Review of EIA for Coral Reef Impacts
For
ARA MACAO Resort & Marina
Located In
Placencia, Stann Creek District

April 30, 2006

By The

And with contributions from
Report by Todd R. Barber, Chairman, Reef Ball Foundation,
Underwater Monitoring by Dr. Rachel Graham Associate Conservation Scientist
Appendix 1 Comments by Dr. Tom Williams, University of California, Berkeley

(A public 501(c) 3 non-profit organization functioning as an international environmental NGO)

Disclosure: The Reef Ball Foundation was NOT compensated to create this report.

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Reef Ball Foundation Background

The Reef Ball Foundation, Inc. is a 501(c) 3 publicly supported non-profit that functions as an international environmental NGO and is headquartered in Florida. We have conducted reef restoration projects in 55 countries and have programs in over 70 countries. The Reef Ball Foundation has acted as advisors to governments around the world to aid in the protection of coral reef assets. The Reef Ball Foundation also works with developers to improve their designs, construction techniques and eco-practices to preserve or enhance the reef asset value of their development. We also work at the grassroots level assisting communities with the technology and information they need to best manage their reef ecosystems.

The Reef Ball is a non-political organization, and we do not "side" with any particular point of view regardless of whom instigated our involvement. It is our mission to provide honest, practical and non-partisan advise to help preserve coral reefs while recognizing the economic and human-interest constraints in any given project. When we are fully engaged, we often provide solutions and work to sort out differences between opposing goals to the advantage of all.

Our organization also offers a wide variety of novel environmental technologies to aid in solutions to difficult issues in preserving reef health. These include designed artificial reef modules (see www.reefball.org), coral propagation and planting technologies (see http://www.reefball.com/reefballcoalition/index.html) , environmental erosion control solutions (see http://www.reefbeach.com) , simplified red mangrove planting technology (see http://www.reefball.com/reefballcoalition/mangroves.htm) , spiny lobster habitat modules (see http://www.reefball.com/reefballcoalition/lobster.htm), and many others such as coral reef relocation or restoration technologies. Because we are a non-profit organization, we do not consider the offering of these technologies as a conflict of interest and if we offer these solutions it is solely to aid in providing practical solutions to problems facing coral reefs.

Through the NOAA Coral List Server, the Reef Ball Foundation was asked to comment on this EIA. We have therefore conducted a review of the EIA in regards to the potential developmental impacts on adjacent coral reefs and will offer our suggestions on how to minimize these impacts for the developer

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NOTE: This report is limited in scope to impacts on coral reefs and does not represent a full review of the EIA. The Reef Ball Foundation does not support nor oppose the development being reviewed. We defer to the public process and laws of Belize to make the decision to approve or disapprove the applicant's EIA.

Coral Reefs in Belize: Should We Worry About Impacts to the Coral Reef?

The first question to ask is if we should even be reviewing this EIA for coral reef impacts? Are there corals new the development? Are corals an important resource in Belize? Is there an economic benefit to Belize from reefs? We believe most people will recognize that the answer to these questions is a resounding YES.

With the second longest barrier reef in the world, Belize is the caretaker of a precious asset. This asset is the main basis for future (and present) tourism, vibrant local fisheries including the economically important spiny lobster (*Panulirus argus),* and a host of additional resources both present and future.

Following is a good review of the importance and status of the coral reefs in Belize.

Belize Coral Reefs (1995)

(*By Sue Wells, UNDP/GEF Coastal Zone Management Project, Belize)*

Belize has one of the most diverse reef ecosystems in the world, with all the main types of reef represented: fringing reefs along the mainland coast; the Barrier Reef itself which grows along the edge of the continental shelf, separated from the mainland by the lagoon; and three offshore atolls (Lighthouse Reef, Turneffe Atoll and Glovers Reef). The presence of atolls is unusual. Most atolls are found in the Pacific, where they form on the top of submerged volcanoes. Very few occur in the Caribbean, and they differ in structure, the three in Belize for example lying on non-volcanic submarine ridges.

Of all wetlands, coral reefs are the most diverse, being home to more species than any other marine ecosystem. Only tropical rain forests rank higher on the biodiversity scale. This huge diversity is a result of careful partitioning of the reef by all its inhabitants - some use the reef at different times of day (many reef species are nocturnal), others share it by eating different food. Although reef diversity is much lower in the Caribbean than in the Indo-Pacific (a result of the geological history of the region), over 1,000 species may nevertheless occur on a single reef. Belize has particularly high species diversity for the region, with about 65 coral species and over 300 fish species, compared with just over 70 coral species and about 520 fish species in the Caribbean as a whole.

In Belize, the coastal waters were used extensively for fishing by the Mayans between 300 B.C. and 900 A.D. Since early this century, the economic role of the reef has increased steadily with the growth of the coastal population. Initially, its importance lay in the fishing industry, with a wide variety of species being harvested ranging from turtles, sharks and finfish, to sponges and seaweeds. Today, lobster and conch are the principal fisheries products, and contribute most of the total value of exported seafood, estimated at over US$10 million in 1995. There is also a domestic fishery for shallow reef fish and a commercial fishery for groupers Epinephelus spp. and snappers Lutjanus spp. However, the main use of the Belize Barrier Reef is now tourism, which is

the country's largest source of foreign exchange generating an estimated US$75 million in 1994; hundreds of divers visit the reef each year to experience its delights.

Belize may be one of the last countries in the world to have extensive areas of almost pristine reef but it is also subject to the many threats that are of global concern and which have already seriously degraded an estimated 10% of the earth's coral reefs and currently threaten a much greater percentage. Greatest damage comes from sedimentation, agrochemical run-off, coastal development, tourism and over fishing. Until recently, the main impacts on the Belize Barrier Reef were from natural events such as hurricanes. However, pressures are mounting from a whole range of impacts including escalating residential and hotel development on numerous cayes, the citrus and banana industries which are causing increasing fertilizer run-off, growing numbers of shipping and recreational vessels in the reef-strewn shallow waters, and a steady increase in divers and snorkellers.

Coral reefs have not yet been used among the primary criteria for listing wetland sites under the Ramsar Convention, although the definition of a wetland allows for their inclusion. Of the 11 Contracting Parties to Ramsar in the Neotropics that have coral reefs, only 3 have listed sites that include these habitats (the Grand Cul de Sac Marin in Guadeloupe, Klein Bonaire Island and adjacent waters in the Netherlands Antilles, and North, Middle and East Caicos Islands in the Turks and Caicos) and in all cases the main interest in these wetlands has been other habitats and waterfowl. Belize is finalizing the process for joining Ramsar and, in the first instance, will be nominating an inland wetland site. However, several parts of the Belize Barrier Reef would qualify for nomination.

For now, we will assume that any reader of this report agrees with our basic assumption that protection of the reefs are worth considering….at least as long as the costs of this protection do not out weigh the social or economic benefits of the development although many would argue the full value of the reef must be considered in this equation.

Potential Threats Reviewed

We limited the scope of this report to the following nine most common causes of coral reef degradation due to coastal developments. These common impacts will then be reviewed in light of the submitted EIA for best practices, or if not covered in the EIA, the pertinent questions to be addressed will be presented.

Reader Note: Questions or Suggestions will be highlighted in blue boxes within the report.

1) **Increased Nutrient Load** (Caribbean & Lagoon)

Run-off of ammonia, nitrates, nitrites and phosphates being the key concerns. Likely sources could be golf course or landscaping run-off, septic tanks, water treatment discharges, boat septic dumping, and other facility activities.

2) **Increased Sedimentation**

Commonly caused by on land construction activities, marine dredging, coastline disturbances/coastal structures and boat operations.

3) **Introduction of Reef Toxins**

Common sources include run off from asphalt use, golf course or landscaping chemicals, marina operations, swimming pool chemicals and other facility operations.

4) Increased Exposure to Boat Groundings

Typically from increased boat traffic over the coral reef, especially poorly marked routes or unlit navigation markers when night traffic is present.

5) **Sand Covering Coral Reef**

Often caused by up-drift accretion of sand by coastal structures or by beach fill activities.

6) **Degradation of Reef Supporting Estuary or Mangrove Systems**

Typically occurs when developments impact bay, estuary or mangrove systems adversely.

7) **Increased Turbidity**

Corals contain captive algae that are photosynthetic and therefore do not tolerate decreases in turbidity well. This can be caused by on-land construction, marine construction (such as seawalls), dredging and boat operations.

8) **Increased Coral Reef Usage Pressure**

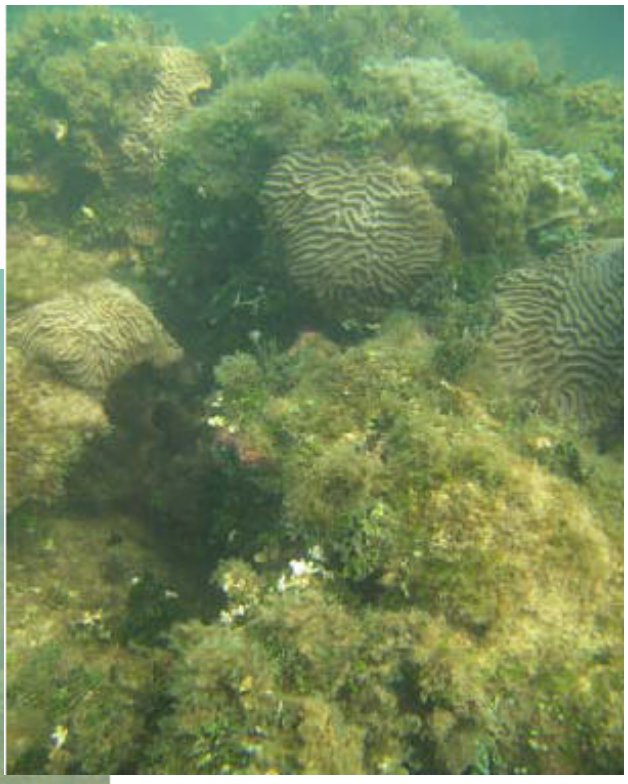
This can occur from increased tourism creating more snorkeling, scuba, and fishing activities on the reef.

9) **Direct Physical Damage to Corals**

Direct loss of corals can occur from dredging operations when corals are within the footprint of dredging operations.

Increased Nutrient Load (Caribbean Side Only)

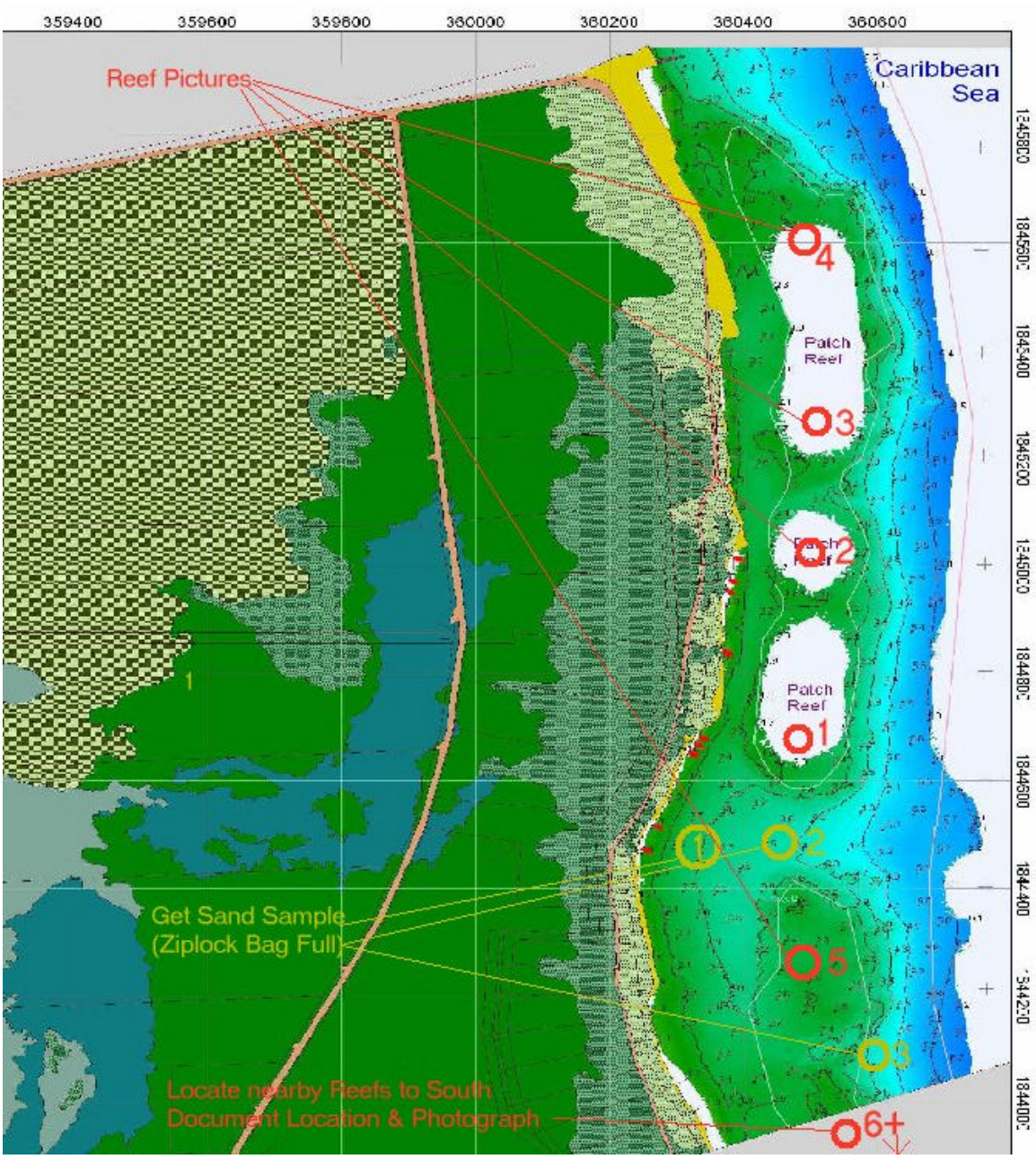
The EIA concluded that the reefs near the development are "severely degraded", blaming banana plantations and shrimp farmers. The report includes only 2 underwater monitoring photos as follows:



