

Feasibility and Designs of Small Scale, Nature Based Coastal Protection Works in Caye Caulker and Goff Caye, Belize

CSD/RND - Climate Vulnerability Reduction Loan Program (BL-L1028)
Design Phase

Final Report



Prepared for

Inter-American Development Bank

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Version Control

Version Number	Date Submitted	Comments
1.0	September 22, 2017	1 st Draft
1.1	September 26, 2017	Corrections to rounding approximations in cost estimates
1.1.1	September 26, 2017	Further corrections to rounding approximations in cost estimates
1.2	September 27, 2017	Clarifications on design

INTRODUCTION

As part of the Climate Vulnerability Reduction Loan Program (BL-L1028), the Inter-American Development Bank (IADB) has undertaken a consultancy effort entitled Feasibility and Detailed Designs of Small Scale, Nature Based Coastal Protection Works in Caye Caulker and Goff Caye, Belize. The main goal of the consultancy is to develop prioritized coastal protection options at identified sites that meet stated criteria to improve the climate resiliency of Goff Caye and Caye Caulker.

The first stage of the project entailed a high-level overview of the coastal erosion problems faced in Caye Caulker and Goff Caye with possible options for protection works for consideration. This next stage (entitled “Design Phase”) requires a more robust stakeholder engagement and deeper analysis to further develop and weigh possible options for protection works.

A second mission in Belize was held from 12th-15th September, where a presentation was made on the proposed concepts and input received from stakeholders. The outcome of the mission has enabled designs to be progressed to a level suitable for a Bill of Quantities to be prepared.

DESIGNS

CAYE CAULKER: PALAPA GARDENS BEACH REDEVELOPMENT

Objectives:

The objectives are to:

- reduce the erosion of the placed beach fill and consequently increase the longevity between beach nourishment required at Palapa Gardens,
- reduce vulnerability of the infrastructure behind the Palapa Gardens area, and
- enhance the tourism product through beautification of the beach area.

Location and Cartographic information:

Palapa Gardens is located on the east coast of Caye Caulker. It is presently an open beach with little shading. The geographic locations are 17°44'47.70"N, 88° 1'24.62"W. The intervention location is approximately 50m of beach width from the edge of the coastal road/walkway (estimated at 0.5 m-MSL) to the present location of the shoreline (approximately 40 m).



Beneficiaries:

<ul style="list-style-type: none"> • Property: Commercial property (behind Palapa Gardens beach area) • Infrastructure: Main coast walkway/road, general utilities • Nature: Opportunity to revitalize protective vegetation and ecosystem • Livelihoods: Opportunity to develop a safe domestic tourism amenity contributing toward a sustainable and resilient community.
<p>Description of the intervention</p> <p>The Government of Belize has reportedly undertaken beach nourishment in Palapa Gardens 3 times in the last 5 years. There are scant details of the nourishment, notably:</p> <ul style="list-style-type: none"> • the placement of the nourishment (volume and area) • the location of the borrow area • the quality of the sand placed • surveying of the pre-, during- and post-nourishment <p>Regardless, the sand was placed and spread to extend the beach past the mangroves. It has been reported that the sand has been eroding slowly, and it is suspected that the longshore transport at Palapa Gardens is from South to North. The placed sand is likely being eroded and transported to the North, and eventually being lost to the Split system.</p> <p>The proposal is for a “mangrove groyne” to be built on the northern side of Palapa Gardens to “hold” the placed sand from normal erosive forces. The groyne would be from the upper beach to the present shoreline (approximately 25 m). Mangrove will be planted in various locations along the groyne. The groyne will likely be of low elevation (crest elevation ~+1m-MSL) and porous to allow adequate flushing of the mangrove roots.</p> <p>The groyne is intended to hold the sand previously placed. The present beach extent appears adequate for Caye Caulker’s needs. As no new sand will be introduced into the system, the existing piers to the north and south will have minimal risk of additional sedimentation from how they operate presently.</p> <p>In addition, a vegetated beach berm (height 1m, width 3-4m) is proposed for the upland part of the beach along the length of the Palapa Gardens area (approximately 50m). Vegetation on the berm will consist of native species such as seagrape, almond, seapurslane (<i>Sesuvium portulacastrum</i>) and railroad vine (<i>Ipomea pes-caprae</i>). Finally, coconut trees is proposed on the main beach area to provide aesthetic value, shading, and erosion protection.</p> <p>The intervention is intended to reduce the longshore transport erosion, protect the infrastructure behind the beach and provide vegetation for shade.</p> <p>The new beach control structure (mangrove groyne) with nourishment would need to be modelled to determine long-term shoreline changes and impacts resulting from new structures on immediate frontages. Given the complex nature that coastal structures may impact on the coastal dynamics, it is recommended that an EIA will be required.</p> <p>The beach frontage is understood to be public land, and thus is available for development without land acquisition.</p> <p>Design/Construction risk/constraints include:</p> <ul style="list-style-type: none"> • design of a groyne feature that incorporates mangroves (a new and innovative concept); <ul style="list-style-type: none"> ○ provision of a suitable substrate for mangrove growth ○ potential for excessive wave action during north winds ○ potential for covering of mangrove shoots by sand • delivery of rock materials to the site (barged from the mainland, trucked to the site),

- upland or dredge and fill material to comprise the beach berm
- provision for keeping the walkway/road accessible during construction would require careful planning.

Products and Indicators

Length of beach. Baseline = 0. Objective = ~50 m.
Establishment of a mangrove groyne, vegetated beach berm.

