	BDL	BDL	BDL	3.3	BDL	BDL
02/15-7S	Sample 7	BDL	BDL	BDL	BDL	2.5	BDL	BDL
02/15-8S	Sample 8	BDL	BDL	BDL	BDL	2.6	BDL	BDL

BDL = Below detection limit ppm = parts per million (mg/kg) * = tests subcontracted to IAG

Figure 5.7 Sediment contaminant testing results

Of the eight samples tested, no organotins, PCBs, dieldrin or DDT were detected. No metal contamination was found in any of the samples, except for lead, which was present in all samples. Lead was historically added to paint and fuel and used in old water pipes. It is occasionally detected in water samples in Barbados, primarily in locations where vessels have historically been present (GOB, 2004).

The Canadian Sediment Quality Guidelines for the Protection of Aquatic Life are routinely used around the world as standards against which sediment contamination is tested. Under the guidelines, the Threshold Effect Level (TEL) is defined as the minimal effect range within which adverse effects rarely occur. For lead, the TEL is 30.2mg/kg. All the sediment samples collected from the study area show levels of lead well below this level, indicating that although some lead is present, it is not at levels that would cause adverse effects to aquatic life.

5.2.5 Coastal Processes and Hydrodynamics

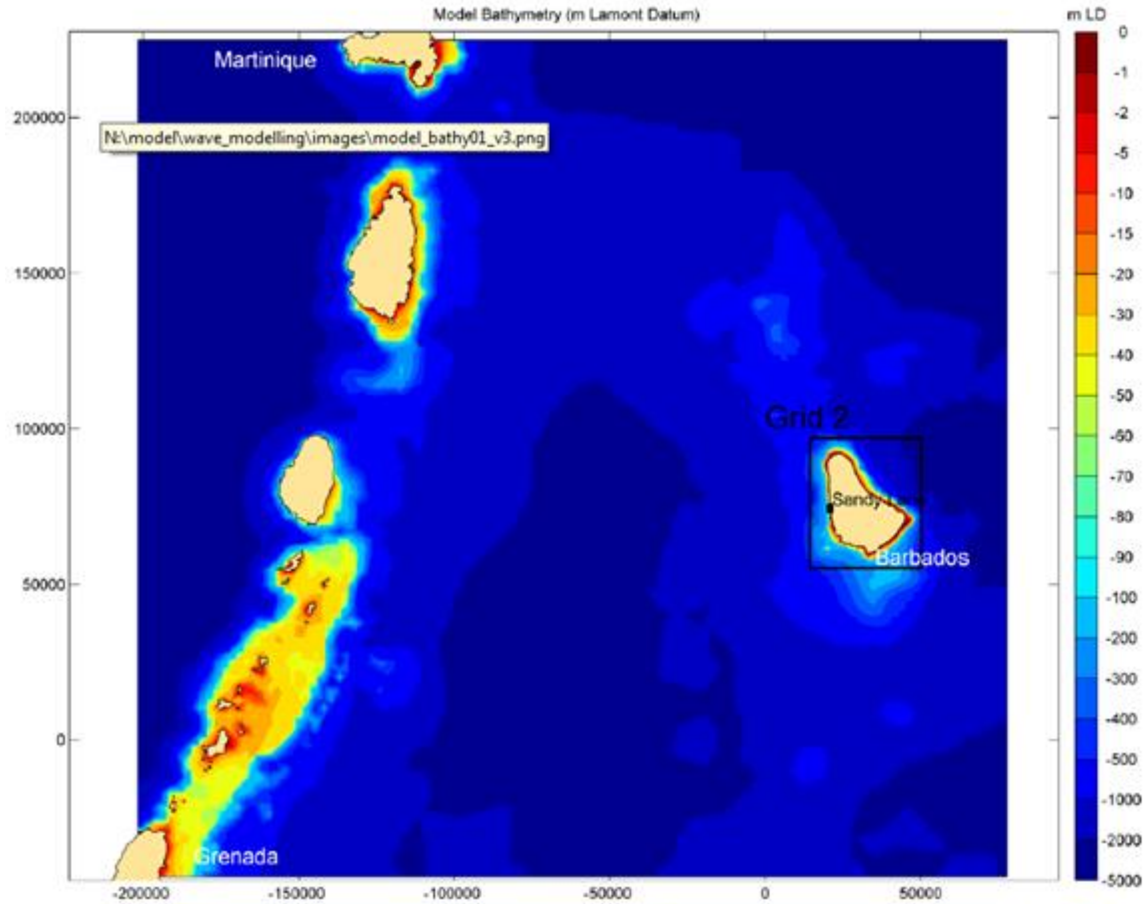
5.2.5.1 Waves

Barbados is affected primarily by waves generated by the following:

- North east (NE) Trade Winds;
- North Atlantic Ocean Swells (North swells);
- Hurricane and Storm Activity (Tropical storms).

As part of the numerical and physical modelling studies completed, HR Wallingford have completed a metocean study in order to fully understand the local climate at Sandy Lane Bay and which has ultimately been used to drive the numerical and physical modelling work. In order to provide conditions within the Bay, a series of grids were set-up on a regional (Caribbean), national (Barbados) and local (Sandy Lane Bay) basis. These are shown in Figure 5.8.

Offshore wave data was used to generate waves across the regional model and calibrated to recorded data at the northern tip of the island. A long-term time series of wind and offshore wave conditions has then been run at the local scale at higher resolution to provide wave conditions for Sandy Lane Bay. Annual offshore conditions (seasonally by month), in 20m of water, and extreme nearshore sea states including the effect of hurricanes were derived for several return periods. Four wave roses have been produced to cover the study area and are shown below in Figure 5.9. Point 1 is at the -20mLD contour approximately 500m offshore and points 2 and 3 (as shown in Figure 5.10) are at the -5mLD contour on the seaward side of the NESs. Point 4 was studied prior to removal of a structure in the southern part of Sandy Lane Bay.



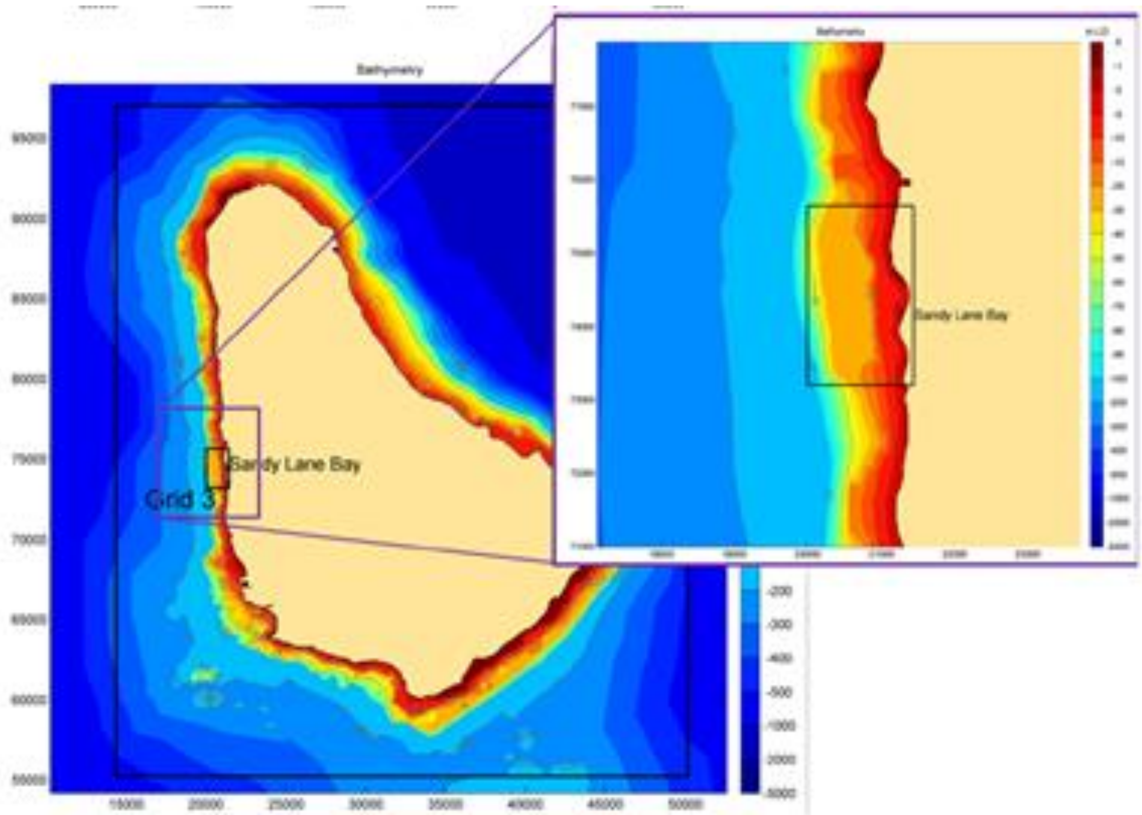


Figure 5.8: Wave Model Grid Extents (source: HR Wallingford 2015)

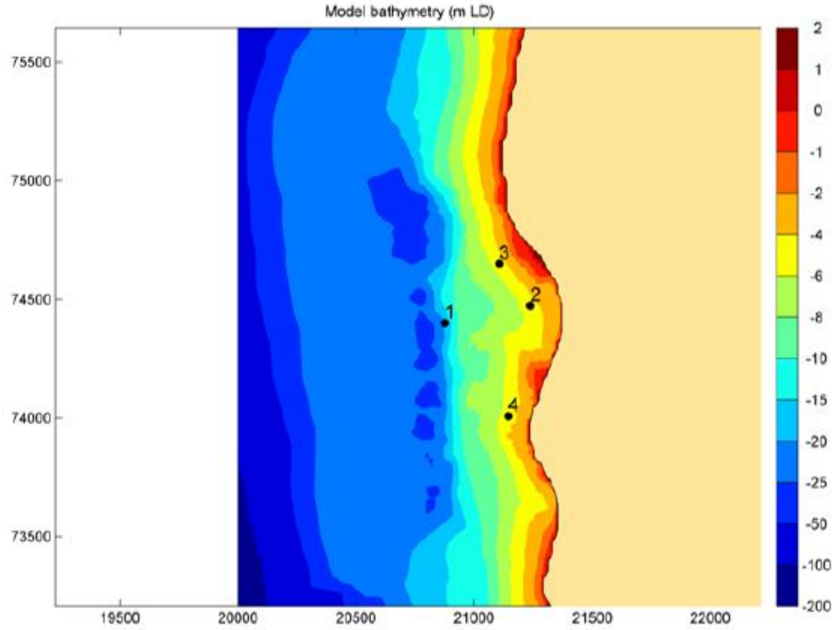
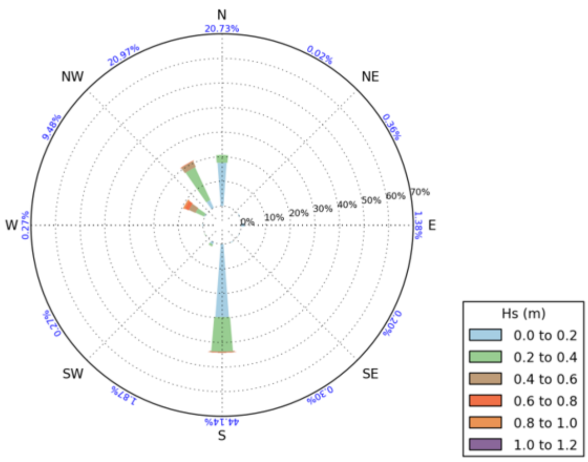
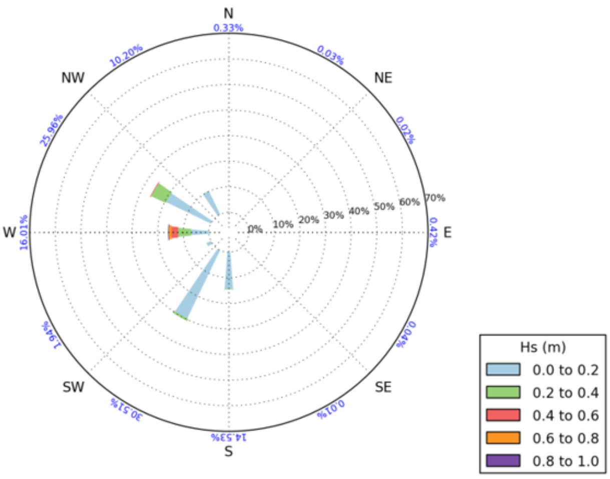


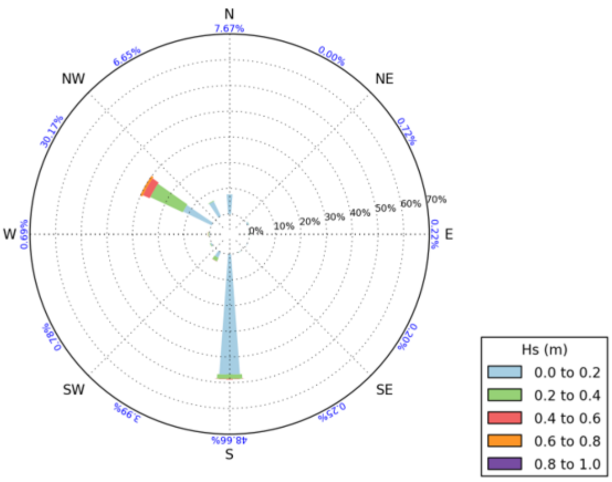
Figure 5.9: Location of wave modelling points



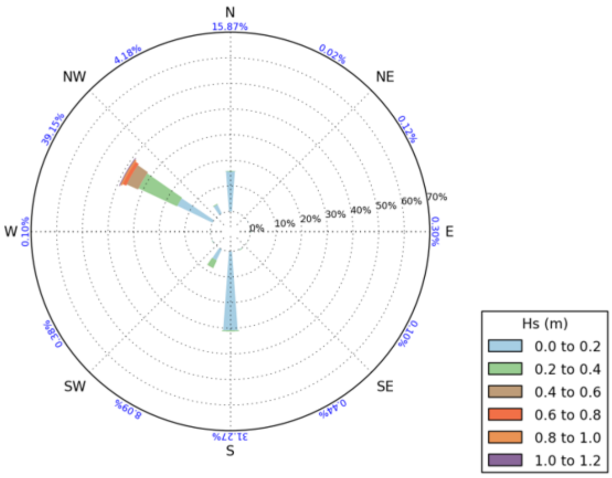
Point 1



Point 2



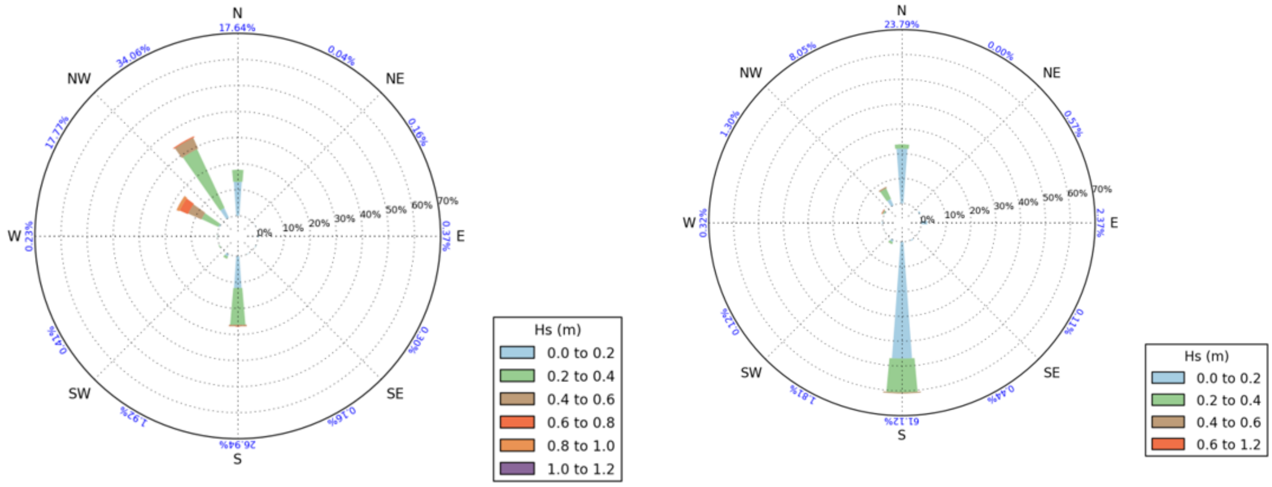
Point 3



Point 4

Figure 5.10: Annual Wave Roses

Figure 5.11 reflects the typical seasonal climate offshore from Sandy Lane Bay in a water depth of 20m (Point 1). During the winter months (November to April), the coastline is exposed to stormier weather. The waves from the north-west dominate (wave heights up to 1m) with some smaller waves from the south (generally less than 0.4m). The beach profile is likely to steepen during this time into a 'winter' profile. During the summer months of May to October conditions are less severe. Southerly waves are prevalent (wave heights generally less than 0.4m). These calmer conditions are likely to provide a less steep beach profile.



Winter months: November - April

Summer months: May - October

Figure 5.11: Seasonal wave roses at Point 1

Storm return periods obtained from the numerical modelling identify 1 in 1yr return period waves of approximately 0.9m (Point 1) and 0.8m (Points 2 and 3) with incident wave directions of 305° offshore and approximately 275-285° within the Bay. These results are supported by observations made during site inspections undertaken 22-24 February 2014 and 24-28 November 2014, where waves were observed coming from the north-west in the Beachlands area and from a more westerly direction for the Sandy Lane Bay area.

Higher return periods have been estimated by modelling hurricane conditions. A 100-year return period extreme wave height of 10.1m with a peak period of 15.3s is predicted at the location on the -20m contour. Further inshore the waves within the shallower parts of the Sandy Lane Bay will be depth limited.

An Acoustic Doppler Current Profiler (ADCP) was deployed (February 2015 and August 2015) within Sandy Lane Bay. The location of this was inshore, at a local sea-bed level of approximately -9mLD. The location of the February installation is given in Figure 5.12. The location of the August deployment was in slightly deeper water. The equipment recorded wave height, period and direction, water turbidity as well as water levels within the bay. Data retrieved from the ADCP was used in the calibration of the numerical wave model and used as a component of the coupled sediment transport model. It is a requirement of the CZMU that this recorded baseline wave data of the hydrodynamic climate be is used to calibrate the numerical models. Details of the initial ADCP deployment recordings are presented in Appendix 5h and in Annex E of Appendix 5g.

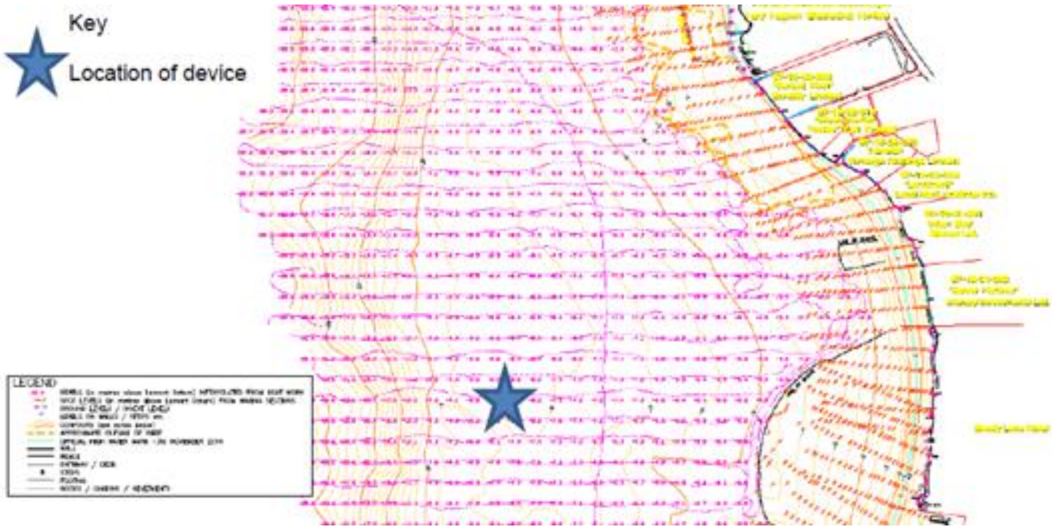


Figure 5.12: Indicative location of ADCP instrument placement

5.2.5.2 Tidal Levels

The tidal range for Bridgetown is shown below in Figure 5.13. This data has been sourced from Admiralty Tide Tables, NP202 Vol 2, 2014. Due to the relative proximity of Bridgetown, these tidal levels have been used for the study area. The average tidal range in Barbados is 0.6m, with an astronomical tidal range of 1.5m. In a micro-tidal environment such as the project area, any tidal currents will not be significant compared to the effects of wave action. Local features, such as the presence of the surf break however, can have the effect of generating localised areas of strong currents. Figure 5.14 shows the tide bar relevant to Lamont Datum (approximately +0.5m CD).

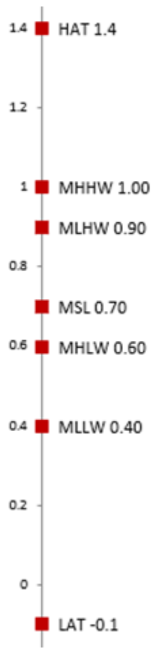


Figure 5.13: Tide bar Bridgetown, Barbados (relative to Chart Datum)

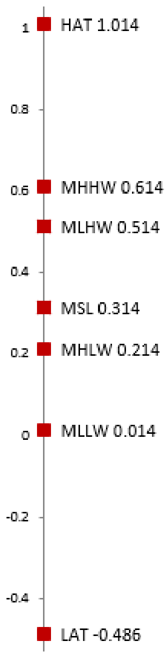


Figure 5.14: Tide bar Bridgetown, Barbados (relative to Lamont Datum)

The tide levels to Lamont Datum have been calculated assuming that Chart Datum is the base datum. All levels in the calculations and drawings are to Lamont Datum. The relationship between Chart Datum and Lamont Datum, provided by HHF Inc, is shown in Figure 5.15.

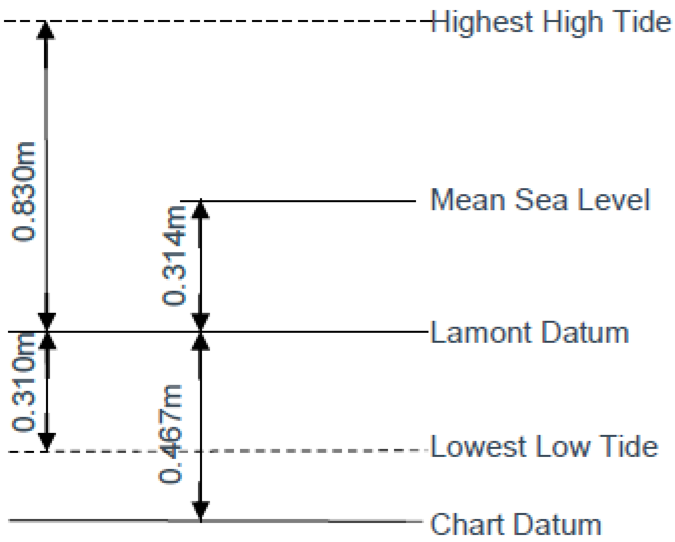


Figure 5.15: Relationship of sea level to Lamont and Chart Datum

Admiralty Tide Tables indicate that mean sea level is 0.7m above Chart Datum, based at Bridgetown, Barbados. Taking HHF's levels, mean sea level is 0.781m above Chart Datum (0.467m + 0.314m = 0.781m), a difference of 81mm.

Work by Miller et al (2012) states that the mean sea level derived from sea level gauges has been confirmed using satellite altimetry and is today 0.34m above the original Lamont Datum. Due to the uncertainty of mean sea level relative to Lamont Datum, the design assumes that water levels are based on levels quoted in the Admiralty Tide Tables. These are converted to Lamont Datum using HHF's mean sea level of 0.314mLD. However, the final version of the Shoreline Morphological Report will include modelling sensitivity analysis on the slight variation in the datums to help assess the impact on the performance of the prospective engineering design.

5.2.5.3 Sea Level Rise

The crest of NES1 is +1mLD. This is equivalent to Highest Astronomical Tide (HAT). The crest levels of NES2 and 3 is -0.3mLD. The depth of water (freeboard) over NES2 and NES 3 is 0.3-0.4m, at Mean Low Water, based upon present day water levels, to accommodate BRI's request that the structures should not be visible above water level.

Estimated sea level rise is given in the Intergovernmental Panel on Climate Change (IPCC) Report 4, discussed in the CARIBSAVE report entitled 'The CARIBSAVE Climate Change Risk Atlas (CCCRA) – Climate Change Risk Profile for Barbados' and in papers by Miller *et al* (2010 and 2012).

Table 5.4 shows the global mean sea level rise for various emission scenarios given by the IPCC. Sea level rise is estimated at 2-5mm/yr across the emission scenarios.

Table 5.4: Sea Level Rise

Projected increases in sea level rise from the IPCC AR4 Scenario	Global Mean Sea Level Rise by 2100 relative to 1980-1999 (m)	Caribbean Mean Sea Level Rise by 2100 relative to 1980-1999 (+/ 0.05m relative to global mean) (m)
IPCC B1	0.18-0.38	0.13-0.43
IPCC A1B	0.21-0.48	0.16-0.53
IPCC A2	0.23-0.51	0.18- 0.56

According to the CARIBSAVE report, global mean sea level rise is 1.8 +/- 0.5mm/yr and that in the Caribbean is consistent with this trend. Miller *et al.* (2010 and 2012) state that the average mean sea level rise globally is approximately 2mm/yr, and that the Caribbean is in close relation with this rate.

According to Miller *et al.* (2010), sea level is falling relative to the land mass at a rate of 1.4mm/yr while the rate of the land mass uplift is between 1mm +/- 1.7mm and 3mm +/- 2mm annually. Therefore, longer term net sea level rise accounting for a corresponding increase in the land mass may be negligible or non-existent.

Early engagement with CZMU (informally) suggests that CZMU assume a sea level rise of 1.6mm/year for this region (160mm/100years). It is assumed that this is net sea level rise and includes tectonic uplift (see Section 5.2.2). This will be confirmed with the CZMU prior to submission of the final EIA. Some numerical modelling sensitivity analysis will be undertaken on a possible future higher sea level.

5.2.6 Shoreline Evolution and Sediment Transport

The reader should refer to Appendix 5g "Shoreline Morphological Response Report" that includes a detailed assessment of the baseline coastal processes and numerical modelling undertaken in assessing the baseline (i.e. no beach recharge or NES's), scheme design and sensitivity runs. This section provides a summary of shoreline evolution and sediment transport that is developed in more detail within Appendix 5g.

Due to the predominant direction of wave attack from the north-west and the north-south orientation of the coastline the primary direction of sediment transport along the west coast of Barbados is in a southerly direction. Work undertaken in the mid-1990's assessed the littoral regime at various locations along Barbados' coastline. Delcan (1995) identified historic trends at numerous locations, comparing historic mapping to aerial photos. Sandy Lane Bay was stated as being "stable" (undergoing no significant erosion or accretion) between 1950 and 1982 with accretion trends recorded in the later stages of the comparison period (1964-82 and 1970-82). The study predicted long term accretion of material within Sandy Lane Bay, although this has not been observed, and instead erosion of beach material has been noted.

Recent anecdotal evidence relating to Sandy lane beach is summarised as follows:

- Prior to 2004, beach width was approximately 15-30ft, (4.57m – 9.14m) at Sunset Reef (verbal evidence suggests that it was possible to play cricket on the beach outside of Sunset Reef – see Figure 4.2).
- Within the centre of Sandy Lane Bay, there has been a 25-30ft (7.6m – 9.14m) decrease in the beach width during the past 8-10 years. The beach within the Bay has also steepened during that time.
- There is seasonal variation in the beach fronting the Leigh House property with an outfall structure at this location occasionally being exposed.

The CZMU has several beach monitoring sites along the west coast. One of the sites monitored is located between the properties Heronetta and One Sandy Lane. Analysis of the data collected for this monitored site between the period 1984 and 2000 revealed fluctuating but steady beach width (see Figure 5.16). It is difficult to clearly conclude that the erosion experienced in the area is mainly due to seasonal swells. This is even more so, especially since data for the last 12 years was not available at the time of this EIA production. However, the observed effects during the scoping study (Blades 2012) does suggest that the level of erosion seems to be attributable not only to seasonal effects, but also to more long term constant impacts on the coastline such as those caused by frequent heavy waves and storm surges.

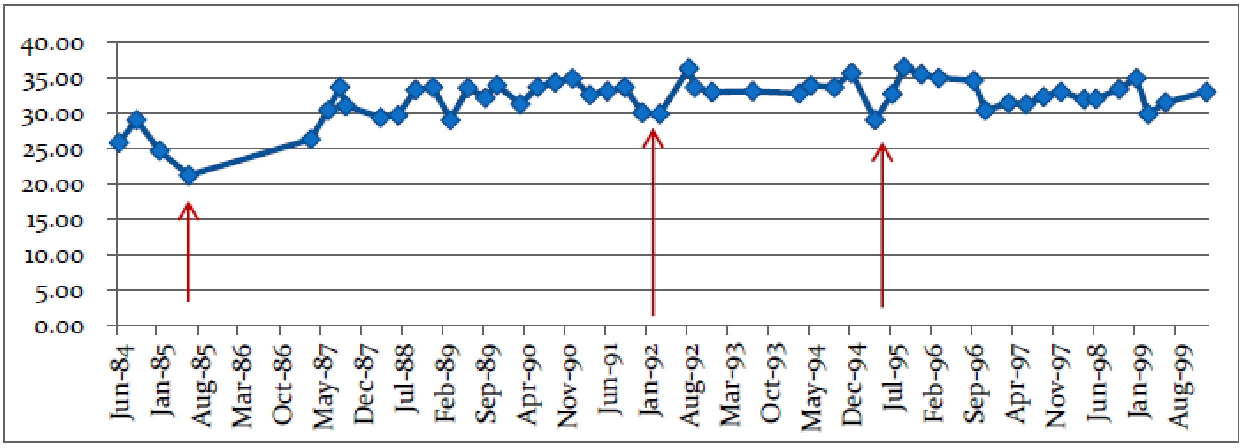


Figure 5.16: Beach width change (meters) during the period 1984-2000 at CZMU beach monitoring site in the areas of Heronetta and One Sandy Lane. Red arrows highlight prominent beach width declines

Beach profiling stations were set out for the study area and new surveys commenced in May 2015 to support the initial topographic survey initiated in November 2014 (see Appendix 5a). The locations of monitoring stations are presented in Appendix 5f. Quarterly reports are to be produced and submitted to CZMU to demonstrate beach stability pre-construction. An annual analysis of findings shall be presented in the updated Shoreline Evolutionary Response Report (see Appendix 5g) that will be provided with the formal EIA submission in 2016.

5.2.7 Sea Water Parameters

5.2.7.1 Sea temperature

The following information (from CZMU 2012 – Figure 5.17) captures the recorded average sea water temperature for Barbados (exact measuring station location unknown) in the vicinity of nearshore marine habitats.

Year	Month	Average Temperature (°C)
2007*	April	28.02
	July	28.40
	December	28.43
2008*	March	26.86
	December	28.05
2009	June	28.23
	July	28.26
	August	28.96
	September	29.00
	October	29.02
	November	28.28
	December	27.58
2010	January	27.17
	February	27.02
	March	27.92
	April	28.20
	May	28.68
	June	29.11
	July	29.01
	August	29.25
	September	29.34
	October	28.80
	November	28.43
	December	27.62
2011	January	27.10
	February	26.52
	March	26.29
	April	26.73
	May	27.42
	June	27.66
	July	27.35
	August	27.77
	September	29.35
	October	28.73
	November	28.23
	December	27.76
2012	January	27.03
	February	26.40

Figure 5.17 Data collected during water quality sampling events (snapshot). All other values from continuous monitoring programme using in situ temperature loggers (source CZMU).

5.2.7.2 Sea Water Quality Parameters

Along the south and west coasts of the island, several of the surface drainage tributary outfalls have been canalized to better control the discharge of surface runoff during periods of peak flow. At these outlet locations a sand bar often forms across the outlet blocking the discharge water from entering the sea. This results in the accumulation of potentially stagnant polluted water behind the sand bar. The sand bar is often breached at times of heavy rainfall thus allowing the runoff to reach the sea. The sand bars may sometimes be breached by mechanical methods to alleviate the problems associated with the stagnant waters (e.g. stench and mosquito breeding) (Brewster & Mwansa, 2001). There are several of these outlets along the coastal frontage of the project area, including at Holetown Hole (north of the project area), Club Barbados, Divi Heritage, Sunset Reef, Sandy Lane Bay, and several small outfalls in Paynes Bay (see Appendix 5i for more detail).

As per any location globally, coastal water quality is integral to the health and viability of a coral reef system. Most reef-building corals require warm, clear, low nutrient (oligotrophic) water with a salinity of between 33g/l and 36g/l (ppt or parts per thousand) (Goldberg, 2013). They are highly susceptible to change in water quality such as eutrophication, sediment load, turbidity, temperature, salinity and toxic chemical load. Sedimentation and the effects of suspended particulate matter are mainly as a result of terrestrial runoff entering the coastal environment via water courses, conducts, drains and terrestrial erosion. The sediments settle out onto the nearshore substrate and can thus reduce light penetration and settle onto any corals or other benthic habitats in the area. The settled out sediment can be naturally re-suspended during periods of high wave energy (Brewster & Mwansa, 2001).

Contamination of coastal waters and deterioration of coral reefs have been linked to inadequate disposal of waste water and other sources of contamination and sediment run off. Along the coast where a sewage system is not yet established, the main forms of waste water disposal are by suckwells (holes dug into the underlying coral), soakaways in sandy areas, packaged treatment plants used by some hotels, septic tanks, and pit latrines mainly in lower income residential areas (GOB, 2000). Coastal groundwater is rich in nitrates as a result of terrestrial runoff from agricultural areas, discharge of domestic sewage effluent, and surface water runoff from storm water drains and watercourses (Brewster & Mwansa, 2001).

The major human health concerns related to coastal waters is in controlling activities and discharges that could affect coastal water quality that is used for recreational activities and bathing. There is a national coastal water quality monitoring programme in place to monitor the bacterial and chemical quality on a monthly basis at the more popular recreational beaches around the west and south coasts. This is carried out by the EED of the Ministry of Health and the CZMU. Standards against which samples are measured are the US Environmental Protection Agency (EPA) for recreational bathing waters (Brewster & Mwansa, 2001). This data is not publicly available.

Water quality samples were taken from a number of locations along the coast of the project area on 27 January 2015. In addition, samples were also taken at Port St. Charles, approximately 11 km north of the project site and at the Flour Mill in Bridgetown Port to provide a control / comparison. Samples were collected between 7.15am and 10.15am from approximately 1m below the surface of the water. Samples were kept in a cool box with ice until delivery at the Government Analytical Services (GAS) laboratory, Bridgetown, who carried out the chemical and microbiological tests.

Water quality standards proposed under the Marine Pollution Control Act set out ‘ambient’ and ‘discharge’ standards (GoB, 2004). Ambient standards are shown in Figure 5.18 and also in Appendices 5j and k. Water quality sample results that do not meet the ambient standards are highlighted in orange in Table 5.5.

Table 5.5 Chemical water quality results

Sample name	Laboratory ID	pH	Dissolved oxygen (mg/l)	BOD (mg/l)	COD (mg/l)	Potassium (mg/l)	Nitrate-N (mg/l)	Ortho Phosphorus (mg/l)	Total Phosphorus (mg/l)	TSS (mg/l)
Port St Charles Inner	201500140	8.3	8.4	1.1	1288	400	0.22	0.02	0.05	10
Port St Charles Outer	201500141	8.2	7.8	1.0	1535	400	0.01	0.02	<0.05	14
Folkestone Marine Park area	201500142	7.9	8.0	1.3	1576	390	0.01	0.02	<0.05	13
Club Barbados	201500143	8.1	7.3	1.3	1529	430	0.01	0.02	0.05	13
Sandy Lane North	201500144	8.2	7.4	1.2	1536	430	0.03	0.02	0.05	14
Sandy Lane South	201500145	8.2	8.1	1.4	1558	420	0.01	0.02	0.05	12
Leigh House	201500146	8.2	8.1	1.5	1907	420	0.01	0.02	<0.05	15
Flour Mill, Port	201500147	8.2	8.1	1.7	3679	420	0.01	0.02	<0.05	12

BOD = Biological Oxygen Demand
COD = Chemical Oxygen Demand
TSS = Total Suspended Solids

Ambient Marine/Coastal Water	
pH	7.0 – 8.7
Salinity ppt	30-38
Temperature ºC	<31
Turbidity NTU	1.5
Total Suspended Solids mg/L	5
Dissolved Oxygen mg/L	6.5 – 7
Nitrates mg/L	0.0098
Phosphates mg/L	0.0025
Enterococci Count/ 100 mL	≤ 35
Faecal Coliform Count / 100 mL	≤ 200
Guidelines based on Draft Ambient Standards for Barbados and LBS Protocol	

Figure 5.18 Draft ambient water quality standards for marine / coastal water for Barbados

Source: Caribbean Environmental Health Institute, http://www.unep.or.jp/ietc/ws/news-nov07/3-1_SaintLucia_Sewage_Needs.pdf

Most of the samples tested met the draft ambient standards. The pH for all water samples fell within the normal ambient range of 7.0 – 8.7 and levels of dissolved oxygen (DO) are above those of the standards (Appendix 5j). DO concentrations tend to be higher around coral reefs due to photosynthesis by coral and aeration from eddies and breaking waves increasing DO levels. These DO levels can fluctuate from 4-15 mg/l, though they usually remain around 5-8 mg/l, cycling between day photosynthesis production and night plant respiration. Many tropical saltwater fish, including clown fish, angel fish and groupers require higher levels of DO, such as those surrounding coral reefs (Kemker, 2014a).