Photos: Ecoworks, 2005

Question: Are the coral reefs around the resort really "severely degraded"? Has there been a comprehensive survey of the habitat zones around the proposed development? What, exactly, are the biological components living within the area that will be dredged or covered by accreted or re-nourished sands?

To answer this question, we conducted our own monitoring and took underwater photos in the locations 1-5 as show on the following graphic.



GPS Positions of photos and notes on sites 1-6 – Riversdale patch reefs

By Rachel Graham, WCS – 25 April 2006

The following sites are described in the order noted on the map sheet provided by Todd Barber presented on the prior page. Sites were surveyed the morning of 19th of April 2006. All GPS points were recorded in UTM under datum WGS84. I am not a coral scientist and the coral notes represent general IDs of coral. However it was clear that corals in the patch reef are dominated by *Siderastrea* (star coral) and that numerous colonies are in good shape. It is worth noting that the substrate at all sites examined possesses a thick cover of Turtle Sea Grass (*Thalassia testudinum).* Please refer to the set of photos attached to ascertain more species ID for algae and sponges especially.

Fish observed during snorkeling at sites 1-6 include grey snapper (juvenile and adult), grey angelfish, cero mackerel, schoolmaster, Sergeant major fish, pork fish (juv and adult), foureye butterflyfish, dusky damsel fish, yellowtail parrot fish, Spanish grunts, Cesar grunts, doctor fish, smooth trunkfish, porcupinefish, stoplight parrotfish, striped parrotfish, spadefish, white grunt.

Sites:

Site 4 and 3 – 16Q0360506 1845589 & 16Q0360555 1845260
Shallow site (1-2 m depth) with thick turtle grass (*Thalassia testudinum*) cover. Dominant coral is *Siderastrea* spp. also *Montastrea annularis* and *faveolata* (one colony at least 1.7 m tall), *Porites* spp. (porites or furcata?) and several healthy plates of *Porites astreoides.* *Halimeda* spp. abundant on or near coral heads, as is *Caulerpa racemosa*. Some fuzz ball algae (*Cyanophyta*) and one

Site 2 – 16Q0360527 1844995
Same species as Sites 4 and 3. Noted several plates of crustose coralline algae on some of the coral heads and a proliferation of *Bryopsis plumosa* green algae on and near corals.

Site 1 – 16Q0360571 1844681
Still abundant *Siderastrea* but more *P. astreoides* and even one large head of *Colpophyllia natans.* One plate of *Agaricia agaricites.*

Site 5 – 16Q0360561 1844211
Dominated by colonies of *Siderastrea*.

Site 6 – 16Q0360529 1843840
Dominated by colonies of *Siderastrea* and *P. astreoides*

Sand sampling. 3 replicates per site, ziplocked (gallon and quart bags) and drained.
1: 16Q0360290 1844421
2: 16Q0360443 1844416
3: 16Q0360554 1844084

Following are thumbnails of the monitoring and they are linked to the on-line larger version in WORD versions of this document. If viewing by PDF, go to http://www.reefball.org/album/belize/placenciapeninsula/eiareview/coralmonitoring/index.html for high resolution photos. Comments by Mr. Barber are under each slide refer to the prior page for comments by Dr. Rachel Graham..

4/19/06 7:11 AM

Site #1 is the closest mapped "patch reef", it is just to the north of the planned channel and faces the possibility of being covered by accreting sands. The corals are already weakened from bleaching and nutrient stress and will not likely survive the channel construction well.

4/19/06 7:11 AM

Mustard Hill coral (Porites astreoides) surrounded by turf algaes, coraline algae, culerpa, and seagrass.

4/19/06 7:11 AM

Groved Brain coral (Diploria labyrinthiformis) surrounded by sea grass and turf algae. Appears to be bleaching or with very low concentrations of zooxanthellae.

4/19/06 7:12 AM

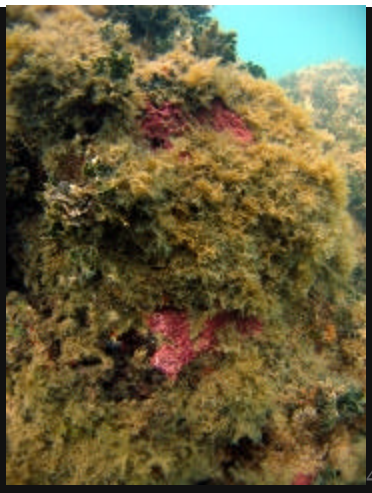
Great Star Coral (Motastrae cavernosa), Beaugregory (or dark phase Sargeant Major) at side. Sponges and algae comunity competiton.

4/19/06 7:13 AM

Anemone in typical algae communities of the area.

4/19/06 7:13 AM

Likely Six Ray Star Coral (Madracis Senaria). Many tube worms in the colony which is typical.



4/19/06 7:14 AM

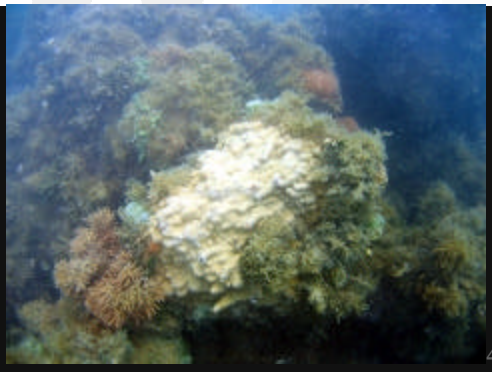
Algae, tunicate and sponge overgrowth of a coral head.

4/19/06 7:14 AM

Likely Masssive Starlet Coral but of an unusual color perhaps due to zooxanthellae.

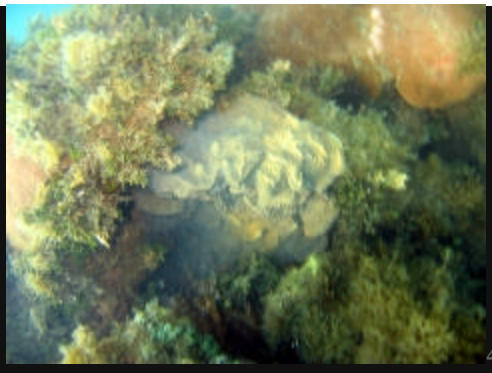
4/19/06 7:14 AM

Typical algae community of site.



4/19/06 7:16 AM

Bleached Mustard Hill coral in typical site algae community.



4/19/06 7:16 AM

Lettuce Coral (Agaricia agaricites)

4/19/06 7:17 AM

Lettuce Coral (Agaricia agaricites)

4/19/06 7:17 AM

Lettuce Coral (Agaricia agaricites)

4/19/06 7:30 AM

4/19/06 7:30 AM

Collection of sand samples

4/19/06 7:30 AM

4/19/06 7:31 AM

Collection of sand samples

4/19/06 7:48 AM

Thin Finger Coral (Porites divaricata) (may be Porites furcata).

Site #2

4/19/06 6:48 AM

Site #2 is second closest Reef to the north of the harbor channel and appears to be the most complex and supports a variety of fish life. (Schoolmaster snapper, foureye butterfly, grey angel, tangs, sargent majors identified in pictures).

4/19/06 6:48 AM

Algae taking over coral heads.

4/19/06 6:48 AM

Algae community taking over coral community.

4/19/06 6:49 AM

Typical reef community. Shows signs of increased nutrients in the form of green hair algae.

4/19/06 6:49 AM

Typical sea grass / algae community over soft bottom in area.

4/19/06 6:50 AM

Typical coral head in the area.

4/19/06 6:51 AM

Starfish

4/19/06 6:52 AM

Typical mixed fouling community in the area.

4/19/06 6:53 AM

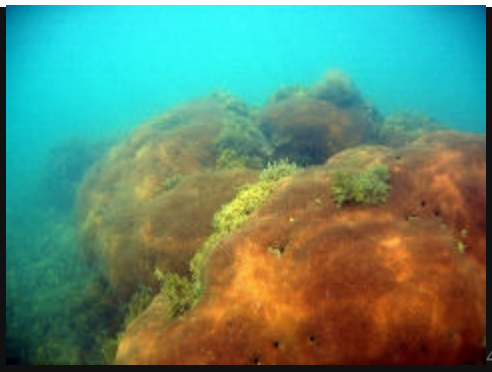
Warty Anemones in the algae community.

4/19/06 6:54 AM

Typical star coral heads in the area.

4/19/06 6:54 AM

Typical star coral heads in the area.



4/19/06 6:54 AM

Typical star coral heads in the area.

4/19/06 6:55 AM

Typical seagrass community in the area.

4/19/06 7:06 AM

Grey Angel, Tang, Schoolmaster Snapper, Sergent Major Damselfish over typical reef comprised of star corals and algae communities.

4/19/06 7:06 AM

Grey Angel, Foureye Butterflyfish, Schoolmaster Snapper over typical reef comprised of star corals and algae communities.

4/19/06 7:06 AM

Grey Angel, Foureye Butterflyfish, Schoolmaster Snapper over typical reef comprised of star corals and algae communities.

4/19/06 7:06 AM

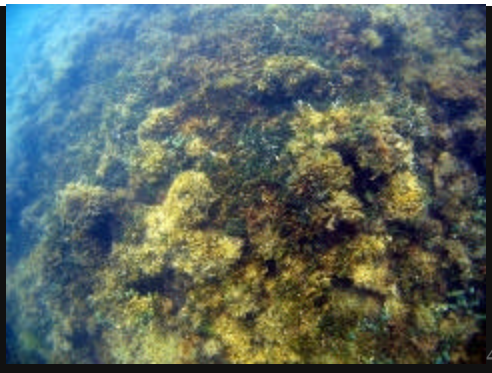
Grey Angel and Schoolmaster over typical reef structures in area.

4/19/06 7:06 AM

Seargent Majors, Tangs (herbavores), Schoolmaster Snappers, Parrotfish over typical area reef structures.

4/19/06 7:07 AM

Sergent Major damselfish over star coral reef formation typical of the area. Sea grasses surround reef.



4/19/06 7:08 AM

Typical algae community in area

Site #3

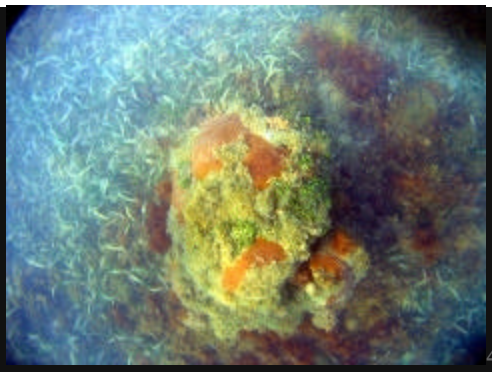
Site #3 is the southern end of the 3rd most northern patch reef in relation to the planned channel. It will face moderate impacts.