General budget

Items	Estimated cost (USD)
Construction *	256,591.48
Further technical studies and designs, EIA, construction management	30,790.98
Contingency (20%)	71,845.61
Total Capital Cost	359,228.07
Operation & Maintenance every 10-yrs (incl. monitoring and evaluation, no renourishment)	30,000

*Comprises groyne, berm creation, vegetation

Management Model

Construction is recommended by a competent marine contractor. There would be opportunity for local involvement in mangrove planting and monitoring, as well as beach performance monitoring.

Implementation schedule

Activity	2017		2018			
	Q3	Q4	Q1	Q2	Q3	Q4
Further technical studies and designs		x	x			
Construction, incl. supervision			x	x	x	

Design basis - Groyne (summary)

WAVE CONDITIONS

(References to calculations relate to Defra/Environment Agency, Flood and Coastal Defence R&D Programme, "Low Cost Rock Structures for Beach Control and Coast Protection, Practical Design Guidance", R&D Technical Report FD2409, Authors: Matt Crossman, Silvia Segura-Domínguez and William Allsop)

Beach slope			0.01
Design offshore wave (within barrier reef, depth limited)	H _{so}	m	2
Wave Period (assumed)	T _m	s	6
	T _p	s	10
Design water level (Cat 3 Surge), from Caribbean Disaster Mitigation Project, Belize Coastal Hazard Assessment, OAS/USAID, Figure 15		m-MSL	1
Minimum beach level (assumed)		m-MSL	-1
Water depth at toe	h	m	2
	L _{op}	m	156.21

h/L_{op}	h/L_{op}		0.013
S_{op}	S_{op}		0.013
Figure 12	H_s/h		0.49
	H_{mo}	<i>m</i>	0.98
	$v(m0)$		0.245
	H_{rms}	<i>m</i>	0.76
	H_{tr}	<i>m</i>	0.816
	\hat{H}_{tr}		1.07
Table 9	$\hat{H}_{1/3}$		1.34
	$\hat{H}_{2\%}$		1.62
	$H_{1/3}$	<i>m</i>	1.02
	$H_{2\%}$	<i>m</i>	1.23

ARMOUR ROCK USING VAN DER MEER

(References relate to CUR Report 154, CIRIA Special Publication 83: Manual on the use of rock in coastal and shoreline engineering', 1991)

Significant Wave Height	HS	m	1.23	
Wave Period	T	sec	6.00	
Wave Angle to Slope Normal		o	0.0	
Deep Water Wave Steepness		s	0.021883	(Eqn 5.1)
Cotangent of Slope Angle		cota	1.5	
Breaking Parameter			4.51	(Eqn 5.2)
Porosity	P		0.60	(Figure 143)
Damage Factor	Sd		2.00	(Table 31)
Breaking Parameter Transition			3.78	(Eqn 5.46)
Type of wave			Surging	
Saturated Surface Dry Density		t/m3	2.650	
Density of Seawater		t/m3	1.03	
Delta	-		1.57	(Eqn 5.6)
Water Absorption	wab	%	0.0	
Maximum Number of Waves	N		3000	(Page 265)
H/DeltaD Parameter			1.666	
Median Diameter of Armour	Dn50	m	0.47	(Eqn 5.44/5.45) Median
Weight of Armour	W50	t	0.27	(Eqn 5.7)

Design basis - Berm (summary)

A sediment transport model – USACE¹'s sBEACH – was used to model the cross-shore movement of sediments with the objective of predicting wave run-up over the existing shoreline features, as well as expected shoreline changes (areas of high erosion or accretion potential) due to the wave impact. The model sBEACH computes the wave energy dissipation with conservation of the wave set up.

A cross-shore profile was delineated from deep water (200m water depth approximately) up to the project site in the nearshore of Caye-Caulker. The resulting wave heights and periods, as well as the wind speeds and water levels set-up from the 1in 50-year storm event were extracted at the 200m contour ($H_s=8.75m$, $T_p=12s$, Wind

¹ US Army Core of Engineers

Speed=30m/s, water level setup=+1m (IBR+GSLR+HAT)), and input to the model with a direction perpendicular to the shore (representative of the worst-case scenario).

