

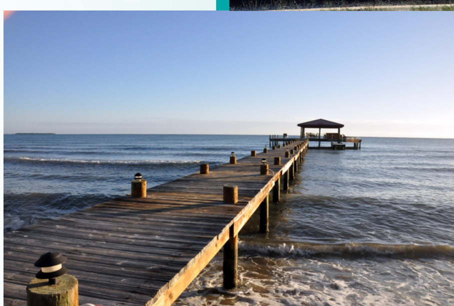
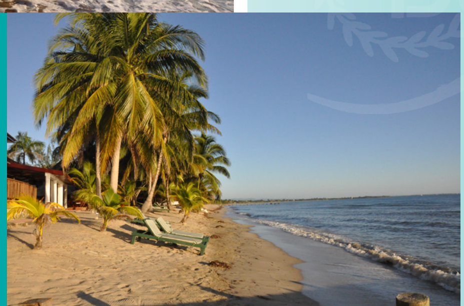


Feasibility Study
for the
Placencia Peninsula Pilot Wastewater Management System

Final Report
July 2, 2012

Volume I - Final Report

Submitted to:
The Government of Belize
Ministry of Finance

Submitted by:
Halcrow
A CH2M Hill Company

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Final Report

Feasibility Study for Placencia Peninsula Pilot Wastewater Management System

Government of Belize, Ministry of Finance

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1 Executive Summary

1.1 Project Summary

The purpose of this Feasibility Study was to determine the need for a wastewater system on the Placencia Peninsula and to analyze various methods and technologies to meet this need. Using existing and projected population data, an analysis was performed on the current and projected water use and wastewater generation to determine the scale of the system through the year 2040.

Local Belize and international design standards for collection, treatment and effluent reuse / disposal were established as a baseline for this project. Various alternatives were developed for the different aspects of the wastewater system, based upon scale, method and technologies. These alternatives were evaluated based upon criteria established within the study (including economic costs and environmental effects), with preferred alternatives determined based upon which were deemed most appropriate for the construction and operation of the system.

These preferred alternatives will continue to be evaluated through the detailed design phase of the project to ensure that the final wastewater system is effective, supported by BWSL (as system operator) and is contextually appropriate.

An environmental analysis was performed on potential treatment facility sites, including potential effluent disposal methods and locations. A further environmental investigation will be performed during the detailed design phase of the project in the form of an Environmental Impact Assessment and Environmental Compliance Plan through the Belize Department of Environment.

An economic analysis of the overall project was performed based upon the anticipated project funding and construction cost estimates to ensure that the project can be built within budget. This analysis was extended across the project timeline (through year 2040) to help prepare an initial water/wastewater tariff model to ensure that the system has positive cash flow through this timeframe. This is especially important to ensure that the project is able to repay its construction loans, as well to ensure that the tariff system is affordable for the Placencia Peninsula communities.

The impacts of the project on the local community were assessed and a project implementation plan was developed.

Placencia is a beautiful peninsula in southern Belize with 16 miles of sandy beaches. The Caribbean Sea is to the east and the charming Placencia Lagoon lies to the west, facing the mainland. The entire peninsula can be easily travelled. The busy part of Placencia is in the south which has the greater concentration of restaurants, shops, the harbor, and guest houses.

1.2 Project Introduction

The U.S. Trade and Development Agency ("USTDA") has provided a grant to the Government of Belize (GoB) for a Feasibility Study for the Placencia Peninsula Pilot Wastewater Management System Project. This Study develops an implementation plan for an effective wastewater management system for the Placencia Peninsula to meet the sanitation needs of this growing region of Belize. This Study was brought to the consideration to USTDA by the Inter-American Development Bank ("IDB") in connection with the Caribbean Regional Fund for Wastewater Management ("CReW"), which is financed and managed by the IDB, in partnership with the Global Environment Facility and the United Nations Environment Program. The CReW seeks to test innovative financing approaches to support the development of wastewater management projects throughout the Caribbean, beginning with the implementation of five pilot projects.

In April 2011, the Belize Ministry of Finance commissioned Halcrow, Inc. to undertake the above-mentioned feasibility study of a wastewater collection and treatment system for the Placencia Peninsula, Stann Creek district. The study is for a 25 year planning period. The selected project can be staged in phases and expanded and/or modified to accommodate future needs for wastewater collection and treatment.

As part of this project, Halcrow conducted a detailed evaluation of the most suitable alternatives and, with the assistance of the Project stakeholders (including Belize Water Services Limited (BWSL) and CReW), selected the preferred alternative for a wastewater collection and treatment system to serve the Placencia Peninsula.

The following criteria were used in the sustainability evaluation and selection process:

- expected effectiveness and reliability,
- ability to be phased and expanded,
- ability to be constructed, operated and maintained,
- environmental benefit,
- life cycle costs, including
  - capital costs and
  - operational costs.

(Photograph by Elio F. Arniella)

1.3 Existing Conditions

In Section 2, starting on page 27, conditions on and surrounding the Peninsula were researched and analyzed to provide a baseline of the existing water supply, water demand, sanitary conditions and estimated environmental framework. A summary of this information is provided below.

Ecology and Environment

The natural vegetation of the Placencia Peninsula, which broadly consisted of littoral forest along the coast and mangroves bordering the lagoon has all but disappeared or at least become fragmented. Natural vegetation on the mainland largely consists of gallery forests along numerous creeks, (pine) savannah on the higher ground, herbaceous swamps, and mangrove swamps along the shores of the lagoon. The mangrove marshlands surrounding the Placencia Lagoon provide important natural environmental functions such as sediment removal and buffering against the impacts of wind and wave action.

The Placencia Lagoon provides a sheltered environment that houses a remarkable biodiversity and includes several endangered and flagship species like the West Indian Manatee, Jabiru Stork, Morelet's Crocodile and American Crocodile. Much of the coast is lined with mangroves which roots are encrusted with a rich variety of sessile life (shellfish, sponges, anemones and algae) and provide shelter for the young offspring of many commercial fish species.

A view of the Placencia Lagoon from the Peninsula. (Photograph by Elio F. Arniella)

Demographics and Development

In past decades, the two small villages of Placencia and Seine Bight were the only centers of human habitation on the peninsula. The 2000 Census noted for Placencia a mere 458 inhabitants and for Seine Bight 831 persons. The 2010 Census showed considerable growth for the two villages: Placencia Village registered 1595 residents and Seine Bight, including Maya Beach, 1498 inhabitants. Based upon the historical annual population growth rate from 2000 – 2010 of 9 percent, the total estimated permanent population in 2011 was 3,375.

The peninsula has experienced explosive growth in development during the last ten years, mainly in the tourism sector. This has led to an increase in hotels, resorts and condominiums, as well as in permanent and semi-permanent residential development for expatriates of pre-dominantly North American origin. The original settlement pattern of the small villages has changed and at present almost no land is un-developed on the east coast of the peninsula. The availability of land along the sea is severely limited, and the inland-facing side of the lagoon is now being developed.

A view of the Placencia Village main road. (Photograph by Elio F. Arniella)

Water Supply

The Peninsula's water system was built around 1996, was partially destroyed by a hurricane in 2001 and rebuilt thereafter. Both the Placencia Water Board (PWB) and Seine Bight Water Board (SBWB) share a pumped well source in Independence Village on the Belize mainland across the Lagoon. Three (3) wells are located in Independence Village (spaced approximately 400 ft apart). One (1) well is designated for the Peninsula, although all wells have the capability to supply the Peninsula in case the primary well is offline. The supply line runs about 2 km across land, about 2 km under the lagoon, and then into the PWB ground storage tank. According to the PWB, the Peninsula supply well runs for 16 hrs per day at 30hp and a maximum capacity 450 gallons per minute (gpm) through a 6" diameter pipe with approximately 50' of 3" diameter pipe just before entering a ground storage tank.

A second supply well to the Peninsula is a private supply for the Placencia Hotel and associated properties and is located on the north side of the lagoon, pumping directly to the Placencia Hotel Resort property. This well produces about 45 gpm and is in constant operation. A third source of water supply is from individual wells, which are estimated within this study to be around 12 gpm. The exact location and ownership of these wells is unknown.

The current consumption records for the entire Peninsula vary between 0.30 – 0.35 million gallons per day (MGD). For the purposes of this study, as detailed in Section 2.5, the estimated average daily flows are shown in Figure E-1.

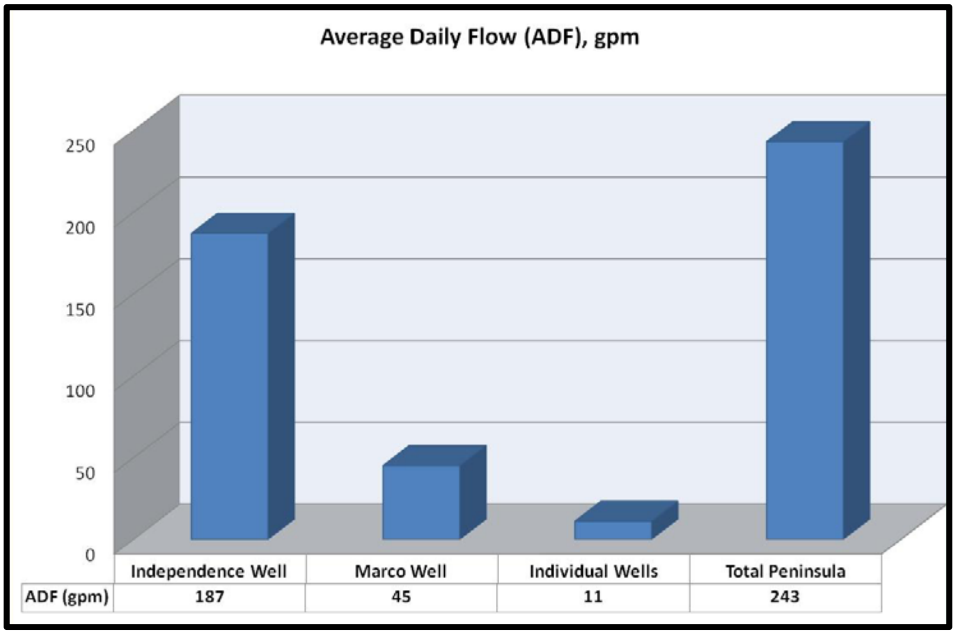


Figure E-1 Average Water Consumption

For the purposes of this study, the per-capita consumption to be used in the water demand projections is provided on Figure E-2. The floating population in Belize has a higher per-capita water consumption rate than the permanent population. The typical tourist per capita water consumption for regions similar to Belize is 400 L/day (106 gpcd).

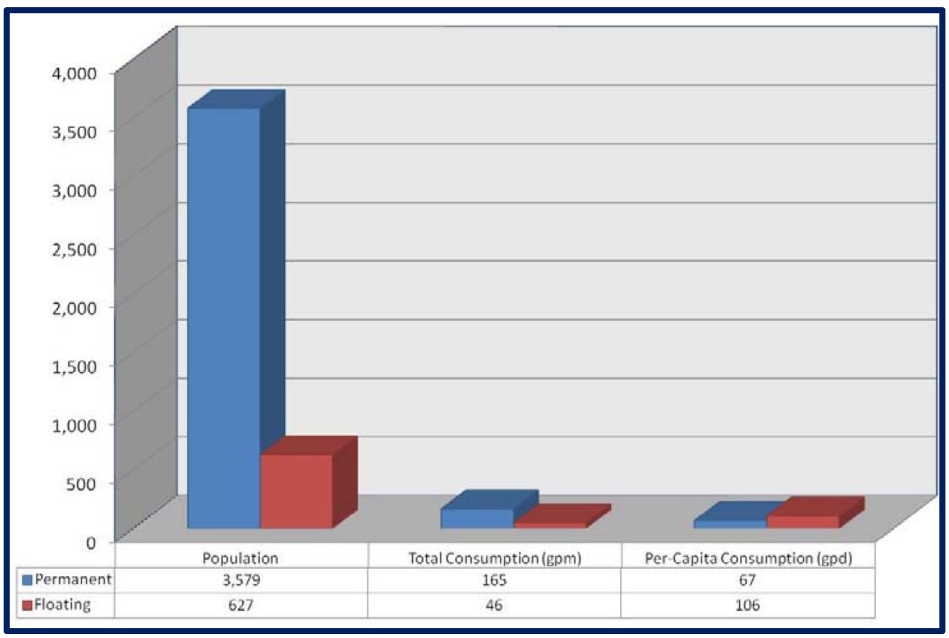


Figure E-2 Water Consumption by Permanent and Floating Population

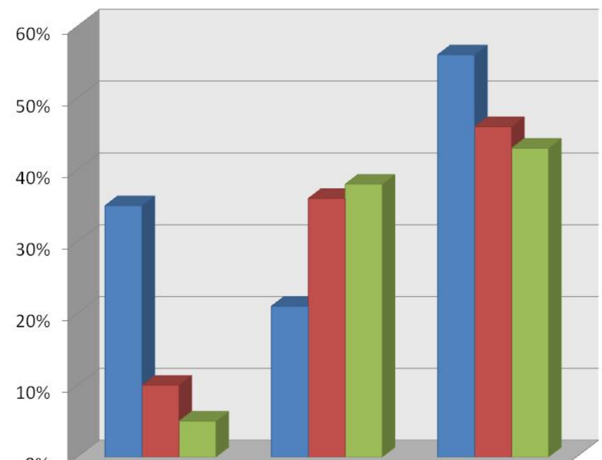
Wastewater Management and Sanitation

At the present time, there is no centralized wastewater system on the Placencia Peninsula. The door-to-door survey conducted by Halcrow as part of this project indicates that each household and business is responsible for on-site wastewater handling and disposal. The predominant wastewater disposal method is the use of septic tanks and soakage pits. The field survey revealed that a significant number of households (about 35%) directly discharge into the soil, beach or lagoon. In addition, the survey shows that +/-10% of businesses and +/-5% of hotels also use direct discharge as their disposal practice. Smaller resorts and hotels have septic systems or soakage pits, while a few of the larger developments comply with the Department of Environment (DOE) requirements to install and maintain individual packaged wastewater treatment plants. Performance records for these facilities are not readily available to determine the systems' effectiveness.