4/19/06 5:57 AM

Coral head completely overtaken by algae community.

4/19/06 5:57 AM

Coral head completely overtaken by algae community.



4/19/06 5:58 AM

This coral head struggles to keep from being overgrown.

4/19/06 5:58 AM

This coral head struggles to keep from being overgrown.

4/19/06 6:00 AM

Typical soft bottom seagrass community, also being over grown by turf, brown and calerpa algaes.

4/19/06 6:01 AM

Typical reef community in the area.

4/19/06 6:02 AM

Typical reef community in the area.

4/19/06 6:03 AM

Red algae in the algae community.

4/19/06 6:04 AM

Sponges in the algae community.

4/19/06 6:05 AM

Sea Plumes (Gorgonianas), a soft coral in the area.

4/19/06 6:06 AM

Sponges in the area.

4/19/06 6:08 AM

Porites finger coral amoung the seagrass.

4/19/06 6:08 AM

Typical algae community in the area. (Very diverse in terms of algae variety due to increased nutrient loads).

4/19/06 6:09 AM

Coraline algae (pink) shows up fighting off the turf algaes.

4/19/06 6:10 AM

4/19/06 6:11 AM

4/19/06 6:12 AM

Encrusting sponge takes over coral head, a sign of high nutrient loads.

4/19/06 6:12 AM

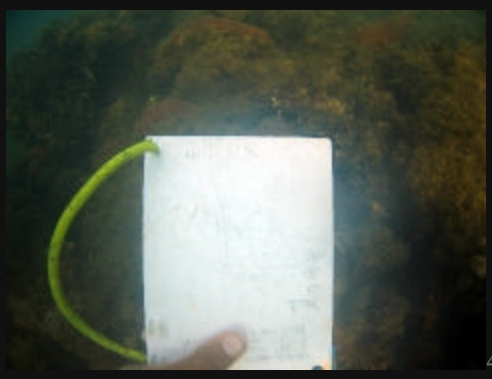
Encrusting sponge takes over coral head, a sign of high nutrient loads.

4/19/06 6:20 AM

Typical reef in the area.

Site #4

4/19/06 6:47 AM



4/19/06 6:21 AM

Site #4 is the most northern patch reef sampled and will probably face only minor impacts from the channel.

4/19/06 6:22 AM

Hard coral showing injury from stress/predation/disease.

4/19/06 6:22 AM

Typical coral head in the area.

4/19/06 6:25 AM

Sponges and algae overgrowth of coral head.

4/19/06 6:26 AM

Sponges and algae overgrowth of coral head.

4/19/06 6:26 AM

algae overgrowth of coral head.

4/19/06 6:28 AM

Corals and Gorgonians (Sea Rods) with algae overgrowth

4/19/06 6:28 AM

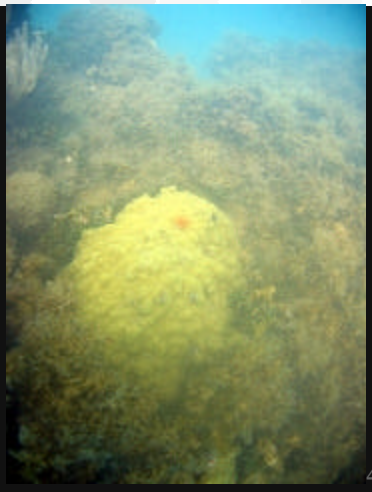
Gorgonians (Sea Rods) with algae and sponge overgrowth

4/19/06 6:29 AM

Typical coral reef in area. Hatian Pink tipped anemones, star corals, christmas tree work (orange/yellow) and some yellow sponges surrounded by algae communities.

4/19/06 6:29 AM

Sponge overtaking coral.



4/19/06 6:35 AM

Mustard Hill Coral.

4/19/06 6:40 AM

Star coral, showing possible signs of bleaching.

4/19/06 6:40 AM

Hustard Hill Coral.

4/19/06 6:40 AM

4/19/06 6:41 AM

Shelf-know Sea Rod in mixed soft/hard bottom community.

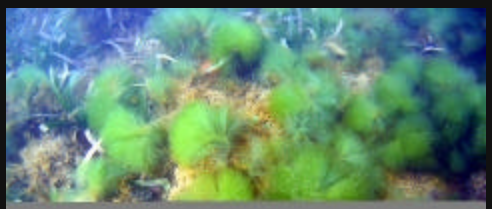
4/19/06 6:42 AM

Overgrown coral head.

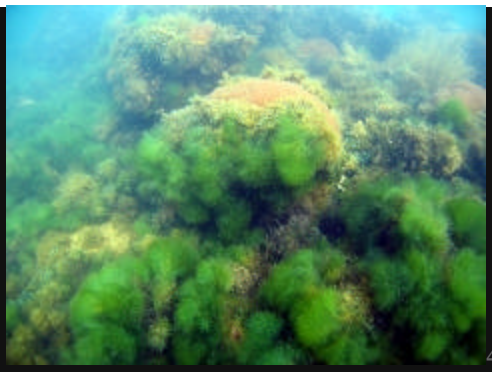
4/19/06 6:42 AM

Black sponge

4/19/06 6:44 AM



4/19/06 6:46 AM



4/19/06 6:46 AM

Site #5

4/19/06 7:48 AM

Site #5 is the closest Reef to the south of the planned channel. It will likely face increased sedimentation.

4/19/06 7:48 AM

Starfish on seagrass bed.

4/19/06 7:49 AM

Star coral next to seagrass

4/19/06 7:49 AM

Sponge and algae over-growth of coral head.

4/19/06 7:49 AM

turf algaes

4/19/06 7:50 AM

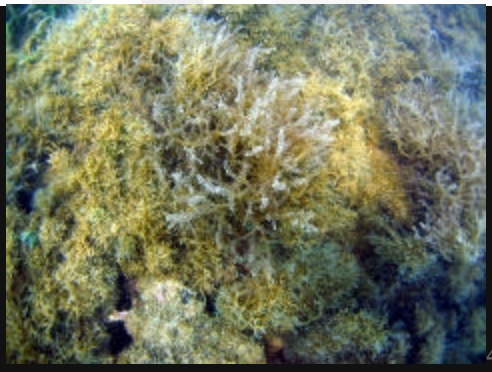
Typical coral head in area.

4/19/06 7:53 AM

Puffer Fish, signs of red boring sponge.

4/19/06 7:55 AM

Typical sea grasses in area.



4/19/06 7:56 AM

Brown and turf algae

4/19/06 7:56 AM

Coral head being overgrown.

4/19/06 7:57 AM

Coral head overgrown by algaes and sponges.

Site #6

4/19/06 8:02 AM

Site #6 is the second closest reef to the south of the planned channel and it will also face sedimentation.

4/19/06 8:02 AM

Coral head being overgrown by algae

4/19/06 8:02 AM

Coral head being overgrown by algae

4/19/06 8:03 AM

Typical Sea grass bed, showing signs of out-competition by algae

4/19/06 8:05 AM

Coral head being overgrown by algae

4/19/06 8:06 AM

Coral head being overgrown by algae

4/19/06 8:06 AM

Typical reef in the area.

4/19/06 8:07 AM

Mustard Hill coral in a coral head being ovegrown by algae

4/19/06 8:07 AM

Sponges and algae overgrowth of coral head

4/19/06 8:07 AM

Star coral with sponge

4/19/06 8:08 AM

Typical coral head in area

4/19/06 8:09 AM

Mustard Hill coral amoung algae and calerpa.

4/19/06 8:09 AM

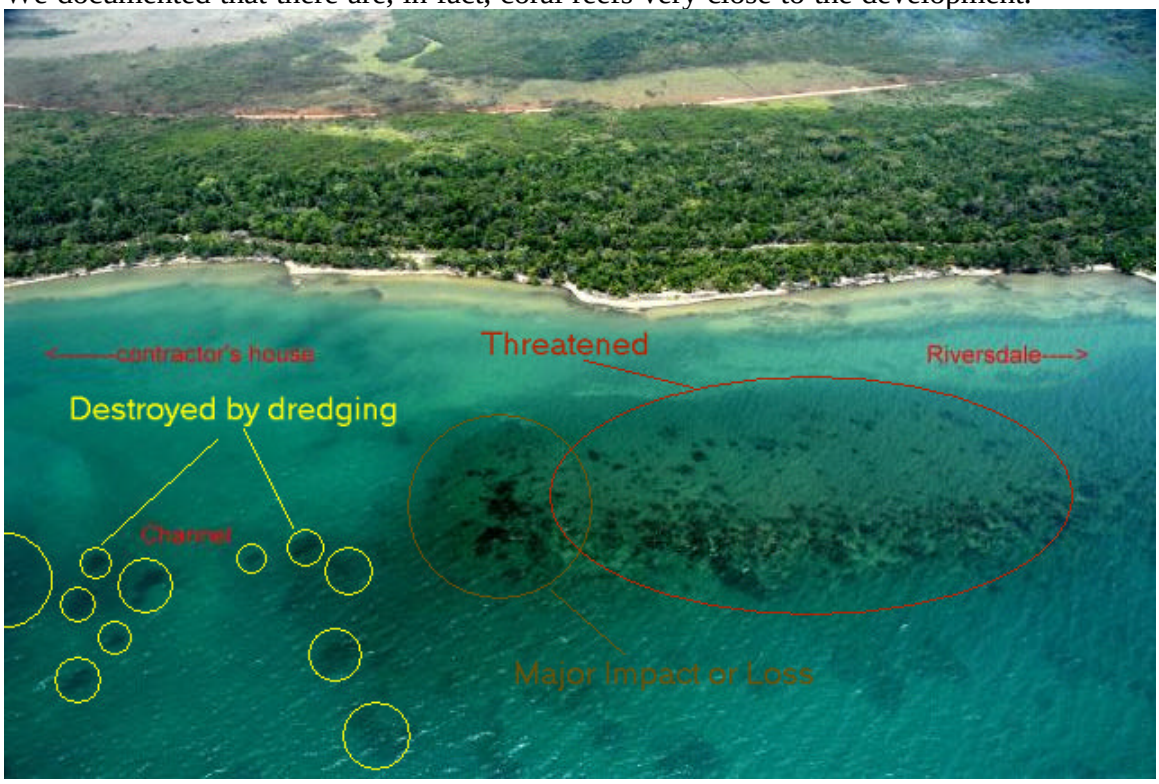
Coral head being over-grown

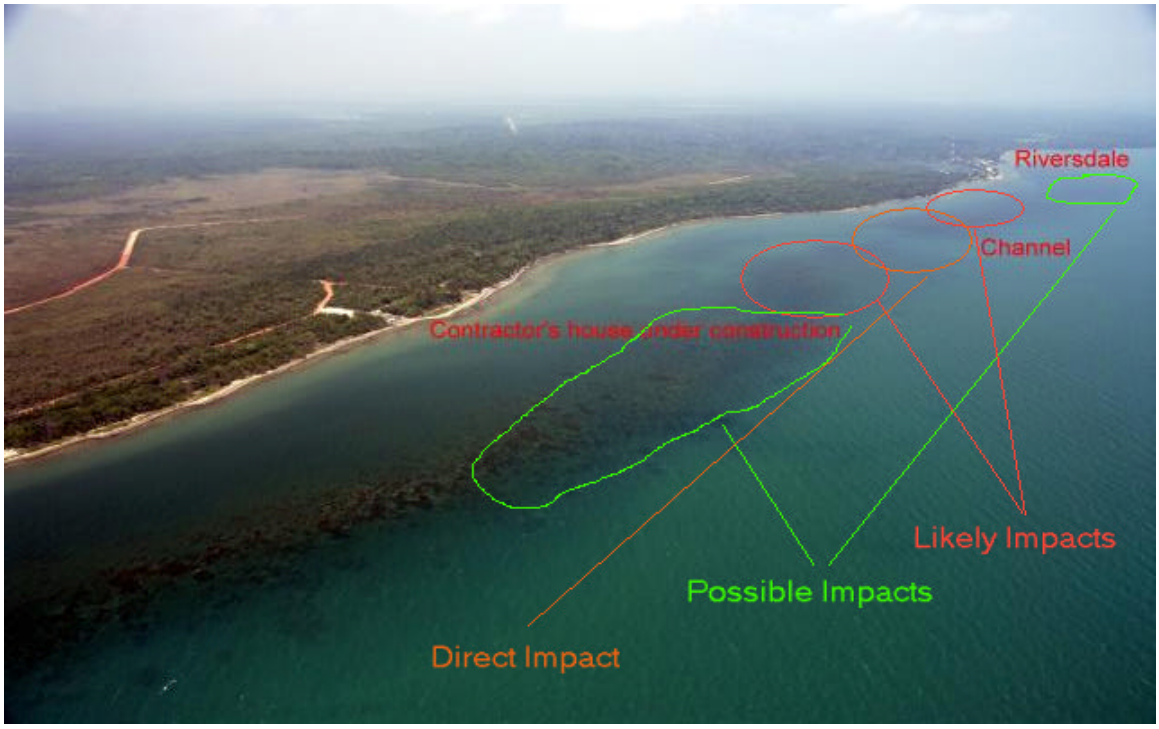
4/19/06 8:10 AM

Sponge over growing coral head.

