

CREATING A

November 2018

SAFE SUSTAINABLE COAST



**An Integrated Coastal
Zone Management Initiative**
by The Coastal Zone Management Unit



An Integrated Coastal Zone Management Initiative

by The Coastal Zone Management Unit



Integrated Coastal Zone Management (ICZM) is a way to manage the coast which includes all aspects of the coastal zone. The goal is to manage our coastal and marine resources properly.



Some of the CZMU Team outside their office in Warrens.

Not Pictured: Marcia Thornhill, Richard Suckoo, Shoneé Howell, Tonya Corbin, Lisa-Ann Hoyte, Terry Hutchinson, Tamesha Jones, Juanita Small, Sandra Kirton, Phillip Mayers.

FOREWORD



Leo F. S. Brewster Ph.D.

Director CZMU

From concept to reality – this document illustrates how science can be broken down into easily understood language to help in the greater understanding of how the coastline of Barbados functions. Integrated coastal zone management has been implemented in Barbados for the past thirty five years. It has contributed to the long term sustainable development of the coastline to date, through the maintenance of the delicate balance between the economic, social and environmental considerations, in all aspects of the development of the coastline – despite the increasing pressure to see significant transformations to an already heavily urbanized coastline.

Science has always been at the forefront of, and the driving force behind the work of the Coastal Zone Management Unit (CZMU,) since its inception 35 years ago. It is how we continue to be able to provide the best designs for the continued stabilization and/or enhancement of the prioritized areas of the coast.

This document summarizes the work of the Coastal Risk Assessment and Management Programme (CRMP) – Component 6 of the ongoing Barbados Coastal Conservation Programme – being implemented by the CZMU.

It demonstrates that Barbados' coastline is highly complex and unique! The ability to present this information has been a challenge but the end result clearly illustrates the scope and talent of the staff of the CZMU, and their associates. It represents their ongoing quest to provide information to the public, in as easy to understand format as possible, given the complex environment in which they work. As the CRMP begins to draw to a close, the final component will be the development of the island's Integrated Coastal Zone Management Plan (ICZMP). It is hoped that through this book, the decision-makers and leaders of Barbados will then be in a position to readily respond to the ICZMP and help capture how Barbados' coast should be developed as we move into the third decade of the 21st century.

I congratulate all who took part in developing this document – from the distillation of the data and information to the refinement of the final product. It should become a must read for all!

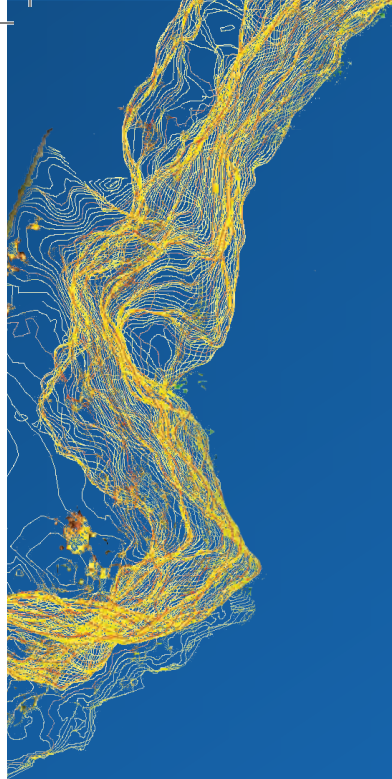
It continues to demonstrate the motto of the CZMU:

“A coast to be proud of!”

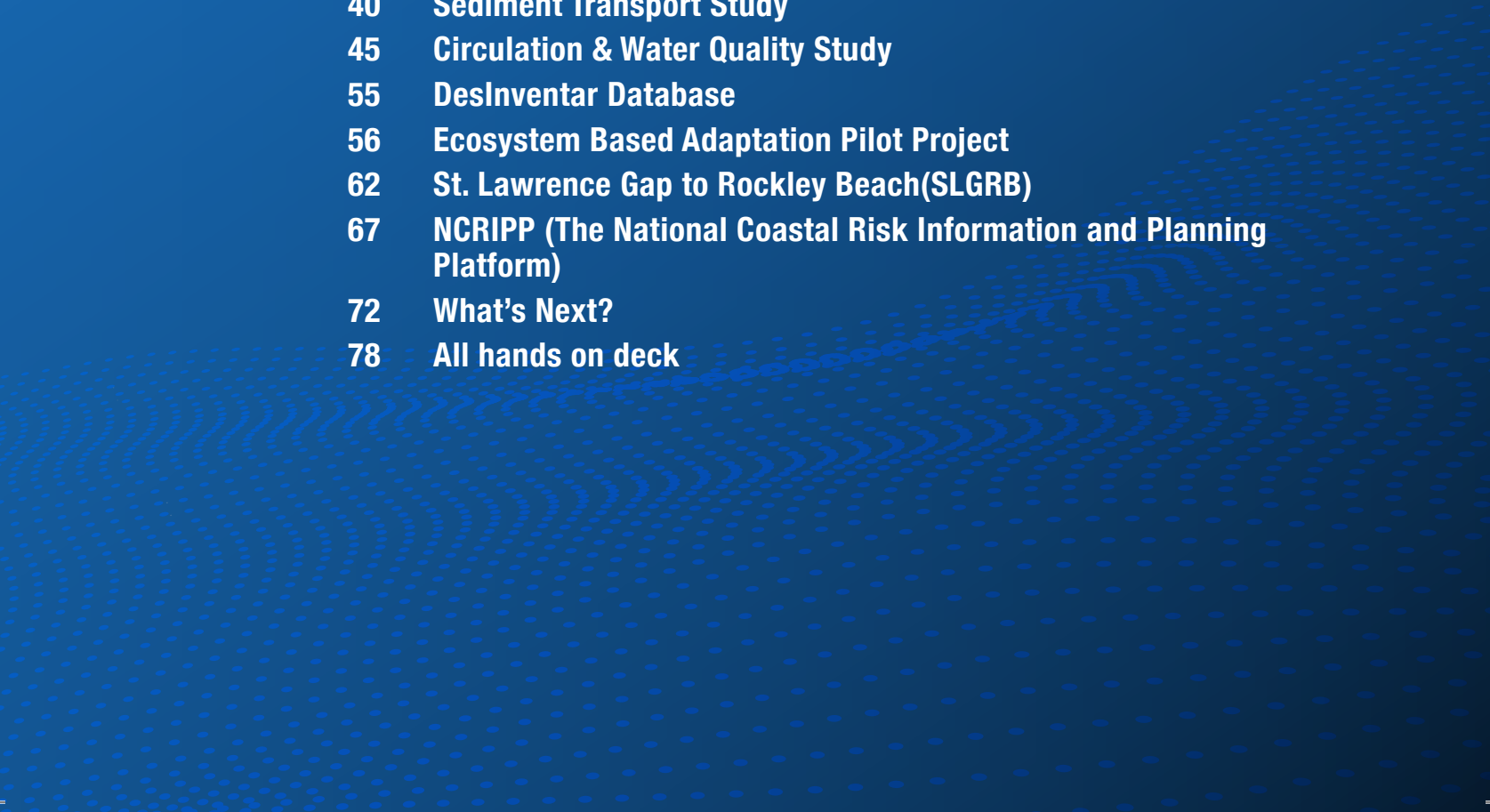
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EXECUTIVE SUMMARY

In 2017 the Caribbean incurred about US \$10 billion in damages to residential and commercial infrastructure, equipment and goods from Hurricane Irma alone.¹

Barbados, through the Coastal Zone Management Unit (CZMU) and other stakeholders, has made significant strides with regard to Integrated Coastal Zone Management (ICZM). ICZM seeks to manage our coastal and marine resources properly so that they are healthy and benefit the island socially and economically, through hospitality, tourism and other activities.

Whether we live along the coast or in parishes bordered by land, whatever happens along the coast impacts us all - positively or negatively. The CZMU through a project called the Coastal Risk Assessment and Management Programme (CRMP) has identified certain vulnerabilities we face because of climate change and sea level rise and ways to address them.

Less than 20% Coral Cover Around Island

Currently there is just under 20% coral cover around this island. Coral reefs protect coastlines from the damaging effects of storm surge and tropical storms. Not having adequate coral cover is like a country without protective borders.

To make matters worse, we found through the project that almost 10% of our coastline is being eroded while only 2% is experiencing growth through the depositing of sand. Most of this erosion has occurred between Sandy Lane in St. James and the Arawak Cement Plant in St. Lucy.

What does this mean? That this area populated with homes, businesses and tourist attractions is more susceptible to the impacts of climate change.

Land-based chemicals main source of marine pollution

Another study out of the CRMP project found that land-based actions from the use of fertilisers in agriculture and the disposal of wastewater was the main source of pollution to our marine environment. The declining coral cover is likely to worsen if harmful chemicals are not significantly reduced. If this doesn't happen our ecosystem biodiversity will not be the only casualty. The stability of our beaches, our local fisheries and tourism industries, as well as the health of the public will be impacted.

Government, businesses, visitors and residents all have role to play

As a result of these threats, we have incorporated more Disaster Risk Management and Climate Change Adaptation processes into our daily functions. We are making some headway. But much more is needed including financial and human resources. A responsible, holistic and conservative approach to managing erosion, restoring coral health, and reducing the impact of storm surge is needed. It will need to involve government, businesses, visitors and residents regardless of parish or constituency.

Our coastline is the first line of defence when storms and hurricanes approach and if it is not managed and cared for properly we all stand to lose. And more than we think.

Hurricane impacts, tourism losses and infrastructure damage from sea level rise could amount to US \$22 billion per year by 2050 and US \$46 billion per year by 2100. This is 10% and 22% of current regional GDP.¹

Global average temperature increase has led to detrimental impacts across the spectrum of life in the Caribbean.¹

References:¹

https://climateanalytics.org/media/Ind_costing_and_financing_mechanisms_caribbean_outlook.pdf



The story behind
**THE COASTAL
RISK ASSESSMENT
& MANAGEMENT
PROGRAMME**



The Coastal Zone Management Unit (CZMU) of Barbados has made significant strides in Integrated Coastal Zone Management (ICZM), including achievements in coastal erosion control, resource conservation, institutional strengthening and capacity building. But there is more to be, and being, done.

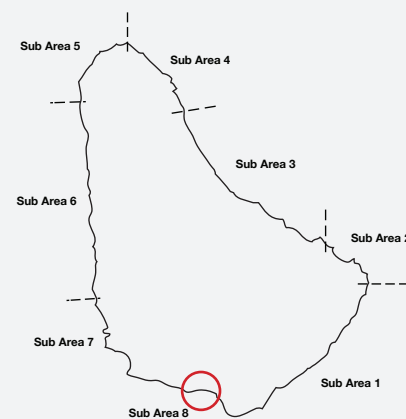
This is a story about enhancing the ICZM capacity of the CZMU, and by extension Barbados, while incorporating sound Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) principles so that those who live along, work in and visit our coastline can do so more enjoyably and safely. This is a story about the Coastal Risk Assessment and Management Programme (CRMP).

Let's start by briefly going back to the end of another project, a building block for the CRMP. We refer to the Coastal Infrastructure Program (CIP) in which three waterfront improvement projects were successfully undertaken from 2002 – 2009:

- Welches Beach Improvement Project
- Richard Haynes boardwalk
- Holetown Waterfront Improvement Project (HWIP)

WELCHES BEACH

Improvement Project



Did you KNOW?
**0.5 km of coastline at Welches,
Christ Church, is now protected.**

Welches beach is located at Welches in Christ Church on the south coast of Highway 7, approximately 0.5km west of Oistins. The main road along this stretch is immediately adjacent to the sea at Welches.

Before construction of the project, it was exposed to waves and flooding during storms. Flooding of the road was hazardous to motorists, and made walking along it difficult or even impossible at times. It was believed that continued exposure of the road to waves was likely to lead to the road being severely damaged, resulting in its closure for repairs.

The Welches Beach Improvement Project at a budget of US\$1.5 million was designed to provide a solution to this problem.

By the end of the project, 0.5 km of coastline had been protected from erosion by a combination of revetments (structures placed in such a way as to absorb the energy or impact of incoming water), breakwaters and **groynes**.

Additional recreational beach area was established for public use.

¹ **Groyne** - Low barriers built from the beach to the sea to combat erosion.



Welches Beach before improvements

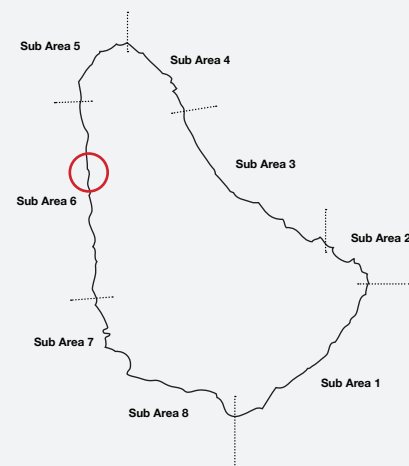


Welches Beach after improvements

HOLETOWN WATERFRONT

Improvement Project

Did you KNOW?
Holetown beach now provides
continuous beach access.

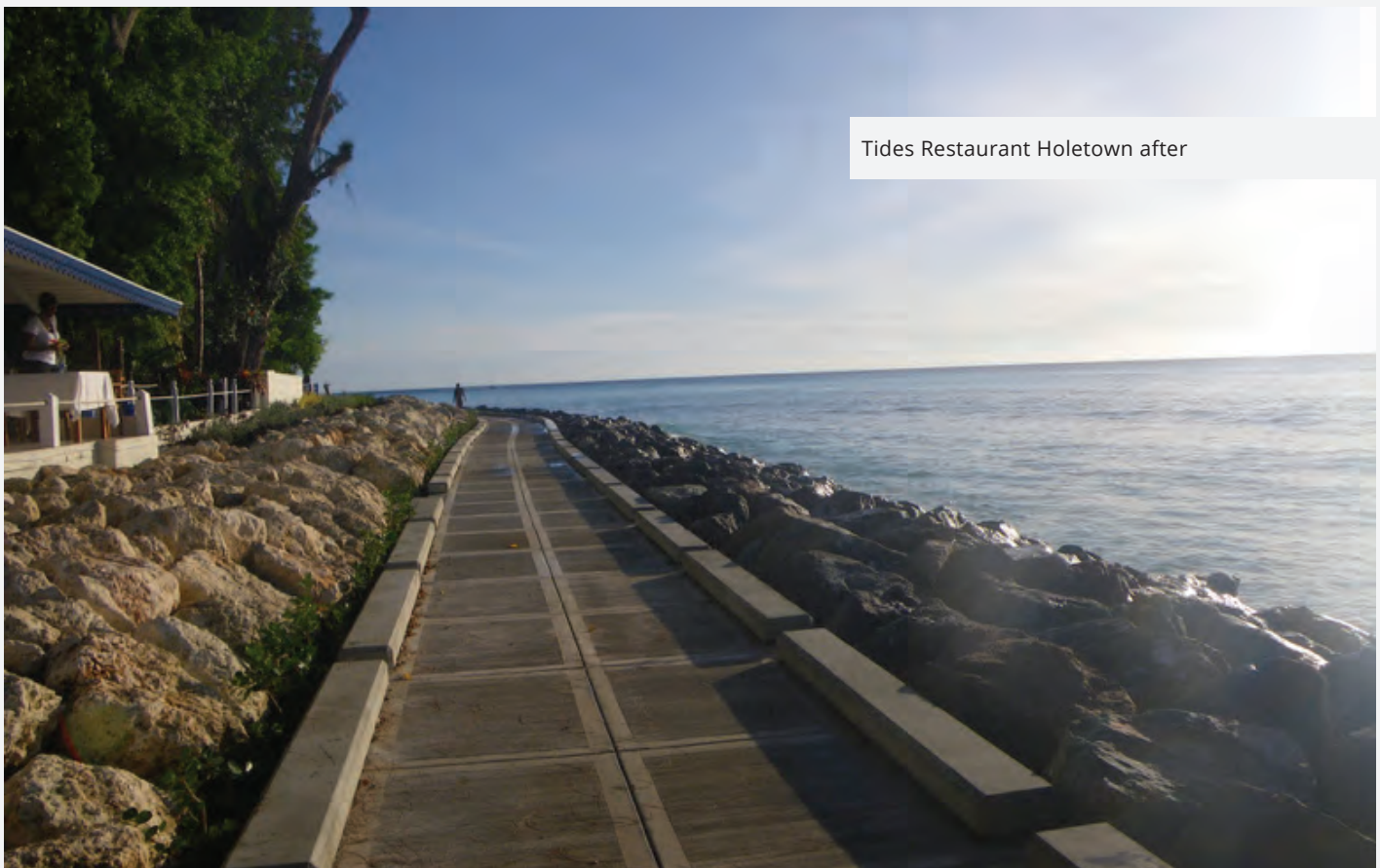


Holetown beach, on the west coast of the island, is one of the island's most popular tourism beaches. However, it was narrow and along some portions of the coastal strip there was little or no beach. This traditional lack of beach can be attributed to the coastline configuration along the west coast which is characterized by bays and headlands, and compounded by many coastal structures and developments which protrude into the active beach zone, inhibiting the natural beach building processes.