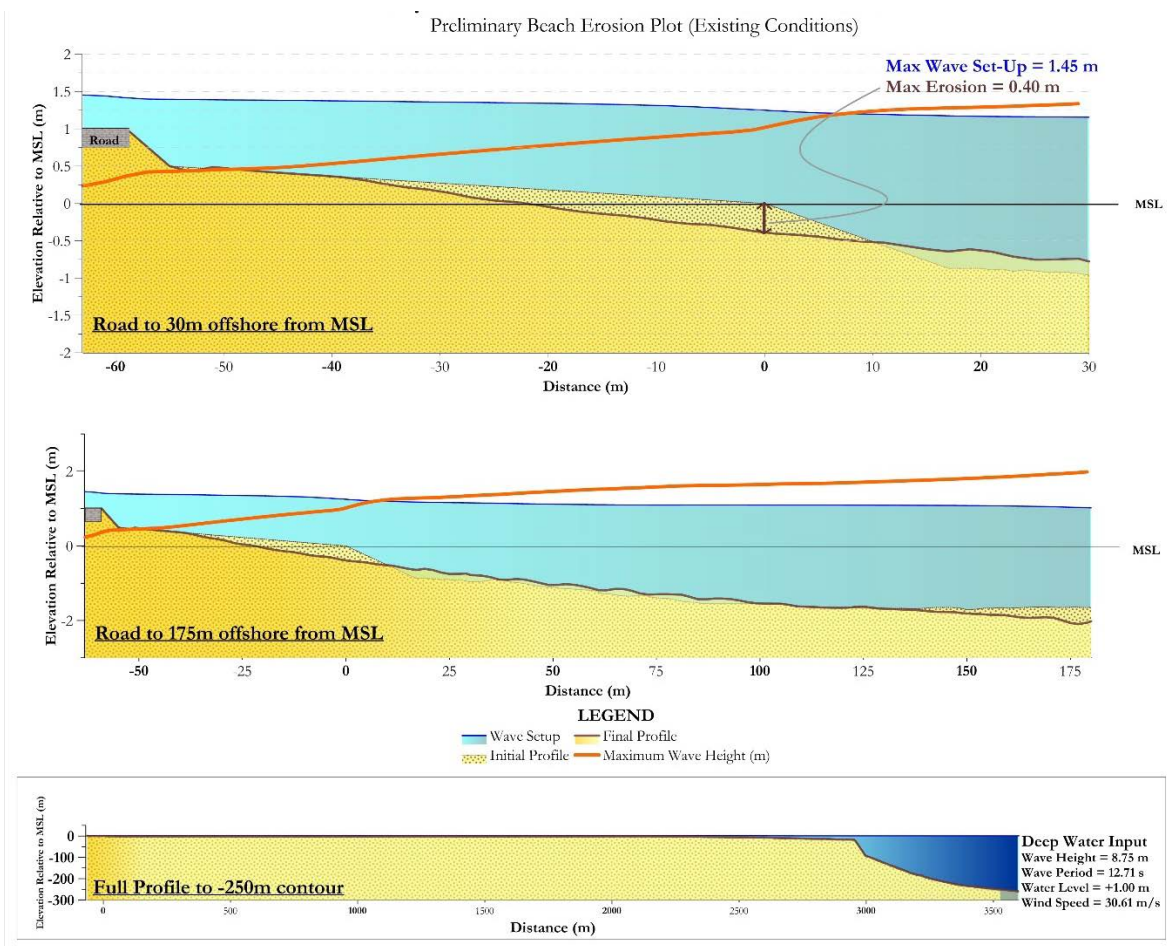
For the beach sand, a mean grain diameter of 0.2mm was used as a standard value (to be confirmed with the results of sediment sample sieve analysis).

The sBEACH model was run to produce the inundation levels and the beach profile changes in existing conditions. Results were plotted for the 50-year return period. The wave, inundation levels and extent of erosion predicted by the model over the considered profile are presented Figure below.

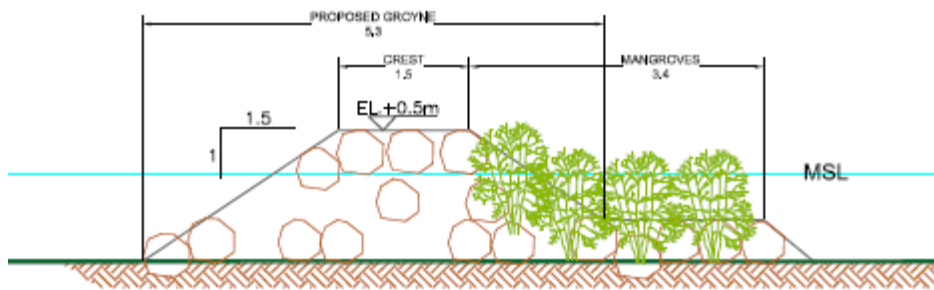
Results indicate that for the considered 1 in 50-year storm the water level is predicted to be up to +1.45m while vertical erosion occurs up to 0.40m (at the shoreline) below the existing beach profiles.

Overall results are indicative of a cross-shore movement of sand with a clear mechanism of erosion/deposition along the beach slope. the sand is being deposited up or down the beach slope depending on the intensity of the storm. The sand deposited further offshore does not move beyond the surf zone which indicates that day-to-day wave conditions could be sufficient to bring the sand back up onto the beach.

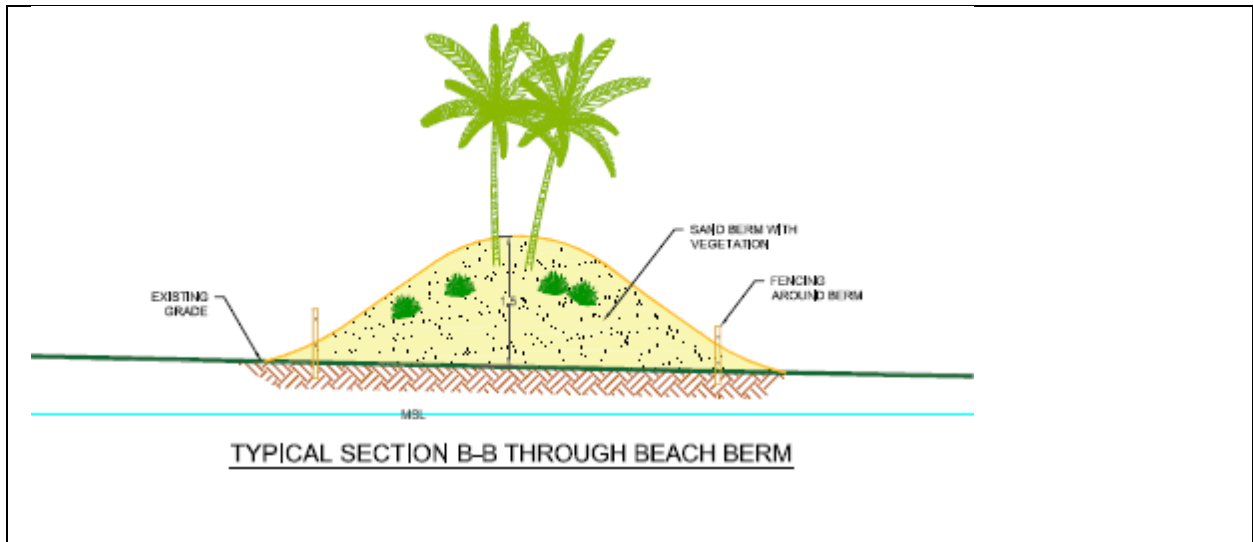
Sbeach Run Results



Drawings



TYPICAL SECTION A-A THROUGH GROYNE



GOFF CAYE: PIER RECONSTRUCTION

Objectives:

