Annex 3B. Characterization Form for Defining the Costs and Benefits of Domestic Wastewater Management – Southwest Tobago

==========

STUDY SITE: **Southwest Tobago**

==========

RESPONDENT INFORMATION

This report was completed by:

Name: Erin Gray, Lauretta Burke, World Resources Institute; Roger Karim and Carl Santana, Trinidad and Tobago Water and Wastewater Authority (WASA)

Organization: World Resources Institute and WASA

Date: August 12, 2015

==========

Contents:

==========

I. DEFINE THE STUDY AREA

Objective: Define and map the study area including key geographic and land use data to identify wastewater pollution and other water pollution pathways and populations of interest.

Possible data sources: National environmental, water, and/or marine agencies; non-profit organizations (NGOs); academic institutes with marine/environmental centers that conduct research within the study site.

1. Please define the study area by providing a detailed description.

The study area should include the sewage catchment name(s) and geographic area, the populated area to be served by improved wastewater treatment, the area downstream which is expected to be influenced by the change in wastewater management (including receiving water bodies (e.g., rivers, lakes, oceans) and water catchments), and the upstream catchment (which might be contributing pollutants to the water body of focus).

The study area focuses on southwestern Tobago, including mostly St. Patrick Parish but also parts of St. Andrew. The study area includes the Buccoo Reef / Bon Accord ecological complex and includes the Courland, Buccoo and Bon Accord water catchments. The following developments are included: Bon Accord, Milford Court, Samaan Grove and surrounding area, and the Coral Gardens and Buccoo neighborhoods. The study area does not include Scarborough and the Scarborough wastewater treatment facility (WASA 2015)

2. Can you put it on a map? (with GIS; Google Earth; or participatory mapping)

If possible, indicate on a map the information provided in Question 1. This can be done in GIS, using Google Earth, and/or working with stakeholders using a participatory mapping approach to highlight on a hard copy map the response to Question 1.

Based on data received from the Institute of Marine Affairs (IMA 2015) sand WASA's Water Resources Agency (WRA 2015) we have the following maps:

Figure 1 - Tobago study area map (represented in a GIS)

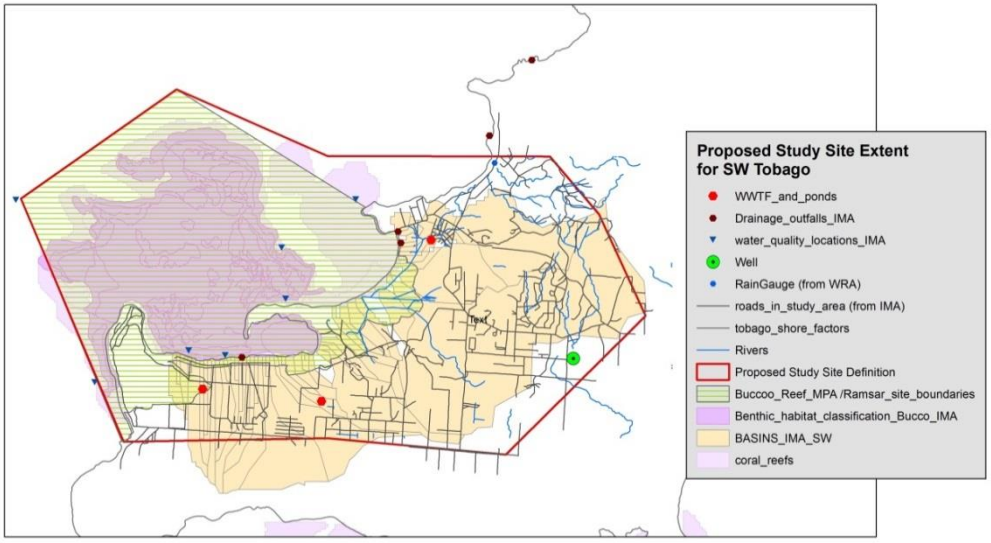


Figure 2 - Tobago study area, represented in Google Earth

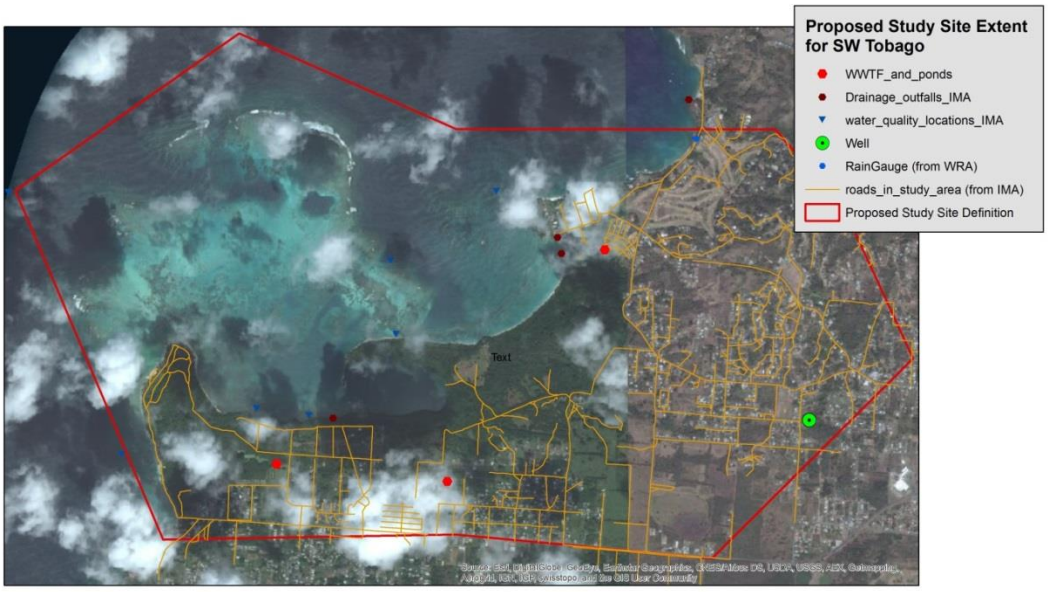
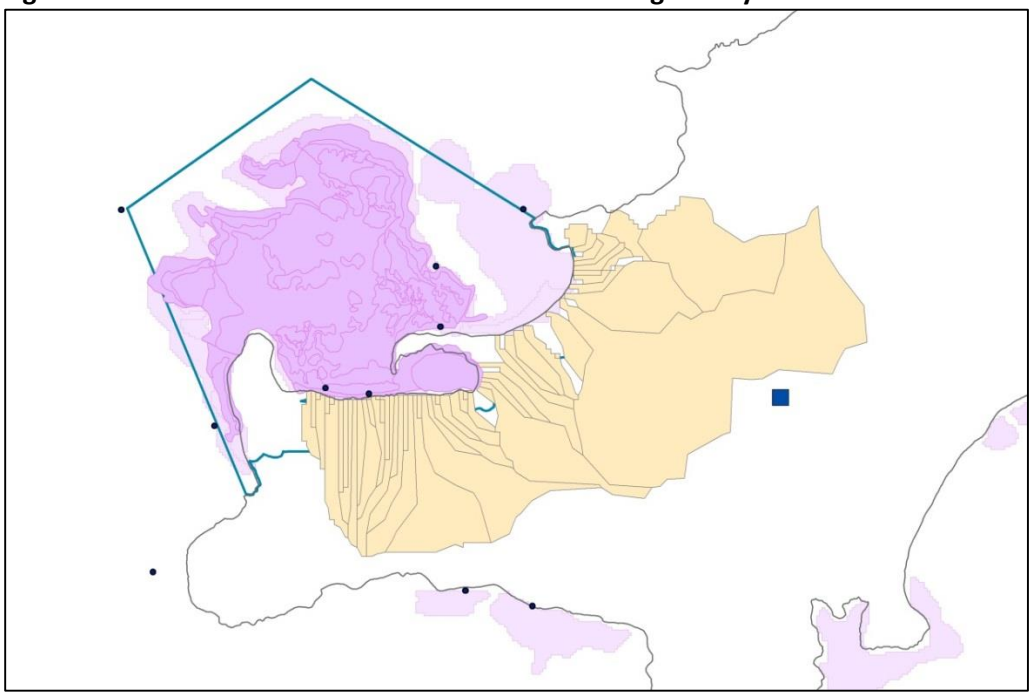


Figure 3 - Watersheds and Coral reefs of the SW Tobago study area



3. What are the major land uses (such as residential, commercial, agricultural, open space / natural) in the study area?

- **Could you do rough estimates of percentages of each major land use?**

Existing land use data for southwest Tobago from Town and Country Planning Division (TCPD) from 1996 showed that the predominant land use in southwest Tobago is built development accounting for some 2416 ha or 38%. IMA reports that between 1992 and 2002, southwest Tobago experienced rapid growth and development in the tourism and related service sector (Juman and Bacon 2002). Alpha Engineering (2011) states that there is a high density of development in southwest Tobago with narrow roadways.