In general, the existing septic systems are inappropriate for the environment; pollutants are able to easily move between the groundwater system, the lagoon and the ocean. Placencia's high groundwater levels and the high permeability/porosity of the soils make even a properly designed and constructed septic system a potential health hazard. In addition, many of the observed existing septic systems in the densely populated areas of Placencia and Seine Bight Villages were not constructed properly and leak directly into the groundwater. These systems are generally located too close to each other and/or to homes to function effectively. During high tides and heavy rains it is likely that contaminated effluent from soakage pits overflows into low-lying residential areas putting residents (and particularly children) at risk from direct exposure to fecal matter derived from inadequate sanitation systems.

The door-to-door survey conducted by Halcrow as part of this study addressed the existing wastewater management and sanitation methods and systems being used in the Placencia Peninsula. The survey revealed that a large percentage of the systems are inadequate and represent a potential threat to the environment and public health. Figure E-3 shows the estimated percentage of inadequate systems surveyed.

Portion of Inadequate Existing Wastewater Sanitation Systems



	Direct Discharge	Soak Pit	Total Portion of Systems Inadequate
Residences	35%	21%	56%
Businesses	10%	36%	46%
Hotels	5%	38%	43%

Figure E-3 Percentage of Inadequate Wastewater Management Systems

Source: Halcrow's door-to-door survey

1.4 Future Conditions

Based on the population projections developed by the Statistical Institute of Belize and the Belize Tourist Board, in Section 3, starting on page 64, Halcrow developed future water demand and wastewater loads through year 2040. A graph of the anticipated water demands and wastewater loads is presented on Figure E-4.

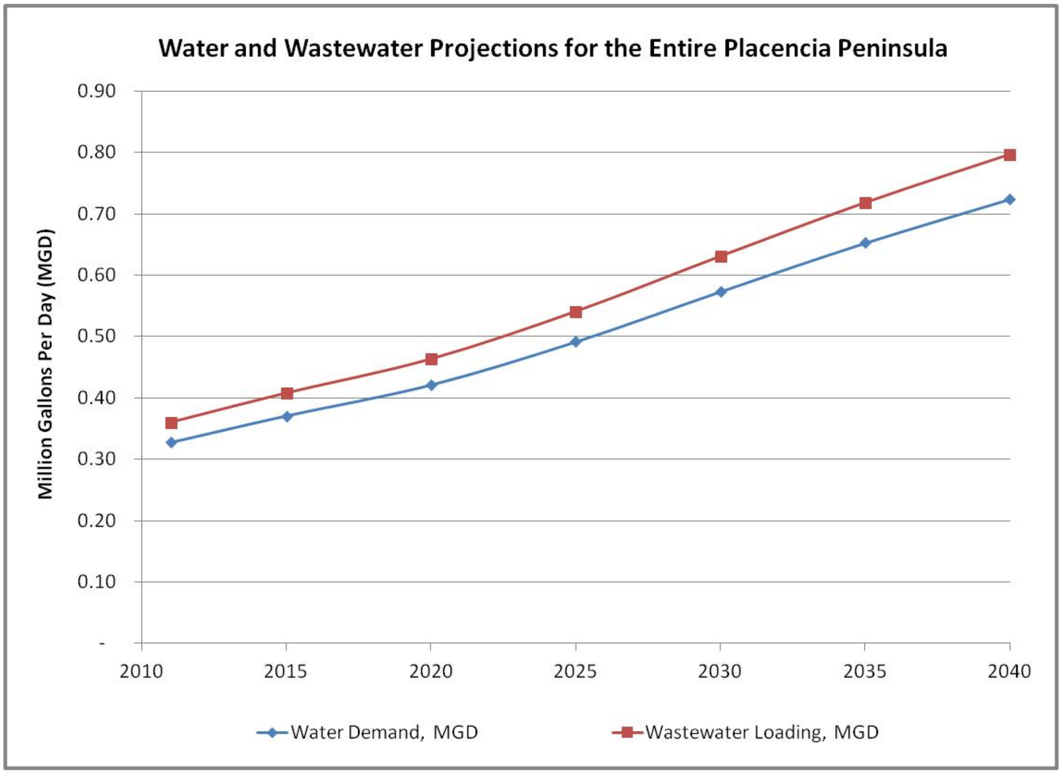


Figure E-4 Water and Wastewater Projections

Note: Projected wastewater loads include infiltration and water retained by the customer and not discharged to the collection system.

Increases in future water demands and wastewater loadings are a result of the following factors:

- Increase in resident population;
- Increase in water use by the resident population (for instance: households using a simple latrine will use a water closet model in the future);
- Increase in hotel facilities;
- Increase in the occupation rate of the accommodations.

There is concern that existing conditions have already exceeded the peninsula's ecosystems capacity to safely assimilate and dilute the generated wastewater. Current treatment and disposal methodologies are not effective: bacteria, viruses and nutrients are leaching through the soils, through the water table and into the surrounding lagoon and sea prior to effective natural treatment processes. It is estimated that the average daily generated wastewater from 2011 – 2040 will increase from 0.35 MGD to 0.79 MGD, increasing the daily disposal of BOD, fecal coliforms and nutrients into the environment by ~125%. These increases will subsequently increase the environmental and public health risks.

1.5 Design Standards and Technologies

In Section 4, starting on page 78, Halcrow compiled the appropriate design standards and technologies for the evaluation and conceptual design of the wastewater collection, treatment and disposal alternatives. These design parameters are presented in more detail in Section 4.3 on page 91. One important set of design parameters are the effluent standards for the wastewater treatment system. These standards are a combination of Belize National Standards and international best-practice standards. Table E-1 summarizes the key wastewater effluent discharge standards used in this feasibility study.

Table E-1 Proposed Effluent Discharge Standards

Parameter	Effluent Limitations
Total Suspended Solids	30 mg/L *
Five-Day Biochemical Oxygen Demand (BOD5), at 20 °C	Less than 30 mg/L
pH	5 – 10
Fats, Oil & Grease	15 mg/L
Fecal Coliform	Fecal Coliform: 200 mpn/100ml, or
E.coli (freshwater) & Enterococci (saline water)	(a) E.coli: 126 organisms / 100ml,
	(b) Enterococci: 35 organisms / 100ml
Total Phosphorous, mg/l **	3.5
Total Nitrogen, mg/l **	5
Floatables	Not visible

*Notes: * Does not include algae*

*** Proposed by Halcrow based on international best-practice standards*

With the exception of total phosphorous and nitrogen, all standards listed in Table E-1 are Belize National standards. The total Phosphorous (Total P) and Nitrogen (Total N) standards are proposed by Halcrow based on the evaluation of various international standards, including US EPA, European Union (EU), World Health Organization (WHO), etc. It is worth mentioning that the available nutrient standards for all Latin American Countries are less stringent that the proposed standards for Total P and Total N. For example, for most countries that have a nutrient discharge standard in Latin America, as listed by the WHO, the standard for total P is 10 mg/l. On the other hand, the standard for the US EPA and EU are 1 and 2 mg/l, respectively. Therefore, the proposed Total P standard for Belize is closer to the developed country standards and lower or more stringent than the standard for other developing countries.

1.6 Evaluation of Alternatives

Section 5, starting on page 114, established and evaluated alternative design concepts and technologies for the wastewater system, including alternatives for wastewater collection, treatment, and discharge/reuse. Table E-2 presents a summary of the evaluated alternatives.

Table E-2 Summary of the Collection and Treatment Alternatives Evaluated

System	Alternative	Brief Description of Alternative
Collection Section 5.3 Page 121	1	Cluster to Cluster Pumping
	2	Common Force Mains (no parallel force mains)
	3	Common Force Mains (parallel force mains)
Treatment Section 5.4 Page 132	1	Facultative Lagoons and Maturation Ponds
	2	Aerated Lagoons
	3	Extended Aeration
Effluent Disposal and Reuse Section 5.5 Page 137	Supplement	Agricultural Effluent Reuse System
	1	Additional Nutrient Ponds
	2	Land Application: Infiltration, Percolation & Evaporation
	3	Use of Treated Effluent for Agricultural Irrigation

The following criteria were used in the sustainability evaluation and selection process:

- expected effectiveness and reliability,
- ability to be phased and expanded,
- ability to be constructed, operated and maintained,
- environmental benefit,
- life cycle costs, including
  - capital costs and
  - operation costs.

As part of the alternative screening process, Halcrow selected the preferred wastewater collection alternative first and then proceeded to select the most cost-effective treatment option. Once the preferred treatment option was selected, the Halcrow team proceeded to evaluate effluent reuse and disposal alternatives.

The alternatives were also analyzed based upon an initial construction and a full-build out construction. This analysis was based upon current versus anticipated need, as well as on economic considerations.

1.7 Economic Analysis of Alternatives

In Section 6 starting on page 148, Halcrow used a Life-Cycle Cost (LCC) Analysis as part of the economic analysis of this project. LCC is a typical engineering economic analysis tool which allows professionals to quantify the differential costs of alternative investment options for a given project. The LCC of an asset or project is defined as the total cost, in present value or annual value, including the initial costs as well as operation, maintenance, repair and renewal costs over the service life or a specified life cycle. The LCC is based on the understanding that the value of money changes with time; expenditures made at different times are not equivalent, a concept referred to as the "time value of money". This is the basis for the LCC analysis performed by Halcrow.

1.7.1 Collection System

Table E-3 summarizes the wastewater collection system cost estimate provided in Section 6.2.4 on page 151. Schematic Collection System maps are included in Figure E-5 and Figure E-6. It is preferable to build a collection system that extends the full extent of the Peninsula and connects to 100% of the existing facilities. However, as shown below, this 100% coverage area collection alternative is estimated to cost US$9,850,000, which is effectively the entire project budget. A reduced scope collection system was developed that connects approximately 92% of the existing facilities, excluding facilities that are isolated and a relatively long distance from the proposed collection system. The cost estimate for this system is estimated at US$7,570,000, which is within the project budget.

Table E-3 Summary of Collection System Costs

Collection System Scenarios			million USD
Combo: Sc #1, 2, & 3	Initial Recommended 92% Coverage Service Area	Total Capital	$7.57
		Annual O&M	$0.28
		Annual Life-Cycle Costs	$0.79
	100% Peninsula Coverage Service Area	Total Capital	$9.85
		Annual O&M	$0.34
		Annual Life-Cycle Costs	$1.01

