Annex 3C. Characterization Form for Defining the Costs and Benefits of Domestic Wastewater Management – Chaguanas, Trinidad

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STUDY SITE: **Chaguanas, Trinidad**

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RESPONDENT INFORMATION

This report was completed by:

Name: Erin Gray and Lauretta Burke, World Resources Institute (WRI); Roger Karim, WASA

Organization: WRI and WASA

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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[1]), and the upstream catchment (which might be contributing pollutants to the water body of focus).

The study area for Chaguanas encapsulates the Borough of Chaguanas (including the Chaguanas sewerage catchment) and the potential growth boundary as Chaguanas develops from a borough to a city. The study area includes the Cunupia, Guayamare watersheds and a section of the Caparo watershed - these watersheds are upstream of the southern portion of the Caroni Swamp. As a result, the southern portion of the Caroni Swamp is also included in the study area. The Chaguanas sewerage catchment is roughly 3,000 – 5,000 hectares and includes approximately 9-12 sewerage catchments (WASA 2015).

There are three reports from WASA that discuss wastewater in Chaguanas. These reports are valuable for providing some additional context, but may not reflect current knowledge. Thus, the first paragraph of this section best represents the overview of the study area. The three reports include:

1) **WASA 2008**: A report by WASA's Wastewater Unit from 2008 entitled, "Wastewater services in Chaguanas and Environs," prepared by WASA's Wastewater Unit
2) **GENIVAR 2009:** A report drafted by GENIVAR for WASA entitled, "WASA Water and wastewater master plan and policy development: Wastewater alternatives Report for Trinidad – Draft" that appears to be from 2009. We have received section 4.12 and 6.6.9 of this report from WASA.
3) **WASA (Chapter 3.3.9)**: Chapter 3.3.9 of a report by WASA from an unknown year, "Detailed designs and tender documents for construction contracts for the rehabilitation, expansion, and integration of wastewater treatment facilities."

The WASA 2008 report defines current and future wastewater infrastructure scenarios for an area called "the Chaguanas Catchment." This area is defined as covering 2,955 hectares, with 86% of that area being developed (2,529 ha). The boundaries of the study area include:

- Warrenville to the north
- Felicity to the west

[1] See glossary for definition of water bodies and water catchments

- Cunupia to the east
- Edinburgh to the south

This report states there are 12 separate wastewater systems (or catchments) existing in the area that serve the following developments:

1. Boodram Development
2. Centre City Mall
3. Homeland Gardens
4. Mid Center Mall
5. Orchard Gardens
6. Point Pleasant
7. Charlieville
8. Edinburgh 500
9. Penco Lands
10. Chaguanas Senior Comprehensive School
11. Lange Park

The WASA chapter 3.3.9 states that the Chaguanas sewerage catchment occupies an area of 4,773 hectares which corresponds to the area of the Borough of Chaguanas. The report states there are 9 sewerage catchments existing within the area including:

1. Boodram Development
2. Centre City Mall
3. Homeland Gardens
4. Mid Centre Mall
5. Orchard Gardens
6. Point Pleasant
7. Ramsaran Park
8. Saint Anthony's Park
9. Simon Development

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.

A map provide to WRI by WASA ("Chag-Edin Catchment" – figure 1) provides an overview of the Chaguanas region sewage collection system. This map (including both the North and South sections) represents the wastewater treatment catchments, but based on input from WASA (2015), we believe the Cunupia, Guayamare, and Caparo watersheds should also be included in the study area, as their respective river/streams run through Chaguanas and into the Caroni Swamp. WASA (2015) notes that we may need to examine this closer to determine how these two watersheds fall into the Chaguanas catchment since other factors need to be considered including proximity to water courses, geotechnical

considerations, population density, population growth, and economic criteria. Figure 2 reflects this broader definition of the study area, including these catchments.

Figure 1 - Map showing contour line that divides Northern and Southern sections of the Chaguanas region sewage collection. (WASA, 2008)