Development consists mainly of residential and commercial areas, and supporting infrastructure (roadways, sidewalks, drainage canals, parks, etc…). The southwestern tourist area around Crown Point, Store Bay, Buccoo Reef, and Pigeon Point has large expanses of sand and is dominated by resort-type developments.

There is also a cattle farm in the study site (Juman 2015).

==========

II. POPULATION

Objective: Population data is critical for understanding current and future wastewater demand as well as the number of people who may swim in or eat from waters contaminated with untreated wastewater.

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. How many people live in the study area? (Approximate if necessary)

The population of Tobago grew from 54,084 in 2000 to 60,874 in 2011 (CSO, 2012). About 54 percent of Tobago's population lives within the southwestern area (15,560 in St. Patrick and 17,536 in St. Andrew parishes), though these parishes exceed the study area. We estimate about 15,000 people live in the study area. The area also has many hotels and hence visitors creating additional need for wastewater treatment.

2. Can you disaggregate this by neighborhood / area / housing development / smaller administrative unit?

No.

3. How many households are in the study area? (Approximate if necessary.)

The 2011 CSO Census estimates that the average household size for Tobago in 2011 was 3 people. Hence, we estimate that there were about 5,000 households in the study area in 2011.

4. What is the population projection for the study area over the next 20, 30, and/or 50 years (for each period if data are available)?

The average annual growth rate in population for Tobago between 2000 and 2011 was 1.2%.
We currently do not have projection data for Tobago. Based on the 1.2% growth rate, we project the population for St. Patrick and St. Andrew Parishes to be:

- Current (2015): 15,730
- In 20 years (2035): 19,970
- In 50 years (2065): 28,560

==========

III. ECONOMIC ACTIVITIES

Objective: Economic data are important for understanding the economic activities that are important for the local economy that rely on ecosystems (especially those potentially impacted by water pollution).

Possible data sources: Government census data; International population datasets from multilateral, intergovernmental, or NGOs (e.g., World Bank, United Nations).

1. **Are the following sectors important for the local economy (ideally for the study area)? Can you estimate the relative contribution from each sector to the local economy? If quantitative data are not available, please rate the sector's importance based on the following scale:**

   Importance Scale:
   - **Not important:** The sector is not relevant as it does not contribute much to local GDP (e.g., through jobs or financial contribution)
   - **Moderate importance:** The sector is important, but is not the main contributor to local GDP.
   - **Very important:** The sector contributes substantially to local GDP.
   - **Critical:** The sector contributes the largest amount of any sector to local GDP

   - **Tourism? (Note types of tourism)**
   - **Agriculture? (Note types of agriculture)**
   - **Fisheries? (Note major fish species)**
   - **Industry? (Note what industry/ies)**
   - **Other?**

The most important sectors for Tobago's economy are tourism and fishing (mostly artisanal) (Wikipedia 2015). The island hosts a significant number of yachts and cruise ships each year (THA 2015; Ministry of Tourism 2015), which add to the demand for water and sanitation services, particularly in the ecologically-sensitive coastal zone.

Within the study area there is also a goat racing facility and a fish processing plant.

==========

IV. KEY ECOSYSTEMS

Objective: To understand potential benefits to ecosystem health from wastewater management improvements, it is necessary to a) identify key ecosystems in the study sites, b) their economic contribution in terms of key goods and services they provide, c) their contribution to key economic sectors. This will help to characterize the dependence of these sectors on healthy ecosystems, and as a result, the value of these ecosystems to the study population and the nation.

Possible data sources: Government environmental/water/natural resource agencies or ministries; Academic institutes and environmental NGOs conducting research or working towards the protection or conservation of ecosystems; Peer-reviewed and grey literature on key ecosystem both within and outside of the study area; Government reports including environmental impact statements, water quality permits, or benefit-cost analyses;

1. **What are the key ecosystems in the study area (e.g., coral reefs, mangroves, seagrass beds, beaches, forests, wetlands), especially downstream from population, sewage discharge, or treated**

wastewater discharge? Key ecosystems are those which are important to the local economy or those which provide important cultural services.

The study area includes the **Buccoo Reef Complex,** which is a mangrove-seagress-coral reef continuum that covers an area of 7 km^2 and includes the Bon Accord Lagoon and the Buccoo Reef. Included in the BRC is:

a. **Bon Accord Lagoon** (Juman 2005a and 2005b)**:** The Bon Accord Lagoon (BAL) forms the southern boundary of the Buccoo Reef Marine Park and has a surface area of 1.2 km^2. The BAL includes a **mangrove forest** (~0.8km^2) dominated by red mangrove, but also includes black, white, and buttonwood mangrove. This is the largest remaining mangrove system in southwest Tobago. The BAL also includes a **seagrass community** dominated by *Thalassia testudinum* which measures 0.5km^2. The BAL forms part of the BRC so impacts and is impacted by the health of the Buccoo Reef.

   The tide is mixed, mainly semidiurnal with a significant diurnal inequality. The lagoon is well-flushed, is an average of 2 meters deep, and has a reasonably high rate of tidal exchange between the lagoon and the adjacent coral reef.

b. **Buccoo Reef**

   The Buccoo Reef is a Holocene formation comprised of coralline limestone. The reef system consists of five emergent reef platforms, arcing seaward of the reef lagoon from Pigeon Point in the west to Sherrbird's Point on the east. The reef platforms are: Pigeon Point Reef, Western Reef, Northern Reef, Outer Reef, and Eastern Reef (Juman and Bacon 2002). The Buccoo Reef Complex was officially designated a marine protected area in 1973, the Buccoo Reef Marine Park.

c. **Recreational beaches**

   The southwest area of Tobago is popular for swimming/recreational beaches, including: Pigeon Point, Buccoo Point, Store Bay, and Crown Point.

d. **Nylon Pool**

   Nylon Pool is a popular tourist destination – it is an in-sea shallow white ground coral pool located off of Pigeon Point and is accessible by boat.

2. Please rank how important these ecosystems are to the economic sectors previously listed in Section III (within the study area) (e.g., is tourism in the area dependent on healthy ecosystems?). Please indicate in Table 1 below the relative importance based on this scale:

Importance Scale:

- **Not important**: The ecosystem has no relevance to the economic sector.

- **Moderate importance**: The economic sector is dependent on resources/services provided by the ecosystem but substitutes for natural resources are available (e.g., forest ecosystems provide water filtration services that can improve the health of fisheries, but water filtration systems are also available to filter water).
- **Very important:** The economic sector is dependent on the resources/services provided by the ecosystem and substitutes are not available or are exorbitantly expensive (e.g., mangroves provide important coastal protection services, guarding some shoreline industries from flooding and hurricanes. While options exist to improve coastal protection like dikes jetties, this type of infrastructure can be costly to build and maintain).
- **Critical:** The ecosystem is vital to the economic sector in that the sector would not profit or exist without the ecosystem (e.g., tourism in a coastal community may be completely dependent on coral reefs for scuba diving, snorkeling, and sand creation as these activities provide the most income to the local economy).