Nitrate levels are raised in the Sandy Lane North sample (approximately three times higher than ambient) and very elevated in the near shore Port St. Charles sample (Appendix 5k - over 20 times higher than ambient). This is potentially concerning as elevated nitrogen levels can lead to increased algal growth, which may smother coral, with knock-on effects to species that rely on coral reefs. Algae have rapid growth rates and where nitrogen levels are higher these are more favourable for algae, which out-compete coral for space. Algal levels are normally controlled by grazing reef fish species (or *Diadema* sea urchin), but can outpace the rate of grazing if the number of grazing organisms is reduced (e.g. by disease induced mortality, or overfishing). High nitrate levels also reduce calcification in coral. Calcification is the process by which hard corals build up calcium in the form of calcium carbonate ($CaCO_3$) and increase their skeletal mass (i.e. grow bigger). The rate of growth of coral off the coast of Barbados has been shown to be lower in nitrogen-polluted waters than in nearby more pristine water (Szmant, 2002; cited in Pastore, 2014). Increased nitrogen levels can make coral more susceptible to disease. Infection rate and disease transfer are accelerated by increased nitrogen levels, possibly because marine fungi and bacteria are nitrogen-limited (Bruno *et al*, 2003; cited in Pastore, 2014).

Increased nitrogen levels may be as a result of sewage inputs to the area, or run off from the land that contains nitrogen from agricultural / horticultural fertilizers or from animal wastes. Given the low levels of sewage-related bacteria in the water samples (see below), the source of nitrogen at these locations is more likely to be from land-based run off. The 2015 Beach Survey (see Appendix 5i) noted that most of the properties which back onto the beach in the survey area have well-managed gardens / lawns. This could be a source of nitrogenous fertilizer. In addition, the Sandy Lane Golf Course is located <1km away on higher ground.

Total suspended solid (TSS) results for all water samples were much greater than the ambient standard (5mg/l), ranging from twice as high (at Port St. Charles Inner; 10mg/l) to three times the standard at Leigh House (15mg/l) (Appendix 5k). High levels of suspended solids can have a range of detrimental effects to marine organisms, including coral and reef fish. The presence of suspended sediment in the water column reduces light penetration and increases turbidity, leading to lower rates of photosynthesis, which will affect coral growth rates. In addition, suspended solids can contain pathogens such as bacteria and protozoa (Kemker, 2014b).

Although the water quality fails to meet ambient levels for some parameters, it is generally good across the whole study area and the in areas sampled for comparison (Folkestone, Port St. Charles, Flour Mill - Appendix 5j). The high degree of algal growth observed on the reefs in the study area (see Section 5.3.3) may not be as a result of current water quality conditions. It is well documented that water quality on the west coast of Barbados has historically been an issue and this, combined with a depletion of grazers (sea urchin and fish), coupled with the low growth and reproductive rate of coral species, may mean that the current state of the reefs is a result of historic damage (from a variety of sources) and slow recovery from disturbance / damage.

Barbados has proposed ambient water quality standards for sewage-based bacteria based on international standards, from the EPA, United Nations Environment Programme (UNEP) and the LBS Protocol (The Protocol Concerning Pollution from Land-Based Sources and Activities):

- Faecal streptococci / enterococci - geometric mean of min. 5 samples should not exceed 35 colonies/100ml in any 30-day period.
- Faecal coliform - geometric mean of min. 5 samples should not exceed 200 colonies/100ml in any 30-day period. No more than 10% samples to exceed 400 colonies / 100ml.

Table 5.6 shows the results of microbiological testing of the water samples (Appendix 5j).

Table 5.6 Microbiology water quality results

Sample name	Laboratory ID	Total coliform (CFU/100ml)	Escherichia coli (CFU/100ml)	Enterococcus (CFU/100ml)
Port St Charles Inner	201500140	4	<1	<1
Port St Charles Outer	201500141	<1	<1	<1
Folkestone Marine Park area	201500142	<1	<1	<1
Club Barbados	201500143	<1	<1	1
Sandy Lane North	201500144	<1	<1	<1
Sandy Lane South	201500145	<1	<1	<1
Leigh House	201500146	<1	<1	1
Flour Mill, Port	201500147	56	17	33

CFU = Colony Forming Units
<1 = limit of detection i.e. no CFUs observed

Although samples were only taken on one day, all samples fell well below the limits for both streptococci/enterococci and coliforms, indicating sewage pollution are not present in any of the sample areas (Appendix 5j).

5.3 Flora and Fauna

5.3.1 Terrestrial Habitats

Details of the Study Area have been recorded in detail as part of a Walkover Survey undertaken in January 2014. The project area is a predominantly urban / developed shoreline, with hotels and private residences, Vegetative cover is subject to a high degree of disturbance from human activity by guests, residents and people using the beach (trampling). The properties along the top of the beach in the project area contain cultivated gardens with a range of plants, many of which are not native to Barbados. Most of the properties fronting the beach are bounded by a wall or fence, to protect the property from erosion, to retain privacy or to provide beachfront viewing / seating for hotel guests, such as at Club Barbados (see Appendix 5i).

There is little natural vegetation along the foreshore. For the most part, where vegetation communities occur, they are composed primarily of non-native species introduced to Barbados (for example, see Figure 5.19).

Figure 5.19: Manchineel trees (*Hippomane mancinella*) along the frontage

There is a vacant lot along the project frontage (Beachlands). Platinum Bay development has started construction works as of May 2015. In these areas the vegetation is less managed, however, it is very similar in nature to those of the adjacent, actively managed plots.

The Holetown Hole lagoon is probably the most natural ecosystem within the foreshore zone of Folkestone Park. The "Hole" is the largest watercourse, with the largest reservoir of brackish water along the west coast. It is a remnant of a habitat type that once dominated the area, and one of the few remaining mangrove lagoons in Barbados. There have been few studies conducted on the biota of the Holetown Hole lagoon. White mangrove (*Laguncularia racemosa*), mahoe (*Thespsesia populnea*), casuarina (*Casurina equisetifolia*), clammy cherry (*Cordia obliqua*), castor oil (*Ricinus communis*), mimosa (*Mimosa pudica*) and at least 45 other plant species are relatively common. The faunal composition is diverse, and includes several species of crabs (e.g., *Uca, Callinectes, Cardiosoma*), insects, spiders, snails, birds (at least fifteen species are common; including the cattle egret which nests there), fish (e.g., tarpons, tilapia), reptiles and mammals.

A number of other mangrove fragments also exist in the Folkestone area: one to the north of Folkestone at Reads Bay; two stands north and south of Heron Bay; and one between the Colony Club and Coral Reef Club. In the area to the south of the reserve, mangrove remnants occur north of Paynes Bay (near the Bamboo Beach).

5.3.2 Terrestrial Fauna

The only remaining extant indigenous mammals of Barbados are six species of bats (see Section 5.3.2.2), about which very little is known (Horrocks 1997). Instead, the mammalian fauna of Barbados is dominated by exotic or introduced species including mongoose (*Herpestes javanicus*), European hare (*Lepus europaeus*), mice (Rodentia sp.) and rats (Rodentia sp.) (RES 2003). The island's ubiquitous green or vervet monkey (*Cercopithecus aethiops sabaeus*) was introduced originally as a pet from West Africa some 350 years ago (UNEP, 1995).

Found only on Barbados is the non-poisonous and rarely seen grass snake (*Natrix natrix*) (RES 2003). The island also has a small harmless blind snake (*Leptotyphlops humilis*), whistling frogs (*Eleutherodactylus johnstonei*), lizards (Reptilia sp.), and red-footed tortoises (*Geochelone carbonaria*) (Government of Barbados 2002; RES 2003). The endemic grass snake (*Liophis perfuscus*) has not been sighted since 1961, likely affected by human, rat and mongoose predation, land clearance, pesticide use, and the spread of field fires (Horrocks, 1997). This species could be considered one of the world's rarest and there is therefore an urgent need to assess its status and initiate a conservation program (GoB, 2002).

None of Barbados' mammals are endangered, with the exception of the raccoon (*Procyon gloveralleni*) should it be proved still extant. There is no published information on the habitat use of the Barbados raccoon but in the unlikely event that a viable population of raccoons still exists. The rarity of this species would make them extremely valuable for scientific, educational and intrinsic values, and for the direct economic value if the animal were exploited as an ecotourism attraction (Government of Barbados, 2002).

The hare (*Lepus capensis*) is rare, presumably partly as a result of a historically growing mongoose population and partly because of hunting by local people (Government of Barbados 2002). Recent rises in numbers are likely due to favoured crops that are being grown, increased availability to grassland that was formerly under sugar cane, and decreased use of herbicides (Horrocks, 1997). Hare would be unlikey to be found in the beach area, even if they were not considered to be rare.

Green velvet monkey (*Cercopithecus aethiops sabaeus*) and mongoose (*Herpestes javanicus*) can be seen in the Folkestone Park Marine Reserve and domestic cats can often be seen making their way in and out of coastal properties along the coast, generally at quieter times of the day (e.g. morning / evening).

5.3.2.1 Avifauna (birds)

More than 180 species of birds have been sighted on Barbados. Since Barbados lies on a major migratory flyway for the eastern North American populations of many shorebird species, over 150 species of migratory birds have been recorded in Barbados, including seabirds (e.g. gulls and terns) and shorebirds (e.g. plovers and sandpipers). Furthermore, bad weather events cause migratory birds to fly low over Barbados, and the presence of suitable aquatic habitat attracts the birds to land. Only a fraction actually nest on Barbados, including wood doves (*Turtur* sp.), blackbirds (*Icteridae* sp.), bananaquits (*Coereba flaveola newtoni*), guinea fowl (*Numida meleagris*), cattle egrets (*Bubulcus ibis*), herons (Ardeidae sp.), finches (Fringillidae sp.) and three kinds of hummingbirds (Trochilidae sp) (Government of Barbados 2002; RES 2003).

The bird fauna of Barbados is much more diverse than the island's mammalian fauna; however,much of the diversity is attributable to seasonal migrants passing through the island on the way to South America towards the end of the year. The resident bird species are relatively few by comparison, the numbers of species having declined primarily due to habitat loss following the island's colonization in the 1600s and through predation by introduced mammals such as the mongoose and the green monkey (Government of Barbados 2002).

Reports estimate at least 36 species of birds are resident and confirmed as nesting in the wild in Barbados including at least sixteen exotics, eight of which occur naturally due to expanded range (although some may have been unintentionally human-assisted), and eight of which have been deliberately introduced (Government of Barbados 2002). Although most of the resident species adapt well to human-altered habitats, and are considered to be common, a few species with more specialized habitat requirements (e.g. Audubon's shearwater and the yellow warbler) are rare. Many of the island's resident avian species are protected under the Wild Birds Protection Act (1985).

The project area has limited intertidal area available for foraging and the nearshore waters are in almost constant use by swimmers, snorkelers, powered and unpowered watercraft, making it generally unsuitable for most bird use. Common Barbados birds such as grackle (*Quiscalus lugubris*) and Zenaida dove (*Zenaida aurita*) are, however, seen regularly in the beachfront properties. The only birds observed on the beach during site visits (Appendix 5i) were small numbers of sanderling (*Calidris alba*), either individually, or in small groups.

5.3.2.2 Bats

Of the six species of bats present in Barbados, one species, *Monophyllus plethodon plethodon*, is an endemic sub-species, and another is likely an endemic subspecies of *Myotis nigricans* (Government of Barbados, 2002). There is no available information on the distribution and abundance of bats in Barbados, except that the house bat *Molossus molossus molossus* is apparently common (Government of Barbados, 2002).

A general lack of knowledge about the ecology of the bats of Barbados makes it difficult to assess additional threats to populations or habitats. As one or possibly two of the bats of Barbados are endemic sub-species, they are therefore unique to Barbados and of significant scientific, educational and intrinsic value (Government of Barbados, 2002).

No regular observations of bats were recorded in the project study area during the times of surveys undertaken (Appendix 5i).

5.3.3 Intertidal and Marine Habitats

5.3.3.1 Intertidal

Between 19 and 31 January 2015, several walk over surveys of the project beach and wider study area were carried out by Atkins and CARIBSAVE staff to document the terrestrial and intertidal habitats along the shore. The results are briefly summarised below and the full report can be found at Appendix 5i. This also includes an initial beach and nearshore risk assessment exercise carried out in February 2014.

The intertidal zone within the project area is characterised by sandy beach habitat. There are also areas of hard substrate, some of which is natural (coral rubble) and some of which is man-made (walls, rock revetment, concrete boardwalk at Holetown- north of the study area). The sandy foreshore is sparsely colonised, with the most conspicuous species being the burrowing ghost crabs (*Ocypode quadrata*). Burrows can be seen along much of the shore and the easily disturbed crabs can occasionally be seen darting back into their burrows (Figure 5.20).

Figure 5.20 - Ghost crab burrow / Scuttle crab

The areas of hard substrate are predominantly lacking any algal colonisation. The most abundant species present are numerous molluscs (*Turbo castanea*) and scuttle crabs (*Grapsus grapsus*).
The most landward edge of the shore is bounded by private properties and hotels, with each having some form of wall demarking the boundary between the property and the beach. The majority of the properties have managed gardens with lawns, shrubs, hedges and some large trees, which provide shelter for birds. The only property that backs on to the beach in the study area which is not currently managed / landscaped is the 'Beachlands' plot, which is currently vacant and is in a more overgrown state.

5.3.3.2 Marine

A survey of the reefs in the study area was carried out by Carib Marine Contracting & Research during 2015.This survey was comprehensive and (at the time of the survey) needed to consider the possibility of a fourth NES structure to the south of the study area. This was subsequently DELETED from the scheme, though the survey remains thorough and addresses this southern most location as if an NES4 were to be constructed.

Specific detailed reports have been produced and these are included as Appendices 5l and 5m. The techniques and methodologies adopted are listed below:

- Photographic survey of shore-parallel belt transects – using surface and sub-surface boat tows to rapidly identify habitats / communities and long swims to identify reef species.
- Establishment of seven (7) long term monitoring sites to allow post construction monitoring / comparison (see Appendix 5l), including quadrat and belt transect surveys. Six (6) sites are within the study area, while the seventh is a control site, outside of the area (at Greensleeves reef, 6.5km from the site).
- Survey within the footprints of the proposed submerged engineering structures, plus a 'buffer' to take account of slight amendments in breakwater design (see Appendix 5m).
- Survey within the footprint of any predicted areas of sand accretion in the lee of the NESs (see Appendix 5m).

A summary of the findings is presented below.

The coastline and marine area is characterised by fringing reefs, which extend outwards (seawards) from the shore, interspersed with sandy bays. Fringing reefs may extend as far seaward as 200m from shore. Within the Folkestone Marine Reserve there are four well-developed fringing reefs, several patch reefs and an offshore bank reef. Sand areas separate the three reef types within and beyond the boundaries of the Reserve. Benthic fauna in these areas include worms (*Bispira variegata*) and occasional urchins (*Tripneustes ventricosus*), however, there is little information on the fauna of these sandy areas (Axys, 2000).

Patch reefs are not attached to the shore though are found in water depths ranging from 3m to 40m. They are irregular in shape, size and species dominance. On the west coast they occur in the shallow areas and bays between the shore and the fringe reefs, or between the fringe and bank reefs. There are several patch reefs within the study area.

Bank reefs are parallel to and separated from the shoreline. They are found 500m – 1,200m from the shoreline in deep water with the crest of the reef ranging from 15m to 30m below the water surface (along the west and south coasts). In some instances the reef crest occurs in much shallower water with the top of the reef at or near the surface thereby creating a wave break. This latter condition results in the reef being termed a bank barrier reef. This reef structure is found on the south east coast and southern sections of the east coast of the island (Brewster & Mwansa, 2001). Bank reefs on the west coast have changed little over the 1982 to 1992 decade, but deteriorated somewhat between 1992 and 1997. In particular the bank reef location closest to the Holetown Hole shows signs of water quality stress, and bank reef sites in the reserve that are heavily used recreationally (e.g., Dottins Reef) show considerable localised anchor damage, as do patch reefs in the FPMR (Axys, 2000). There are no bank reefs in the project area where the NESs and beach nourishment interventions are planned.

An important habitat type found within the project area is coral rubble. Coral rubble is a product of the erosion of coral reefs, created when high energy waves break fragments off of the reef and transport the pieces into the nearshore and beach areas. The rubble is deposited in shallow areas and becomes partially buried in sand. It can then be colonised by various marine invertebrates (sponges, soft corals, tunicates, sedentary polychaetes, anemones), algae (coralline turf and macro algae) and sea grasses. The rubble habitat is also important as a nursery and shelter area for most juvenile marine organism including important reef fish, gastropods, molluscs, and sea urchins (Brewster & Mwansa, 2001).

The health of the fringing and patch reefs in the project area and surrounds is very variable. The fringing reefs within the FPMR, along with others on the west coast deteriorated substantially between 1982 and 1992. Coral abundance decreased by 40-50 percent and turf algal abundance increased by 150-200 percent (Axys, 2000; Blades *et al*, 2012, GOB, 2000). The grazing sea urchin *Diadema antillarum* (known locally as 'cobblers') suffered a severe mortality (of about 94 percent of the population) in 1983, significantly decreased grazing pressure on fringing reefs. This resulted in substantial increases in algal turf abundance on the reefs and *D. antillarum* populations have not recovered. Parrot fish and other urchins (*Tripneustes ventricosus*, also known as sea eggs) that graze the reefs are also depleted.

There is evidence of coral bleaching on Sandy Lane Bank Reef which resulted from mass bleaching events in 2005 and 2010 due to increased temperatures. According to an assessment of the reefs in the area between 2008/2009 (Blackman and Goodridge, 2009, cited in Blades *et al*, 2012) 4% of coral population and 33% individual coral colonies on the Sandy Lane Bank reef showed signs of bleaching. The assessment also found that Sandy Lane Bank Reefs exhibited signs of boat / anchor and other types of coral damage. The same assessment highlighted low fish abundance on fringing reefs highlighting that key reef fish species such as groupers, butterflyfish, snappers and moray eels were not evident. Invertebrate species such as flamingo tongue, lobsters, banded coral shrimp and sea eggs were limited to non-existent on the fringing reefs. They also report high levels of algal growth on the fringing reefs. No black sea urchins (*D. antillarum*) were found on Sandy Lane Bank reef.

Anchor damage, algal turf growth and limited numbers of grazers (cobblers and parrot fish) were also observed on the reefs in Sandy Lane bay and in the area around the Vauxhall patch reef during site visits on 26 and 27 January 2015. One, very small *D. antillarum* was observed. It is stressed that these issues are not confined to the reefs in Sandy Lane or the wider project area; 80% of Barbados' fringing reefs are reported as seriously degraded (GOB, 2010).

Based on the Carib Marine Contracting & Research (2015) survey results (see Appendix 5m), six distinct and sometimes overlapping habitat types were identified within the study area (see Table 5.7 and Figure 5.23). Of note, coral coverage tended to increase with increasing distance offshore and algal coverage shifted from turf algae to macro-algae, although coverage remained relatively high.

Table 5.7 Marine Habitat types

Habitat Type	Description
Bank Reef	Offshore reef running along the coast in water depths ~ 14-30 m
Patch Reef	mid AOI variable reef habitat between ~ 8-14 m. Approx 250-350 m from shore
Relic Fringing Reef	Estimated with less than 5% live coral cover. Holds shape of fringing reef but not the live health
Fringing Coral Reef	Coastal reef system with more than 5% live coral cover
Rubble	Beach rock, relic reef with no apparent reef structure
Sand	Inter reef calcium carbonate based sediment. No predominant reef or rock structure

Figure 5.21shows the benthic coverage at each of the monitoring sites in the study area and the control site at Greensleeves.

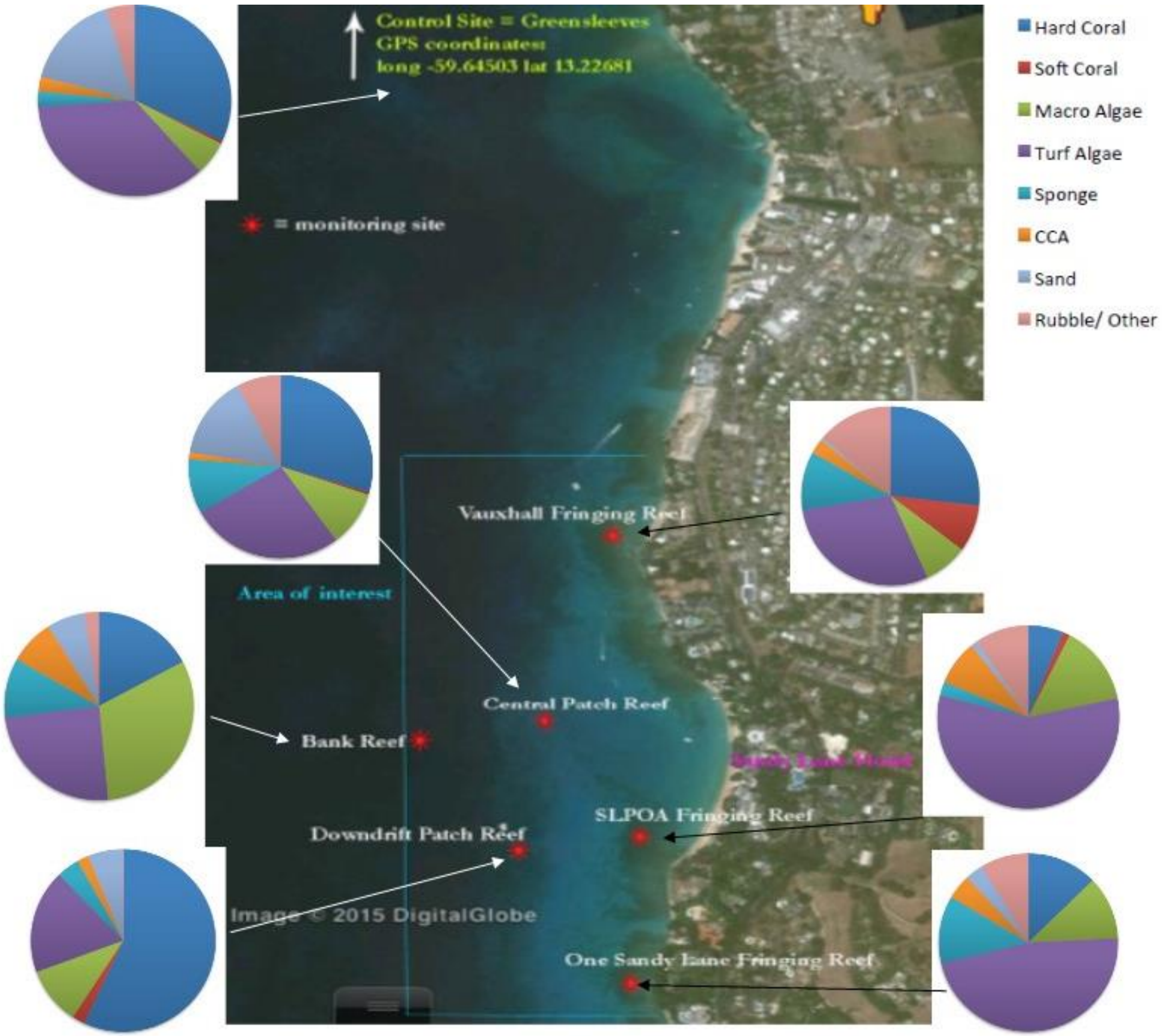


Figure 5.21 Benthic coverage at reef monitoring sites

The recent 2015 survey work (Appendices 5l and 5m) shows that marine ecosystem health increases with distance from the shore. In the nearshore area, from low water mark (LWM) to 70m offshore, most of the fringing reefs were moribund, lacking reef structure and had <5% hard coral coverage and generally over 50% algal coverage, with very few fish seen in these areas. Turf algae was the dominant species in the nearshore area of relic reefs.

The shallower sections (HWM - 45m from shore) of the fringing reefs within the study area are dead, or at the very least moribund. More specifically, the shallowest part of the habitat is more accurately described as algal flats, as opposed to 'coral reefs', due to the prevalence of algae. The turf and macroalgae assemblage peaked on the shallow SLPOA (71.25%) and One Sandy Lane frontage (63.75%) monitoring sites. It was also approximated that 25% – 50% of the corals on the fringing reefs showed some form of stress such as: bleaching, diseases, partial mortality on the upper surfaces, physical damage, or more often algal overgrowth. The more productive parts of the fringing reefs were only estimated to have an average percentile of hard coral of only 15.25%.

Coral and fish abundance (see below) tends to increase on the "spurs and grooves" of the outer edges of the fringing reefs, although it remains very low for a tropical reef. Several corals were being smothered with the boring sponge *Cliona deletrix*, which is often an indicator of sewerage in the water column (Figure 5.22). Water quality samples taken during January 2015 (see Appendix 5j) however, show low levels of bateria normally associated with sewage in the water (see Section 5.2.7). Despite this finding, as there is no long term publicly available water quality data, it is not possible to comment on average or historic water quality.

Twenty five species of hard coral were observed in all surveys, however, not all species were present on all three reef types (fringing, patch and bank). Coral bleaching and coral disease was observed on all three reef types, as was evidence of fishing and anchor damage.

Figure 5.22 Relic reef in the inner fringing reef zone of the study area; *Cliona deletrix* (boring sponge)

Findings suggest that the patch reefs areas appear to be in a healthier state than the fringing reefs, however, reef fish abundance and diversity remained low (see section below). Coral abundance on some of the patch reef transects exceeded 62%. Coral abundance was greater again on the bank reef (see Appendix 5l).

5.3.3.3 Coral Rehabilitation Programmes

A sunken steel barge is situated to the north west of Vauxhall Reef. This was one of the recipient sites for coral reef transplantation during 2001/2002 when over 750 hard corals were moved from Barbados Port to Vauxhall (see Figure 5.23).

Figure 5.23 Transplanted coral on the sunken barge at Vauxhall

The high degree of algal growth observed on the reefs in the study area may not be as a result of current poor water quality, as it appears to be generally good across the whole study area (see Appendices 5j and k). It is well documented that water quality on the west coast of Barbados has historically been an issue influencing coral health and this, combined with a depletion of grazers (sea urchin and fish), coupled with the low growth and reproductive rate of coral species, may mean that the current state of the reefs is a result of historic damage (from a variety of sources) and slow recovery from disturbance / damage. This is not a proven hypothesis, but a possible explanation. It does, however, highlight the importance of reducing potential sources of additional disturbance / damage to already stressed coral habitats.

5.3.3.4 Coral Coverage in the "Footprint" of each NES

Table 5.8 and Figures 5.24 and 5.25 summarise the habitats and coral found within the footprints of each NES. The areas surveyed as potential footprints included the maximum physical area that each NES could cover, with a 'buffer zone' around each structure, which extended 15m seaward and 45m landward of the mid line of each structure (Appendix 5m). The area of the buffer takes account of any minor amendments in the alignment or location of the NESs, along with the area that could be affected by the construction process.

Table 5.8 Habitats and species within proposed NES footprint area

Nearshore Engineering Structure (NES) footprint	Habitats and species present
NES 1	Northern edge of the breakwater is within <1m of the reef spurs of the fringing reef fronting Club Barbados. Approximately 14 viable hard corals within the footprint. Most are 10 – 25cm diameter, although two larger mounds were observed. Two of the *Diploria* (brain coral) colonies were not complete coral mounds as the tops were moribund and had well established turf and macro algae growth.
NES 2	Footprint dominated by sandy bottom that appears to be part of the dynamic littoral zone.
NES 3	As for breakwater 2
NES 4 *(excluded from the scheme)*	Runs approximately parallel to the Sandy Lane Property Owners' Association fringing reef. Water depth is approx. 2.5m – 3m. Approximately 12 hard corals are within the footprint, just seaward of the reef spurs. Largest coral colony was 55cm diameter.

Figure 5.25 shows the same information, but being overlayed on aerial photography of the study area. It should be noted that NES 4 is no longer part of the proposed works, however, the area was surveyed for completeness.

The “buffer zones” were surveyed for all corals and sensitive marine communities present (Appendix 5m). In addition, the survey sought to identify hard corals with the potential for transplanting, should it be necessary. Generally in order to be suitable for transplanting, it is preferable to have hard corals, with a diameter of greater than 5cm and exhibiting no signs of distress, either from parasities, diseases or bleaching.

Finally, since the purpose of the proposed scheme is to result in a widened beach, both through beach replenishment and then subsequently natural accretion, it was important to assess the zone of likely accretion / replenishment to ensure that no sensitive marine species, including corals would be adversely impacted.

Approximatly 45 % of Buffer Zone 1 (Northern Breakwater) overlaps with the fringing reef. Approximately 290 corals were estimated to have been observed within the identified “buffer zone”. Live coral cover was seen to be higher in the spur and groove sections of the reef. The brain coral (*Diploria* spp) was identified as the most abundant, with the star coral species *Montastrea* sp also prevelant. In general they were observed to be 10 – 30 cm in diameter with approximatly 30 percent of the corals showing signs of distress.

Also observed were the starlet coral (*Sidastrea sidarea*) and the mustard hill and finger corals (*Porites spp*).

The majority of the Buffer Zones 2 and 3 coincide with a large expanse of loose fine sand in the centre of Sandly Lane Bay. There is a small area of coral rubble boulders in the northerly of the two buffer zones. No sensitive marine communities were observed within either of the “buffer zones”.

Although 17 *Acropora* colonies were observed within the overall project area, no *Acropora* colonies were observed within any of the buffer zones observed although one small cluster was found landward of the demarcated buffer zone (NES 1). It was also evident that many “different” colonies were fragments of the same parent colony that were propagating via asexual fragmentation.

Acropora palmata was the most abundant *Acropora* species observed however smaller stands of *A. cervicornis* and *A. prolifera* were also observed in the northern end of the study area of interest (AOI). As the AOI is within the Folkestone Marine Park and some of the rare and sensitive *Acropora* colonies are still being physically damaged, it is further proposed that some of these damaged colonies be recovered and used to seed the NESs and/or coral nurseries (see Section 11).

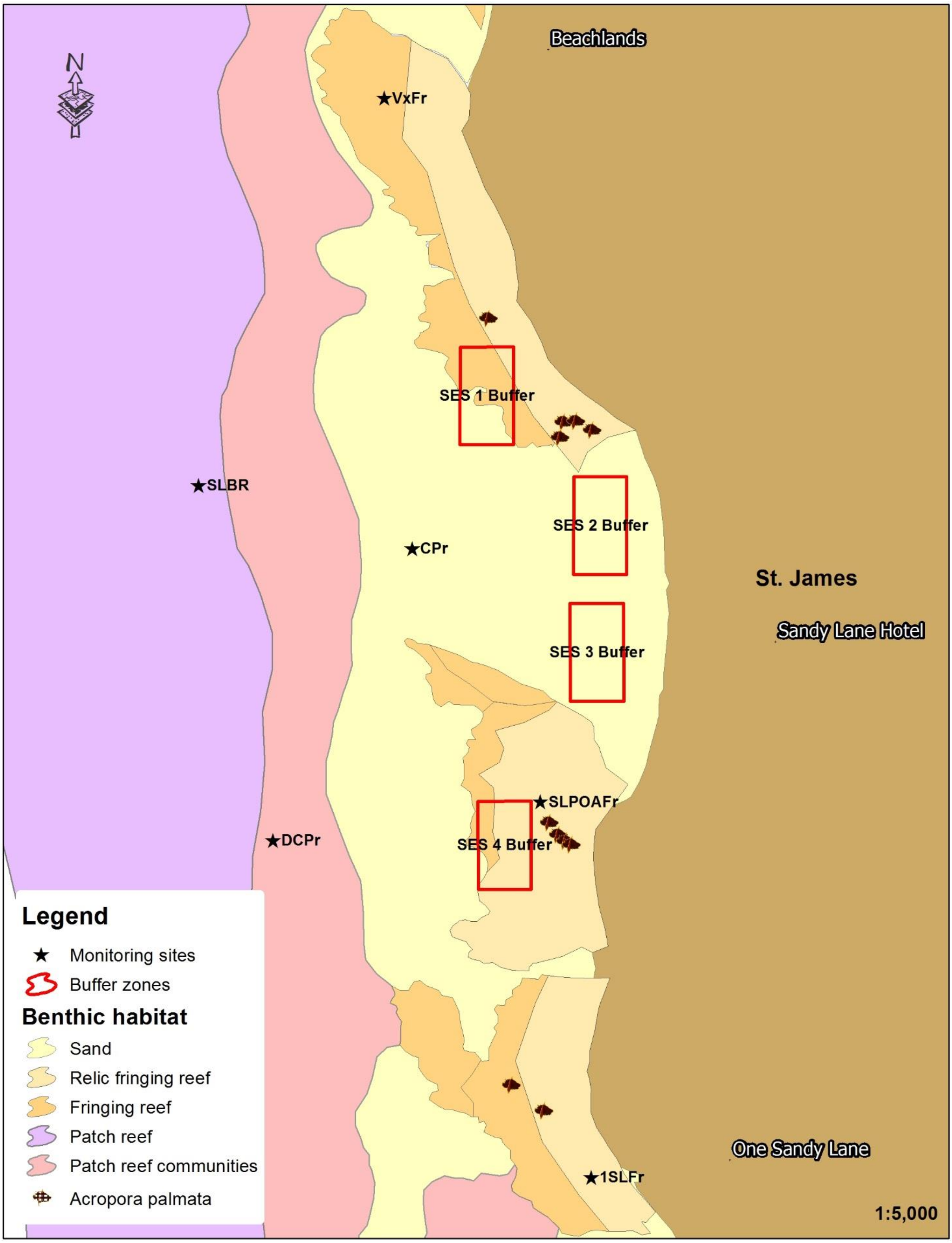


Figure 5.24 – Benthic habitats and location of *Acropora* stands within the study are and NES footprints (*NB: NES 4 is NOT part of the proposed scheme but is included for completeness).*

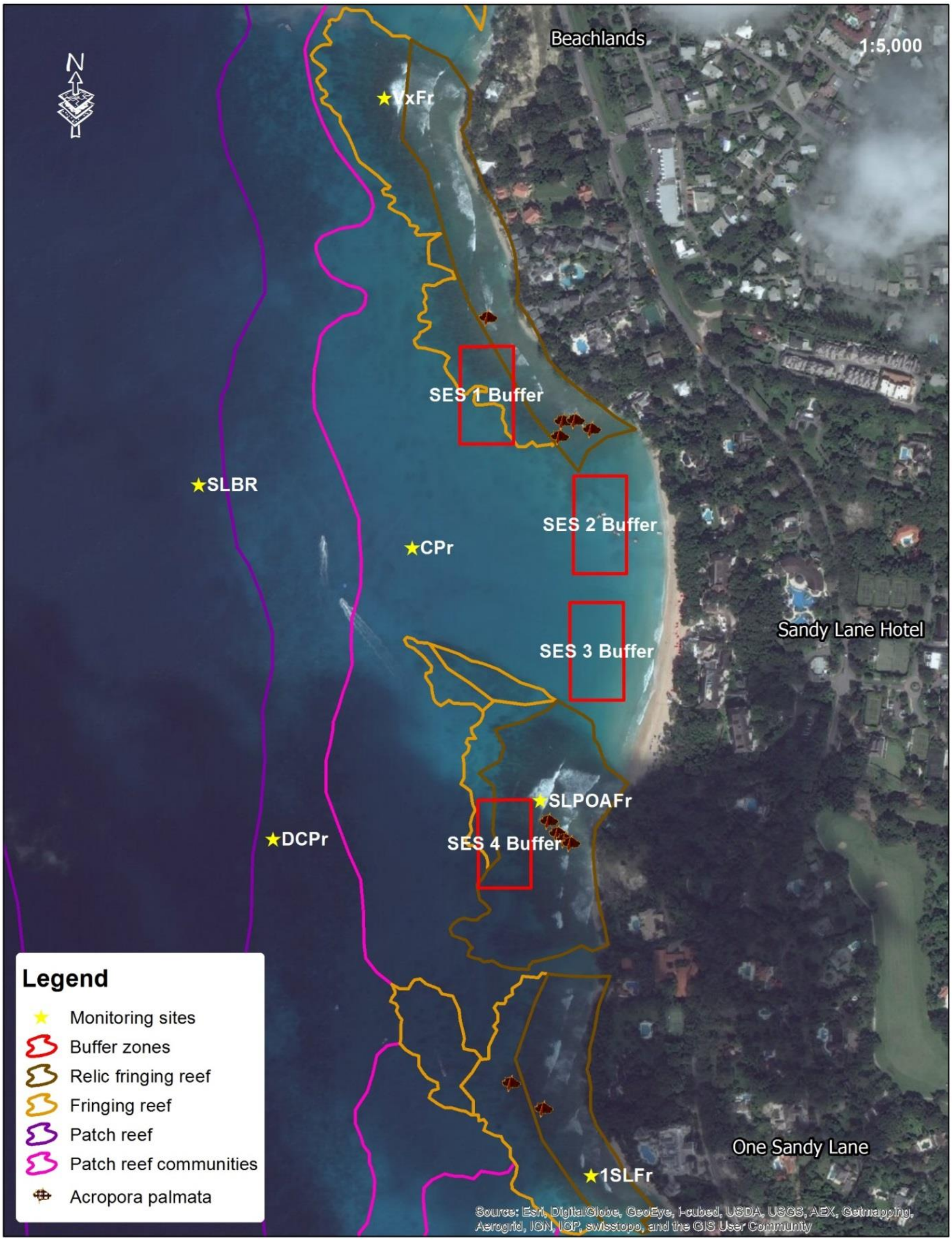


Figure 5.25 – Benthic habitats and location of *Acropora* stands within the study are and NES footprints (*NB: NES 4 is NOT part of the proposed scheme but is included for completeness).*

5.3.4 Fish and Invertebrates

It is reported that fish abundance on west coast reefs is low due to historical over-fishing, poor habitat quality, and the severe disease-induced mortality of reef-associated fish that occurred in 1994 whereby mortality rates were between 73% and 85% (Axys, 2000).