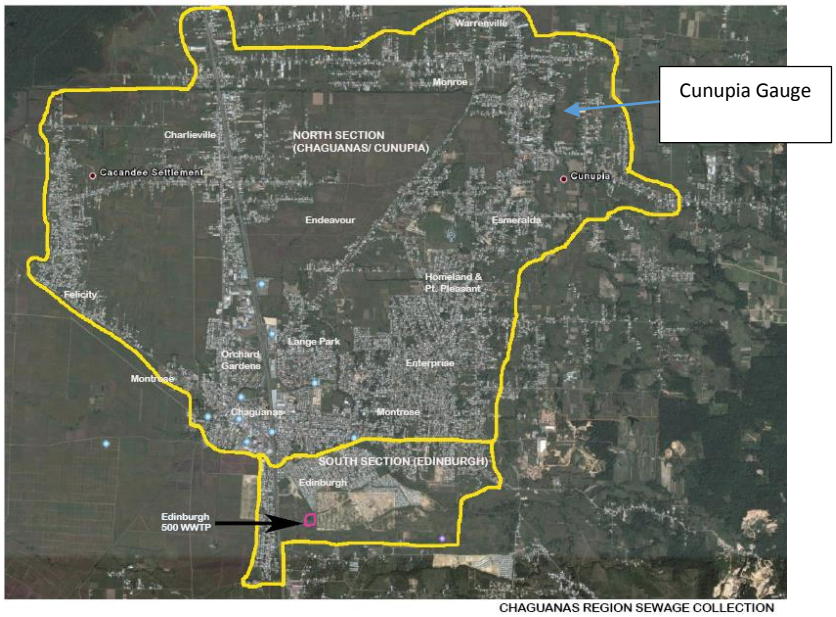


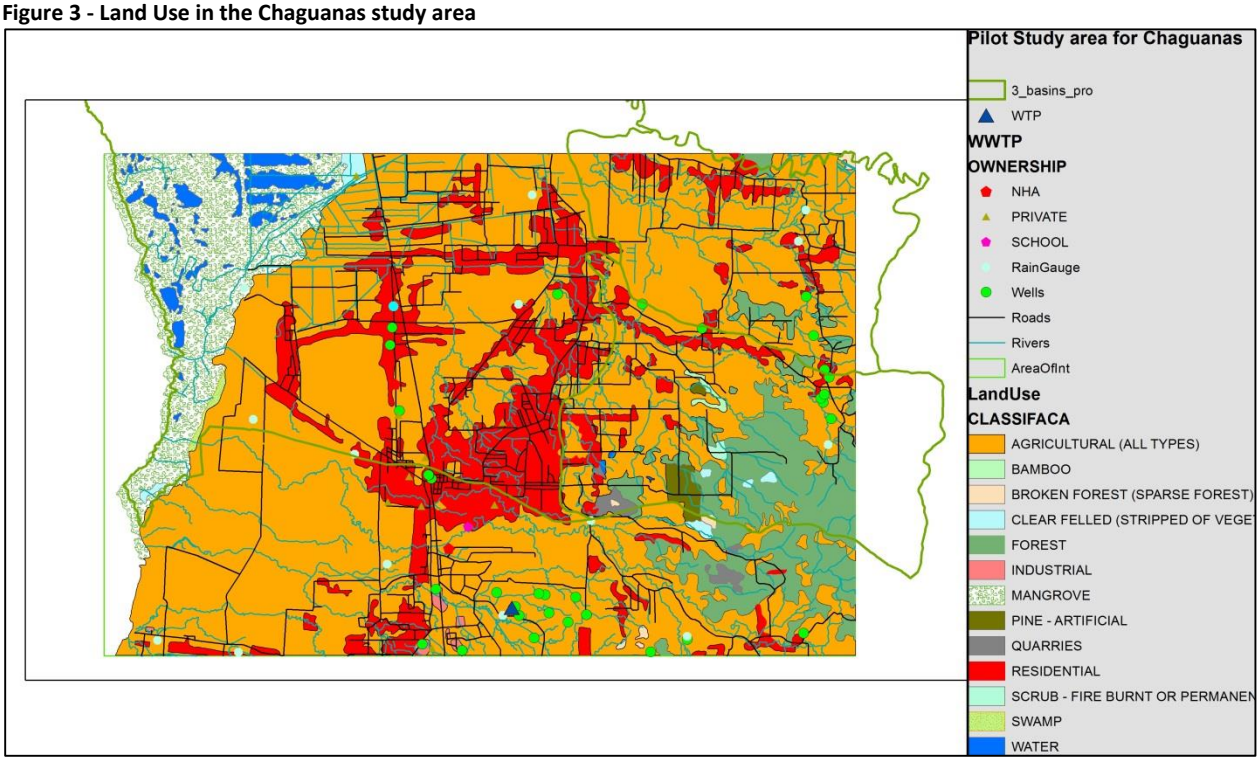
Figure 2 - Chaguanas study site with satellite imagery and watersheds, streams and key features

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?**

Figure 3 provides an overview of major land cover types in the study area. The major land uses are agriculture, followed by residential, and mangrove.

Figure 3 - Land Use in the Chaguanas study area



The WASA 2008 report states that there has been a major thrust towards development in the Chaguanas catchment towards land development, catering to residential, light industrial, commercial, and agricultural purposes. WASA (2015) states that Chaguanas may soon grow from being a Borough to a city.