Table 1: Ranking of ecosystem important to key economic sectors

ECOSYSTEM	AGRICULTURE	FISHERIES	COMMERICAL
Example: Coral reefs	*Not important*	*Critical*	*Very important*
Coral Reef	Critical	Critical	Very important
Mangroves	Critical	Very important	Very important
Seagrass Beds	Critical	Moderate	Not clear
Beaches	Not important	Critical	Very important

3. What goods and services do these key ecosystems provide (i.e., what are each of the ecosystems used by people for?). Please fill out Table 2 below and add or delete ecosystems as needed. You may refer to Table 3 which provides a general list of ecosystem services for major Caribbean ecosystem types, for guidance.

Mangroves:

- Habitat for larvae, juveniles, and adult estuarine and marine organisms.
- Water filtration services (mangroves take up nutrients) that reduce over nutrient enrichment of the reef.
- Shoreline protection services during storms that help reduce flooding and erosion.

Seagrass beds:

- Habitat for larvae, juveniles, and adult estuarine and marine organisms.

- Water filtration services (mangroves take up nutrients) that reduce over nutrient enrichment of the reef.
- Shoreline protection services during storms that help maintain beach areas and integrity of the coastline.

Buccoo reef:

- Tourism and recreation (snorkeling and diving site; glass bottom tours site)
- Beach formation
- Habitat for marine organisms that support fisheries (the main catches are groupers and snappers (Juman and Bacon 2002))
- Shoreline protection services.

Table 2: Ecosystem goods and services

Ecosystem Goods and Services	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Food	X	X		X
Raw materials	X	X	X	X
Medicinal resources				
Genetic resources				
Other…	X	X	X	X
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X		X
Other…		X		X
Tourism and recreation	X	X	X	
History, culture, traditions		X		
Science, knowledge, education	X	X	X	X
Other…				
Primary production	X	X		X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X
Other…				

Table 3: Examples of coastal ecosystem goods and services

ECOSYSTEM GOODS AND SERVICES	CORAL REEFS	MANGROVES	BEACHES	SEAGRASSES
Provisioning services				
Food (e.g., fisheries)	X	X	X	X
Raw materials	X	X	X	X
Medicinal resources	X	X		X
Genetic resources	X	X		X
Regulating services				
Flood/storm/erosion regulation	X	X	X	X
Climate regulation	X	X	X	X
Cultural services				
Tourism and recreation	X	X	X	
History, culture, traditions	X	X	X	X
Science, knowledge, education	X	X	X	X
Supporting services				
Primary production	X	X	X	X
Nutrient cycling	X	X		X
Species/ecosystem protection	X	X	X	X

Source: WRI Coastal Capital Guidebook (Waite et al. 2013)

4. Are there any existing estimates of the economic values of these uses of ecosystems for this study area or nearby (e.g., through peer-reviewed or grey literature)? If so, please list these values, describe the methodology used to develop them, and provide a citation.

Yes – we identified 3 economic valuation studies. However these studies did not look at impacts from wastewater.

Brown et al. 2001:

Estimated the recreational value of Buccoo Reef Marine Park in Tobago, West Indies. Benefits derived from total annual visitor expenditure in estimates of Net Present Value (NPV) ranged from US $9.1 to $18.7 million over a 10-year period for different scenarios. Recreational user benefits were estimated as the total Willingness To Pay of visitors to southwest Tobago, both users and non-users of the park. The mean Willingness To Pay by all respondents, including those not willing to pay, ranged from $3.70 to $9.30. The resulting estimates showed an equivalent surplus of $600,000 to $2.5 million in NPV depending on the resulting environmental quality implied by the scenarios.

Burke et al. 2008:

- Coral reef-associated tourism and recreation in the Buccoo Reef area contributed an estimated US$7.2 to $8.8 million a year in 2006, of which approximately US$1.4 million were from glass bottom boat and snorkel tours, alone.
- Coral reefs provide shoreline protection services from waves and storm damage worth $18 – 33 million USD annually in 2006 for all of Tobago (Burke et al. 2008). In addition, the same study estimates the "Damages avoided" due to the presence of the Buccoo Reef to be between US$140 and 250 million over a 25-year time period.
- Burke et al. estimate the annual value of coral-reef related fisheries for all of Tobago was $0.8 – 1.5 million USD in 2006.[1]

Beharry-Borg and Scarpa,

- Uses two choice experiments designed to estimate willingness to pay (WTP) for an improvement in coastal water quality for two groups of beach recreationists: snorkellers and nonsnorkellers.
- Results indicate that individual specific-means of WTP estimates vary significantly between snorkellers and nonsnorkellers

5. Do you have statistics on visitation / tourism (both foreign and national) to key ecosystems and/or statistics on visitation/tourism for the country for eco-tourism? For example, do you have data on the number of tourists (including cruise ship passengers, national and international tourists, and others) that visit the key ecosystems identified above?

We have the following data from the Tobago House of Assembly for tourist visitation to Tobago (Tobago House of Assembly 2015; Ministry of Tourism 2015):

Table 4: Tourism visitation data from 2003 - 2014 for Tobago (THA 2015; Ministry of Tourism 2015)

Number of persons	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Yacht arrivals[1]	1,695	1,610	1,587	2,355	1,391	1,175	1,345	1,027	1,037	1,005	1,082	886
Cruise ship passenger arrivals[2]	25,661	29,120	32,919	29,708	18,426	22,257	70,134	61,615	44,623	31,364	20,274	29,735
Direct inter-national passengers (air)[3]	68,548	82,159	87,796	68,791	67,354							26,185

1. Data from 2003 – 2009 from THA (2015); Data from 2010 – 2014 from Ministry of Tourism (2015).
2. Data from THA (2015).
3. Data from 2003 – 2007 provided by THA (2015); Data for 2014 provided by the Ministry of Tourism

[1] Includes all of Tobago's coral reefs.

A Tobago Exit Survey Report from 2013 (Division of Tourism and Transportation 2013) and found that the average length of stay was 11 days, and that the average expenditure per person was calculated at USD $2,273. Expenditure per person per day with an average length of stay of 11.1 nights was USD $189. A typical visitor to Tobago is in the 45-54 age demographic, university educated professional whose main purpose of visit is for a vacation (> 80%). Business visitors were negligible averaging under 1% of total visitor arrivals to the island. The typical visitor travels with his/her spouse and prefers to stay at a hotel (>60%). Most international visitors are coming from Europe and North America.

Generally, the visitor is usually a first time visitor (68%) to the island. Of the repeat visitors (32%), the majority had travelled to the island 1-3 times (54.9%).

The most popular activity was visiting the various beaches on the island (28.4%). This was followed by sightseeing (22.6%), shopping (14.4%) and water sports/scuba diving (13.4%).

The most popular sites/attractions that tourists visited were Pigeon Point Heritage Park (PPHP), the Rain Forest, Buccoo Reef and Argyle Waterfall. Visitors were asked to rate the various sites/attractions on a scale of 1 to 5 with 1=Poor and 5=Excellent. The Buccoo Reef scored 3.7 points, up 0.1 point over 2011.

A possible indication of ecosystem decline might be related to quality of tours. The survey states, “Although visitors were generally pleased with the quality of the tours and tour guides on the island, the percentage of visitors that rated these services as very satisfactory declined consistently throughout the three-year period. 46.9% of visitors in 2011 compared to 34.3% in 2013 said that they were very satisfied with the tour guides. Tours also dropped from 45.5% rating them as highly satisfactory in 2011 to 37.8% in 2013.”

The Trinidad and Tobago Ministry of Tourism (2015) found that the total contribution of travel and tourism to domestic GDP has increased from $10.5 million TT in 2010 to $12.6 million TT in 2014.

Note: This is to understand the potential health costs from exposure to wastewater pollutants so it is important to understand whether the key ecosystems identified a) receive untreated wastewater effluent and b) are important for fishing and recreational swimming/bathing.