Reef fish are subject to fishing pressure, although fishing is prohibited in the FPMR, except for cast net fishing. The most frequently caught fish in the shallow reef fishery are goatfish, grunts, groupers, parrtofish, squirrelfish and surgeonfish (GOB, 2000).

More structured surveys of the reef fish were undertaken as part of the marine surveys carried out by Carib Marine Contracting & Research during 2015 (see above and survey report in Appendix 5l). The surveys recorded 42 species of fish across all surveys. Reef fish abundance and diversities were calculated for each of the monitoring sites (see Table 5.9). They also observed several fish pots and discarded fishing gear in the survey area, at the edges of the fringing reefs and around the patch reefs.

Appendix 5l also shows that the sandy "spur and groove" areas, tend to be largely free of fish, with the exception of individual rays, flounder, flying gurnards and small trunkfish. Fish abundance was greater on the patch reefs than on the fringing reefs or on the sandy areas between reefs. Common species observed on the fringing and patch reefs in the project area during 24 – 26 January 2015 site visits included Sergeant majors, blue headed and yellow headed wrasse, parrot fish and blue tang. A small moray eel was also seen. Mid-water species such as chromis, silver sides, creole wrasse were observed in small schools. Larger individuals and small schools of grazing fish species such as parrotfish, blue tangs and surgeonfish were also seen on the patch reefs, as were predatory fish species (mahogany tail snappers, grunts, bar jacks).

Fish abundance and diversity was greater at the bank reef monitoring site, although still lower than would be expected, with barracuda and mackerel observed, along with parrotfish, snapper, jacks and hogfish. Evidence of pot and line fishing was again seen on the reef.

Table 5.9 Fish abundance and diversity at monitoring sites

Monitoring Site	Abundance No. fish/10m^2	Diversity No. spp./100m^2
Vauxhall	43.2	17
SLPOA	12.0	15
1 Sandy Lane	18.4	12
S Patch Reef	37.0	18
N Patch Reef	31.8	15
Sandy Bank Reef	26.2	22
Control- Green	22.6	17

Mobile invertebrate presence was very low with only three juvenile spiny lobsters observed, along with a few crabs and a small number of brittle stars in all the surveys. No mobile invertebrates were seen during the snorkel site visits carried out in January 2015.

As described above (Section 5.3.3.3) a sunken steel barge is situated to the north west of Vauxhall Reef and is populated by reef fish, corals and sponges. The fish are attracted by artificial feeding from the glass bottomed tourist boat trips. Large numbers of fish were observed around the barge during snorkelling site visit on 26 January 2015, including Sergeant major fish, Bermuda chub, trunkfish, and ray (Figure 5.26).

Figure 5.26 Fish species seen around the barge, near Vauxhall patch reef – Bermuda chub and Sargent Majors; ray;

5.3.5 Turtles

There are three species of turtle that can be found in Barbados – the green turtle (*Chelonia mydas*), the leatherback (*Dermochelys coriacea*) and hawksbill (*Eretmochelys imbricata*). The green turtle feeds on sea grass and algae, particularly on the south and east coasts, but does not nest on Barbados. Analysis of genetic material from the local green turtle population has revealed that the green turtles seen around Barbados are from Ascension Island, Aves (Bird) Island, Surinam, Costa Rica, Florida and Mexico (Barbados Sea Turtle Project (BSTP) website – www.barbadosseaturtles.org).

The leatherback is primarily an oceanic species, only coming ashore to breed and nest. A small number nest on the east coast of Barbados and so is unlikey to be found in the area of the project (see Figure 5.27).

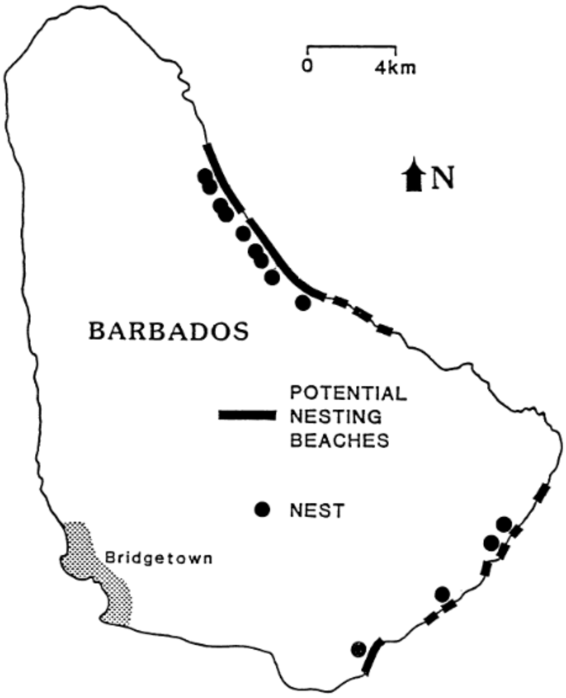


Figure 5.27 Locations of potential nesting beaches and actual nests for the leatherback sea turtle (*Dermochelys coriacea*) in Barbados (1984-1991). (From Horrocks 1997).

The hawksbill (*Eretmochelys imbricata*) is found along the west coast of Barbados and nests all year round, with activity peaking in June and September (BSTP). Coral reefs in Barbados provide critical habitat for both juveniles and adult hawksbill turtles. Juveniles reside in Barbados year round, while adults migrate to Barbados to breed (Beggs, *et al*, 2007). Hawksbill turtles have been seen foraging and nesting within the FPMR, although nesting activity is greater to the north and south of the reserve than in central areas, because central beaches are typically narrower and more brightly lit (Axys, 2000). Hawksbill turtles come ashore to lay their eggs on the island's sandy beaches on a regular basis, whereas the leatherback turtle is an occasional nester (RES 2003). Data suggests that the number of hawksbills nesting on Barbados has increased by up to 8 times in the ten years since 1992 (Figure 5.28).

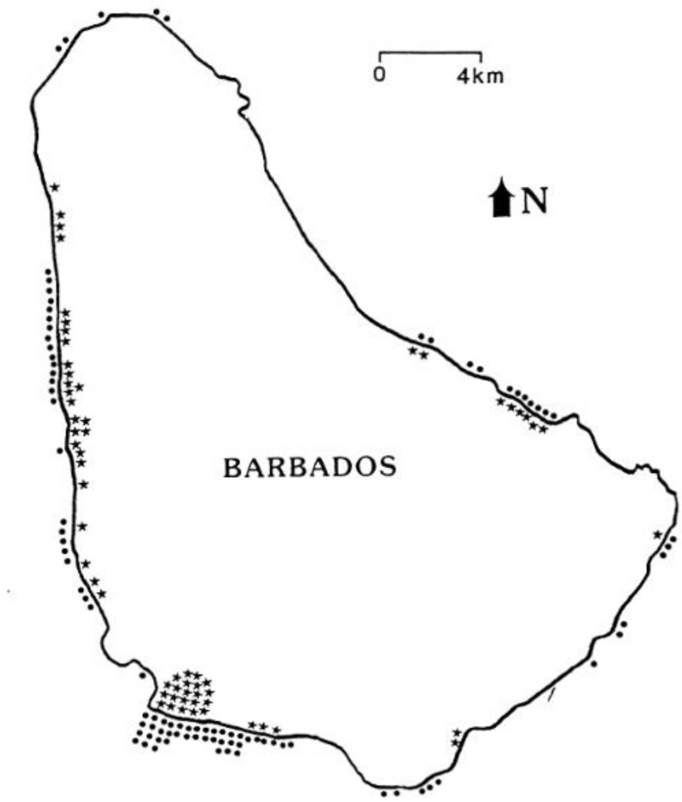


Figure 5.28 Location of hawksbill sea turtle (*Eretmochelys imbricate*) nests reported by the public in 1990 (stars) and 1991 (dots) (From Horrocks 1997)

It is likely that hawksbill turtles are present in the vicinity of the project, as this is within and close to the FPMR and tourist vessels offering turtle sightings operate along the coast, off of the Sandy Lane Hotel and other properties within the project area. The beach at Sandy Lane is, however, likely to be too busy for turtles to use as a nesting site. Despite this there is always the potential for turtles to nest there, as the beach remains relatively wide, compared with other beaches along the west coast. The most significant nesting occurs on the beach at Needham's Point, although other high-density nesting beaches occur along the west coast between Speightstown to the north and Fitts Village to the south, and along the south coast between Rockley and Dover (Betts *et al*, 2007).

5.3.6 Marine mammals

Marine mammals are not frequently seen in Barbadian waters; some species however, particularly bottlenose dolphins (*Tursiops truncatus*) and humpback whales (*Megaptera novaeangliae*), are occasionally seen offshore. None were recorded during the time of the project surveys (2015 – see Appendices 5l and 5m).

5.4 Human Beings

5.4.1 Social Setting

Adjacent to Sandy Lane Hotel, the surrounding residential properties are relatively consistent in size and value and this represents the social economic dynamics in the area, which are characterized as having predominantly an established, high to middle income population. To the south of the Resort the housing areas of Paynes Bay are generally mid to low income residents, as is the area to the east, which additionally has a mixture of small commercial properties and the Esso petrol station south of Tamarind Hotel resort. Paynes Bay beach is a popular bathing area for residents and tourists.

5.4.2 Demographics

The most recent national census (15th national census) was carried out in 2010 though not published until October 2013. Barbados' population stood at 277,821 persons. Statistics show that for St James Parish, the population had increased from 21,000 (1990) to 28,498 (2010), an increase of over 35%. There were 10,116 dwelling units with 338 Townhouses/Condominiums of which at the time of the survey only 38 were occupied(BSS, 2013) (11% occupation).

5.4.3 Land Use

The project area is located in the Parish of St James on the west coast of Barbados in what is considered the island's premier tourism zone. It falls largely within the the Folkestone Park and Marine Reserve (FPMR) (see below for details). There are several private properties and luxury hotels along this stretch of coastline which includes (from north to south) Bali Hai, Divi Heritage, Club Barbados, Sunset Reef, West We Go, Land Fall, Sandy Lane Hotel, Laughing Waters, Leigh House, Yeoman's Point, Bouganvillea, Bonaventure and Heronetta.

The types of existing land use that occur in the Project Area (as defined within the PDP) are set out below:

- Agricultural: Areas of land that are used primarily for agricultural purposes;
- Residential: Areas where the use of the land is primarily for residential dwellings and homes;
- Commercial: Areas that have predominantly commercial operations such as shops, restaurants, bars, gas stations, etc.;
- Industrial: Areas that are used primarily for industrial purposes including airports, generating stations, cement/asphalt plants, warehouses, factories and storage;
- Institutional: Areas that are used primarily for institutions such as government, churches, schools, libraries, etc.;
- Employment: Areas that are intended to accommodate General Industrial and Light Industrial uses;

The site is a 40 minutes drive from the airport and a twenty minute drive to Bridgetown with direct access to the highway. Landfill facilities are available 10 minutes drive to the north near Lancaster, and recycling facilities are centered north of Bridgetown around Warrens. Local commercial enterprises are predominately small.

Environmentally Sensitive Areas (ESA) are areas that are recognized, either by legislation, the scientific community or the general public, as being a particular component of the ecosystem that is especially sensitive to disturbance by anthropogenic events. The National Physical Development Plan (1998) also lists a number of Significant Natural Features and Hazard Lands. A number of areas of inland Barbados would be categorized as environmentally sensitive areas, including:

- Gullies;
- Escarpments;
- Chancery Lane Swamp;
- Harrison Caves;
- Public Parks and Open Spaces;
- Nationally Protected Landscapes;
- Natural Heritage Conservation Areas;
- National Forest Candidate Sites; and
- Coastal Management Zones.

The Project Area only encounters the latter ESA (Coastal Management Zones).

5.4.4 Health

The national health profile of Barbados is characterised by a decrease in the incidence of some communicable diseases, with the exception of HIV/AIDS and vector borne diseases, possibly dengue fever, and a rise of chronic non-communicable diseases (CNCDs) (PAHO, 2008). A number of health challenges have been identified. This include an elderly population, increases in CNCDs as well as vector-borne diseases, and the increased cost of providing adequate health care (Government of Barbados, 2008).

5.4.5 Solid Waste Management

Sound waste management and disposal is challenged with the significant volume of solid waste being generated on the island. Solid waste is mainly generated by the importation of large volumes of consumer items. This high volume is due to the high population density on a small land area and the annual stay-over tourist arrivals that almost double the local resident population at any given time. The main method of sanitary solid waste disposal is by sanitary landfill at the main facility at Mangrove, St. Thomas. The island experiences illegal dumping by private citizens and businesses in gullies, quarries and on roadsides. This has contributed to breeding sites for vector borne disease agents. (Carter & Singh, 2010).

5.4.6 Water Production and Supply

Barbados' primary source of potable water is from rain-fed natural aquifer located within Pleistocene coralline reef formations that overlie the island's oceanic base. Barbados is classified as a water-poor country based on estimated potable resources versus population. The problem is well recognized the GoB, through the Barbados Water Authority (BWA) has been working proactively to stay ahead of them. For example, the BWA has been augmenting the supply by injecting desalinated water into the system. One of the contributing factors is that about half of all water production is classified as "unaccounted for," meaning that it is lost through leakage of aging pipes and other defective equipment, or through unmetered consumption. The government is planning refurbishments to the water mains as an additional measure. Another option being considered is the expansion of the two existing desalination plants that supply 20% of the potable water. In addition, a recent regulation requires all new residences to install rainwater cisterns to supplement water supply for to irrigation and other non-potable use. Despite the efforts of BWA, with growing per capita consumption, a rebound in tourism, and the cyclical nature of rainfall intensity, it is conceivable that water resources will be increasingly strained. Several recent studies on the implications of climate change for water resource management on Caribbean tourism also suggest that Barbados is likely to see the issue of water scarcity exacerbated by climate change.

The project shall place no additional burden on water production and supply.

5.4.7 Waste Water Treatment and Sewage Disposal

Barbados has a limited sewer system and two wastewater treatment plants (WTPs) at Bridgetown and on the South Coast. The two sewer mains are also in Bridgetown and along the South Coast. The GoB is considering installing a municipal West Coast sewer, but discussions have been ongoing for over a decade and have been placed on hold indefinitely. For now, coastal developments including Sandy Lane Hotel are required to have their own tertiary treatment plants.

The project shall place no additional burden on waste water treatment or sewage disposal.

5.4.8 Tourism

Tourism remains one of the largest growth industries in the world and continued benefit to Barbados is dependent on the provision to visitors of an acceptable natural and built environment. There are few parts of Barbados where the hand of human intervention has failed to leave a mark on the natural environment. Development has resulted in coastlines along the west coast of Barbados being dominated by tourism and luxury residential infrastructure. Impacts of un-restrained development along the west coast have included loss of natural marine habitat, encroachment on active beach areas, poor water quality, and reduced reef health.

The tourism sector which is the backbone of the Barbados economy over the past 40 years and has earned about $172 million out of GDP that was estimated at $1.15 billion for the year 2008. Over 90% of all hotels in Barbados are within or proximal to the beach and are therefore highly vulnerable to climate[14]. In 2010 overall occupancy rates were 67.1%[15]. Over the years, tourists have consistently visited Barbados mainly for leisure and in December 2014, visitors who came for recreational purposes accounted for **86.3%** of all stay-over arrivals.

In 2013, it was estimated that tourism contributed 10.9% to the GDP of Barbados and is forecasted to rise to 11.3% of GDP by 2024. This was mainly attributed to the activities of “hotels, travel agents, airlines and other passenger transportation services (excluding commuter services).” Travel and tourism directly generated 14,500 jobs in 2013 (11.1% of total employment) and included employment by hotels, travel agents, airlines and other passenger transportation services (excluding commuter service, restaurants and leisure industries directly supported by tourists. Travel and tourism’s share of total national investment was estimated at 21.7% in 2014 and is projected to rise to 26.3% in 2024 (World Travel and Tourism Council, 2014). By the end of 2014, it is forecasted that travel, tourism and investment will support 52,000 jobs (38.4% of total employment), and is expected to increase of 0.9% pa over the period. In 2013, travel and tourism attracted capital investment of BBD302.8mn and is expected to rise by 4.5% per annum over the next ten years to BBD472.8mn in 2024.

Tourism is the most important industry in the Paynes Bay community, and has been growing since the 1960s with the construction of the Sandy Lane Hotel. Located at the centre of the “Platinum Coast”, the present-day St James coastline (Paynes Bay to Holetown) features a heavily-developed coastline, numerous high-end resorts and multi-million dollar homes. There are many condominium complexes, apartments and guest houses as well as shopping facilities and restaurants catering to the tourist industry. Many persons here are employed in reef related occupations as the nearshore area is a very popular place for watersports activities such as jet-ski rentals, glass-bottom boat trips, catamaran cruises and SCUBA diving. The FPMR (see following sub section) encompasses part of the project area coastline, and many of these reef related activities are concentrated within the reserve. Reef related tourism activities are undertaken all year round

[14] Op. cit.
[15] http://www.onecaribbean.org/content/files/Strep1AnguillaToBonaire2010.pdf

by all operators interviewed, although the main tourism season in Barbados is from November until May, with the quieter season in the summer months coinciding with the hurricane season.

There is pressure to ensure that adequate investment continues not only in the construction and maintenance of engineering coastal defence structures designed to protect critical infrastructure and key built assets, but also to integrate environmental and social dynamics into decision making to help ensure that sustainable development plans take these into consideration to ensure a sustainable and thriving national economy exists[16]. Against this background, the GoB recognises the need to adopt a coastal risk management and planning approach, expanding the existing ICZM mandate as a necessary strategy for sustainable development. This approach, being taken forward in the design of the CRMP (2014-2017) seeks to incorporate risk management solutions into ICZM that address current and future vulnerabilities as well as reflect changes in environmental and socio-economic conditions over time.

5.4.8.1 Folkestone Park Marine Reserve

On the west coast of Barbados, Folkestone Park Marine Reserve (FPMR) was established in 1981 and was Barbados' first marine protected area. The FPMR was established in 1981 by the Designation of Restricted Areas Order (1981), and the Marine Areas (Preservation and Enhancement) (Barbados Marine Reserve) Regulation 1981, and managed by the NCC, the government agency responsible for the management of marine protected areas in Barbados. In 1997, the Environmental Special Projects Unit (ESPU) implemented a project to upgrade the Folkestone Marine Reserve and to establish a Marine Park. This three (3) year project resulted in the development of a comprehensive draft management plan.

The FPMR consists of four zones, namely: the Scientific Zone designated for marine research, the Recreational Zone (recreation, including swimming and snorkelling), and the Northern Water Sports Zone, and the Southern Water Sports Zone. Approximately 900m of the coastline of the proposed project area falls in the recreational and southern watersports zones of the FPMR, with the majority in the southern water sports zone. Approximately 300m at the southern end of the area falls outside of the FPMR (see Figure 5.29).

[16] http://www.eclac.org/publicaciones/xml/7/45297/LCARL.326.pdf

Figure 5.29: Boundaries of the proposed project area in relation to the FPMR boundaries. Red arrows highlight northern and southern boundaries of proposed project area (Map not scaled).

Since the FPMR was established in 1981 as a no-take zone, fishing has been restricted to outside the reserve. Issues have arisen related to the lack of clearly defined boundary markers for the reserve and have resulted in infringement by fishers (AXYS et al. 2000). The Folkestone area has also been one of the major traditional cast net fishing sites and after a long series of negotiations, fishers were allowed to continue this activity (Gill, 2011). This might have significantly affected the amount of bait fish in the area, and needs further investigation.

The marine space of the Project Area largely falls within the Southern Water Sports Zone of FPMR (see Figure 5.29). The water-based activities permitted and observed in the Southern Water Sports Zone include swimming, water skiing, jet-skiing, glass bottom boat tours, renting of small sail boats, paddleboards, snorkeling and scuba diving. Fishers also utilise this area, especially the southern portion outside the FPMR, for small-scale fishing activities such as pot fishing and cast net fishing. Spear fishing was also observed within the FPMR to the north of Sandy Lane Bay. All motorised watercraft must operate at speeds less than 5 knots/no wake within 75m from shore, and speed boats can operate at higher speeds within 75 - 200m from shore. Jet skis must maintain speeds of less than 5 knots within 200m of shore and can operate at higher speeds beyond 200m from shore.

The foreshore area along the length of the Reserve does not fall under the management authority of the FPMR, instead the National Conservation Commission (NCC) and the CZMU have jurisdiction on the foreshore (especially to the south of the reserve – the Project Area). According to the legislation involving the creation of the FPMR in 1981, fishers are not allowed to fish within the designated marine zones. Experience, on the other hand, evidences that there are m any competing and sometimes conflicting users of this marine space and enforcement of designated or regulated uses is lacking.

During the winter months between 10:00am-2:00pm, the use of the FPMR peaks on the days when there are five or more cruise ships in port (AXYS et al. 2000).

5.4.9 Livelihoods and Past-times

The livelihoods identified in the project area are:

In water

- Commercial fisheries;
- Motorcraft/pleasure craft power boats engaged in high speed water sports;
- Jetski hiring and launching from the Bay;
- Day charter boats anchoring in the middle of the Bay and allowing swimming and snorkelling activities;
- Sea bathers both in a designated swimming area and in other areas used by boats and jetskis;
- Glass bottom boat cruises collecting and returning passengers in the middle of the Bay;
- Hobie cat sail boats launching and returning to the Bay;
- Windsurfing, paddle boards and kite surfing (latter not common).

Onshore

- Food vending at various locations from permanently established busineses;
- Food and drinks sold from temporary tents ;
- Craft vending both by mobile persons and stationary stalls.

Interviews undertaken with local residents and business owners showed that the benefits of the proposal were important in providing economic stability to the area. The risks relating to the development were predominately construction related issues such as suspended sediments, noise, and safety, all of which require mitigation plans, but in general if managed properly and effectively would pose little impact. Previously the Resort had a low level of interaction with the community; however as part of the resumption of the Project a Social Awareness program was developed as part of good corporate governance.

5.4.9.1 Commercial fisheries

The total value of local fisheries in Barbados was estimated at about US$ 25 million in 2006 (Mahon *et al*., 2007), and includes both the ex-vessel value (the value of landed raw fish) and the on-shore value-added components such as deboning, filleting and processing into fish fingers and other convenience products (Moore et al., 2014).

The Parish of St. James has five of the 30 fish landing sites on the island – Holetown, Brooklyn Beach, Paynes Bay, Fitts village and Prospect. Paynes Bay and Fitts villages have “sheds and slabs for cutting fish” while the remaining sites have no physical infrastructure established for processing and marketing fish (McConney et.al, 2003). There are three traditional fisheries in the area, namely coastal pelagic, pelagic and reef (AXYS Environmental Consulting (B’dos) Inc, 2000). Coastal pelagic fisheries in Barbados provide bait fish for all other fisheries except for those using seine nets and thus play a significant role in Barbados’ fishing industry (AXYS Environmental Consulting (B’dos) Inc, 2000). The reef fishery is a multi-species fishery and is reported to have declined over the years (AXYS Environmental Consulting (B’dos) Inc, 2000). Offshore pelagic fisheries sustain the fishing industry in Barbados providing the majority of fish for production. This is also the main source of employment for the fishing industry (AXYS Environmental Consulting (B’dos) Inc, 2000). The number of fishermen in the area has declined over the years due to alternative employment opportunities in construction and tourism industry (AXYS Environmental Consulting (B’dos) Inc, 2000).

5.4.9.2 Recreation, Diving and Snorkeling

Many people used the sea and beach for bathing or swimming and said that it was important for health, relaxation and recreation. According to AXYS et al. (2000) the majority of marine based recreation in the FPMR is carried out by tourists, while locals tend to be involved in the terrestrial based activities. Cruise ship passengers account for a large portion of the users of the FPMR and they usually embark on catamarans near the cruise terminal and travel up the West Coast to various stop points.

The foreshore and beaches in the proposed project area are used mainly by the long-stay visitors from the private residences, villas and hotels along the coastline (Gill, 2010; Residents pers. comm.). These users engage in activities such as sunbathing, swimming, water skiing, jet-skiing, glass bottom boat tours, surfing, renting of small sail boats, snorkelling and scuba diving. The FPMR also benefit from this market through the rental of snorkelling equipment and sale of souvenirs to some of the visitors. The Sandy Lane bank and Vauxhall reefs in the proposed project area are main dive sites for both short stay and long stay visitors. More information on beach users is captured within Section 8 and also Appendix 8a.

Diving is a popular activity for some of the tourists that visit Barbados (see Figure 5.30). Interviews with over 150 tourist divers in Barbados showed that the majority were visiting the island for the first time. These divers were also relatively well experienced, averaging 117 logged dives in their lifetime, however only around half were certified as 'advanced' or higher. Approximately 42% of these divers were from the UK, 25% from the US, and about 19% from Europe (Force Project 2011). The majority of these divers are well educated, holding a college education or higher, and about two-thirds were male. Fisherman's and Dottins were some of the more popular dive sites in the Holetown area.

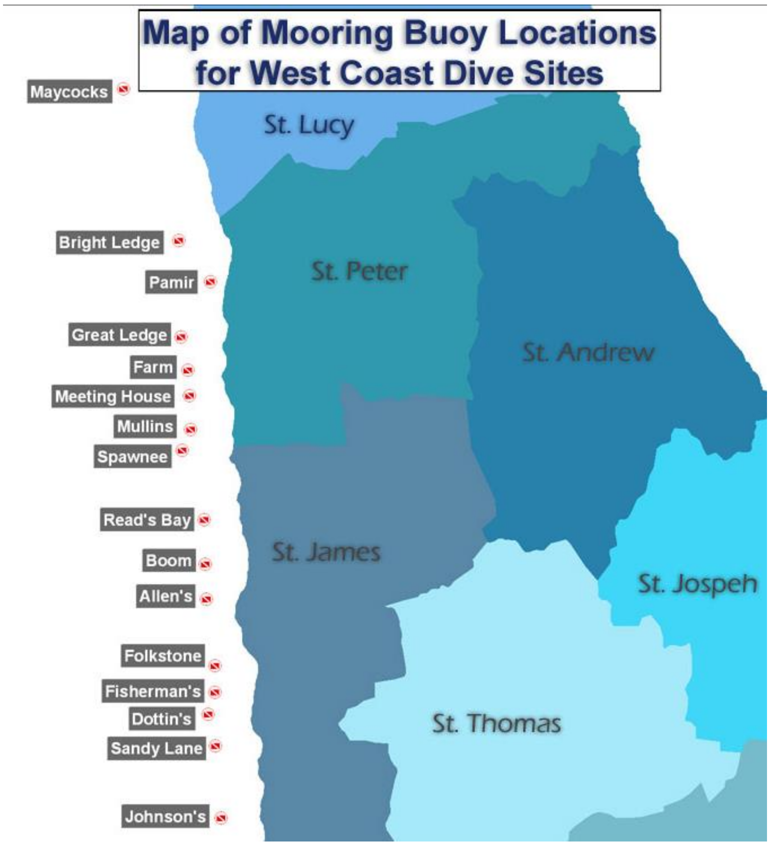


Figure 5.30: Map of Mooring Buoy Locations for West Coast Dive Sites.

5.4.9.3 Recreational fishing

Fishing used to be an important source of income and popular recreational activity for people in Paynes Bay and Holetown, however there are now fewer people that fish for their living or recreationally. Cast-net fishing is the only type of fishing that is allowed within the FPMR and there is only one (tertiary) landing site where fish from the park surroundings are sold. The majority of people that fish use line fishing to catch pelagic species further from shore such as kingfish, tuna (bonitos) and red snapper. There is also some potfishing and recreational spear fishing, as well as fishing trips for tourists.

The total value of local fisheries in Barbados was estimated at about US$ 25 million in 2006 (Mahon et al., 2007), and includes both the ex-vessel value (the value of landed raw fish) and the on-shore value-added components such as deboning, filleting and processing into fish fingers and other convenience products.

There is little data available on the valuation of recreational fishing in the Caribbean region and specifically in Barbados, but the activity directly contributes to the commercial fishing industry in Barbados. The Barbados Game and Fishing Association is the entity responsible for organizing all fishing events and tournaments and organises a Game Fishing Tournament every year during December to April. The typical recreational fisher is usually a fulltime professional or executive and normally owns his boat (& Cowx, 1996). Given this fact it is likely that such an individual would live in the platinum coast. Data in 2000 suggest that the average annual gross revenue per boat, in CARICOM, solely for sport fishing, could be US$ 78 000 estimated to be around about 9 percent of the value of commercial fisheries at that time (FAO, 2000).

5.4.9.4 Surfing

The "Friends for the Protection of Surf and Beach Recreation areas – Barbados" (Surfers) was recently established as an informal group of concerned citizens and recreational users of the marine space in Barbados. In particular, this group was formed as a result of concerns about the Sandy Lane Project. Local surfers have been using the Sandy Lane surf break for over 40 years. Payne's Bay and Sandy Lane Bay are the most stable bays on the West Coast. The Sandy Lane Bay surf break is declared by the surfers as the most consistent break on the west coast during the winter. It remains a popular spot for both professional surfers and amateur surfers and has done so for at least 3 generations. The presence of the fringing coral reef makes the location a treacherous left surf break that is essentially for experts only, who usually choose high tide as a preferred surfing time. Despite this, the location continues to be a place for teaching youngsters to surf and this is reflected in the number of surf "schools" and "instructors" that make a living from the Sandy Lane Bay break. Those instructors based on the south coast incur significant travel costs to use the Sandy Lane Bay "break", however, most tend to reduce this cost by using south coast locations unless a client specifically requests a west coast or east coast surf break. Despite the potentially dangerous coral reef presence, its role as a key place to learn how to surf is relevant as it helps to teach beginner surfers how to paddle round a surf break, rather than having to paddle through it.

The break occurs with a northerly swell (also a north-west swell and on occasion a north-east swell) when the wave approaches at an angle of 340 to 0 degrees. One of the unique features of the break is that according to the surfers, water (tide) level makes no difference to its "surfability", unlike other breaks on the island. Therefore, Sandy Lane Bay is considered a unique break, with the particular characteristics of the local fringing reef helping to "bend" or "diffract" the incoming wave, ensuring that it hits the specific patch reef at the exact angle to create the best surf break on the west coast. A number of world renowned surfers, including Kelly Slater have visited the Sandy Lane surf break and regularly come back to surf it when the conditions are right. Whilst not a consistent surf break, there is a popular sharp shallow reef location within a short, perfect left break that occasionally occurs to the south of Sandy Lane Bay. It is estimated that between December and March/April there are approximately 4 to 6 weeks where the surf is effective and "running". The section of surf break that projects from the fringing reef is deemed to be a ledge reef and has a crack running through it. This helps to bend the incoming wave so that it strikes the fringing reef at the perfect angle and subsequently breaks. Wave heights can vary, though have (on occasion) reached close to 8ft (see Figure 5.31 (a & b)).


Figure 5.31 (a and b) (a) 5 foot surf recorded at Sandy Lane Bay on 6 February 2015. (b) Surfer at Sandy Lane (2010) on a 4 ft break.

Figure 5.32 includes an outline of the surf break, located in the southern part of the bay. The applicant has met with representatives of the local surfing community on 30th January 2015 and in March 2015. Minutes from those meetings (held on site with representatives of the local surfing community) are included in Appendix 8a (Appendix V). The applicant was advised that the break occurs with a northerly swell (also a north-west swell and on occasion a north-east swell) when the wave approaches at an angle of 340°N - 0°N. It is estimated that between December and March/April there are approximately 4-6 weeks of surf.

Based on the information available during the design phase numerical modelling, the submerged sand containers have been positioned to not adversely impact the surf reef.

Figure 5.32 Sandy Lane surf break (marked with an "*")

5.4.10 Beach Access Points

The only formal public beach access point within the Project Area frontage is at Heronetta (see Figure 5.33). This access route is also used by local beach riding classes. Shower facilities are also present here (see Figure 5.34).

Beach access to the north from this point (towards Sandy Lane Bay) is challenging with minimal beach width resulting in precarious walking past poisonous machineel trees and in approximately 1-2ft of water and incoming waves (see Figure 5.35).

Access from north of the Project Area frontage is possible (adjacent to Beachlands property), however just north of Sandy Lane Bay access is treacherous (at high tide) due to plunging wave activity directly against property boundary wall. A newly constructed access path exists parallel to the shoreline just to the south of Sandy Lane Bay. However, this is narrow and elevated (Figure 5.36).

A number of pedestrians were observed turning back, from both the north and the south, choosing not to continue along to Sandy Lane Bay.

Figure 5.33: Public access to beach – South of Heronetta Villa

Figure 5.34: Public shower facilities

Figure 5.35: Limited beach access along Heronetta

Figure 5.36: Limited beach access to Sandy Lane Bay from Heronetta

5.4.11 Cultural Heritage

The parish also has three significant historical sites. These include the site of settlement of the first English explorers, the St. James Parish Church, the Portvale Sugar Factory and Sir Frank Hutson Museum as well as the location of the island's only marine protected area. More detailed information is presented below.

5.4.11.1 St. James Parish Church

St. James Parish Church stands on one of the oldest parcels of consecrated land on the Island, often referred to as "God's acre". The original wooden structure was built in 1628 near the landing site of the first English settlers to Barbados. Many of the original settlers and renowned Barbadians are buried in the church and on its grounds. A popular legend says that a gate in the north wall of the churchyard - "The Devil's Gate" is used by the devil to depart the church before service. The gate is opened one hour before service and when the bell is rung it is said the devil is driven out through the gates which are closed as the service begins. http://stjames.truepath.com/history.php.