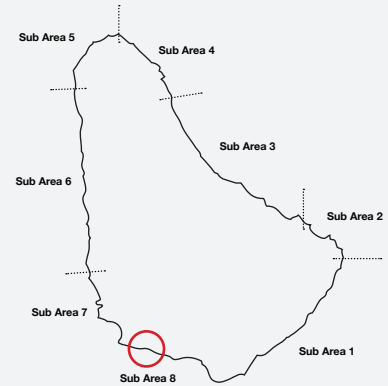
Holetown beach was given a construction budget of US \$3 million to improve its value through the creation of continuous access along the beach, and stabilisation and enhancement of beach width, resulting in continuous access for the public. The widening of the beach was achieved through the design and implementation of coastal structures and the removal of structures currently causing damage to the coastline or the repair of functional but damaged structures.



Tides Restaurant Holetown before



Tides Restaurant Holetown after



ROCKLEY TO COCONUT COURT

Waterfront Improvements Project

Did you KNOW?
Beach utility and convenience
has been greatly improved.

The project site stretches over 1.2km of coastline from Rockley Beach to just west of Sierra Hotel in Hastings, Christ Church. The project was designed based on a headland-beach concept. Five headlands were constructed along the project site and beaches were created using a total of 12,000 cubic metres of beach sand. An offshore breakwater and several spurs were also constructed. The prominent feature of the project is a 1.2km long boardwalk known as the Richard Haynes Boardwalk.

The boardwalk satisfied the objective to provide continuous public access along the shoreline and is an alternative to the current unsafe pedestrian access on Highway 7. The headlands have stepped outer edges and walkways that can be used by beach walkers to walk around each headland without ascending to the main boardwalk. The five enhanced or new beaches provide a significant increase in the beach amenity along this shoreline.



Rockley Caribee before



Rockley Caribee after

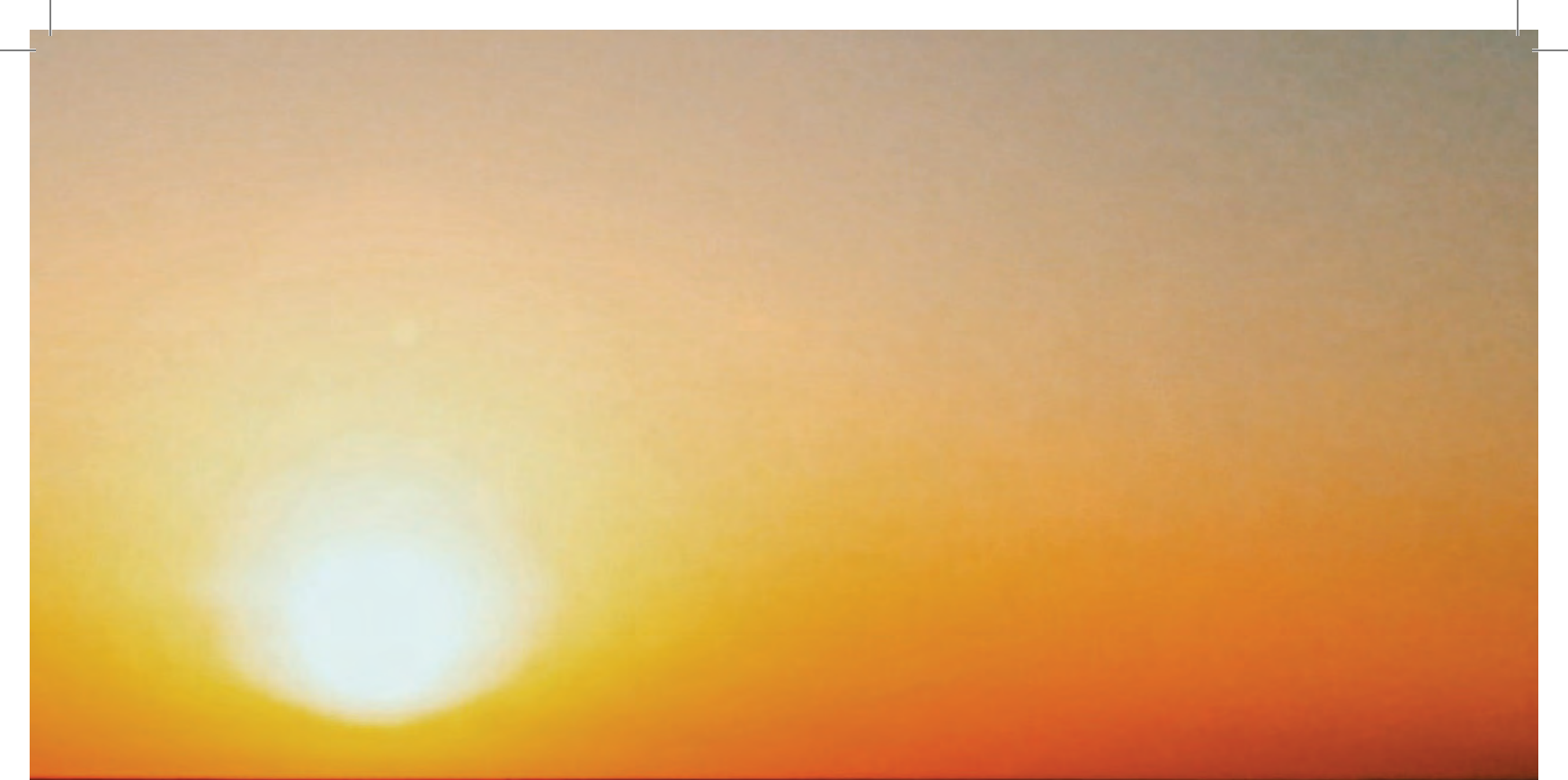
NEW HORIZONS FOR CZMU

As the Coastal Zone Management Unit (CZMU) looks towards the future, Integrated Coastal Zone Management (ICZM), Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) are being more deeply integrated into our mandate.

In addition to making decisions based on hazards and engineering considerations, we'll now also focus on economic analysis, budgeting and cost benefit analysis to mitigate the impact of coastal hazards. This is as a result of the Coastal Risk Assessment and Management Programme (CRMP), a groundbreaking initiative which will see the increased use of science taking CZMU and the government further in terms of land development and DRM (planning, mitigation, and response).

We look ahead with a new vision, one that embraces not only the coast, but the ocean:

"Coast and seas to be proud of, that are valued, appreciated and safeguarded as places to live, work, use and relax; places where development and use of resources will be sustainable and where the natural environment is protected and enhanced to keep their essential and unique place in the Barbadian Heritage."



To help us achieve this vision we've set Five Foundation Principles:

- + Principle 1:
Sustainable Development to support Risk Resilient ICZM
- + Principle 2:
Ecosystem Service Management
- + Principle 3:
Integrated Coastal and Ocean Governance and Knowledge Systems
- + Principle 4:
Public Participation and Stakeholder Engagement
- + Principle 5:
Financial Sustainability for Risk Resilient ICZM

A wide cast of players, across Government, State-owned agencies, NGOs, utility companies, coastal businesses, residents and visitors, have a stake in valuing and looking after our coast and seas.

We all have a part to play.

Will you join us?

Coastal Risk Assessment and Management Programme:

Incorporating Disaster Risk Management & Climate Change Adaptation into Daily CZMU Functions

Let's turn now in more detail to our most recent programme - the Coastal Risk Assessment and Management Programme (CRMP). Recognising the vulnerability of Small Island Developing States, like Barbados, to climate change and sea level rise, this programme seeks to incorporate Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) into the daily functions of the CZMU and by extension, the Government of Barbados.

The information collection and monitoring component of the CRMP began with a series of Baseline studies, investigations and the development of a platform consisting of:

- The Coastal Zone LiDAR Study (LiDAR)
- Geotechnical Survey Investigations (GSI)
- Nearshore Wave Study (NSW)
- Sediment Transport Study (STS)
- Shoreline Change Study (SCS)
- Circulation and Water Quality Study (CWQS)
- Ecosystem Based Adaptation Pilot Project (EBA)
- St. Lawrence Gap to Rockley Beach (SLGRB)
- National Coastal Risk Information and Planning Platform (NCRIPP)

The Coastal Zone **LIDAR STUDY**

LIDAR-Light Detection and Ranging -
is a remote sensing method used to
examine the surface of the Earth.

The Coastal Zone LiDAR Study is a “super study” which captured land and water depth information in 3D using Light Detection and Ranging, essentially equipment with a laser array mounted in a plane.

It has provided Barbados with a detailed description of both the topographic (land) and the **1bathymetric** (ocean) details of Barbados. It captured the 3D shape of the island and the surrounding seabed at a very high spatial resolution. Bathymetric information was collected in the fall of 2014 and extends from the shoreline to a depth of approximately 30 to 40 m. Topographic information was collected in February and March of 2015. Data were collected during two time periods as a result of challenging weather conditions and persistent low cloud cover.

Because of the high quality of data collected, the study has generated positive and useful results for modelling and managing Barbados’ coastal and terrestrial environments.

¹Ba.thy.me.try - Measurement of water depth in oceans, seas or lakes.

The LiDAR study provided the foundation for other studies under the CRMP:

- Nearshore Wave Study: This study used the detailed bathymetry to define depths throughout the wave model analysis areas
- Coastal Water Quality Study: The LiDAR data has provided depth information to the nearshore ¹hydrodynamic model
- Sediment Transport: The LiDAR data has provided the necessary data to define the water depths from about 40 m depth right through the area of beach which is normally impacted by waves on a daily basis (active beach). This level of detail has never been available in the past
- Geotechnical Studies and Investigations: The revised topography has allowed for a much more detailed assessment of cliff and slope stability
- Shoreline Change: The Shoreline Change Study relied heavily on the new imagery to define the 2014/2015 shoreline positions. These data were more detailed than past imagery and provided a detailed assessment of current shoreline positions
- St. Lawrence Gap to Rockley Beach (SLGRB) Waterfront Improvements: Detailed bathymetry from the study was used in both physical and numerical modelling of the waterfront improvements. This included both offshore regions as

well as the position of shoreline infrastructure such as buildings and walls

- Ecosystem Based Adaption: The EBA pilot project used the reflectance data collected during the LiDAR survey to enable habitat classification and mapping at the bottom of the sea. Information related to ocean depth was also used to assess possible coral nursery and donor areas.

Outcomes

The high-quality data collected from the study provides inputs for modelling and other purposes

- LiDAR data will be used to support projects covering conservation and management of the coastal zone of Barbados
- Datasets have been shared with various stakeholders: Lands and Surveys, Town & Country Development Planning Office(TCDPO)/ Prime Minister's Planning Unit, Housing and Lands, Drainage Division, Barbados Water Authority
- Limited data was given to construction companies and developers
- The quality of inputs into the model and the model itself are very good. This should give policy and decision makers confidence in the results of the modelling activities

¹Hy.dro.dy.nam.ics - The branch of science dealing with forces acting on or exerted by fluids.

Government can now reduce its costs for feasibility studies.

What this means:

The LiDAR study yielded positive and useful results for modelling and managing Barbados' coastal and terrestrial environments.

- The aerial photography has been very useful to government departments, such as the Town and Country Planning and Development Office, and The Lands and Surveys Department, in classifying different kinds of land use
- Marine habitats and resources have been better classified so that users can see the difference between coral reefs, sand and rock. This means that they can better identify the type and state of different marine habitats and better advise stakeholders such as private developers
- There's potential for reducing costs of feasibility studies for government stakeholders as well as costs associated with major infrastructural works such as highway expansion.

Drone Detailed Geometry Point Cloud Data -
Location DR18 - Ocean City - St Philip



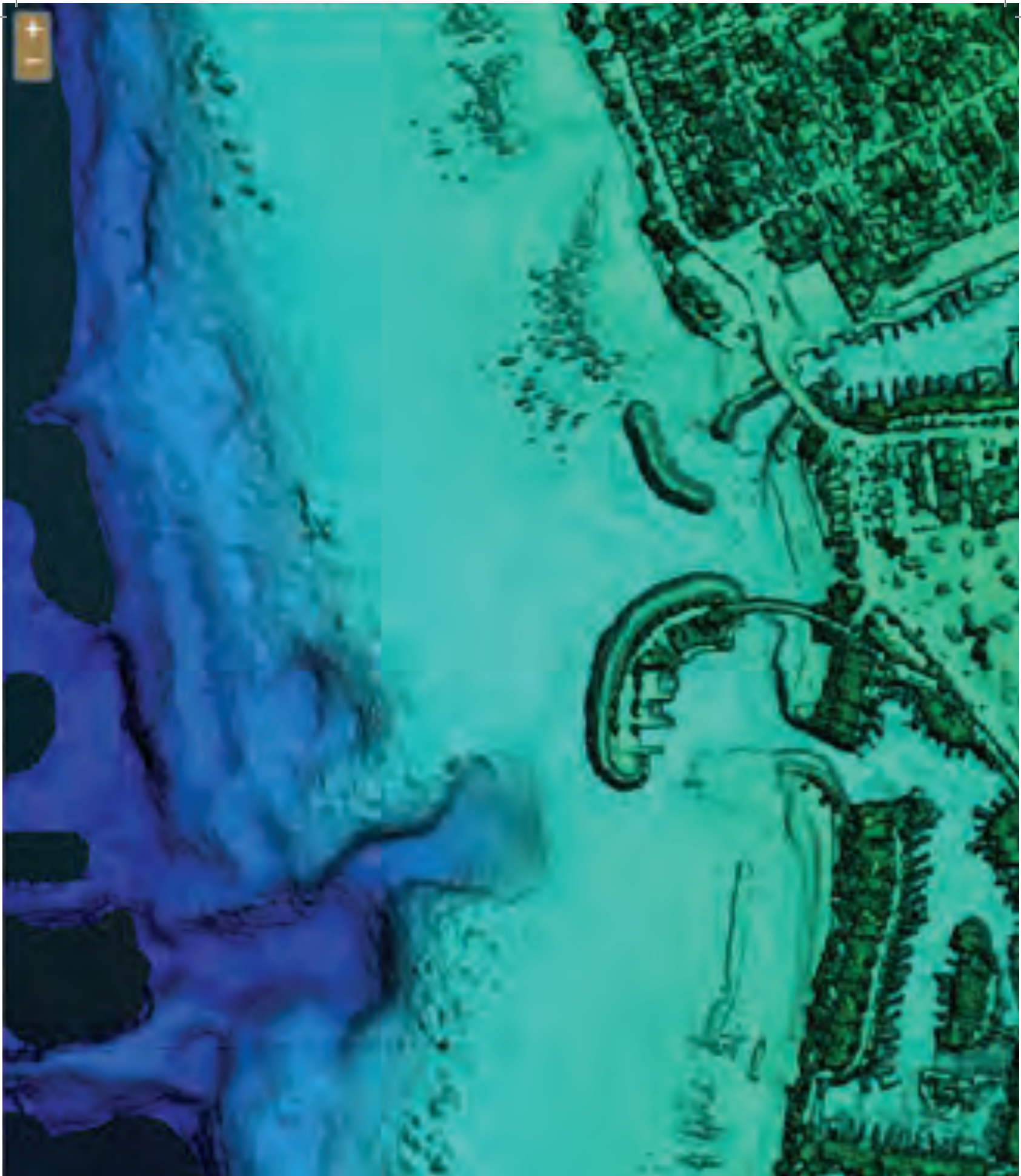
Aerial Photo of Accra Beach Hotel taken from LIDAR