==========

V. CURRENT WASTEWATER MANAGEMENT SITUATION

Objective: To understand how wastewater is currently treated within the study site to allow comparison against future wastewater management alternatives in terms of population served, untreated wastewater, pollution removal effectiveness for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits; Wastewater experts; Historical costs; National price books.

1. On-site wastewater treatment coverage:

- **Please estimate the percentage of the total domestic wastewater sector within the study that uses each type of on-site system below. For example: 30% of the total population uses on-site treatment. Of this 30%, 10% uses septic system, 10% uses pit latrines, and 10% uses soakaway systems).**
    - **Septic systems**
    - **Pit latrines**
    - **Soakaway systems**
    - **Other?**

WASA estimates that 88% of the study area population is serviced by pit latrines or on-lot systems (WASA 2015).

- **What percentage of on-site systems (septic systems, pit latrines, soakaway systems, etc.) are properly maintained (i.e., regularly pumped out, drain fields not clogged, etc.)?**

Alpha Engineering (2011) states:

- In periods of heavy rain, the soakaway and filter trench systems in the Bon Accord catchment do not function as they should and can release harmful fecal coliform into the surface drainage network and the coralline sub-structure, and ultimately into the sea. This can impact nearby bays used for bathing, recreation, and habitat.
- The commercial buildings along Milford Road utilize mostly septic tanks. During periods of high water table levels, the soakaway and filter trench systems release effluent directly into the surface drainage network and ultimately into the sea. In the dry season the effluent finds its way into the coralline sub-surface and also discharges itself into the sea.

2. Wastewater collection system (i.e., sewerage):

- **Please describe the coverage of the current sewage collection system in terms of length of pipelines and the ultimate treatment point.**

WASA estimates that 12% of Tobago's population is connected to a central system or private wastewater treatment plant (WASA 2015).

- **Please estimate the percentage of the total population and commercial and industrial establishments within the study that are connected to a centralized sewerage system.**

No commercial or industrial establishments are connected to a centralized sewerage system within the study area (WASA 2015).

3. Wastewater treatment plants:

- **Please describe the number and type of wastewater treatment plants (WWTP) currently in place in the study area.**

WASA owns and operates two wastewater systems in the study area: the Milford Court WWTP (adopted from the National Housing Agency (NHA), and the Coral Gardens WWTP (adopted from the NHA). In

addition, the Golden Grove and Bon Accord Waste stabilization ponds provides wastewater treatment for the established housing developments within these communities. The remainder of the population within the study area is served by small package/ septic facilities (for the hotels and guest houses) and on lot septic tanks and soakaway system (for the individual households).

The **Bon Accord catchment** area includes all hotels and guesthouses along the western end of Old Store Bay Road and the Bon Accord housing development. The hotels and guesthouses mostly use septic tanks with soakaway or filter trench systems with the Bon Accord housing development using the Bon Accord waste stabilization ponds. In periods of heavy rain, the soakaway and filter trench systems do not function as they should and can release harmful fecal coliform into the surface drainage network and the coralline sub-structure, and ultimately into the sea. This can impact nearby bays used for bathing, recreation, and habitat (Alpha Engineering 2011).

The **Milford Court area** includes a WWTP referred to as the **Milford Court or Bon Accord WWTP**. The Bon Accord WWTP has a capacity of 259 m^3/day and was originally designed as a package plant with activated sludge treatment. It was converted to a membrane bioreactor plant in 2003 and is currently operating at capacity with acceptable treatment levels most of the time (Santana 2014). However, the draft CEC application (Alpha Engineering 2011) states that the WWTP servicing Milford Court is dysfunctional and is contributing untreated effluent into the surface system and ultimately into the ocean.

There is also a **fish processing plant** and commercial buildings in the area. According to the Draft CEC application (Alpha Engineering 2011), the wastewater being produced at the fish processing plant does not undergo any treatment prior to entering the drainage system. The commercial buildings along Milford Road utilize mostly septic tanks. During periods of high water table levels, the soakaway and filter trench systems release effluent directly into the surface drainage network and ultimately into the sea. In the dry season the effluent finds its way into the coralline sub-surface and also discharges itself into the sea. There is a new Metal Industries Company building which is currently under construction has in place a proposal for its own packaged WWTP to treat the wastewater generated in the facility. This will potentially add yet another source of effluent into the surface water drainage system. However WASA plans to integrate the discharges from the MIC building into its proposed system for the area

The **Coral Gardens/Buccoo area** includes a school, a community center, goat race facilities, a fish depot and a pan yard. There is also an existing WWTP, the **Coral Gardens WWTP**, that services the Coral Gardens residential development. According to the Alpha Engineering report (2011), the plant is currently not functioning the way it was designed to and the effluent from this plant does not meet the requirements of the EMA or WASA and currently flows into the surface water drainage system and ultimately into the sea. This Plant has been in operation for approximately 40 years, it is well past the expected lifetime. The design flow rate is 136 m^3/day and it serves roughly 959 people in Tobago.

WASA (2014) states that the Coral Gardens WWTP has a capacity of 240 m^3/day. WASA also states that the plant originally designed as a package plant with activated sludge treatment. It was converted to a membrane bioreactor plant in 2004 and is currently operating at capacity with acceptable treatment.

There are three drainage outfalls located within the study area (see Map #1). In Bon Accord Lagoon there is one sewage outfall and one outfall draining the Latour's cattle farm. In Buccoo Bay, there is one sewage outfall.

- **For each WWTP, please fill in Table 5 to the best extent possible. Please see Annex 2 for a glossary of wastewater terminology. Please copy and paste this table as needed if more than one treatment plant exists within the study site:**

Table 5: Wastewater Treatment Plant information for current situation (WASA 2015)

Data need	Data
Design	
Location	Milford Court (a.k.a. Bon Accord)
Design capacity - Nominal design capacity for dry and wet weather flows.	259 m^3/day (average daily flow)
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Membrane bioreactor
Effluent limits	T&T Water Pollution Rules
Sludge treatment and disposal	Via tanker to Studley Park Landfill (Louise et al. 2005)
Discharge location (receiving water body). If coastal, identify the outfall locations.	The Bon Accord Sewage outfall carries land-based runoff from a cattle farm, housing development, and sewage treatment plant into the Bon Accord lagoon via the mangrove forest.
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	currently at design capacity of 259 m^3/day (average daily flow)
Annual energy usage (kW hours, total cost)	

Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	Reported over flow occurrences during period of very heavy rainfall
Annual average discharged concentrations and loads of:	Not available
BOD_5 (mg/l, kilograms per year)	
Dissolved oxygen (mg/l)	
Total Nitrogen (mg/l, kilograms per year)	
Ammonia Nitrogen (mg/l, kilograms per year)	
Total Phosphorus (mg/l, kilograms per year)	
Total Suspended Solids (mg/l, kilograms per year)	
Faecal coliforms (units as reported)	
Enterococci (units as reported)	

Table 6: Wastewater Treatment Plant information for current situation (WASA 2015)

Data need	Data
Design	
Location	Coral Gardens (a.k.a. Buccoo WWTP)
Design capacity - Nominal design capacity for dry and wet weather flows.	The design flow rate is 136 m^3/day and it serves roughly 959 people in Tobago
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Membrane bioreactor
Effluent limits	T&T Water Pollution Rules

Sludge treatment and disposal	Via tanker to Studley Park Landfill (Louise et al. 2005)
Discharge location (receiving water body). If coastal, identify the outfall locations.	Canals – drain into the Buccoo Bay (Louise et al. 2005)
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Current flows (annual average flow, monthly average peak flow)	at capacity of 136 m^3/day (average daily flow)
Annual energy usage (kW hours, total cost)	
Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	Reported over flow occurrences during period of very heavy rainfall
Annual average discharged concentrations and loads of:	Not available
BOD_5 (mg/l, kilograms per year)	
Dissolved oxygen (mg/l)	
Total Nitrogen (mg/l, kilograms per year)	
Ammonia Nitrogen (mg/l, kilograms per year)	
Total Phosphorus (mg/l, kilograms per year)	
Total Suspended Solids (mg/l, kilograms per year)	
Faecal coliforms (units as reported)	
Enterococci (units as reported)	

4. **What is the estimated annual percentage of total wastewater generated that is untreated and released into water bodies? What is the estimated annual volume?**

Not sure, but there is definitely some untreated wastewater that is being released directly into water bodies.