Monitoring Findings

We documented that there are, in fact, coral reefs very close to the development.



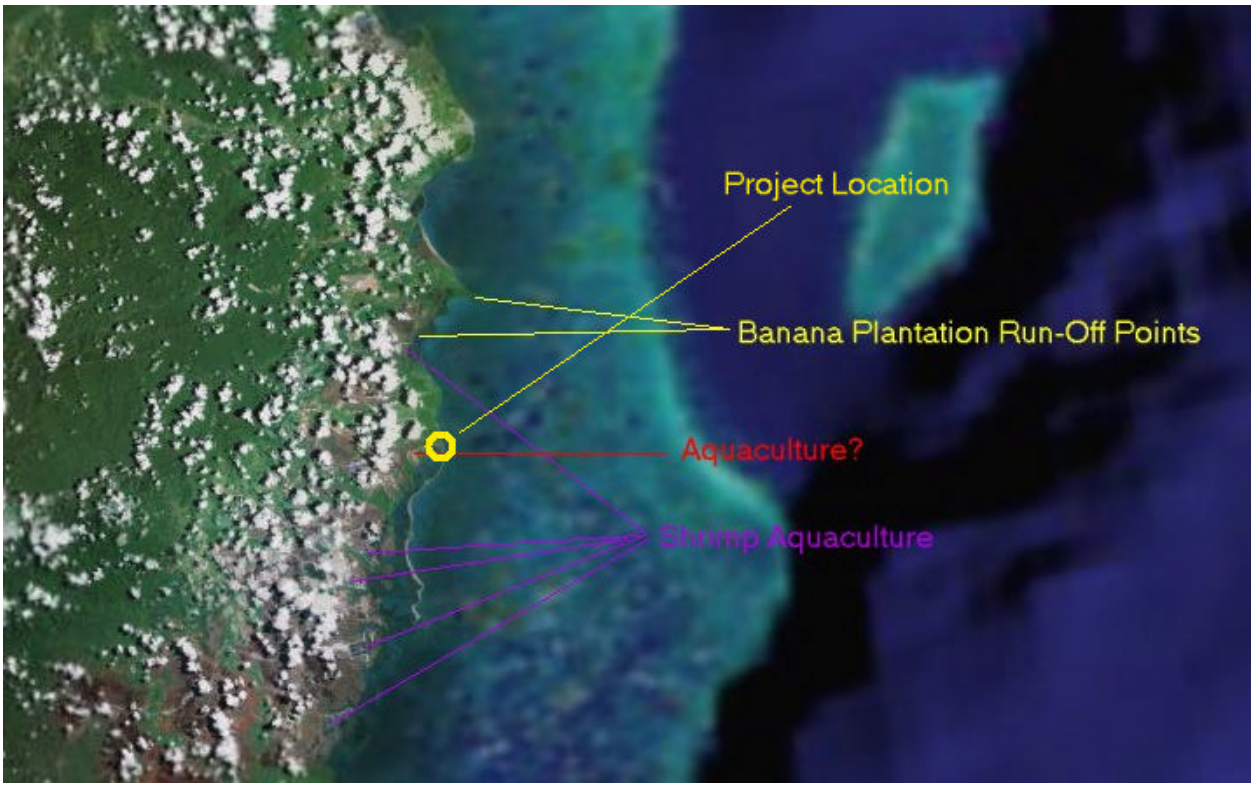


The pictures on the prior page illustrate the likely impacts. We verified, that in fact, the coral reefs in the area ARE degraded by excess nutrients. However, they are still functioning biologically as reef systems due to the coral head structures built in times before the nutrient loadings occurred. Unfortunately, the reefs are bio-eroding faster than they can rebuild themselves which means in the long run the reefs will continue to decline in size. That means that in additional to additional biological losses, the area will begin facing increased erosion rates as more wave energy is transmitted to the land that had been previously attenuated by the coral reef. The lobster fishery will also begin showing declines in adult populations as the ledge habitat is degraded.

It is our opinion that these reefs cannot handle any more impacts, and efforts should immediately be made to reduce nutrient loadings to reverse the algae over-growth of the reefs to allow for reef recovery before the underlying substrate is lost.

This issue is independent of the development, but tied to issue because tourism in this area is linked to the coral reefs. It is in the best interest of both the community and the developer to work to resolve the nutrient loading problems that face these vital coral reefs.

Our review of satellite photographs of the region show that most shrimp farms discharge into the Placencia Bay, and not directly into the Caribbean Sea except for a single farm site 10 miles to 20 miles to the north and far to the south. The Banana Plantations are about 15 miles north of the project site. It has also been reported to us that there is one banana plantation 1.5 miles north of the development site. Given the predominate flow to the south, we expect the Banana Plantations are the biggest nutrient treats to the reef system in the area and probably the source of the nutrient loadings affecting the reef.



(Satellite Photo showing obvious point sources of nutrients in the area: Source: Google Earth)

The EIA presents insufficient evidence to accurately evaluate how much additional nutrient stresses will be placed on the coral reefs near the development site. It also lacks seasonal monitoring of these nutrient levels.

However, we can analyze one nutrient sample presented in the EIA taken in October that can give us some insights into this issue.

First, we should explore what levels of nutrients a coral reef can tolerate. There is controversy over the levels of nutrients that coral reefs can tolerate without being destroyed by algae over growth. The primary nutrients that cause algae overgrowth are phosphates and nitrogen.

It is not disputed that levels near zero are desirable for a pristine coral reef system…but this is rarely possible when people exist in proximity to the reef systems. To further complicate matters, many near shore reefs are adapted to higher nutrients during the rainy season and low levels during the dry season. This means that discharge of nutrients can have different impacts (i.e. relatively low impacts during the rainy season and relatively high impacts during the dry season).

Ignoring the impact of seasons, following is a review on some accepted limits of nutrients for coral reefs.

Dr. Thomas Goreau, of the Coral Reef Alliance takes a conservative approach and suggests that, " It has been established that, The nutrient limits above which over fertilization of the algae causes them to overgrow and kill the reef has been found to be 1.0 micromole per liter (0.014 ppm) of available nitrogen and 0.1 micromole per liter (0.003 ppm) of available phosophorus (Thomas F. Goreau, Nora I. Goreau, Thomas J. Goreau, 1979)"

At the other end of the spectrum, the reef keeping aquarist hobby has tested the limits of nutrient overload in closed systems and found that,

"Systems with high levels of phosphates tend to be infested with hair algae. An upper level 0.1 ppm is recommended by Tullock (1991) with less than 0.05 ppm given by Thiel (1991). Nitrate needs to be below, or at a maximum, of 10 ppm, total nitrogen. Thiel (1991)."

Note: These are very high levels based on closed systems.

So, to account for seasonal impacts it would be safe to assume that Goreau's limits should be used during the dry season and Tullock/Theil's limits should be used during the rainy season as the maximum nutrient load that would allow for safeguarding of the near shore reef systems.

Next, we looked to the EIA to find out what conditions the reefs are actually facing nutrient wise. Unfortunately, the only nitrogen and phosphate analysis was in October during the rainy season when one would expect nutrient levels to be at their peak. To draw conclusions, this analysis needs to be done monthly for at least one full year to account for seasonality and to determine if limits are exceeded during the dry season. (The same it true for photographic monitoring of the reef condition).

Suggestion: Get nutrient data, over time, to obtain seasonal variations of several sampling points within the Caribbean Sea near the development to include (N), (DO), (P) and Secchi Disk turbidity readings.

Of the four samples taken in October 2005, the average total nitrogen was 6.25 PPM and one sample was at the 10 PPM total upper limit. All the samples also showed elevated Phosphate levels averaging .067 PPM with all readings being over the maximum limit for the rainy season. These high levels tend to support the EIA observations that the reef is facing degradation by algae overgrowth…at least during the rainy season. The EIA lacks information if the reefs have a recovery period during the dry season when nutrient levels are lower. Based on our experiences with near shore coral reef systems, this is likely the case and the reason there are still hard corals in the near shore ecosystem.

The following tables summarize the findings for October, 2005.

	Total Nitrogen "Crash Point" (Rainy Season) 10 PPM-Aquarium Industry	Total Phosphate "Crash Point" . (Rainy Season) - .005 to .01 PPM- Aquarium Industry
Site Samples	6.25 PPM (range 3-10)	.0175 PPM (range .012 -.022)
	Total Nitrogen "Crash Point" (Dry Season) 014 PPM - Goreau	Total Phosphate "Crash Point" (Dry Season) 003 PPM Goreau
Site Samples	Not Taken	Not Taken

October 12, 2005

PHYSICAL	UNIT	METHOD	3	4	5	6
CONDUCTIVITY	µs/cm	CONDUCTIVITY (probe)	49200	27900	31300	18380
pH	unit	pH/ISE meter (probe)	8.05	7.01	7.32	6.98
SALINITY	ppt	Mercuric Nitrate titration	29	18.8	21.6	11.2
SUSPENDED SOLIDS (SS)	ppm	Colorimeter	4	21	12	36
TEMPERATURE (IN LAB)	°C	Probe/Thermometer	20	20.5	20.4	21.1
TOTAL DISSOLVED SOLIDS (TDS)	ppm	CONDUCTIVITY (probe)	24600	13940	15640	19190
NITROGEN, TOTAL (N)	ppm	Cadmium Reduction/UV VIS Spectro	5.0	7.0	10.0	3.0
DISSOLVED OXYGEN (DO)	ppm	PROBE	4.07	2.33	2.58	3.27
PHOSPHORUS, TOTAL (P)	ppm	PhosVer/ Orthophosphate/ UV VIS Spectro	0.02	0.016	0.022	0.012

(Sabica & Associates 2006)

Questions: The near shore reef is being threatened by nutrient over-load, at least during the rainy season, from banana agriculture and shrimp farming. How much further degradation is permissible in the long term strategic planning by the government for this area?

-Does the government have long term plans to address the nutrient run-off from the Banana Plantations?

- Does the government have long term plans to address the nutrient run-off from the shrimp farms?

The answer to these questions can help determine what monitoring limits should be set for the development.

To account for the dry season, we did an analysis of average rainfall amounts and adjusted the above rainy and dry season limits for rainfall amounts and projected the "background" level of the nutrients presuming the October nutrient averages vary by rainfall amounts.

We created this chart, based on actual values in October. October numbers form the baseline for the projected background levels of total nitrogen (N) and total phosphates (P). Levels in RED indicated levels significantly past the “crash” point. Levels in Orange are at critical levels.

Month	Avg. Monthly Precip. (inches)	Max N	Projected Background	Max P	Projected Background
January	4.54	4	2.9	0.008	0.0082
February	2.45	2	1.6	0.004	0.0044
March	2.04	2	1.3	0.003	0.0037
April	3.19	3	2.1	0.0055	0.0058
May	4.15	4	2.7	0.007	0.0075
June	8.82	8	5.7	0.01	**0.0160**
July	8.48	8	5.5	0.01	**0.0154**
August	6.81	6	4.4	0.01	**0.0123**
September	9.61	9	6.2	0.01	**0.0174**
October	9.66	9	*6.3*	0.01	***0.0175***
November	7.3	7	4.7	0.01	**0.0132**
Decœmber	6.57	7	4.3	0.01	0.0119

(Analysis would be strengthened by putting actual October 2005 rainfall into the this spreadsheet and recalculating. However, we could not locate rainfall records for that period so we used the average instead).