5.4.11.2 Portvale Sugar Factory and Sir Frank Hutson Museum

This is the only remaining sugar factory on the island. It is fully operational during January to May crop season in Barbados and available for visits. The Sir Frank Hutson Museum is located on the grounds of the sugar factory. It houses photographs and memorabilia of the sugar industry from the eighteenth and nineteenth centuries accumulated by an engineer, Sir Frank Hutson, with the assistance of the Barbados National Trust. http://www.barbadospocketguide.com/our-island-barbados/sugar-factories/portvale-sugar-factory.html

5.5 Traffic and Transport

Barbados has a dense road network system that plays a critical role in the country's social and economic development. The transport network consists of more than 1,600 km of paved public roads, two active marine ports - the Bridgetown Port and Port St Charles, both regulated by the Barbados Port Authority - and one airport (the Grantley Adams International Airport). In 2010, the total value-added for Transportation, Storage and Communications Industry was US$ 308.1 million, or approximately 8 per cent of GDP (UNEP 2014). This represents a return to growth after contracting in the previous two years, reflective of the overall slowdown in the Barbados economy.

The highway network consists of seven major highways that radiate from Bridgetown. Numbers 1 to 7 signifies these – Highway 1 (H1) heads due north from Bridgetown along the west coast and numbering continues sequentially in a clockwise direction. Other highways are the Ermie Bourne Highway, the Ronald Mapp Highway, the Adams-Barrow-Cummins (ABC) Highway and the Spring Garden Highway. In 2010, an assessment released by the Economic Intelligence Unit (EIU) of the United Kingdom ranked Barbados 6th in the world with 3.7 km of road for every km of land, and the top spot in the Western Hemisphere for road network density. Apart from the highways, the road network consists of roads that are, generally, relatively narrow. In 1998, it was estimated that the transport industry accounted for 33 per cent of all the fuel imported (UNEP2014).

There are inevitable traffic congestion issues including air pollution, emissions and waste management issues that can be attributed to the volume of vehicles on a small island. (Carter & Singh, 2010). In 1995, Barbados had a total of 55,668 vehicles on the island, of which 42,821 were private cars. By 2005, only ten years later, the number of vehicles had doubled to 116,675 of which 94,496 were private as opposed to buses, taxis, zr's etc. According to statistics from the Barbados Licensing Authority, the number of vehicles on the island's roads stood at 131,680 in 2009. It is estimated that between 2008 and 2010 the number of vehicles grew at a compounded annual rate of 3.8 per cent. The number of vehicles registered for the period January to July 2011 was 112,995, with an estimated total of vehicles in use for 2011 being 150,000.

Traffic in Barbados has become increasingly congested in the last few years by the proliferation of privately owned automobiles. This is further impacted by the large number of development and construction projects on the Island, as well as ongoing maintenance of roads and municipal services.

Given the relatively small size of Barbados and its system of centralized government, urban transport planning is not carried out as a separate activity to transport planning at the national level. In the late 1970s, the Government of Barbados commissioned the undertaking of the first integrated land-use transport study for the island. In the 1980s there was a Bridgetown traffic management study done that proposed the upgrade of the road corridors that form the inner and outer bypass system that exists today.

Along with the Ministry of Transport and Works (MTW), the most relevant national organisation relating to traffic and public transport is the Barbados Transport Board (BTB). BTB is a Government owned and funded public transport system. As can be found with many other areas which are deemed to be important in Barbados' achievement of sustainable development, the Barbados Sustainable Development Policy speaks to the issue of transport addressing the need to reduce environmental damage associated with various aspects of transport whilst ensuring that its valuable economic and social contributions are not undermined. Within the context of these broader goals, however, the policy has identified specific recommendations that will place a special emphasis on improving the efficiency and reliability of the public transport system. The Transport Board has a fleet of approximately 304 buses. The use of Government-run bus services in Barbados is increasing and may continue to increase once the Transport Board can demonstrate to the general public the reliability of services provided through maintenance of the fleet and improved regularity of services. Bus services are heavily subsidized with a fixed bus fare of $1.50 per trip.

The MTW is addressing climate change impacts by re-designing its road net-work to facilitate better drainage as a result of recent heavy rainfall events. However, some of these changes, such as curbs will assist with drainage in heavier downpours, which may be associated with climate change. The Adams-Barrow-Cummins Highway (ABC) was constructed as an inland highway, running from the Grantley Adams International Airport to the West Coast of the island, bypassing the capital city, Bridgetown. Although not its sole reason for its construction, the development of this highway has successfully mitigated against the vulnerability of the coastal highways being vulnerable to sea level rise.

5.6 Air Quality (incl. emissions to atmosphere, generation of dust, climate change)

This aspect was scoped out of the EIA ToR (see Appendix A). Baseline information is not included for St James Parish. Specific details on the additional quarrying demand at Lears Quarry is addressed in Section 9 of this EIA.

5.7 Noise and Vibration

5.7.1 Noise

The study site is located on the west coast of Barbados. It is bounded by open water to the west (Caribbean Sea). The location and nature of the site means that it will be subject to a reasonably high level of background noise likely to comprise natural coastal noise (waves, wind, wildlife), noise generated by beach and sea users (tourists/visitors, personal water craft, motorised boats, tour boats, 'party boats', bars/restaurants). These noises can be classified as intermittent (users, boats, traffic) and constant (waves).

Noise levels at the eastern side of the Sandy Lane property are high due to the close proximity to the highway, but it is generally quieter moving towards the sea and western boundary.

Highway 1 (West Coast road) is approximately 50m - 100m east of the site and runs parallel to the beach along the length of the study site. There are properties (private residences, hotels), walls, gardens, hedging and trees between the beach and the road, which form a barrier to noise from the road. There is no industry in the vicinity of the study site.

The beach is open to the public at all times and local people, visitors and tourists that use the beach throughout the year. The main tourist season runs from October to March with over half a million visitors a year (2010 data) (CTO, 2010). Recreational water craft use and pass through the area. These may be powered (launches from yachts moored offshore, jet-skis, motorboats) or unpowered (sailing dinghies, catamaran, paddle-boards). Both powered and unpowered craft can either launch from the beach in front of the hotels or enter the area from the north or south. Tour boats also pass through the area further offshore, taking people to view the reefs or sunken barge. Party boats also regularly visit the area. An example of which is the well-advertised "Jolly Roger". These vessels can generate a lot of noise locally due to the sound systems on board, however they are generally restricted to the weekend.

There are no general noise standards in Barbados and there is no published information on ambient noise levels at the site. However, it is anticipated that the noise levels generated by the Hotel will be low, and that there will have minimal impacts on adjacent residential neighbours.

5.7.2 Underwater Noise and Vibration

Many of the activities that generate noise on land or above the water also generate noise underwater. The main sources of underwater noise are powered watercraft operating in or passing through the study area e.g. motorboats, motor launches, jetskis, tour boats. Watercraft users entering and using the water can also generate underwater noise, particularly if jumping or diving from vessels.

Waves and wave action (both natural and generated by the wake from vessels) also generates underwater noise. There are, however, no anthropogenic or natural sources of vibration in the area.

There are no underwater noise standards in Barbados and there is no published information on ambient underwater noise levels at the site. There are no anthropogenic or natural sources of underwater vibration in the area.

6 ASSESMENT OF SIGNIFICANT ENVIRONMENTAL IMPACTS

6.1 Environmental Receptors

6.1.1 Definitions

This section of the EIA serves to identify those environmental components ("receptors") that are likely to be affected by the project. The potential interactions between project receptors or project activities and environmental receptors of concern (ERC), were identified during an issues scoping process. ERCs include the biological, physical and socio-economic environment. As a result of this process, the actual assessment will focus (only) on ERCs as identified within the EIA ToR (Appendix 1c).

Consultations with stakeholders (e.g. regulators and the public) as well as the scientific community, are part of the issues scoping process (Appendix 1c) and help in the identification of ERCs. The parallel approach to ERC selection is based on experience gained during other comparable environmental assessments, available information on the environment surrounding the proposed project, and the technical and professional expertise of the consultant team from Atkins/CARIBSAVE. The evaluation of the environmental issues resulted in the following Project ERCs:

- **Human Beings**:
  - Local Residents;
  - Visitors and Tourists;
  - Surfers;
  - Cultural Heritage.
- **Flora and fauna**:
  - Terrestrial habitats;
  - Terrestrial fauna, birds, bats and mammals;
  - Intertidal and marine habitats, fish, invertebrates, turtles and marine mammals.
- **Physical environment :**
  - Topography and bathymetry;
  - Geology and surficial soils;
  - Hydrogeology and groundwater quality;
  - Sediments;
  - Coastal processes and hydrodynamics;
  - Shoreline evolution and sediment transport;
  - Sea water parameters;
  - Landscape and seascape.
- **Noise and vibration**
- **Traffic**
- **Cumulative Effects (see Section 7).**

For each receptor, the likelihood of significant impacts arising will be described in terms of their duration (short, medium, long term), permanence of impact (temporary or permanent) and effect (positive or negative). Effects will be considered in terms of:

- Direct and indirect / secondary impacts during construction;
- Direct and indirect / secondary impacts during operation; and

- Cumulative impacts arising from the proposed development in combination with other developments with extant planning permission or currently under construction.

Each receptor is then ranked/scored with one of the following qualitative impact descriptors:

- Negligible;
- Minor;
- Moderate;
- Major.

6.1.2 Temporal and Spatial Assessment Boundaries

The traditional approach to project bounding involves assessing changes to the environment within the physical boundaries of development. Beanlands and Duinker (1983) determined that in order to properly evaluate impacts, physical and biological properties must be determined temporally and spatially. This approach has been taken for the determination of bounds for the assessment of the proposed project. The effects of a specific project activity on an ERC may differ in both space and time from the effect of any other activity. Some project activities may have long-term consequences, while others will be of short duration. Temporal project bounding for the proposed Project includes the short-term construction activities as well as the long-term maintenance of the coastal engineering structures. There is some temporal variability, since regular maintenance of the structures being built is likely. This will likely double the lifetime of the structures (NESs). Also, the duration of the effects is likely to vary with the ERC and the project activity. Therefore, different temporal boundaries may be used to reflect:

- the nature and duration of the effect;
- the characteristics of the indicator; and
- the types of actions and projects that will need to be considered within the cumulative effects assessment.

The spatial boundaries for assessing potential effects will typically be established by determining the spatial extent of an effect of a project component or a project activity. The physical boundaries of the site are as shown on Figure 6.1.

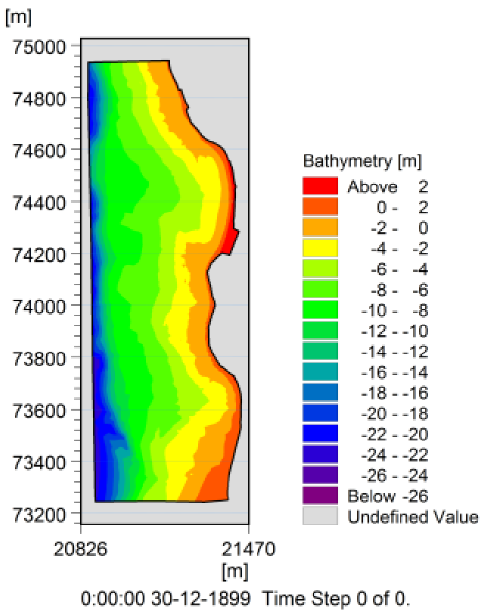


Figure 6.1:Spatial boundary (maximum) of numercial modelling area (including Paynes Bay)

The physical (spatial) boundaries of the project may vary depending on the individual ERC. For example, for each key coral reef species identified, the project boundaries will be restricted to specific “footprint areas” of the structures and ancillary structures (see Appendix 5m). However, for socio-economic impacts, the boundary extends the project footprint to include local communities/towns at a minimum. Scientific and technical knowledge, input from the public, professional experience and traditional knowledge has thereby been used to develop the temporal and spatial boundaries.

6.2 Human Beings

6.2.1 Local Residents

As stated in Appendix 8a, local residents beach recreational and social activity preferences are relatively wide ranging. However, an above average involvement of over 60’s includes beach exercising and walking, thus re-affirming the social preference for longitudinal beach access (long beach walks) for health and wellness purposes. Other activities undertaken by local residents are shown in Figure 6.2.

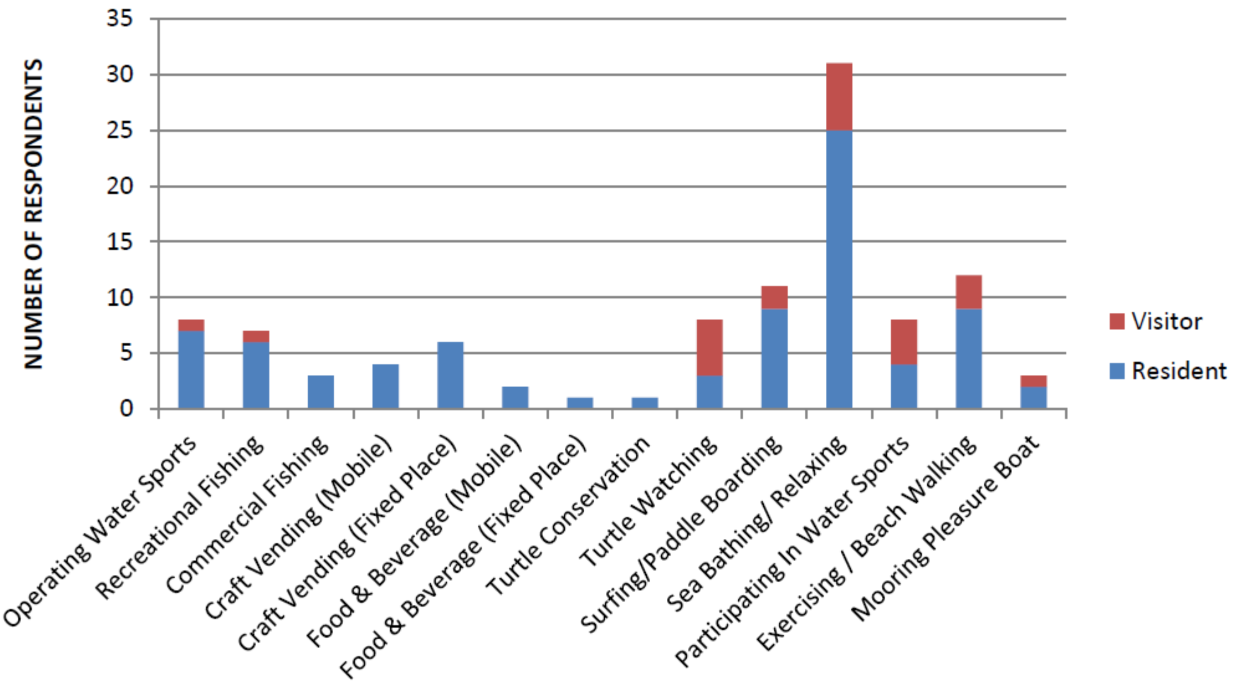


Figure 6.2: Activity participation, by residency of respondents.

With a particular focus on sea bathing/relaxing and beach walking, the following sub-sections provide an impact assessment of the project on local residents.

6.2.1.1 Construction impacts

Component 1 of the project (coastal engineering) involves construction works taking place both within the sea, from vessels or other floating structures, and on the beach (beach nourishment activities). During the latter work (scheduled for a 10 day period of construction works in September 2016), there will be beach closure signs on operation, though this is likely to only for a restricted period. At this time there will be limited open access to the beach for locals and visitors alike (Sandy Lane Hotel will be closed). Therefore, beach walking impacts will be moderate but short term. During the construction of the NESs, no motorised boat related activity will be allowed within Sandy Lane Bay, through necessary re-routing (new zoning – see

Section 6.2.2) of recreational watercraft away from construction vessels shall be set up to reduce impact on local economic / commercial activities.

Potential construction impacts for locals on the beach and/or using watercraft could range from negligible to major, however, with risk management measures put in place (signage etc), impacts are considered to be minor and short term. Mitigation measures set out in Section 10.

Construction works during the beach operation works of Component 1 are expected to have no impact on water based activities. The sediments being deposited on the beach in the project shal be from a land-based quarry and the works do not pose a risk to motorised boats in the area.

6.2.1.2 Post-construction / operational impacts

After construction, any impacts will be associated with maintenance or repair activities.

6.2.2 Visitors and Tourists

As shown in Figure 6.2, the majority ot visitor (tourist) related activity takes place either on the beach or in nearshore waters within Sandy Lane Bay (and into Paynes Bay). This point is also clearly demonstrated in Appendix 8a (see Figure 2.6 of that Appendix). To this end, risk management procedures for all activities are deemed to be of direct relevance to current day management procedures plus future project design. Up until recently (see below), there have been no International Standards for beaches and very little guidance on beach management for operators. As a result, many beaches have not been developed or managed in a sustainable way, often resulting in bad experiences for beach users and to the detriment of the beach environment. With specific reference to Sandy Lane beach a new management scheme is likely to be needed that is flexible enough to adapt to visitor demands in the same way as any other business or service. Having such a management system in place at Sandy Lane will seek to ensure that the beach remains safe and enjoyable for all users (Bajan and tourist) now and in the future.

ISO 13009, *"Tourism and related services — Requirements and recommendations for beach operation*", has just been published by the International Standards Organisation (ISO). This is the first standard that provides beach operators with the information and guidance needed to manage beaches effectively, anywhere in the world. The ISO13009 brings a range of important elements together that could offer guidance to Sandy Lane to help sustain a hotel or resorts economic future. As well as general beach management, the ISO 13009 includes initial guidance on beach safety, beach cleaning and waste removal, beach access, infrastructure, beachfront planning, stakeholder communication, beach promotion and commercial services (vendors etc). Therefore, assisting the tourism sector to comply with ISO 13009 is likely to help significantly towards generating both media and public interest within resorts and beach fronted hotels. This in turn may help secure public funding for future improvements to the surrounding beach area.

The CZMU believe that if adapted in a sensitive manner to reflect the local needs of Barbados for both high and low activity beaches (as part of a new Barbados National Standard), this could prove of great value to Barbados as a nation. The main reasons for this are that ISO 13009 sets a world benchmark for beach management and safety and consequently, if clear advice can be provided to the public and private sector in Barbados (through regulatory processes and non-statutory guidance e.g.: codes of practice etc), this may provide added value to the tourism sector that is consistent and based on best practice.

6.2.2.1 Construction impacts

Component 1 of the project (coastal engineering) involves construction works taking place both within the sea, from vessels or other floating structures, and on the beach (beach nourishment activities). During the latter work (scheduled for a 10 day period of construction works in September 2016), there will be beach closure signs on operation, though this is likely to only for a restricted period. At this time there will be limited open access to the beach for locals and visitors alike (Sandy Lane Hotel will be closed). Therefore, beach walking impacts will be moderate but short term. During the construction of the NESs, no motorised boat related activity will be allowed within Sandy Lane Bay, through necessary re-routing (new zoning – see Figure 6.3) of recreational watercraft away from construction vessels shall be set up to reduce impact on local economic / commercial activities.

Potential construction impacts for locals on the beach and/or using watercraft could range from negligible to major, however, with risk management measures put in place (signage etc), impacts are considered to be minor and short term. Mitigation measures are set out in Section 10.

Construction works during the beach operation works of Component 1 are expected to have no impact on water based activities. The sediments being deposited on the beach in the project shall be from a land-based quarry and the works do not pose a risk to motorised boats in the area.

6.2.2.2 Post-construction / operational impacts

After construction, any impacts will be associated with maintenance or repair activities. There will be a need to revise the zoning of water space in Sandy Lane and this will require specific attention during the post construction phase (see Section 11 EMP for specific details). At present, marker buoys are in place within Sandy ane Bay for swimming areas and to prevent personal water craft (PWCs or jetskis) plus motorised boats being too close to swimmers. The current bouyage system is marked in red in Figure 6.3 below.

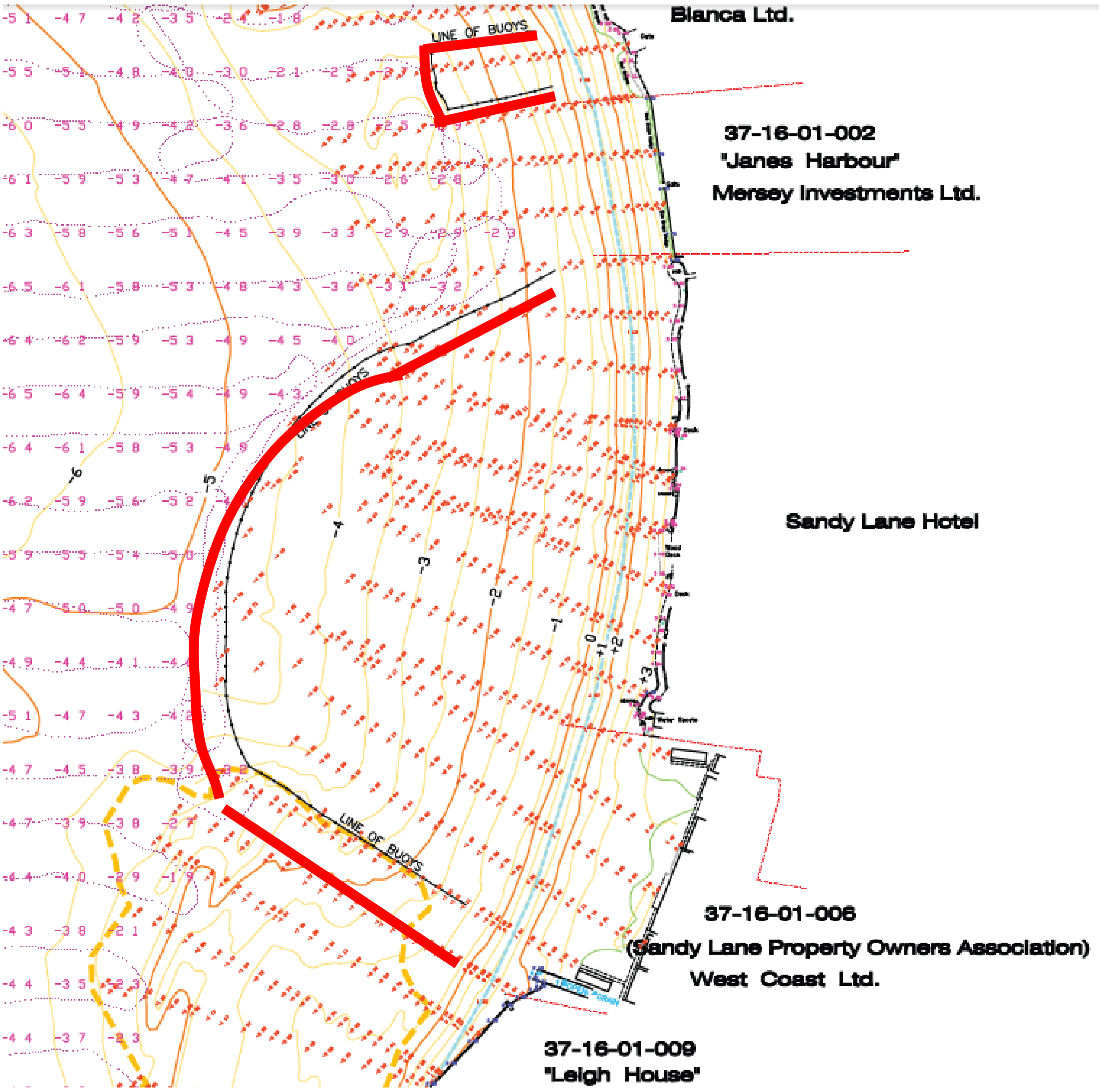


Figure 6.3: Current location of swimming zone "buoys" within Sandy Lane Bay

Section 10 outlines the approach needed towards revising the position of swimming marker buoys, though their exact location will need to be determined following a specific risk assessment exercise following placement of the 3 NESs. Their location will need to be set in consultation with beach operators (paddleboard hire and jetski hire agents) along with Sandy Lane motorboat operators to ensure that both motorised recreational activities can continue to take place in parallel with passive beach recreational (swimming) activities. The consultation will also need to determine the most appropriate communication technique with regards to swimming risks close to the NES structures.

If a suitable set of control measures are put forward, that are effectively manged by Sandy Lane Hotel, the impacts during construction will be minor and short term during the post- construction phase.

6.2.3 Surfers

As identified above and in Appendix 8a, there are a number of beach and sea user activities taking place in the proposed project area. Perhaps the most vocal group relates to the surfing community and the risk that the proposed project may have on natural surf breaks in the area. This user group are thereby focused on in more detail as follows.

Although water quality is an important issue for surfers in Barbados for health reasons, this Section focuses on whether the proposed scheme may modify the physical processes around surfing breaks and their effects on the 'surfability' of surfing waves. Although the way that surfing waves transform is complex (see Black, 2001a;, 2003; Scarfe *et al.*, 2003a), it can be generally stated that waves break along contours relative to the wave height. Offshore focusing and varying seabed gradients complicate the breaking location, but it is assumed that waves break along a single contour.

The preferred layout of the scheme is set out in Figure 6.4.

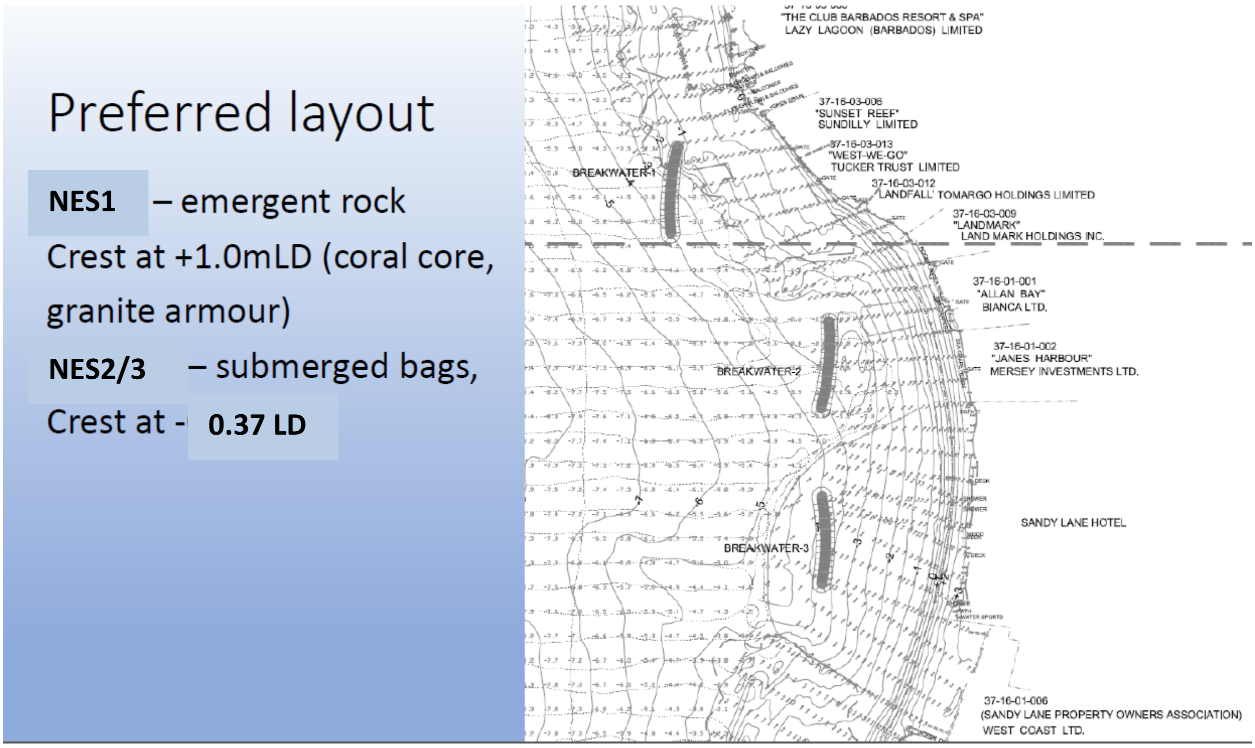


Figure 6.4: Proposed Scheme Layout

The main wave break occurs with a northerly swell (also a north-west swell and on occasion a north-east swell) when the wave approaches at an angle of 340°N - 0°N. It is estimated that between December and March/April there are approximately 4-6 weeks of surf. Whilst not a consistent surf break, there is a popular sharp shallow reef location within a short, perfect left break that occasionally occurs to the south of Sandy Lane Bay.

Initial modelling results for the 'surf condition' of the study area, and assuming that 3 NES structures are adopted (as per Figure 6.5), then there is limited (if any) impact on the surf break when the wave approaches at an angle of 340°N - 0°N. Based on the information available during the design phase and the numerical modelling exercise, the NES containers have been positioned so as to not adversely impact the surf reef. Modelling results of the local surf break are set out in detail within Appendix 5g.

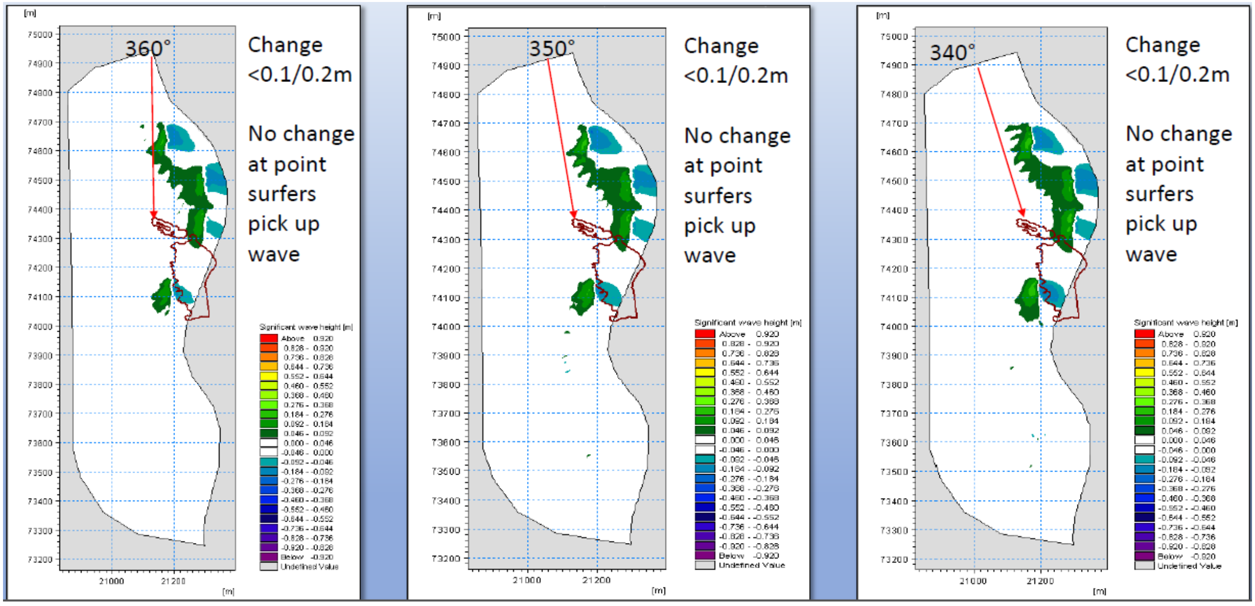


Figure 6.5: Surf Reef Impact Numerical Models outputs

It is not foreseen (through the modelling results) that there will be any impacts to the surf reef. Should there be any alteration in wave dynamics, this will be in a small area and will be experienced during the post- construction phase. The impacts are, therefore, considered to be minor and long term.

6.2.4 Cultural Heritage

6.2.4.1 Construction impacts

As stated in Section 5.4.11, there are no culturally significant features within the immediate footprint (or access to the footprint) of the proposed development. Coupled with this, the majority of construction works will take place in the sea, from vessels or other floating structures. There will be limited activities associated with the scheme taking place on lands close to culturally significant locations. Activities that will take place on land will take place in industrial areas such as Lears Quarry and Barbados Port. Therefore, cultural impacts will be negligible and short term.

6.2.4.2 Post-construction / operational impacts

After construction, any impacts will be associated with maintenance or repair activities. As stated in Section 5.4.11, there are no culturally significant features within the immediate footprint (or access to the footprint) of the proposed development and so any future beach nourishment activity will have similar effects on cultural sites to those experienced during construction, which are considered to be negligible.

6.3 Flora and Fauna

6.3.1 Terrestrial Habitats

6.3.1.1 Construction impacts

The majority of construction works will take place in the sea, from vessels or other floating structures. There will be limited activities associated with the scheme taking place on land. Activities that will take place on land will take place in industrial areas such as Lears Quarry, Black Bess Quarry and Barbados Port. In these areas impacts will be negligible, as they will be part of the normal operation procedures for those sites.

Access to the beach from the storage area is likely to involve the removal of some beach vegetation in order to allow trucks onto the beach (see Figure 6.15). Replacement of any removed beach vegetation will have to take place. There may also be some impacts to terrestrial habitats in the area where beach nourishment material is stored prior to placement on the beach (location to be determined but within the property boundary of Sandy Lane Hotel) and where plant / vehicles move material from this store area, onto Highway 1 and then onto the beach. The storage areas (on Sandy Lane property) will be restored to their pre-construction state after use. These impacts will be in a small area and will be temporary, during construction only. The impacts are, therefore, considered to be minor and short term.

6.3.1.2 Post-construction / operational impacts

After construction, any impacts will be associated with maintenance or repair activities. For the geosynthetic NESs, the manufacturer guarantees the fabric for a period of 10 years, although states that they will last for a considerably longer period than this (possibly 25 years). Evidence from other geosynthetic underwater reefs shows them to still be functioning 15+ years after installation (a number of coastal protection projects in Australia (from estuarine to open coast) have been built using sand filled geotextile containers since 1985 (Restall *et al*)). Examples of the longevity and resilience of nearshore geosynthetic structures are presented in both Appendices 6a and 6b.

Additional beach nourishment will be required at some point in the future, as natural processes will gradually transport beach sands, although the NESs' strategic design is purposely set out to slow this littoral drift. The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016.

Future beach nourishment activity will have similar effects on terrestrial habitats to those experienced during construction, which are considered to be negligible.

Proposed mitigation measures are set out in Section 10.

6.3.1.3 Terrestrial Fauna, Birds, Bats and Mammals

6.3.1.3.1 Construction impacts

The main impacts to terrestrial fauna, birds, bats and mammals arising as a result of construction relate to disturbance effects (light, noise, physical presence) due to the presence of construction plant, equipment, materials and personnel. As the majority of works and equipment will be carried out at sea or on the intertidal (beach) area, impacts to terrestrial fauna, birds, bats and mammals are considered to be negligible.

There may be some impacts to terrestrial habitats in the area where beach nourishment material is stored (on the property of Sandy Lane Hotel) and where plant / vehicles move from this location to the highway and then onto the beach. As these areas are to be within the Sandy Lane property boundaries, they are horticulturally managed areas within a busy operating hotel and unlikey to be home to significant and / or rare populations of fauna, birds, bats and mammals. Any impacts will be confined to the construction period of a few weeks and are therefore, considered to be minor and short term.

6.3.1.3.2 Post-construction / operational impacts

Following construction, impacts will be associated with maintenance or repair activities. Such activities are not anticipated to be needed on a regular basis (less than annually). Any maintenance / repair activities will be similar to those carried out during construction and will, therefore, be focussed on the marine and intertidal area. Repairs will be of a smaller magnitude than construction activities and, as such, impacts to terrestrial fauna, birds, bats and mammals are considered to be negligible.

Proposed mitigation measures are set out in Section 10.

6.3.2 Intertidal and Marine Habitats

6.3.2.1 Construction impacts

6.3.2.1.1 Intertidal area

It is anticipated that the majority of construction plant workings will take place seaward of mean low water through the use of boats, barges and other floating craft, however some works (beach nourishment) will be required within the intertidal area. This work will involve placing 37,000m^3 sand on the beach and shaping / profiling it using motorised land-based plant.

Beach nourishment programmes within the project area will result in the smothering of any fauna or flora on the beach in the area where sediment recycled/moved/placed. The ecological surveys carried out to date (Appendix 5i) show there are a limited number of species present on the beach in Sandy Lane Bay, apart from the prevalence of burrowing ghost crabs (*Ocypode quadrata*) (see Section 5.3.3 and Appendix 5i). The depth of material being placed on the beach will at it's maximum be approximately 4m. This will mean that crabs will be unable to burrow out of the newly placed sand. The use of construction plant / vehicles on the beach may also result in disturbance to the beach environment which could result in impacts to any species buried within the sand.

Some mobile species will be able to move away from any disturbance and / or smothering that occurs, however, others may not, most likely resulting in their burial and death. Given the number of crab burrows present across the wider study area, any losses of burrowing crab are likely to replaced by natural re-colonisation from neighbouring areas. Other invertebrates living in the sand or between grains are also likely to be replaced over time by colonisation from neighbouring areas. The rate of re-colonisation will, however, depend on a number of factors, including the degree of matching between the renourished sand and the original beach sand and the rate of movement of the species moving back onto the nourished beach from adjacent areas.

Smothering and damage / disturbance by plant are, therefore, considered to be minor (restricted to the immediate scheme footprint) and short term.