5. **If there is untreated sewage, where does this go? If possible, please also note on a map the receiving water bodies and ecosystems that receive the untreated sewage – either directly, or via an outfall.**

Untreated sewage seems to enter primarily through canals directly into coastal areas including the Buccoo Bay / Bon Accord Lagoon.

Juman et al. (2002) state that the drainage area for the Buccoo/ Bon Accord Lagoon falls in the Southwestern Coast Hydrometric area No.15. The immediate drainage area are bounded to the east by Grafton and Shirvan Roads, to the south by Milford Road and to the northwest and west by the coastline running diagonal from Mt. Irvin Bay to Bon Accord Lagoon, and to the west from Pigeon Point to Milford Bay at the western end of Milford Road. There are no rivers within this drainage area; however there are several streams and surface drains transporting runoff from a cattle farms and sewage treatment plants (STP's) (Coral Garden and Mt Pleasant STP) into Buccoo Bay and Bon Accord Lagoon.

6. **Is there an interest in improving, upgrading, or expanding the current wastewater management system in the area? If so, please describe who is interested and why.**

Yes – the area has been looking to improve wastewater management for almost two decades, beginning with a wastewater study for Tobago by Thames Water. In 2011, WASA submitted CEC applications to the EMA to undertake upgrade works and CECs were granted, drafted a CEC application. The new system design aimed to reduce risk to human and environmental health and enhance tourism (WASA 2015).

7. **Current wastewater treatment costs - What capital and annual operating and maintenance costs are associated with the current wastewater management situation? Please fill in Table 7 to the best extent possible. If you do not have specific cost data, please provide a description of the *likely* costs associated with the current scenario by referring to Annex 2, section D.**

Table 7: Current wastewater scenario costs (WASA 2015)

Data need	Current wastewater management situation
Year of installation	2003 (refurbished)- Coral Gardens and Milford Court WWTPs
Life expectancy (years)	10-15 years
Total land area occupied by the plant (hectares)	500 m2
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced	- $TT 1 Million(estimated) per year per plant,

within the next 20 years and the total capital cost, including likely year of replacement and the frequency of replacement)	- plus a regular swap out of some components , costing about TT$2-3 million every five years.
Annual recurring expenses: -Salary/wages for all personnel plus personnel of any contracts associated with operation of the WWTP. -Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	$TT 0.5 Million (estimated) per year per plant
External services costs (if applicable, net value of total costs of external services including outsourcing, costs for construction)	$ TT 0.1 Million (estimate) per year per plant
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	
Other costs?	
Net present value over infrastructure's lifetime	

==========

VI. WATER QUALITY

Objective: To identify and list water quality standards and requirements that are applicable to the wastewater sector and identify and provide historic data (over the past five years) on water quality within wastewater receiving bodies and key ecosystems in the study area.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants or engineers that work with the wastewater authority

1. What water quality standards/requirements apply for the study area?

- **National/Regional and Local water quality standards?**
  - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
  - **Numeric criteria?**

- **Bathing/swimming standards**

- **International standards (e.g., LBS Protocol)**
    - **Designated uses (e.g., bathing/swimming) or water body classification (e.g. fisheries, recreation)**
    - **Numeric criteria?**

The national water standards are the Water Pollution Rules by the Environmental Management Authority. T&T is also a signatory the Land-Based Sources and Activities (LBS) protocol. Standards are summarized below:

Table 8: Water quality standards for Trinidad and Tobago

Parameter	Unit	LBS Protocol		Trinidad and Tobago (Water Pollution Rules Schedule II)			
		Class I waters	Class II waters	Inland surface water	Coastal nearshore	Marine offshore	Environmentally Sensitive
Total Suspended Solids	mg/l	30	150	50	150	100	15
Biochemical Oxygen Demand (BOD5)	mg/l	30	150	30	50	100	10
pH	pH units	5 to 10	5 to 10	6 to 9	6 to 9	6 to 9	6 to 9
Fats, Oil and Grease	mg/l	15	50	10	15	100	no release
Faecal Coliform ((Parties may meet effluent limitations either for faecal coliform or for E. coli (freshwater) and enterococci (saline water))	Unit? ???	Faecal Coliform: 200 mpn/100 ml; or a. E. coli: 126 organisms/100ml; b. enterococci: 35 organisms/100 ml		400	400	400	100
Floatables	mg/l	not visible	not visible	not visible	not visible	not visible	not visible
Toxicity	mg/l			no acute toxic effects	no acute toxic effects	no acute toxic effects	no acute toxic effects
Dissolved oxgyen	mg/l			<4	<4	<4	<4
Total Phosphorus	mg/l			5	5	5	0.1
Sulphide	mg/l			1	1	1	0.2
Chloride	mg/l			250	no increase above ambient	no increase above ambient	no increase above ambient
Total residual chlorine	mg/l			1	1	2	0.2
Dissolved hexavalent chromium	mg/l			0.1	0.1	0.1	0.01
Total chromium	mg/l			0.5	0.5	0.5	0.1
Dissolved iron	mg/l			3.5	3.5	3.5	1
Total petroleum hydrocarbons	mg/l			25	40	80	no release
Total nickel	mg/l			0.5	0.5	0.5	
Total copper	mg/l			0.5	0.5	0.5	0.01
Total zinc	mg/l			2	2	2	0.1
Total arsenic	mg/l			0.1	0.1	0.1	0.01
Total cadmium	mg/l			0.1	0.1	0.1	0.01

Total mercury	mg/l			0.01	0.01	0.01	0.005
Total lead	mg/l			0.1	0.1	0.1	0.05
Total cyanide	mg/l			0.1	0.1	0.1	0.05
Phenolic compounds	mg/l			0.5	0.5	0.5	0.1
Radioactivity	mg/l			NIAA	NIAA	NIAA	NIAA

2. What data or information do you have about water quality in the study area? Can you provide:

- **Ambient water quality monitoring data in freshwater bodies?**
- **Ambient water quality monitoring data in coastal waters?**

The Institute of Marine Affairs (2015) has provided the following water quality data: nitrates, ammonia, total suspended solids, reactive phosphates, Chl A, Dissolved solids, and DDPH. Only total suspended solids, however, are covered by the Water Pollution Rules and the LBS Protocol.

3. Please compare these data to water quality standards/requirements:

- **Are any water quality standards being violated in lakes, non-tidal streams and rivers, and coastal areas? Please provide frequency and severity.**
- **What are the pollutants causing the violation and what are their sources (e.g., untreated wastewater, WWTP effluent, onsite septic systems, soakaways, pit latrines, sources from other sectors such as mining or agriculture)**

Data not available.

4. If any water quality standards are being violated, have the violations been linked to wastewater discharges? If so, please provide specific information on the linkage.

Data not available.

==========

VII. ECOSYSTEM IMPACTS

Objective: To understand if there is a demonstrated link between wastewater pollution and ecosystem health.

Possible data sources: Environmental/water/natural resources agencies or ministries; Wastewater authorities; Consultants/engineers working with the wastewater authority; Environmental impact statements; Environmental/marine NGOs and government agencies; Academic and grey literature.

1. Within the study area, are any of the following causing ecological impacts, such as algal blooms or damage to coral reefs:

- **Discharge of untreated or partially treated sewage?**
- **Discharge of treated wastewater effluent?**
- **Irregular release of wastewater from a WWT system due to overflow, rainwater events, or power failure, etc.?**

Yes – discharge of untreated/partially treated sewage and irregular release of wastewater. Treated wastewater effluent is not a problem.