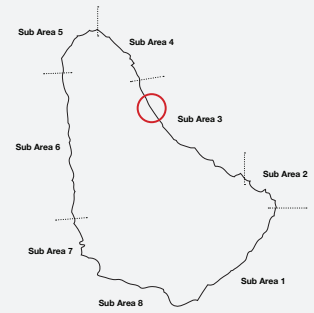
Aerial Photo of Hilton Barbados taken from LIDAR





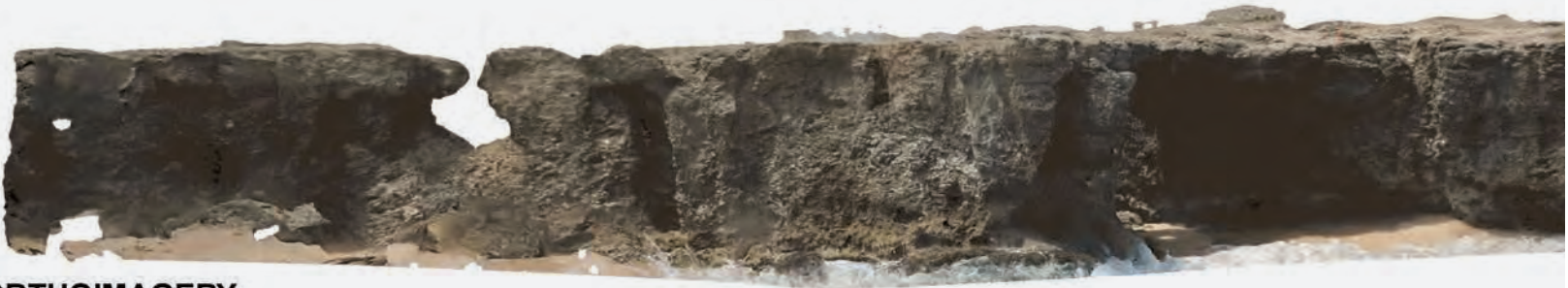
An aerial photograph of a coastal region, likely Port St. Charles and Port Ferdinand, with a Digital Surface Model (DSM) overlay. The DSM is color-coded by elevation, with a color gradient from dark blue (low elevation) to light blue (high elevation). The image shows a mix of urban development, including buildings and roads, and natural features like trees and water bodies. A prominent road or canal runs diagonally through the center of the image. The DSM overlay is semi-transparent, allowing the underlying aerial imagery to be visible. A small yellow rectangular marker is positioned on the left side of the image, near the center vertically.

Digital Surface model of the Port St. Charles,
Port Ferdinand area of the west coast. It is coloured
according to elevation



GEOTECHNICAL SURVEY

Investigations



ORTHOIMAGERY

Geotechnical Surveys and Investigations study (GSI) were done to examine the coastal zone and define the geological characteristics that pose concern for building development and long-term stability around the shorelines. The goal was to provide CZMU with mapping outlining:

1. Cliff and Bluff Instability Zones for the coastline, outside of the Scotland District, subdividing these zones with respect to appropriate building and access set-back guideline widths, measured from shore-line or cliff-line, depending on geologic and morphological shoreline conditions; and,
2. Land Slippage Hazard Zones within the Scotland District, delineating different hazards, levels of instability and risks within the coastal planning area, and subdividing these zones for appropriate building guidelines for future development.

Outcomes

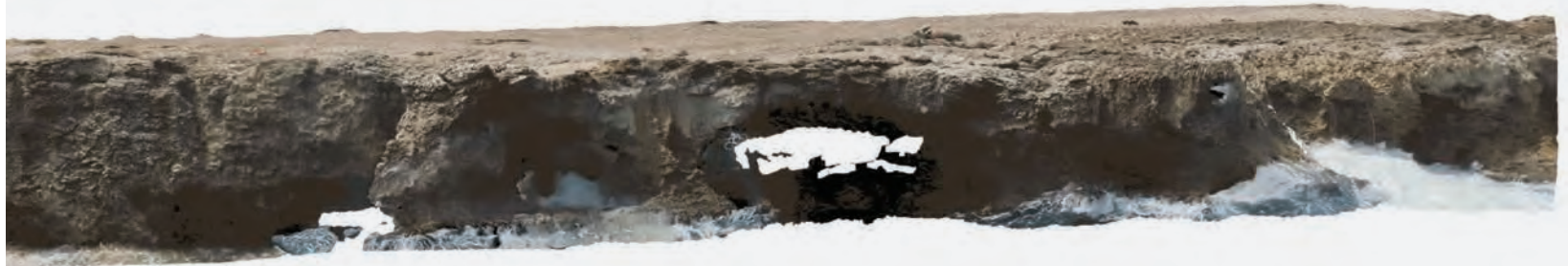
Geotechnical surveys were performed to map and classify cliffs around Barbados

- The surveys accurately mapped cliff instability zones around Barbados, and provided exact positions of land slippage hazard areas within the Scotland District

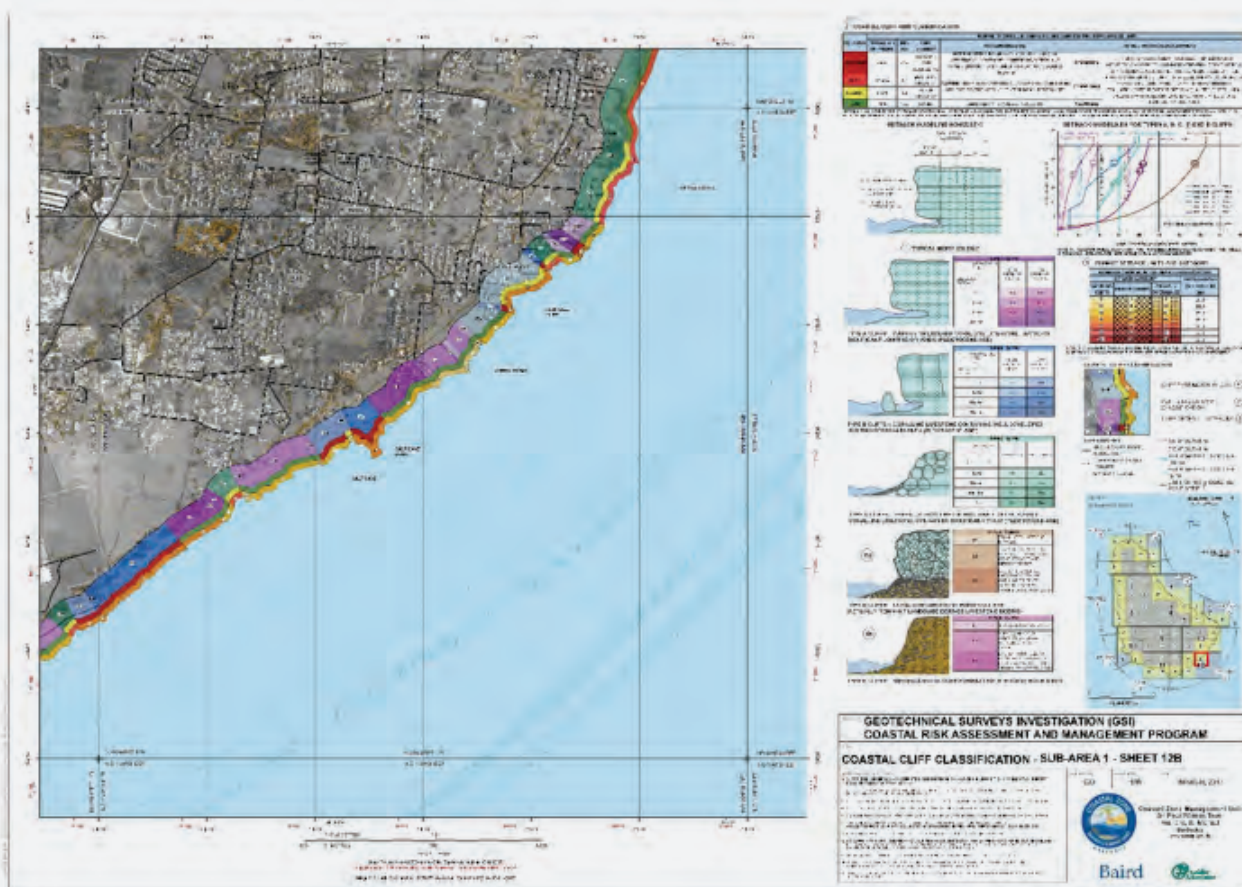
What this means

The findings have important implications for land use and development

1. They are significant for how development applications are made, assessed and approved, and for existing developments near or on cliffs

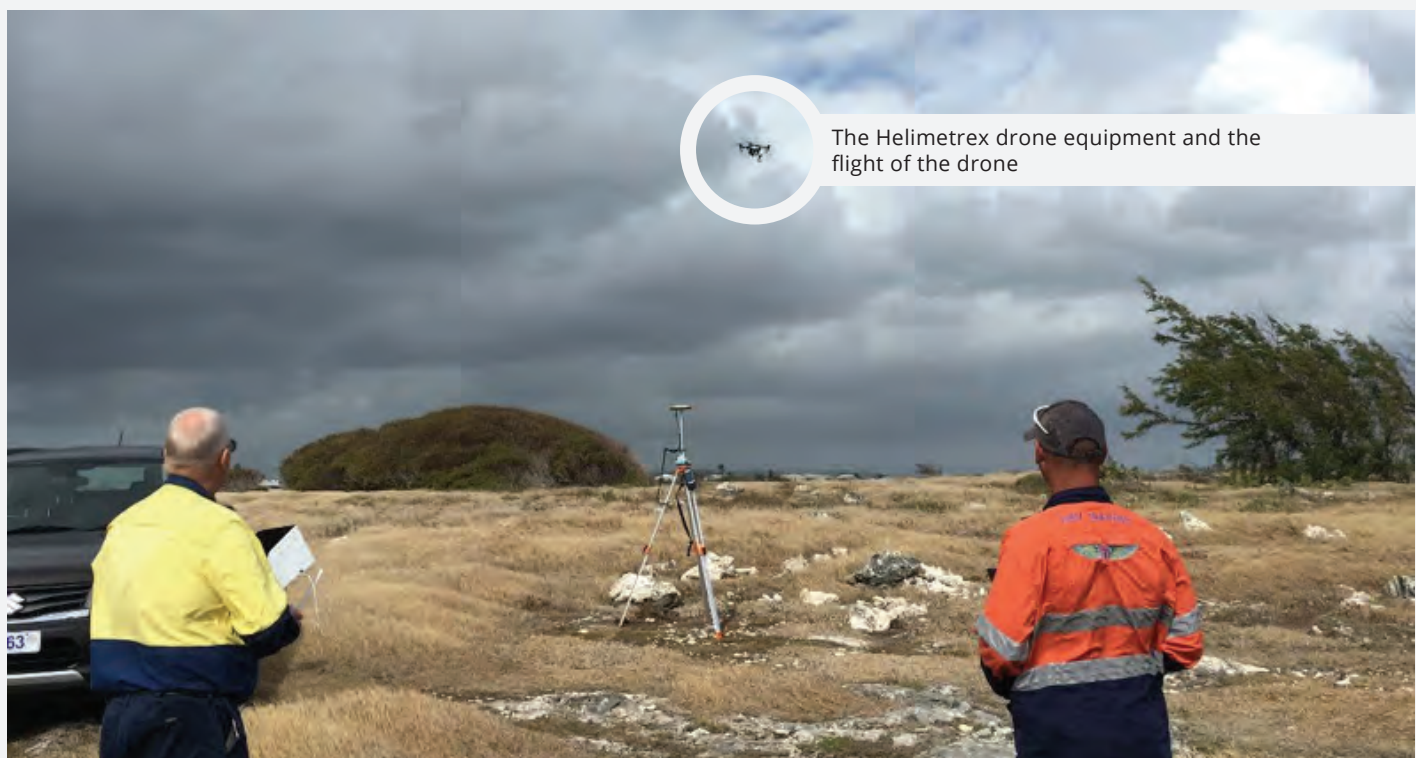


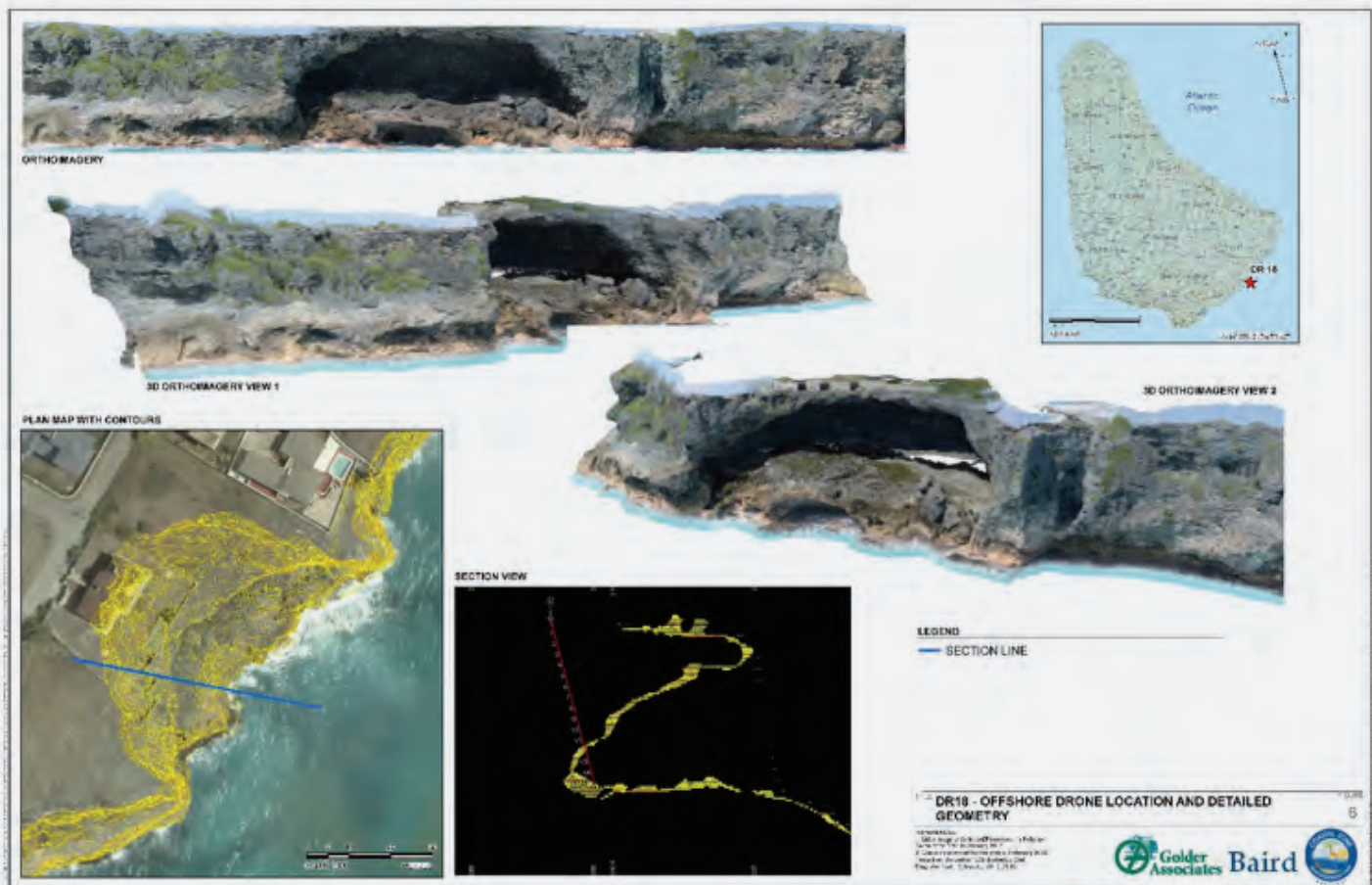
- They classified cliffs along the shoreline of Barbados as different types of cliffs react differently to wave impact
 - Drones were used to identify and measure undercuts (erosion at the base of cliff that creates a void) along the coastline
 - In the Scotland District drilling was done to look for the soil profile to identify small areas of sand and clay that could cause fractures and lead to land slippage during intense rainfall.
2. The slope stability analysis and assessment for the Scotland District has led to production guidelines for existing and future development within the coastal strip (up to 150m inland) of the Scotland District. These guidelines are organised according to different risk classifications for the potential for landslip in certain areas
 3. The Generalized Coastal Slope Risk Classification is defined based on three (3) risk classes, described in terms of state of stability of the slopes in the particular area:
 - **Low risk** - generally stable
 - **Medium risk** - marginally unstable (long-term creep movement likely to occur)
 - **High risk** - generally unstable



Foul Bay to Gemswick -

The intended purpose of this map is to provide a summary of cliff conditions at the particular site with zones of low, medium, high and very high risk. The three coloured strips included show: (1) Cliff Type; (2) Risk Class and; (3) Setback Category.