Literature (Winnard, 2012) suggests that for sandy beaches that do not contain any particularly important habitat, beach nourishment will not have long term ecological impacts, provided that some clear 'rules' are implemented as follows:

- Use sediment that is of a similar grain size composition and similar material as that already found on the beach (see Section 5.2.4 for information on sediments).
- Restrict the amount of both fine material and coarse material, including shell fragments in the re-nourishment material.

In addition, several additional mitigation measures (developed further in Section 10) are suggested that could be used to further reduce any short term impacts and promote a faster recovery:

- Apply nourishment slowly, in relatively thin layers (<1m thick);
- Do not cover very large stretches of shoreline (<1km) so that adjacent areas are able to re-colonise nourished areas;
- Do not allow nourishment activities to continue for protracted periods.

As these conditions will be met for the project, impacts are likely to be minor and short term.

Use of construction plant and / or equipment or vehicles on or near the beach has the potential to result in accidental spillage / release of oils / fuels, which could contaminate beach sediments and adversely affect intertidal species, with knock-on effects for marine water quality (see below). Hydrocarbons, if released, can persist in the environment for decades and be re-worked and re-released over time as they are uncovered and re-buried as the beach sediment moves. So, although restricted to a potentially small area of the environment, they may pose a risk for many years, if not remediated. Potential mitigation measures are set out in Section 10.

6.3.2.1.2 Marine area

Potentially the most significant impact on the marine area is the physical placement and construction of the nearshore engineering structures, which will inevitably damage / smother species within the footprint of the structures and the associated construction area (ie: where construction equipment needs to be positioned in order to place the NESs).

It is anticipated that some subtidal sediment will have to be temporarily removed and the seabed slightly reprofiled to provide a stable base for machinery (plant) to help construct each NES. The exact detail of this shall be determined through closer consultation with local contractors during early 2016. Should this be required, this would result in an impact on marine substrate and any associated species both within the area from which substrate is removed and where it is temporarily replaced to.

It is expected that the majority of construction plant will be floating however the use of anchors for the securing vessels, plant, pipelines for pumping sand or materials during construction may also result in damage to any marine habitats present below.

The outcome of additional marine ecology surveys to demonstrate the impact on the footprint of each SES was undertaken (Appendix 5m) to determine whether:

- The seabed below the structures is sand and there will be no loss of sensitive coral habitat;
- The structure is over an area of good coral cover and the position, size and or orientation of the structure needs to be adjusted to ensure minimal impact to the coral habitat. Consideration of coral relocation and / or other mitigation measures will therefore be necessary;
- The structure is over an area of now algae dominated reef. The structure will not result in the loss of sensitive coral habitat but will result in loss of natural hard seabed and thus mitigation and replacement of hard substrate should be considered.

The results of the survey are clearly presented in full within Appendix 5m. The area surveyed for each proposed NES incorporates a 'buffer zone' around each NES to take account of the maximum extent over which the footprint of the structures and construction will take place. The buffer is 15m seaward and 45m landward of the mid line of each structure to take account of:

- Potential minor changes in NES size, shape or;

- The footprint of any material moved when re-profiling the seabed before geobag placement (which will be temporarily placed on the landward side of the structures before being backfilled against the NES);
- A buffer around the whole NES and working area.

The key findings from the additional ecological survey suggest the following:

- The areas in the footprint and buffer zones of NES 2 and 3 in Sandy Bay are dominated by sandy bottom that are part of the dynamic littoral zone. There are no hard corals or other sessile benthic invertebrates that could be damaged / destroyed by the construction or presence of the structures and consequently no impact.
- NES 1 is in an area of fringing reef. The 2015 survey work (Appendix 5l) shows most of the fringing reefs to be lacking reef structure with low coral cover (5% - 15.25%) and high (generally >50%) algal cover. A few (14) viable hard corals were observed within the footprint, mostly 10cm – 25cm in diameter. There is potential for these small, viable hard corals to be damaged / destroyed during construction, which would result in a permanent, negative impact.
- There are no *Acropora palmata* (Elkhorn coral) stands within or near the footprints of any of the proposed structures (NES 1 – 3). *A. palmata* is considered to be one of the most important reef building corals in the Caribbean and loss or damage to stands in an area of Barbados that has historically suffered from losses of elkhorn would be significant. As there is no *A. palmata* present in the footprints, there is no impact to these species.
- There is an *Acropora* stand landward of NES 1 which could be impacted by beach nourishment or the accretion of sand in the lee of NES 1. Recent survey work of this area (see Appendix 5mi) declares that in general the area close to NES1 where sand accretion is anticipated (5 m seaward of the seawalls/HWM) does not include significant biota, nor does it contain any viable hard corals. However, there is a scattering of *Acropora* colonies starting approximately 7m from shore and these include a few fragments that would be easily relocated or used to seed a nursery. There are a few healthy colonies found between the nearshore accretion zone and the SES1 buffer zone. These are very low rugosity colonies, mostly *Diploria* (Brain) corals, and are currently exposed to some fairly hostile conditions (high irradiance levels, elevated wave energy, partial colony exposure during combination low tide, poor water quality, over fishing, and high energy wave events. To avoid such impacts, the stand would need to be relocated (see Section 10 on mitigation, Section 11 the EMP and Appendix 10b marine conservation enhancement).

In addition to physical loss of habitat or species as a result of construction and the presence of the new structures, any impacts to water quality may have knock-on effects for marine habitats and species from:

- The suspension of sediment within the water column during dredging / construction;
- The release of any contamination potentially present within the sediment being used as part of the construction;
- Accidental or deliberate spillage / release of oils, fuels or other chemicals.

NB: NES 4 (southern most structure of 4 originally proposed) is no longer part of the scheme and as no construction is planned in this area, there will be no direct physical impacts within the footprint of NES 4.

The potential for impacts to water quality are covered in Section 6.4.7 and mitigation measures are set out in Section 10.

6.3.2.2 Post-construction / operational impacts

Once built, there will be no further loss of marine habitat from within the footprint of the new structures. The structures will instead provide additional areas of hard substrate that may become colonised by species such as corals, sponges, invertebrates and fish, potentially overall resulting in an increase in biodiversity in the area. The increased complexity of the seabed has the potential to provide “nursery” / refuge areas for fish which in turn may result in an increase in fish populations locally to the NESs and the natural reefs (see Section 6.3.4).

These positive impacts could be increased / encouraged through the design or integration of eco-engineering components into or near to the NESs. These measures are considered further in Appendix 10a and Section 10. Benefits could range from negligible to moderate beneficial, depending on the complexity of the structures and associated eco-engineering intervention proposed.

During the “operation” of the NESs, the sand filled geotextile containers (NES2 and 3) have potential for some loss of fill material from the containers, either the loss of fines through the geosynthetic material, accidental or deliberate damage (cutting, ripping, tearing, vandalism) of the geosynthetic material, or natural degradation of the bags over long-term (post 30 years) use. The loss of fill material from the bags thereby has the potential to reduce marine water quality through an increase in turbidity in close proximity to the damaged NES and through diluted turbidity down current of the structure with increasing distance. As a result, there would be an expected impact to marine habitats through smothering. This risk is considered to be low however, as similar structures have been used in coastal and estuarine environments around the world for over 20 years with little evidence of significant losses or failures (see Appendix 6a). Mitigation measures to minimise losses are set out in Section 10.

Additional beach nourishment will be required at some point in the future, as natural processes will gradually move the sediment, although the SESs will slow this movement. The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016.

Future beach nourishment activity will have similar effects to those experienced during construction, which are considered to be negligible.

Other impacts will be associated with maintenance or repair activities, which are considered to be minimal. Damage to sand filled geotextile containers can be ‘patch repaired’ by divers using small scale equipment, with minimal impacts to the marine area or species. Such impacts are considered to be negligible.

6.3.3 Fish

6.3.3.1 Construction impacts

Construction activities are unlikely to have any lasting impacts to reef fish species. Fish are highly mobile and will tend to move away from vessels, divers and equipment, such that the risk of collision, damage or death is considered to be low. Consequently such direct impacts are determined to be negligible.

Loss or damage to marine habitats (see above) can have knock on impacts to fish by removing habitat they use for feeding, shelter or breeding. Fish abundance on the west coast of Barbados is low due to historical over-fishing, poor habitat quality, and the severe mortality of reef-associated fish that occurred in 1994. The 2015 marine survey (Appendix 5l) showed that abundance was greater on the patch reefs than on the fringing reefs or on the sandy areas between reefs (“spurs”), which were largely free of fish. As such, the loss of the relatively small area of reef within the footprint of the northernmost NES (NES 1) is not considered to be significant and the impacts to fish from loss or damage to marine habitat will be negligible.

Impacts to water quality may also have knock-on effects to fish from:

- The suspension of sediment within the water column during dredging / construction which may directly affect fish’s gills or indirectly affect food sources, through sedimentation / smothering.

- The release of any contamination potentially present within the sediment being used as part of the construction, which may either directly affect fish or indirectly affect food sources or habitat.
- Accidental or deliberate spillage / release of oils, fuels or other chemicals, which may either directly affect fish or indirectly affect food sources or habitat.

Direct impacts are considered to be negligible due to the mobile nature of fish able to move away from sedimentation, contamination or pollution. Indirect effects may have a longer lasting effect, if they adversely impact on important food or habitat sources. However, given the small area potentially affected, the low fish species numbers and diversity observed in the area and hence its probable minor importance to fish populations, knock-on impacts are considered to be minor at most.

The potential for impacts to water quality are covered in Section 6.4.7 and mitigation measures are set out in Section 10.

6.3.3.2 Post-construction / operational impacts

The NESs will provide additional areas of hard substrate that may become colonised by species such as corals, sponges and invertebrates, potentially providing food for a range of fish species. The increased complexity of the seabed has the potential to provide nursery / refuge areas for fish. This may lead to a beneficial increase in fish populations in the local area (see Appendix 5m).

These positive impacts could be increased / encouraged through the design or integration of eco-engineering components into or near to the NESs. This is developed further in Appendix 10a. These measures are also considered further in Section 10 on mitigation measures. Benefits could range from negligible to moderate beneficial, depending on the complexity of the structures and associated eco-engineering.

For those NESs made from sand filled geotextile containers (NES2 and 3), accidental or deliberate damage to the geotextile material or general wear / degradation of the bags over time may result in some loss of fill material. This has the potential to reduce water quality through an increase in turbidity and may have impacts to fish similar to those identified in the construction section above. The risk of sand loss and associated increases in turbidity is considered to be low, based on the experiences of similar structures in coastal and estuarine environments around the world (see Appendix 6a). Mitigation measures to minimise losses are set out in Section 10.

Other impacts will be associated with maintenance or repair activities, which are anticipated to be very minimal. Damage to sand filled geotextile containers can be ‘patch repaired’ by divers using small scale equipment, with minimal impacts to the marine area or species. Such impacts are considered to be negligible.

The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016. Future beach nourishment activities will have similar effects to those experienced during construction, which are considered to be minor.

6.3.4 Turtles

6.3.4.1 Construction impacts

Construction activities are unlikely to have direct impacts to turtles as they are mobile and will tend to move away from vessels, divers and equipment, such that the risk of collision, damage or death is considered to be low. Consequently such direct impacts are determined to be negligible.

The use of machinery/plant on the beach to place the beach nourishment material may pose a risk to individual turtles nesting on the beach though this is scheduled to operate within a very tight window (2 circa weeks) in September 2016. Loss or damage to terrestrial habitat used for turtle nesting also has the potential to adversely impact populations. The hawksbill (*Eretmochelys imbricata*) is the only species that nests within the project area and is, therefore, the only species potentially affected by impacts to nesting areas. Hawksbill turtles nest all year round making it difficult to completely avoid nesting periods. Nesting activities peak in June and September (BSTP, 2010). Females come ashore mainly at night to lay their eggs. Mitigation measures are described in further detail in Section 10.

Placing additional beach nourishment on top of buried turtle eggs may also adversely affect the survival of the eggs and the hatching of young turtles. This could have a significant impact on the turtle population.

Loss or damage to marine habitat (see above) can have knock on impacts to turtles by removing habitat they use for feeding or resting. Hawksbill turtles feed primarily on sponges, but also on algae, cnidarians, comb jellies, jellyfish and sea anemones. These food sources are widespread throughout the study area and around the coast of Barbados as a whole. The loss of the relatively small area of reef within the footprint of the northernmost NES (NES 1) is not considered to be significant and impacts to turtles and fish from loss or damage to marine habitat will be negligible.

Impacts to water quality may also have knock-on effects by indirectly affecting food sources, through sedimentation / smothering, release of any contamination potentially present within the sediment being used as part of the construction or the accidental or deliberate spillage / release of oils, fuels or other chemicals. However, given the small area potentially affected, the low risk of contamination within the courishment as shown my testing and the wide range of alternative food sources available, knock-on impacts are assessed to be minor at most.

Direct impacts from sedimentation, pollution or contamination are assessed to be negligible due to the mobile nature of turtles able to move away from these impacts.

The potential for impacts to water quality are covered in Section 6.4.7 and mitigation measures are set out in Section 10.

6.3.4.2 Post-construction / operational impacts

Following construction, there will be a wider (broader) and less steeply sloping beach which may be more attractive as a habitat for nesting turtles. The actual benefit of the re-nourished beach to turtles will depend, in part, on the management of human activity and lighting on the beach, which can adversly affect nesting behaviour and may offset / counteract any benefits. The re-nourished beach could provide negligible – moderate beneficial impact, depending on how the beach facilities and services are managed post construction (linked to the new ISO13009 Beach Standard being proposed – see Section 10).

The NESs, whether they are rock (NES1) or made from geosynthetics (NES2 and 3), will provide additional areas of hard substrate that may become colonised by species such as sponges and invertebrates, potentially providing food for turtles. This may encourage turtles to the area or to remain in the area for longer periods. These positive impacts could be increased / encouraged through the design or integration of eco-engineering components into or near to the NESs. These measures are considered further in Appendix 10a and Section 10 on mitigation. Benefits could range from negligible to moderate beneficial, depending on the complexity of the structures and associated eco-engineering approaches.

NESs2 and 3 (built from sand filled geotextile containers) may experience some loss of fill material over time as a result of accidental or deliberate damage to the geotextile material or general wear / degradation of the bags. This may lead to a reduction in water quality down-stream through an increase in turbidity and may have impacts to turtles similar to those identified in the construction section above. The risk of sand loss and associated increases in turbidity is considered to be low, based on the experiences of similar structures in coastal and estuarine environments around the world (Appendix 6a). Mitigation measures to minimise losses are set out in Section 10.

Additional beach nourishment will be required at some point in the future, as the NESs will not completely prevent the loss of sediment from the beach. The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016. Future beach nourishment activity will have similar effects to those experienced during construction, which are considered to be minor with mitigation measures in place (see Section 10).

Other impacts will be associated with maintenance or repair activities, which are anticipated to be very minimal. Damage to sand filled geotextile containers can be 'patch repaired' by divers using small scale equipment, with minimal impacts to the marine area or species. These activities are assessed as having no impact to turtles.

6.3.5 Marine Mammals

6.3.5.1 Construction impacts

Although marine mammals are susceptible to underwater noise, which may be generated by construciton activities, the low level of noise anticipated (from pumps, vessel propulsion) and the low importance of the area / Barbados to marine mammals, means construction of the scheme is assessed as having no impact to marine mammals.

6.3.5.2 Post-construction / operational impacts

No impacts are anticipated to marine mammals post construction. Marine mammals are not frequently seen in Barbados and the scheme is not considered to generate changes capable of impacting on any marine mammals in the area.

6.4 Physical Environment

In assessing the potential for the proposed development to impact the physical environment as a receptor, the following will be considered, as set out in the baseline information in Section 5:

- Topography and Bathymetry;
- Geology and Surficial Soils;
- Hydrogeology and Groundwater Quality;
- Sediments;
- Coastal Processes and hydrodynamics (including erosion and deposition);
- Shoreline Evolution and Sediment Transport;
- Sea Water Parameters;
- Landscape & Seascape.

6.4.1 Topography and Bathymetry

6.4.1.1 Construction impacts

The project is designed to raise the level of the beach through beach replenishment using sands from quarried sources. The construction of NES in the marine area is also designed to change the bathymetry of the local area. The impact of these changes will be felt post-construction (see below).

6.4.1.2 Post-construction / operational impacts

Beach nourishment will add 37,000m^3 sediment to the beach at Sandy Lane. This will raise the beach by approximately 4m at its greatest depth and increase its width by a maximum of approximately 20m. These changes are integral to the design of the project and aim to improve the amenity and access of the beach, contributing to the longer term sustainability of the beach in the face of climate change and sea level rise. These changes are assessed socially as being major positive effects to the immediate area of Sandy Lane Bay (see Section 8).

The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016. Future beach nourishment activity will have similar effects to those experienced during construction and ensure that positive impacts are continued in the longer term.

Improvements to beach levels will also have knock-on positive effects to the socio-economic receptors in the immediate area, wider community and contribute to the island's tourism industry (see Section 6.2 for impacts to human beings and Section 8, the social impact assessment).

The presence of the NESs in the marine area will alter the bathymetry in these areas. Again, these changes are integral to the design of the project and aim to improve amenity and access to the beach, retaining the beach nourishment added to the beach. The presence of the NESs will be a potential hazard to navigation, however, they will be clearly marked both in the marine environment, with appropriate navigational markers (adhering to international standards) and their position placed on navigation charts.

6.4.2 Geology, Tectonic Uplift and Surficial Soils

6.4.2.1 Construction impacts

The project will add circa 37,000m^3 sediment (artificially) to the beach at Sandy Lane. This will be sourced from Lears Quarry on Barbados. All efforts have been made to ensure that the sand added to the beach will be of a similar make-up to that already on the beach. The quarried sands petrology is clearly presented in Appendix 5c which shows that the sediments are predominantly coralline limestone-derived soils. There will be no impacts to the terrestrial soils in the area, as works will be confined to the beach and marine area.

There will be no construction impacts to the geology or any seismic related considerations during construction.

6.4.2.2 Post-construction / operational impacts

Post construction, there will be a need for further beach nourishment. The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016. Future beach nourishment activity will have similar effects to those experienced during construction i.e. there will be no impact.

There will be no impacts to the geology or tectonic uplift post construction.

6.4.3 Hydrogeology and Groundwater Quality

6.4.3.1 Construction impacts

None of the construction activities are likely to affect the hydrogeology or groundwater of the area. There will be a small amount of subtidal sediment excavation, to create a level base on which to build the NESs (in particular NESs2 and 3 made of geosynthetic material only), however, this will not penetrate to a depth at which groundwater or hydrogeology would be put at risk. This is because the construction includes no piling or deep excavation works. The project site is within groundwater protection Zone 5 (see Section 5.2.3), which represents the lowest priority and provides no constraints to development. The assessment therefore concludes that there are no pathways for impact and that there will be no impacts as a result of construction.

6.4.3.2 Post-construction / operational impacts

Post construction, there will be no activities likely to affect the groundwater or hydrogeology of the area. Additional beach nourishment required in the future will have similar effects to those experienced during construction, which will not require any ground penetrating works (piling, excavations). Any repairs to the geotextile NESs (NES2 and 3) are anticipated to be minor and capable of being carried out by divers using small scale equipment. Repairs to the rock NES (NES1) are not anticipated. For all NESs, regardless of material type, no impact on groundwter is expected.

The assessment therefore concludes that there are no pathways for impact and that there will be no impacts to hydrogeology or groundwater quality post construction.

6.4.4 Sediments

6.4.4.1 Construction impacts

The project will add 37,000m^3 sediment to the beach at Sandy Lane. This will be sourced from Lears Quarry in St Georges Parish, Barbados. Surveys carried out for the project tested samples taken at seven (7) locations from the beach and inshore area (see Section 5.2.4) and one from Lears Quarry (the source of beach nourishment and geotextile bag fill sediment) for physical properties and chemical contaminants (see Appendix 5c).

The results of the specific tests for Lears Quarry are presented in Appendix 6c and show that, in general, there is a good physical match between the sediment that will be used for beach nourishment and that already on the beach (see Figure 6.6) and that they do not breach commonly used international sediment contamination standards (the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life) (see Figure 5.7 in Section 5.2.4). Sediment from an alternative quarry on the island (Black Bess) was also tested, however, this did not show a good match with the physical characteristics of the beach sand (see purple line on Figure 6.6) and was, therefore, rejected.

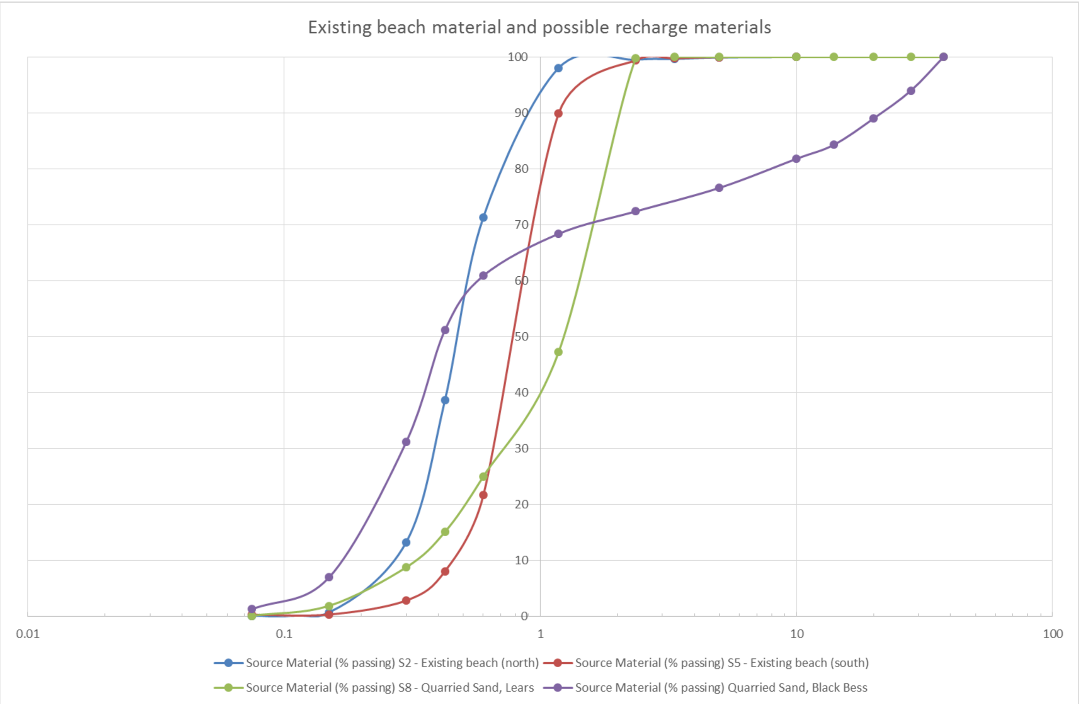


Figure 6.6 – PSD curve comparison of existing beach material (north and south) - Lear's Quarry/ Black Bess Quarry

Based on the results of both chemical and physical tests, the addition of sediment from Lears Quarry to the beach is assessed as having a negligible impact on sediment during construction.

6.4.4.2 Post-construction / operational impacts

Post construction, there will be a need for additional beach nourishment. The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Response Report) submitted in 2016. Additional beach nourishment required in the future will have similar effects to those experienced during construction, which are assessed as negligible.

6.4.5 Coastal Processes and Hydrodynamics

6.4.5.1 Construction impacts

The construction of the NESs and beach nourishment activity is not expected to result in any lasting impacts to coastal processes and hydrodynamics. Impacts instead will be felt in the post-construction phase (see below).

6.4.5.2 Post-construction / operational impacts

Post construction, the presence of the NESs in the nearshore area will affect local coastal processes, as their purpose is to help retain the beach nourishment material and the formation of salients in their lee, to create and maintain a wider, less steep beach.

The NES size, shape and locations have been modelled both numerically and physically (by HR Wallingford – see Appendix 5g). Numerical modelling has looked at their impact on local coastal processes and and far-field impacts they may have beyond Sandy Lane Bay, in particular to Paynes Bay. Modelling work has also looked at the affect on the waves at the surf-break. Physical modelling was undertaken to look at the beach response for typical annual conditions and storm conditions.

These changes are integral to the design of the project and aim to improve the amenity and access of the beach, contributing to the longer term sustainability of the beach in the face of climate change and sea level rise. These changes are assessed as being major positive effects to the immediate area of Sandy Lane Bay.

Further beach nourishment will be required in the future. The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016. Future beach nourishment activity will have similar effects to those experienced following construction and ensure that positive impacts are continued in the longer term.

Improvements to beach levels will also have knock-on positive effects to the socio-economic receptors in the immediate area, wider community and contribute to the island's tourism industry (see Section 6.2 for impacts to human beings and Section 8 for the social impact assessment).

6.4.6 Shoreline Evolution and Sediment Transport

NB: Specific details / impacts with regard to shoreline evolutionary response are shown in detail within Appendix 5g.The following provides a summary of impacts associated with littoral drift/shoreline and beach profile evolutionary change though it should be noted that additional work is underway to record beach profile changes and findings shall be used as part of the pre and post construction conditional assessment work.

6.4.6.1 Construction impacts

The construction of the NESs and beach nourishment activity is not expected to result in any impacts to shoreline evolution. Impacts will be felt in the post-construction phase (see below).

The placement of beach nourishment and the excavation of subtidal sediment to create a stable base on which to build the NESs may result in the generation of small amounts of suspended sediment. The amount of sediment that would be generated is small compared with the quantity of sediment that naturally moves along the shore as a result of natural processes. Impacts to sediment transport are assessed to be negligible.

6.4.6.2 Post-construction / operational impacts

The NESs are designed to help retain the beach nourishment material, slow sediment transport through and from Sandy Lane Bay and contribute to the formation and maintenance of salients and a wider, less steep beach. As such, they will lead to post-construction changes to shoreline evolution and sediment transport.

The NES size, shape and locations have been modelled both numerically and physically (by HR Wallingford) to determine these impacts. These changes are integral to the design of the project and aim to improve the amenity and access of the beach, contributing to the longer term sustainability of the beach in the face of climate change and sea level rise. These changes are assessed as being major positive effects to the immediate area of Sandy Lane Bay.

The frequency and amount of future beach recharge will be investigated within the numeric modelling and reported within the final EIA and associated Appendix 5g (Shoreline Morphological Report) submitted in 2016. Future beach nourishment activity will have similar effects to those experienced following construction and ensure that positive impacts are continued in the longer term.

Improvements to beach levels will also have knock-on positive effects to the socio-economic receptors in the immediate area, wider community and contribute to the island’s tourism industry (see Section 6.2 for impacts to human beings and Section 8 for the social impact assessment).

6.4.7 Sea Water Parameters

6.4.7.1 Construction impacts

Construction activities have the potential to adversely impact on the water quality in the area through the following pathways:

- Generation of suspended sediment in the water column by:
  - Temporarily moving and reprofiling the subtidal sediment to provide a stable base on which to build the NESs;
  - Filling and placement of geotextile bags for the construction of the NESs;
  - Addition and profiling of beach nourishment material on the beach (see Figure 6.7);
- The release of any contamination potentially present within the sediment being used as part of the construction;
- Accidental or deliberate spillage / release of oils, fuels or other chemicals.

Figure 6.7 Sediment plume from a coastal construction site

Source: Brathwaite et al.

Water quality samples were taken from a number of locations along the coast of the project area on 27 January 2015. These tests showed that water in the project area generally meets the 'ambient' water quality standards proposed under the Marine Pollution Control Act, with the exception of Total suspended solids (TSS), which were much greater than the ambient standard (5mg/l). It is therefore important that the construction works do not add to these levels.

Chemical contamination testing of the sediments on the beach and from Lears Quarry show that they do not contain significant quantities of contaminants (PAHs, heavy metals, pesticides). The risk of releasing any contamination in the sediment during construction is therefore extremely low.

Increases in suspended sediment or pollution incidents can have significant impacts on coral health, as they are highly susceptible to changes in water quality such as eutrophication, sediment load, turbidity, temperature, salinity and toxic chemical load.

Pollution incidents are generally a low risk during well-managed construction works, however, incidents if they do occur can have significant and persistent impacts on water quality. Potential construction impacts could range from negligible to major, however, with risk management measures put in place, impacts to water quality are considered to be minor and short term. Mitigation measures set out in Section 10.

Construction works are expected to have no impact on microbiological water quality. The sediment to be used in the project is from a land-based quarry and the works do not pose a risk to foul / sewage disposal in the area.

There will be no impacts to water temperature as a result of the construction of the project.

6.4.7.2 Post-construction / operational impacts

Once built, there may be some loss of fill material from the sand filled geotextile containers used to build the NESs over time as a result of accidental or deliberate damage or general wear and degradation of the bags. This may lead to a reduction in water quality through an increase in suspended sediment and a related decrease in dissolved oxygen. The risk of sand loss is considered to be low, based on the experiences of similar structures in coastal and estuarine environments around the world. Mitigation measures to minimise losses are set out in Section 10.

Other impacts post-construction are connected with maintenance or repair activities, which are anticipated to be very minimal. Damage to sand filled geotextile containers can be 'patch repaired' by divers using small scale equipment, with minimal impacts to water quality.

It is anticipated that additional beach nourishment and / or re-profiling of the beach will be needed in the future, as although the NESs are designed to slow the loss of sediment from the beach, they will not stop it completely (and halting all movement of sand is not desirable from a coastal process perspective). Impacts of future nourishment activities are likely to be similar to those during construction and are assessed to be minor and short term with similar mitigation measures in place.

There will be no impacts to water temperature post-construction.

6.4.8 Landscape & Seascape

6.4.8.1 Construction impacts

There are various methods regarding pumping sand onto the beach and the choice of option will depend on the bathymetry, plant available, draft, impact etc. Rainbowing, for example, will require dredge plant to be able to sit safely in the bay in fairly close proximity to the shoreline. Pumping onshore could also be done via sinkerline/floating line from plant offshore. Again the bathymetry will dictate where the dredge plant can sit in the bay. The exact methodology is currently being determined with the contractor there would still, however, need to be plant on the beach to profile material away from the pipeline and blade to the profile. At this stage the client deems this to be a preferable option due to less local disturbance. There are, however, similar traffic movements though these will be concentrated at the port which has the better infrastructure to deal with such volumes of sand, rather than stockpiling closer to the hotel. During construction, using this example, the equipment and materials (coral rock and quarried sands) will be offloaded at the Port of Barbados onto a barge and will be ferried to the Sandy Lane Beach.

The advantage of this mode of transfer is that it allows for higher and wider assemblies to be shipped than is possible to negotiate via the network of roads between the port and the site. This will reduce assembly times, improve schedule and reduce the disruption of traffic during equipment transfers.

Re-profiling of the beach and temporary access to the beach from Leigh House (see Section 6.7.1.3) will be required, potentially using a temporary bund placed at mean low water to assist truck access over a reduced time period (over a complete 12 hour tidal cycle). Upon completion, the temporary track bund will be removed and the beach restored.

Seascape impacts from a construction perspective are assessed to be moderate though short term. Specific mitigation measures are put forward to address these impacts in Section 10.

6.4.8.2 Post-construction / operational impacts

The main post construction issue regarding landscape/seascape issues are linked to the visibility of the structures at low water. Appendix 6d addresses this point in more detail though salient outcomes are reflected below. Raising the crest and reducing the depth of water over the structures is proven to be more effective in reducing wave heights landward of the structures. With the results of both model runs, the consultant team compared beach response under both schemes to assess the balance between visibility and effectiveness of the schemes.

The preferred scheme layout (Figure 6.1) shows that the most northerly NES is to be comprised of rock and emergent above water. The other two NESs shall be made of geosynthetic materials and shall be submerged at all states of the tide. The above was deduced from physcical and numerical modelling work and analysis of predicted tidal data (2015). The recorded data from the Acoustic Doppler Current Profiler (ADCP) deployed within Sandy Lane Bay, by Environmental Sciences Limited (ESL), was also reviewed in the process.

For the crest elevation used within test series A (-0.37mLD), the crest of the structures would not have been emergent for the reviewed data period (2015). At MLLW and above, the crest of the structures would become emergent during low tide. The average number of times the structures would be emergent (i.e. above water) and the associated duration, was quantified and shown in Table 6.1 for the following crest levels.

• 0.314mLD (MSL);

• 0.214mLD (MHLW);

• 0.014mLD (MLLW);

• -0.370mLD (Initial crest level within physical model, test series A – see Appendix 5g).

	MSL		MHLW		MLLW		Initial crest level	
	Per day	Per daylight hours	Per day	Per daylight hours	Per day	Per daylight hours	Per day	Per daylight hours
January								
Average number of times emergent	2	1	2	1	1	0	0	0
Average duration emergent (hrs)		9.1		4.7		0.0		0
February								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		10.0		6.7		0.5		0
March								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		11.0		7.6		1.0		0
April								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		11.6		8.3		1.7		0
May								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		12.2		9.1		2.4		0
June								
Average number of times emergent	2	2	2	1	1	1	0	0
Average duration emergent (hrs)		12.5		9.0		2.8		0

	MSL		MHLW		MLLW		Initial crest level	
	Per day	Per daylight hours	Per day	Per daylight hours	Per day	Per daylight hours	Per day	Per daylight hours
July								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		12.2		8.4		2.8		0
August								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		11.5		7.5		2.0		0
September								
Average number of times emergent	2	1	2	1	1	1	0	0
Average duration emergent (hrs)		10.8		6.7		0.7		0
October								
Average number of times emergent	2	1	2	1	1	0	0	0
Average duration emergent (hrs)		9.7		5.4		0.0		0
November								
Average number of times emergent	2	1	2	1	1	0	0	0
Average duration emergent (hrs)		8.9		3.8		0.0		0
December								
Average number of times emergent	2	1	2	1	1	0	0	0
Average duration emergent (hrs)		8.7		4.0		0.0		0

It is noted in Table 6.1 that emergent structures will only be seen in daylight hours so this has also been taken into account. A simple review of sunrise / sunset times provided the daylight hours for each month of 2015. The average times for each have been used for this analysis (to the nearest 15 minutes for sunset and sunrise). *NB: This analysis is based on still water levels. Under wave action the structures will be more visible in the wave trough but less visible under the wave crest.*

For a crest level at MLLW, the structures would become emergent on average once a day. Further increasing the crest level results in a significantly longer period of emergence (on average over 9 hours at MHLW and around 12 hours at MSL). In order to test the effectiveness of the structures in retaining the bach material, this, it was proposed to raise the crest by approximately 0.4m for the second physical model run (test series B), with a crest elevation of MLLW (0.014mLD). This minimises the amount of time the structure is seen (a key part of the client brief), relative to higher crest levels, e.g. MHLW / MSL, whilst aiming to make them more effective in retaining the beach material, relative to test series A.

Following a review of the physical model tests and recorded tidal data for 2012 that was received from the CZMU following completion of the physcial model tests, and discussion with BRI, the crest height of NES2 and NES3 was chosen to remain at -0.37mLD. There will be negligible and long term impacts on landscape/seascape issues regarding the submerged NES2 and NES 3 post-construction.

Following a review of the physical model tests and discussion with BRI, the crest height of NES1, as an emergent rock strucutre was chosen as +1.0mLD. There will be minor impacts on landscape/seascape issues regarding the emergent NES1 rock structure post-construction.

NB: Additional work is underway with regards to assessing beach recharge volumes. The final beach recharge volume is awaited, in terms of what local plant can expect to practically bring to site and place within the one-week period afforded for the works as a result of the hotel closure. The calculations on the positions of the structures in plan and beach shape to date reflect the beach volume currently being physically modelled.

6.5 Air Quality (incl. emissions to atmosphere, generation of dust, climate change)

This receptor was scoped out in the EIA ToR as the release of emissions will be limited to the periods when construction plant, equipment, vessels and vehicles are actually in use. Given the relative scale and duration of the proposed works and that given the coastal location of the works, any emissions will be rapidly be dispersed, the construction of the proposed scheme will result in no significant impacts on air quality.

6.6 Noise and Vibration (impacts to both fauna, humans, human activities and buildings)

6.6.1 Noise

There is no general noise standard in Barbados however there is legislation governing noise in the workplace - The Workplace (Noise) Regulations, 2007. These regulations state that in the case of impulse or impact noise, no exposure in excess of 140 dB peak sound pressure level as measured by setting the sound level meter at the position designed for reading impulse or impact noise, shall be permitted. They further state that where the noise level to which workers are exposed exceeds 80 dBA but is below 85 dBA, the employer shall provide employees with information, instruction and training regarding the effects of noise and make hearing protection available.