Preliminary Conclusion: The Caribbean coral reefs can probably tolerate some nitrogen discharges but addition of any amount of Phosphates, particularly during the dry season could have devastating effects on the coral reefs. Our monitoring suggests that both nutrients are already near dangerous levels.

Next, we evaluated the monitoring plan suggested in the EIA to see what levels the resort would consider safe and what levels would raise alarm bells to reduce discharges.

Following is the monitoring table from the report

RECOMMENDED MONITORING PLAN
ARA MACAO MARINA

PARAMETERS	FREQUENCY	CRITICAL LEVELS	AREA/LOCALE	PRIORITY
Effluent Impact				
Phosphate	Bi-monthly	10 mg/l	S. marina entrance channel at max ebb tide. N. side of N. breakwater- control.	High Priority
E-Coli	Bi-monthly	>0/100 ml	Same as above	High Priority
Nitrate	Bi-monthly	10 mg/l	Same as above	High Priority
TSS	Bi-monthly	100 mg/l	Same as above	High Priority
Heavy Metals	Bi-monthly	26 - 39 mg/l (EPA/WHO)	Same as above	High Priority
Turbidity	Bi-monthly	5 ft. Secchi Depth	Same as above	High Priority
BOD	Bi-monthly	200 mg/l (EPA/WHO)	Same as above	High Priority
Dissolved Oxygen	Daily	5.0-6.5 mg/l (EPA/WHO)	Same as above	High Priority
Temperature	Daily	30 C (EPA/WHO)	Same as above	Low Prioity
Bathymetry				
Depth in Marina	During Dredging	no loose sediment accumulation	Channels	High Priority
Hydrology				
Flow Rates & Volume	Bi-monthly esp. during rainy season	(Estab. baseline data)	Bridge over south channel at max ebb and max flood tide	Low Prioity
Salt Wedge Penetration - salinity at surface and bottom	Bi-monthly esp. during rainy season	(Estab. baseline data)	West end of marina basin at slack tide	Low Prioity
Beach Dynamics**				
Erosion	Bi-monthly	No significant beach loss	Beaches – ALL	Moderate Priority
Sea Defenses	Bi-monthly	No collapse of sea defenses	Section across heads of both channel breakwaters	Moderate Priority

100 times higher than acceptable for reefs

10 times higher than acceptable for reefs

We recomend 10 ft Secchi depth

This is recommended, who is responsible for this and what actions will take place if levels are exceeded?

33

SHABICA & ASSOCIATES, INC. 2006

The levels that would raise the alarm were 10 (N) to 100 (P) times higher than required to crash the reef if the reef were located directly in front of the marina entrances. However, modeling would show that dilution will take place before these nutrients reach the nearby reefs. The question is…how much dilution? What levels are safe?

Although extensive modeling was done for the flows within the marina, there was no modeling offered as to the dilution factors for nutrients approaching the nearby reefs. This would be necessary to calculate the amount of nutrient discharge for the Caribbean side of the development. As an alternative once the development is constructed, dye studies could be conducted to gauge the dilution factors.

The biggest concern should be phosphates, because these are already at high levels. It is also important to monitor turbidity and our recommendation at the marina is to maintain at least 10 feet secchi disk visibility rather than 5 feet, at least until dilution factors are calculated.

Suggestion: Model the nutrient flows from the development to the coral reefs to determine acceptable discharge limits. Remember the calculation has to include the maximum limit to the reefs, less current nutrient loads, less nutrient loads added by the development.

Questions: Who is doing the monitoring long term as suggested in the EIA? What mechanism will insure that the monitoring continues? What enforcement will insure that action is taken to reduce nutrient loads if they are exceeded?

Noteworthy: "Increased levels of a range of contaminants (trace metals, pesticides, polyaromatic hydrocarbons) were found in soil samples and river sediments, but these were well below globally acknowledged safe levels. No significantly elevated concentrations of any contaminants were found in marine sediments." *(WRIScS)*

Increased Nutrient Load (Placencia Lagoon Only)
& Degradation of Reef Supporting Estuary or Mangrove Systems

It is also presumed that the Placencia Lagoon has high nutrient levels. The number of shrimp farms on the lagoon suggests that this observation is probably correct.

However, tolerable nutrient levels for estuary systems are much higher than for offshore coral reefs. Nitrogen, for example can be as high as 100 ppm without harming fish.

One of the most important variables to look at for estuary heath is dissolved oxygen levels (DO), which are actually a surrogate for nutrients because high nutrients can lead to low dissolved oxygen levels because planktonic life consumes oxygen when "fertilized" by nutrients.

There were DO measurements taken in September and October. They indicate the health of the lagoon was better in September than October. Likely, there was less rain in September or perhaps a rainfall in October prior to the measurements being taken.

September 20, 2005 Lagoon / Estuary

NITROGEN, TOTAL (N)	ppm	Cadmium Reduction/UV VIS Spectro	N/D
DISSOLVED OXYGEN (DO)	ppm	PROBE	5.66
PHOSPHORUS, TOTAL (P)	ppm	PhosVer/ Orthophosphate/ UV VIS Spectro	

October 12, 2005

NITROGEN, TOTAL (N)	ppm	Cadmium Reduction/UV VIS Spectro	2.0
DISSOLVED OXYGEN (DO)	ppm	PROBE	3.2
PHOSPHORUS, TOTAL (P)	ppm	PhosVer/ Orthophosphate/ UV VIS Spectro	0.011

As dissolved oxygen levels in water drop below 5.0 mg/l, aquatic life is put under stress. The lower the concentration, the greater the stress. Oxygen levels that remain below 1-2 mg/l for a few hours can result in large fish kills. Clearly, there was a great deal of stress within the bay in October.

That is a big concern since nearly all of the run off from the golf course and most of the resort nutrient load will be discharged to the lagoon. This is certainly preferable to discharging into the Caribbean side and it is fortunate that the drainage pattern will allow for discharges in this direction. However, DO levels need to be monitored for a year to ascertain the range the lagoon experiences and to determine if the planned development discharges will not lower DO levels to anoxic conditions causing marine life death.

Another concern is the lagoons ability to absorb the nutrients and prevent their discharge into the Caribbean sea. Estuaries tend to adapt to nutrient loads by algae and seagrasses occupying more space on the sea floor using the sun's energy to convert the nutrients into

plant growth. When this space runs out, nutrients begin to start spilling into the sea at the exits of the estuary system.

It has been estimated that the leaching and runoff rate of nitrogen in the chemical fertilizers applied on golf courses averages about 32%. (This can be improved significantly with an active nutrient management plan). Leaching rates are higher for phosphorus so added importance should be given to controlling the phosphorus loading for the management the golf courses. We could not find in the report the maximum amount of fertilizers that would be permitted annually on the golf courses and resort associated landscaping. This should be stated in the EIA and maximum limits set by regulators based on the amount of mitigation offered. We suggest the limit of phosphorus be more stringent than other nutrient limits. Whatever limits are imposed, the EIA should then perform calculations to estimate how much of these will be discharged into the lagoon and how much of an impact on DO is anticipated.

Since it is not possible to add more bottom to the lagoon, we believe a reasonable mitigation for the loadings presented is the planting of additional red mangroves (*Rhizophora mangle*). This will increase the ability of the estuary to absorb the added nutrients and prevent them migrating to the Caribbean.

"The mangrove habitat of Placencia Lagoon is one of the most important ecosystems in Belize." (www.belizediscover.com).

Red Mangroves roots provide a large amount of surface area for conversion of nutrient and provide excellent habitat for juvenile lobster, and juvenile fish including herbivores necessary to convert plants to animal matter for assimilation into the food chain.

Without a site survey, we cannot recommend where to plant the Red Mangroves for maximum benefit, but certainly the water boundaries of the resort on the Lagoon side could benefit from reforesting red mangroves. The process of reforesting is very simple and inexpensive on the lagoon side since the site has minimal wave climates and low tide ranges. These mangroves would serve as additional habitat for the snowy egret, the white ibis, frigate birds, brown boobies, pelicans and other wildlife in the area.

If Red Mangroves are not desired for mitigation, perhaps the developer could help the shrimp farmers or banana plantations to reduce their nutrient loadings to offset those added by the resort.

If at all possible, reducing the golf course to 9 holes from 18 holes would dramatically cut nutrient run-off (presuming the golf course footprint was equally halved) as the golf course is typically the worst "nutrient" offender. Perhaps the golf course could be eliminated altogether and build a short distance inland?

Limitation: "There is not enough information to determine impacts to the Lagoon." Suggestion: Get an estuary specialist to review the impacts to the estuary system.

Increased Sedimentation (Caribbean Side)

Note on current conditions: "Based on these findings, there is no evidence to suggest that changed sedimentary processes resulting from farming activity to date in the study area are having a negative impact on the Barrier Reef. The natural coastal system is effective in dealing with the impact of increased sediment yield and sediment contaminant loading produced by current land-use." *(WRIScS)*

Next to nutrient loading, sedimentation is one of the greatest enemy's of coral reefs. We have two major concerns in regards to sedimentation. 1) sedimentation from dredging & subsequent sand by-passing operations, 2) sedimentation generated by the Marina and increased boating traffic.

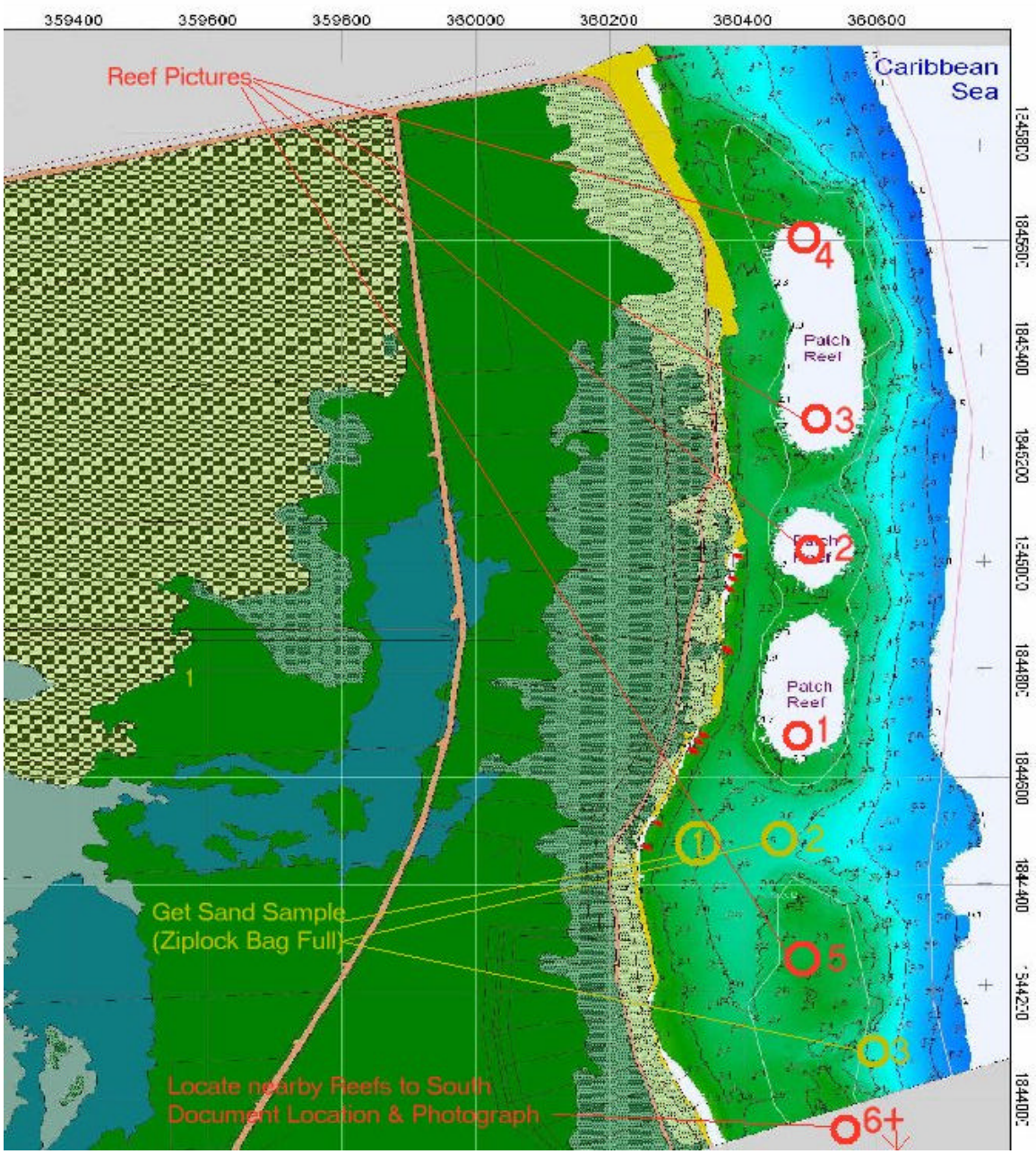
Sedimentation from dredging & subsequent sand by-passing operations