Drone detailed Geometry: – Ocean City, St. Philip.

Due to the high irregular geometry of the cliff faces and since most were generally inaccessible, high resolution, digital photogrammetric techniques to image selected cliff areas were used to generate high precision, georeferenced, 3D point cloud models from which detailed topography, contouring, three-dimensional surface models were generated.

NEARSHORE WAVE STUDY

This Buoy measures both directional waves and a 3D water column profile of ocean currents in real time. The buoy has been modified to allow the integration of a current profiler in a downward facing configuration.

Did you KNOW?
Studies like this make Barbados better prepared to protect against extreme weather events.

The Nearshore Wave Study (NWS) defined the wave climate around Barbados based on measured data, numerical modelling of wave conditions and climate change scenarios. The study involves a review of past data, collection of new data using ocean monitoring equipment, and development of a long-term data collection program as well as the development of a numerical model to produce wave climates for numerous locations around the island. The NWS will have implications for how coastal communities and businesses better prepare and respond to events such as serious storm surge resulting from tropical storms or hurricanes.

A nearshore wave study was conducted for Barbados

- The study gives an understanding of how the wave climate varies around the entire shoreline of Barbados
- There is now a better understanding of what to expect in terms of extreme/serious storm events



Outcomes:

The study yielded several important findings

- It better predicts how waves behave in the nearshore environment
- It has significantly increased the level of knowledge surrounding wave conditions in Barbados, both qualitative and quantitative
- In addition to the large volume of measured and hindcast data, the extent to which ocean currents affect wave conditions is now better understood. However, there is still a limited understanding of the current patterns at any given time, which impacts the ability to accurately predict waves at any point in time
- Three offshore buoys were installed off North Point, East Point, and Oistins. They provide continuous data on oceanographic conditions to the CZMU, with snapshots of wave conditions posted to the CZMU website every hour.
- Data can be used to help in the design of future coastal protection structures
- Training was done for CZMU staff in the use of wave data management software and wave buoy maintenance as well as the use of the wave model

What's next?

Several key actions involving CZMU will be taken.

- A rigorous forecasting system where information is inputted to understand what waves will be like several days in advance is to be developed. This has major benefits when it comes to disaster preparedness and early warning
- CZMU will create a series of maps/ graphs/plotted geographical locations to support legislation and protocols. They will also collaborate and engage with coastal communities. This will help with evacuation planning, preparation and procedures
- If mariners detect issues with the buoys while out at sea, they should contact CZMU

What should the public do?

The public is encouraged to take several steps to prepare for and mitigate storm surge


- Storm Surge, as a result of tropical storms and Hurricanes, pose a threat to Barbados' coastline
- Residents can move or use better building practices
- What else can they do? Pay attention to:
 - a. emergency officials
 - b. warnings
 - c. planning guidance
- They should also
 - a. have an evacuation plan
 - b. insure their property
 - c. clear drains
 - d. not litter!



† The S4A is an instrument for water current sensing, designed to directly measure the true magnitude and direction current motion in any water environment using two pairs of titanium electrodes located symmetrically on the equator of the sensor



⌚ This buoy measures both directional waves and a 3D water column profile of ocean currents in real time. The buoy has been modified to allow the integration of a current profiler in a downward facing configuration



The AXYS 3 metre buoy is a very capable and rugged metocean platform that can be configured with a wide range of sensors for monitoring meteorological, oceanographic and water quality parameters. The 3 metre buoy's long term operational life and its substantial reserve capacity make it an excellent offshore metocean platform. This buoy has been installed off the south coast of Barbados



SHORELINE CHANGE STUDY

Did you KNOW?
**10% of our coastline is
eroding**

This study looked at the entire shoreline of Barbados to determine the state of its beaches; which beaches were eroding, growing or stable.

A major finding was that almost 10% of our coastline is eroding and only 2% of it is growing through the depositing of sand. Also most of this erosion has occurred in the area between Sandy Lane, St. James and the cement plant in St Lucy. This makes homes, businesses and infrastructure along this stretch more susceptible to the impacts of climate change. Strategies to address coastal erosion have been identified.

The results of this study were then useful for the Eco-system Based Assessment (EBA) pilot project as well as to give the Government of Barbados, a more targeted approach to coastal infrastructure works and identifying which areas of the coastline need shoreline protection.

The Shoreline Change Study was conducted to map historical shoreline positions along the coast of Barbados

- The study examined the evolution of beaches from the 1950s until the present day and surveyed the techniques currently being employed
- The study sought to measure and quantify long-term erosion and depositing (accretion) of sand along the beaches
- It shows how Barbados' shoreline has evolved due to man-made interventions and natural processes
- Man-made interventions have negatively impacted the coast more
- The study helped to identify the priority areas where mitigation is needed
- Specific features with a long-term history of coastal erosion were identified. As a result, this was the criteria for pinpointing sites for transplantation of corals

Outcomes

The Shoreline Change Study has made significant findings and identified several mitigation strategies

- Almost 10% (8%) of our coastline is eroding and only 2% of it is growing through the depositing of sand
- Most coastal erosion has occurred in the area between Sandy Lane, St. James and the Arawak Cement Plant

in St Lucy. This makes the area more susceptible to the impacts of climate change

- The study found that the expansion of the Barbados Port Inc. port and in the area of the carenage reduced the amount of sand coming from Carlisle Bay along the west coast
- The study highlights the importance of setback, or building restriction, policies for coastal development due to the changing nature of the island's shoreline
- The CZMU has seen success in its coastal erosion mitigation efforts

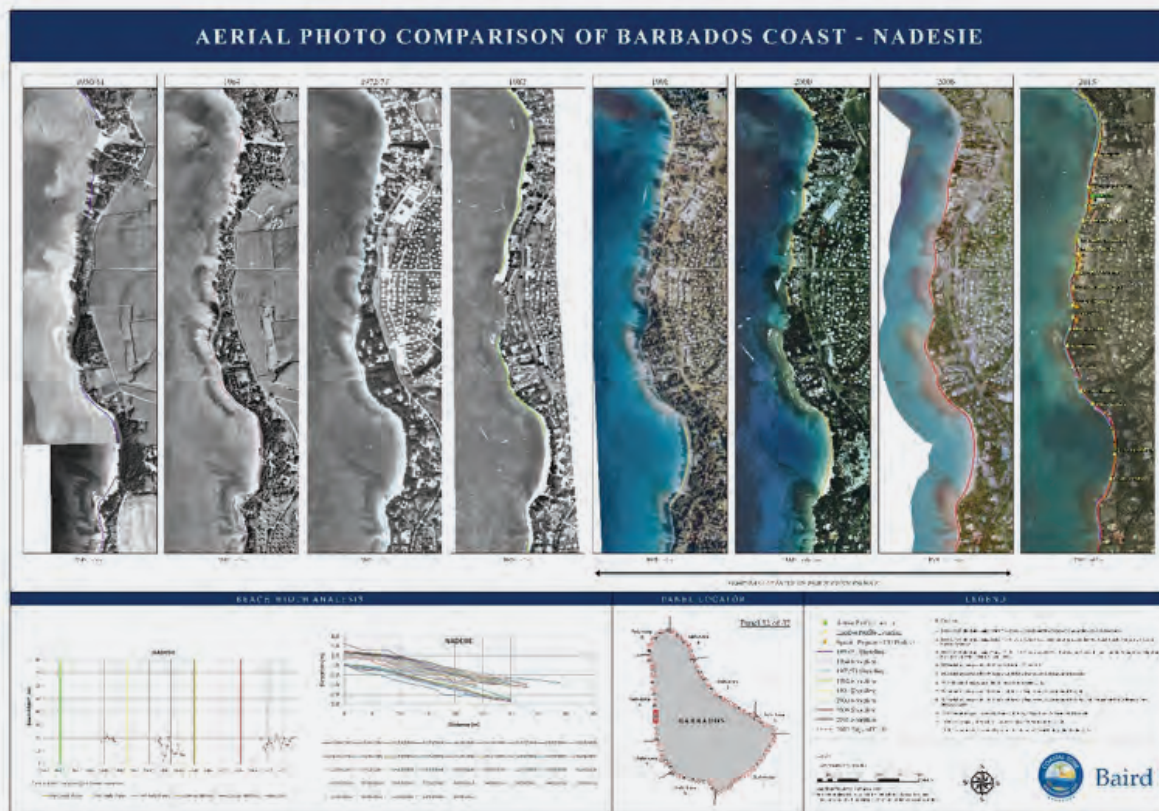
What this means

A responsible and holistic approach to mitigating erosion is needed

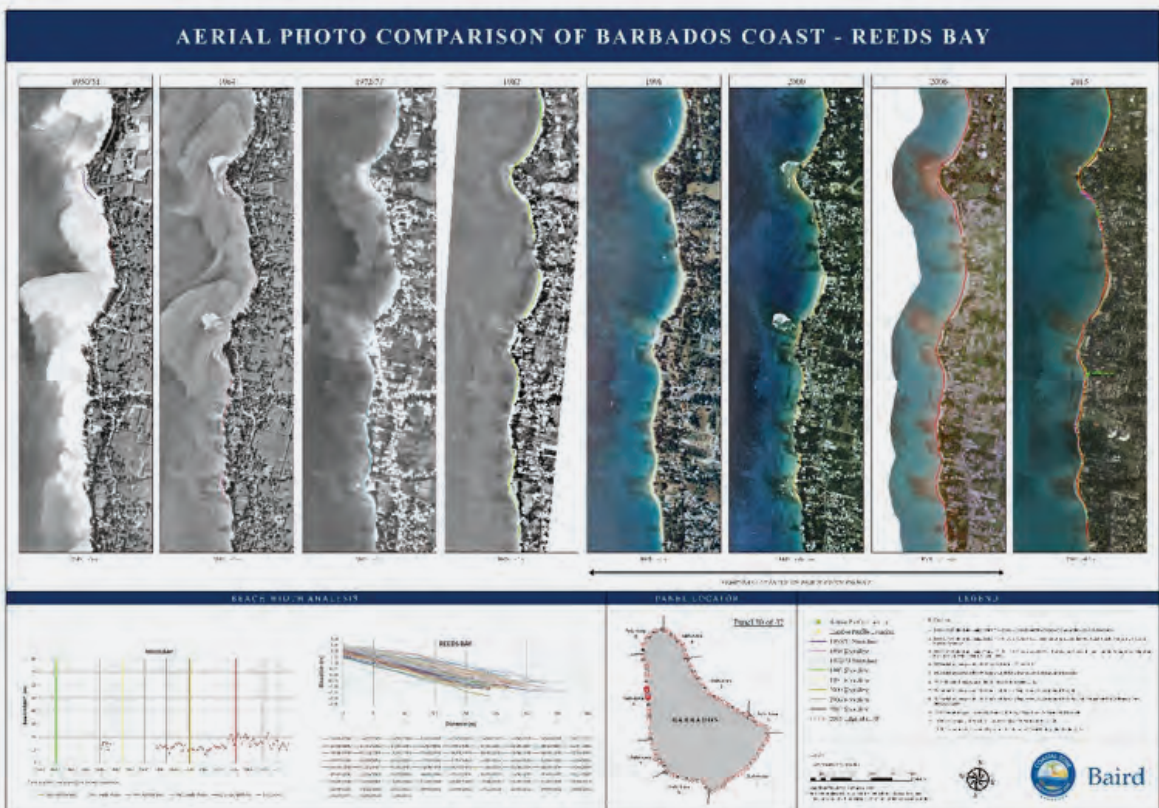
- The areas north and south of the Barbados Port Inc. in Bridgetown were the only areas of the coast where sand was deposited by natural or man-made means. This augurs well for improved resilience to the impact of climate change in this area



IS GROWING THROUGH
THE DEPOSITING OF SAND



Aerial photo comparison for the coastline between Sandy Lane and Holetown showing the changes in the coastal environment from the 1950s to 2015



Aerial photo comparison for the coastline between The Garden and Gibbes Beach showing the changes in the coastal environment from the 1950s to 2015.



SEDIMENT TRANSPORT STUDY

Did you KNOW?
**Sea level rise is negatively impacting
beaches on the southwest and west coasts.**

The main objective of the Sediment Transport Study (STS) was to develop a model that predicts future beach changes by determining the balance between supply and loss of sediment for individual beaches under future sea level rise (SLR) scenarios.

This model will serve as a management tool for the CZMU to understand trends and risks, highlight key future issues/challenges, and support beach management actions over a planning horizon of 50 to 100 years.

It was found that sea level rise could negatively impact some of our beaches on the southwest and west coasts of Barbados making them narrower and steeper (coastal squeeze). The good news is that Long Beach Main and Bottom Bay are not significantly affected by **¹coastal squeeze**. They are backed by natural vegetation. This gives them the flexibility to naturally migrate landward and accommodate the rising sea level.

¹*Coast.al Squeeze - Coastal habitat loss due to sea level rise.*

The Sediment Transport Study was conducted to improve understanding of the production of sand and movement trends around the coastline. It:

- makes coastal erosion risk factors easier to quantify and manage
- sought to enhance understanding of coastal sediment transport processes to quantify coastal erosion risk and risk factors
- involved the collection and analysis of sand samples at 26 beaches to reveal grain size constituents and possible sediment sources. The study also produced sediment budget models.

Outcomes

Findings are being used for ¹beach nourishment and other mitigation practices

- Findings are being used for ¹**beach nourishment** to ensure that a similar type of sand is used on the coastline
- 85% of south coast sand comes from the southeast. This is critical to managing Carlisle Bay and other beaches on the south
- Sediment production on the southeast coast is instrumental in the resilience of the entire south coast as it provides most of its sand
- Therefore, the health of the reefs in this area should be maintained, ensuring development planned does not interrupt the flow of sand from the south east coast.