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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)

See #3.

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.)

According to the 2011 Census (CSO 2012), there were 24,644 households in the Borough of Chaguanas in 2011, with an average household size of 3.4. The population living downstream of the Borough and/or in the southern portion of the Caroni swamp is uncertain.

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)?

Table 1: Summary population and household data by WASA report for the Borough of Chaguanas

REPORT	CURRENT POPULATION	PROJECTED POPULATION
WASA 2008	98,396 (as of 2007)	132,930 (for 2037)
GENIVAR 2009	85,502 (as of 2010)	89,025 (for 2035)
WASA 3.3.9	84,000 (as of 2012)	123,600 (for 2040)
CSO 2011 Census[2]	83,516 (as of 2011)	151,277 (for 2041)

The Central Statistical Office found that the annual population growth rate for the Borough of Chaguanas between 2000 and 2011 was 2%. The population then that could be predicted for 2041 based on a population of 83,516 from the Central Statistical Office (CSO) for 2011 would be 151,277.

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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).

[2] Corresponds to the Borough of Chaguanas from CSO 2011.

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

According to Wikipedia (2015), "[Chaguanas] originally grew in size due to its proximity to the Woodford Lodge sugar refinery and the Central Trinidad town of Couva. It remained a minor town until the 1980s when it began to grow rapidly as it drew people for its bargain shopping and moderately-priced housing. However, its rapid growth has seen property values increase dramatically. Chaguanas became a borough in 1990; prior to that it was part of the County of Caroni.

- **Tourism? (Note types of tourism):** Moderately important. Caroni swamp is a designated Ramsar site and is a popular ecotourism destination for birdwatching and boat tours. The site is a roosting ground for the national bird, the Scarlet Ibis. Thus – the site is important both economically and culturally. It is unclear, however, the importance for the local economy of the Borough of Chaguanas.

- **Agriculture? (Note types of agriculture):** Somewhat important – while agriculture appears to be a predominant land use in the area, we are not sure of the importance to the local economy. The Chaguanas Spatial Development Plan (Ministry of Local Government 2013) states, "the loss of relatively good agricultural lands has led to the economy being based on mainly commercial activity and to a lesser extent light industrial activity. There is a dependence on these sectors to generate jobs. The economy needs to be more diversified and good agricultural lands need to be protected through zoning regulations."
- **Fisheries? (Note major fish species):** Moderately to very important – Caroni Swamp is a popular fishing site, especially for oysters. It is unclear, however, the importance for the local economy in the Borough of Chaguanas.
- **Industry? (Note what industry/ies):** Moderately important – According to Wikipedia, ABEL or Alstons Building Enterprises Limited is a member of the ANSA McAl Group of Companies and is situated in Longdenville. It is the largest manufacturer of clay building blocks and Metpro steel and aluminum windows and doors and Astralite and Spectra uPVC windows and doors in the

English-speaking Caribbean. Also, the dissolution of the state-owned sugar company, Caroni (1975) Limited, had a profound effect on Chaguanas, since this company was a major employer.

- **Commercial:** Very Important. According to Wikipedia (2015), "Chaguanas developed as a market town and still attracts bargain shoppers. Much of Chaguanas' development has centered around the Chaguanas Main Road where numerous shopping plazas have been constructed. The Chaguanas Main Road (east of the Chaguanas flyover) continued to develop, primarily through small and medium size businesses, to fulfill the expanding population centers. Retail development expanded with the construction of three malls in the downtown in the 1980s (Centre City, Mid Centre and Ramsaran Plaza, later to become Centre Pointe Mall). Centre City Mall has been significantly renovated and there are future plans to expand further to become the largest mall in the Caribbean. It will feature two major buildings, one near to the Uriah Butler Highway and another close to the center of Chaguanas, joined by an enclosed walkover above the Mulchan Seuchan Link Road. More recently, construction of Price Plaza in Endeavour expanded upscale retail opportunities. Price Plaza includes a warehouse-style store PriceSmart, TGI Friday's and Ruby Tuesday restaurants, a food court, SuperPharm, as well as many other retail outlets. MovieTowne is situated nearby the Price Plaza and continuing further expansion. Adjoining to the Movietowne complex are other restaurants and bars, e.g. Woodforde Cafe, Wild Olive Restaurant, and Hollywood Grill. A new shopping complex is planned to be built in 2013-15 in the Brentwood planned housing and commercial development."
- **Financial:** Moderately important. According to Wikipedia (2015), "Chaguanas has also developed into a financial center. The Unit Trust Corporation (UTC), First Citizens Bank (FCB), Sagicor, Republic Bank of Trinidad and Tobago, Scotiabank, RBTT, and the Bank of Baroda all have major corporate offices in Chaguanas."