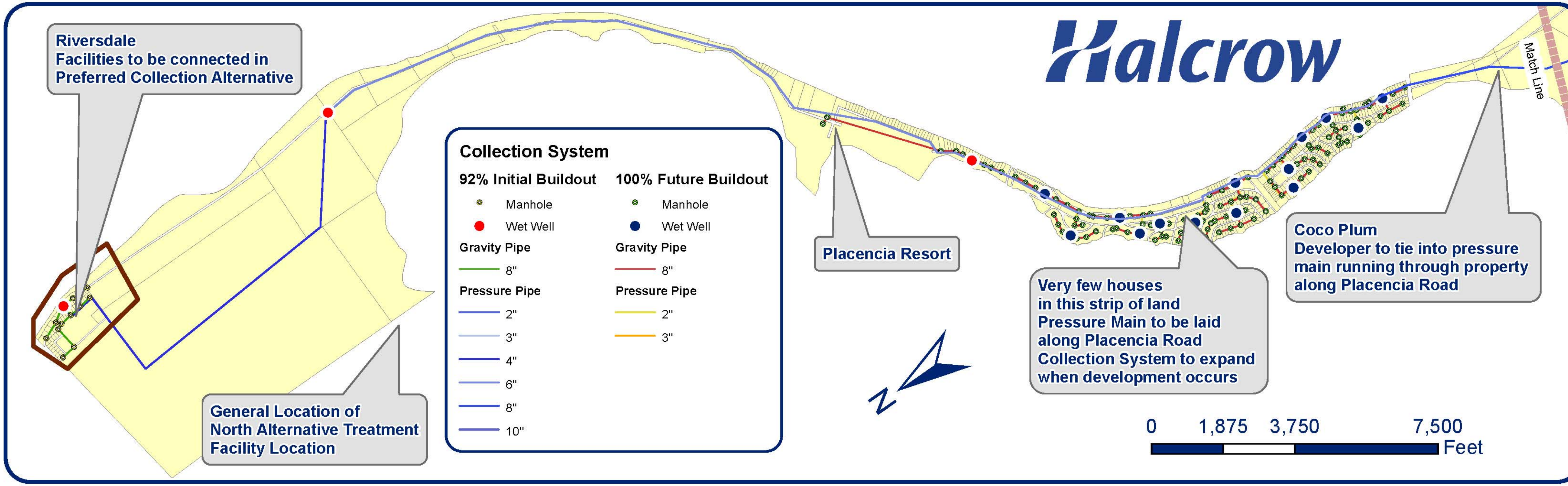


Figure E-5 Collection System Schematic, Page 1 of 2

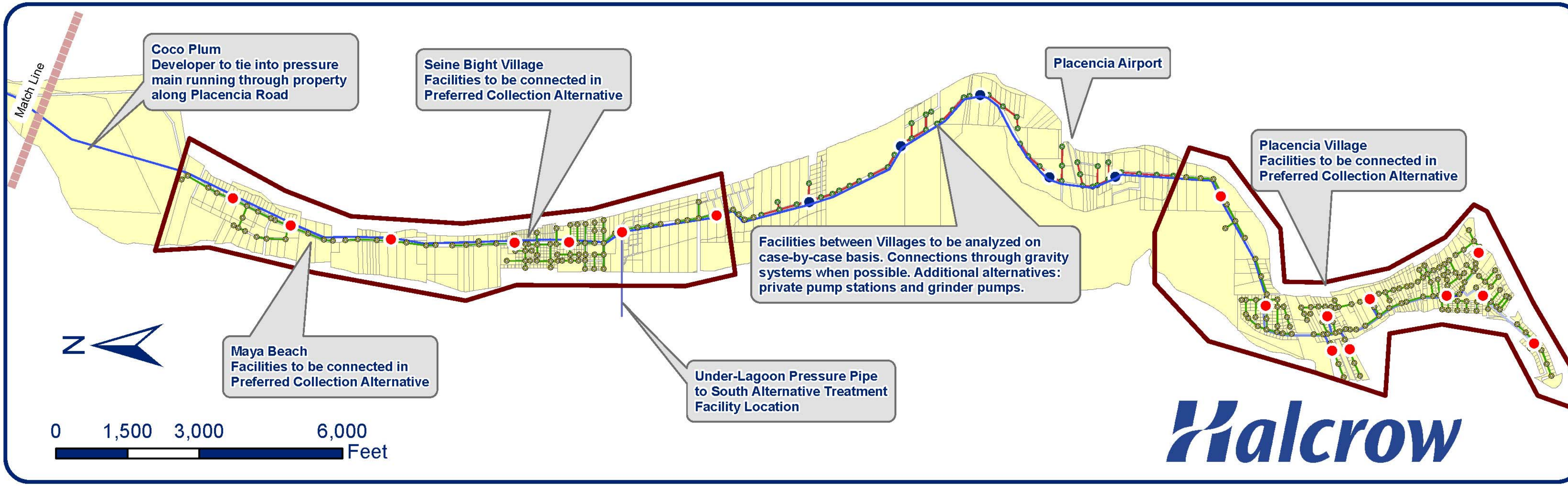
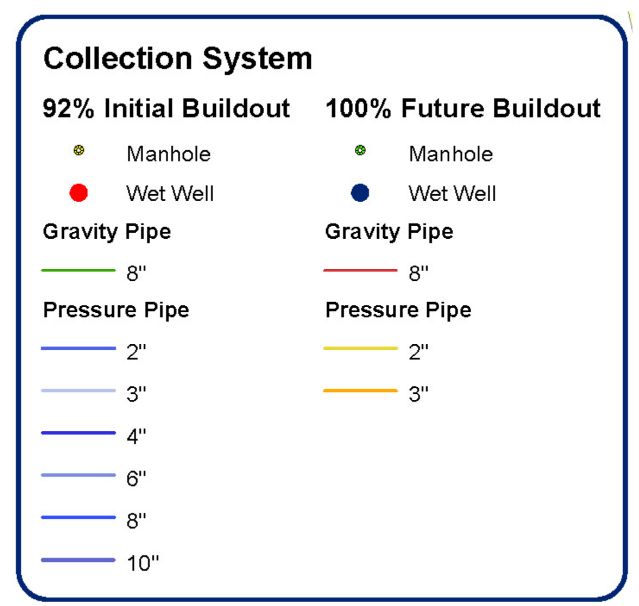


Figure E-6 Collection System Schematic, Page 2 of 2



1.7.1 Treatment and Effluent Reuse and Disposal Systems

Table E-4 summarizes the anticipated capital improvement costs for the wastewater treatment provided in Section 6.3.3 on page 155, and effluent reuse/disposal alternatives provided in Section 6.4 on page 156, looking at three (3) different treatment technologies and two (2) treatment locations. As shown in the chart, given the cost of land assumptions listed below, the location has little effect on the overall cost estimate. The 92% Collection System alternative cost is embedded in the overall costs to provide a total project cost estimate. The preferred system is Facultative Lagoon with Maturation Pond (Treatment Alternative #1) with an Infiltration, Percolation and Evaporation Effluent Disposal Field (Disposal Alternative #2), which is highlighted in red.

Table E-4 also summarizes the anticipated annual costs, taking into account the US$5,000,000 grant from the Inter-American Development Bank, which reduces the project payback costs.

Table E-4 Capital Improvement Cost Analysis of Wastewater System Alternatives

Wastewater System Cost Estimate Matrix

92% Collection System	
Capital Costs	$7,225,000
CReW Grant	($5,000,000)
Total Annual Expense *	$431,000

			Wastewater Treatment Alternatives	Alternative 1 Facultative Lagoon (0.80MGD)				Alternative 2 Aerate Lagoon (0.80MGD)				Alternative 3 Extended Aeration (0.80MGD)			
				Across Lagoon on Crown Land (Req'd Land: 50 acres)		North of Peninsula (no Lagoon crossing) (Req'd Land: 50 acres)		Across Lagoon on Crown Land (Req'd Land: 61 acres)		North of Peninsula (no Lagoon crossing) (Req'd Land 61 acres)		Across Lagoon on Crown Land (Req'd Land: 65 acres)		North of Peninsula (no Lagoon crossing) (Req'd Land 65 acres)	
				Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *
Wastewater Treatment				$2,890,000	$246,000	$2,890,000	$246,000	$2,100,000	$443,000	$2,100,000	$443,000	$2,100,000	$363,000	$2,100,000	$363,000
Effluent Disposal Alternatives			Lagoon Crossing	$345,000	$23,000			$345,000	$23,000			$345,000	$23,000		
Nutrient Alternative 1	Nutrient Pond w Facultative Lagoon	Capital Costs	$570,000	$11,030,000		$10,685,000									
		Total Annual Expense *	$119,000		$819,000		$796,000								
	Nutrient Pond w Aerated Lagoon	Capital Costs	$920,000					$10,590,000		$10,245,000					
		Total Annual Expense *	$143,000						$1,040,000		$1,017,000				
	Nutrient Pond w Extended Aeration	Capital Costs	$1,040,000									$10,710,000		$10,365,000	
		Total Annual Expense *	$111,000										$928,000		$905,000
Alt. 2	Infiltration, Percolation and Evaporation Land Application	Capital Costs	$490,000	**$10,950,000**		**$10,605,000**		$10,160,000		$9,815,000		$10,160,000		$9,815,000	
		Total Annual Expense *	$73,000		**$773,000**		**$750,000**		$970,000		$947,000		$890,000		$867,000

Notes: Annualized CIP based upon 20 year loan at 3.5%

Per request of BWSL, land costs were not included within this analysis

Recommended 92% Collection System costs per Table E-3.

** Total Annual Expense includes the CReW Grant to offset capital costs, Capital Improvement Loan repayment plus Operation and Maintenance Budget; does not include Water System operational, BWSL corporate, or future system capital improvement expenses.*

1.8 Preferred Collection System

Section 7.1 (starting on page 165) shows that the overall annual expense for each of the three various collection system alternatives is effectively the same. Each alternative has various construction, operation and cost advantages and disadvantages. The final design will likely incorporate some aspect of each of these alternatives, based upon the localized needs and circumstances of various portions of the system. For example, in the densely populated areas within the villages, a single common force main has the advantage of keeping the individual pump stations small. In the sparsely populated portions of the South Region, a cluster to cluster design may prove simpler to design and operate. In the North Region, where the initial population and flows are low, the force main size will depend on where the treatment facility is constructed; if the facility is in the South Region, then the North Region force main will need to be a small diameter pipe to carry its low flows; however, if the facility is built in the North Region, then the force main will need to be large diameter pipe to allow the passage of the South Region flows.

Based upon available project funding, it is likely that the initially constructed collection system will focus on the most densely populated and economically viable facility connections. For the economic analysis portion of this study, a reduced-scale collection system that connects approximately 1,000 of the 1,100 facilities (92% of service area) was developed, to ensure that the project was within budget. A cost summary is provided in Table E-5. The service area limits for the collection system are based upon an LCC analysis of the overall Peninsula to determine which land areas would provide service for the largest extent of the population while maintaining an affordable monthly billing structure for the citizens of the Peninsula. Case by case decisions will be made during the detailed design and construction phases of the project as to exactly which properties are initially connected to the system.

Table E-5 Preferred Collection System Cost Estimate

Collection System	**Full Penninsula (Placencia Village to Riversdale)**
Capital Improvements	**Initial Recommended 92% Coverage Service Area**
Initial Capital Costs (US$)	$7,570,000
Annualized CIP (US$)	**$510,000**
Operations and Maintenance	
Annualized O&M (US$)	**$280,000**
Total Annualized Expenses:	**$790,000**
Estimated Accounts:	*1,000*
Annual Cost per Service	$790

Note: Annualized CIP based upon 20 year loan at 3.5%

The Wastewater Collection and Treatment System project for the Placencia Peninsula consists of the installation of a collection system with +/- 19 miles of gravity pipe and +/- 20 miles of pressure pipe across the Placencia Peninsula. The purpose of the collection system is to connect all existing buildings within the wastewater service area to the collection system to eliminate localized on-site wastewater disposal.

1.9 Preferred Wastewater Treatment System

Section 7.2 on page 169 summarizes the preferred and most cost-effective wastewater treatment system alternative: Facultative Lagoon and Maturation Ponds. The proposed plant has been sized to adequately treat the projected 2040 wastewater flows, with multiple options for expansion beyond that timeframe. The plant will provide primary and secondary treatment, ensuring that the effluent leaving the facility meets the Belize Department of Environment standards.

As shown in Table E-4, based upon the information analyzed within this study, whether the treatment facility is located across the Lagoon from Seine Bight village or at the north end of the Peninsula, the final location does not have a large effect on the overall project costs.

Table E-6 provides a summary of the overall capital improvement costs, annual amortization costs and annual operations and maintenance costs for the preferred treatment system alternative. The costs estimates provided below do not take into account the cost of land purchase, which may drastically affect the overall project costs.

Table E-6 Preferred Wastewater Treatment System Cost Estimate

Financing Summary	Wastewater Treatment
	Alternative #1
	0.80 MGD
Capital Improvements	**Facultative Lagoon**
Total Capital Costs (US$)	$2,890,000
Annualized CIP (US$)	$200,000
Operations and Maintenance	
Total O&M (US$)	$50,000
Total Annualized Expenses:	**$250,000**

Note: Annualized CIP based upon 20 year loan at 3.5%

1.10 Preferred Effluent Reuse / Disposal Strategy

1.10.1 Effluent Reuse Strategy

Figure E-7 illustrates the effluent reuse and management strategy analyzed in Section 5.5.1 starting on page 136. The proposed long-term strategy is to reuse the effluent water for irrigation. This strategy needs to be validated through an Effluent Market Analysis, as described in Section 10.8, page 236. In order to implement this alternative, the following actions are highly recommended:

1. The Ministry of Finance and BWSL or their consultant should conduct a market feasibility analysis regarding the farmers' willingness to pay to use the treated effluent for irrigation. The study should gather information regarding the seasonal crop irrigation demands, customer locations, delivery water pressure, infrastructure and metering requirements, life-cycle costs, financing needs, and tariffs to be charged to system users.
2. Determine days of the year that irrigation is not needed and what to do with the effluent during such wet-weather periods. Evaluate the environmental impact of periodic effluent discharges to the Placencia Lagoon during periods of low irrigation water demand (wet -weather events)
3. Evaluate the current regulatory framework and recommend ordinances or norms for effluent reuse in Belize.

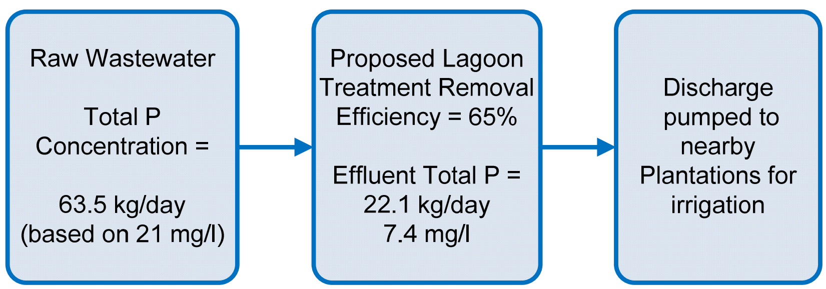


Figure E-7 Ultimate Effluent Reuse and Management Strategy

Environmental Impact of Effluent Reuse

A complete environmental analysis of an effluent reuse system will be based upon the specific design and implementation of the system. However, generalized benefits include:

- Reduction of water withdrawal from surface and subsurface sources;
- Reduction of required additive fertilizer;
- Reduction of effluent disposal into Placencia Lagoon ecosystem, with subsequent concerns regarding nutrient loadings

1.10.2 Treatment and Disposal Strategy

Based on historical nutrient removal efficiencies for similar lagoon treatment systems in Belize (Belize City and San Pedro), the preferred Facultative Lagoon treatment system is anticipated to provide significant nutrients removal within its system. Table E-7 presents the nutrient removal data of these two existing treatment systems in Belize.

Table E-7 Historical Nutrient Removal Efficiency of Existing Lagoon Treatment Systems in Belize

Nutrient	Anticipated % Removal
Phosphorus	65%
Nitrogen	85%

For the preferred Treatment Alternative (Facultative Lagoon), there are comparable costs between the Nutrient Pond and Infiltration, Percolation and Evaporation (IPE) Land Application nutrient removal and disposal alternatives. The final decision regarding which alternative is to be utilized should be based upon which alternative is best suited to the final design, the land available for the project, and stakeholder input.

Section 5.5.2, starting on page 140, includes an analysis on the various alternatives for the treatment and disposal of wastewater effluent: nutrient ponds and infiltration, percolation, evaporation fields. Based upon the information available at the time of this study, both alternatives are economically similar in costs and environmentally sustainable. The final system will be determined during the detailed design phase of the project based upon the final location of the treatment facility, the results of the recommended Placencia Lagoon Nutrient Fate and Transport Study, and input from project stakeholders. A summary of these alternatives is provided below.

1.10.2.1 Nutrient Treatment via Nutrient Ponds

The Nutrient Pond alternative reduces the concentration of nutrients within the effluent through nutrient uptake with floating water hyacinths on the pond surface. The effect of these ponds is presented on Figure E-8.