¹*Beach Nourishment - Process where sand lost through erosion is replaced from other sources.*

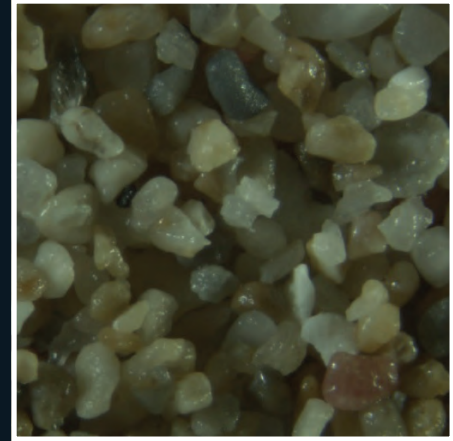




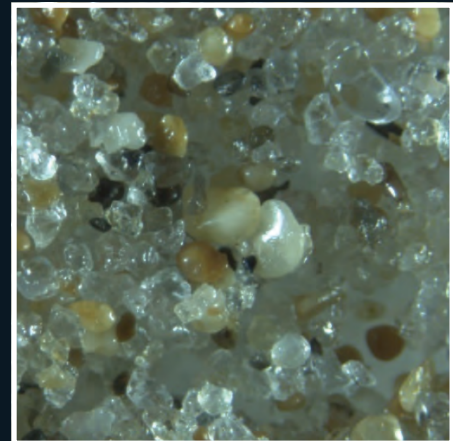
Beaches are being negatively impacted by Sea Level Rise

- Sea level rise may result in narrower and steeper beaches as the profile of the beaches adjust. Development in the beach further from shore may not allow for it to retreat and adjust and thus exacerbate erosion
- The results of sea level rise modelling demonstrate the need for maintaining 30m minimum development setbacks on sandy beaches
- Predictions by the model indicated that the most sensitive locations to sea level rise are those susceptible to coastal squeeze, where the beach is prevented from migrating landward during SLR by an existing hard barrier at the back of the beach
- Coastal squeeze makes the beach become narrower and steeper and lose its ability to preserve a reservoir of sand for temporary storm loss
- Beach overtopping or over-washing events would increase resulting in sand (and water) being washed across roads or properties behind the beach
- Beaches on the southwest and west coasts of Barbados are susceptible to coastal squeeze (e.g. Sandhurst Main, Drill Hall, the southern reach of Carlisle Bay, Fitts Village, Folkestone and Heywoods South) due to manmade structures along the densely populated shoreline
- Improvement of nearshore underwater habitat conditions along the southeast and west coasts (as well as the southwest coast) is therefore critical to the resiliency of beaches in Barbados
- The good news is that Long Beach Main and Bottom Bay are not significantly affected by coastal squeeze. Their being backed by natural vegetation gives them the flexibility to naturally migrate landward and accommodate the rising sea level.

Bulk sediment sample from Mother's Day Bay beach under a microscope showing the structure of the grains.



Bulk sediment sample from Bathsheba beach under a microscope showing the structure of the grains.



Bulk sediment sample from Carlisle Bay beach under a microscope showing the structure of the grains.



Diagram of grain size distribution for individual sediment samples taken from around the island






- A similar response is expected for beaches on the east coast that are not backed by manmade structures. Morgan Lewis Beach is one such an example since it is backed by large sand dunes that would allow landward migration of the beach.
- Vegetation, such as plants and trees, can help, in some degree, to mitigate coastal erosion so leave vegetation on the beaches
- The reef habitat is endangered by man-made waste products entering the marine environment and killing sea-life and their habitat
- Leave our sea and sand clean by properly disposing of your litter as the marine environment is endangered by improper garbage disposal

What should the public do? We can play our part to protect Barbados' beaches

- Understand that sand comes from coral reefs and becomes part of the beaches that we enjoy
- Beaches are eroded by storm surge, inappropriate coastal construction, and coral reef degradation
- You can help by not removing sand from the beaches, and by protecting coral reefs

A decorative illustration at the top of the page features a dynamic splash of water with numerous bubbles and droplets. To the right, a vertical test tube is shown, partially filled with a light blue liquid. The overall theme is water and science.

CIRCULATION & WATER QUALITY STUDY

Did you KNOW?

There is less than 20% coral cover around Barbados. Coral protects us from storm surge.

The study included island wide assessments but was focused on three sites: Holetown, Bridgetown (Carlisle Bay), and Consett Bay. The objectives of the study included: developing management tools and approaches that can be used by CZMU to examine coral health, identify key water quality stressors, and evaluate mitigation alternatives at the three study sites.

The study found that land-based practices such as using fertilisers in agriculture are the primary source of pollution to the marine environment in Barbados. Understanding these loads, their transport mechanisms, and the impact on marine water quality were key aspects of the Circulation and Water Quality Study (CWQS) Study.

It also found that there was less than 20% coral cover around the island and that it was reasonable to assume that this will decline further if these land-based nutrients are not significantly reduced. More deterioration in reef health will have detrimental impacts on ecosystem biodiversity, carbonate production rates, beach stability, local fisheries, tourism and public health.

- It's clear we need to improve wastewater disposal and improve agricultural processes to reduce the impact of these land-based nutrients on our marine environment.

The Circulation and Water Quality Study included several types of assessment

- It sought to develop tools to identify marine water quality stressors, model pollutant dispersion processes and evaluate various potential water quality improvement strategies
- It included island wide assessments but was focused on three sites: Holetown, Bridgetown (Carlisle Bay), and Consett Bay.

Outcomes

There were several major findings from the study which have implications for coral and public health

- Nitrogen / nitrates in wastewater and groundwater (water beneath the earth's surface in the soil or in pores and crevices in rock) are negatively impacting the health of the coral reefs around the Island
- There was less than 20% coral cover around the island and it is reasonable to assume that this will decline further if these land-based nutrients are not significantly reduced
- Further deterioration in reef health will have detrimental impacts on ecosystem biodiversity, carbonate production rates, beach stability, local fisheries, tourism and public health
- Reefs provide protection from waves and supply sand to the beaches. While climate change is a global issue, nearshore pollution from land-based inputs is a local concern that

Eliminate suck wells and implement advanced sewage treatment systems

has been identified as a key stressor impacting the health of the coral reef system. Only 2% of the beaches are accreting (or growing)

- Agricultural practices and residential wastewater disposal (including hotels) were identified as a significant source of nutrient contamination in surface water and groundwater
- The study has calibrated and validated local circulation and water quality models for Barbados which are linked to a regional circulation model operated by the National Oceanic and Atmospheric Administration
- The study showed how far pollution at a certain location would spread. For example, if an entity wanted to set up an ethanol plant that would have certain pollutants, the findings indicate the extent of the potential impact
- The study gives its users the ability to look at development and make decisions based on impacts likely to occur based on contaminants
- Eliminate suck wells and implement advanced sewage treatment systems.

What this means

Measures must be taken to mitigate and address these issues

- Land-based nitrates, such as nitrogen fertilisers, and phosphates must be significantly reduced to lessen the impact on the decline of coral cover around the island.



- Improved processes in agriculture and in disposal of wastewater can have a positive impact on reducing nitrogen loads into the marine environment
- Nitrogen loads can be reduced by 60%, using a combination of improved agricultural and wastewater disposal practices. A single practice alone is not sufficient
- The findings strengthen the evidence for a ridge-to-reef, watershed approach to environmental management. This seeks to protect, demonstrate sustainable approaches, and provide better economic understanding of the links between river/wetland and coastal water ecosystems
- Clean-up scenarios at Holetown and Bridgetown focused on reducing residential wastewater and agricultural nitrogen loads in groundwater, diverting the Spring Garden Generating Station (SGGS) cooling water discharge further offshore, and retrofitting the Bridgetown Sewage Treatment Plant (STP) diffuser system
- At Consett Bay, the clean-up scenarios included the implementation of ¹**riparian** buffers around streams and the reduction of agricultural nitrogen entering the surface water. The approach taken in this study was to evaluate large scale clean-up scenarios of priority sources in order to understand the potential improvements under the most effective remedial solutions, regardless of cost
- A reduction in land-based pollution, in particular from sewage and agriculture practices, will improve marine water quality and encourage healthy marine growth and diversity of corals. This will result, eventually, in sustainable ²**carbonate sand** beaches

Taking care of the coral reef can reduce the impact of flooding and storm surge on the island's coast

What should the public and others do?

Stakeholders as well as members of the public can take specific actions to mitigate against damage to corals by taking personal responsibility for actions

- Greater coordination between CZMU, the Ministry of Agriculture, Barbados Water Authority and Environmental Protection Department on nearshore water quality initiatives is needed
- Residents, farmers, tourists, boat operators and fishermen can care for coral reefs by:
 - a. not polluting
 - b. not using /reducing nitrates in agriculture
 - c. not harvesting coral
 - d. not overfishing
 - e. avoiding damage to the reef with boat anchors
- Households and hotels are encouraged to increase their use of products with ingredients more likely to break down harmlessly in the environment, such as vinegar, lemon juice, or baking soda.

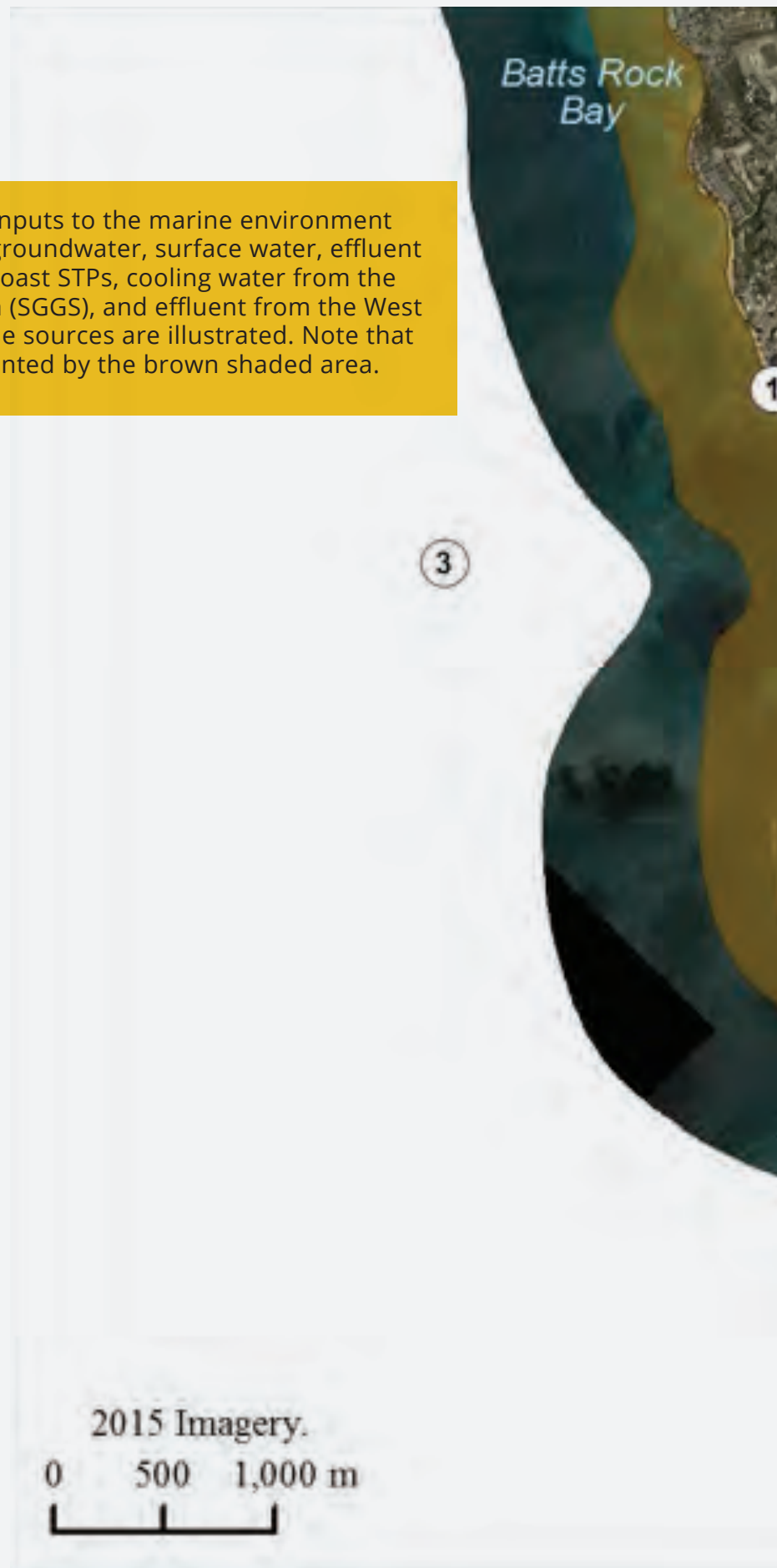
¹*Ri.par.ian* - Related to, or situated on, the banks of a river.

²*Car.bon.ate Sand* - Sand derived predominantly from carbonate materials such as corals, algae, mollusc shells.