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IV. KEY ECOSYSTEMS

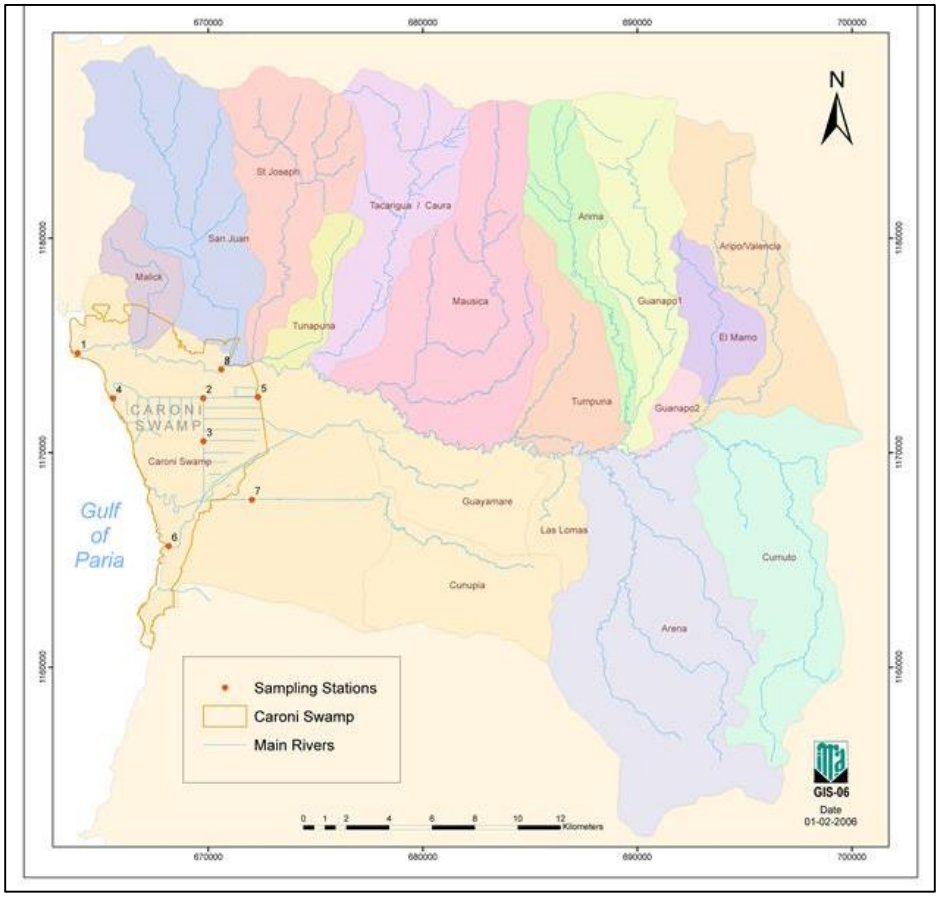
Objective: To understand potential benefits to ecosystem health from wastewater management improvements, it is necessary to a) identify key ecosystems in the study sites, b) their economic contribution in terms of key goods and services they provide, c) their contribution to key economic sectors. This 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.**

An important ecosystem in the study area is the Caroni Swamp. Juman, Bacon, and Gerald (2002) provide an overview of the Caroni River Basin (CRB). The CRB covers a total of about 883.4 km2, equivalent to 22% of the land surface area of the island (Juman et al). The CRB includes the Caroni Swamp, which is a Ramsar site as of 2005 and is the largest mangrove area in Trinidad. The swamp consists of 5,611 ha of mangrove and herbaceous marsh, interrupted by numerous channels and lagoons. The swamp comprises eight mangrove species. It is situated on the eastern coast of the Gulf of Paria, a semi-enclosed sea bordered on the north by the Caribbean Sea and the southeast by the Atlantic Ocean and lying between Trinidad and Venezuela. It is shallow, with an average depth of about 25 m and a maximum depth of 300 m in a trench to the north. Figure 5 provides an overview of the CRB and IMA water quality sampling locations.

Figure 4 - IMA water quality sampling stations in Caroni Swamp and Caroni River Basin Catchments (IMA)



Beyond the Caroni Swamp, there are also important riverine ecosystems within the study area. However, little information is available on characteristics of these water bodies.

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 2 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).

The table below indicates our best guess based on information reviewed in studies listed in the bibliography and consultations with stakeholders.