6.6.1.1 Construction impacts

The use of construction plant, equipment and vehicles associated with the construction of the proposed scheme will result in noise which has the potential to negatively impact local residents, tourists, and beach and sea space users disturbing their enjoyment of the beach and near shore area.

Construction activities and the noise generated also has the potential to impact on terrestrial ecology (e.g. birds) in the vicinity of the beach and near shore area, disturbing feeding or roosting activities.

The use of construction plant and vessels in the near shore area will generate both surface and underwater noise which has the potential to negatively impact local residents, tourists, beach and sea space users as well as marine species (e.g. fish and turtles). The placement of rock for the construction of NES 1 is also likely to generate underwater noise, as is the small amount of sediment movement in the footprints of NES 2 and NES 3.

The nature of the construction activities envisaged is likely to result in noise initially triggering a startle response in marine species or birds, causing them to move away from the area quickly as soon as the works commence. The frequency and intensity of the noise generated is likely to be fairly constant for the duration of the construction phase and as such it is anticipated that species will quickly become accustomed to the noise and return to the vicinity of the works, or move to an adjacent area until all construction noise ceases at night or on completion of the works. Construction works will be limited to a relatively short period of several weeks. Working hours will also be limited to 8am to 6pm, with the first two hours and the last hour of each working day being limited to ‘quiet’ activities associated with mobilisation and demobilisation of plant and equipment. Noisy activities such as pumping and rock placement would be limited to 10am to 5pm (see Section 4 for working hours and construction activities).

Adjacent areas of both the terrestrial and marine environment are similar to the project construction area, and able to provide similar services in terms of food, shelter and habitat. There are no barriers to fish, birds or other species moving to and from these adjacent areas.

Given these factors, the impacts of noise generated during construction are considered to be minor – moderate and short term.

6.6.1.2 Post-construction / operational impacts

Following completion of the construction works, the proposed scheme is not anticipated to generate any additional noise or vibrations above ambient levels. Any repair or maintenance activity may generate similar types of noise to those experienced during construction, but at a lower level and shorter duration. As such any impacts on noise and vibrations as a receptor, including impacts to fauna, humans, human activities and buildings are considered to be negligible.

6.6.2 Vibration

The nature of the construction works for the proposed scheme are not anticipated to generate vibrations, on the beach and land adjacent that could result in impacts to humans, human activities or buildings. The movement of plant and vehicles (delivering materials) may generate some local, small scale vibration.

The size of the plant and vehicles that will be used are not unusual and, as the main highway runs past the beachside properties in the project area, similar magnitudes of vibration could be expected normally (i.e. in the absence of the scheme). As such, vibration generated by the scheme is not considered to be significantly different from the baseline and impacts are, therefore, assessed as negligible.

The placement of rock for the construction of NES 1 may generate some underwater vibration, as rocks ‘knock’ against each other and the relic reef. These small vibrations may result in a similar ‘startle’ response to that generated by underwater noise (see above). They will not generate vibrations capable of causing physical damage or death to fish, turtles or other species in the vicinity.

The generation of underwater vibration will be limited to construction only and to the prescribed working hours described above and in Section 4. Mobile species such as fish or turtles will be capable of moving to adjacent areas and returning when the source of the vibration has stopped (or they become accustomed to the vibrations). Based on this information, the impacts of underwater vibration are assessed as being minor and short term.

6.6.3 Underwater Noise and Vibration (impacts to fauna and human activities)

6.6.3.1 Construction impacts

The nature of the construction works for the proposed scheme is not anticipated to generate underwater vibrations and as such no impacts are expected as a result of underwater noise or vibrations.

6.6.3.2 Post-construction / operational impacts

Following construction, the scheme will not generate any underwater noise or vibration and no impacts are expected as a result of underwater noise or vibrations.

6.7 Changes in the availability or service of infrastructure and utilities

This receptor was scoped out in the EIA ToR as the proposed scheme is not anticipated to have any impacts upon the availability or service of infrastructure and utilities, either during construction or post-construction.

6.8 Traffic

6.8.1 Construction impacts

6.8.1.1 Transport from Storage Area to End Destination (Sandy Lane Beach)

There may be some impacts to terrestrial habitats in the immediate locality where stored quarried sands are reloaded onto trucks and transported to the backshore of the beach as part of the beach nourishment exercise. ***(NB: this issue is currently being determined through consultation with a contractor and no decision has been made on exact details as yet)***. The storage areas (regardless of their location) will be restored to their pre-construction state after use. These impacts will be in a defined area (yet to be confirmed) and will be temporary, during construction only. The quarried sands storage impacts are, therefore, considered to be minor and short term.

There may need to involve some terrestrial habitat impact to help enable machinery (trucks) to access the beach from Leigh House (car parking area). This may result in the removal of a small amount of beach vegetation and temporary removal of the beach wall to the south of Leigh House (see Figure 6.15).

Figure 6.15: Possible temporary access point for vehicular truck access for beach renourishment exercise.

It can be seen from Figure 6.15 that careful temporary removal (or replacement) of coastal vegetation will need to occur post construction. Should this removal be required, all beach vegetation shall be reinstated as it is acknowledged that the roots of beach vegetation aid in stabilising the beach in the event of storms. The use of the proposed machinery/plant on the beach (to transport and subsequently) place the beach nourishment material may pose a risk to individual turtles nesting on the beach though this is scheduled to operate within a very tight window (2 circa weeks) in September 2016. This has been addressed in the section above (turtles). The prevalence of burrowing ghost crabs (*Ocypode quadrata*) (see Section 5.3.3 and Appendix 5i).

The use of construction plant / vehicles moving northwards from this point to Sandy Lane Bay may result in disturbance to the beach environment which could result in impacts to any species buried within the sand. However, as stated in Section 6.3.3, most mobile species will be able to move away from the temporary disturbance that occurs. Given the number of crab burrows present across the wider study area, any losses of burrowing crab are likely to replaced by natural trans-migration re-colonisation from neighbouring or immediate adjacent areas. Other invertebrates living in the sand or between grains are also likely to be replaced in time by colonisation from neighbouring areas.

Any impacts will be confined to the construction period of a few weeks and are therefore, considered to be minor and short term.

Direct impacts of this aspect of the traffic variable are considered in the table below based on the scale of the issue to be assessed*:*

Traffic/Transport Impact Title	Description	Defined Impact "Score" (construction)	Defined Impact "Score" (post construction/ operational
Quarry to Storage Area Traffic	3000 truck loads of quarried sands via various public highway routes.	moderate	Dependent upon need for additional materials long term (volumes significantly less than after intial recharge hence negligible impact).
Storage Area to Beach Traffic	3000 truck loads of quarried sands over a week long period in September 2016 through Leigh House private area and onto intertidal beach for (60m intertidal beach access at low water or potential short term bund creation at higher tide states).	moderate	Dependent upon need for additional materials long term (volumes significantly less than after intial recharge hence negligible impact).
Transport of coralline rock (1-2 tonne units) from Black Bess Quarry to Port of Barbados	Circa 150 truck loads of 1-2 tonne coral boulders from Black Bess Quarry to Port of Barbados over a 2 week long period in July/August 2016. Rock amount for NES1 represents normal transported truck loads already on the road from Black Bess Quarry.	Low impact / negligible Transport volumes represent part of the normal operation procedures for Black Bess Quarry.	Low impact / negligible Transport volumes represent part of the normal operation procedures for Black Bess Quarry.
Boat Transport	Transport of geosynthetic tubes and rock from Port of Barbados to Sandy Lane Bay.	Low impact / negligible	Low impact / negligible

The proposed traffic related mitigation measures, with regard to the impact assessment scoring above, are set out in Section 10.

7 CUMULATIVE EFFECTS ASSESSMENT

7.1 Overview

An important part of the EIA process is to consider the cumulative effects of the development. Cumulative effects are the combined impacts of a single activity or multiple activities. The individual impacts from a single development may not be significant on their own but when combined with other impacts, those effects could become significant. Some of the effects may be already happening and when combined with the effect of newly implemented projects will result in cumulative effects.

The cumulative effects assessment process attempts to evaluate the Projects' contribution to stress on receptors in combination with other past, present and future human actions. It therefore involves:

- assessing effects over a larger area than just the Parish of St James; [Includes effects due to natural perturbations affecting environmental components and human actions.]
- assessing effects during a longer period of time into the past and future than the Project implementation duration
- consider effects on Valued Ecosystem Components (VECs) due to interactions with other actions, and not just the effects of the single action under review;
- include other past, existing and future (e.g., reasonably foreseeable) actions; and
- evaluate significance in consideration of other than just local, direct effects.

Cumulative effects assessments also consider the possible impacts arising as a result of the project being assessed along with those from other projects in the same area or time frame. The cumulative effects assessment process therefore involves identifying other projects in the area, identifying information on an area basis and finally conducting the assessment.

Cumulative Effects can be defined as changes to the environment that are caused by action in combination with other past, present and future human actions. The central question is what contribution the proposed Project would make to the overall stresses on the environment that are caused by all stressors due to human activities.

7.2 Valued Ecosystem Components and Project Boundaries

This section describes the process used to identify Valued Ecosystem Components (VECs), which involves issues scoping and pathway analysis. This analysis builds on the initial stakeholder identification and the report of the assessment of recreational users in the project area. An important aspect of the effects assessment process is the determination of the boundaries of the assessment. Temporal and spatial boundaries encompass those periods during, and areas within which, the VECs are likely to interact with, or be influenced by, the Project. The temporal boundaries are extended to include activities in the past, those that are under way in the area, and known projects planned outside of the time boundaries established for the Project.

Spatial boundaries for the assessment are specific to each VEC, and may extend beyond the Project footprint area. For example, effects on traffic may include a more regional perspective, while effects on soils are limited to the immediate Project area. The boundaries may be physical (e.g., watersheds), biological (e.g., habitats), or political (e.g., counties).

Table 7.1 below presents the rationale for the selection of the VECs. VECs selected for Cumulative Effects Assessment are highlighted and the following sub-sections develop further each VEC as appropriate.

Table 7.1 Issues Scoping/Pathway Analysis Summary Matrix Valued Ecosystem Components of Concern (VECs)

Environmental Components of Concern (ECCs)	Pathway of Concern		Possible Pathways	VEC		Rationale for Inclusion/Exclusion as Valued Ecosystem Component (VECs)
	Yes	No		Yes	No	
Fauna and flora		x	Operation		x	Excluded as a VEC – The Project is likely to support the increase in biodiversity levels at a national scale with some positive new steps being introduced within Sandy Lane Bay.
Environmentally Sensitive Areas and Designated Areas		x	Operation		x	Excluded as a VEC during operations – Project is compatible with existing land uses and designated zones in the Folkestone Park and Marine Reserve Area. No critical habitat features impacted by Project during operations.
Land use		x	None		x	Excluded as a VEC – Project is compatible with existing land uses.
Archaeological/ Heritage Resources		x	Construction Operations		x	Excluded as a VEC – St. James Parish Church, Portvale Sugar Factory and Sir Frank Hutson Museum are heritage resource located in Project area. Excluded as a VEC because potential effects on heritage sites have been addressed with other VECs (air and noise)
Traffic	x		Construction Operations	x		Included as VEC – Potential effect from construction and operations related traffic on existing traffic patterns.
Nearshore turbidity	x		Construction	x		Included as VEC – Potential effect from construction during construction of coastal structures

7.2.1 Ambient Noise

The analysis for noise included existing background levels from current sources in the area of the site as identified above and estimated noise level from machinery during construction. The analysis (Section 5.7) indicates that the World Bank Guidelines for noise can be met with the recommended levels of sound attenuation.

7.2.2 Traffic

Traffic in Barbados has become increasingly congested in the last few years by the proliferation of privately owned automobiles. This is further impacted by the large number of development and construction projects on the Island, as well as ongoing maintenance of roads and municipal services. The proposed Project will result in some short term traffic impacts during the construction phase. Preliminary estimations are that circa 12,500m^3 of sand is required for the NESs and over 37,000m^3 is required for the beach replenishment work. Assuming road transport using 12m3 truck capacity vehicles, this amounts to over 3,000 truck- loads of sand to be transported collectively on the nation's roads/highways to either the port or to storage areas within the property boundary of Sandy Lane. To ensure the stock of sediment is available in time, mining works would need to start (from a quarrying perspective) by the end of May 2016 to ensure material is available in time for August/September 2016. A strategy will be implemented to minimise traffic congestion closer to the time (see Section 10). This will include movement of the majority of materials after peak hours and temporary stock piling near Sandy Lane beach, within the confines of Sandy Lane hotel for subsequent transfer to the beach.

7.2.3 Nearshore turbidity

Sedimentation and the effects of suspended particulate matter are mainly as a result of terrestrial runoff entering the coastal environment via water courses, conducts, drains and terrestrial erosion. The sediments settle out onto the nearshore substrate and can thus reduce light penetration and settle onto any corals or other benthic habitats in the area. The settled out sediment can be naturally re-suspended during periods of high wave energy (Brewster & Mwansa, 2001)

The project has undertaken a water quality sampling programme (Appendices 5j and 5k) from a number of locations along the coast of the project area on 27 January 2015. In addition, samples were also taken at Port St. Charles, approximately 11 km north of the project site and at the Flour Mill in Bridgetown Port to provide a control / comparison. Samples were collected between 7.15am and 10.15am from approximately 1m below the surface of the water. Samples were kept in a cool box with ice until delivery at the Government Analytical Services (GAS) laboratory, Bridgetown, who carried out the chemical and microbiological tests.

7.3 Cumulative Effects – Adjacent Projects

The impacts of the proposed works need to be considered alongside the potential impacts of other known projects in the area. We are aware of the following developments or potential developments that may have cumulative impacts with the Sandy Lane project.

7.3.1 Beachlands development

This site (http://www.beachlandsbarbados.com/) is currently undeveloped and surrounded on three sides by white boarding. It is approximately 400m north of the northernmost NES in Holetown, St James Parish. There is a rock breakwater beach control structure offshore of the Beachlands plot.

This development is to be built on more than four acres and was to originally include 40 apartments and six penthouses. It is unclear when construction work is likely to take place at the Beachlands site, however any construction will be confined to the terrestrial environment and within the Beachlands plot. The presence of an existing rock breakwater means that any construction in the sea for development at Beachlands is extremely unlikely.

The plot is north of the Sunset Reef headland. Sandy Lane Bay cannot be seen from the Beachlands plot or the beach fronting the plot. Vessels associated with the Sandy Lane construction will not be visible from Beachlands and will not head north from Sandy Lane, as the harbour is to the south.

Work at Beachlands (when planning consent is granted) is likely to generate some construction traffic to / from the site, however, as access to the site is from the main road (Highway 1), which is designed to carry a significant flow of traffic. The majority of materials associated with the Sandy Lane project will be delivered by sea, with quarry traffic heading to the harbour, well away from Beachlands, cumulative impacts are considered to be negligible.

Given the information above, the likelihood of any interactions or cumulative effects with the scheme are considered negligible.

7.3.2 Platinum Bay development

This development consists of 5 exclusive villas, located to the north of Beachlands development site in the centre of Holetown, St James. Sandy Lane Hotel is just a ten-minute walk along the beach in the next bay (see Figure 7.1).

This site is also currently being developed (work commenced in April 2015). It is approximately 500m north of the northernmost NES in Holetown, St James Parish. All construction is confined to the terrestrial environment and within the Platinum Bay plot. The beach at Platinum Bay is relatively wide and a dry beach is maintained at high water. BRI are not aware of any plans for beach control structures or works in the sea as part of the development at Platinum Bay.

The plot is north of the Beachlands plot and Sandy Lane Bay cannot be seen from the Platinum Bay plot or the beach fronting the plot. Vessels associated with the Sandy Lane construction will not be visible from Platinum Bay and will not head north from Sandy Lane, as the port is to the south.

Work at Platinum Bay is likely to generate some construction traffic to / from the site, however, as access to the site is from the main road (Highway 1), which is designed to carry a significant flow of traffic. The rock, sediment for NES construction and geotextile bags associated with the Sandy Lane project will be delivered by sea, with quarry traffic heading to the harbour. However, sand for beach nourishment (37,000m^3, equating to over 3,000 trucks) will be delivered by road from Lears Quarry, to be stockpiled at Sandy Lane Hotel before being placed on the beach. This could result in significant impacts to traffic, which may have cumulative effects with the Platinum Bay development. Specific mitigation measures to address traffic impacts are discussed in Section 10.

Figure 7.1: Platinum Bay Development villas (artist impression – taken from http://platinumbaybarbados.com/).

8 SOCIAL IMPACT ASSESSMENT

8.1 Overview

Activities that interact with environmental systems have typically relied on scientific analysis to project the impacts of projects and have operated on the assumption that good science could reveal and remedy potential problems. This conceptualization often assumes that managing natural resources is a purely physical scientific enterprise. Good science is certainly essential, but because environmental management is fundamentally a human activity, effective predictions of human impacts demand, at the very least, equal attention to the social, political, cultural, and economic systems in which environmental management takes place (Ludwig et al., 1993). Social Impact Assessments (SIAs), as part of the larger environmental management enterprise, need to be approached with this in mind.

SIA is therefore the process of managing the social issues of planned interventions (projects, policies, plans, and programs). SIA can also be used to consider the effects of gradual landscape change. Key concepts in SIA that are applicable to coastal projects (similar to this project proposal) include: sense of place and place attachment, island-ness, cumulative effects, social carrying capacity, not in my backyard (NIMBY) responses, resilience and vulnerability, corporate social responsibility, social legitimacy, social license to operate, sea-change communities and second home ownership.

There is a relationship between social aspects of development and the environmental impacts of proposed project therefore conducting both SIA and EIA together helps to establish the linkage between the impacts of the environment on society. The dominance of EIA over SIA when they are conducted together adversely affects the ability of mitigation measures to address social impacts of the projects. Therefore, careful consideration has been given to the role of both and how they should be inculcated into the final decision making process. This SIA (following sub-sections) thereby incorporates stakeholder analysis, public participation and community engagement not only to predict the impacts of planned interventions or policy changes, but also to develop effective adaptive management and enhancement strategies.

8.2 SIA Essentials for the Project

This SIA takes into consideration the Inter-organizational Committee on Principles and Guidelines for Social Impact Assessment (ICPGSIA) which released an updated set of guidelines and principles for conducting SIAs in 2003 (ICPGSIA, 1993, 2003). The ICPGSIA principles and guidelines provide a solid foundation for conducting SIAs (ICPGSIA, 2003) and are adhered to as far as possible within the requirements of the TCDPO guidance set for Barbados.

This international organization lists six principles that are foundational to an effective SIA. They are:

1. Achieve extensive understanding of local and regional setting;

2. Focus on key elements of the human environment related to, and impacted by the project;

3. Utilize sound and replicable scientific concepts and methods, based on widely accepted, peer-reviewed natural science, social science, and economics;

4. Provide quality information for decision making;

5. Ensure that environmental justice issues are fully described and analyzed;

6. Undertake project, program, or policy evaluation/monitoring and mitigation.

In line with these basic principles, there are several essential components of SIAs that will precede coastal engineering related projects such as this proposed project. It is critical to begin the SIA as soon as possible and for this project, the SIA process took place within 5 weeks of project award (with Xmas vacations in 2014 being the key reason for this not starting any earlier). The work undertaken (see Appendix 8a) was well established and included the following essential elements:

A. Integration and Implementation of Baseline Investigations (see Section 8.3)

It is imperative that any and all SIAs are completed in consultation (and coordination with) those studying the biophysical and hydrological impacts of the project. To achieve coordination, the project has ensured that (where possible) simultaneous data collection took place. A summary of all baseline data collection programmes undertaken for the project is presented clearly in Section 8.3 and Appendix 8a.

B. Effective participation and inclusion of local knowledge (see Section 8.4)

Based on the above first principle of the SIA process which calls for achieving extensive local understanding, eliciting local expertise and engaging the public have proven to be powerful tools for adding detail to the potential impacts and avoiding conflict after a project is underway. ICPGSIA emphasizes the importance of considering what counts, and not what is easily counted. The project team thereby embraced this principle by engaging closely with key focal groups, such as the *Friends for the Protection of Surf and Beach Recreation areas – Barbados* group. Close interaction with this group ensued from late January 2015 onwards with members being involved directly to add specific insights into surfing needs and preferences. The qualitative methods adopted enabled the consultancy team to effectively field test conclusions drawn from quantitative methods (physical and numerical modelling etc), and also to suggest analytical approaches based on local concerns. Specific details of the meetings held with key focal groups are presented in Appendix 8a and also in Section 8.4.

C. Geographic and temporal scale social impacts (see Section 8.5)

Two related issues that are particularly pertinent to coastal engineering projects in Barbados are linked to geographic and temporal dimensions. Coastal "downstream" impacts have the potential to effect parishes and populations other than the ones where the actual structures will be built. The proposed project may, for example, impact fishing communities in Paynes Bay to the south. Consequently, the SIA must consider the entire spatial reach of the socioeconomic influences on either side of the project area. To this end, the parallel coastal modelling work undertaken was extended to cover the shoreline and nearshore areas off Paynes Bay.

In terms of the temporal scale, it is also essential to keep in mind that social impacts can occur before construction begins. The announcement of a project can give rise to a social response. Thus, the social impacts can begin long before construction and the SIA and planning/development processes need to include the pre-project influences and outcomes. Also, a viable SIA must consider the social impacts throughout the duration of the process. To this end, the projects SIA has engaged with key stakeholders prior to the submission of the final EIA and also key meetings during the formal consultation period. Section 8.5 focuses on this issue in more detail.

D. Economic and social considerations: "PIES" – Property, Income, Employment, and Stakeholders (see Section 8.6)

In addition to the environmental justice economic issues and standard cost-benefit analysis, an effective SIA considers the impact on property values, income levels, and employment opportunities for a full range of stakeholders (PIES) in the impacted area. Consideration should be given to pre-existing conditions and trends and any alteration to those conditions and trends caused by the project/policy/program. Section 8.6 of this EIA summaries employment related issues associated with the proposed project.

F. Communication of uncertainties (see Section 8.7)

As part of the public outreach element of an SIA, the project team has provided stakeholders with information about the uncertainties associated with the project. Projecting future impacts, both in terms of biophysical and social dimensions, has inherent uncertainties. Exploring and communicating these uncertainties will ensure that stakeholders are adequately informed about this reality. Section 8.7 focuses on this issue in more detail.

G. Consideration of the trade-offs and alternatives (see Section 8.8)

Proposed projects will produce both losses of existing opportunities and the creation of new opportunities. The SIA should reveal as much as possible about the gains and losses (i.e., benefits and costs) associated with the pending project as part of the projection of economic, social, and cultural impacts to different communities. Exploration of multiple scenarios and the uncertainties will help reveal what the trade-offs are. Section 8.8 focuses on this issue in more detail.

H. Social conditions with and without the project (see Section 8.9)

Although the emphasis of an SIA tends to be on a project's social impacts, a fundamental component of an EIS is to consider the alternatives. This would include conditions without the project/policy/program, along with other realistic options. This is particularly pertinent in coastal engineering related projects. Since the west coast of Barbados is a highly dynamic setting, there will be inevitable environmental changes even without the engineering work, and stakeholders need to be informed of these biophysical changes and how they may impact coastal communities. A thorough accounting of social conditions with and without the projects is needed as part of the SIA. Section 8.9 focuses on this issue in more detail.

The following sections of this SIA demonstrate how each of the above SIA international principles have been taken into consideration within the design of the project.

8.3 Integration and Implementation of Baseline Investigations

In tandem to the environmental baseline surveys already identified in Appendix 3a, a parallel social and recreational survey was initiated during early January 2015. Two primary tasks were carried out as part of this exercise:

1. Identification of primary and secondary stakeholders in the project area, clarifying their activities in relation to passive and active recreational use of the area (their own activities as well as recreational activities they support through their livelihoods); and
2. Engagement of stakeholders (through interviews/focus groups etc.) to solicit feedback on their perceptions of how the proposed project could impact (positive or negative) on their specific recreational activity.

The interviewing strategy for the social survey involved letters of introduction / participation (see Appendix 8b) and consent (as per local protocol). Also, the nature of the survey process required a degree of adaptability and judgment on the part of field interviewers. To achieve this, it was planned that appropriate facilitators be used who were familiar with the location and possibly the stakeholders being interviewed. Interviews were also scheduled at times most appropriate for respondents (for instance in the afternoon or evening for fisherfolk).

The approach to the social interviews was structured as a conversation (even though a structured survey was used) which was carefully guided to address particular questions from the respondents. In some cases, the natural flow of the interview would inevitably at times deviate from the questionnaire particularly on asset ownership and access. The interviewers in this case were then primed to use a "checklist" provided as well as to encourage the respondent to identify any other issues not mentioned on the list.

The interview was designed to accommodate free discussion and it need not necessarily have to proceed in the order as laid out in the survey. For example, many relevant questions/responses only become obvious as the interviewing process developed (and follow-up interviews may need to be conducted as necessary). New issues which had not been considered at the outset were then recorded.

At the end of each day of conducting interviews, the interviewers took time to debrief and discuss the events of the day, highlighting any issues and/or concerns, and coming up with solutions to facilitate a more efficient data collection the following day. At the conclusion of the interviews, respondents were asked if they would like to be notified when we will return for a public presentation. If yes, accurate contact information was recorded for future reference. Details of the interviewees and survey instruments used are presented in the final survey report in Appendix 8b.

8.4 Effective participation and inclusion of local knowledge

A total of 50 respondents were interviewed during the survey which was conducted between Saturday, January 10th and Friday, January 16th, 2015. Figure 8.1 displays that the majority of respondents were male (68%), a good demographic cohort of ages were captured and importantly, the survey has benefitted from 86% of respondents being local Barbadian residents (only 14% visitors) (Figure 8.2).

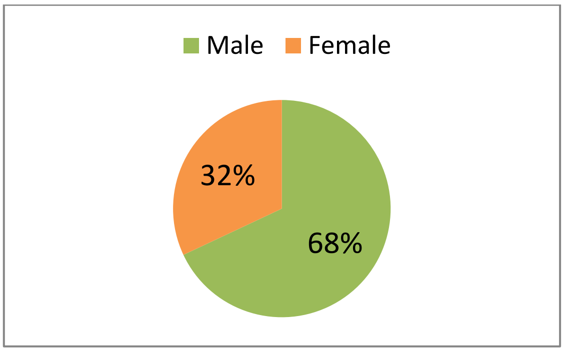


Figure 8.1: Gender ratio of respondents (%)

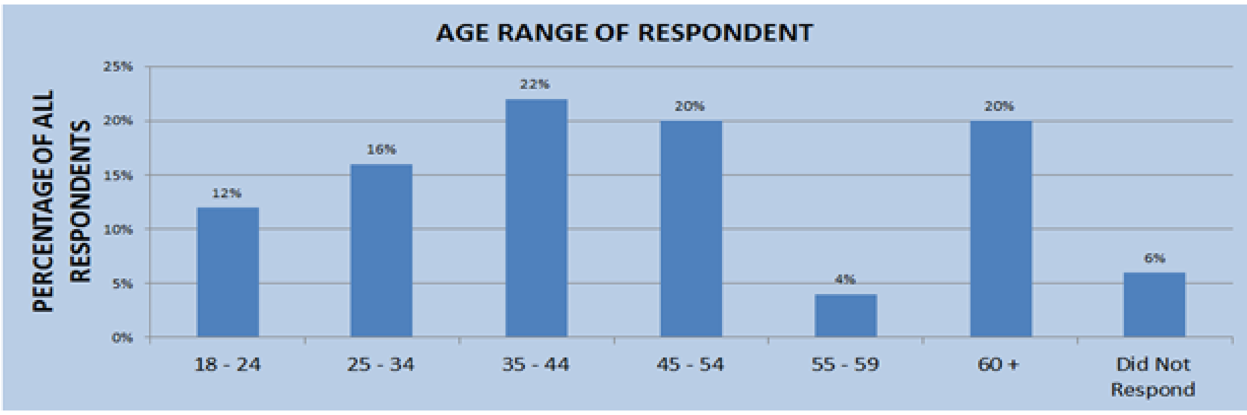


Figure 8.2: Age range of respondent (%)

Figure 8.3 displays the target audience (age, gender, visitor type) that activities are targeted at within the project area. A key observation is that there is no targeted activity specifically focused on a specific age, gender or visitor group. All users (Barbados or visitor) at all ages and gender make use of all the activities listed.

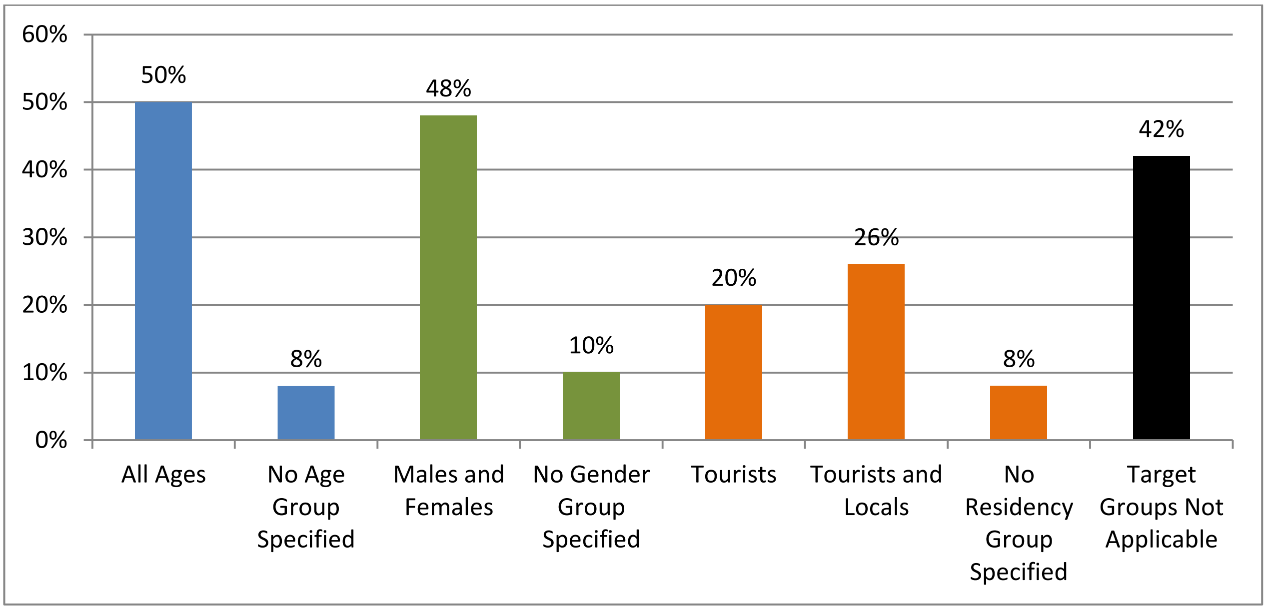


Figure 8.3: Target Groups for Recreational or Vending Services

Figure 8.4 displays the needs and interests of all respondents for the project area. It shows that the highest priority need is that of beach access (28%). Based on the respondents interviewed, only 8% declared that wave activity (surfing) was important, however, no surfers specifically were involved in the final respondent list. The majority of the remaining answers clearly relate to improving beach management practices (safety, zoning, regulating activities). The implementation of the new ISO13009 Beach Management standard for the study area may prove an important aspect that seeks to address these issues (see Section 11 of this EIA).

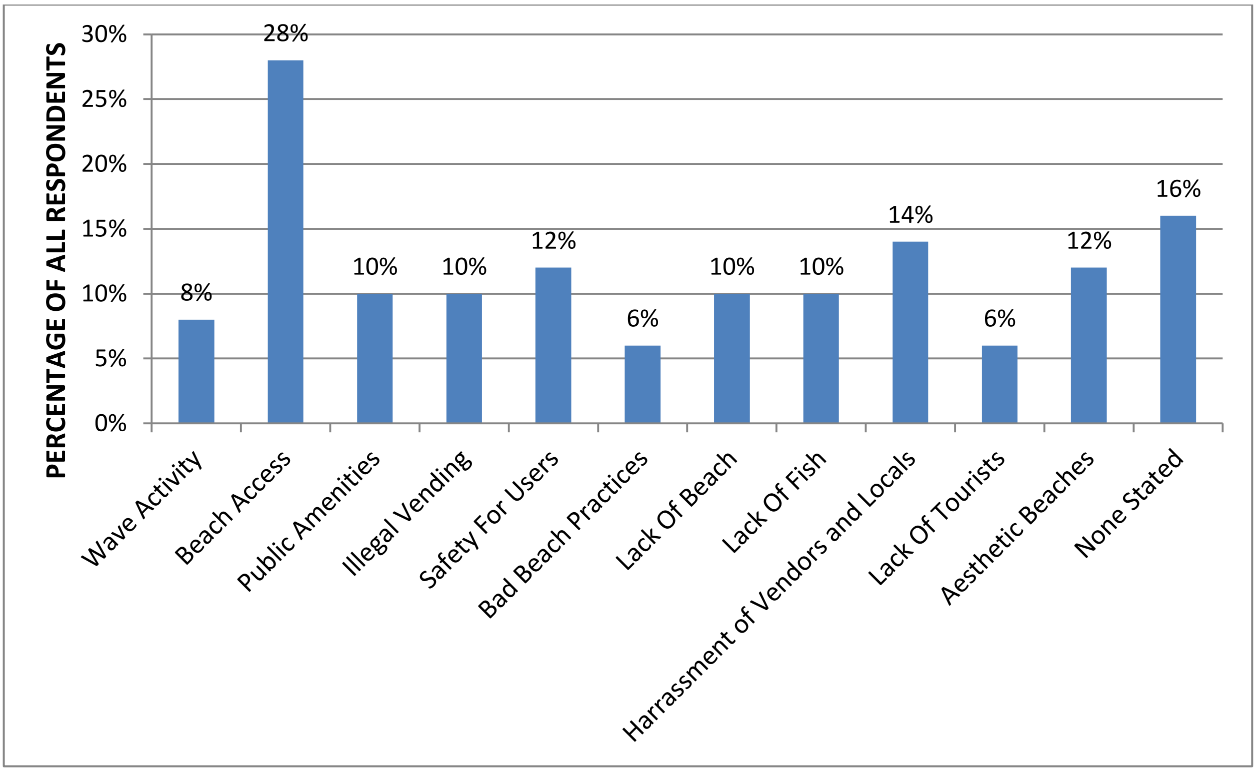


Figure 8.4: Needs and Interests of Respondents

With respect to specific aspects that local communities and users would like the project to support and enhance within the project area, Figure 8.5 displays the response of respondents to future beach management control measures. Improved beach access (longitudinal and from main road) (42%) and improved comfort facilities (showers, toilets, washing facilities, etc.) (40%) represent the key replies to this question. Beach infrastructure, shade/shelter and improved beach safety measures are presented as the remaining key measures for consideration. Of interest, the newly published international standard (ISO) on beaches outlines clear advice on these specific measures. This new ISO13009 Beach Standard should be considered in the final design of any beach scheme for the project area (considered in Section 11 - Environmental Monitoring Plan).

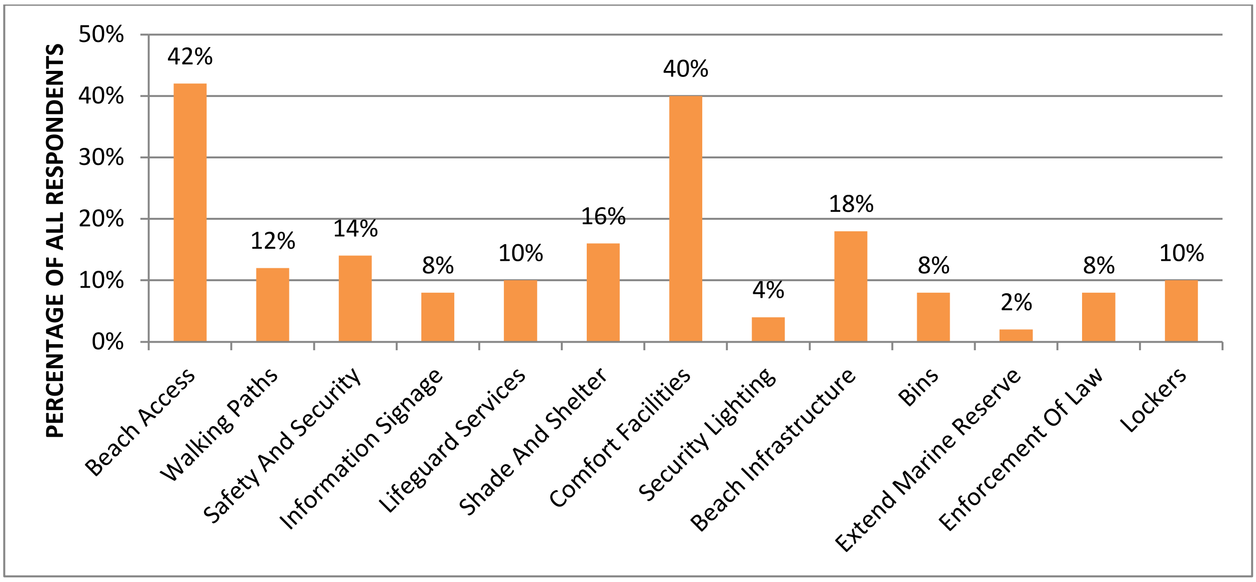


Figure 8.5: Respondent Indications of Desired Beach Management Control Measures

Table 8.1 displays the response of respondents to any other concerns that the proposed project needs to be aware of or consider from a social perspective. Of interest, 76% of respondents stated that there is no additional concern or issue that needed to be raised. A long list of all issues is presented in Appendix IV: Other Concerns of Survey Respondents. All issues raised will, however, be considered as part of the scheme design through the EIA and SIA process.