The objectives are to:

- Reconstruct pier to reduce vulnerability to storm events and minimize maintenance requirements

Location and Cartographic information:

The existing pier is a wooden jetty structure extending ~80 m from the welcome Palapa to deeper waters.



Beneficiaries:

- Nature: Removal of existing pier away from naturally forming spit feature
- Tourism: Security in docking facilities and possible increase in desirable beach area footprint in the spit feature
- Local beneficiaries: Security in docking facilities

Description of the intervention

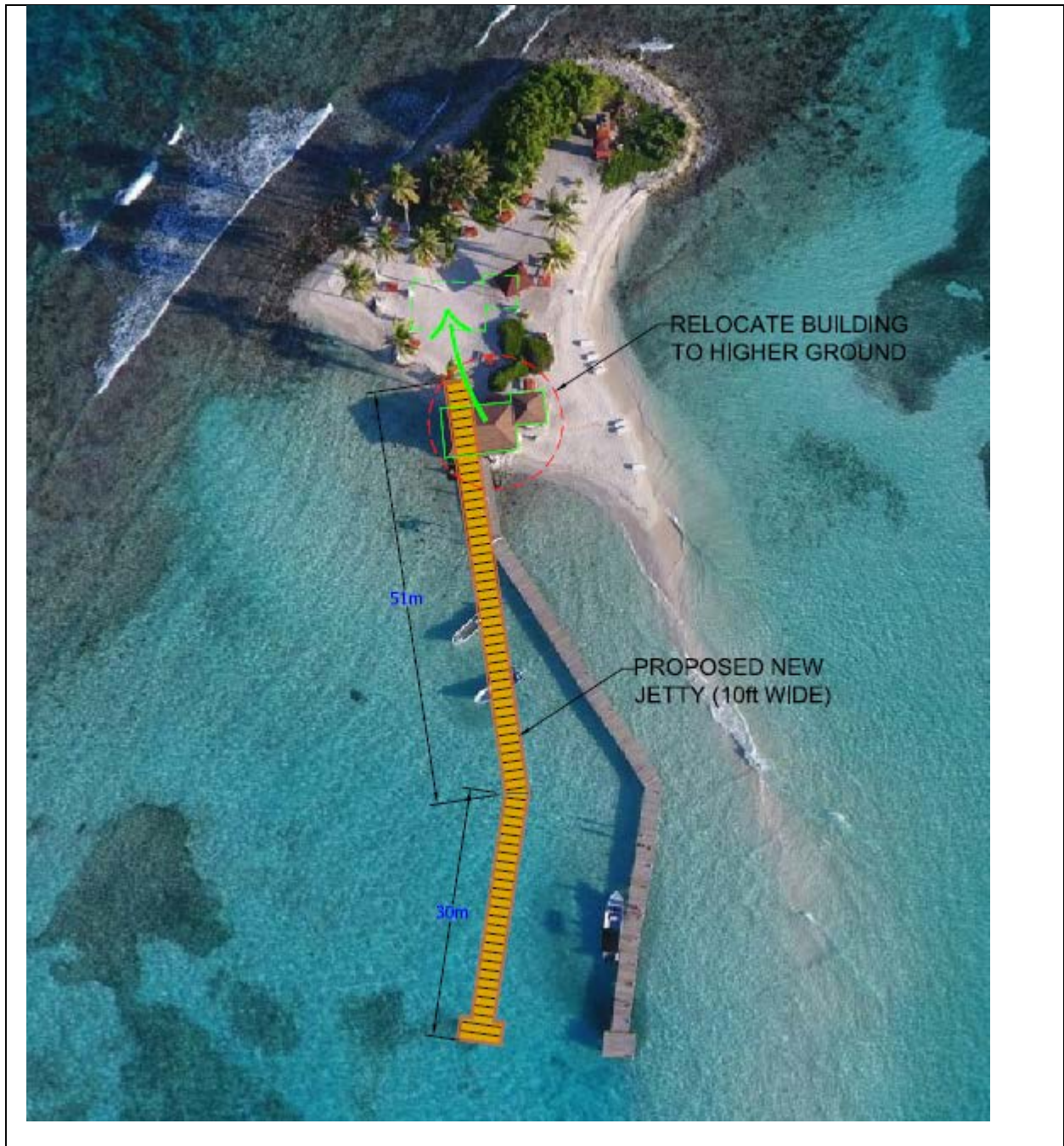
The existing pier is weathered and frequently needs repairs, both from regular wave and atmospheric conditions as well as storm events. The pier does not appear to have been designed for any condition in mind and has been extended a few times over the years.