Table 2: Ranking of ecosystem important to key economic sectors

ECOSYSTEM	AGRICULTURE	FISHERIES	INDUSTRY	TOURISM	COMMERICAL	FINANCE
Caroni swamp	Not important	Very important	Not important	Very important	Moderate importance	Not important
Riverine ecosystems	n/a*	n/a	n/a	n/a	n/a	n/a

*n/a = not available

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 the table below and add or delete ecosystems as needed. You may refer to Table 4 which provides a general list of ecosystem services for major Caribbean ecosystem types, for guidance.**

Table 3: Ecosystem goods and services

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

Table 4: 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.**

There is a study by Rambial (1980) that estimates the recreational and fishing value for the Caroni Swamp from Rambial (1980). The study found that the economic benefits of the Caroni Swamp were estimated to be TT$2020 per hectare across the 5000 hectare reserve based on estimated recreational and fishing resources in 1974 by Rambial (1980).

Additionally, it appears that an additional study was recently conducted by Mackoon, entitled, “An Economic Valuation of the Recreational Resources at the Caroni Swamp Bird Sanctuary.” This study will estimate the domestic access value of the recreational resources at the Caroni Swamp Bird Sanctuary. The major economic activity is recreation which occurs in the form of guided boat tours. An Individual Travel Cost Model (ITCM) was used to estimate the domestic access value of this direct use of the Swamp. Results are not yet available, however.

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?

No data is available on visitation to the Caroni Swamp. However, daily boat tours are conducted within the swamp.

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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?**

A report by the CSO (2000) states that within the Chaguanas *municipality*, ~15% of people are connected to a sewerage system, ~65% use septic tanks or soak-away systems, almost ~20% use pit latrines, and 0.23% have no treatment whatsoever. WASA recently confirmed this estimate in July, 2015 (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.)?**

Not clear – although stakeholders at both the introductory Environmental Management Authority (EMA) and World Resources Institute (WRI) wastewater workshop in October 2014 (EMA and WRI 2014) and the follow-up workshop in July 2015 (EMA and WRI 2015) indicated that there is some untreated wastewater from on-site systems leaking into local water bodies. Additionally, the Chaguanas Spatial Development Plan (Ministry of Local Government 2013) identified untreated wastewater as a hazard for the local area.

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.**

Information not available.

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

According to the WASA 2008 report, only 14% of the total population in the study area has access to centralized sewerage facilities. Additionally, stakeholders at the follow-up WRI/EMA workshop in July 2015 indicated that industrial wastewater discharge into WASA's network is a concern – if industrial sources discharge into WASA's sewerage network they are not required to meet Water Pollution Rule standards, and can overburden the sewerage system.

3. Wastewater treatment plants:

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

Currently, there are 14-15 package wastewater treatment plants and up to three may be constructed in the near term (WASA 2015). These systems serve the following developments:

- Charlieville
- Orchard Gardens
- Centre City Mall
- Centre Pointe Mall
- Mid Centre Mall
- Edinburgh 500
- Penco Lands
- Chaguanas Senior Comprehensive School
- Lange Park
- Boodram Development
- Homeland Gardens
- Point Pleasant

The Orchard Gardens plant is currently dysfunctional and is discharging untreated wastewater directly into its receiving water bodies (WASA 2015). WASA plans to address this plant immediately. A large number of the remaining package plants are operated by private operators and are in a dire state of disrepair, with raw sewage discharging directly into the receiving streams.

There are four major wastewater treatment plants in the study area: Edinburgh 500, Penco, Lange Park, and Charlieville plants. WASA states these are operating satisfactorily (2015). The Environmental Management Authority (EMA) has provided WRI with recent Certificate of Environmental Clearance (CEC) for WASA from 2009 for the Chaguanas area and environs for the activity, "the establishment, modification, expansion and decommissioning or abandonment (inclusive of associated works) of pipeline distribution systems for the delivery of potable, process water and sewage." In 2013, a CEC was issued to WASA for the decommissioning and demolition of the existing Homeland Gardens and Pointe Pleasant WWTPs and the establishment of a new WWTP at the corner of Mahogany Drive and Teak

Drive in Chaguanas. Certificates of Environmental Clearance are issued by EMA (under the Environmental Management Act, Section 35) and certify the environmental acceptability of a proposed activity, provided that all conditions in the CEC are met. The status of these activities, however, are unknown.

Environmental Impact Statements are not available for any of these plants.

- **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:**

Information is not available for any of the four main WWTPs nor the package plants. WASA (2015) states that as most plants were constructed before the establishment of the Water Pollution Rules in 2001, water quality monitoring is not required for these plants.

Table 5: Wastewater Treatment Plant information for current situation

Data need	Data
Design	
Location	
Design capacity - Nominal design capacity for dry and wet weather flows.	
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	
Effluent limits	
Sludge treatment and disposal	
Discharge location (receiving water body). If coastal, identify the outfall locations.	
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)	

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)	
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)	

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?