Table 8.1: Other Concerns Raised by Respondents

OTHER CONCERNS / SPECIFIC INFORMATION	# OF RESPONDENTS	% OF TOTAL
No	38	76%
Disruption to natural processes	5	10%
Boardwalk should be extended	1	2%
Wave / surf will be affected	3	6%
Drainage issues need to be addressed	1	2%
Native beach vegetation could be a better alternative	1	2%
Beach cleanliness	1	2%

A full list of user concerns is presented in Appendix 8a.

Regarding the surfing focal group, specific meetings were held to determine the local situation. The following represents some of the findings of these meetings. It was appreciated that the surfing community have the greatest knowledge of the reef and surf break.

Over the past 40 years (since surfers have been using Sandy Lane Bay), during that time, surfers have observed sand and beach levels change, but it was agreed amongst the surfers that the beach at this current time (2015) is the worst they have seen it. They know this is due to the structures that have been built to the north which are gradually pushing the erosion south along the west coast. It is not helped by the fact that property owners continue to push their hard boundaries seaward. The retaining wall at Leigh House and the deck at Bougainvillea were given as examples.

Other observations from surfers suggest that in 2004, the fringing reef at the south of Sandy Lane Bay was heavily bleached. Since that time local surfers have observed the corals recovering. Surfer representatives have collectively stated that the degradation of the reefs in the vicinity of Sandy Lane Bay was partly related to the construction of the Sandy Lane golf course, the fertilizer chemicals that were used on it initially and the large quantities of sediment run off that had resulted. However, they also acknowledged that Sandy Lane (as a company) have since changed to more organic fertilizers.

Of interest for the proposed project, it is believed by the surfing focal group that the originally proposed NES 4 (southern-most structure – now erased from the scheme) is perhaps the most important. They explained that the beach access from the public access between One Sandy Lane property (Paynes Bay) and Heronetta has become very dangerous at high tide and particularly with spring tides. Surfers have witnessed people being swept on to the rock wall of Heronetta by the incoming waves. They regularly have to rescue people that have been caught by the rip tides that form there and there is no emergency access on to the beach should it be required at anything other than low tide. Beach access is therefore a significant concern both for the surfing community that want to reach the break but also for hotel guests, local residents and beach users. It is believed that a suitably placed structure could assist in building the beach, thereby improving access.

This issue is likely to become a separately funded issue as the most southerly NES is now not included within the scheme.

8.5 Geographic and temporal scale social impacts

8.5.1 Geographic Impacts

With regard to geographic impacts, the project has extended the scope of the numerical modelling programme to extend the area of coverage to cover Paynes Bay. Additional data has been purchased to run the model to demonstrate what (if any) impact the submerged engineering structures may have on Paynes Bay. A second modelling exercise addresses the numerical surf reef model. This will involve comparison of existing (baseline) and estimated future wave parameters at locations around the reef, to understand the effect of the proposed works on the surf reef.

The recreational survey (see Appendices 8a and 8b) incorporated users from a broad geographic area, though who essentially were deemed of being of geographic relevance to the project. The views of stakeholders from Paynes Bay northwards to Holetown (and beyond) are deemed of specific relevance to the SIA.

8.5.2 Temporal Impacts

From a temporal perspective, Section 8.7 outlines the consultation meetings that have been held since the early project initiation (2012) through to the submission of the EIA (June 2015). This was deemed important to ensure that social impacts are listened to prior to any construction taking place. This is important as social impacts can begin long before construction and the SIA and planning/development processes needs to include the pre-project influences and outcomes. Also, a viable SIA must consider the social impacts throughout the duration of the process. To this end, this projects SIA has engaged with key stakeholders prior to the submission of the EIA (date to be determined) and also key meetings during the formal consultation period and during the project pilot phase in May 2013 when a specific stakeholder event was carried out (see Appendix 1a). Details of the pre-Project influences and perceived outcomes are presented within that Appendix.

One key temporal issue and which raised concern specifically with the surfing focal group is the short duration of recorded baseline coastal hydrodynamic data sets compiled. Surfers compared the situation with the Holetown boardwalk scheme (Baird Consultants Ltd) and on the south coast to install the boardwalk whose design was based on two years' worth of tide, current and wave data collection before construction commenced. The Representatives from the surfing community confirmed that the concern is that the wave and current climate is highly seasonal and even over the last 4 years there has been significantly more Southern swell, with it persisting for weeks at a time. This southern swell moves large amounts of sediment from the southern headland at Sandy Lane Bay up to the Northern headland. When the Northerly swells return, they start to move this sediment back. Concern has therefore been raised that without a data set and understanding of the existing conditions that spans at least 1 year, the design and subsequent modelling work (undertaken by HR Wallingford) is not able to properly to ensure that it has no impacts to either to the surf break or to Payne's bay and the wider coastal environment.

8.6 Economic and Social Consideration of the Project

Figure 8.6 displays the factors that are deemed to influence success (from an economic business perspective) and enjoyment (from a social recreational perspective) for the study area based on the findings of all respondents for the project area. While some respondents indicated more than one factor, results indicate that the key factor for both business and recreation (82%) is clearly having good public recreational amenities in place. This highest priority need is that of beach access (28%).

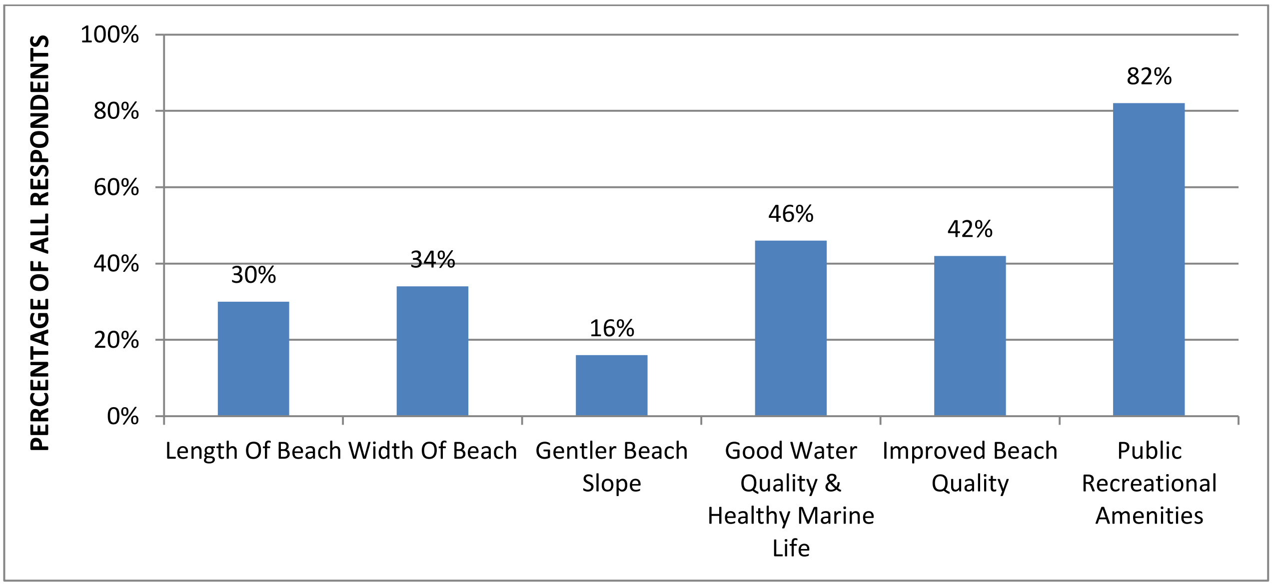


Figure 8.6: Factors Influencing Success (Business) / Improved Beach Experience

Figure 8.7 displays the beach access points that are most commonly used by respondents to activities within the project area. The two most common access points are at Holetown beach and at Beachlands (linked to the geographic variance as identified in Section 8.5). Both have car parking facilities nearby (Sunset Crest shopping complex for the latter) which influences the results collated. 28% of respondents use the off road parking areas close to One Sandy Lane and beach access pathway that runs along that property. A small percentage (4%) reported accessing the beach area by boat or catamaran.

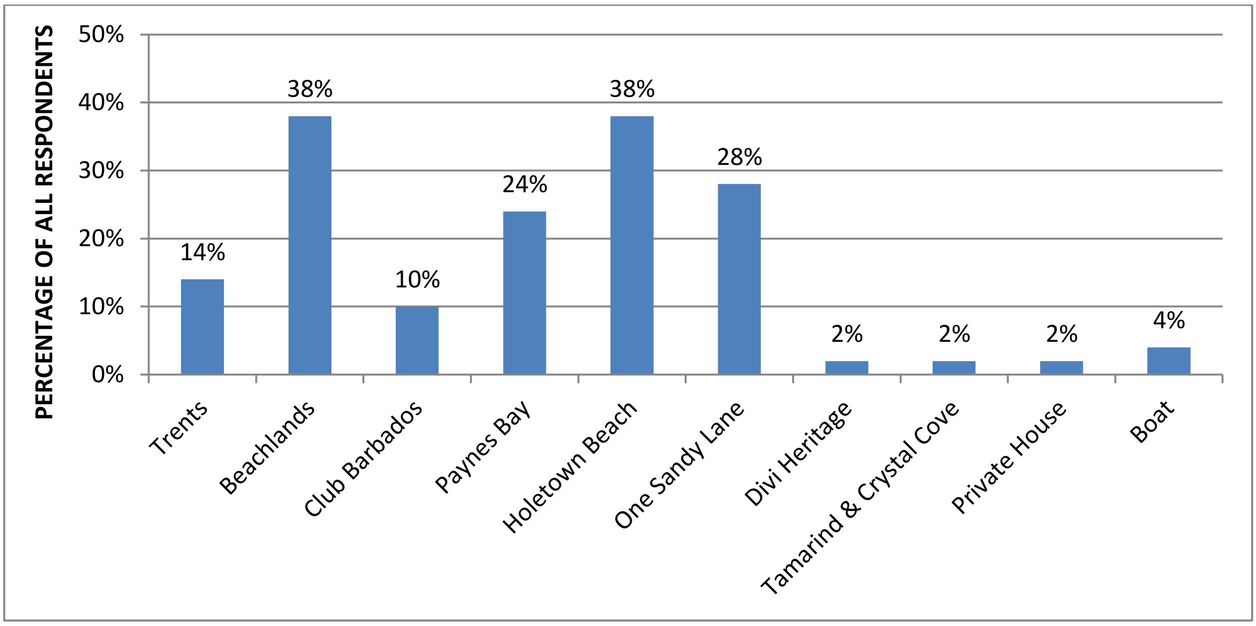


Figure 8.7: Beach Access Used for Main Activity

Whilst no new recreational employment opportunities can be guaranteed from the project, the project (from an environmental perspective) is likely to safeguard all existing tourist employment positions that currently exist within the project area. This cannot take into consideration factors associated with economic downturns or private sector management decisions to close hotels etc. To this end, the following hotel staff employment levels are likely to remain unchanged due to the enhancement of the beach and marine environment:

a) Club Barbados (70);
b) Sandy Lane Hotel (680 per annum);
c) Sandy Lane Property Owners Association (SLPOA – 10 staff).

8.7 Consideration of the trade-offs and alternatives

Section 9 of this EIA covers the issue of alternatives in more detail. From the perspective of the SIA

8.8 Social conditions with and without the project

Figure 8.8 displays the response of respondents to the project's purpose and intended outcomes and how it supports the needs and interests for user activities. An overwhelming majority of those interviewed (62%) stated that the projects intentions did support the needs of users and their activities.

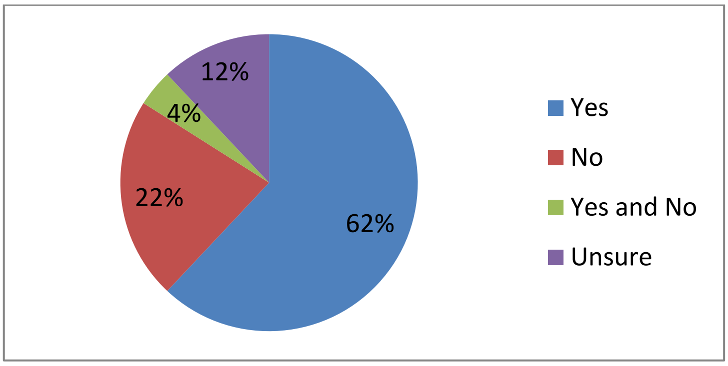


Figure 8.8: Respondent Opinion on Whether the Project's Purpose and Intended Outcomes Support the Needs and Interests of Users

9 ANALYSIS OF ALTERNATIVES

9.1 Overview

In terms of the EIA regulations as defined in Section 2, the applicant is required to demonstrate that alternatives to the proposed project have been described and considered in sufficient detail. The project is being developed on an area used for tourism and addresses particular issues at the location. The analysis of alternatives has, therefore, focused less on location, and more on different approaches to addressing the problem of beach erosion and protection at Sandy Lane and the wider bay area. The alternatives analysis has, therefore, focused on aspects of design, construction and operation.

This section therefore describes in appropriate detail the various engineering option alternatives evaluated for responding to the beach loss threat along the project study area. These alternatives include:

- Alternative 1 – No Action (Continue Current Management Practices);
- Alternative 2 – Abandon / Retreat;
- Alternative 3 – Beach Fill Only (recharge);
- Alternative 4 – Beach control structures;
- Alternative 5 – Number of beach control structures ;
- Alternative 6 – Construction materials.

A summary of the assessment of each alternative is provided below, taking account of the following general aspects:

- Technical engineering matters;
- Marine ecology;
- Coastal processes;
- Stakeholder concerns ;
- Cost;
- Legislation, policy and planning drivers and requirements.

The primary tools used to evaluate the effectiveness of the various alternatives in meeting the needs and objectives include:

a) Physical model work (HR Wallingford)- Details of the application of the model are provided in Appendix 5g.
b) Numerical modelling - the primary modelling package used for evaluating this project is used to help simulate flows, sediment transport, and bathymetric changes by using advanced sediment transport formulations that respond to forcing functions that include waves, tides, winds, and density gradients. The model takes into account the movement of sediment along the bottom (bedload transport) as well as sediment transported in the water column (suspended transport). Details of the application of the model are provided in Appendix 5g.
c) Baseline information gathered during the assessment – this includes information from published sources, stakeholder discussions and surveys of the intertidal, marine and physical environments.
d) Expert opinion and judgement – as applied by the design and environmental team, who are experienced in the assessment of impacts and options for similar projects.

As described in Section 4, the preferred option is to use a combination of rock nearshore engineered structure (NES1) and sand filled geotextile bags (NES 2 and 3).

NB: The generic term 'beach control structures' is also used in the following sections, as it considers the use of options other than the preferred NES.

9.2 Alternative 1 – No Action (Continue Current Management Practices)

The "No Action" (i.e. "do nothing") alternative implies that none of the proposed development components are implemented. For the purposes of this study this means that neither Coastal Engineering Component 1 (NESs plus beach renourishment interventions) nor the Marine Conservation Component 2 intervention approaches will take place. As such, the environmental status quo in respect of the biophysical environment would be maintained.

However, as described in Section 1.5, the work of CARIBSAVE (2012) revealed that approximately 80% of all beach areas in the Holetown area would be affected by a 2 m mean sea-level rise scenario, while a rise of 3.5 m would result in 100% of beach areas being affected. All major resorts in the Holetown area would also be extremely vulnerable to structural damage by a 3.5 m flood scenario. The permanent or temporary loss and relocation of major private sector run resorts (such as Sandy Lane) would affect the livelihoods of thousands of employees.

The vulnerability of Sandy Lane Hotel (in particular) to the effects of climate change has significant implications on future business (CARIBSAVE 2012). The results depicted are summarised below:

- A 3.5m flood scenario would result in over total loss of over 18,411.4 sq.m of beach area with an additional loss of 14,059 sq.m of land area. (CARIBSAVE 2012). (see Table 1.1 in Section 1.5).
- A 0.5m SLR would result in a 36.78% inundation of the highly valued Sandy Lane beach whereas under a 3m SLR, significant tourism infrastructure would be at risk (CARIBSAVE 2012). (see Table 1.2 in Section 1.5).

Without a degree of coastal engineering intervention within the Bay (Component 1), beach levels will continue to fall and beach width will continue to reduce as has been demonstrated in Section 5.2.3 and Appendix 5g.

From an ecological perspective, the patch and fringing reefs within Sandy Lane Bay are suffering from anchor damage, algal turf growth and limited numbers of grazers (cobblers and parrot fish) on the reefs in Sandy Lane bay and in the area around the Vauxhall patch reef (Section 5.3.3). It is stressed that these issues are not confined to the reefs in Sandy Lane or the wider project area; as under a "No Action" scenario, it is estimated that 80% of Barbados' fringing reefs are already reported as seriously degraded (GOB, 2010).

Without a degree of marine conservation intervention within the Bay (Component 2), coral reef condition will continue to reduce as has been demonstrated in Section 5.3.3 and Appendix 5l.

The following relevant principles were agreed (as defined in Section 1.5) that set the framework for the project's design and approach.

- "Hold" the current property lines (2014);
- Restore a walkable beach to the projects "intervention" area (approximately 500m in linear length) for all users;
- Avoid any "visible" structures where possible.

Based on the above, Alternative 1 would not comply with the intentions of the project.

9.3 Alternative 2 – Abandon / Retreat

This alternative strategy would involve the physical relocation of the Sandy Lane Hotel, properties of Sunset Reef, Leigh House and the likely relocation of a considerable number of additional properties/hotels (such as Club Barbados) in the process. On economic grounds, and with regards to issues of property ownership (re-setting property boundaries), this is not a viable alternative. The only way this alternative strategy would potentially see any benefit would be if national policy provided financial support to all west coast property owners to either abandon or relocate their investments further inland to less vulnerable locations.

The following relevant principle was agreed (as defined in Section 1.5) that set the framework for the project's design and approach.

- "Hold" the current property lines (2014);
- Restore a walkable beach to the projects "intervention" area (approximately 500m in linear length) for all users;
- Avoid any "visible" structures where possible.

Based on the above, Alternative 2 would not comply with the intentions of the project.

9.4 Alternative 3 – Beach Fill Only (recharge)

Beach nourishment (also known as beach recharging) involves the importing of sands (or gravels) to make good losses due to erosion. If the source of material is local and related by coastal processes to the eroding area then this approach is known as recycling. Foreshore recharge alone (as an alternative soft solution) reduces the energy and power of the waves through the introduction of extra sediments onto the intertidal (foreshore) zone. This can reduce wave energy before storm waves reach the upper beach and hard defence line. It is also an effective way of protecting damaged defenses or re-creating eroded foreshore areas. It can help in a long-term strategy of adapting to sea level rise. The technique is not activity undertaken in Barbados mainly due to the lack of a readily available source of marine sands.

As a specific alternative to the proposed project, due to changing littoral drift patterns in operation along the west coast of Barbados (different seasons) and is most likely to require intertidal groyne structures to be constructed to hold beach recharge material in place that will reduce longshore transport losses. Where high value assets are to be protected (such as Sandy Lane Hotel), the nourishment scheme may be backed by a fixed line of defence such as a sand bag revetment, possibly buried by the nourishment.

The following relevant principles (as defined in Section 1.5) were agreed that set the framework for the project's design and approach.

- "Hold" the current property lines (2014);
- Restore a walkable beach to the projects "intervention" area (approximately 500m in linear length) for all users;
- Avoid any "visible" structures where possible;
- Avoid any use of rock where possible;
- Protect and enhance the coral reefs.

Based on the above, Alternative 3 would not comply with the intentions of the project. Not recharging the beach is not considered as a viable alternative, as it would take longer for the Sandy Lane beach to rebuild to the required width by natural processes alone. Not recharging would also 'starve' downdrift beaches of sediment, causing knock-on impacts outside the project area.

9.5 Alternative 4 – Beach control structures

NB: a thorough assessment of alternative coastal protection structures was undertaken by CARIBSAVE (2014) and presented in Annex B of that report. That list is presented in Appendix 9a for completeness.

Based on the project principles defined in Section 1.5 and in line with work already carried out by CARIBSAVE (2014), the generic beach control structure options that were considered were:

- Nearshore/offshore breakwaters ;
- Buried structures on the beach.

Both of these options would be combined with beach recharge (adding extra sand to the beach). Table 9.1 outlines a summary of the complete list of coastal protection measures presented in Appendix 9a.

Table 9.1 Summary of the assessment of options for beach control structures / methods

Option	Technical engineering	Ecology	Coastal processes	Stakeholder concerns	Costs
Nearshore /Offshore breakwaters	Well accepted technique. Design and construction well understood. Proven track record in the area.	Loss of habitat in the structure footprint. Could provide "habitat support structures".	Dissipates wave energy before reaching the beach. Allows creation / maintenance of salient / wider beach.	Impacts to surf reef. Visual impact if exposed at low water. Potential benefits by creating a 'feature'. Improved beach width and access.	Medium cost option – construction in the sea is higher cost. Potentially low future maintenance costs.
Buried structures on the beach	Not previously used in Barbados.	Low marine ecology impact. No ecology benefit. Possible impacts / interactions with turtles' beach use.	Physically 'holds' sand above a certain level on the beach. Does not slow sediment transport 'outside' the structure.	Possible safety issues when exposed. Visual impact when exposed. Loss of beach areas in the footprint of the structures. Creates 'obstacles' on the beach. Potentially higher future maintenance needs results in more disturbance to beach users. Improved beach width and access.	Low – medium cost. Construction can take place on land. Potentially high future maintenance costs – need to be re-buried when exposed.

Based on the assessment of the different issues summarised above, the preferred option chosen for the type of beach control structure was <u>nearshore breakwaters</u>. Although this has a higher initial cost, the benefits of reduced future maintenance and disturbance to hotel guests and beach users, coupled with the 'tried and tested' results of this type of structure, compared with the untried approach of buried bund type structures, made this the preferred option.

9.6 Alternative 5 – Number of beach control structures

Numerical and physical modelling of the effects figured heavily in the consideration of the preferred number of beach control structures (breakwaters) to determine both the required technical engineering outputs (i.e. beach width and stability) as well as any potential adverse impacts to coastal processes.

Table 9.2 Summary of the assessment of options for the number of beach control structures

Option	Technical engineering	Ecology	Coastal processes	Stakeholder concerns	Costs
2 NESs: **Sandy Lane N** **Sandy Lane S**	Does not provide a dry beach at Sunset Reef – does not meet the project brief (principles).	Loss of habitat in the structure footprint – smallest potential footprint option. NESs located in mainly sandy marine habitat – low natural reef impact. Could provide 'artificial' habitat for reef species.	Beach within Sandy Lane Bay is returned to historic beach widths. Some modification of currents around the structures.	Visual impact if exposed at low water. Potential benefits by creating a 'feature' Improved beach width and access.	Lowest cost option
3 NESs: **Sunset Reef** **Sandy Lane N** **Sandy Lane S**	Provides a dry beach at Sunset Reef and a wider beach at Sandy Lane.	Loss of habitat in the structure footprint – medium potential footprint option. NESs located in mainly sandy marine habitat, with some potential for natural reef impact. Could provide 'artificial' habitat for reef species.	Current patterns in the physical model were measured at different locations. There is some movement of water offshore between the structures. In Sandy Lane Bay. The average recorded currents were 30-40cm/s, confirming that rip currents observed during the morphological wave condition do not pose serious hazards to swimmers.	Visual impact if exposed at low water. Potential benefits by creating a 'feature'. Improved beach width and access.	Medium cost option
4 NES: **Sunset Reef** **Sandy Lane N** **Sandy Lane S** **SLPOA**	Provides a dry beach at Sunset Reef and a wider beach at Sandy Lane. SLPOA NES provides minimal additional benefit to 3 NES option.	Loss of habitat in the structure footprint – largest potential footprint option. NES located in both sandy and natural reef marine habitat – highest natural reef impact. Could provide 'artificial' habitat for reef species.	Observations during Test Series A of the physical model showed that the structure offshore Leigh House was not contributory to the retention of beach material. Material accreting at Leigh House and being retained there is a function of the intricate local bathymetry.	Greatest degree of concern regarding adverse impacts to the surf break off the reef at SLPOA. Visual impact if exposed at low water. Potential benefits by creating a 'feature'. Improved beach width and access.	Highest cost option

Based on the assessment of issues summarised in the table above, the preferred option chosen was three (3no) NESs. This provides a medium cost option that meets all the design requirements, while minimising the potential for impacts to coastal processes, beach / water users (surf break impacts) and natural reef habitat.

9.7 Alternative 6 – Construction Materials

9.7.1 Beach control structures

In considering the type of materials from which the beach control structures are made, the two options were considered:

- Rock armour (despite this being against one of the key project principles set in Section 1.5);
- Sand-filled geotextile bags.

There are several potential impacts that are independent of the type of construction material. These have not been included in the table below and include:

- Changes to coastal processes, currents, waves;
- Loss of habitat in the footprint of structures (see Section 9.1 - type of beach control structure);
- Disturbance during construction – noise, light, presence of vessels / machinery / people;
- Pollution / contaminant risk during construction – spillages, fuel, chemicals;
- Provides opportunities to be augmented with habitat improvement measures to encourage coral growth and colonization.

Table 9.3 Summary of the assessment of options for the type of construciton material

Option	Technical engineering	Ecology	Coastal processes	Stakeholder concerns	Costs
Rock armour	Well accepted technique. Design and construction well understood. Proven track record in the area.	'Natural' material Provides a hard natural substrate for colonisation. Creates refugia for marine life to use e.g. reef fish	n/a – no appreciable difference between options	Visual impact – proliferation of rock structures in the area is considered detrimental to the area. Potential safety risk from people climbing on them. Possible risk of injury during a collision (boat / jet-ski, etc.)	Potential high costs – material is not available locally (granite)
Sand-filled geotextile bags	Novel technique to Barbados, but proven elsewhere e.g. Australia, Asia. Time-limited manufacturer's guarantee (see Appendix 6a and 9b).	Accidental / deliberate damage to the structures may result in loss of sand – knock-on impacts to water quality / marine environment. Less 'complex' habitat created for marine life	n/a – no appreciable difference between options	Potentially lower visual impact – less visible against the sandy sea bed. Accidental / deliberate damage to the structures – the manufacturer assesses this risk as low (see	Medium – high cost. Geotextile bags not manufactured locally, however sand is locally abundant. Potentially high future maintenance / replacement

		colonisation / use. Appendix 6b demonstrated is environmental product credentials.		Appendix 6a).	costs.

Based on the assessment of issues summarised in the table above, the preferred option chosen was sand-filled geotextile bags. This provides a lower construction cost, which may be offset by the need to replace bags in 20 – 50 years, however, this postponement of cost is considered beneficial by BRI. The lower visual impact of geotextile bags compared with rock structures, which have a poor visual acceptance rating with tourists, is considered to be a strong driver by BRI. Appendix 9b is produced to provide a summary justification case to support this option evaluation.

9.7.2 Sources of Sand

Several potential sources of sand for the beach nourishment and geotextile bag fill exercises were considered as follows:

- Dredged marine sand (around Barbados);
- Lears Quarry;
- Black Bess Quarry;
- Imported sands (e.g.: from Guyana).

Physical and chemical testing of the material from different sources played a large role in the consideration of the preferred source of material (see Appendix 5c). It is important that sediment used for beach nourishment matches as closely as possible the sediment already on the beach. This will ensure the 'new' beach functions in the same way as the existing beach and that material doesn't wash away too quickly or cause other physical problems such as compaction or 'cliffing'. It is also important that the new sediment does not introduce contaminants to the beach which may have adverse impacts on the environment or beach users.

In November 2014, the project undertook a survey to review the location and volume of possible suitable sand deposits in the area of Sandy Lane Bay. The survey area tested was approximately 900m x 100m stretching from Club Barbados in the north, to Bougainvillea in the south, and extended seaward for approximately 100m from the reef. Thirty (30) sediment probe locations were sampled within the Sandy Lane Bay to find the elevation of the rock head. Chemical analysis of sediment samples at 4 locations was also carried out to compare existing chemical components on possible dredged materials. In addition, physical testing of the material was undertaken to assist in determining its geotechnical properties (to assess suitability for assessing the short and long term settlement of the proposed NESs). The project has also undertaken an analysis and assessment of beach and marine sediments (plus inland quarry sourced sands). All sediment samples from the Sandy Lane Bay have been tested by the Barbados National Standards Institute (BNSI) laboratories for particle size and density analysis. Results suggest that existing beach sands are classified as being between coarse and fine grade grey to white sands. The mean particle density for the tested material was found to vary between 2.69 and 2.76 g/cm3.

Table 9.4 summarises the sand source options based on results collated by the project.

Table 9.4 Summary of the assessment of options for the source of beach nourishment and geotextile bag fill

Option	Technical engineering	Ecology	Coastal processes	Stakeholder concerns	Costs
Dredged marine	Best physical	Best 'match' for	Potential	Best 'match' for	High cost due to

sand	match for existing beach sand. No reliable source of sediment in sufficient quantities.	the existing sand. Marine ecology impacts in the area of dredging.	impacts in the areas of dredging.	existing beach – reduced visual and 'feel' impacts.	marine dredging and 'exploration' to find a suitable source.
Lears quarry	D50 ~ 1.2mm – coarser than existing beach. Sediment supply tolerances will need to be tightly specified.	Chemicals – no contamination found (below detection levels), except Lead (Pb). Pb levels similar/lower than existing beach sediment	Introduction of 'new' sediment to the coastal system – potential positive and negative impacts.	Potential visual impacts. Concern about the 'feel' of quarry sand.	Land based extraction – lower cost
Black Bess quarry	Poor physical match – higher proportion of much courser grained sediment	Chemicals – not tested, as sand was not a physical match	Introduction of 'new' sediment to the coastal system – potential positive and negative impacts.	Potential visual impacts. Concern about the 'feel' of quarry sand.	Land based extraction – lower cost
Imported sand – possible sources include Guyana and Trinidad	Not tested – though d50 is expected to be coarser than Barbadian beach sands	Petrology and colour are very different to that experienced on Barbados beaches and so would likely have an socio-environmental impact.	Introduction of 'new' sediment to the coastal system – potential positive and negative impacts.	Potential visual impacts. Concern about the 'feel' of imported sand.	High cost of transportation.

10 MITIGATION MEASURES

10.1 Introduction

Mitigating measures are proposed here for the negative impacts identfied in Section 6 pertaining to the construction of the NESs and beach renourishment aspects of the project (Components 1 and 2 as identified in Secton 4). ***NB: Mitigation measures are <u>not</u> identifed for impacts assessed as being negligible or minor.***

Optional mitigation measures, which would further assist in reducing the environmental impacts associated with the proposed development, but the implementation of which cannot be guaranteed (and have thus not been considered in the assessment of the significance of environmental impacts) have also been listed. These mitigation measures should be considered by BRI.

10.2 Human Beings (Social Impact Mitigation Measures)

Up until recently (see below), there have been no International Standards for beaches and very little guidance on beach management for operators. As a result, many beaches have not been developed or managed in a sustainable way, often resulting in bad experiences for beach users and to the detriment of the beach environment. With specific reference to Sandy Lane beach a new management scheme is likely to be needed that is flexible enough to adapt to visitor demands in the same way as any other business or service. Having such a management system in place at Sandy Lane will seek to ensure that the beach remains safe and enjoyable for all users (Bajan and tourist) now and in the future. ISO 13009, "Tourism and related services — Requirements and recommendations for beach operation", has just been published by the International Standards Organisation (ISO). This is the first standard that provides beach operators with the information and guidance needed to manage beaches effectively, anywhere in the world. The ISO13009 brings a range of important elements together that could offer guidance to Sandy Lane to help sustain a hotel or resorts economic future.

<u>*An "ISOBeach Management Scheme"*</u> is hereby recommended to be prepared as a specific Environemntal Action Plan. As well as general beach management, this would include initial guidance on beach safety, beach cleaning and waste removal, beach access, infrastructure, beachfront planning, stakeholder communication, beach promotion and commercial services (vendors etc). Therefore, assisting the tourism sector to comply with ISO 13009 is likely to help significantly towards generating both media and public interest within resorts and beach fronted hotels. This in turn may help secure public funding for future improvements to the surrounding beach area. <u>***The project proposer shall include (as part of the ISOBeach Management Scheme) the introduction of new beach safety signage throughout the project area plus the introduction of new demarcation buoys for all of the FMP (as part of a PPP with FMP/NCC).***</u>

The CZMU also believe that if adapted in a sensitive manner to reflect the local needs of Barbados for both high and low activity beaches (as part of a new Barbados National Standard), this could prove of great value to us as a nation. The main reasons for this are that ISO 13009 sets a world benchmark for beach management and safety and consequently, if clear advice can be provided to the public and private sector in Barbados (through regulatory processes and non-statutory guidance e.g.: codes of practice etc), this may provide added value to the tourism sector that is consistent and based on best practice.

Some mitigation "control" measures that may be considered as part of the ISOBeach Management Scheme (post construction) should include the following in Table 10.1:

Table 10.1: Indicative Structure and Content of an ISOBeach Management Scheme Environmental Action Plan for Sandy Lane

Recommended Contents of the ISOBeach Management Scheme Environmental **Action Plan** for Sandy Lane	**Owner (main party in bold)**	**Start / Completion (if not continuous)**	**Indicative Costs (US$)**
Improving Beach Quality			
Produce Guidance Document for ensuring appropriate beach quality			
Ensure appropriate cleaning of beaches (mechanical /manual methods – see www.beach-trotters.com or www.beach-tech.com.			
Produce Action Plan for regular surveying and cleansing of the beach			
Coral Reef Quality			
Produce Guidance Document for private sector run beaches where coral reefs exist within 500m of the beach			
Establish reef monitoring programme “Reef Watch”			
Additional volunteer training on “Reef Check” Coral Reef Monitoring Program			
Bathing Water Quality			
Produce Guidance Document to outline the sampling and testing methodology for bathing water quality.			
Set out MoU between Sandy Lane, FMP, BNSI and CZMU regarding bathing water quality.			
Set out a monitoring calendar for sampling and testing at each bathing site			
Set up signs to display information on beaches			
Pilot a digital real time seawater quality display system around key sites in Holetown			
Beach Facilities - Litter Bins			
Produce Guidance Document on the appropriate style, material used, character and placement of litterbins - recommend the piloting of the “ecobyn” concept (see www.ecobyn.com			
Placement of new litter bins as appropriate			
Litter Management			
Purchase cleaning machine (shared amongst users if a large area. (see www.beach-trotters.com or www.beach-tech.com.)			
Purchase ashtrays for beach users to dispose of cigarette butts. (recommend the piloting of the “ecobyn” concept (see www.ecobyn.com))			
Beach Risk Assessments			
Carry out beach and sea use risk assessments			
Lifeguarding			
Train new lifeguards to international qualification.			
Purchase internationally recognised red/yellow uniform making them easily recognisable on a crowded beach.			
Public Rescue Equipment and First Aid			
Purchase appropriate public rescue equipment (PRE – e.g. life buoys, torpedo buoys, hook, life vests, life rafts, etc).			
Set up an emergency phone system.			