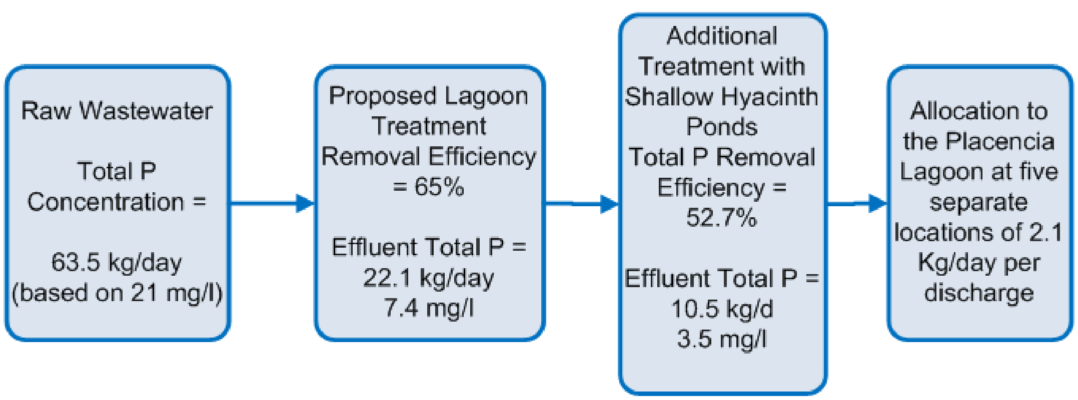


Figure E-8 Nutrient Management through Nutrient Ponds

Table E-8 summarizes the surface area requirements and cost estimates for the nutrient ponds. These cost estimates do not account for land expenses. The major portion of the

O&M budget involves a vegetative management crew. The ponds themselves require minimal maintenance.

Table E-8 Nutrient Management Strategy Size and Cost Estimate: Nutrient Ponds

	Alternative #1 - Nutrient Pond
	0.80 MGD
Capital Improvements	Treatment Alt. #1: Facultative Lagoon
Minimum Surface Area (acres)	17
Total Capital Costs (US$)	$570,000
Annualized CIP (US$)	$40,000
Operations and Maintenance	
Total O&M (US$)	$70,000
Total Annualized Expenses:	**$110,000**

1.10.2.2 Nutrient Treatment via Infiltration, Percolation and Evaporation Land Application System

The Infiltration, Percolation and Evaporation (IPE) Land Application system disperses the effluent across a designated property constructed to absorb the effluent volume. Nutrient uptake occurs through plant absorption and other natural processes. The effect of these ponds is presented on Figure E-9.

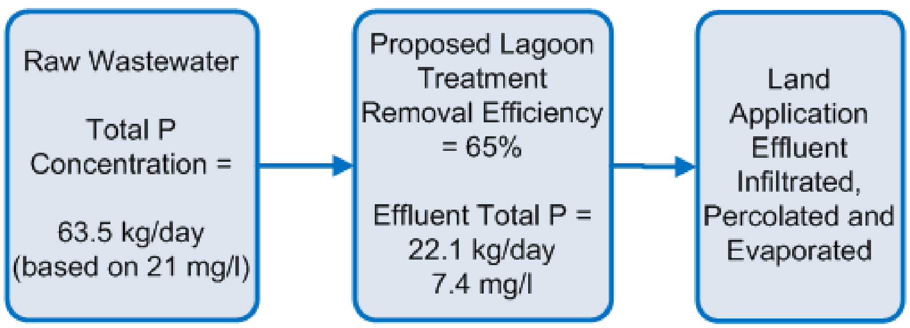


Figure E-9 Nutrient Management through IPE Fields

Table E-9 summarizes the anticipated cost estimate for the construction and operation of an IPE system. These cost estimates do not account for land expenses. The saturation grounds themselves require minimal maintenance.

Table E-9 Nutrient Management Strategy Size and Cost Estimate: IPE Field

	Alternative #2 - IPE Field
	0.80 MGD
Capital Improvements	Same system for Treatment Alt: #1, 2 & 3
Minimum Surface Area (acres)	14
Total Capital Costs (US$)	$490,000
Annualized CIP (US$)	$30,000
Operations and Maintenance	
Total O&M (US$)	$40,000
Total Annualized Expenses:	**$70,000**

1.11 Environmental Feasibility Assessment

As shown in Section 8, starting on page 177, the overall conclusion of the Environmental Feasibility Analysis is that the project as a whole presents substantial benefits to both the biological and human environments. Particularly, the reduction of the pathogen load on the peninsula itself will have benefits for public health extending into benefits for the tourism industry, which serves as the economic mainstay for the peninsula.

The current methods of wastewater disposal, combined with high ground water levels and highly permeable soils (in the non-mangrove areas), no doubt have negative effects on the surrounding marine habitats, and thus specifically on the Placencia Lagoon. The lagoon is a critical habitat for the endangered West-Indian Manatee which relies on the seagrass beds in the lagoon. The principal risk to these seagrass beds is formed by algae blooms as a result of eutrophication. To what extent this eutrophication is the result of residential wastewater input is unclear as limited data exists. Concerns that the proposed wastewater treatment facility would replace the current diffused nutrient disposal method (spread out across the peninsula) with a point based nutrient disposal (out of a single pipe from a WWTP) led to the addition of tertiary treatment as outlined in Section 1.10 on page 17.

The short-term strategy involves tertiary treatment by either nutrient removal ponds or infiltration, percolation and evaporation flow field with a long-term strategy to reuse the effluent for crop irrigation. This option has the benefits of utilizing nutrients as fertilizers and reduces the use of water being drawn by farmers from rivers and aquifers in the region.

An additional concern on the socio-economic level is that low income households would not be able to invest in proper sanitary facilities and thus not be able to connect to the wastewater system. A portion of the project budget is allocated to providing basic restroom facilities for residents who currently do not have them. The costs associated with these expenses are accounted for within the Collection System budget.

1.12 Developmental Impacts

The project's developmental impacts are analyzed in Section 9, starting on page 217. Developmental impacts are important in determining the success of investments in developing countries. For example, the U.S. Trade and Development Agency (USTDA), the U.S. Overseas Private Investment Corporation (OPIC) and the World Bank Group's International Finance Corporation (IFC), among others, use objective measurements to demonstrate the developmental success of their programs. They find it important to consider the potential impacts of projects on host country job creation, worker training, local procurement, and social responsibility, among others.[i]

With respect to infrastructure improvements, the project has the following potential developmental benefits:

- The collection of wastewater from residents, commercial businesses and hotels significantly decreases the volume of untreated wastewater being disposed directly into the groundwater and leaching into the surrounding ocean and lagoon
- The removal of wastewater from the currently used localized disposal systems will decrease odor issues and public health hazard concerns and help ensure that the Peninsula's tourist industry continues to prosper.
- The project will have a positive impact on the property values and tourism development.
- As a pilot project, it will also provide a model for other areas of Belize and the Caribbean region for the development of wastewater systems.
- The project's economic analysis contributes to the Caribbean Regional Fund for Wastewater Management (CReW) revolving fund for future infrastructure projects within Belize.

With regard to Human Capacity Building, the project described herein can result in both short-term and long-term impacts on the workforce. In general, the project will require existing skill sets as well as new skills that must be learned to complete some tasks successfully. This means that some jobs may be saved in addition to other jobs being created.

1.13 Implementation Plan

With participation and input from The Ministry of Finance, Belize Water Services and the Ministry of Works, the Halcrow team developed a proposed implementation plan for the improvements to the Placencia Peninsula Pilot Wastewater Management System in Section 10, starting on page 227. The proposed projects are separated into separate packages as follows:

- PW01 – Placencia Lagoon Baseline Conditions Study
- PW02 – Land procurement
- PW03 – Reuse Water Market Analysis (see Section 10.8, page 236 for schematic analysis scope)
- PW04 – Consulting Services for Design and Development of Contract Documents
- PW05 – Environmental Impact Assessment
- PW06 – General Contractor for Procurement of Equipment and Materials and the Installation and Construction of the Wastewater Management System
- PW07 – Consulting Services for Construction Oversight, Operations and Maintenance Manual, Startup and Training

As an option, the Consulting Services (PW04, PW05 and PW07) can all be procured in the same contract. The package PW06 is anticipated to be awarded to a contractor for the procurement, installation of the collection system and construction of the wastewater treatment plant. Per BWSL, equipment and materials such as pumps, pipes, water meters, etc., will be purchased by the Contractor as a part of PW06 contract. However, as stated in Section 11.1.1 on page 239, centralizing material and equipment procurement for the entire project through BWSL would provide a cost savings opportunity by increasing the procurement economy of scale and decreasing the Contractor product handling markup.

The proposed Project Implementation Schedule is shown on Figure E-10.

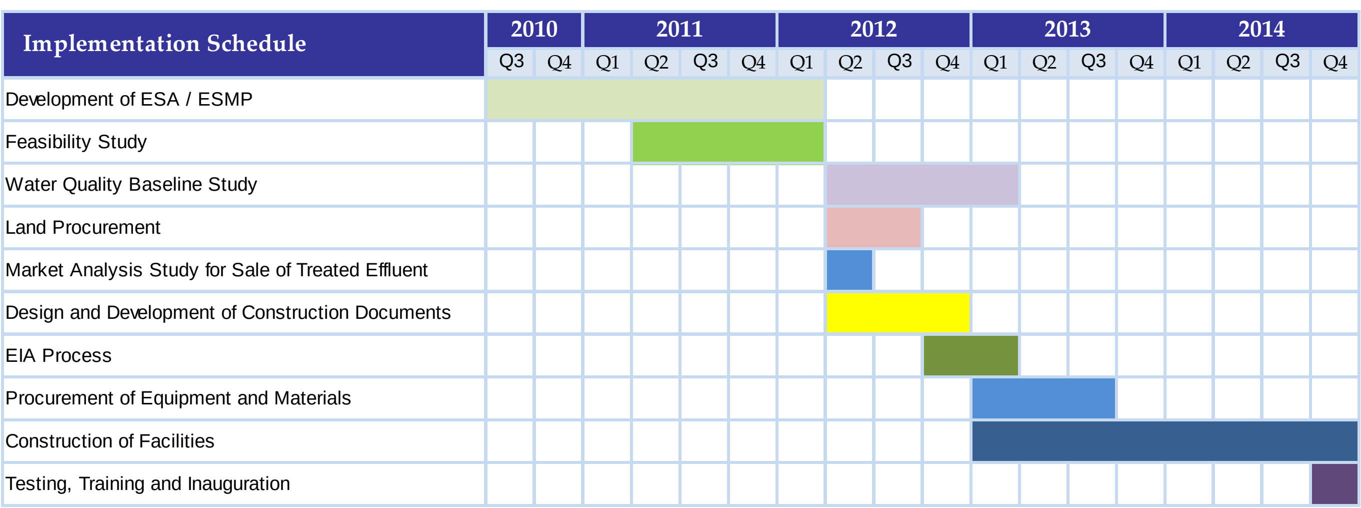


Figure E-10 Proposed Project Implementation Schedule

1.14 Financial Plan

A financial plan for the project's income and expenses during both its capital improvements stage as well as its operation and maintenance stage (through 2040) was developed in Section 11, starting on page 239.

1.14.1 Project Cost Estimate

Based upon the information available at the time of this study, and the preferred collection, treatment and effluent reuse/disposal strategy outlined in Sections 1.8 – 1.10, the estimated capital improvement costs is US$10,950,000, as shown in Table E-4. Of this amount, US$884,000 is provided within the cost estimates as "Contingencies" to account for unforeseen expenses, and US$296,000 is included for road repair after completion of the project. This cost estimate will be updated throughout the final design phase of the project as specific decisions are made and the project scope is finalized. Section 11.1 (page 239) provides suggestions for methods to reduce capital expenses, if it is determined necessary. The project team will need to determine which parties will be responsible for any expenses that exceed the project budget.

The anticipated project funding is US$ 10,700,000. Cost controls and adjustments to the final scope of the project (particularly in the final extent of the collection system) will have to be put in place to reduce the actual project costs to below the funding limit.

1.14.2 Project Funding Sources

The potential sources of funding for the proposed project are summarized in Table E-10. Additional information on the project budget is in Table 11.2-1.

Table E-10 Project Financing Summary

Item	Unit	Value
Loan #1: CReW grant to Belize Government, in turn loaned to BWSL		
Loan #1 Amount	US$	5,000,000
Loan #1 Term	Years	20
Loan Deferment	Years	Upon Project Completion
Loan Rate	%	3.5
Grant #1 IDB to BWSL for Project Detailed Design		
Grant #1 Amount	US$	700,000
Grant #2 IDB loan to Belize Government, in turned granted to BWSL		
Grant #2 Amount	US$	5,000,000

1.14.3 Proposed Tariff System

The Government of Belize and BWSL will recover the project implementation costs through a user charge system. The user's tariff developed for the project start-up year is shown on Table E-11. Additional information on the tariff structure, including a comparison with BWSL tariffs throughout Belize, is provided in Section 0, on page 244.

Table E-11 Proposed Startup Rate Structure

Monthly Usage		Base Charge	Water Rate	Water & Sewer
FROM	TO		BZ$	BZ$
0	1,000		$8.00	$12.00
1,001	2,000	Cost Per Additional Gallon	$0.016	$0.024
2,001	3,000		$0.019	$0.029
3,001	4,000		$0.022	$0.033
4,001	5,000		$0.025	$0.038
5,001	6,000		$0.028	$0.042
6,001	7,000		$0.031	$0.047
7,001	8,000		$0.034	$0.051
>8,001			$0.038	$0.057

Table E-12 summarizes the monthly water and wastewater bill, by total monthly consumption, based upon the proposed tariff rate structure.

Table E-12 Water and Wastewater Bill, by Monthly Water Consumption

Monthly Consumption	Proposed Placencia	
	Rate per	Bill (BZ$)
1,000	$12.00	$12
2,000	$24.00	$36
3,000	$28.50	$65
4,000	$33.00	$98
5,000	$37.50	$135
6,000	$42.00	$177
7,000	$46.50	$224
8,000	$51.00	$275

Section 11.5, starting on page 249, provides a cash flow analysis to ensure that the project is economically sustainable, able to be financially viable through the critical period during project construction and while construction loans are being repaid.

1.14.4 Agricultural Reuse System

A separate analysis was performed in Section 11.7 starting on page 251 on the effluent irrigation system discussed in Section 5.5.1 (page 136), and summarized in Section 1.10.1 (page E-17). Based upon the preliminary evaluation, it is anticipated that the cost of the basic infrastructure for the effluent reuse and irrigation system is about US$700,000. Likewise, the range of possible tariffs charged to agricultural customers is anticipated to range from about US$1.20-$2.00 per 1,000 gallons (US$0.30-0.50/cubic meter).