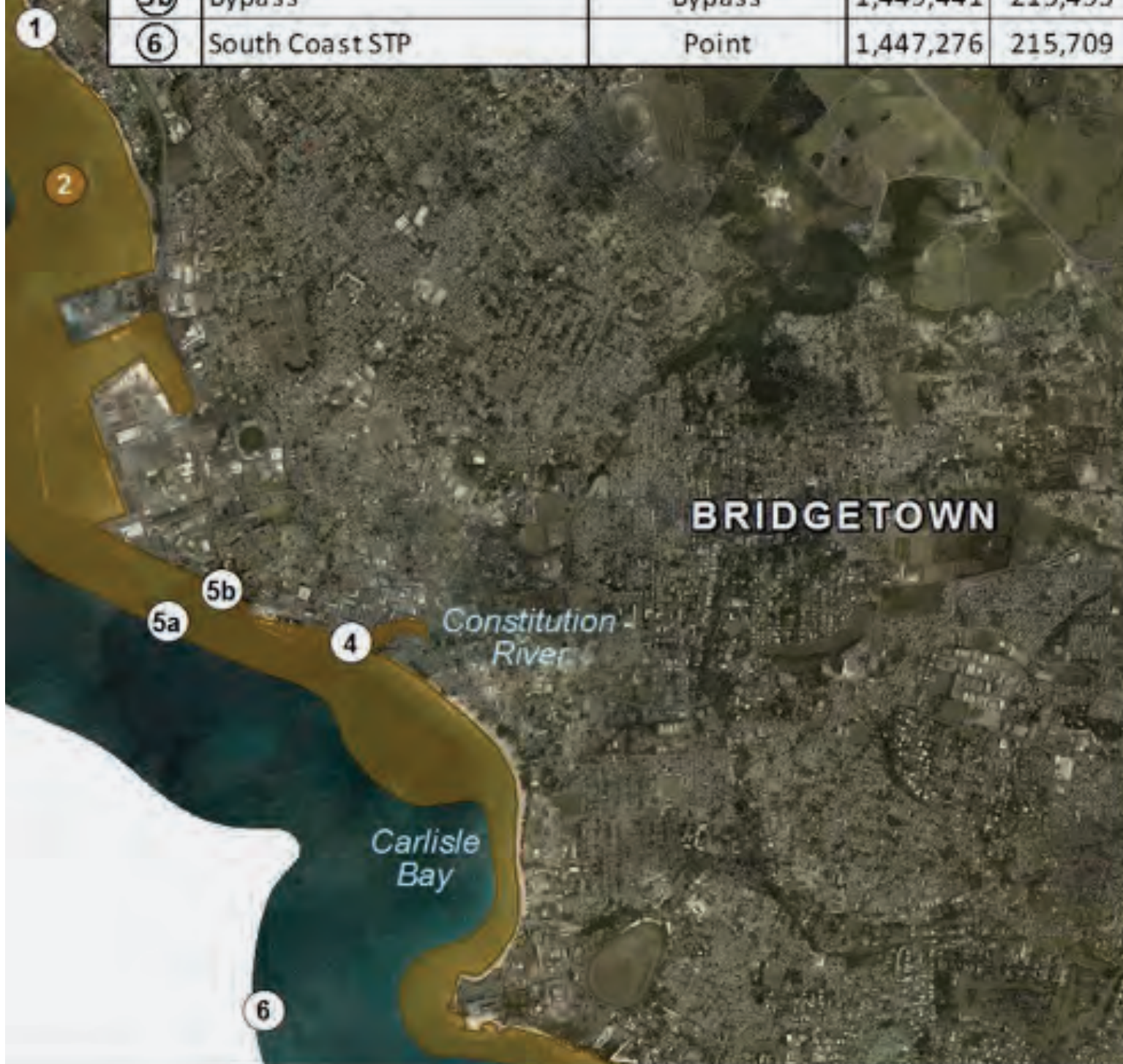


Photo Credit: Kiera Bloom @ BarbadosBlue

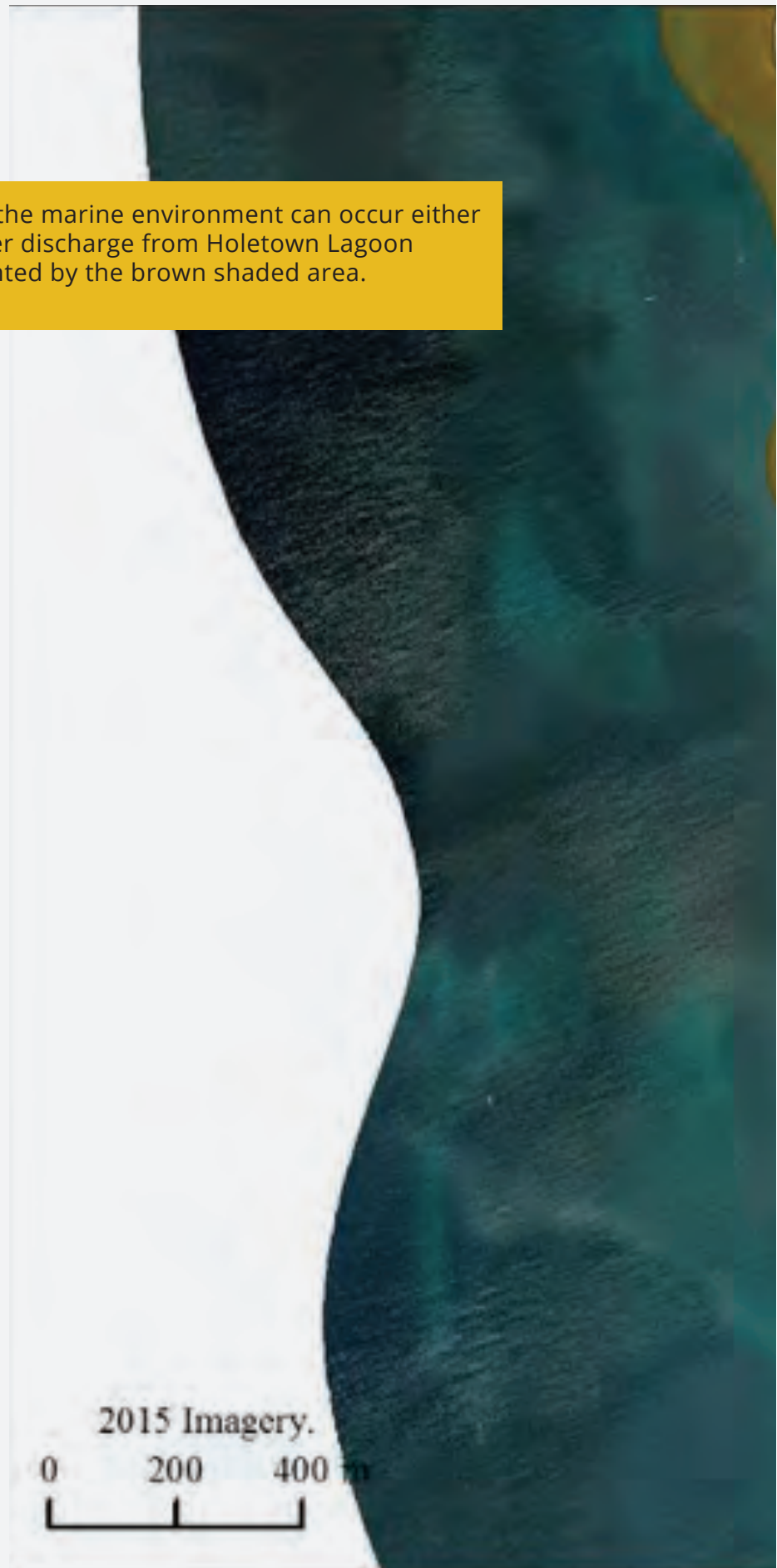
Potential terrestrial sources and inputs to the marine environment within the study area, including: groundwater, surface water, effluent from the Bridgetown and South Coast STPs, cooling water from the Spring Garden Generating Station (SGGS), and effluent from the West Indies Rum Distillery (WIRD). These sources are illustrated. Note that groundwater discharge is represented by the brown shaded area.



No.	Location	Discharge	Northing	Easting
①	Barbados Light & Power	Point	1,452,336	214,538
②	Pore Water Discharge			
③	WI Rum Distillery Discharge	Point	1,451,549	213,055
④	Careenage	River	1,449,169	216,155
⑤a	Bridgetown STP	Diffuser	1,449,278	215,215
⑤b	Bypass	Bypass	1,449,441	215,493
⑥	South Coast STP	Point	1,447,276	215,709

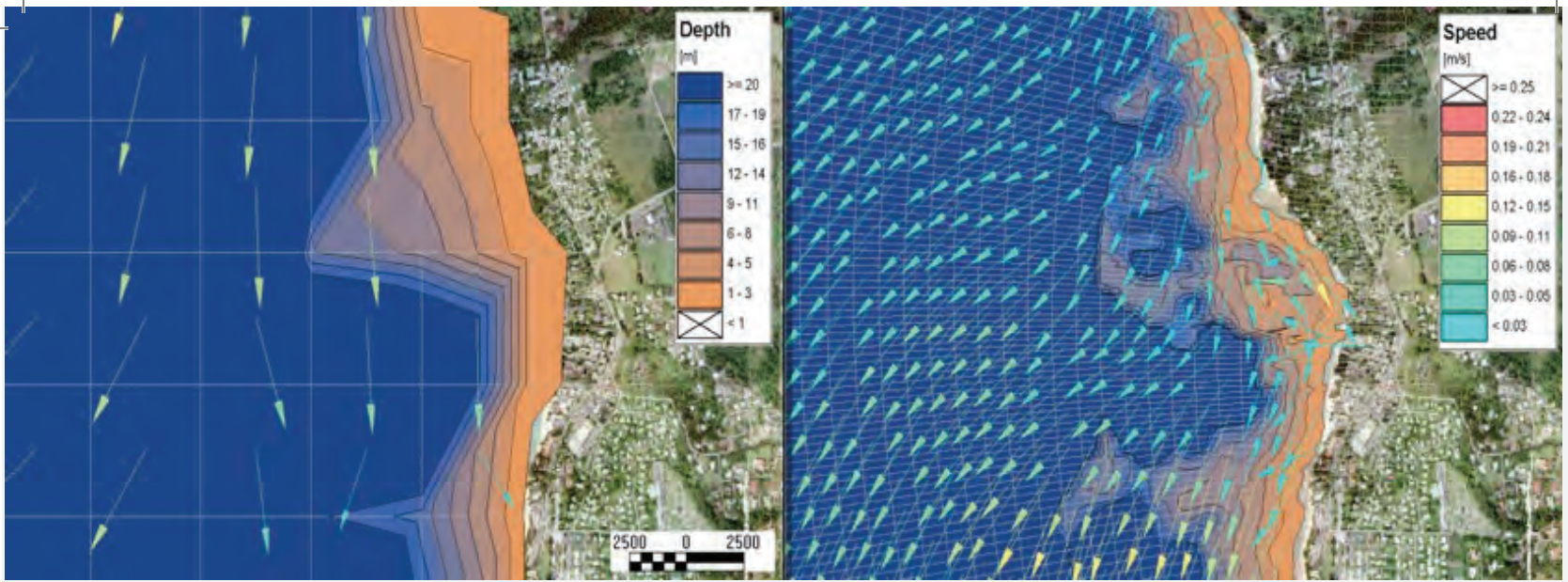


Potential terrestrial discharges to the marine environment can occur either as groundwater or as surface water discharge from Holetown Lagoon groundwater sources are represented by the brown shaded area.

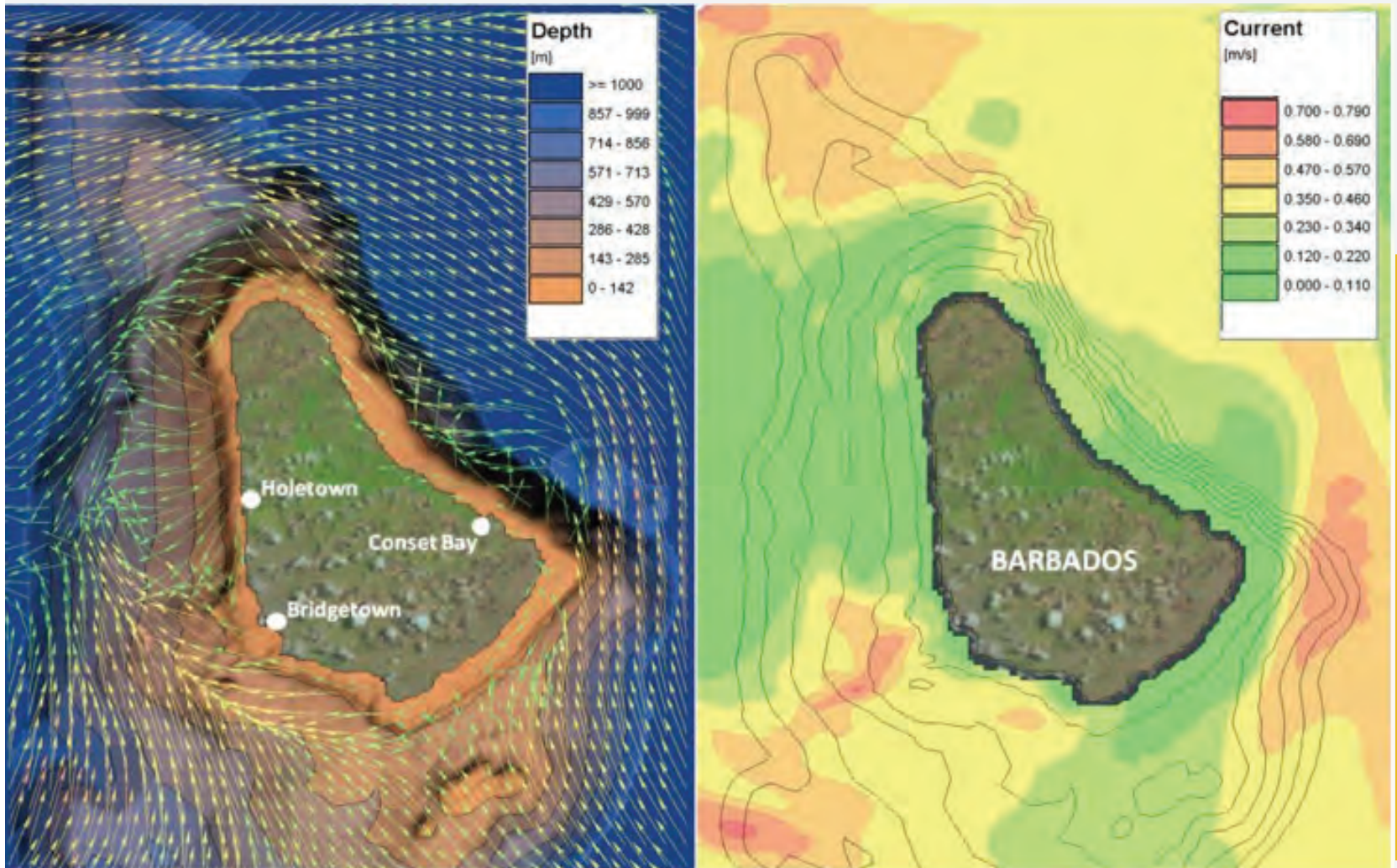


No.	Location	Discharge	Northing	Easting
①	Holetown Lagoon	Outlet & Fluidizer	1,459,381	214,071
②	Pore Water Discharge			





Comparison of predicted currents from the island-wide and local models at Holetown. Predicted current conditions (scatter plots) generated by the local models as complex bathymetric and shoreline features are resolved through higher resolution grids.



Illustrates the current vectors and magnitudes typically observed island-wide during dominant north-westerly flow fed by both the North Equatorial Current and the seasonally driven Guyana Current. The shape and bathymetry of Barbados significantly influences local current patterns.

DESINVENTAR DATABASE



DesInventar is a methodology for recording historical disaster information at sub-national scales. The term is also used to describe an online database of the disaster information which can be queried for statistics on the frequency and effects of different types of local-scale disasters (fires, floods, high winds, etc.) For Barbados, the database uses information collated from daily newspaper articles from 1980 to 2017 which describe the impacts of disasters at the local level and aggregated to the parish level. The database for Barbados is available online at:

<https://online.desinventar.org/desinventar/#BRB-20150303200848>

ECOSYSTEM BASED ADAPTATION PILOT PROJECT



Did you KNOW?
Agricultural fertilisers & human waste disposal are a main cause of pollution in our marine environment.



The Ecosystem Based Adaptation Pilot Project focused on the feasibility of coral reef restoration as an ecosystem-based adaptation approach to mitigate the impacts of climate change, such as sea level rise and accelerated beach erosion.

Based on the findings of the technical studies, the recommended approach for the coral nursery pilot project is to culture coral in an aquaculture laboratory, using artificial sea water (ASW) in a recirculating system (Baird, 2015a). Following consultations with the CZMU and stakeholders, it was agreed that this recommendation would be implemented by establishing the coral nursery in an existing laboratory at the Bellairs Research Institute of McGill University (Bellairs), known as the 'Bellairs wet lab'.

One of the main findings was that the island's marine environment has excess harmful nutrients from land-based sources, primarily fertilisers used in agriculture, and human waste disposal.

An ecosystem-based assessment sought to establish the feasibility of using coral reef restoration and rehabilitation to mitigate the effects of climate change

- Coral reefs around Barbados have different characteristics in different areas and therefore their management should not be the same
- The impact on water quality in the marine environment due to elevated nutrient levels are having a negative impact on coral reproductive health
- **'In situ'** water samples indicate that the island's marine environment has an excess of harmful nutrients from land-based sources, primarily fertilisers used in agriculture and human waste disposal

Outcomes

Coral reef restoration as a shoreline protection measure is a key response and needs to combine different approaches

- Coral reef restoration as a shoreline protection measure, is most effective when it combines the traditional use of man-made, engineered structures, with corals planted on the crest of the structures using approved methods.

Coral reef and marine health is also affected by issues such as sewage and pollution

What should stakeholders and the public do?