Accreting Beach in Swash Zone Harbor Entrance Location **BAM 002** **UTM Coordinates: N1844650, E360230 ***

Wentworth Classification	U.S. Std. Sieve	Weight (g)	%	Cum %
Very Coarse Sand	5 to 12	3.1	10.26	10.27
Coarse Sand	12-20	12.6	41.72	51.99
Coarse Sand	20-30	3.3	10.93	62.91
Medium Sand	30-60	2.1	6.95	69.87
Fine Sand	60-100	3.8	12.58	82.45
Very Fine Sand	<100	5.3	17.55	100.00
	TOTAL	**30.2**	**100**	

Above is the analysis of the sand just outside the marina entrance where dredging of the channel for boat access will take place. 17.55% of the sand is of a size smaller than #100. This need to be further analyzed at #120, #230 & Greater (silt). Grains as small as #120 can be adequately contained by sediment skirts. #230, even on very calm days can affect corals 300-500 meters away and silt or mud (smaller than #230) can travel miles.

We therefore analyzed this area ourselves and found the following that shows even finer sand distributions than reported in the EIA.



Sample #1 Yellow #1 on map

	Volume (ML)	Weight (G)	Vol	Wgt
#10	2	1	0.43%	0.17%
#35	2	6	0.43%	1.00%
#60	260	336	55.56%	56.00%
#120	170	215	36.32%	35.83%
#230	30	34	6.41%	5.67%
> 230	4	8	0.85%	1.33%
Total	468	600		

Percent Greater than #230

7.26% 7.00%

Sample #2
Yellow #2 on map

	Volume (ML)	***Weight (G)***	***Vol***	***Wgt***
#10	***65***	***57***	***12.15%***	***12.05%***
#35	***125***	***107***	***23.36%***	***22.62%***
#60	***125***	***109***	***23.36%***	***23.04%***
#120	***100***	***95***	***18.69%***	***20.08%***
#230	***50***	***48***	***9.35%***	***10.15%***
> 230	***70***	***57***	***13.08%***	***12.05%***
Total	***535***	***473***		

Percent Greater than #230

22.43% 22.20%

Analysis by Todd Barber, sand collected by Dr. Rachel Graham. Unfortunately, there is at least 22% of mud/silt that cannot be contained by even with sedimentation curtains at the area closest to the reef. Inshore, it is a bit better sorted with 7% that cannot be contained when dredged.

Additional monitoring

Sample #3

	Volume (ML)	Weight (G)	Vol	Wgt
#10	90	65	16.79%	12.42%
#35	220	199	41.04%	38.01%
#60	155	160	28.92%	30.56%
#120	65	78	12.13%	14.90%
#230	5	21	0.93%	4.01%
> 230	1	0.5	0.19%	0.10%
Total	536	523.5		

Percent Greater than #230	
1.12%	4.11%

Site #3 was not in the dredge zone, and is useful as a baseline.

Dredging is possible without major harm when water is calm, and water temperatures are below stress levels, (When http://coralreefwatch.noaa.gov/satellite/ge/ levels are below 1). Corals could handle 2-4 weeks of minor situation stress with a recovery period of 90 days without significant damage.

Therefore, dredging operations should not to last longer than 14 days with 90-day breaks and only when the NOAA Sea Surface Temperature scales for the area indicate no thermal stress on the corals.

Proper use of silt curtains should always be required even though they may not be effective for the finest sediments we located in the channel.

If the developer needs to accelerate the dredging pace, this, too, is possible with additional sediment monitoring on the nearby reefs. (For example, it may be okay to resume with less than a 90-day break if prevailing currents have changed and the impacts will be to reefs that were not previously stressed by dredging activities).

Suggestion: “Develop a coral sedimentation stress plan for dredge scheduling?”

Sedimentation generated by the Marina and increased boating traffic.

A large marina will generate a lot of boat traffic. And boat traffic can stir up the sea bed and create sedimentation. The designed flushing of the marina (a good feature from a nutrient load point of view) could carry some of this sedimentation to the sea.

This will be especially bad when the marina is new, because newly the newly created seabed will contain many fines, silt and mud. Therefore, silt curtains should be maintained at the harbor entrances until the marina is opened for boat traffic to allow the new bottom to stabilize.

If possible, the bottom should be excavated to a depth of 1 foot deeper than desired, and a bed of course sand can be laid on top of the bottom to better seal off the fines, silt and mud. This may be economical if the developer has more dredge material than needed for land reclamation. However, an extra step in processing is required to remove the fines from the dredged materials.

Another step is to make sure the marina is dredged to a sufficient depth that the largest vessels entering the marina still have plenty of clearance for their prop wash.

The magnitude of this problem may be so negligible that it can be dismissed or very important depending upon the analysis of the final layer of bottom left after dredging. The EIA should specify this being tested and appropriate remedies taken if required.

Suggestion: “Perform a sieve analysis on the bottom of the marina after it is excavated and take appropriate action to reduce sedimentation if necessary”

Whatever is decided upon, the sedimentation generated by the marina (especially during construction when first opened to the sea) needs to be factored into the rest periods and maximum situation stress on the corals as defined in the previous section.

Introduction of Reef Toxins

Most developments will have a variety of toxic run-offs as it relates to marine life such as asphalt surfaces, pesticides, insecticides, pool chemicals, and the like. However, the main concern for this development are golf course chemicals and chemicals used in the marina operations. Fortunately, the Golf course toxins will impact the Lagoon, not the coral reefs but they will still impact marine life and the more persistent ones can find their way to the Caribbean. Additionally, because the health of the lagoon is linked to the

coral reefs, it is still an important issue for reefs. Unfortunately, the chemicals used in the Marina operations may very well leach directly to the Caribbean.

In an initial response to the EIA, Mary Toy of Destinations Belize created a list of chemicals that would be used to upkeep the golf course we have bolded potential impacts to marine life from her descriptions:

- **Permethrin:** a neurotoxin and is classified by the EPA as a carcinogen (cancer causing). Permethrin is toxic to honey bees and other beneficial insects, **fish**, **aquatic insects, crayfish, and shrimp**. For many species, concentrations of less than one part per billion are lethal. Permethrin causes deformities and other developmental problems in tadpoles, and reduces the number of oxygen-carrying cells in the blood of birds.

- **Benomyl**: **highly toxic to fish**

- **Carbofuran:** granular form banned in the US because of very high toxicity to birds. One granule is sufficient to kill a small bird. Bird kills have occurred whenbirds ingested carbofuran granules, which resemble grain seeds in size and shape, or when predatory or scavenging birds have ingested small birds or mammals that have eaten carbofuran pellets. **Carbofuran is also highly toxic to many fish.**

- **Lambda cyhalothrin**: **highly toxic to fish**

- **Methomyl**: highly toxic compound in EPA toxicity class I. It is classified as Restricted Use Pesticide (RUP) by EPA because of its high acute toxicity to humans. Methomyl is highly toxic to birds and **aquatic invertebrates** (such as lobster).

- **Chlorpyrifos**: highly toxic to **aquatic invertebrates and estuary (lagoon) and marine organisms**. Due to its acute high toxicity and its persistence in sediments, chlorpyrifos may constitute a hazard to sea bottom dwellers. Aquatic and general agricultural uses of chlorpyrifos pose a serious hazard to wildlife and honeybees. Chlorpyrifos may be toxic to some plants, such as lettuce [36]. Residues remain on plant surfaces for approximately 10 to 14 days. Data indicate that this insecticideand its soil metabolites can accumulate in certain crops.

- **Cyflurthrin**: highly toxic to marine and freshwater organisms. **Marine and estuarine invertebrates are also extremely sensitive to cyfluthrin**.

- **Abamectin: highly toxic to fish and extremely toxic to aquatic invertebrates**.

- **Paraquat (Preglone):** highly toxic compound in EPA toxicity class I. DANGER - POISON. Paraquat is a Restricted Use Pesticide (RUP).

Obviously, some chemicals are required for the management of golf courses. The EIA should present how the developer will minimize the use of these toxins and select alternative solutions that have less impact on the marine and terrestrial ecosystem.

Question: "How will the developer minimize the use of environmentally damaging chemicals on the golf courses?"

We suggest mitigation requirements for corresponding uses of these compounds to give the developer incentive to minimize their use.

In terms of the management of the marina, major concerns include oil & gas management (in particular fueling stations), management of anti-fouling paints, management of boat septic pump-out, management of fiberglass materials (including acetone, resins and hardners), use or sale of plastic bags (will this be prohibited?), management of fish cleaning stations, and other industrial operations.

All of these need to be reviewed in light of their potential impacts to the surrounding coral reefs and these impacts should be contained in the EIA.

Increased Exposure to Boat Groundings

The large number of new boats that will be attracted to the marina begs the question,

Question: "Are the reefs near the development marked and lighted to allow navigation to the port without un-intentional ship groundings?"

Groundings and prop scars are a major source of damage to reef systems world-wide. In the US, developers rarely worry about this because the Coast Guard maintains navigational markers. However, many developing countries lack the adequate resources to build or maintain navigational markers. The EIA should present a plan to make sure this is accomplished.

Sand Covering the Coral Reef

To address the issue of accreting sands potentially covering patch reefs, on a wider scale we need to address the coastal structures proposed by the project and their probable impacts.

Boat access to the marina necessitates a channel being cut, and a groin to protect the channel from being filled by sand during the generally southward sand transport system along the littoral coast of Placencia.

"Currents inside the reef are mostly southward flowing, but were observed on occasion to reverse to produce northerly flow, persistently during the months of September and October. Geostrophic forces are thought to be the primary control of flow inside the reef, wind, tide and river discharge playing secondary roles." *(WRIScS)*

Coastal processes dictate that with a net southerly sand transport, a groin will accrete sand to the north, and starve sand to the south in the normal system condition. This could be exaggerated greatly in the case of a hurricane or other unusual storm event.