The Placencia Wastewater System cost estimates (collection, treatment and disposal) exceed the current project budget. As discussed in Section 11.1.1, the project will need to incorporate cost control measures to stay within budget. It is not recommended to incorporate the irrigation reuse system capital costs within the initial project budget. If it is determined to proceed with this phase of the system, additional funding for this project needs to be acquired.

2 Existing Conditions

2.1 Placencia Peninsula

The Placencia Peninsula is located in the Stann Creek district, Belize, between 16°30′ and 16°40′ N latitude and 88°15′ and 88°25′ W longitude. The peninsula is a 24 km (16 mile) long strip of land between the Caribbean Sea on the east and the Placencia Lagoon on the west. The widest point of the peninsula is 3.5 km (2.2 mile); the narrowest point is 50 m (180 feet) wide. The peninsula is the largest sand spit along the Belizean coast.

There are two villages located on the peninsula: Placencia Village at the southern tip and Seine Bight about four miles north of Placencia village. The small settlement of Riversdale in the north is usually regarded as part of Seine Bight.

Population of the peninsula is rather small, around 3200 residents, but the tourist high season adds an additional 800 persons staying on the peninsula (based on a 55 % occupancy rate, 729 hotel rooms). Altogether, it is still a rather small population; but because of the small land area suitable for habitation, the population density is rather high in some places.

Placencia Lagoon lies to the west of the Placencia Peninsula. It is a narrow, 3.4 km (2.2 mile) at its widest and about 24-km long estuary that is mainly shallow, (1-2 meters), with a few deeper holes and channels. The lagoon actually consists of four wider lagoon sections separated by three rather deep and narrow channels. The deepest point of the lagoon is in its most southern lob and reaches a depth of 5.8 meters below MSL (Mean Sea Level).

2.2 Physical and Biological Environment

2.2.1 Geology and Topography

The geology of the coastal area of Placencia is dominated by the uplifting of an area that is now called the Maya Mountains. Erosion material of the Maya Mountains was transported by numerous rivers and deposited in what is now the Caribbean Sea. In periods of relatively low sea level, the sedimentation took place further to the east. During times of a relatively higher sea level, the sediments were deposited more to the west closer to the present location of the peninsula. Sea currents transported the sediments in southerly direction, creating the sand spit that is now the Placencia Peninsula.

The quartz sand deposits on the peninsula are of a relatively young age: the Holocene Age (10,000 BC-present). The quartz sand is overlaying alluvial clays, formed in the Pleistocene when the sea level was relatively lower and the alluvial fan reached further to the east.

Continuous, relative rising of the sea level created conditions on the west side of the sand spit that favored the development of peat; but tidal sea water movement and local streams and creeks draining the coastal plain prevented the lagoon from becoming dry land.

2.2.1.1 Tectonics

The underground of Belize counts numerous fault lines. Some fault lines are obvious such as the Southern Boundary Fault line of the Maya Mountains that resulted in the sudden rise of the Maya Mountains from the coastal Plain. It is clearly visible traveling the southern highway. About 0.6 miles east of the peninsula there is the smaller fault 'Placencia' which is not visible (Cornec, 2003). The fault system is tectonically active with minor tremors occurring relatively often.

In May 2009 a major earthquake originating in the Polochic Fault Zone (the northern boundary of the Cayman Trench) affected the area and resulted in damage to houses and infrastructure such as the total collapse of the water tank at nearby Independence.

2.2.1.2 Peninsula

All surface deposits of the Placencia peninsula originate from the Holocene Age. They consist of plastic sediments of coarse to medium fine mineral sand, erosion products from the Maya Mountains transported by the rivers originating there. The coastal sea current transported the sediments in a southerly direction, forming the sand pit we know now as the Placencia Peninsula.

The soils of the peninsula are recent deposits consisting of coarse sands along the Caribbean Sea and silt and mangrove peat deposits on the lagoon (west) side. The whole peninsula is very low lying with the highest levels following the Caribbean coast but barely 3 meters above sea. This is also the area where most developments started. Development of the lagoon side has required great amounts of fill material.

On the leeward side of the peninsula, mangrove peat deposits dominate.

The narrow strip of land with sandy soils shows some low ridges. These higher spots were the locations of the first houses and tourism developments. All coastal properties are in private hands; the demand for land has resulted in the development of the mangrove areas on the lagoon side. This requires substantial investment in creating the proper foundation for the buildings to prevent subsiding of the structures. The peaty underground is compressed by the weight of the structures and the only solid foundation is created by sturdy concrete pillars that reach down into the sandy underground.

Alterations in the discharge of the South Stann Creek, the main river north of the peninsula that transports sand, resulted in a reduced sediment load of this river. Changes made on the seaside of the peninsula (for instance the construction of marinas and piers in combination with the reduced sediment load of the sea current) may have substantial impact on the coastline.

The highest point on the peninsula is at most 10 feet above average sea level. The highest points are the sandy ridges on the seaside, about 3-4 feet above the depression between the ridges. The profile on the lagoon side shows the land gradually subsiding in the lagoon without any major feature.

2.2.1.3 Mainland

The mainland consists of recent sediments: alluvial deposits of material originating from the Maya Mountains. The sediments are a complex system of sandy soils and heavy clays, cross cut by numerous small streams. The lagoon edge of the mainland is fringed by wetland vegetation including mangrove. The underground of the fringe consists of mangrove peat.

The alluvial plains along the major rivers are ideal places for the development of large scale banana plantations. Just west of the Riversdale settlement at the northern part of the peninsula, a major banana plantation is located on the alluvial plains of the South Stann Creek, as shown on Figure 2.2-1.

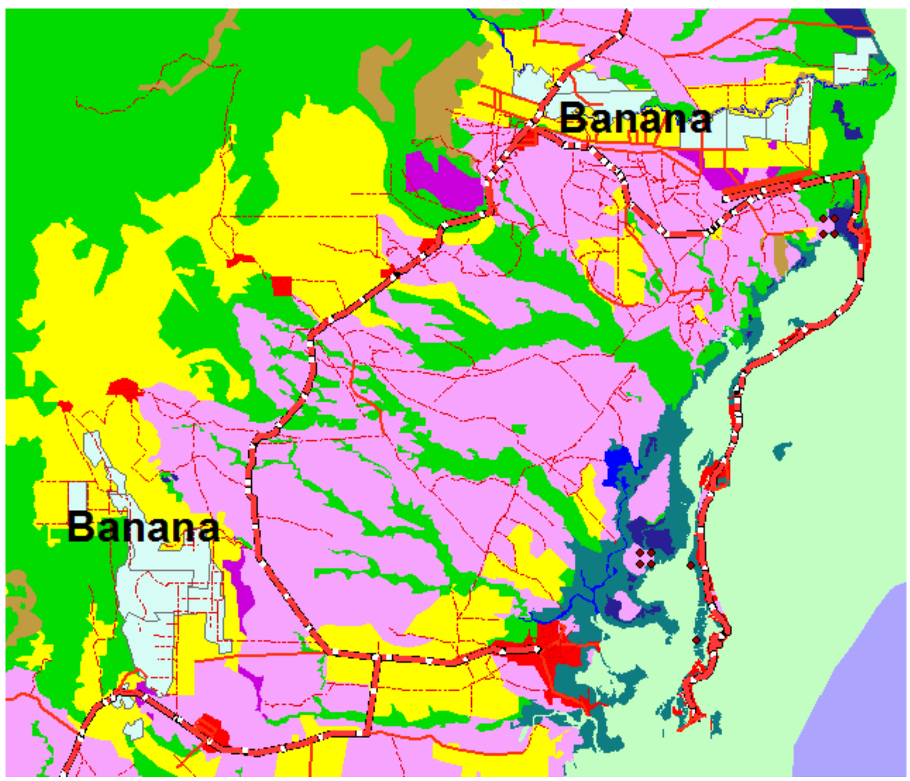


Figure 2.2-1 Placencia Area Banana Plantations

Because of the numerous streams and their ill-defined watershed, the mainland is a difficult terrain to navigate by vehicle. Access to the lagoon by road would only be possible after major construction efforts. As a result, present development of these lands is limited to a few large scale aquaculture developments on the ill drained clay soils on the coastal plain, which are ideal for these developments. Several farms are to be found near the lagoon as shown on Figure 2.2-2.

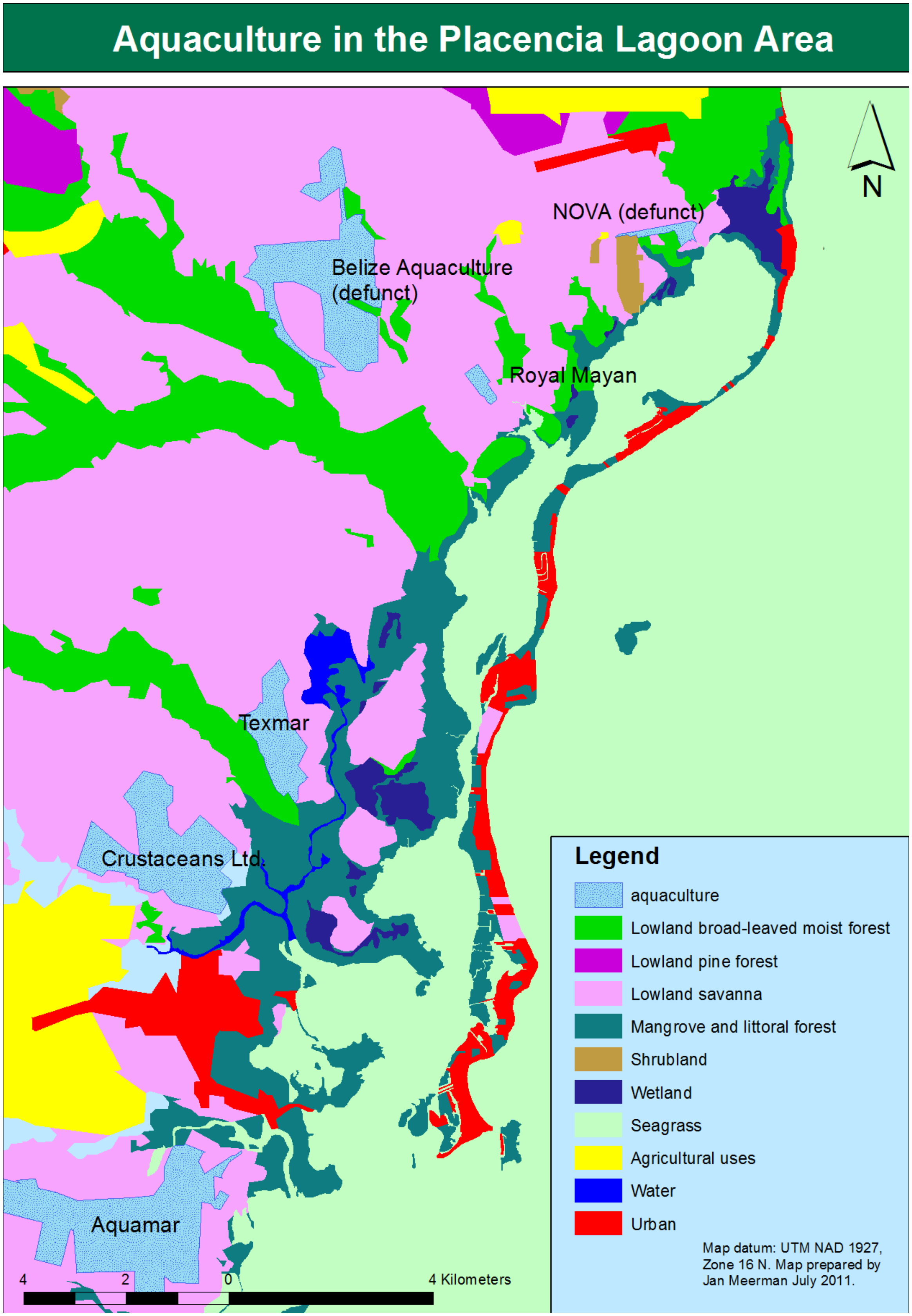


Figure 2.2-2 Placencia Area Aquaculture

2.2.2 Climatology

The average annual rainfall for Placencia was approximately 90" (2,250 mm) over the period 1971-1996[i]. The driest season extends from February through May, with an average of less than 4" (100 mm) rain per month (see Figure 2.2-3). A period of a full month without rainfall is quite possible. Most of the annual rainfall falls in heavy showers which produce >25 mm or 1" per day[ii].

Wind patterns along the coast are mainly south-easterly to north-easterly winds with velocities typically ranging from 3 to 20 miles per hours. Tropical storms and hurricanes are accompanied by stronger winds with velocities of maximum sustained wind speeds of 39 miles per hour and 75 miles per hour respectively.

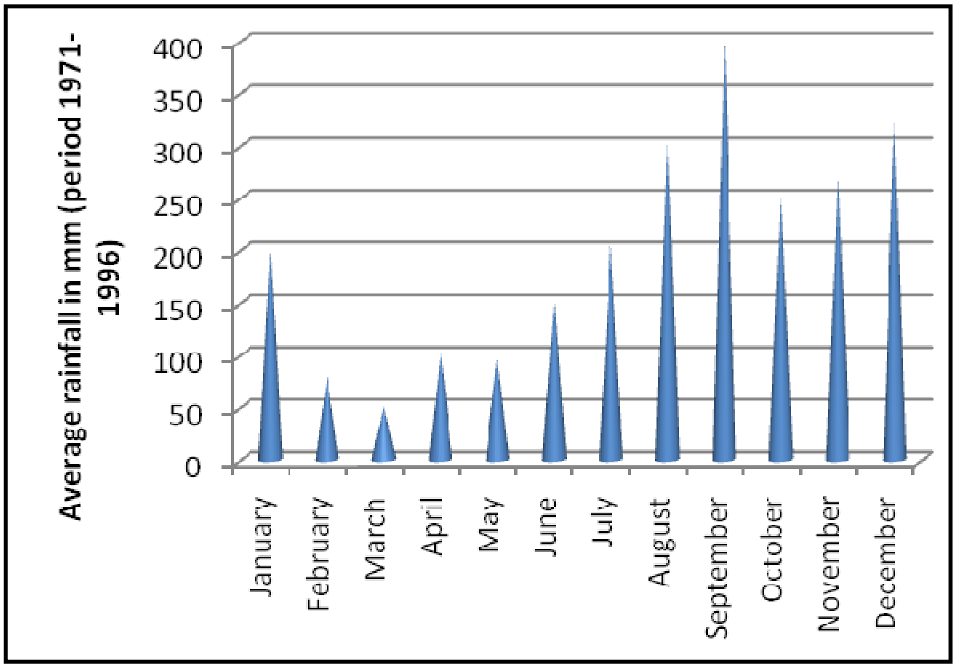


Figure 2.2-3 Average Rainfall by Month, Belize

2.2.2.1 Hurricanes

Belize has been affected by tropical storms and hurricanes on several occasions. Hurricane Iris hit the peninsula in October 2001, resulting in wind, rain and storm surge damage. Because of its long coast, the peninsula is particularly vulnerable to hurricane inflicted damage. Hurricane Iris was accompanied with a storm surge of at least 15 ft high that completely flooded the peninsula at the point where the eye of the hurricane passed.