Data is not available on untreated wastewater volume delivered to receiving water bodies. However, WASA (2015) noted several sources of untreated wastewater, including:

a. Unauthorized/unplanned developments
b. Grey water: Grey water is not treated from the 86% of the population using on-site treatment
c. Dysfunctional package WWTPs
d. Population pressure: the population is expected to exceed the capacity of the current plants

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.

It is thought that untreated sewage travels to the southern portion of the Caroni swamp.

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 –evidenced by the studies conducted by WASA and GENIVAR, the Chaguanas Spatial Development Plan, and the CEC application submitted by WASA.

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 6 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 Annex 2, section D.

Limited cost information has been provided to date from WASA.

Table 6: Current wastewater scenario costs

Data need	**Current wastewater management situation**
Year of installation	
Life expectancy (years)	15 years
Total land area occupied by the plant (hectares)	
Recurring capital expenses (e.g., please list which infrastructure components will need to be replaced within the next 20 years and the total capital cost, including likely year of replacement and the frequency of replacement)	Recurring capital expenses are not known, but the average cost for a package WWTP is approximated at $10 million TT per plant (WASA 2015)
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)	$20,000 - $30,000 TT per month per plant (excludes electricity) (WASA 2015)
External services costs (if applicable, net value of total costs of external services including outsourcing, costs for construction)	
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	

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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 LBS protocol. Standards are summarized in Table 7 below:

Table 7: 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))		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?**

Table 8: Caparo River water quality data from WASA (2015)

Date taken	Turbidity	pH	Organic Nitrogen (mg/l)	TSS (mg/l)	Dissolved oxygen (mg/l)
04-Sep-13		7.95		130	6.66
27-May-13	28.9	8.96			5.26
03-Jul-13	28.4	6.92			6.39
17-Jul-13	27.52	6.96		140	5.86
16-Aug-13		7.53		220	7.28
16-Oct-13		7.64		160	7.74

08-Nov-13		7.93		92	7.25
23-Jul-14		7.33			5.63

Table 9: Cunupia River water quality data from WASA (2015)

Date Taken	pH	TSS (mg/l)	Dissolved Oxygen (mg/l)
04-Sep-13	6.97	120	5.78
16-Oct-13	7.32	20	6.34
15-Nov-13	7.26	22	5.58
18-Jun-14	6.97	40	5.3
18-Jun-14	6.97	40	5.3
16-Jul-14	7.25		6.22

Additionally, IMA has provided some data for points within the study area, shown in Table 10.

Table 10: IMA (2015) water quality data for research stations within the Chaguanas study site

Date Taken	Caroni River	Guayamare	Madame Espagnole /Bejucal Canal	Cunupia	Cunupia	Tumpuna
2000	43	20	37	28	59	61
2004	2.5	5.4	3.6	1.9	5.9	1.9
2004	0	0	0	0	0	0
2004	58333	107837	3833	38283	29700	13190

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)**

Overall, water quality data retrieved to date are very sparse and do not cover all pollutants listed in Table 7, and as a result, do not provide a good depiction of water quality nor potential wastewater impacts.

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.

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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?** Not sure
   - **Discharge of treated wastewater effluent?** Not sure
   - **Irregular release of wastewater from a WWT system due to overflow, rainwater events, or power failure, etc.?** Not sure

Juman and Ramsewak (2013) state that the Caroni Swamp receives water polluted with sewage, wastewater from industry and agriculture run-off, but the study does not say where the wastewater and sewage is coming from exactly.

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?**

No.

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?**
   - **Is there odor due to pollution?**
   - **Are there impacts to fish or other aquatic life (e.g., fish kills, overgrowth of algae on coral reefs)?**
   - **Are you seeing a change in ecosystem health and/or growth?**

Juman and Ramsewak (2013) conducted a study on land cover changes in the Caroni Swamp between 1942 and 2007 using remote sensing technology, geographic information systems, and extensive field surveys. The report found that freshwater marsh and agriculture increased from 1942 to 1957, but declined after this period as freshwater was diverted away from the wetland and salt water intruded further inland. The study also found that, "Although mangrove forest was cleared for built development, its coverage has consistently increased in the Swamp from 1957, with the exception of 2003 when there was a decrease by less than 100 ha. This is in contrast to most areas in the tropics where mangrove coverage continue to decline. In this case, the mangrove trees are outcompeting/shading marsh vegetation, causing shift in the wetland communities. In the Caroni Ramsar Site, the natural wetland

communities generally increased from 1942 to 2003, but declined in 2007, as built development more than doubled."