2. **Have any studies been conducted within the study site or your country or region that link wastewater pollution to ecosystem health? If so, what are the findings?**

The primary study was conducted by La Pointe (201), which found evidence of elevated wastewater pollution, especially in the wet season when wastewater ammonium loads from soakaways and other sources are maximal.

A 2001 study of water quality and benthic biota at fringing coral reefs in Tobago found that recent increases in local nutrient pollution, particularly from sewage, had served to push Tobago's coral reefs over the threshold indicative of eutrophication on Caribbean coral reefs (La Pointe, 2007).

Secondary treatment of sewage does not remove dissolved nutrients sufficiently to protect coral reef ecosystems – enters the area from the sewage treatment plants servicing subdivisions like Coral Gardens Estates and Bon Accord.

3. **Is there evidence of the following in any of the key ecosystems present in the study area: (e.g., freshwater, wetlands, mangroves, beaches, coral reefs, forests, wetlands):**
    - **Is it unsightly due to pollution? Are there algal blooms or obvious evidence of pollution?**

There are occasional algal blooms in the study area, including at the coral reef. It is not clear if these are seasonal or related to wastewater.

- **Is there odor due to pollution?**

There are reports of odor in coastal mangroves.

- **Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?**

Not sure.

- **Are you seeing a change in ecosystem health and/or growth?**

The Buccoo Reef encloses the Bon Accord lagoon. Sewage discharge and nutrient and sediment runoff into the lagoon are major problems, resulting in the poor condition of the inner reef, while the outer reef is relatively healthy.

There is a general decline in coral reef health over the past few decades – and this is thought to be due to coral bleaching events (which could be tied to eutrophication). Additionally, tourists were previously allowed to walk on the reef, although this practice has now been banned.

Juman (2005a) and LaPointe et al. (2010) found evidence of eutrophication citing higher biomass of macro-algae. LaPointe et al.'s study found evidence of domestic sewage wastewater being the most important source of marine pollution in the BRC. The study found evidence of dissolved inorganic nitrogen (DIN) enrichment in the BRC due to elevated macroalgal δ15N in the BRC compared to other areas in Tobago, primarily from submarine groundwater discharge of leachate from soakway sytems and from direct sewage outfall discharges. Additionally, LaPointe et al. found elevated Chl a concentrations during the wet season which provides additional evidence of watershed-driven eutrophication in the BRC.

Juman (2005b) states that the enhanced nutrient delivery from pollution sources has enhanced the mangrove's productivity.

Juman (2005a) states that the seagrass community is diminishing. In the wet season there is increased run-off from the mangrove and the land, resulting in increased sedimentation and nutrient loading. High nitrate and phosphate concentrations and total suspended solids were recorded close to the Bon Accord sewage outfall. This could be related to nutrient loading within the BAL that may be increasing the proliferation of phytoplankton, epiphytic and macro-algae that compete with seagrass for light and space.

LaPointe et al. (2010) found that Thalassia tesudinum had invaded the Nylon Pool, stating that this is a symptom of sewage-driven eutrophication in oligotrophic coral reef regions.

4. Beyond wastewater, are there any other sources of water pollution contributing to these problems? If so, please indicate the relative contribution to total water pollution using the following scale:

No contribution – Minor contribution – Moderate contribution – Significant contribution

- **Runoff from croplands?**
- **Runoff from livestock?**
- **Runoff from aquaculture?**
- **Industrial discharge?**
- **Cruise ships/yachts?**
- **Others?**
- **Do you have a sense of the relative contribution from wastewater to overall pollution of key ecosystems compared to these other sources? If so, please describe.**

Yes – some water pollution from cruise ships/yachts; and runoff from the cattle farm and fish processing plant.

No because water quality data is not tracked or is not available for wastewater discharge locations.

5. **Are there any economic or cultural uses of the key ecosystems that are in decline due to wastewater discharge issues (from untreated or improperly treated wastewater)? Please refer to Annex 2, section B for examples of Caribbean coastal ecosystems and impacts that have been documented from exposure to untreated or improperly treated wastewater.**

6. **Do tourists have any awareness of water quality issues and do they modify activities / visitation? Are you able to quantify or describe the change in visitation (e.g., reduced annual snorkeling rates or reduced number of visitors to recreational beaches)?**

There does not appear to be a decline in tourism at this time.

==========

VIII. HUMAN HEALTH IMPACTS

Objective: To understand if there is a link between wastewater pollution and key human health illnesses including gastroenteritis, ear and eye infections, and other illnesses (as listed in Annex 2, section C); and to estimate the impacts on the local economy due to human health impacts (e.g., from hospitalization, medication, time taken off work, and death).

Possible data sources: Health agencies or ministries; Hospitals or doctor's offices; national statistics/census data; international statistics from multilateral, intergovernmental or NGOs (e.g., World Bank or World Health Organization); peer-reviewed or grey-literature.

1. **Please describe any known human health impacts, such as gastrointestinal illness, respiratory illness, ear infections, eye infections, or skin rashes/lesions that are occurring in the study site that relate to wastewater. Please see Annex 2, section C for a list of human illnesses related to swimming in, drinking from, or eating seafood from water contaminated with wastewater.**

    - **Are health data recorded on any of these key illnesses? If so, who collects this data? What can you say about the average frequency and duration of occurrence for each type of illness (e.g., 50 cases per year; 1 case per resident person per year)?**
    - **Do reported incidences of these illnesses result in doctors' visits, hospitalization, or death? Do you have statistical data on illnesses and hospital data?**
    - **What activities seem to be contributing (e.g., swimming; eating contaminated seafood)?**
    - **How specific can you be about location?**
    - **Is wastewater pollution the main cause of these health issues? If not, what are the main causes of these diseases?**

LaPointe et al. (2010) state that sewage pollution presents a significant health risk (e.g., from elevated coliform bacteria and fecal streptococci counts found in the area). However, stakeholders present at the WRI/EMA introductory workshop say health data is likely not available.

In 2013, a study by Lahkan et al. was conducted on acute gastroenteritis and food-borne pathogens in T&T. The study states, "During 2000-2005, there were seven large outbreaks of [Acute GastroEnteritis] AGE with over 20,000 cases reported per year but less than 70 cases were of known aetiology (11). The national surveillance system for AGE in T&T is based on both syndromic cases of AGE and its laboratory confirmed pathogens collected using standard data collection forms—weekly syndromic and monthly laboratory data-collection forms (11)—based on the Caribbean Public Health Agency (CARPHA), formerly known as the Caribbean Epidemiology Centre (CAREC).[….] The reason why these illnesses are not well understood lies in the fact that most affected people are not captured by the National Surveillance Unit (NSU).

For acute gastroenteritis - the annual incidence rate was 0.6748 episodes per person-year, with 0.7083 episodes per person-year in males and 0.6321 episodes per person-year in females. The major reasons cited for cases of acute gastroenteritis were food consumption (35.1%), drinking water (17.1%), contact with another sick person (9.9%), contact with an animal (9.9%), and bacterial infection (<1%). Thus – it is unclear the percentage of average cases that might be due to wastewater pollution.

Foodborne pathogens found in the study were *salmonella, Shigella*, rotavirus, and norovirus – all of which have a link to wastewater.

Lahkan et al. found that the common duration for diarrhea was 3 days (with a range of 1-10 days). Time spent away due to diarrhea can involve the following costs: medication and medical costs, costs for a caretaker, loss of leisure activity, loss of income, and loss of days from school.

For acute gastroenteritis, the mean duration of illness was 2.3 days.

2. Have any studies been conducted within the study site or your country or region that link wastewater pollution to human health?

LaPointe (2010 states that wastewater seems to be the major source of water pollution in the Buccoo Reef area (LaPointe et al. 2010)

3. Do any of these studies estimate a dose-response relationship between a given wastewater pollutant and a human health illness (e.g., gastroenteritis)? (See the BCA methods section for more detail.)