2.2.3 Hydrology

2.2.3.1 Placencia Lagoon

Placencia Lagoon lies to the west of the Placencia Peninsula. It is a narrow, 3.4 km (2.2 mile) at its widest and about 24-km long estuary that is mainly shallow, (1-2 meters), with a few deeper holes and channels. The lagoon actually consists of four wider lagoon sections separated by three rather shallow and narrow channels. The deepest point of the lagoon is in its most southern lob and reaches a depth of 5.8 meters below MSL (Mean Sea Level).

The pH levels of the lagoon water generally average from 7.0 to 7.5 in the northern sections to 8.0 and 8.6 in the more saline areas in the south. Most marine organisms prefer conditions with pH values ranging from 6.5-8.5 (U.S. EPA, 1993). The observed pH values are well within the acceptable range for most marine organisms and provides for a healthy estuarine environment.

Ariola (2003) studied the salinity of the water of the lagoon. Shifts in salinity can be attributed to evaporation, freshwater influx from the many streams draining into the lagoon, and the net water exchange between the lagoon and the sea. The average salinity of the lagoon water ranged from 22.59 – 31.78 ppt for the surface water and 24.94- 32.4 ppt for the bottom water. The Caribbean Sea has a constant salinity (33-35 parts per thousand), so the changes in salinity in the lagoon can be explained by the very low flushing rate of the upper part of the lagoon that strongly depends on wind and tidal forces.

The tidal fluctuations within the lagoon appear almost non-existent but are still enough to cause distinct currents within the Lagoon itself.

This combination of low flow and limited tidal movements within the lagoon makes the lagoon, and specifically its northern part, very vulnerable to human impacts through settlement, agriculture and aquaculture. The discharge of large volumes of untreated wastewater in the upper lagoon could rapidly decrease water quality and affect the natural ecological balance. Some years ago, algae bloom was noted in the uppermost lob of the lagoon; the algae caused the sea grass to die, and manatee sightings in this part of the lagoon became very rare. No detailed study was undertaken to determine the cause of the algae bloom. However, after the shrimp farm of the Bowen Company closed and the discharge of their effluents in the uppermost part of the lagoon ceased, the algae disappeared[iii].

Dissolved Oxygen (DO) levels for the lagoon range between 5.79 and 8.02 mg/l, indicating a healthy environment for aquatic life (most organism perform best when DO exceeds 5 mg/l) (Ariola, 2003). However, the discharge of wastewater with a high Biochemical Oxygen Demand (BOD) can quickly result in an oxygen depleted environment with limited aquatic life carrying capacity.

2.2.3.2 Mainland Creeks

Three catchment areas drain into the lagoon. From the north to the south are Santa Maria Creek, August Creek and Big Creek. In the south, the lagoon widens up and is in open contact with the Caribbean Sea (see Figure 2.2-4).

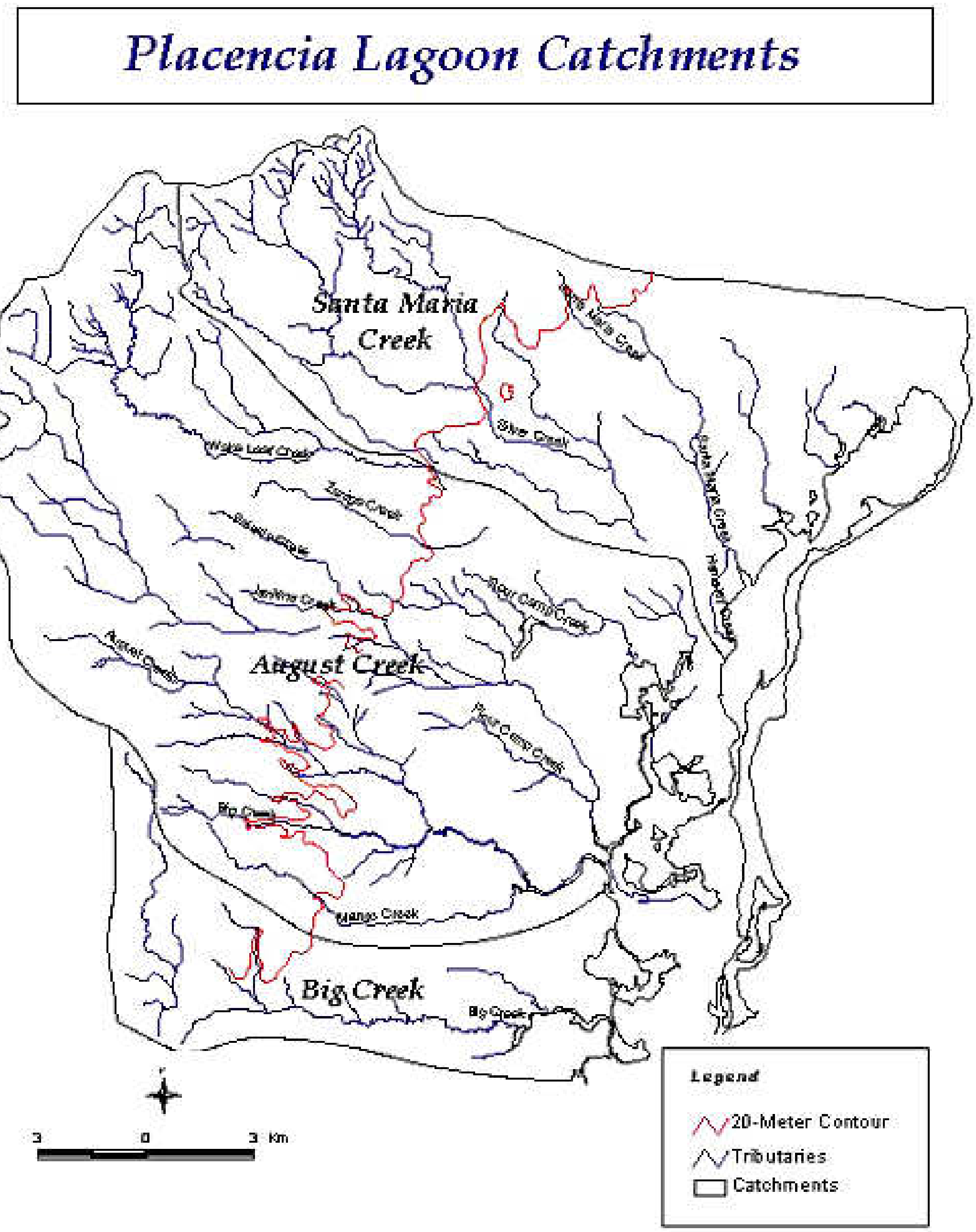


Figure 2.2-4 Placencia Lagoon Water Catchments, Ariola, 2003 [iv]

The Santa Maria Creek watershed has an area of 347 km^2. The terrain is relatively low-lying with a maximum elevation of 500 meters on its westernmost boundary. Hemsley Creek, Silver Creek and a number of several small, unnamed creeks are also part of the Santa Maria watershed. Some creeks flow directly into the lagoon while others flow into wetlands that display connectivity to the Placencia Lagoon.

The August Creek Catchment has an area of 250 km^2. The major waterways in this watershed are Mango Creek and August Creek that converge at the lower section of the catchment before they flow into the Placencia Lagoon. Flour Camp Creek, Jenkins Creek and several minor waterways also contribute to the net discharge of Mango Creek.

The Big Creek Watershed is the smallest of the three catchments adjacent to the Placencia Lagoon and has an area of 59 km^2. Most of the lands in this basin are less than 20 meters in elevation. This basin exhibits low relief and a moderate flood risk potential. The principal waterway, Big Creek, is fed by numerous small streams and debouches at the southernmost end of the Placencia Lagoon.

It is worth pointing out that none of the watercourses that flow into the Placencia Lagoon are gauged; hence there are no time series on the discharge and water levels (Hydrology Service, 2003). However, Ariola (2003) purports that the combined low flow for August and Mango Creeks is 0.7 cubic meter per second (CMS). The low flow for Jenkins and Flour Camp Creeks was estimated at 0.8 CMS. Silver Creek was estimated to have a low flow of 1.3 CMS.

2.2.3.3 Caribbean Sea

The Watershed Reef Interconnectivity Scientific Study (2001) purports that water within the barrier reef lagoon flows predominantly from north to south at a rate of 0.05 to 0.15 m/s and rarely exceeds 0.3 m/s. (Ariola, 2003).

Tides of the Caribbean and along the Belize Barrier Reef are micro-tidal and of mixed semidiurnal type with a mean range of 0.5 feet (Kjerfve, 1981). PASCO (2002) states that the tidal fluctuations on the east side of the peninsula range from 0.40 to 1.5 feet.

2.2.3.4 Groundwater Resources

The groundwater resources map of Belize divides the country into ten regions based on water availability and quality (Buckalew et al., 1998). The terrestrial zone of influence on the Placencia Lagoon falls into two of these regions:

1. The Placencia Peninsula and the western margin of the lagoon are classified as areas where small to large quantities of brackish to saline water are available. Also, meager to very small quantities of fresh water are available from quaternary alluvium and coastal deposits along the coast. Depth to water is 6 to 150 feet.
2. The wider extent of the terrestrial zone of influence is that part of the Central Coastal Plain composed of sandy shales, shales, claystones, mudstones, and alluvium. These deposits bear meager to moderated quantities of freshwater. Depth to water is generally less than 200 feet.

Although there is limited information about the groundwater distribution in the terrestrial zone influencing the lagoon, it is envisaged that groundwater might have some effects on the water budget of the Placencia Lagoon. (Ariola, 2003)

2.2.4 Land Systems and Agricultural Value

The soils of the peninsula are derived from recent deposits (Holocene) consisting of coarse sands along the Caribbean Sea. These sands show virtually now profile development and are characterized as follows:

- Extremely coarse,
- Excessively drained,
- Acidic, and
- Base deficient.

Agriculture value of the peninsula proper is very limited (see Figure 2.2-5). There is potential to establish cashew and coconut groves, but the poor soils, salt water spray and strong sea breeze reduce the potential of the land for other agricultural practices (King et al, 1989).

Along the shores of the lagoon, silt and mangrove peat deposits are found, forming the Stann Creek Saline Swamp land system. Limiting factors are wetness and salinity and the most important function of these soils are in coastal protection.

At the preferred location of the treatment ponds, two major land systems are present:

- In the center, forming the higher ground, is an area of the Puletan Plain land system, main subunit saline plain. Limitations of this land system include a lack of nutrients, drainage problems and high salinity. Agriculture value is for shrimp farming (King et al, 1989) but the limited area makes it unsuitable for a large operation.
- The higher ground is surrounded by the aforementioned Stann Creek Saline Swamp land system with no agricultural value.

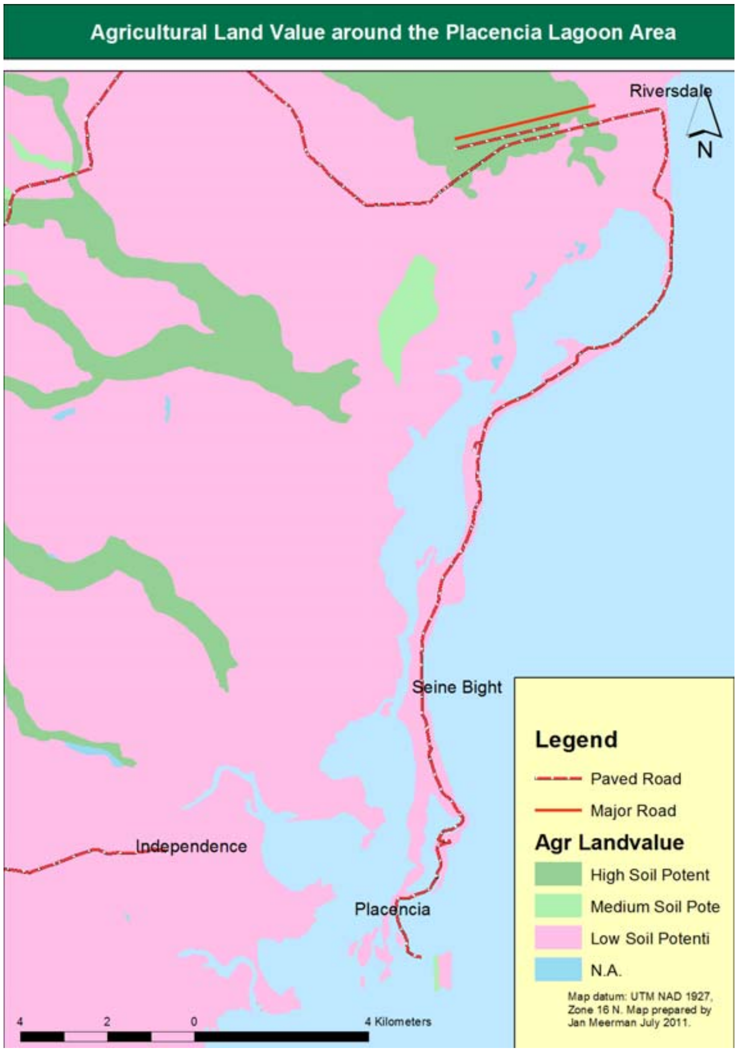


Figure 2.2-5 Agricultural Land Value

2.2.5 Ecology

The natural vegetation of the Placencia Peninsula, which broadly consisted of littoral forest along the coast, and mangroves bordering the lagoon, has all but disappeared or at least become fragmented. The last patches of natural vegetation will disappear in the near future if development of the peninsula continues at the current pace. Due to the loss of natural vegetation on the peninsula, natural wildlife has also diminished. Specifically, migratory birds have been hit by the loss of littoral forest which provided them with natural habitat to recuperate during their migration.