The Ministry of Food Production reported two pollution incidents to Water Resources Agency in March and June 2014 within the Caparo River in the vicinity of Petersfield (WRA 2015). The area is currently under cultivation as former Caroni lands. Farmers reported fish kills in the two incidents at the same location. Water quality analysis showed high nutrient concentrations and a heavy foam presence was observed during the field investigation. The suspected pollution source is discharge from a commercial laundromat located upstream.

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.**

Local stakeholders have indicated that agricultural and industrial pollution are two other major contributors to water pollution. Industrial polluters also frequently discharge into the WASA sewerage network and as a result, do not have to meet Water Pollution Rule standards for their effluent (EMA and WRI 2015).

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.**

Not sure – no data available.

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)?**

The Trinidad and Tobago Ministry of Tourism (2015) has provided tourism data for Trinidad as a whole (so not specifically for the study site). This information helps to shed light, however, on the contribution of the tourism sector to the national economy.

Table 11 provides arrival data by mode of transportation.

Table 11: Tourism arrival data for Trinidad (Ministry of Tourism 2015)

	2010	2011	2012	2013	2014
Air arrivals					386,262
Cruise arrivals	40,605	15,654	17,745	12,770	13,085
Yacht arrivals				1,060	1,030

For accommodations in Trinidad, there are 152 establishments including 21 apartments, 34 bed and breakfasts, 34 guest homes, 5 host homes, 53 hotels, and 5 villas. In total there are 3,788 rooms. The average expenditure per visitor has increased from $6,527 TT to $8,199 TT. Direct employment in Trinidad and Tobago from tourism is equal to 27,200 jobs and the total contribution to GDP from travel and tourism for both Trinidad and Tobago has increased from $10.5 million TT in 2010 to $12.6 million TT in 2014.

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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?**

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.

There is currently no specific data for the study site, but do have data for T&T on gastroenteritis, diarrhea, and food-borne illnesses for T&T. 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.

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.

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

Lahkan et al. (2013) – see above.

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.)**

No.

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?**

Stakeholders indicate that agricultural runoff and industrial pollution are likely sources of water pollution in the study area (EMA and WRI 2014, 2015). No data are available, however, to support this.

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.**

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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 for each major wastewater treatment plant or infrastructure element. Please add columns as necessary if more than two alternatives are being considered.**

Based on recent guidance from WASA (2015) and the WASA 2008, GENIVAR 2009, and WASA Chapter 3.3.9 reports, there appear to be two future wastewater management scenarios that are being considered:

1) Regionalized treatment at two main wastewater treatment plants: the existing Edinburgh 500 WWTP and a proposed Chaguanas WWTP in the northern area.
2) Regionalized treatment at one main wastewater treatment plant that will replace all existing treatment plants.

1) *Regionalized treatment at two wastewater treatment plants: Edingburgh 500 and Chaguanas WWTP*

For the purpose of this report, we focus on the WASA 2008 report, as this was initially recommended to us by WASA. The report identified the following as being included in this future wastewater management scenario: developments located south of the contour will have their wastewater treated at the Edinburgh 500 WWTP while the wastewater for developments located north of the contour will be directed to a new WWTP, referred to as the Chaguanas Regional WWTP. The total construction period would be roughly two years.

The ultimate average wastewater flow anticipated for the catchment area is 66,000 m^3/d; this is broken down as follows: Edinburgh 500 WWTP: 12,000 m^3/d; Chaguanas Regional WWTP: 54,000 m^3/d.

- **Edinburgh 500 WWTP -** The plant currently uses an activated sludge-extended aeration process, using aerated lagoons. The plant was constructed in the late 1980's and has a design capacity of 3000 m^3/d. The Plant is bordered by housing developments and the Caparo River. In 2004, the Firm MacViro Consultants Ltd undertook a condition assessment of the Edinburgh 500 WWTP and prepared detailed designs and Tender Documents to refurbish and expand the WWTP to a design flow of 12,000 m^3/d. The total flow from the existing and planned developments is estimated to be 9,334 m^3/d. The ultimate flow from the Edinburgh area is anticipated to fall below the design flow of 12,000 m3/d planned for the expanded WWTP, thereby allowing some spare capacity for servicing other developments and un-sewered areas near-by. The ultimate population that will have access in the Edinburgh area is 28,730 persons.