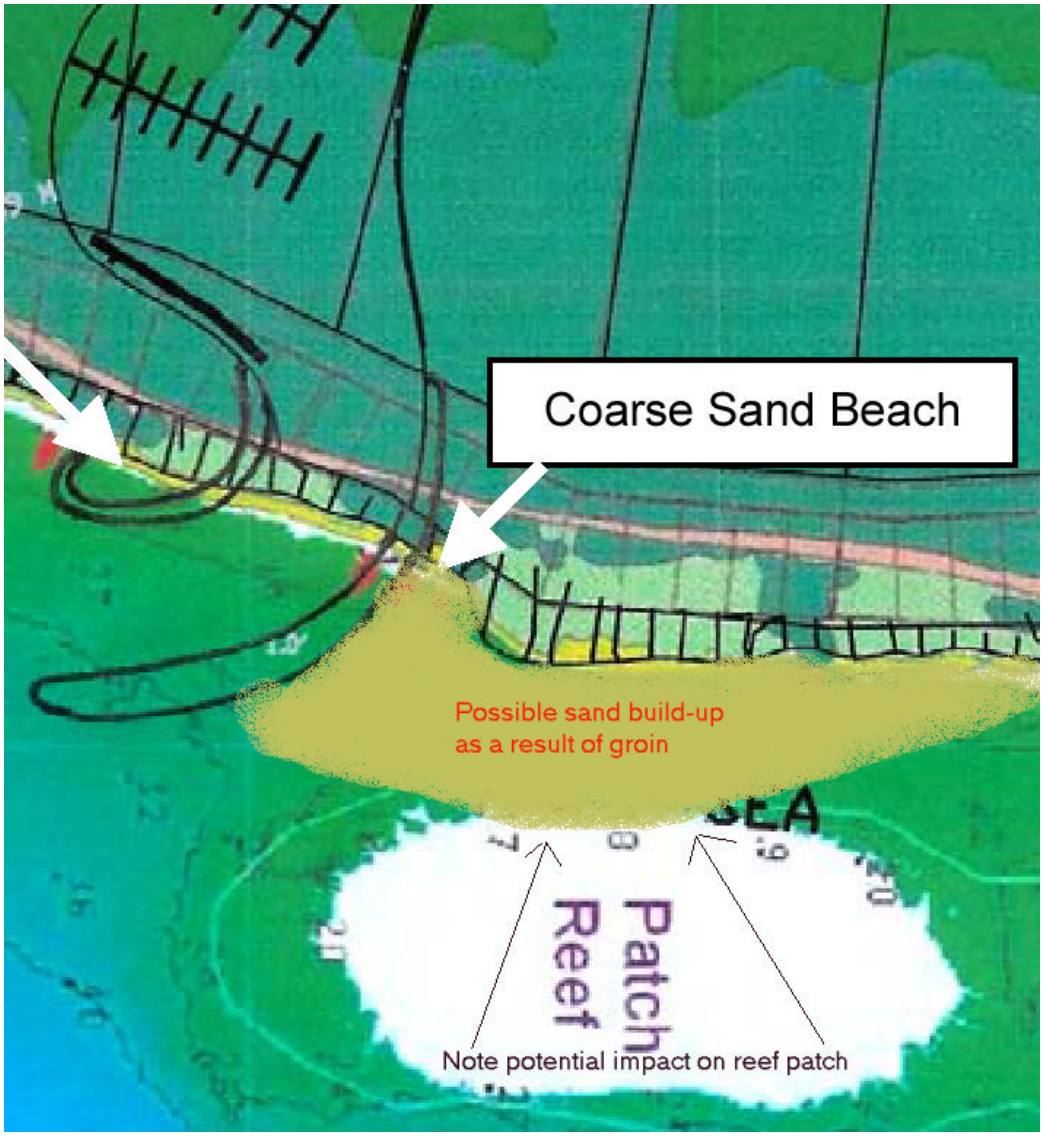
The engineers have tried to minimize this effect by minimizing the eastern length of the groin and this is to be commended as it will likely allow some natural sand by-passing.

To compensate for this interruption of sand flows, the project recommends sand by-passing which amounts to re-dredging the channel when it fills and placing this material on the southern side of the groins/channel. This is the correct engineering solution for the proposed coastal structures. If everything works "as planned", down drift erosion could be limited only to the starvation from the initial filling of the beaches north of the jetties.

However, interval sand by passing cannot guarantee the lack of downstream erosion to the south nor can it guarantee that the sands do not over-accrete to the north.

Additionally, this means that maintenance dredging and beach sand filling will become necessary in perpetuity as long as groins and channel remain. There is also the very real possibility that sand will try to by pass the channels offshore and this sand may or may not make it back to shore south of the structures. If it does not make it back to shore, erosion will be the result. Either way, this sand may flow over natural reefs offshore, killing them.

Additionally, the sand that accretes to the north may back up sufficiently to cover the natural reefs as shown in the diagram below:


Coarse Sand Beach
Possible sand build-up
as a result of groin
Patch
Reef
Note potential impact on reef patch

Recommendation: We recommend an independent evaluation of the down stream erosion potential, upstream over accretion possibility and offshore sand transport over reefs by Dr. Lee Harris of The Florida Institute of Technology who is a renowned expert on the effect of coastal structures. Dr. Harris can be reached at lharris@fit.edu.

Evidence that the conclusions about no downstream erosion impacts need review

There is a contention in the report that the coastal works will reduce sedimentation on the coral reefs by covering eroding areas with course sands and that this will lead to reef recovery. The eroding sands all contain less than 2% of silt (sieve smaller than #100)

So, at best, and any gains will be offset by the perpetual dredging activities. Claims that the development will aid in the recovery of the reefs due to reduced sedimentation (as presented) are unfounded.

Degradation of Reef Supporting Estuary or Mangrove Systems

See "Increased Nutrient Load (Placencia Lagoon Only)" Page 10

Increased Turbidity

See "Sedimentation generated by the Marina and increased boating traffic." Page 13

Increased Coral Reef Usage Pressure

A development of this size will increase the usage of the coral reefs for fishing, diving, and snorkeling. There are a number of things a developer can do to help offset the additional damage or pressure on the reefs.

Some of the following are useful tools for the management of increased use of reefs:

- Installation of Mooring Buoys at commonly dived reef sites
- Installation of an artificial snorkeling trail off the main resort beach areas to take pressure off nearshore natural reefs.
- Creation of a no-take zones
- Guest education program for appropriate coral reef interaction.

Direct Physical Damage to Corals

The EIA lacks a comprehensive marine life bottom survey for the seabed that will be dredged. Technology exists to easily remove, propagate and replant corals or other marine species that are in the path of the dredge work. It is unclear if this needs to be undertaken but unless the area is a barren sand bed some work may be necessary.

Note: Supplement this section with Rachel's report

EIA Review Summary

The developer has taken care to hire some of the best talents in industry to assist with the EIA and included valuable local specialists which is essential for EIAs. Special attention was paid to the discharges of wastewater and the careful management and treatment of the water used by the resort.

The economics of the project from the developer's point of view are well founded. And the developer states that there is a need for the services the marina and resort will offer in this part of the Caribbean. However, the resort would be the largest resort in the country of Belize and could overwhelm the local infrastructure (garbage collection and disposal, electricity, health care, schools, police, roads, water, etc). Although a marina may be needed, perhaps it does not have to be as large as proposed. In this part of the world, there are few, if any public resources to respond to oil spills or other toxic waste spills, and there are no hazardous waste disposal resources. However, the development does seem to be consistent with the management plans of the government of Belize for this region and for the country as a whole.

Sighting the marina inside the peninsula by bucket dredging rather than in the Caribbean is also a good choice, since it avoids additional direct impacts to the sea floor.

To improve the EIA, the coastal engineering section should be redone from a "developing country" perspective. That section was written from a "Developed Country" perspective. It assumes an enormous amount of on-going monitoring and maintenance that admittedly works well in the developed world where monitoring is required by law and enforced. However, it has been our experience in developing countries that the on-going monitoring efforts are abandoned after the project is completed unless there are problems that negatively impact the operator of the resort.

On-going monitoring is not typically enforced in developing countries so any monitoring associated with environmental impacts are quickly abandoned due to costs and fear of uncovering damaging practices that will be expensive to correct.

Appendix 1: EIA Review by Dr. Tom Williams

TOR for EIA (basis for studies) Appendix 1, p. 1

The provided EIA does not comply with the specific requirements of the EIA Terms of Reference as included in the Annex I and thereby is inadequate and incomplete for the purposes of review of the Project..

The available responses to the TOR are also inadequate and incomplete, and some appear to be erroneous or contrived.

Item i. Water Resources

Item I Water Resources is indicated as an important element of the TOR defining the Scoping elements. Under Section 2, p.4, the TOR clearly defines many parameters to be included in Water Resources.

The EIA fails to address the following elements in the TOR:

- Establish seasonal variations;
- Dissolved oxygen levels – surface and below surface – am/pm all at the same time;
- Temperature, DO, and pH were to be tested in the field – not lab;
- No detail was provide for household appliances, or others, only summarized as Lpd;
- No sustainable safe “maximum” yield was developed for the confined, pressurized aquifer;
- No inventory of deep wells in the same pressurized aquifer provided;
- No adequate pre-EIA or post-EIA monitoring program has been defined and committed to for the groundwater aquifer;
- No separation of grey and black waters has been provided.

The absence of these data and information renders review of the inadequate data provided indicative at best. Various issues arise from the review of these data to clearly indicate that the persons collecting, handling, analyzing, and assessing the water parameter are either inexperienced or they are not unbiased toward the project.

Water Use (Sec. 5)

The overall impression is that the proponent is grossly underestimating the water demand and thereby the sewage flows in order to reduce the appearance of

effects of and on the projects. No information is provided as to whether the project financials are based on the same assumptions as those used in the EIA.

The basis of water resources assessment for the project starts first with the population and floor area, then the rates of consumption for each, and arrives at the overall supply requirement. Use of the Belize City "rates" can not be used as a rate for the proposed development, as the population of the proposed development is expected to be more similar to the retirees of Maimi rather than the permanent residents of Belize City and those persons occupying the larger than average Belize City villas, townhouses, and condo.

The project occupancy (p.5.1) indicates 4-6 persons per occupation/dwelling units (813 DUs and 50 units for labor accommodation) which appear to be high for "retirees" unless they are included frequent visits of relatives. Such inflated residential numbers may indicate the proponents need to get the local retail population up sufficient to justify the commercial and marina development, as most people would see the total population and think these would be a lot of buyers of goods and services.

No explanation is given for the 5648 persons in the "reception and commercial areas" as to whether these are the visitors, the employees, or some other unit. Without definition of the "areas" uses or the character and duration of the persons within the "areas", these render the rates per person virtually useless. Such inflated visitor numbers may indicate the proponents need to get the retail population up sufficient to justify the commercial, casino, night club, and marina developments, as most people would see the total population and think these would be a lot of users of casinos, nightclubs, and other related services.

This number may also reflect the presence of other outside visitors arriving at the Project from Belize City, other Cruise ports, or being lightered from passing cruise ships in order to enjoy the gambling and nightclubs on land, rather than in the ships. Water uses of this area of the Project remain low compared to other such venues in the Caribbean, Florida, and the Bahama; such cruise ship users generally demand services requiring far higher "cleanliness and hygiene" than that inferred by 150 Lpd.

Generally the population of employees should be stated separately from the visitors and customers for all of the commercial areas.

Similarly the 880 persons in the "Maintenance Area" appears to be employees in excess of those in the Employee Housing (300p, dealers, performers, executives, etc.) and the reader has to assume that these "maintenance" employees are those to be housed OFF-SITE.

70% occupancy can only be applied to the purely commercial residential units as employees would be presumably still on duty whether the occupancy is 70% or 100%. 70% is usually for financials, while 100% should be applied to utilities, unless as not mentioned there is adequate water storage and sewage handling capabilities. A 70% occupancy rate for villas and large condos would suggest a very affluent retirement community or again the proponents are attempting to reduce the volume of water needed from the groundwater wells.

Water Use Rate

No recognized source of water use rates is given, and no technical approach is provided (i.e., so much per sq.m of floor area + so much for employees, etc.), therefore the entire development of water use appears fabricated without substantive basis, totally inadequate and incomplete for review and assessment.

Water use rates of 150 Lpd are unusually low especially for Casinos and hotels which can go up to 500Lpd.

A water use rate of precisely 38 Lpd for the undefined “reception and commercial areas” with the precise 5648 persons can not be justified as such accuracies would indicate that the rate and personages are based on information far more reliable than that suggested by the EIA.

Use rates should be perhaps doubled those given (250-300 Lpd) but without clear analyses as to how the personages were derived it is meaningless to have such precision or to modify it – the entire analyses are either unsubstantiated or erroneous or they are developed to avoid dealing with the issues of water resources.

Groundwater Confined Aquifers

As a confined aquifer is the only practical source of water for the project, the description of a stable, high head is typical of a confined aquifer, as long as one does not pump a great deal. An aquifer test rather than a “well” or pump test is required – pumping for four-ten days at a rate of at least equivalent to the project supply requirement. As no other deep boring information is available, no confirmation is possible for the adequacy of the well No.s 1-2.

The assessment of the aquifer does need a qualified hydro-geologist or geo-hydrologist and a good “well”, better yet aquifer, test in order to assure the conditions are satisfactory for supplying probably twice to three times the volume used here in the EIA.

Well Water Analyses

Annex VI is provided by an “accredited laboratory” (Belize Brewing Company Ltd.) but no accreditation is provided. Also there is no chain of custody form to indicate who/where/when the samples were collected. Therefore, they can not be considered as “accredited” or even “accreditable” by anyone; see below for other issues.

The water analyses on p.5-7/Table 5.5 and Annex VI are in deed remarkable and unexplainable, and without remarks by the Proponent other than the water quality is “excellent”. The water quality is TOO excellent, with a TDS of only 32-37 ppm, which is suitable for use in automotive batteries; even 250ppm may be used and which is virtually impossible in such a location. At the levels presented, the assessor should also indicate that the pipe work must be suitable to handle such corrosive waters and the water should not be exposed to cement or concrete products.