Natural vegetation on the mainland largely consists of gallery forests along numerous creeks, (pine) savannah on the higher ground, herbaceous swamps and mangrove swamps along the shores of the lagoon. The mangrove marshlands surrounding the Placencia Lagoon provide important environmental services such as sediment removal and buffering against the impacts of wind and wave action.

The alluvial plains of the mainland are considered the most suitable lands for shrimp aquaculture in Belize. Although several shrimp farms are located on the coastal plain, large stretches of natural vegetation still remain on the coastal plain. Coastal plain vegetation has many plant species restricted to Belize (Belizean endemics). Yellow-headed Parrots and Aplomado Falcon depend largely on coastal plain savannas for their existence. The savanna ecosystem on the west coast of the lagoon leads into gallery forests that provide a biological corridor to the Cockscomb Jaguar Reserve and the Maya Mountain Massif beyond.

Placencia Lagoon provides a sheltered environment where adult marine mammals like the Bottlenose Dolphin and West Indian Manatee can care for their young. Over 70 species of fish have been identified in Placencia Lagoon including Goliath grouper, Tarpon, Snook, Bonefish, varieties of snapper and other species. However, individual fishes tend to be very small and it has been suggested that Placencia Lagoon serves as an important nursery for juvenile fish. Studies have shown that sea-grass supports the food web of fisheries in Placencia Lagoon as both a carbon source and habitat. Unique sea-grass species, including *Halophilla baillonii* have been found in the lagoon and have been shown to be a major diet item of the West Indian Manatee (Short et al. 2006). As mentioned above, changes in the sea grass densities reportedly occurred over the last decade. Algae bloom was perceived as the reason for the disappearance of the sea grass beds. Recently, a decrease and disappearance of the algae was observed along with an increase of the sea grass beds in the southern lobe of the lagoon[v]. Two shrimp farms (Nova and Belize Aquaculture) stopped operations a few years ago; both shrimp farms discharged their effluents in the northern lobe of the lagoon. SEA claims to monitor sea grass in the Placencia Lagoon, but no records are available. The international monitoring site http://www.seagrassnet.org does not contain any data from Placencia Lagoon.

The lagoon houses a remarkable biodiversity and includes several endangered and flagship species like the Jabiru Stork, Morelet's Crocodile, American Crocodile and West Indian Manatee.

Much of the coast is lined with mangroves whose roots are encrusted with a rich variety of sessile life (shellfish, sponges, anemones and algae) and provide shelter for juveniles of many commercial fish species.

2.2.6 Archaeology

The Archaeology of the general area is quite well studied (shown in Figure 2.2-6). No traditional Maya sites with stone buildings, ceremonial sites or similar have been discovered. However, the Placencia area was probably used for trade, fishing and hunting. A principal aspect of the activities around the lagoon appears to have consisted of salt extraction by means of boiling brine (“sal cocida”). MacKinnon and Kepecs (1989) found a total of 16 sites around the lagoon where this activity appears to have been practiced. These salt gathering sited did not consist of permanent (built up) sites but were rather temporary camps; consequently, little scattered waste-artifacts are obvious when visiting these locations.

The remains encountered by MacKinnon while investigating the coastline of the Placencia Lagoon were fragments of fired clay cylinders. These cylinders were used as pedestals for the salt boiling vessels. No intact remains of the vessels were found. Small, relatively thick jar shards were found. Mounds, measuring about 12 x 20 m by 1.5 m high, were also encountered. These mounds were most likely refuse disposal sites and not traditional house mounds. The relatively sea level rise since 800 resulted in burying the temporary campsites with sediments.

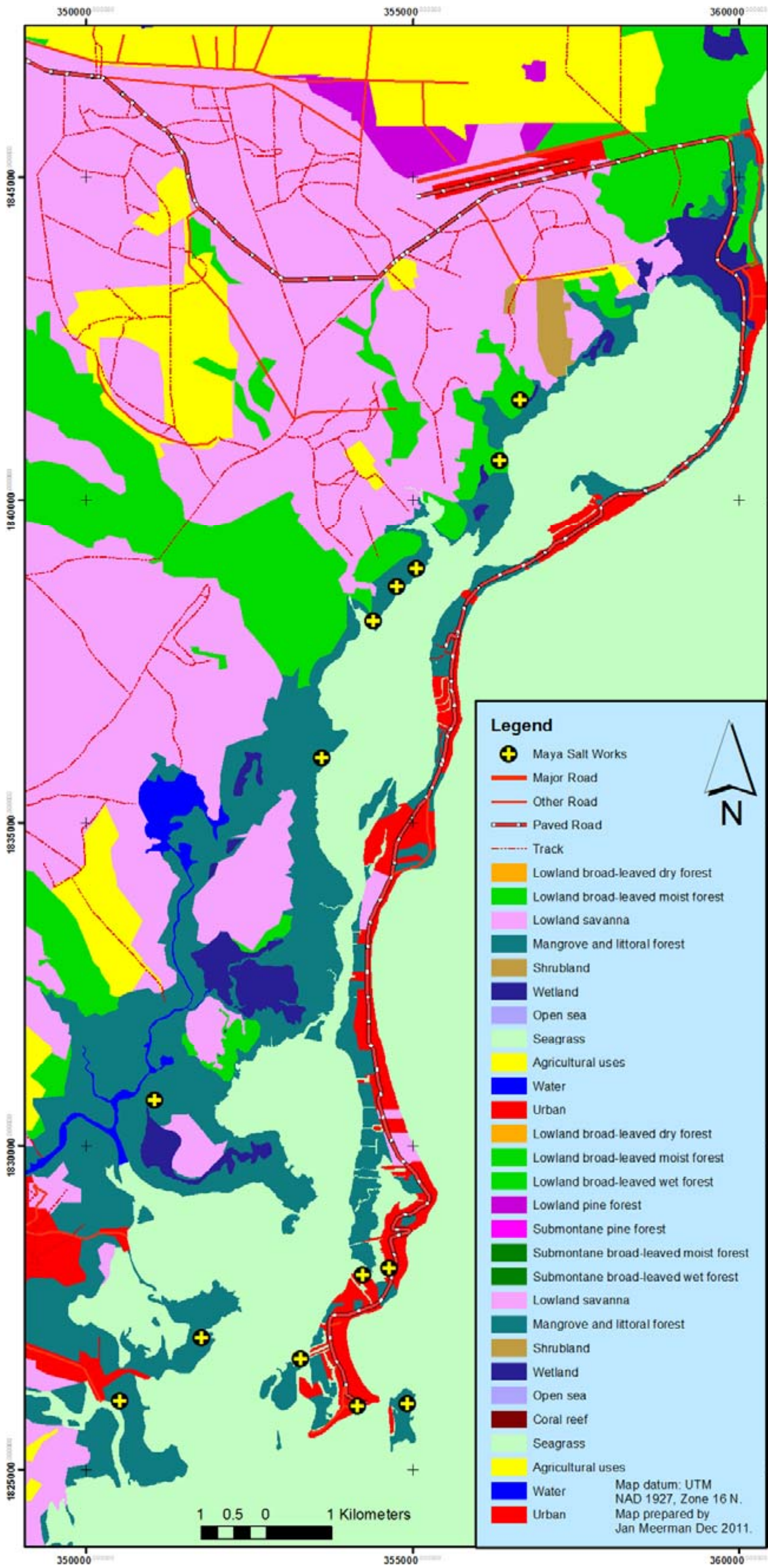


Figure 2.2-6 Placencia Region Archaeological Map
Source: MacKinnon and Kepecs, 1989

2.3 Socio-Economic Conditions

2.3.1.1 Schools

There are primary schools in Seine Bight and Placencia, but there are no high schools or junior colleges on the peninsula. The nearest secondary education facilities are in Independence and Dangriga.

2.3.1.2 Health care facilities

Seine Bight and Placencia have health clinics; Placencia has a resident doctor and a nurse, Seine Bight has a resident nurse and a nurse aid. The nearest hospital is the Southern Regional Hospital in Dangriga, about a 1.5 hour drive from Placencia. Other health facilities are in Belize City, a one hour flight from the Placencia airstrip.

2.3.1.3 Roads

Apart from some side roads, there is basically one road on the peninsula, stretching from Placencia village to the southern highway. This road has recently been improved and is fully paved.

2.3.1.4 Public transportation

Several buses make a daily run to Dangriga.

2.3.1.5 Telephone

The peninsula has telephone services by both national telephone companies. These services also include mobile phone and internet services. Internet cafés are found in the villages. Most hotels and lodges have internet services available to their guests.

2.3.1.6 Airstrip

In the centre of the peninsula is an airstrip which is used by local air companies for flights to and from Belize City and the south. A larger airport is being developed along the access road to the peninsula; this airport has a landing strip more than 8000 feet in length, which potentially can accommodate larger airplanes from international destinations.

2.3.1.7 Electricity

Electricity services are provided by the Belize Electricity Limited. The peninsula's grid is connected with the national grid.

2.3.1.8 Water supply

The peninsula is supplied with water by a Rudimentary Water System (RWS) managed by local water boards. The water is derived from a well near Mango Creek on the mainland, and then piped under water to the peninsula. The system was damaged by hurricane Iris in 2001, when the underwater pipe was broken and it took several months before the system was repaired.

At more or less the same location near Mango Creek are two more wells which produce water for Independence/Mango Creek and Big Creek. Apparently, all three wells tap into the same source(s). The water source is believed to be an aquifer, but the actual size and capacity of the aquifer has not been determined.

A financial analysis of the income and expenses of RWS over the period mid 2007-mid 2008, done in July 2008 by the Ministry of Rural Development (MRD) is provided in Table 2.3-1.

Table 2.3-1 Water Board Financial Summary
Ministry of Rural Development, 2008

Village	No. of Accounts	Water Rates	Average Monthly Income	Average Monthly Expenses	Monthly Water Use, per Monthly Income
Placencia	520	1 cent per gallon	BZ$ 57,292	BZ$ 41,021	5,729,200 gallon (@ 2.6 persons per household, 86 gallons per capita day)
Seine Bight	323	1 cent per gallon	BZ$ 24,052	BZ$ 8,288	2,490,520 gallon (@ 4.0 persons per household, 63 gallons per capita day)

The total average monthly use over a 12 month period in 2007-2008 of the two RWS was approximately 8,000,000 gallons.

A detailed survey regarding the use of water and the system of wastewater disposal of consumers was carried out by Halcrow in June 2011. The average amount of water (January-September 2011) produced by the Independence well amounted to 7,500,000 gallon per month. Additional potable water resources information is provided in Section 2.5.

2.3.1.9 Sanitation

There is no centralized piped wastewater system that services the two villages on the peninsula. Each household and business is responsible for disposal of its own wastewater. The most common systems are septic systems with a form of soak-away (soak away field, leach pit), a vaulted pit latrine, and a vaulted septic system (whereby the vault does not have a sealed bottom). Sanitary waste is also collected and dumped on the beach or in the sea/lagoon ('honey pots').

Smaller resorts and hotels have septic systems, but the larger developments are required by the Department of Environment (DOE) to install and operate package treatment plants. DOE is responsible to monitor the effluent discharge by these package plants.

The 2006 EWB study calculated an average monthly wastewater flow of 240,000 gallons per day (7,200,000 gallon per month) of wastewater.

A summary of the data collection for the existing wastewater systems is provided in Section 2.6. Of the average monthly use of 8,000,000 gallon in 2007/2008 (MRD), about 85% of this volume (6,800,000 gallon/month) will be disposed of through sanitation systems, but ultimately will be returned to the environment.

2.3.1.10 Fire service

Placencia Village has a fire engine which is stationed next to the police station.

2.3.1.11 Police stations

Police stations are located in Seine Bight and Placencia.

2.3.1.12 Economics

Tourism

Tourism is the major economic activity on the peninsula. Placencia as a tourism destination has been slowly discovered since the early 1990s. Figure 2.3-1 shows the developments that are either planned or under construction. The economic recession of the past years has slowed down the speed of these plans, but it is anticipated that the industry will recover when the world economy expands.

With the growth in tourism accommodation, comes an increase in construction and maintenance business. Also, there is an increase in staff needed in the hotels, lodges and restaurants. Some upscale lodges in the Cayo district have a staff guest ratio of one to one. On the average, a staff guest ration of 1 to 4 will implicate a future need for more employees in the tourism sector. It is uncertain where these employees will reside on the peninsula, considering the shortage in affordable houses/lodging facilities. Employees may stay on the mainland and commute to the Peninsula on a daily basis.

Caged Fish Farming[vi]

The Placencia area currently has no caged fish farming. An Environmental Impact Assessment (EIA) was submitted for a caged fish farm at the Lark Caye Range, but was withdrawn after being met with strong community opposition.

Shrimp Farms

Per Ariola (2003), considerable attention was given to the impacts of shrimp mariculture operations in the margin of the Placencia Lagoon. At the time of this 2003 study, the upper portion of the lagoon was not affected by aquaculture effluent. Nova Toledo has been non functional for several years (Tunich Nah, 2001). On the other hand, Belize Aquaculture Ltd. was then fully functional super intensive, closed system operation. (Boyd et al., 2002). Royal Mayan, Tex Mar and Crustaceans Ltd. are three operations that are in close proximity to each other. Each of these operations meet the settling pond requirements (10% of the production area) stipulated by the Department of the Environment. Effluents discharged from these operations are subjected to mangrove wetlands for nutrient and sediment reduction prior to entry into the lower portions of the Placencia Lagoon. The fact that the lower portion of the lagoon has a much higher water exchange rate with the sea (as opposed to the upper portion) is likely why there is no reported impact on the ecological and environmental conditions of the lagoon. Aqua Mar is located at the southern boundary of the lagoon and its effluents are released into wetlands in the northeastern tip of the Sennis River Catchment. Taking into account the predominant southerly coastal currents, the impacts of this operation on the Placencia Lagoon are questionable.