4. Beyond wastewater, are there any other sources of water pollution contributing to these problems? (If so, please note how large of a contribution.)

- **Runoff from agriculture?**
- **Runoff from livestock?**
- **Runoff from aquaculture?**
- **Industrial discharge?**
- **Cruise ships/yachts?**
- **Others?**

Yes – some water pollution from cruise ships/yachts; and runoff from the cattle farm and fish processing plant.

5. Do you have a sense of the relative contribution from wastewater to overall health impacts compared to these other sources? If so, please describe.

No – no health data were available or provided by the county medical office and no site-specific dose-response relationships are available for wastewater pollutants.

==========

IX. FUTURE WASTEWATER MANAGEMENT SCENARIO(S)

Objective: To identify and define at least one future wastewater management scenario to compare against the current infrastructure situation in terms of population served, untreated wastewater, pollution removal efficiency for key pollutants, and capital and recurring costs.

Possible data sources: Wastewater authorities; Wastewater consultants or engineers that work with the wastewater authority; Environmental/water/natural resource agencies or ministries that issue wastewater permits.

1. What option or options are under consideration for improving wastewater management in the pilot area? Please provide a description and fill in Table 9 for each major wastewater treatment plant or infrastructure element. Please add columns as necessary if more than two alternatives are being considered.

The future infrastructure scenario is based on the Alpha Engineering Draft CEC application from 2011. The scenario involves:

Bon Accord. The proposed solution for the Bon Accord catchment includes the expansion of system by the installation of an expanded collection system (e.g., small bore sewer lines and lift stations) that will transport effluent from area that are not currently connected, to the existing waste stabilization ponds at Bon Accord. This will be made possible by utilizing the existing anaerobic tanks (septic systems) on individual properties. The solution allows the elimination of some dysfunctional package plants and treatment of liquid wastes from on site (septic) systems. Gray water will not be treated.

Milford Court. The proposed solution for the Milford Court area includes the expansion of the system by the installation of a collection system (small bore sewer lines and lift stations) to transport effluent from the area that are not currently connected, to the existing WSP at Golden Grove. This will be made possible by utilizing the existing anaerobic tanks on individual properties. The solution also involves converting the Milford Court WWTP into anaerobic treatment tanks only. The effluent from these tanks will be piped to the Golden Grove WSP. Gray water will not be treated.

Coral Gardens / Buccoo. The proposed solution for the Coral Gardens/Buccoo area is to allow for full removal and treatment of all domestic wastewater (black and grey water) from the community. This

would involve the conversion of the Coral Gardens WWTP into anaerobic tanks and the construction of a new lift station to allow for the discharge of the effluent via pipelines to the Golden Grove WSP. Additionally, new sewer lift stations will be built at the site of the Buccoo Integrated Facility (goat race facility). A full bore 200 mm gravity collection mains to collect sewage from the school, goat race facility, community center, fish depot, and pan yard and houses not currently connected to the system would be constructed.

Table 9: Future wastewater management scenarios description

Data need	Alternative 1
Design	
Location	Southwest Tobago
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)	Bon Accord catchment= 1834 m3/ d ADF Golden Grove catchment= 1666 m3/d ADF
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Current system upgraded (see description above), waste stabilization ponds, wetland, and increased distribution pipelines, gravity lift stations
Will effluent and water quality standards be met?	Yes
Sludge treatment and disposal	Via tanker to Studley Park landfill
Discharge location (receiving water body). If coastal, is there an outfall(s)?	Alpha Engineering (2011) states there will be fewer discharge locations than the current situation. Principal discharge point at the Bon Accord and Golden Grove constructed wetlands
Ease of operation (description of the no. of staff needed to operate; the technical complexity of operation; and overall ease of operating and maintaining the infrastructure)	
Performance	
Flows (annual average, peak)	Estimated 2035 ADF of 3500 m3/d
Annual energy usage (kW hours, total cost)	

Occurrence of bypassing at the treatment plant for the period 2010-2014 due to high flows, equipment failures, or power outages (list date, cause and estimated bypassed volume for each event).	
Occurrence of overflows in the collection system due to heavy rain, equipment failures, or blockages (average per year)	The occurrence of overflows is expected to be reduced (but unclear on the improvement level)
Annual average discharged concentrations and loads of: • BOD_5 (mg/l, kilograms per year) • Dissolved oxygen (mg/l) • Total Nitrogen (mg/l, kilograms per year) • Ammonia Nitrogen (mg/l, kilograms per year) • Total Phosphorus (mg/l, kilograms per year) • Total Suspended Solids (mg/l, kilograms per year) • Faecal coliforms (units as reported) • Enterococci (units as reported)	WP standard to be met Bon Accord : BOD: 5 mg/l SS : 4mg/l FC : 83#/100 ml Golden Grove: BOD : 0 mg/l SS : 0 mg/l FC : 93#/100ml

2. What are the evaluation criteria for choosing an infrastructure option and who decides what these criteria are? For example, criteria may include cost-effectiveness, pollutant removal efficiency, and/or environmental impacts.

For WASA, the following are important evaluation criteria:

- Cost (this option is 10% of the cost of a full conventional collection and treatment system for the South west Tobago) – including both capital and O&M costs
- Shorter time to implement- (10 months versus 36 months)

For EMA, the following are important to consider:

- Water Pollution Rules
- Requirements of Certificates of Environmental Clearance and Environmental Impact Statements

Other stakeholders from the WRI/EMA workshops indicated:

- Human health impacts
- Ecosystem impacts
- Ecosystem service impacts
- Economic growth/disruption related to construction of new facilities
- Energy consumption of plant
- Ease of operation of infrastructure

3. What sort of improvements are expected from each future wastewater management scenario?

- **Increased coverage in terms of population treated?**
- **Improvement in water quality of receiving water bodies and downstream water bodies?**
- **Reduced levels of:**
    - **BOD5**
    - **Dissolved oxygen**
    - **Total nitrogen**
    - **Ammonia nitrogen**
    - **Total phosphorus**
    - **Total suspended solids**
    - **Faecal coliforms**
    - **Enterococci**

WASA expects that the future scenario will meet WPR and LBS protocol standards.

The improvement also caters for expected wastewater flows to the year 2025.

4. Will the new wastewater treatment technology allow any reuse of water?

- **Where does the treated water go – back in a river, out an outfall, or into a specific use (e.g. irrigation, industrial use, or drinking water)?**
- **Has anyone estimated the potential cost savings associated with reuse of this wastewater?**

Potentially.

- The treated water enters the constructed wetlands adjacent to the Bon Accord Lagoon
- Some discussions were held but the cost for implementation of the treatment required was found to be prohibitive and the reuse customers were very limited (watering of the golf courses)

5. Have any engineering or financial analyses been conducted for future wastewater management alternatives? Do they provide cost data?

The Alpha Engineering (2011) CEC application has cost data.

- Scenario 1, Alpha Engineering proposed solution utilizes the existing waste stabilization ponds (Bon Accord and Samaan Grove) to treat waste from the major polluters in the South West Tobago and is estimated at $ TT 120 million –capital cost.
- The development of a conventional gravity sewerage collection system and Wastewater Treatment Plant for the entire South West Tobago was estimated at $ TT 800 Million in 2009 including a 1.4 km outfall pipeline in the sea- capital cost.

6. Please fill in Table 10 to the best extent possible based on either engineering/financial reports from the wastewater authority and relevant consultants, OR by referring to Annex 2 which provides information on relative cost by infrastructure type.