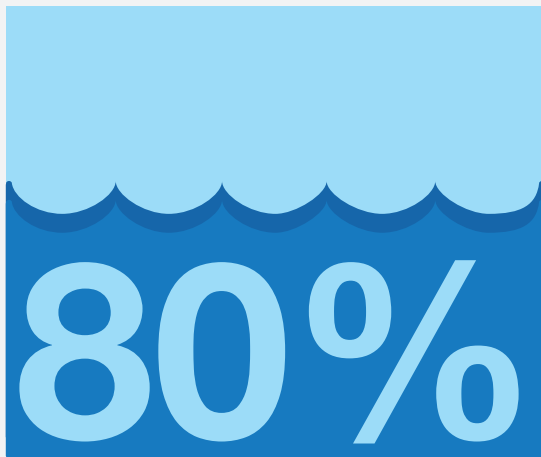
- Sewage contributes to land-based pollution which impacts the marine environment (Ridge to Reef impacts) so if you manage sewage, you'll better manage the marine environment
- Maintenance of the sewerage network is extremely important
- All beach users should ensure that anything they bring to the beach, they take it away. The only thing they should leave are footprints.

¹*In Si.tu - In its original place.*

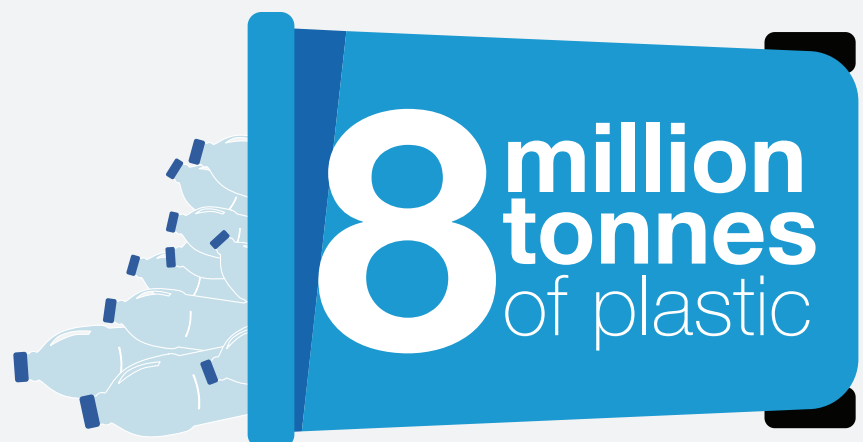
Some stats

Globally, plastic pollution is causing tremendous harm to our marine resources. For example:

- Plastic pollution costs the lives of 1 million seabirds and 100,000 marine mammals per year
- Fish eat plastic, and we eat the fish
- Plastic causes \$8 billion in damage to marine ecosystems each year



of all pollution in the ocean comes from people on land.



per year ends up in the ocean, wreaking havoc on wildlife, fisheries and tourism.

Locally

- In 2017 an underwater dive retrieved items such as snorkeling gear, hard plastic plates and cups, bottle caps as well as beverage bottles and other single-use items.



Information sourced from Loop News September 16, 2017:
<http://www.loopnewsbarbados.com/content/beach-cleanup-nets-over-800-lbs-garbage>

In 2016

4008

WAS COLLECTED ON A FEW OF BARBADOS' BEACHES

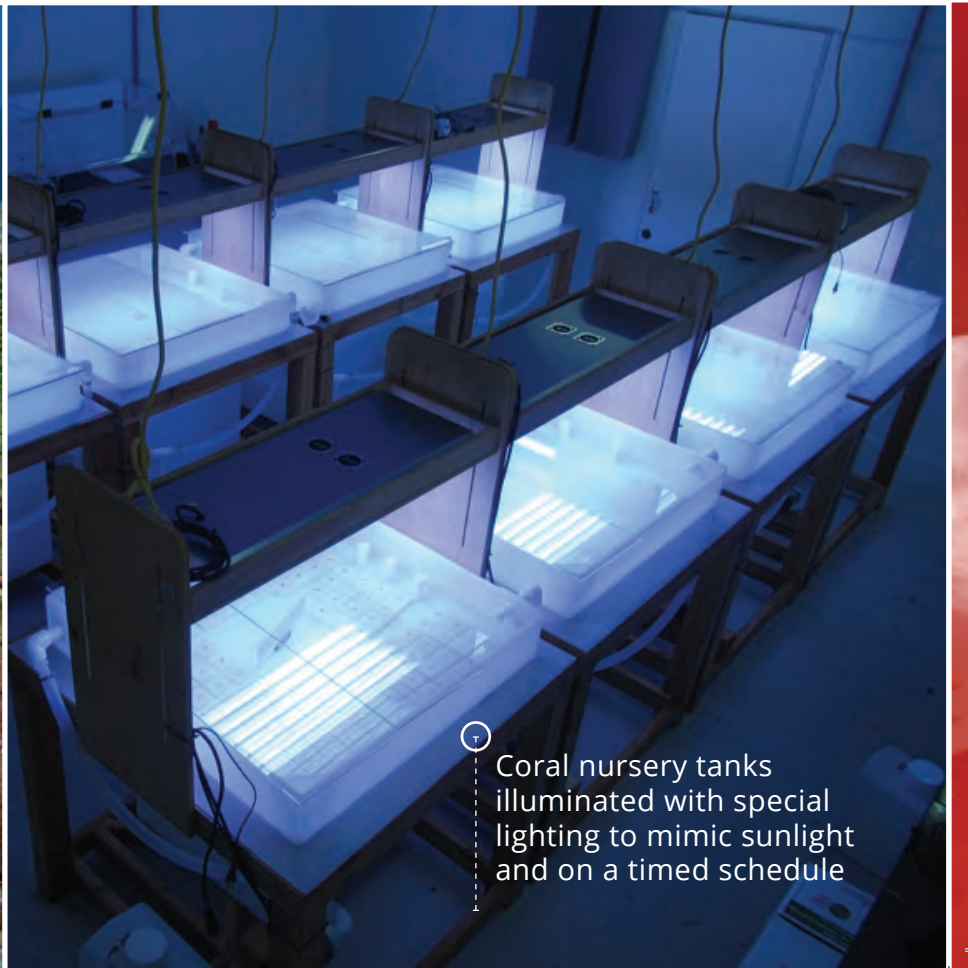




At donor sites, suitable coral colonies from one of 4 species were removed from the seabed by professional divers using a hammer and chisel




Dislodged coral colonies from donor sites were handled very carefully to reduce the stress on the living coral organisms



Coral nursery tanks illuminated with special lighting to mimic sunlight and on a timed schedule

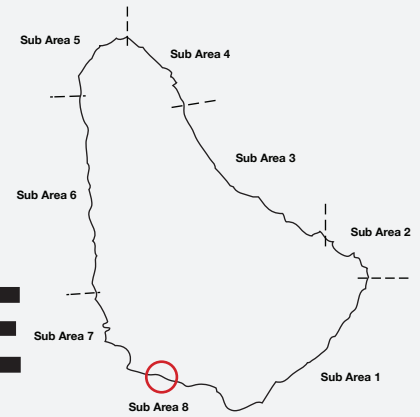


Donor colonies were carefully checked for signs of sponge infestation before they were removed from the marine environment



Several donor coral colonies in a cooler being transported to the coral lab by boat

ST. LAWRENCE GAP TO ROCKLEY BEACH (SLGRB)



Did you KNOW?
This project will create a continuous beach walkway!

Final designs for the walkway from St. Lawrence Gap to Rockley Beach were developed based on direction from the CZMU, as part of the CRMP.

The goals of the study are to create a continuous walkway along the project site, while improving public access and providing shoreline protection that will mitigate future climate change influences. The design follows significant data collection and analysis from the baseline studies of the CRMP, including the Coastal Zone LiDAR Study, the Nearshore Wave Study, the Sediment Transport Study and the Shoreline Change Study.

The design consists primarily of a back of beach walkway with the amount of ¹**armouring** dependent primarily on wave exposure. This results in more heavily armoured sections around headlands and reduced levels of armouring as the wave exposure drops. Where possible, the walkway is landward of the beach, such as along much of Rockley Beach.

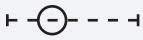
¹*Ar.mour.ing* - Using physical structures to protect shorelines from erosion.



Partial view of proposed boardwalk east of Rockley Beach



Proposed walkway alignment near Rockley carpark



Stakeholder Support is crucial

One of the primary remaining design challenges relates to stakeholder concerns and property definition along the beaches. Some of the smaller properties (compared to the hotels) have concerns over privacy, and some stakeholders have voiced opposition.

In contrast, the general public has been very receptive to the project, rate it very highly, and are generally in support of this proposed walkway extension. The Barbados Hotel and Tourism Authority (BHTA) is strongly in favour of this development and views it as important to the economic success of the South West coast

tourism-related businesses. Therefore, the largest of the hotels and businesses have generally indicated their intention to cooperate, although some local property owners may be less cooperative.

At this point, there is no formal agreement with any of the stakeholders. In some regions, agreements will need to be reached to allow access across private property.

For example, at Accra, much of the beach technically belongs to Accra so that a back of beach walkway would be on private land. Accra management have also indicated strong support for the project.

Aerial view of Rockley Beach concept





1B CACRABANK (LOOKING EAST)



3B CACRABANK (LOOKING WEST)



2B ROCKLEY BEACH & CACRABANK



4B ST. LAWRENCE (LOOKING WEST)



5B SANDY BEACH PIER



6B ST. LAWRENCE BAY



St Lawrence Gap to Rockley Beach overhead view of alternative conceptual designs 1



St Lawrence Gap to Rockley Beach overhead view of alternative conceptual designs 2

NCRIPP

The National Coastal Risk Information and Planning Platform

Did you KNOW?

We can now determine how different severities of hazards can impact people, buildings & infrastructure.

The National Coastal Risk Information and Planning Platform comprises evaluations and planning tools expected to lead to the development of hazard, vulnerability and risk maps for the coastal zone and inland areas for a range of hazards. They will also provide a web-based, geographic information system (GIS) platform for evaluating risk due to coastal hazards for use in development planning and disaster management. A Hazard Assessment, Vulnerability Assessment and Risk Assessment were undertaken.

Hazard Assessment

The Hazard Assessment of the Risk Evaluation looks at how different severities of hazards can impact infrastructure, buildings, and people across the island

- The hazards evaluated included: storm surge, hurricane winds, coastal erosion, earthquakes, tsunamis, landslides, rainfall-induced flooding and oil spills. Climate change factors were also considered

- Hazard maps are the outputs of the assessment. They show the areas impacted by different hazards at different levels of severity based on probability analysis.



Vulnerability Assessment

The Vulnerability Assessment determines how susceptible to damage assets can be when exposed to different types and severities of hazards

- The assessment outlines how susceptible different types of assets such as natural habitats, communities, environmental resources, infrastructure and essential services are to various types and strength of hazards. For instance, a road may be exposed to flooding and earthquakes but may only be susceptible to damage from earthquakes

Risk Assessment

The Risk Assessment places dollar values on losses of assets based on the severity of a given hazard.

- It allows cost estimates to repair or replace a building that was damaged by storm surge to a certain degree.

NCRIPP

The National Coastal Risk Information and Planning Platform involves the development of a web-based, shared knowledge software system.

- NCRIPP allows for analysis, planning and decision-making regarding risks resulting from the natural and man-made hazards evaluated under the comprehensive hazard risk evaluation.

The NCRIPP will help to confirm risk profiles (from island size to smaller local scales) related to hazard scenarios, potential impacts, and losses

- The system will also allow for cost-benefit analysis for mitigating potential losses

For the NCRIPP study, hazard severity is assessed based on an estimate of how frequently a hazard of a certain severity would be expected to occur (also known as a return period)

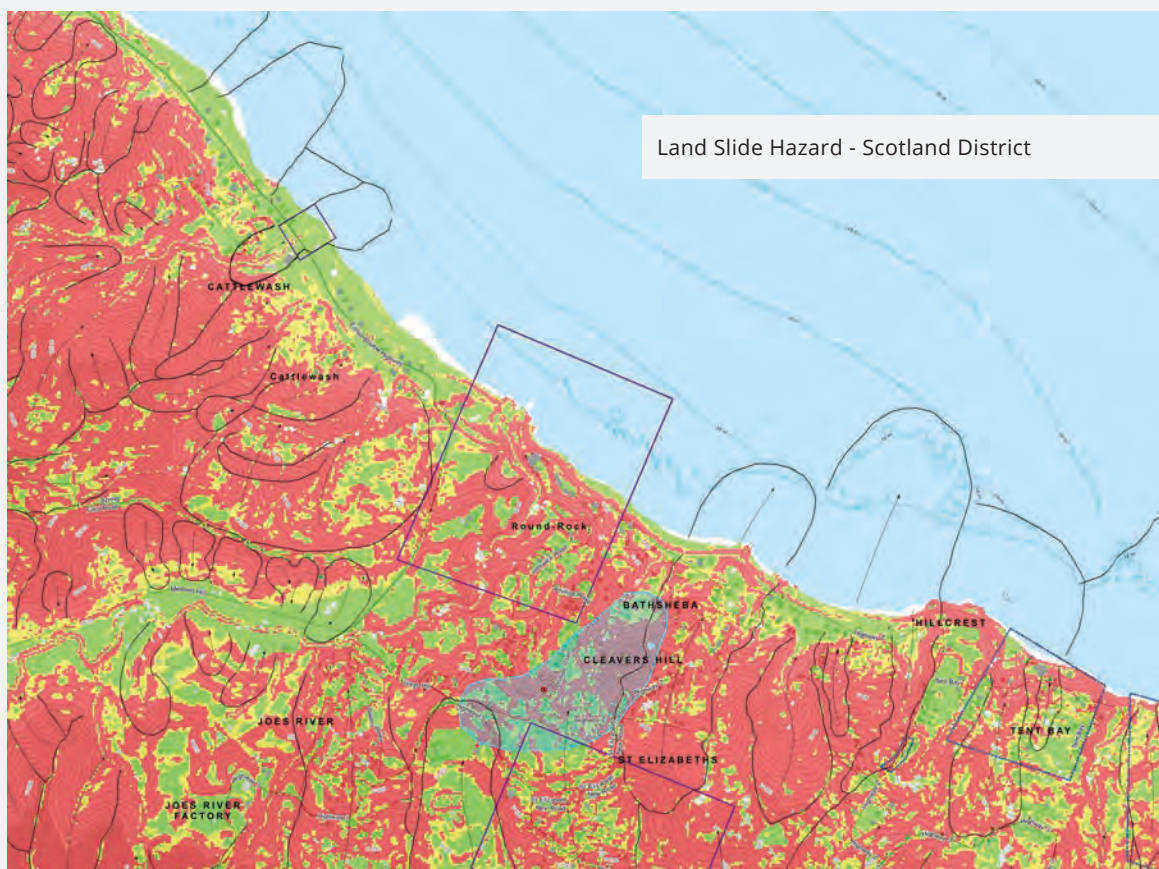
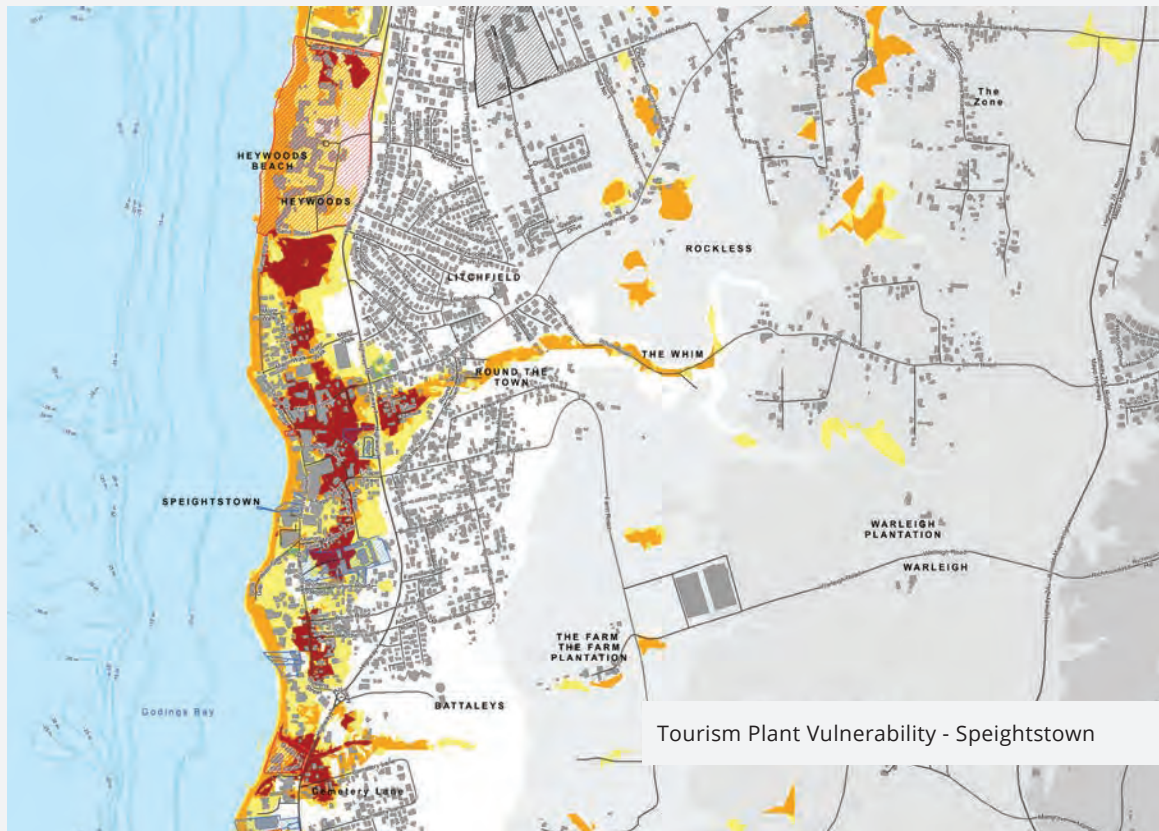
- For example, if over a 100 year period there were two floods of a certain intensity, then that level of flooding would be classified as a 1 in 50 year event
- This does not mean that a flood of this magnitude will happen every 50 years. It means that over a long time period, you'd expect a flood like this to happen with an average frequency of 50 years (or four times over 200 years)
- Another way of thinking about it is that in any given year there is a 1% chance or likelihood that a hazard event of a certain intensity could occur.