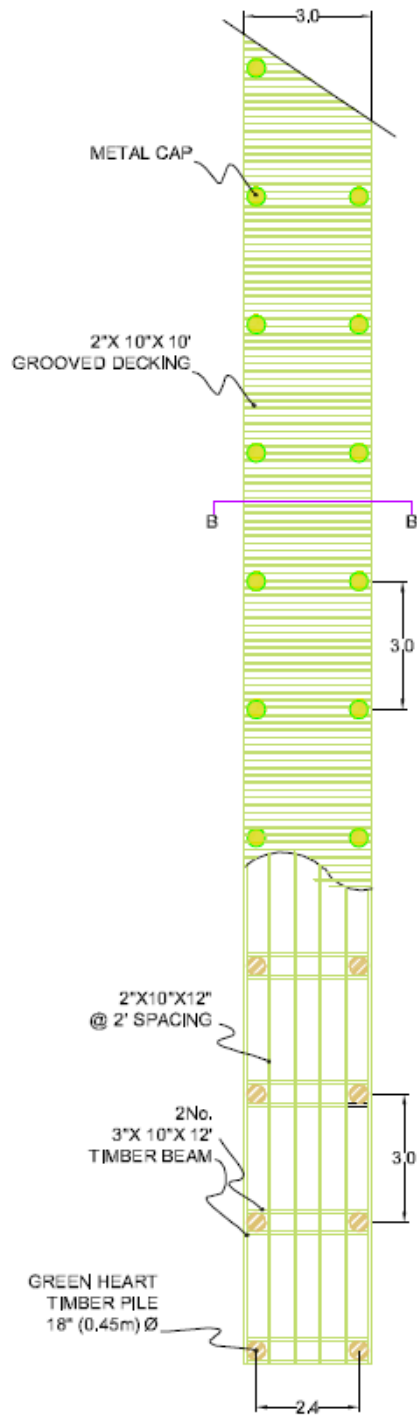
A new pier is proposed that is sufficiently robust to minimize maintenance and can withstand a modest storm event without failure.

Design/Construction constraints include:

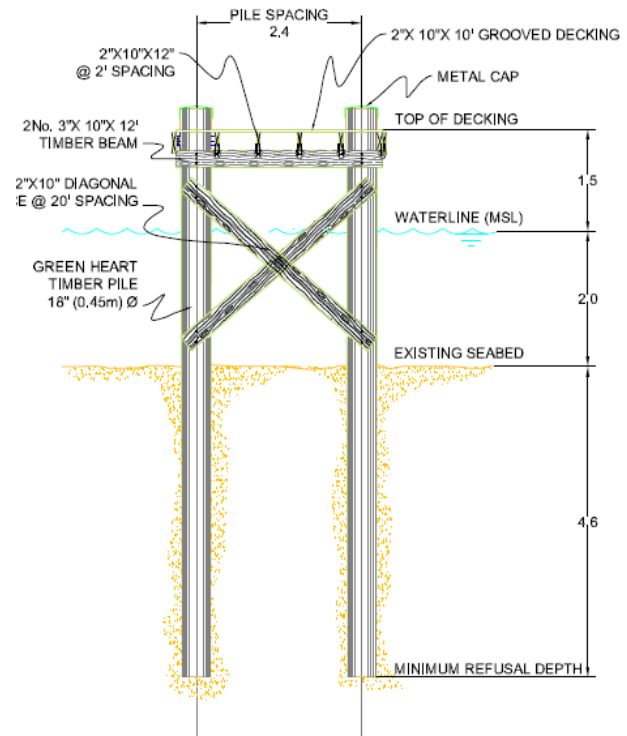
- Goff Caye is a remote location and thus all plant and material would need to be brought in

<ul style="list-style-type: none">• Lack of survey and geotechnical information• Likely limitation of barge with crane for construction of jetty• Disruption during construction						
Products and Indicators						
Construction of new jetty and demolition of old jetty. Baseline = 0 m, Objective = ~80 m.						
General budget						
Items					Estimated cost (USD)	
Construction					309,347.64	
Further assessments, studies and designs (17%)					52,579.10	
Contingency (20%)					72,387.35	
Total Capital Cost					434,324.09	
Management Model						
Construction of new jetty and removal of existing jetty should be performed by competent marine contractors with marine-based plant who are aware of the constraints of working remotely.						
Implementation schedule						
Activity	2017		2018			
	Q3	Q4	Q1	Q2	Q3	Q4
Further technical studies and designs		x	x			
Construction, incl. supervision				x	x	
Design basis (summary)						
Timber design for aesthetics 10 ft wide Assumed 1 m surge ((Cat 3 Surge), from Caribbean Disaster Mitigation Project, Belize Coastal Hazard Assessment, OAS/USAID, Figure 15) Top of decking +1.5 m-MSL						
Drawings						





**PLAN OF PROPOSED
TIMBER JETTY**



**TYPICAL CROSS SECTION THROUGH
PROPOSED TIMBER JETTY**

GOFF CAYE: RELOCATION OF PALAPA

Objectives:

The objectives are to:

- Relocate the existing palapa to a higher, safer location
- Remove the existing palapa foundation that may contribute to shoreline erosion
- Open additional beach area for tourism activities

Location and Cartographic information:

The Palapa is presently a simple structure approximately 10m x 15m located on the northern side of the island adjacent to the active spit feature. Historical information has shown that the area to the south east of Goff Caye has been stable. It is proposed that the palapa is relocated towards the southeast to more stable grounds.