Table 10: Cost estimates for future wastewater management scenarios

Parameter	**Alternative 1**
Year of installation	2015 (estimated at end of 2014)
Life expectancy (years)	50 years
Total area of the plant (please list the area that will need to be purchased for the treatment facility)	Bon Accord- 4.6367 hectares Samaan Grove- 6.0997 hectares
Capital/Investment expenses (This includes one-time construction, planning, and design costs, costs for new development, and cost for replacement and renovation of existing assets – including external or consulting services)	Engineering & construction supervision costs: $4.91 million TT Collection system and WW treatment : $120 Million TT Land management issues: $ 22 million TT **Total = $ 146.91 million TT (Costs include connections to individual properties)**
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced sooner than the life expectancy of the treatment facility and the recurring capital cost, including likely year of replacement and the frequency of replacement)	Not available
Annual recurring expenses: -Salary/wages for all personnel -Land rental value for land purchased (i.e., the value of land purchased to install the wastewater infrastructure)	Not available $TT 3 Million /yr

-Operational and maintenance costs (e.g., chemicals, consumables, maintenance, etc.) -Energy costs (annual energy costs only for the operation of the selected project)	
Discount rate (please list the discount rate(s) typically used by the wastewater management authority for infrastructure projects)	Not available
Other costs	
Net present value over infrastructure's lifetime	**Total = $ 146.91 million TT**

==========

X. CHANGES TO ECOSYSTEM AND HUMAN HEALTH UNDER IMPROVED WASTEWATER MANAGEMENT SCENARIOS

Objectives: To quantify and/or describe how ecosystems and the goods and services they provide will change under each future wastewater management scenario, and the potential impacts on the local economy in terms of costs;

To quantify and/or describe how human health will be impacted under each future wastewater management scenario in terms of numbers of reported illnesses and costs.

Possible data sources: Peer-reviewed and grey literature; Government documents including environmental impact statements.

1. **Have any evaluations, studies, or environmental impact statements been conducted that estimate the impact on key ecosystems and human health under each new wastewater management scenario *compared to the current wastewater management situation*? Do you know of any experts that are currently studying potential impacts? If so, please describe these findings, including how likely management under each scenario is to:**

    - Reduce the annual loading of pollutants on receiving water bodies?
    - Reduce odor?
    - Reduce the incidence of harmful algal blooms and/or nutrient over-enrichment?
    - Reduce human health risk and/or the number of cases for illnesses previously identified?
    - Improve ecosystem health conditions for the key ecosystems identified previously?
    - Improve the provision of key ecosystem goods and services identified previously (e.g., increased likelihood of tourist visits, increased productivity of fisheries due to improved coral reef and mangrove health)

No – we are not aware of any studies that estimate the potential change in ecosystem and ecosystem service condition due to the proposed wastewater management scenario. As a result, a cost-benefit analysis cannot be conducted.

WASA (2015) provided the following data: Within the targeted areas of the project, the system is designed to capture the major polluters (commercial). The impact of this initiative will be to capture approximately 90% of the building structures along the Crown point/Pigeon point coastline. All buildings within reach of the coastline in the Buccoo area would be sewered under this project. The net result of the works in both Crown Point/ Pigeon point and Buccoo areas would be 80% central sewer coverage. Individual homes within the project area that are not targeted for connection to the sewer system would be inspected to insure that their on-lot system is functioning properly.

The upgraded waste stabilization ponds are considered secondary treatment. WASA has indicated that treated effluent from the ponds will meet water quality levels established by the Water Pollution Rules.

Alpha Engineering listed potential benefits from the upgrades listed in the CEC application (2011). These benefits include:

- Fewer outfall locations which means fewer pollution sources and more control over the quality of wastewater discharged
- Better quality effluent that meets EMA water quality standards
- Possibility of reusing effluent in agriculture or aquaculture
- Lower capital and O&M costs (as waste stabilization ponds require less operators, electricity and mechanical equipment)

2. Can you establish a quantitative relationship between an improvement in water quality due to the future wastewater management alternative and a change in provision of ecosystem services for each key ecosystem? If so, please list your assumptions and quantitatively describe these changes (e.g., by reducing the amount of untreated wastewater entering the coral reef ecosystem, total nitrogen levels will decrease by 30% surrounding the reef which will improve coral reef health such that fisheries production increased by 20%).

No.

3. Can you monetize or value the change in ecosystem service provision (e.g., what is the economic value of reduced coral reef degradation in terms of fisheries improvement – this is often quantified by estimating the market value of fish sold in a marketplace)?

No.

==========

XI. OTHER INFORMATION

1. **Please list any additional data or information you think would be useful to the study that might not have been discussed previously in this characterization form.**

==========

XII. REFERENCES

Alpha Engineering & Design, 2011. Draft CEC Application for Bon Accord.

Beharry-Borg, N ., Scarpa, R., 2010. Valuing quality changes in Caribbean coastal waters for heterogeneous beach visitors. Ecological Economics. Vol. 69 (5): 1124-1139.

Brown, K., Adger, W.N., Tompkins, E., Bacon P., Shim, D. and Young, K. 2001. Trade-off analysis for marine protected area management. Ecological Economics 37(3):417–434.

Burke, L., Prager, D., Cooper, E., Greenhalgh, S., 2008. Coastal capital: Economic valuation of coral reefs in Tobago and Saint Lucia. World Resources Institute. Washington, DC.

Central Statistical Office, 2012. Trinidad and Tobago 2011 population and housing census demographic report. Ministry of Planning and Sustainable Development, Government of Trinidad and Tobago.

Division of Tourism and Transportation, 2014. Tobago stay-over arrivals (Exit survey) 2013. Tobago House of Assembly.

Institute of Marine Affairs, 2015. Personal communication between IMA and Lauretta Burke, WRI in May, 2015.

Juman, R., 2005a. Biomass, litterfall and decomposition rates for the fringed *Rhizophora* mangle forest lining the Bon Accord Lagoon, Tobago. Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 53 (Suppl. 1): 207-217.

Juman, R., 2005b. The structure and productivity of the *Thalassia testudinum* community in Bon Accord Lagoon, Tobago. Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 53 (Suppl. 1): 219-227.

Juman, R., Bacon, P. 2002. Buccoo Reef Case Study Pp 34-41 In: Kjerfve B., Wiebe, W. J., Kremer, H. H., Salomons, W., Marshall Crossland, J. I (Caribbean); Morcom, N., Harvey, N. and Marshall Crossland, J. I. (Oceania) Caribbean Basins, LOICZ (Land-Ocean Interaction in the Coastal Zone) Global Change Assessment and Synthesis of River Catchment/Island-Coastal Sea Interaction and Human Dimensions; with a desktop study of Oceania Basins. LOICZ Reports and Studies # 27, ii + 174pp, LOICZ, Texel, The Netherlands

Lahkan, C., Badrie, N., Ramsubhag, A., Sundaraneedi, K., Indar, L., 2013. Burden and impact of acute gastroenteritis and foodborne pathogens in Trinidad and Tobago. Journal of Health and Population Nutrition. 2013 Dec. 3 Issue 4: Suppl 1: S30-S42.

LaPointe, B.E., Langton, R., Beford, B.J., Potts, A.C., Day, O., Hu, C., 2010. Land-based nutrient enrichment of the Buccoo Reef Complex and fringing coral reefs of Tobago, West Indies. Marine Pollution Bulletin. Vol. 60: 334—343.

Louis, G.E., Magpili, L., Singleton, A., 2005. Capacity Assessment and Mapping of the Municipal Sanitation Infrastructure in Tobago. University of Virginia. Retrieved from http://web.sys.virginia.edu/files/tech_papers/2005/SIE-050005.pdf on May 15, 2015.

Ministry of Tourism, 2015. Personal communication between the Ministry of Tourism and Vidjaya Ramkhalawan, EMA, August 2015.

Santana, C., 2014. WASA/CREW/WRI - The status of wastewater services in Tobago. PowerPoint presentation. Water and Sewerage Authority (WASA).

Tobago House of Assembly, 2015. Personal communication between THA and Vidjaya Ramkhalawan, EMA on May 18, 2015.

WASA 2015. Personal email communication between Roger Karim and Carl Santana, WASA and Erin Gray and Lauretta Burke, July 1, 2015.

Water Resources Authority 2015. Personal communication between WRA and WRI in July, 2015.

Wikipedia 2015. Tobago. Retrieved from https://en.wikipedia.org/wiki/Tobago on May 15, 2015.

==========