At these values, one could expect that the water came from a rainwater cistern or similar situation or from mountain lakes/rivers. However the claim that the samples are from the deeper groundwater does not seem supported by the actual analyses; in addition to the creditability of the laboratory and its analytical methods and supplies..

Table 5.5 and Annex VI also provide additional chemical values which were not described in the EIA text. Based on the Annex VI values, the pHs of less than 6 (too acidic, 5.5 SU) and thus renders the water unhealthy for human use or even discharges to surface water as indicated in the discharge requirements for treated sewage. As indicated in the Sec. 6 list of wastewater parameters, the low, acidic pHs render the water as hazardous for discharge and also for potable use.

Absence of any text reference to the pH values indicates that the Proponent or the preparers took steps to avoid mention of any negative aspects and provide a simple mitigation of adding pH neutralization along with the chlorination. As indicated below, the entire water quality analyses, sampling, and review of data appears suspicious at best; an alternative consideration is that the water samples were not collected from the supposed sources and could have been fabricated, contaminated, or altered prior to analyses.

The analyses of surface water samples also show strange values. The dissolved oxygen (DO) measured in the laboratory are high for some samples which also have the highest CODs, no nitrates, and coliforms; later samples show high CODs, high NO3, coliforms with moderate to high DOs. Such values clearly indicate that the samples may have been improperly preserved and transported to the laboratory (temperature were taken in the laboratory at 20+ ^{O} but samples

should have been a 4^{O} (iced, chemically fixed, etc.) as the coliform, nutrients and temperature will interact and totally change the DO, coliform, nitrates, etc.

Analyses of the groundwater well samples are incomplete and include unusual salinity and TDS, generally salinities of 10-20 ppm should resemble the TDS of 32-37ppm both of which approach distilled water. Similarly the pHs of 5.7-5.8 (acidic) are unusual for groundwater where waters have passed through carbonate/coralline sands expected in such a project location. Such water would not be acceptable for direct human consumption.

The laboratory analyses can not be considered as indicative of water quality at the site; all samples and analyses should be re-done as they appear to have no validity.

Supply to outside the Project

P. 5-7 suggests that the project "…will consider the supply of potable water to the village." where 880 employees will reside. As this is not mentioned elsewhere, the reviewer can assume that "consider" really means if the villagers can pay for it, even though the employees will presumably reside in the village.

Item ii. Liquid [wastes]/Sewage

As in keeping with the above comments, the reviewer notices that the Proponent has assumed the lower flow of sewage coming from the water use, 70% rather than 80%. No provision is indicated for sewage from 400 boats over and above those of the land-based generation.

The proposed BESST unit can achieve the national standards and well below those as indicated in the EIA. Unfortunately, the description of the actual facilities is totally inadequate as to the number and individual site capacities compared to the flows to BESST units provided to each water zone, and therefore, a total of 12 treatment sites will be required as indicated but with a range of flows of 7 (from 10) to 146 (from 209) cumd; some indication as to the number of BESST units will give a factual basis for the assessment and a number required for the Proponent to installed in order to avoid adverse effects. The 10% difference relates to 120 cumd of additional sewage flows.

If the BESST is overloaded by actual flows of 10-50% purposeful underestimates to keep costs down, and too few units are not treating the sewage properly (not BESST's fault, but the consultant's and proponent's faults), the effluent may not reach the BESST level and perhaps not even the Belize Nat'l. levels.

An additional item indicated in other sections but not addressed in the wastewater involves the effects of highly variable population, 70%, occupancy. All sewage treatment systems depend on some form of biological decomposition of the organic matter in the sewage and this is usually conducted under aerobic, oxygen rich, conditions. However, when sewage loads vary widely across many days, weekend/weekdays, first week of month, Christmas, etc., the food for the good bacteria may be adequate for a few days and promotes and maintains a good population which then may be starved when the populations, sewage flows, and nutrients decline during the "off-season" and requires special measures to maintain the bacteria population at levels sufficient to meet the next increased population. If measures are unsuccessful, the bacteria will die-off and the population will be insufficient to biologically process the sewage when the next high flows arrive. The EIA does not reflect any effects of variable and low flow conditions and adverse effects on discharge quality from the normally adequate facilities.

Golf Course and Water Quality

Golf courses require huge amounts of irrigation water and significant amounts of nitrogen and phosphorus nutrients in order to keep the grass green and with sufficient resilience for golf uses. Water demands generally relate to both evaporation and rainfall. Assuming 1500mm of seasonal rainfall (in 200 days), the rainfall plus once/week irrigation would be sufficient to balance any evaporation during the same period (10-12mm/day. However, the rainfall has not nutrient value and in fact provides a very effective leaching medium, removing at nutrients from the grass root zones.

So especially during adequate to surplus rainfall, the Project must apply nutrients in order to balance those "leached out" of the golf grass root zones and soils. Few golf courses can manually (labor costs) apply sufficient nutrients to balance those leached by rainfall. Many times visitors to golf courses may see the irrigation system operating during or after a rain, and this may reflect the more typical application of nutrients through the irrigation system in order to compensate for nutrients leached from the soil during the earlier rain.

During the drier seasons, irrigation of a 60+ha (155ac) golf course will require 6,000 cu m (15,000 US gal) of irrigation per day. Nutrients and pesticides would be added to the irrigation water and distributed via the sprinkler systems or may be dispensed by mechanical equipment. Golf irrigation practices would tend to minimize any leaching of the nutrients applied before the grass roots were able to absorb most.

The very long list of pesticides and absence of nutrients is then followed by statement that they "…will be reduced." without ever specifying how much was

used and the means by which the amounts will be reduced. Similarly, types of grasses and "slow release fertilizers "…will be recommended." Without any distinctions as to whether recommendation would be followed or are legally stipulated by the Proponents..

Total avoidance of quantification of well known industry requirements and vague promises regarding usage does not support the cursorial review and "no impact" assessment of the golf course effects on surface and groundwater.

The presentation does not deal with a simple model of mass transfer of nutrients/fertilizer and pesticides, as to how much is applied, how much is used by the plants to make more plants, and how much is passed through to the groundwater and adjacent surface waters. Based on the volumes in the EIA, total wastewater production from the Golf Clubhouse (>20,000 gpd, >6000 cum/d) would be sufficient to meet the total demands of the course, everyday and thereby major excess treated effluent would be available most days of the year. Other areas would not be required for irrigation of the golf course.

Item iii – Sediment Plume

The only mention of sediment plume comes in sec. 10.6, p.10-6 and only in regard to the clam-shell excavation and suction dredging. Suction dredging does reduce the disturbance of sediments in the site of the dredging, BUT the discharge of suction dredging requires the control of silts and turbidity in perhaps x10-x50 the volume of dredged materials as the volume of water released from the dredged/placed sediment. Most sediment does not come from the dredging but from the reclamation. Many controls are available for the treatment of the reclamation waters discharges, however, the high silt and peat content as indicated by the borings shows that "silt-ponds" (=settlement ponds) and filters would be required to control the silt and turbidity of the discharge. These ponds after the reclamation is completed, however, become largely UNUSABLE as they may have more than 3m of deposited silt and clay which can not be safely built on.

This entire item is inadequately, and incompletely presented and indicates that either 1) the proponent is unaware of or inexperienced with the silt issue and the potential impacts of turbid waters upon water quality and the marine life and of future land uses of the silt ponds OR 2) is purposefully avoiding description and mitigation of this Significant and Adverse Impact from the discharge of reclamation water.

10.2/p.10-1 discusses and casts away the issue of the water quality model for the marina by saying that Moffet and Nichols has modeled the situation and shows that the entire volume is changed over in 2-3 days. However, the model uses a clean and clear channel without boats, while the successful project requires that

307 boats up to 30+m length which will severely reduce the turnover/flushing of the lagoon/marina. With a small, <0.5m, maximum normal tides, the "successful" flushing does not appear warranted.

10.4 / p.10-2 discusses how good algae and filter feeders are for cleaning up the water, but coral have many problems with nutrient load high enough to promote algae.

"A number of studies have been conducted" but without specific references as to those pertinent to the western Caribbean.

Pre- and post-construction to measure turbidity and BOD (the latter is difficult) and probably not practical – analyses in Annex VI does not include any turbidity values and suspended solids in one set of samples indicates water which exceed sewage discharge limits.

10.5 silt, clay, and peat are not suitable materials for reclamation for "roads, etc." and structures, STPs, etc.
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Item viii – Socio-Economic Factors

Social

Current requirements of internationally recognized agencies (World Bank, World Health, and UN-EP) for assessment of Socio-Economic Factors cover a much wider array of subjects than those briefly addressed in the materials presented.

The issues as to numbers of in-migration of labor and the needs for training of local labor (moving from unskilled/semi-skilled to skilled levels) must be seen in the context of the CASINO. The direct and indirect labor requirements of the CASINO far exceed the levels indicated in the EIA and are generally of much higher levels of experience and skills than even can be met by general training.

The Casino Culture often conflicts with those of the surrounding communities (especially if they are conservative Christian or as in the UAE, Muslim).

Health Impacts

World Bank and World Health currently requires a "human health" assessment element for EIAs which is not included, generally under the Socio-Economic Element and would be quite pertinent to such a project which is designed to bring into rural areas affluent visitors, occupants, and owners.

Such in-migrations can contribute to movement of diseases and new health risks to a relatively isolated populations.

Infrastructure – Transport, Utilities, and Services

Most EIA now include sections with regard to the project's impacts on the surrounding current infrastructure context, mentioned above. The traffic impact of getting 5000+ persons into the commercial/recreational areas and the casinos/nightclubs would suggest that additional analyses and mitigation is required for both road buses and for more private, exclusive boat traffic from ships in deeper water ports/moorings elsewhere.

As indicated elsewhere, the increased surrounding supporting populations around the project will create higher demands for power and water and generate larger amounts of sewage and solid wastes. As the local populations will not have sufficient financial resources to fund and implement sufficient utilities support, the service levels can be expected to decline significantly, severely, for a few years until crises bring greater urgency and resources. .

Community - Security, Fire, and Medical - Services

No relevant discussion deals with effects on the the various community services due to the increased population and in/out migrations and visitations, especially with respect to the health impact assessment and need for greater security requirements. No discussion is presented regarding the direct needs of the Casino and nightclub, reception, and commercial areas with several 1000s affluent users, visitors, and residents. Security services will be required by the project and would be expected to be handle as a private security service for the project facilities. Therefore, a private security service will operate in the context of a surrounding population under a different public-based police service system; this private service is expected to operate similar to a project militia and may create adverse effects within the surrounding community.

Economics

The EIA fails to adequately and sufficiently describe the economic conditions at present, during the construction of the project, and during the operational phases and therefore again either indicates inexperience/lack of awareness or purposeful avoidance of the issue and the direct and immediate impacts of the project on the surrounding social and economic conditions of the project.

As indicated by the EIA, a large numbers of visitors (not owners) are anticipated to come for the Casino/Night Club and "Reception and Commercial Areas", and thereby far higher levels of in-migrants will be required than suggested by the EIA. However, accommodations, catering, and services for these employees and the overall labor has not been addressed and generally falls on the surrounding communities (compare with the Atlantis Project in the Bahamas).

Positive and negative impacts will arise from employee/labor accommodation, services, and catering largely falling on the surrounding community which will see greatly increased prices as market forces increase demands for a small supply regime at present and higher incomes of in-migrant employees. After a few years, these forces may be moderated but then the costs of water supply, sewage collection/treatment, and power generation will fall on the surrounding community, NOT the project. Once prices have increased, they seldom fall back to near their original levels.

Such price increases generally force local residents to move above from the market into lower level conditions and other communities, which often further expands the economic impacts of the project – directly on the surrounding community but also in the communities which will receive the economically displaced migrants from the project's surrounding communities.

Topics That Could Be Added Upon Request

Lobster Jetties

Add section on Lobster Habitat Enhancement

Potential Breach from Caribbean to Lagoon

Add section about possible hurricane breach to Lagoon and possible impact

Seawalls enhancements in Marina

Add section for Sea Wall biological enhancement mitigations

Submerged Breakwaters

Add section on submerged breakwater options