Beneficiaries:

- Nature: Removal of existing foundation to allow the beach to move freely
- Tourism: Increase in desirable beach area footprint adjacent to the spit feature
- Local beneficiaries: To be provided a building with an improved layout for their specific needs in a more stable area

Description of the intervention

The foundation of the existing “welcome” palapa is exposed during certain times of the year. When the concrete slab is exposed, it acts as an impermeable vertical wall that reflects oncoming wave energy (as opposed to dissipating it) and exacerbates localized erosion.

The palapa is thus located in what is the active and dynamic coastal zone, and is better sited towards the more stable south-eastern side of the island. It is recommended that the palapa is rebuilt in a more suitable and safer location and more appropriate design to minimize damage potential during storm events.

The palapa should also be designed to include solar panels and/or a wind generator with associated system to provide electricity so that the gasoline-powered generator is no longer needed.

Design/Construction constraints include:

- Goff Caye is a remote location and thus all plant and material would need to be brought in
- Limited information exists on the historical evolution of Goff Caye
- Carrying capacity needed on island
- Architectural layout needs to consider users
- Disruption during construction

Products and Indicators

Relocation of Palapa. Baseline = Existing location. Objective = new location.

General budget

Items	Estimated cost (USD)
Construction	176,051.50
Further assessments, studies and designs (17%)	29,928.76
Contingency (20%)	41,196.05
Total Capital Cost	247,176.31

Management Model

Removal of existing palapa and reconstruction in new location can be performed by competent local contractors who are aware of the constraints of working remotely.

Implementation schedule

Activity	2017		2018			
	Q3	Q4	Q1	Q2	Q3	Q4
Further technical studies and designs		x				
Construction, incl. supervision			x			

Design basis (summary)

Construction of new palapa to be designed and constructed appropriately – pile supported (as opposed to slab foundation), suitably elevated, with accommodation to withstand the desired level of protection (recommended guidance is the Coastal Construction Manual (FEMA P-55 / Volume I / August 2011, available at: https://www.fema.gov/media-library-data/20130726-1510-20490-2899/fema55_voli_combined.pdf).

Architectural features to include specific needs of local vendors.

Solar panels and battery bank to be installed.

GOFF CAYE: MOORING FIELD

Objectives:

The objectives are to:

- Establishment of a mooring field for day vessels

Location and Cartographic information:

Three locations for mooring fields are proposed: one adjacent to the jetty, and the others adjacent to the popular dive sites. The mooring blocks will likely be a cube of mass concrete approximately 0.5 x 0.5 x 0.5 m. The mooring blocks will be placed on sand or away from the living reef system.



Beneficiaries:

- Nature: Avoidance of damage to coral reef and seagrass
- Tourism: More secure locations for vessels (less potential for damage as compared to jetty)
- Local beneficiaries: Improvement to the dive and snorkel sites and overall tourist experience

Description of the intervention

Vessels typically tie up to the existing jetty when visiting Goff Caye. However, it was noticed that vessels who accommodate snorkelers or scuba divers use their anchors on or near the reef. It is proposed that a simple mooring field is developed to avoid damage to reef and seagrass. The mooring field would comprise of concrete blocks, chain, associated hardware and a mooring buoy.

Design/Construction constraints include:

- Goff Caye is a remote location and thus all plant and material would need to be brought in

Products and Indicators

Mooring field. Baseline = 0 moorings. Objective = 10 moorings.

General budget

Items	Estimated cost (USD)
Construction	50,300.43
Further assessments, studies and designs (17%)	8,551.07
Contingency (20%)	11,770.30
Total Capital Cost	70,621.80
Operation & Maintenance every year	5,000

Management Model
Construction and installation of mooring field can be performed by competent local contractors who are aware of the constraints of working remotely.

Implementation schedule

GOFF CAYE: BEAUTIFICATION ACTIVITIES: BATHROOM UPGRADE, REVEGETATION, SIGNAGE

Objectives:

The objectives are to:

- Improve the tourism product on Goff Caye

Location and Cartographic information:

Throughout Goff Caye: bathrooms, revegetation, signage



Beneficiaries:

- Nature: Discontinue discharge of waste to nearshore areas, revegetation for shade and coastal protection
- Tourism: Better signage for awareness of reef and sensitive island
- Local beneficiaries: Improvement of Goff Caye facilities and overall tourist experience

Description of the intervention

The beautification scheme consists of three aspects:

1. Goff Caye is serviced by 2 bathrooms that are flushed using sea water drawn from a pump driven by a gasoline generator, which leads to a soakaway system. The toilet facilities on Goff Caye should be upgraded to either a modern eco-friendly facility that does not rely on a pump facility, or one that can be driven by green energy (solar or wind generator).
2. Revegetation of the native species could contribute to the coastal erosion resilience. In addition, a recent CZMAI survey indicated that there is a high demand for shade at Goff Caye. Development of a vegetation plan is recommended.
3. There is little reef signing awareness for visitors to Goff Caye. As such, it is recommended that signs describing the reef and the delicate nature of the corals are posted in conspicuous places.

Design/Construction constraints include:

- Goff Caye is very small hence an appropriate toilet facility must be selected.
- Carrying capacity is recommended for present and future use.

- Goff Caye is a remote location and thus all plant and material would need to be brought in
- Disruption during construction

Products and Indicators

Mooring field. Baseline = 0. Objective = bathroom facility, signage, revegetation.

General budget

Items	Estimated cost (USD)
Construction	50,300.43
Further assessments, studies and designs (17%)	8,551.07
Contingency (20%)	11,770.30
Total Capital Cost	70,621.80
Operation & Maintenance every year	5,000

Management Model

Construction and installation can be performed by competent local contractors who are aware of the constraints of working remotely.