Commercial Building Risk | 100yr Storm Surge - Bridgetown



Beach Erosion Hazard. Welches - Oistins



WHAT'S NEXT ?

The Coastal Zone Management Unit is now poised to embark on a new and exciting strategic direction by incorporating Disaster Risk Management (DRM) and Climate Change Adaptation (CCA) into our daily functions. This direction commenced with a suite of scientific studies of coastal processes and hazards such as coastal erosion, coastal inundation and cliff stability. This information is being harnessed in the National Coastal Risk Information and Planning Platform (NCRIPP) which is a cloud-based software which will be used as a decision making tool in order to quantify coastal risk.

Strengthening CZMU

The next step in this journey is to strengthen the policy, regulatory and institutional capacity of the Unit and its strategic partners in mainstreaming Disaster Risk Management and Climate Change Adaptation. This is being done through the implementation of Component 3 - Institutional Sustainability for Integrated Coastal Risk Management, which is a range of studies such as:

- Development of a Strategic Action Plan for DRM and CCA in the coastal zone
- Training of staff of the Unit, PET and strategic partners in DRM and CCA

Photo Credit: Kiera Bloom @ BarbadosBlue

- Cost recovery mechanisms
- Policy for information sharing
- Design of a communication strategy and action plan on coastal risk management
- Preparation of an operations manual for the Coastal Zone Management Unit

Directing investments along the coastline

The highlight of the Component is the upcoming update of the integrated coastal zone management amendment of the Coastal Zone Management Act and preparation of coastal zone management regulations consultancy. This activity is expected to utilise the risk, hazard and vulnerability assessments from the NCRIPP to produce a policy document which can be used by public agencies and the private sector to direct investments along the coastline.

This will be the first time that such a comprehensive Plan will be undertaken through the incorporation of risk into development planning, a major achievement for Barbados. The Coastal Zone Management Unit developed and operationalized coastal infrastructure projects across the island through various programmes:

- The Holetown Beach Improvements Project
- The Rockley to Coconut Court Waterfront Improvements Project
- The Welches Beach Improvement Project
- Holetown Waterfront Improvement Project (HWIP) from Holetown to Heron Bay

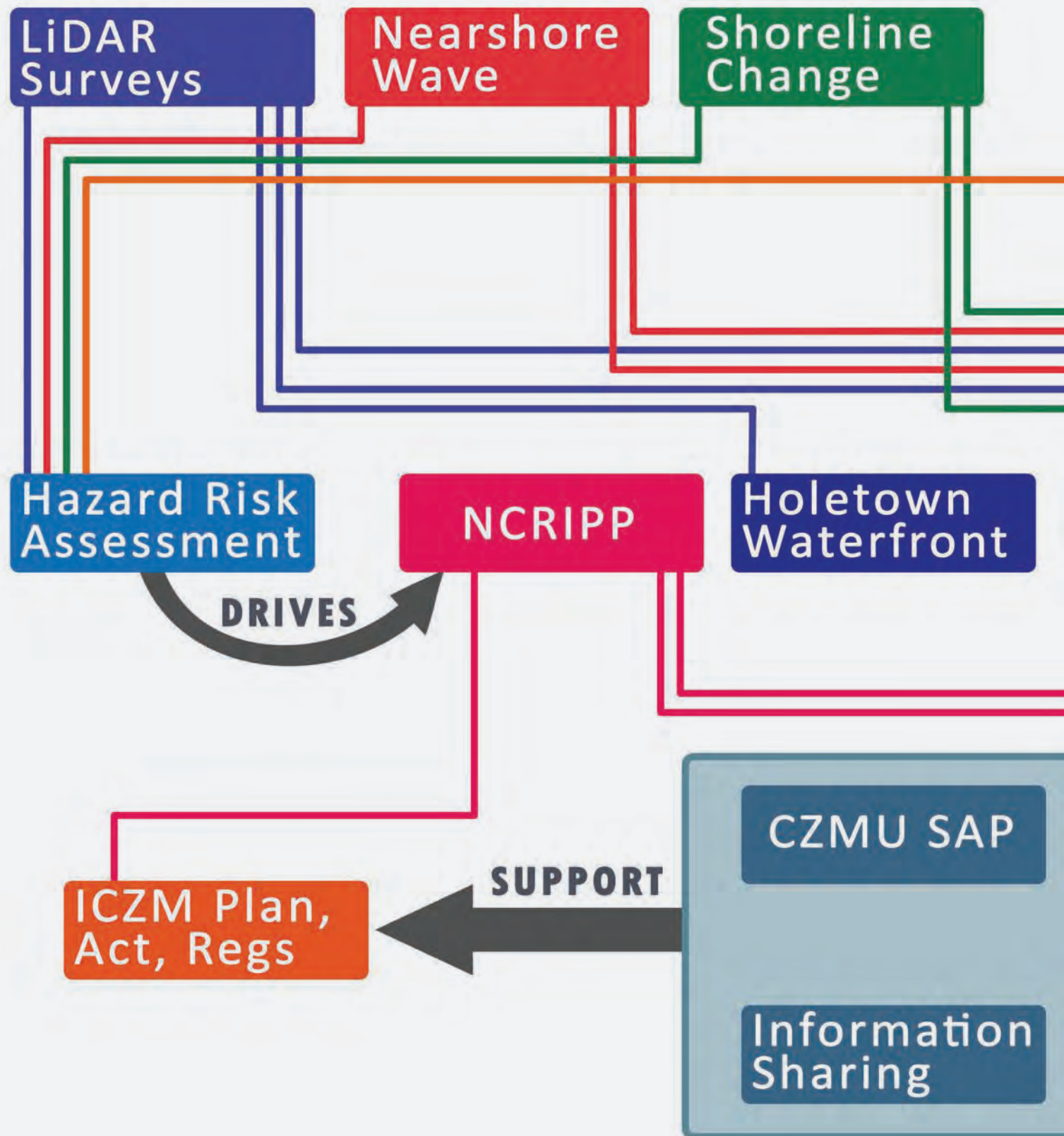
The objective of the engineering works was to ensure the stabilization of the shoreline, reduction in coastal erosion and improvement of public access to our coastal assets. The unit monitors the beaches across the island on a quarterly basis and additional sites have highlighted as being susceptibility to coastal hazards.

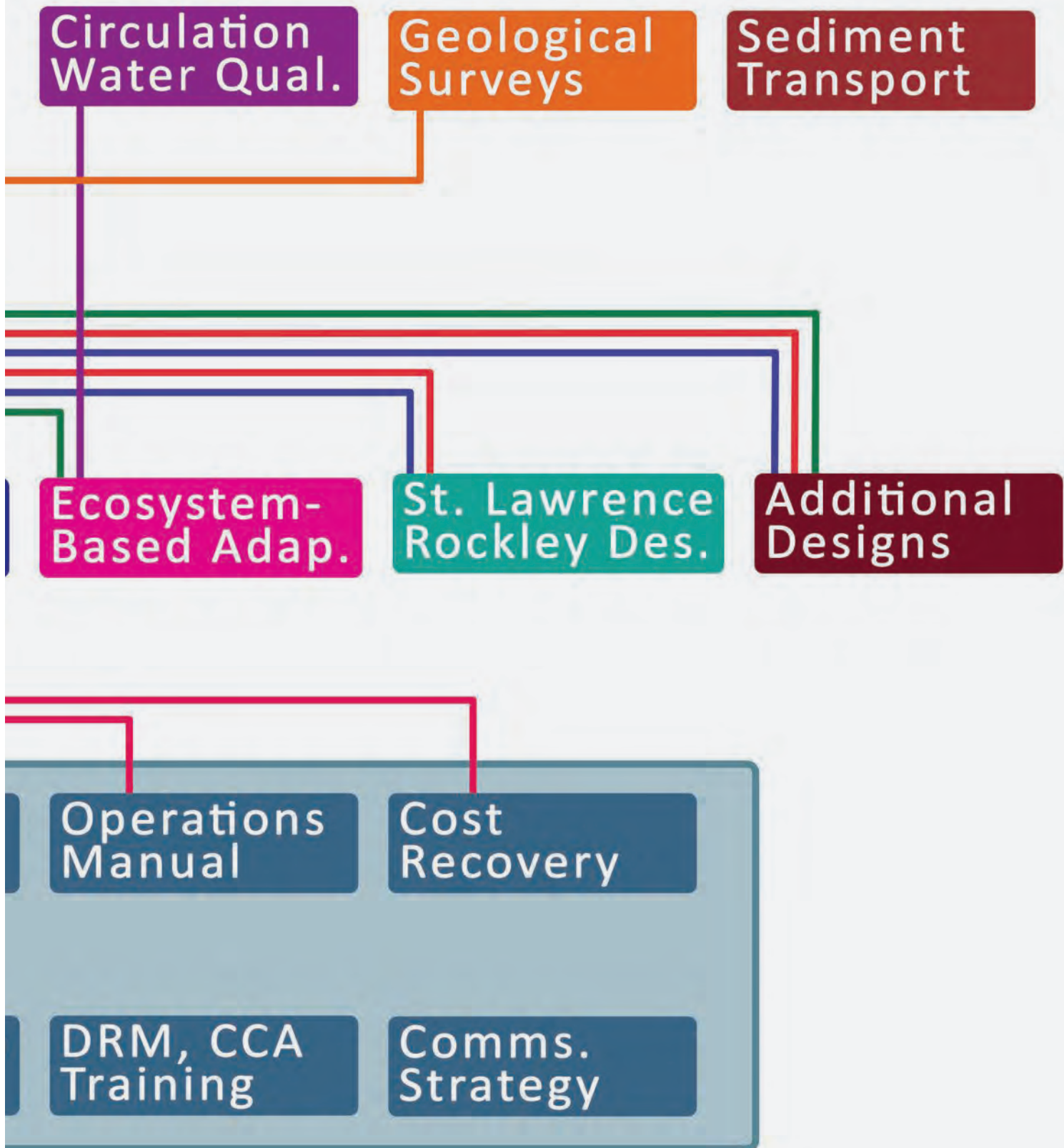
Through the Coastal Risk Assessment and Management Programme (CRMP) the CZMU has designed solutions to improve the waterfront for Rockley Beach to St. Lawrence Gap. We are developing engineering designs for more coastal areas in Barbados. The sites are:

- Clinketts, St. Lucy;
- Mullins to St. Peter's Bay, St. Peter;
- Sand Street, St. Peter; and
- Oistins Bay, Christ Church

The overall objectives of the designs at these four sites are to provide waterfront and drainage improvements, highway protection, shoreline stabilisation and enhancement along stretches of shoreline.

The next steps after the designing process are to construct the solutions designed during this programmes. Each site is unique and the solutions developed will incorporate a range of engineering solutions, with the product containing some of the features from previously constructed works.





A large white sailboat with a yellow hull is on a sandy beach. The sail is up, and the mast is visible. The text 'CREATING A' is in small blue capital letters, and 'SAFE, CLEAN, CLIMATE RESILIENT COAST' is in large blue capital letters. A yellow horizontal line is under the word 'COAST'.

CREATING A

SAFE, CLEAN, CLIMATE RESILIENT COAST



ALL HANDS ON DECK

As Barbados incorporates risk management solutions into Coastal Zone Management in a way that addresses current and future vulnerabilities, it's all hands on deck.

We have a collective vision. We have done much work. Yet more is needed to make our lives on this rock safe and sustainable.

What we need from....

Cabinet

- Going forward as part of the Coastal Risk Assessment and Management Programme (CRMP), CZMU is looking at updating the Coastal Zone Management Plan and Act as well as regulations. Once a draft is achieved, we wish Parliament to pass the policies and legislation to enable us to work more effectively.

Department of Emergency Management

- Coming out of the findings of the Nearshore Wave Study, the CZMU will be creating a set of maps and graphs to support legislation and

protocols. We will also collaborate and engage more closely with the Department of Emergency Management.

Ministry of Agriculture, Barbados Water Authority, & Environmental Protection Department

- In order to mitigate pollution to our marine environment, greater coordination is needed between CZMU, the Ministry of Agriculture, the Barbados Water Authority and the Environmental Protection Department.

Farmers, residents, tourists, boat operators and fishermen

- The wider population also has its role to play regarding caring for coral reefs. Farmers, residents, tourists, boat operators and fishermen should reduce the use of fertilisers with harmful chemicals such as nitrites, stop harvesting coral, not overfish, and not damage the coral reef with boat anchors.

A wooden lifeguard stand is positioned on a sandy beach. The stand is made of light-colored wood and has a slanted top. In the background, the ocean is visible under a clear blue sky. The entire image has a semi-transparent blue overlay.

Mariners

- We're asking mariners to contact us if they detect issues with the offshore buoys that we'd installed (North Point, East Point and Oistins).

Beachgoers

- When it comes to combating coastal erosion, we want beachgoers not to remove sand or plants from the beaches or around the coastline, and to understand it's illegal to do so.

Householders and hoteliers

- All householders and hoteliers should be encouraged to reduce the use of cleaners with harmful chemicals and instead use those which breakdown harmlessly in the environment such as vinegar, lemon juice, or baking soda.

Let's all play our part to better manage our coastal and marine resources. Our future, and the future of our children and grandchildren, may depend on it.

CREATING A

SAFE SUSTAINABLE COAST

November 2018

Integrated Coastal Zone Management (ICZM) is a way to manage the coast which includes all aspects of the coastal zone. The goal is to manage our coastal and marine resources properly.



**An Integrated Coastal
Zone Management Initiative**

by The Coastal Zone Management Unit