- **Chaguanas Regional Wastewater Treatment Plant -** A 14.1 ha site on the northwestern corner of the catchment Caroni lands has been identified as potentially available to locate the Chaguanas Regional Wastewater Treatment Plant. The spacious location allows for modular expansion of the WWTP as growth takes place in the catchment area. It also ensures that the closest neighbors will have the minimum 20-metre setback to cater for odors and noise from the new facility. It is located at a low point in the catchment, which is ideal, since it will facilitate a gravity feed system from the majority of the area to the new treatment facility. The ultimate average design flow to be sent to the new Chaguanas Regional WWTP is anticipated to be 54,000 m^3/d; this translates into approximately 104,200 persons having access to a centralized wastewater system. Ten plants can be decommissioned with the construction of this new facility. The new plant borders developments that have been earmarked for agricultural and light industrial growth; which may present the potential to reuse the effluent and sludge generated from the process in these adjacent developments. The effluent could also be exported for reuse. The effluent generated from the Plant can also be used to supplement the base flow in a tributary of the Cunupia River particularly during the dry-season; this will have a positive impact for downstream users in the agriculture and farming industry.

Reuse of wastewater might be possible for this scenario.

1. Regionalized treatment at two wastewater treatment plants: Edingburgh 500 and Chaguanas WWTP

This scenario was first described to WRI by WASA at a meeting in 2015 (WASA 2015).WASA is considering a scenario whereby all package plants and the four major WWTPs would be decommissioned over time, and WASA would construct one large centralized wastewater treatment plant and sewerage connections with the goal of connecting everyone in Borough of Chaguanas to this centralized system. For the population that is difficult to connect, WASA plans to have them use primary treatment (i.e., septic systems) with added disinfection. The treatment technology for the WWTP would likely include anaerobic digesters and clarifiers (conventional treatment).

Additionally, treated wastewater could be reused based on this solution.

WASA is currently in the planning stage of hiring a consultant to conduct a cost-effectiveness analysis and identify a future wastewater management strategy.

Table 12: Future wastewater management scenarios description: Scenario 1: Two regional plants (WASA 2008, 2015)

Data need	Edinburgh WWTP	Chaguanas WWTP
Design		
Location	South of the contour (bordered by housing developments and the Caparo River)	North of the contour (northwestern corner of the catchment Caroni lands)
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)	12,000 m^3/d	54,000 m^3/d
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Activated sludge-extended aeration process, using aerated lagoons	Not sure.
Will effluent and water quality standards be met?	Yes	Yes
Sludge treatment and disposal	Not sure	Not sure

Discharge location (receiving water body). If coastal, is there an outfall(s)?	Not sure	Not sure
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)		
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)		
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)		

Table 13: Future wastewater management scenarios description: Scenario 2: one regional plant (WASA 2015)

Data need	Regional WWTP
Design	
Location	
Design capacity - annual average and peak (if actual capacity is lower, that will be covered below under performance)	
Treatment technology (e.g., waste stabilization pond; oxidation lagoon)	Anaerobic digesters and clarifiers
Will effluent and water quality standards be met?	Yes
Sludge treatment and disposal	
Discharge location (receiving water body). If coastal, is there an outfall(s)?	
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)	
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)	
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)	

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 (WASA 2015):

- 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?** Yes –as planned for the next 15-20 years.
- **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**

The improvements for both scenarios would allow for additional treatment required by expanded population growth and development, and WASA expects that water quality standards will be met as set by the Water Pollution Rules.

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?**

Possibly yes for both scenarios. This decision has not yet been made.

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

Not that we are aware of.

6. Please fill in Table 14 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 14: Cost estimates for future wastewater management scenarios (WASA 2008)

Parameter	Scenario 1: Two WWTPs	Scenario 2: One WWTP
Year of installation	Unknown	Unknown
Life expectancy (years)	Unknown	Unknown
Total area of the plant (please list the area that will need to be purchased for the treatment facility)	14.1 hectares	Unknown

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)	PHASE 1 COSTS: (TT$164.2 million) • Land acquisition – TT$2 million • Expand Edinburgh 500 – TT$25.8 million • Chaguanas Regional Phase 1 - TT$106.7 million • Trunk sewers to existing Chaguanas collection areas - TT$15.7 million • Environmental impact assessment - TT$2 million • Lange Park and Orchard Gardens WWTPs - TT$12 million PHASE 2 COSTS: (TT$866.4 million) • Expand Chaguanas WWTP - TT$191.8 million • Trunk sewers Cunupia - TT$25.3 million • Collection piping, Chaguanas - TT$261.3 million • Collection piping, Cunupia - TT$388 million	Unknown
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)	Unknown	Unknown
Annual recurring expenses: -Salary/wages for all personnel	Unknown	Unknown

-Land rental value for land purchased (i.e., the value of land purchased to install the wastewater infrastructure) -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)	Phase 1 Engineering and Contingency costs - TT$57.47 million Phase 2 Engineering and contingency costs - TT$303.24 million	Unknown
Other costs	Unknown	Unknown
Net present value over infrastructure's lifetime	Unknown	Unknown
	TT$1,391.31 million	Unknown

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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.

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.

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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.**

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