Set up first aid stations with trained personnel			
Set up first aid equipment at other beach facilities at the beach			
Arrange for appropriate first-aid personnel training to receive accepted qualifications.			
Purchase stocks of basic commodities such as bandages, disinfectant, plaster, etc,			
Purchase first aid bed,			
Beach and Sea Zoning (Sea Use Management Plan)			
Carry out sea use management planning project of recreational activities			
Implement zones for swimmers, surfers, wind surfers and motorised craft.			
Set official bathing areas,			
Establish agreed roles and responsibilities for Lifeguards to enforce any zoning of recreational.			
Adopt the recognised flag zoning system			
Emergency Contingency Plans			
Produce Guidance Documents on how to produce emergency plans for Blue Flag beaches for oil spills, hazardous/toxic waste spills, discharge of storm water (within FPMR)			
Carry out beach emergency simulation exercise(s) once a year.			
Safe Access to the Beach			
Produce Guidance Document on appropriate safe beach access.			
Construct or upgrade steps with handrails.			
Ensure pedestrian crossings across roads to beaches have designated crosswalks.			
Construct steps onto the beach			
Place hazard signs where edges are higher than 2 metres above the beach			
Maps and Signs			
Prepare maps showing the boundaries of the FPMR beach and the location of key facilities and services			
Agree and approve suggested content of signs;			
Agree suggested location for signs;			
Agree funding of signs with third parties;			
Establish the budget for sign management (maintenance, repairs and inspections);			
Arrange for installation of signs.			
Environmental Education and Information			
Display information relating to coastal zone eco-systems on the beach (beach library – see www.beach-trotters.com)			
Produce Information about the Marine Park (signage) away from the FPMR			
Produce brochures, tourist newspapers, or hotels pamphlets in both English and French.			
Produce information both on boats or at marinas or boat launch locations.			
FMPR produced Action Plan to demonstrate management of visitors and recreational use that prevents long-term irrevocable damage to the local natural environment.			
Display Information about bathing water quality			
Display Information about the Marine Park			
Display information about Marine Park Regulations			
Set up a minimum of 5 environmental education activities			

10.3 Flora and Fauna (Environmental Mitigation Measures)

10.3.1 Mitigation during Scheme Construction

10.3.1.1 Terrestrial Habitats and Fauna

As described in Section 6, the majority of the construction works will take place within the marine environment, either from vessels or floating structures. As such, the potential for impacts to the terrestrial environment associated with this scheme during both construction and operation are minimal.

Recommendations for key mitigation measures associated with impacts to the terrestrial environment are as follows:

- Minimise movement / presence of plant and vehicles on areas not intended as public or private highways (e.g. grass verges etc);
- Ensure that all vehicles have been checked for leaks and that the storage of any fuels / oils is undertaken against an appropriate Environmental management plan to minimise the potential for impacts to the terrestrial environment;
- Should removal of beach vegetation be required, all beach vegetation shall be reinstated as it is acknowledged that the roots of beach vegetation aid in stabilising the beach in the event of storms.
- Minimise the footprint of any materials or equipment stored prior to use in construction, including any temporary buildings associated with construction supervision or management; and
- Return any areas degraded through the storage or placement of materials and equipment as well as from the tracking of vehicles (e.g. through private properties to gain access to the beach) to their pre-construction state once works have been completed.

10.3.1.2 Intertidal area

Activities undertaken within the intertidal zone are likely to be limited to the beach nourishment / replenishment works along the project frontage. As described in Section 5, the intertidal habitat is dominated by sandy beach habitat with patches of rocky substrate. Although this habitat predominantly supported crabs and various species of molluscs, it is sensitive to compression since some species burrow / nest in the sand (mainly limited to crabs but this could include turtles – although mitigation measures for turtles are described further in Section 10.3.2.4) As such, recommendations for key mitigation measures associated with impacts to the intertidal environment are as follows:

- Minimise the tracking of plant and vehicles across the beach and ensure that materials are deposited evenly and as close as possible to their finished position to minimise the requirement for re-profiling. Nourishment / replenishment activities should be undertaken against a construction management plan which provides details regarding rate of and duration of deposition;
- Where plant is required on the beach to undertake re-profiling and shaping of the beach, it is preferable to make use of several smaller pieces of plant rather than larger plant which will result in greater compression of sediments and will be less manoeuvrable on the beach;
- Material used for renourishment should match as close as possible the existing sediment, both in terms of grain size and chemical composition to aid swift recolonization. Beach material, if coming from a terrestrial source, should be washed and flushed through with seawater prior to being deposited on to the beach;
- All beach recharge should be undertaken at low tide. There should be no tracking of any plant or vehicles through the water and no deposition of material in the water;

- As in the terrestrial environment, the use of construction plant and / or equipment or vehicles on or near the beach has the potential to result in accidental spillage / release of oils / fuels, which could contaminate beach sediment and adversely affect intertidal species as well as marine species. All equipment and plant used as part of the construction of the scheme should be regularly checked for oil or fuel leaks. Vehicles or plant working on the beach should not be operating with more fuel than is required to undertake the current activities and wherever possible and fuels and oils used should be biodegradable. It is expected that all works should be undertaken against a construction management plan which includes necessary information relating to the procedures to be followed in the event of an oil or fuel spill.
- Should removal of beach vegetation be required, all beach vegetation shall be reinstated as it is acknowledged that the roots of beach vegetation aid in stabilising the beach in the event of storms.

10.3.1.3 Marine area

The majority of the construction activities will be undertaken from the marine environment and the placement of materials will predominantly be within the marine environment. Thus, as discussed in Section 6, the most significant impacts are likely to be to the marine environment, in particular from the physical placement and construction of the NESs, which will damage / smother species within the footprint of the structures and the associated construction area.

Recommendations for key mitigation measures associated with impacts to the marine environment are as follows (it should be noted that the mitigation measures relating to coral and associated species are predominantly of relevance to NES 1):

- As described above, all construction activities will be undertaken against a Construction Management Plan ensuring that all appropriate procedures are in place in the event of oil, fuel or chemical spills as well as large releases of sediment in to the marine environment;
- Any coral colonies suitable for transplanting within the footprint of the structures and the “construction buffer zone” should be removed prior to the works being undertaken and stored appropriately for reattachment following the completion of the construction works. A summary methodology covering the removal, storage and reattachment of corals is presented in Appendix 1 of Appendix 10aXXX and will be detailed further within the construction management plan;
- A survey of the footprint of the structures, including the “construction buffer zone” should be undertaken immediately prior to the works being carried out and any mobile and immobile but moveable invertebrates (e.g. sea urchin, holothurians, etc.) should be removed from the footprint of the structures and relocated outside of the area of likely impacts;
- Disturbance to the seabed associated with preparation of the substrate prior to the construction of the NES should be kept to a minimum, only removing / profiling substrate absolutely necessary for the works;
- Although the majority of plant will be floating, it will be necessary for vessels / floating platforms to be anchored to ensure they remain on station. Wherever possible, it is expected that if a vessel will be required to anchor in the same location for a number of days a “semi-permanent” mooring will be installed with the aid of a diver to ensure that it is not damaging any sensitive habitats. When anchoring as a one off, if there is potential for sensitive habitats to be damaged, the anchor should be lowered only after ensuring that it is not over an area of coral or other sensitive habitat (diver to check seabed suitability). If the anchor would affect a sensitive habitat, the vessel and anchor should be re-positioned to avoid the sensitive habitat;
- Any pipelines or materials that are required to be laid across the seabed should be laid with the aid of a diver to ensure that that they are not lain across an area of sensitive marine habitats e.g. corals;

- Whilst there will be a construction "buffer zone" around the structures to allow for a workable construction area, the placement of materials for the construction of the northern SES should be undertaken with the aid of a diver where practicable to ensure that there is no physical impact to corals outside of the construction footprint;
- As described in Section 6 there are a number of sources of potential impact to water quality during the construction works, in particular the release of large quantities of sediment resulting in concentrated levels of suspended sediment / turbidity. The construction management plan will include procedures for checking connections and couplings in the sediment pipelines as well as between the geotextile sand containers and the sediment pumping line. In the event that a leak in the pipeline or a break in a bag occurs, all activities will stop until the problem has been resolved and the suspended sediment has dispersed;
- Suspended sediment levels will be monitored throughout the construction process, as will the direction of any sediment plume created. If either of these exceed thresholds / conditions put in place as part of the construction management plan then works will stop until they fall to a level sufficient for works to resume. If necessary and appropriate, the use of sediment screens and/or "curtains" should be considered; and
- In the event of an oil, fuel or chemical spill from any of the vessels or plant operating within the marine environment, all works will stop and the relevant procedures followed. The construction management plan should contain the necessary precautions and procedures to prevent, respond to and contain any unforeseen spills within the marine environment.

10.3.1.4 Turtles

Although construction activities are unlikely to have direct impacts to turtles given that they are mobile and the nature of the marine construction activities means that movement of plant will generally be raising and lowering materials at a slow rate which is unlikely to result in direct collisions. It is proposed that as part of the general operation of marine construction activities, should turtles be observed within close proximity of the construction area, then works stop until the turtle(s) have moved on. Turtles should be left to move away naturally.

As described in Section 6, the greatest risk to turtles is from the use of machinery/plant on the beach to place the beach nourishment material, both to individual turtles and to nests. Although hawksbill turtles nest all year round, nesting activity is predominantly at night time, therefore by limiting all beach activities to day light hours it is highly unlikely that there will be any impacts to nesting females.

To ensure that the tracking of vehicles and/or the deposition of material on to the beach does not impact any turtle nests and the eggs that they may contain, a walkover survey of the Sandy Lane Beach should be undertaken to identify areas of the beach that could be suitable for use by nesting turtles. If any suitable area is identified, these will be visually checked each morning up to from 90 days prior to beach construction commencing. Turtle egg development and hatching can take up to 90 days, so it is possible that works could affect nests created up to 90 days before construction. If any signs of turtle nesting on the beach are observed during this period, then the success of the nesting attempt should be confirmed and if successful the eggs should be excavated and transferred to new nest located at a suitable site. These works will be undertaken by a suitably qualified and experienced turtle specialist.

Each morning, prior to the beach construction works being undertaken that day, a visual check of any suitable nesting areas on the beach should be undertaken to identify signs of nesting activity during the night before. If signs of nesting are observed, the same procedure as described above should be followed.

10.3.2 Mitigation during Scheme Operation

10.3.2.1 Terrestrial Habitats and Fauna

As assessed in Section 6, the impacts following construction will be limited to those associated with maintenance and repair activities, and for the most part will be focussed on the marine and intertidal areas. However in gaining access to the intertidal areas, there is potential for impacts to terrestrial habitats similar to those during the construction phase. As such, the same mitigation measures proposed in Section 10.3.2.1 should be applied.

10.3.2.2 Intertidal area

Impacts to the environment during the operation of the scheme are likely to be limited to any incidences of maintenance or repair to the scheme. In the intertidal environment this is only likely to be as a result of additional beach nourishment required to periodically replenish the beach. Whilst the frequency and volume of this replenishment are likely to be considerably less than during the original construction, the activities will be the same. As such, the same mitigation measures would apply. Care should be taken to apply those mitigation measures relevant to turtles also.

10.3.2.3 Marine area

As discussed in Section 6, the provision of increased hard substrate is expected to provide additional areas of hard substrate that may become colonised by species such as corals, sponges, invertebrates and fish, potentially overall resulting in an increase in biodiversity in the area. The increased complexity of the seabed also has the potential to provide nursery / refuge areas for fish which in turn may result in an increase in fish populations locally to the NESs and the natural reefs.

This positive impact could be further enhanced with the provision of additional coral rock structures purposely placed to provide additional substrate for the reattachment and natural settlement of corals as well as to increase the seabed complexity for fish populations. As described in Section 10.3.1, by increasing the area over which corals are transplanted, their density and associated stress signal is reduced. This would reduce the risk of predation and in combination with the monitoring and maintenance described above, maximise the chances of survival of the transplanted corals.

As per the construction phase, one of the risks of impact to the marine environment is from the loss of sediment from the geotextile bags, either through natural degradation or accidental / deliberate damage, and the turbidity and smothering of habitats that would result.

The newly installed NESs should be appropriately marked, both in situ and on navigational charts to reduce both the risk to water users and of accidental damage to the structures from collisions. In addition, the geotextile NESs should be regularly inspected in line with the specifications of the Environmental Management Plan to ensure that they are showing no signs of degradation, abrasion or puncture. In the event that the inspections observe signs of damage or degradation or in the event that a collision occurs, a team of appropriately trained divers would be on station as soon as possible to ensure that the damage is repaired through the use of patches wherever possible, to ensure the loss of sediment in to the marine environment is halted. If the loss of sediment is significant enough, the use of sediment screens or “curtains” will be considered.

In the event that the damage incurred by any one or more geotextile containers is such that the bag(s) need to be replaced. A specific construction management plan will be prepared and followed for the managed discharge of sediment from the damaged bag(s) and the process for replacing the bag(s).

The mitigation measures associated with the installation of replacement bags will be the same as those implemented for the construction stage.

10.3.2.4 Turtles

As assessed in Section 6, following completion of the construction activities there will be limited potential for negative impacts to turtles from the scheme. In fact it is possible that any enhancement of the marine habitats as a result of the placement of the NESs and any additonal rock structures will have a positive impact on turtles through an increase in available food.

Periodically the beach may require additional recharge (subject to the results of post construction beach monitoring programmes). Although the frequency of future beach recharging is unknown at this stage, the addition of new sediment on the beach will have the same potential impacts as during the construction phase and thus the same mitigation measures will apply.

10.4 Physical Environment (Sediment Management Mitigation Measures)

In assessing the potential for the proposed development to impact the physical environment as a receptor, the following will be considered:

- Landscape & Seascape;
- Coastal Processes (including erosion and deposition); and
- Surface run-off of sediment material.

10.4.1 Landscape & Seascape

No essential mitigation measures are required to reduce the visual impacts associated with the project.

Optional mitigation measures may include:

1. Consider the visual impacts of sediment plumes in selection of the most suitable NES filling technique.
2. Limit and screen the area used for construction activities including the associated storage of waste, materials and equipment;
3. Ensure that waste material is removed regularly from the site;
4. Store construction equipment and material in an orderly manner on a designated site (quarried sand store location within the boundaries of Sandy Lane Hotel and appropriately screened from guests);
5. Monitor and react to complaints about plumes generated by project activities.

10.4.2 Coastal Processes (including erosion and deposition)

Mitigation measures required for coastal processes will be determined and this section updated once numerical and physical modelling of the scheme has completed. Mitigation measures will only be required if negative impacts are identified. It is likely that mitigation measures will be based on monitoring of beach levels and 'triggers' for action should adverse or unforeseen impacts occur.

10.4.3 Surface run-off of sediment material

As assessed in Section 6, the surface run-off of sediment material associated with the beach recharge activities as well as the filling of geotextile containers has the potential to impact upon water quality and thus the quality and health of the marine environment.

Prior to the material being deposited on the beach it should be washed with seawater to ensure that all the fines have been removed. It is expected that this will be undertaken at the quarry and / or at the port where there is sufficient space and easy access to seawater. The area used for washing will need to be bunded, or profiled appropriately to ensure that any wastewater from the washing does not enter the marine environment at the port. Washing undertaken at the quarry is part of their normal operations and standard mitigation measures will be employed on site, in accordance with the general operating procedures of the quarry.

When the sediment is delivered to the site for stockpiling, a stockpile location above a sufficient distance above extreme high water will be chosen to ensure that there is no risk of loss of sediment directly in to the water column.

10.5 Air Quality (incl. emissions to atmosphere, generation of dust, climate change)

Although air quality issues were scoped out of the EIA ToR, standard good practice measures for reducing dust emissions will be employed:

- Dust suppression measures such as regular sprinkling of water on accesses and on site in general and regular cleaning are recommended.
- Construction vehicles should be maintained and checked periodically for their emissions.

10.6 Noise and Vibration

As described in Section 5 the project area is a coastal site and as such is subject to a reasonable level of background noise. The construction activities proposed will not result in any particularly ‘abnormal’ noise, given that both vessels and vehicles regularly operate within the vicinity of the project site. However, during the construction activities, the noise will be generated in closer proximity to beach users than normal which has the potential to disturb tourists, residents and general beach users.

All construction activities will be undertaken against the construction management plan to be prepared. Most importantly, throughout the construction activities, the contractor will implement a ‘quiet start’ procedure and limit working hours to 8am to 6pm, with the first two hours and last hour of each working day being limited to ‘quiet’ activities associated with mobilization and demobilization of plant and equipment.

As assessed in Section 6, the construction activities will only result in minor and short terms impacts as a result of vibrations generated. There will be no impacts post construction. As such, no mitigation measures are proposed.

As assessed in Section 6, the construction activities and the operation of the scheme are not anticipated to have any impacts as a result of underwater noise or vibrations. As such, no mitigation measures are proposed for underwater noise or vibration.

10.7 Changes in the availability or service of infrastructure and utilities

This has been Scoped out of the EIA (see Appendix 1c EIA ToR).

10.8 Traffic

Essential mitigation measures include the following:

1. Schedule the bulk of arrivals and departures of truck conveying quarry sands and material during the commuter inter-peak period (between 09h00 and 16h00);
2. Quarry derived materials and construction spoils should be transported in trucks covered with tarpaulins.

Indicative mitigation measures (as follows) shall be elaborated upon within the EMP. Whilst deemed highly unlikely, should any road closures be necessary, the following mitigation measures are proposed.

- Provide the Ministry of Public Works Traffic Division with the schedule possible road closures at least one month in advance so that there will be no conflicts with other road work. The schedule will be updated weekly;
- Prior to commencing quarry extraction of sands and rock, a description of possible road closures and estimated time of closure will be provided to newspapers to ensure the public is aware of the project;
- The public will be provided with advance information on possible road closures through announcements in the newspapers; and,
- Road closures will be posted with detour signs and the detour routes will be fully sign posted throughout to ensure traffic follows the correct routing.

In addition to the above, and reflected recent correspondence with MPW as part of this proposed project application, the following mitigation measures must be considered within the adapted EMP for the project (see Section 11):

a) All existing storm water drainage features that drain into the proposed area being developed (concrete box drains, sluice gates etc) should be made up to acceptable engineering standards if damaged during the construction phase of the project:
b) The introduction of “wheel baths” at site exits from quarries, Sandy lane and the Green Monkey (Sandy Lane) for all trucks transporting sands and other similar materials should be enforced.
c) Direct contact of heavy duty construction equipment such as bulldozers etc should be discouraged from coming into contact with all public roads (as the tracks of these heavy duty equipment contribute to the damage of public highways).
d) On site storage areas for the quarried sands should be on “solid ground” for example compacted marl fill, concrete, kolas and chips etc as quagmire situations or environments at storage sites should be discouraged.
e) Make up to acceptable engineering standards all estate roads etc used during the construction phase if damaged during the project.

f) All beach accesses should be kept clear at all times on existing sites as visibility is paramount for these heavy trucking activities. This is critical because heavily laden (12m3) truck exists sites very slowly with fast approaching (on coming) traffic which can be very problematic,
g) A Traffic Management Plan (TMP) needs to be prepared by the contractor/developer to address in detail the duration of the works. This will give information on daily truck movements and on management of the access to the beach and storage sites for the safety of pedestrians and minimal delay for motorists. Information on signs to be used and traffic directing personnel assigned needs to be included (see Section 11).

11 ENVIRONMENTAL MONITORING PLAN

11.1 Introduction

The Environmental Monitoring Plan (EMP) sets out a framework that contains the requirements for and approach to the follow up activities that are needed to monitor and manage the potential impacts identified within the assessment. It also ensures that the mitigation measures identified are operating effectively to reduce / remove negative impacts and enhance positive impacts.

The EMP should be iterative for BRI. This is because change is inevitable for a development of this size. Its role should be to inform of any amendments to national policy should this be necessary.

As per the TCDPO (2012) Guidelines, the EMP should contain an implementation plan for each of the mitigative protection and enhancement measures. The EMP will provide answers to the following questions ***(NB: examples are purely for illustration and are not specific / relevant to this projec***t):

- What is the objective / need of the activity? e.g. if there is a need for additional mitigation measures (if existing mitigation measures are not effective), is it a legislative requirement?
- Who is responsible for the activity (monitoring, implementation of mitigation measures, etc.) and do other stakeholders have an interest?
- When and how often should the activity be carried out and for how long – at what stage of the project (pre-construction, during construction, post-construction, etc.)? e.g. monthly monitoring of water quality for one year.
- What happens if the follow up activities result in negative findings? e.g. noise levels are significantly higher than expected with mitigation measures in place, there is uncertainty about the impacts and 'adaptive management' is required.

11.2 The EMP as a Living Document

The objective of the EMP is to provide a systematic approach to management of environmental impacts and issues identified by the EIA. It represents the key administrative and communication document for all parties (Government, developer etc). The EMP forms part of a contract of works (documentation) and is incorporated within the specification and/or as Works Information. The developer and TCDPO will have agreed that the EMP is satisfactorily integrated.

The EMP details how the EIA process will continue through to the completion of the works and how the protection, conservation, mitigation and enhancement measures for this proposal will be delivered by the Contractor. The following text outlines the structure and indicative content of the EMP as it produced/updated during 2016 (agreed and adhered to prior to the proposed construction phase which is planned to commence from May 2016 onwards).

An EMP should be developed initially in conjunction with the relevant contractors (for the construction and commissioning phase) and a subsequent EMP developed in conjunction with the operators, leading to slightly different EMP design and structure. The information presented should therefore be used to inform a Construction and Commissioning Environmental Management Plan (CCEMP) and subsequently a full EMP for the operation phase, both of which are to be developed prior to commencement of construction and operation respectively. The impacts associated with the construction and commissioning phase of the development are predominantly associated with engineering design and construction activities, notably by contractors and suppliers. As such the CCEMP will be focused on these areas.

The structure of the CCEMP shall include the following sub-divisions:

- A description of the site and planned activities;
- Identification of appropriate local and national legislation and clear appreciation of GoB policy for the coast;
- A summary of the environmental potential impacts/issues(severity/significance) associated with the planned activities and how these relate to legislative requirements (summary of EIA);
- Identification of mitigation, monitoring and management measures required and their timescale of delivery;
- Indication of who is responsible for implementing such measures and at what stage in the project they need to be implemented.

Repetition of information already provided in the EIA shall be avoided to allow the developer and relevant contractors to better address environmental management through the allocation of resources, assignment of responsibilities and ongoing evaluation of practices, procedures and processes.

The focus of the EMP shall be towards providing pointers to the delivery of appropriate Environmental Action Plans (EAPs). The appropriate EAPs may be included as specific Terms of Reference for contractors during constructions phases of work. Therefore, for BRI, the EMP requires further development to enable its successful implementation as a definitive, yet flexible system allowing for incorporation of revisions and improvements as these become necessary.

The EMP shall develop the following areas with more detail derived from the developer and proposed contractors;

- Emergency response/contingency planning (e.g. for accidents etc);
- Controlling of environmental impacts (actual and potential);
- Establishment and maintenance of communication with interested external and internal parties, including regular reporting to environmental authorities;
- Identification and review of any future legislation that may be passed;
- Development of management and employee commitment;
- Provision of resources, such as training;
- Setting of realistic environmental targets to which the developer can commit;
- Implementation of environmental audit and review systems;
- Encouragement of contractors and suppliers to undertake environmental management;
- Integration of Environmental Management with other aspects of management within the development (e.g. quality, health and safety, training)
- Integration of Environmental Management with that of other developments in the country.

The following sections set out the likely expected monitoring requirements for the impacts and mitigation measures identified in Sections 6 and 9 of this report.

11.3 Human Beings

Measures included in the EMP to monitor identified impacts and mitigation include:

- *"ISOBeach Management Scheme"* is set up and implemented (as a spedicif Environmental Action Plan – EAP) to ensure that zoning/signage/enforcement aspects are clearly defined and regulated by Sandy Lane (in tandem with NCC as appropriate) so that no motorised boat related activity is allowed within Sandy Lane Bay during contruction times through necessary re-routing (new zoning) of recreational watercraft away from construction vessels shall be set up to reduce impact on local economic / commercial activities.

The proposed Sandy Lane *"ISOBeach Management Scheme"* is recommended as a key EMP measure not only to help BRI address important beach management activities as part of the proposed project, but also to help to ensure Barbados is the first country in the world to adopt the new ISO13009 Beach Standard (published in January 2015). Part of which shall be to ensure that all services on the beach are improved, which shall include advice of aspects such as safety, water quality, beach and nearshore zoning, comfort facilities and recreational services for holidaymakers, bathers and surfers alike, thus making Sandy Lane Bay compliant to international ISO standards.

The successful engineering contractor (decision to be awarded during February 2016) shall work with the BRI consultant team to prepare a clear EAP that addresses all issues and beach user risks. Table 10.1 in Section 10 identifies the structure of the ISOBeach Management Scheme EAP that is to be adhered to in future contract documentation.

11.4 Flora and Fauna

Monitoring efforts are generally designed to detect or measure change. Developing a monitoring plan for coral reef management for Sandy Lane Bay includes the need for setting objectives, selecting variables, establishing thresholds and triggers, choosing monitoring methods and deciding on a sampling design. The coral reef monitoring plan shall also help FMP determine what type of a monitoring program should be implemented long term (in tandem with BRI). Responsive and participatory monitoring are two common types of monitoring programs used by coral reef managers and are two approaches that are being considered by Sandy Lane.

Reef Check is a global reef monitoring programme that shall be adhered to as a framework for future reef monitoring for the project. This adheres to existing practices in Barbados. Reef Check was developed in 1996 as a volunteer, community-based monitoring protocol designed to measure the health of coral reefs on a global scale. The aims of Reef Check are to:

- **Educate** the public and governments about the value of coral reefs and the crises facing them;
- **Create** a global network of volunteer teams, trained and led by scientists, that regularly monitor and report on reef health using standard methods;
- **Facilitate** collaborative use of reef health information by community groups, governments, universities and businesses to design and implement ecologically sound and economically sustainable solutions;
- **Stimulate** local action to protect remaining pristine reefs and rehabilitate damaged reefs worldwide.

Reef Check is the only global-scale, volunteer-based organisation that measures reef health using standard methods. It is also already being used and followed in Barbados.

BRI intend to adopt a private public partnership (PPP) approach towards coral reef monitoring in tandem with the CZMU and FMP. This approach is adopted because the Govt of Barbados has limited resources available to support a coral reef monitoring program. . By using volunteer labour in combination with state workers, consultants and academics, the value of government investment in monitoring and management will be increased many times. In addition, by using volunteers, particularly students or community groups, it is possible to attract cash and in-kind cost-sharing for training, surveys etc. In any given year, Reef Check teams leverage several million dollars in support globally.

Measures to be included in the EMP to monitor identified impacts and mitigation (identified above plus as part of a specific PPP Reef Check team programme with CZMU/FMP) shall include:

- Monitoring of transplanted corals that have been moved from within the footprint of NES 1 to their new location to ensure that losses within the NES footprint are mitigated effectively.
- Monitoring of coral in the lee of NES 1, where the beach will widen / salient may form, to determine if coral are adversely affected e.g. through smothering.
- Water quality monitoring measures to limit knock-on impacts from changed to water quality (see below).
- Monitoring of any eco-engineering structures / enhancements built into the NESs.
- Monitoring of the colonisation of geobag and rock NES.
- Monitoring of fish species / populations around geobag and rock NES.
- Turtle use of the beach post-construction – to determine if nourishment has altered use / suitability for nesting (see also Section 11.5.5 below – "coastal processes").
- Management of future beach nourishment / re-cycling works – applying lessons learned from data gathered from construction and post-construction monitoring.

The EMP also recommends the need for BRI to add a variation to the proposed Engineering Contract (placing the nearshore engineering structures (NES)) to delay the placement of any Habitat Support Structures (HSS – see Appendix 10a) until the commencement of Phase 6 (Management and Maintenance phase). This will enable a small period of time (say September 2016 to December 2016) to record and monitor NES performance and any changes to natural suspended sediment levels prior to placing the HSSs. This monitoring phase would be valuable to help target precise locations for their placement based on initial monitoring results of algal settlement patterns actually on each NES.

The EMP also proposes that a small coral nursery be established at the site, using methods developed by the Coral Reef Foundation Institute (CRFI) who are actively establishing coral nurseries in the wider Caribbean.

The EMP shall be designed to reflect the Reef Check Instruction manual (2006) and a copy demonstrated in the link below. Details of the 6 Permanent Monitoring Sites are clearly identified in Appendix 5l (section 3.3). Sediment monitoring traps shall also be deployed at each locations as identified in Appendix 5l (section 3.6). **The frequency of the monitoring shall be determined in tandem with FMP and CZMU, though for the purposes of this EIA, a minimum monitoring frequency of once a year – annual) is proposed. This shall commence at least 1 month prior to any construction works on site (scheduled to commence in June 2016).**

http://www.icran.org/pdf/MAR-Pages/tourism/Docs/RC%20Instruction%20Manual%20(English).pdf

The approach for establishing the proposed "coral nursery" shall adhere to the recommended approach and monitoring protocols clearly set out in Appendix 10a (Appendix A).

11.5 Physical Environment

Measures to be included in the EMP to monitor identified impacts and mitigation include:

- Monitoring of beach levels / width at agreed transects – to monitor (positive) impacts in Sandy Lane Bay and potential (negative) far-field impacts beyond and determine the need for additional mitigation to counter any far-field effects and decide when additional nourishment is needed in Sandy Lane Bay;
- Wave monitoring;
- Water quality monitoring (turbidity) during construction to minimise loss of fines during filling of geotextile bags and minimise impacts to water quality, visual impacts to beach/sea users and knock-on impacts to marine and coastal flora and fauna (particularly coral and fish species);
- Operational monitoring of the NES – particularly the geotextile bag NESs – to ensure their continued functioning to deliver the identified benefits (see Section 6) and to prevent loss of sediment, with associated impacts to water quality and marine and coastal flora and fauna;
- Monitoring of the implementation of pollution prevention and control measures during construction to ensure spills, leaks and other pollution incidents do not occur; or are effectively and efficiently managed should they occur, in order to minimise their impact.
- Monitoring of beach recharge performance (see Section 11.5.5 below).

The successful engineering shall work with the BRI consultant team to prepare a clear EAP that addresses all beach level, water level and operational monitoring activities. Specific details of the beach profile (pre- and post construction) monintoring regime is clearly set out in Appendix 5g (Annex I). The EAP for beach monitoring cannot be completed until the final monthly survey and 12 month "findings" report has been produced and submitted to TCDPO.

11.5.1 Landscape & Seascape

Measures likely to be included in the EMP to monitor identified impacts and mitigation include:

- Monitor and react to complaints about plumes generated by project activities. Maintain a record of complaints and the actions taken in response.

11.5.2 Coastal Processes (including erosion and deposition)

Measures likely to be included in the EMP to monitor identified impacts and mitigation include those identified above for monitoring the physical environment.

Regarding coastal processes, the EMP pays particular attention on the need to ensure the beach nourishment aspect of the project does not indirectly impact on sea turtles (despite the EIA outlining that this is a small risk as the site is not a recorded turtle nesting site). There remains a small risk that the works may influence the quality of any nesting habitat and that beach recharge works may disrupt reproduction and foraging grounds. Incompatibility of nourishment material within the nesting habitat can potentially affect nesting females' ability to successfully nest (Lutcavage et al., 1997). If the nourishment sand is dissimilar from the native sand, results can include changes in sand compaction, beach moisture content, sand colour, sand grain size and shape, and sand grain mineral content, all of which may alter sea turtle nesting behavior (Crain et al., 1995). Nest site selection and digging behavior of the female can be altered or deterred, if she finds the beach unsuitable. Additionally, escarpments may develop on nourished beaches, and can prevent sea turtles from accessing the dry beach and cause the female to return to the water without nesting. Unable to reach preferable nesting sites, females may also choose to deposit nests in unfavourable areas seaward of the escarpment, making them vulnerable to wash-out (Crain et al., 1995).

To provide the most suitable sediment for nesting sea turtles, the colour of the nourishment material must resemble the natural beach sand in the area.

The samples collected by the quarried source (see Appendices 5a, 5b and 5c) do closely represent the existing beach, which is a composite of the characteristics of material that has been placed on the beach during past nourishment projects (around Barbados) and native beach sediment.

As a result of sediment compliance efforts (see Appendix 5civ), compaction of fill material on the beach is less likely to occur due to the lower silt content. Compaction of fill could impact the ability of sea turtles to dig and nest along the nourished beach, resulting in an increase in false crawls. Also, macroinfauna indicative of a healthy benthic community depend upon variable particle sizes and available interstitial pore space in the substrate for aeration properties. Compaction of the fill material could impact resident macroinfaunal populations thereby affecting the migratory and resident shorebirds, waterbirds, as well as the commercially and recreationally important fish that depend upon them.

To this end, regular monthly beach profile and sediment compaction testing is proposed as an important activity that shall comprise part of the post construction monitoring programme.

11.6 Traffic

A specific Traffic Management Plan (TMP) is to be prepared in tandem with the preferred engineering contractor during February 2016. A template for the TMP that shall be adhered to is presented in Appendix 11a. The TMP needs to be prepared by the contractor/developer to address in detail the duration of the works. This will give information on daily truck movements and on management of the access to the beach and storage sites for the safety of pedestrians and minimal delay for motorists. Information on signs to be used and traffic directing personnel assigned needs to be included. Measures to be included within the TMP shall include:

- Monitoring of the implementation of traffic congestion/flow and associated noise prevention and control measures during construction (from quarry to temporary storage area and then from temporary storage area to final beach deposition area) to ensure disruption to local communities /local residents and beach / sea users is kept to a minimum and within the agreed working hours.
- Monitoring of quarried rock transport from Black Bess to Port of Barbados to ensure disruption to daily traffic flows on key highways are kept to a minimum and within agreed working hours.
- Monitor and react to complaints about traffic. Maintain a record of complaints and the actions taken in response.

These measures will aim to minimise the extent of inconvenience to traffic flow by keeping the public and key agencies informed, and confine traffic restrictions to the shortest time possible.

The proposed contents of the TMP are presented below.

1.0	Traffic Management plan
2.0	Pedestrian route checklist
	Action(s) to be taken
3.0	Vehicle routes
	Action(s) to be taken
4.0	Vehicle movements
	Action(s) to be taken
5.0	Hierarchy of control measures for reversing vehicles
6.0	Drivers safe work practices checklist
7.0	Slinger/banksman checklist
8.0	Site use of dumpers checklist
9.0	Central Control Register
10.0	Location map and directions
11.0	Site logistics plan

11.7 Contractor Health and Safety Compliance

Most of the mitigation and management measures discussed in this section are contained within the various environmental and social management plans created, or under development for the Project. Environmental and social management and monitoring will be under the control of BRI during the construction phase, but once the Hotel goes into operations, this will be based on the corporate requirements set out by Sandy Lane. Many of the plans however, span the life of the Project from construction through operations.

BRI shall create a Safety, Health and Environment (SH&E) Management Plan, which defines in detail how health and safety will be managed during the construction phase of the Project. The SH&E Plan shall contain a manual that outlines the responsibilities of the project team under each of the topic headings of SH&E to the designers, construction managers and contractors. The SH&E Plan supplements the statutory obligations on the Company and the project team. The Company will employ a full time Health and Safety Manager to supervise the construction operations.

Contractors will only be able to bring staff on site with appropriate Personal Protective Equipment (PPE) and after completing a comprehensive induction course. Each person on site will be issued with a Disaster Recovery Card giving the contact details of key staff and contact information for security, police, fire, ambulance and other emergency services. First aid stations will be set up in various locations on-site, with clear signage to indicate their location. Contractors and the management team will have trained first aiders so that emergency help can be administered as early as possible.

In terms of construction labor requirements, the Project has committed to set high standards in terms of improving labor practices, safety and working conditions on-site, and is planning certain initiatives such as:

- Contractor awards for contractors who have demonstrated good safety practices;
- Employing a full time Health and Safety Manager, independent from the contractors, to ensure that SH&E Plan is adhered to and to provide independent reporting;
- Providing tool box talks and Health and Safety training/education to the work force
- Working with the government Labor department on educational programs;
- Enforcing PPE as a basic criteria for entering the site and also ensure that new workers have a full site introduction ahead of commencing work;
- Daily inspections and a regime of permits, risk assessment and method statements; and
- Monthly safety audits will be carried out with the labor department.

During Hotel operations, the management plans and procedures will be based on those of Sandy Lane Seasons corporate plans. These address impacts and risks covering key aspects of the operations. Examples of these plans and procedures include:

- Fire Safety & Emergency Response Procedures, including natural disasters
- Occupational Health and Safety, including accident reporting and analysis procedures;
- Contractor Compliance Program that details how all hotel contractors will comply with Sandy Lane Health and Safety and other requirements;
- Hazard Communication Program following the U.S. Occupational Safety and Health Administration (OSHA) guidelines, for the evaluation of hazards in the work place;
- Employee training programs, including hazardous materials handling;
- First Aid response procedures, including training on the use of the Automated External Defibrillator (AED); and
- Safe food handling practices, including a Culinary Safety / Health Checklist.

The Project also has in place, or is planning, a series of community engagement and development plans, the details of which will be reviewed during the EMP into 2016.