Implementation schedule

Activity	2017		2018			
	Q3	Q4	Q1	Q2	Q3	Q4
Construction, incl. supervision		x	x			

GOFF CAYE: MANAGEMENT AND MONITORING PLANS	
Objectives:	
The objectives are to:	<ul style="list-style-type: none"> • Establishment of a management plan to define operational guidelines for Goff Caye • Develop monitoring programmes for both the reef and coastal systems to document and better understand the dynamics of the reef and island morphology
Location and Cartographic information:	
	Not applicable
Beneficiaries:	
	<ul style="list-style-type: none"> • CZMAI: Documentation and better understanding of the complex systems, involvement in management and monitoring plans and implementation • Tourism: Potential for improved tourism product through better management • Local beneficiaries: Improvement in the overall long-term sustainability of Goff Caye
Description of the intervention	
<u>Management Plan</u>	<p>A plan is proposed to be developed for infrastructure, tourism, carrying capacity, people movement, environmental and marine traffic safeguards i.e. – both land side as well as marine spatial planning.</p> <p>Incidentally, sometime after the agreement for the CZMAI to manage Goff's Caye were signed, a management strategy² was developed for a proposed National Park for both Goff's Caye as well as Rendezvous Caye (with surroundings). The strategy laid out the rationale for and objectives to development of the Park, and described the subsequent need for a plan that addresses the following:</p> <ul style="list-style-type: none"> • appropriate zoning, • formation of management committees, • a physical management strategy, • determination of carrying capacity, • the need for mapping, • public support and awareness from an interpretation exercise, • administration, • logistics of effective management, • surveillance/enforcement needs, • budgeting and financing, • monitoring and evaluation of management effectiveness. <p>While this management strategy was never adopted,³ the recommendations made within the strategy for development of a management plan still apply. It is recommended that this management plan proceed.</p>

² Goff's Caye Area and Rendezvous Caye Proposed Management Strategy, Coastal Zone Management Authority and Institute, Year unknown

³ Email communication, CZMAI to Edward Albada, May 11, 2017.

Reef Monitoring

The CZMAI has developed a “Physiochemical and Biological Monitoring Programme Manual” and provided a cost estimate for re-institution of the programme for the first year.

Notably, the CZMAI included a pilot in this year’s Annual Operation Plan (AOP) in order to update the manual and initiate basic training that would assist in the implementation of the program.

Category	Description
Training	Open water certification for 2 staff
Dive gear	Dive gear for 2 staff (BCD, Dive Computer, Regulators, and Octopus)
	Wet suits
	Mask and Fin
Equipment (purchase)	YSI Pro DSS
	Go Pro camera
Equipment (rental)	Dive tanks
Other Materials	Including slates, measuring tapes, Waterproof paper etc.
Fuel	Fuel for pilot project (3 months) and monthly monitoring (1 year)
Subsistence	Lunch for staff (working out of duty station)

Coastal Monitoring

In addition to the reef monitoring, to better understand the complex coastal dynamics it is recommended that basic coastal monitoring is undertaken. Suggestions include:

- a meteorological station to capture wind speed and direction (1 year)
- An Argus video imaging system (collection of snapshots, time exposure images)
- Topographic survey (beach profiles spaced 20 m apart across the island to wading depth taken 4 times per year)
- Bathymetric survey in deeper waters
- A wave-rider buoy or similar to capture wave and current data impacting the island (2 months)

With appropriate training and guidance, the coastal monitoring programme would could be managed and maintained by the CZMAI and would offer a unique opportunity for learning and development of the complex coastal processes.

Products and Indicators

Management Plan. Baseline = 0 moorings. Objective = 1 plan.


Reef Monitoring Programme. Baseline = 0 moorings. Objective = 1 programme.

Coastal Monitoring Programme. Baseline = 0 moorings. Objective = 1 programme.


General budget						
Items				Estimated cost (USD)		
Management Plan (per above)				25,000.00		
Reef Monitoring Programme (per above)				20,000.00		
Coastal Monitoring Programme (per above)				75,000.00		
Contingency (20%)				23,000.00		
Total Capital Cost				138,000.00		
Operation & Maintenance every year (Reef and Coastal Monitoring Programmes)				10,000		
Management Model						
A competent planner versed in tourism planning for tropical tourist destinations is recommended for the Management Plan. The reef and coastal monitoring programmes is recommended to be set up by specialists (who would also train CZMAI staff). CZMAI would then undertake the monitoring programmes themselves.						
Implementation schedule						
Activity	2017		2018			
	Q3	Q4	Q1	Q2	Q3	Q4
Development of plan and programmes		x	x			

BILL OF QUANTITIES

CAYE CAULKER

Bill of Quantities & Engineer's Estimate Caye Caulker PROPOSED SCOPE OF WORKS 22-Sep-17			 Edward Albada, P.E., R.Eng. 3 Anguilla Park Maraval Trinidad & Tobago		
Item	Description	Quantity	Unit	Rate	Contract Amount (US\$)
1	<u>GENERAL ITEMS</u>				
1.01	Mobilization and Site Facilities				
	- Mobilize equipment, machinery and workforce	1	LS	\$6,785.00	\$6,785.00
	-Site facilities (See notes below)	1	LS	\$1,354.24	\$1,354.24
					\$8,139.24
1.02	Insurance (Public and Employer's Liability - Contractor's All risk excluded)	1	LS	\$4,000.00	\$4,000.00
1.03	Communication,Transportation, Administration and Employee Safety	1	LS	\$13,024.00	\$13,024.00
1.04	Surveying	1	LS	\$3,640.00	\$3,640.00
1.05	Temporary Construction	1	LS	\$25,518.45	\$25,518.45
1.06	Demobilization	1	LS	\$5,462.50	\$5,462.50
				Sub-Total	\$59,784.19
2	<u>ENVIRONMENTAL REQUIREMENTS</u>				
2.01	Turbidity monitoring (w kly reports)	1	LS	\$14,300.00	\$14,300.00
				Sub-Total	\$14,300.00
3	<u>TURBIDITY CONTROL</u>				
3.01	Supply and Place Turbidity Barriers	50	m	\$85.00	\$4,250.00
3.02	Maintain and Repair Turbidity Barriers	2.0	mt	\$1,000.00	\$2,000.00
				Sub-Total	\$6,250.00
4	<u>Groyne and Mangrove Bed</u>				
4.01	Excavation and Stockpile - Sand (Preparation)	54	m³	\$25.00	\$1,342.46
4.02	Armor Stone - Supply and Place	192	m³	\$120.00	\$23,029.09
				Sub-Total	\$24,371.55
5	<u>Beach Berm</u>				
5.01	Marine Sand - Supply and Place	201	m³	\$110.00	\$22,148.28
5.02	Dredge Mobilization and Demobilization	1	LS	\$100,000.00	\$100,000.00
				Sub-Total	\$122,148.28
6	<u>Landscaping</u>				
6.01	Excavation and Stockpile - Sand and Base material	54	m³	\$25.00	\$1,342.46
6.02	Soil - Supply and Place	645	ft²	\$5.00	\$3,225.00
6.03	Coconut Trees - Supply and Place	50	ft²	\$5.00	\$250.00
6.04	Shrubs and Grass - Supply and Place	1755	ft²	\$5.00	\$8,775.00
6.05	Supply and Place Mangroves	969	ft²	\$5.00	\$4,845.00
6.06	Fence - Supply and Install	113	m	\$100.00	\$11,300.00
				Sub-Total	\$29,737.46
TOTAL (US\$)					\$256,591.48
7	<u>Design & Construction Management</u>				
7.01	Further Design (7%)	1	LS		\$17,961.40
7.02	Construction Management (5%)	1	LS		\$12,829.57
7.03	EIA & Permitting (5%)	1	LS		\$12,829.57
				Sub-Total	\$30,790.98
TOTAL (US\$)					\$287,382.46
8	<u>Contingency</u>				
8.01	Contingency (20%)	1	LS		\$71,845.61
				Sub-Total	\$71,845.61
TOTAL (US\$)					\$359,228.07

GOFF CAYE

Bill of Quantities & Engineer's Estimate Goff Caye PROPOSED SCOPE OF WORKS 26-Sep-17					 Edward Albada, P.E., R.Eng. 3 Anguilla Park Maraval Trinidad & Tobago
Item	Description	Quantity	Unit	Rate	Contract Amount (US\$)
1	GENERAL ITEMS			Sub-Total	\$100,000.00
2	ENVIRONMENTAL REQUIREMENTS				
2.01	<u>e.g. turbidity monitoring (w kly reports)</u>	1	LS	\$20,000.00	\$20,000.00
				Sub-Total	\$20,000.00
3	Palapa				
3.01	<u>Remove and Dispose of Existing Palapa</u>	150	m ²	\$233.33	\$35,000.00
3.02	<u>Rebuild Palapa</u>	150	m ²	\$700.00	\$105,000.00
					\$140,000.00
4	Jetty				
4.01	<u>Remove and Dispose existing deck and timber frame</u>	246	m ²	\$250.00	\$61,500.00
4.02	<u>Rebuild Jetty</u>	246	m ²	\$750.00	\$184,500.00
				Sub-Total	\$246,000.00
5	Mooring Field				
5.01	<u>Mooring Field</u>	10	LS	\$4,000.00	\$40,000.00
				Sub-Total	\$40,000.00
6	Beautification Activities				
6.01	<u>Bathrooms - Phoenix PF-201 model</u>	3	LS	\$10,000.00	\$30,000.00
6.02	<u>Signs</u>	2	LS	\$2,500.00	\$5,000.00
6.03	<u>Revegetation Activities</u>	1000	ft ²	\$5.00	\$5,000.00
				Sub-Total	\$40,000.00
TOTAL (US\$)					\$586,000.00
8	Design & Construction Management				
8.01	<u>Further Design (7%)</u>	1	LS		\$41,020.00
8.02	<u>Construction Management (5%)</u>	1	LS		\$29,300.00
8.03	<u>EIA & Permitting (5%)</u>	1	LS		\$29,300.00
				Sub-Total	\$99,620.00
TOTAL (US\$)					\$685,620.00
7	Maintenance & Monitoring Plans				
7.01	<u>Management Plan</u>	1	LS	\$25,000.00	\$25,000.00
7.02	<u>Reef Monitoring Programme</u>	1	LS	\$20,000.00	\$20,000.00
7.03	<u>Coastal Monitoring Programme</u>	1	LS	\$70,000.00	\$70,000.00
				Sub-Total	\$115,000.00
TOTAL (US\$)					\$800,620.00
9	Contingency				
9.01	<u>Contingency (20%)</u>	1	LS		\$160,124.00
				Sub-Total	\$160,124.00
TOTAL (US\$)					\$960,744.00

Notes:

Please note that the items below were excluded from the BOQs, and are expected to be borne by the Client: Potable water supply, Room for workers to store valuables doing work, Sanitary convenience for work force, Water source for daily equipment wash-down

DRAWINGS