According to the Peninsula Citizens for Sustainable Development (PCSD), shrimp farms in the past had impacted the flora and fauna of the lagoon by discharging untreated wastewater that resulted in the decline of the sea grass beds which are of particular importance to dolphins and manatees[vii].

During the last years, Belize Aquaculture operation has shut down and most of the remaining shrimp farms on the Placencia Lagoon have reportedly reduced their run-off and effluent load through voluntary efforts[viii].

Figure 2.3-1 Placencia Peninsula Development Map, 2007 [ix]

2.4 Placencia Peninsula Population

Traditionally, two small villages were the only centers of human occupation of the peninsula: Placencia at the southern tip and Seine Bight about halfway up the peninsula. The 2000 Census noted for Placencia a mere 458 inhabitants and for Seine Bight 831 persons. By 2010, the Census showed a considerable growth of the two villages: Placencia Village 1595 residents and Seine Bight including Maya Beach, 1498 inhabitants. In the north, the small settlement of Riversdale is located right at the point where the peninsula connects with the mainland. Although a total population of 685 persons was tabulated during the Census 2010, Riversdale itself is rather small. Most likely residents of more southern located clusters of houses or resident staff of the nearby banana plantation were included in the count for Riversdale.

The peninsula has experienced an explosive growth in development during the last previous ten years, mainly in the tourism sector that led to an increase of hotels, resorts and condominiums and also in permanent and semi-permanent residential development for expatriates of pre-dominantly North American origin. The original settlement pattern of small villages has changed and at present almost no land is un-developed on the east coast of the peninsula. The availability of land along the sea is severely limited, and the inland facing side of the lagoon is also being developed.

The first hotels and lodges were set up rather spaciously. As land is becoming scarce and therefore expensive, intensification of occupation takes place. It is common to see new developments appearing with buildings four or five floors in height. Existing businesses are replaced. For example, the lodge Luba Hati that offered accommodation for a maximum of 40 guests on a 40-acre property is planned to be replaced by a high density development focusing on the condominium market with 46 hotel suites and 106 residences on the same land, a potential 10 fold increase over the current maximum occupancy of the property.

The development in the tourism industry not only resulted in an increase of temporary population but also attracted hundreds of Belizeans who sought employment in the construction or the service industries. Many of these employees live in staff quarters at the lodges and hotels or reside elsewhere on the peninsula or on the mainland in Independence and Santa Cruz.

Plans have been made to develop a 190-lot subdivision on the lagoon side of Placencia Village to accommodate the local residents for whom it is difficult to find house lots for their own growing population. The Environmental Compliance Plan for this sub-division (Crimson Park) requires the provision of a self-contained wastewater system to protect the environmentally sensitive Placencia Lagoon from contamination.

2.4.1 Permanent Population

The 2010 Belize Census population data for the Placencia Peninsula is shown on Figure 2.4-1. Based upon the historical annual population growth rate from 2000 – 2010 of 9%, the total estimated permanent population in 2011 is 3,375. Additional Census information is provided in Appendix A.2.2.

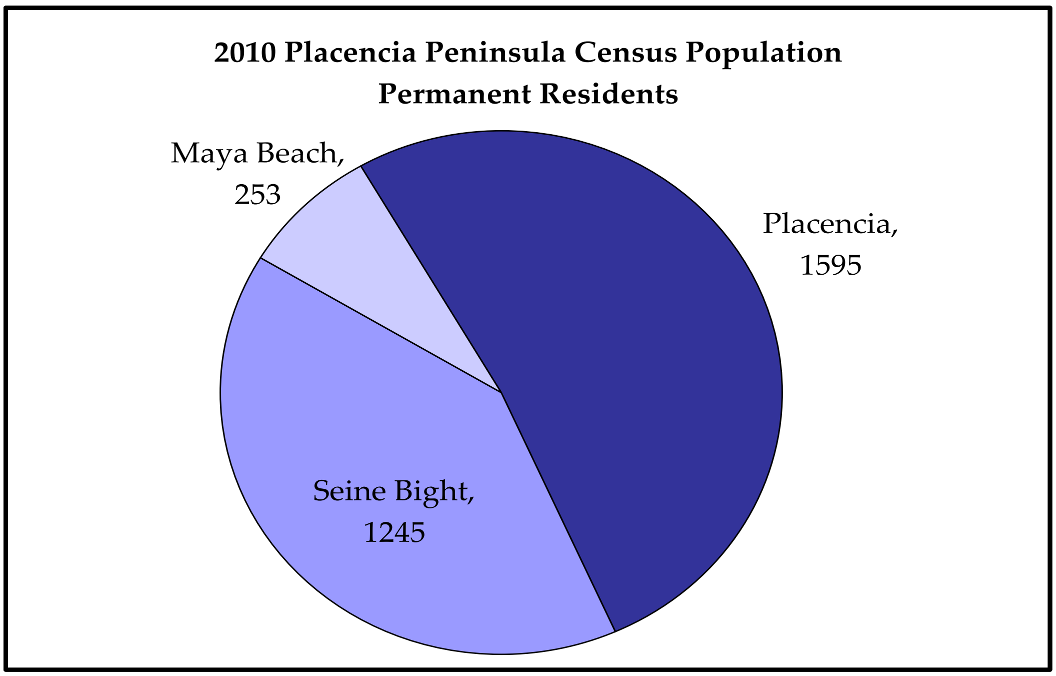


Figure 2.4-1 2010 Peninsula Population

Source: Statistical Institute of Belize, 2011

2.4.2 Floating Population

2.4.2.1 Overnight Tourists

According to the Belize Tourism Board (BTB), there are 729 hotel rooms on the Peninsula. The country-wide monthly historic occupancy rates provided by the BTB are presented in Table 2.4-1 below.

Table 2.4-1 Hotel Room Occupancy Rates

Month	2000	2001	2002	2003	2004	2005	2006	2007	Historic Monthly Average
Jan	41%	48%	48%	48%	49%	47%	47%	48%	**47%**
Feb	53%	59%	56%	54%	57%	57%	58%	59%	**57%**
Mar	55%	60%	57%	56%	55%	59%	58%	59%	**57%**
Apr	49%	49%	44%	46%	45%	47%	52%	53%	**48%**
May	40%	45%	38%	42%	38%	39%	45%	45%	**42%**
Jun	38%	42%	38%	42%	41%	40%	43%	46%	**41%**
Jul	40%	47%	40%	42%	45%	43%	41%	44%	**43%**
Aug	40%	44%	40%	47%	41%	36%	37%	38%	**40%**
Sep	29%	26%	27%	26%	25%	23%	25%	23%	**26%**
Oct	31%	34%	27%	27%	25%	27%	24%	27%	**28%**
Nov	39%	35%	44%	40%	36%	40%	41%	42%	**40%**
Dec	40%	39%	43%	44%	44%	46%	44%	45%	**43%**
Yearly Average	**42%**	**45%**	**42%**	**43%**	**42%**	**42%**	**43%**	**44%**	**43%**

Source: Belize Tourism Board, 2011

Based upon the general understanding that the tourist industry is not as strong in 2011 as it was in 2007, the estimated occupancy rate for June 2011 is likely lower than the rate for June 2007. For the purposes of this feasibility study, the estimated occupancy rate for June 2011 is 43%. Therefore, based on a 729 total rooms in the Peninsula and an average occupancy rate of 43%, the estimated occupied hotel room count is 314. For the purpose of this study, Halcrow assumed 2.0 persons per occupied hotel room, resulting in an estimated floating population of 627 persons for June 2011.

2.4.2.2 Temporary Workers

Based upon visual observation and discussions with the Ministry of Works, daily laborers work on the Peninsula (primarily in construction trades). The total quantity of these laborers varies daily, seasonally and as projects are under construction. For the purpose of this project, 100 day-laborers are estimated to be daily on the Peninsula during June 2011 (the time period water consumption was measured).

Based upon 100 laborers, a 5-day work week, and water consumption estimated at 50% of the permanent population water consumption, the equivalent permanent population of the day laborers is (100 x 5/7 x 50%) 35 persons.

2.4.2.3 Visitors

Visitors to the Peninsula who are not residents and who do not stay in hotels need to be accounted for as well. Based upon conversations with various citizens, it is common for Belizeans to visit the Peninsula for either a day trip or to stay with friends or family in a residential home. The total quantity of these visitors varies daily and seasonally. For the purpose of this project, the visiting population is estimated at 5% of the permanent population (169 persons during June 2011).

2.4.3 Total Peninsula Population

For the purpose of this study, the total population on the Peninsula during June 2011, shown in Table 2.4-2 below, was used to determine the Per Capita Water Consumption.

Table 2.4-2 Total Peninsula Population for Feasibility Study

Population Category	Feasibility Study Population June 2011
Permanent	
Residents	3,375
Temporary Workers	35
Visitors	169
Floating	627
Total	**4,206**

2.5 Potable Water Resources

Water supply information is being used as a baseline of water usage for the current permanent and floating population to help establish an expected water usage for future population projections. Wastewater generation is directly linked to water usage, based on population, water use, and infiltration estimates.

2.5.1 Water Sources

2.5.1.1 Government of Belize Water Sources

Belize Water Services (BWSL) Ltd. does not currently serve the Placencia Peninsula in the delivery, treatment or management of potable water. At the time of this report, there is no known expectation for BWSL to expand its services to the Peninsula.

2.5.1.2 Placencia and Seine Bight Water Sources

Overall System Information

The Peninsula's water system was built around 1996, partially destroyed by a hurricane in 2001 and rebuilt thereafter. Both the Placencia Water Board (PWB) and Seine Bight Water Board (SBWB) share a pumped well source in Independence Village on the Belize mainland across the Lagoon. Three (3) wells are in Independence (spaced approximately 400 ft apart). One (1) well is designated for the Peninsula, although all wells have the capability to supply the Peninsula in case its primary well is offline. The supply line runs about 2 km across land, about 2 km under the lagoon, and then into the PWB ground storage tank. According to the PWB, the Peninsula supply well runs for 16 hrs per day at 30hp and a maximum capacity 450 gallons per minute (gpm) through a 6" diameter pipe with approximately 50' of 3" diameter pipe just before entering ground storage tank.

Placencia Water Board System Information

The Placencia ground storage tank, shown on Figure 2.5-1, holds +/- 150,000 gallons with dimensions approximating 40′ x 40′ x 12.7′ H. The tank has a partition in the middle. The supply line splits just before entering the tank and feeds into both partitions. An external 3″ manifold pipe runs between the two partitions to keep the water level even across both partitions.

Figure 2.5-1 Placencia Ground Storage and Elevated Tank

Water is pumped from the ground storage tank via a single submersible pump into PWB's 20,000 gallon elevated tank. The initial purpose of this tank was to supply the PWB distribution system by gravity. However, the elevated tank effectively operates only during the lower demand periods of the early morning hours. The approximate dimensions of the elevated tank taken from ground elevation are:

- Bottom Elevation: 39′–5″
- Top of Tank: 49′–9″
- Float Switch OFF Elevation: 47′–9″
- Float Switch ON Elevation: 46′–3″

A 3-inch pipe at the bottom of the elevated tank gravity feeds the PWB System during lower demand periods in the overnight and early morning hours. During average and peak demand periods, the gravity system is supplemented by a second pipe pumped from the ground storage tank directly into the PWB system by a submersible pump. The PWB gravity and pressure-boosted pipes cross to the east side of the main road, and then split north and south. The flow to the south is measured by bulk meters. The flow to the north bypasses the bulk meters and is unmeasured. PWB water is chlorinated using a liquid sodium hypochlorite solution. The distribution system has a 3-inch maximum pipe diameter. PWB has approximately 4,000 feet of 6″ PVC pipe stored in the yard. The customers' water consumption is metered with ¾″ meters.

Seine Bight Water Board System Information

Water is supplied to Seine Bight by pumping from the PWB ground storage tank via a submersible pump through a 6" diameter pipe to the SBWB elevated storage tank in Seine Bight Village. There is a bulk meter just north of the PWB property that measures the water flow to Seine Bight. Water in the SBWB service area is served by this elevated tank (see

Figure 2.5-2). There is a ground storage tank adjacent to the SBWB elevated tank that does not appear to be in use.

In addition, SBWB feeds a ground storage tank for the Coco Plum resort community. There is a bulk meter on the lagoon-side of the road at beginning of Coco Plum property just before line enters the Coco Plum wet well. The Coco Plum system is hydraulically separate from SBWB. Coco Plum pumps from their wet well to their elevated tank, supplying their system.

Figure 2.5-2 Seine Bight Elevated Tank

SBWB recently purchased a new 7.5 hp pump to replace the existing submersible supply pump in the Placencia wet well. The pump had not been installed at the time of the Halcrow team visit. The SBWB water distribution system has the following characteristics:

- water is not chlorinated;
- the supply line from PWB tank is a 6-inch pipe;
- the distribution system has a 3-inch maximum pipe diameter;
- all materials are PVC; and
- customer water consumption is metered with ¾" meters.

A PWB and SBWB Water System Map is included in Appendix A.3.2, including the estimated location of the Independence Village Well and the PWB / SBWB Tanks.

2.5.1.3 Private Sector Water Sources

There is an unknown quantity of active or formerly active private wells on the Peninsula. Both Placencia and Seine Bight Villages have abandoned community-wells and ground tanks. Wells on individual properties (residents and resorts) appears to be in use for irrigation and supplementary domestic use.

Rain barrels, cisterns, etc. have been visually observed.

The properties north of Coco Plum, generally known as the "Plantation", are supplied by an independent well located across the lagoon, north of Independence Village and south of the Southern Highway. This well is pumped from the source through a 3" diameter supply line under the Lagoon and into the Plantation ground storage tank. This well is nominally called the "Plantation Hotel Well." The estimated location of this well is shown on the Water System map included in Appendix A.3.2.

In addition, it was stated to Halcrow by local citizens that two wells sites have been identified on the Ara Macao property just south of Riversdale, but have not been put into service. No further information is known of these potential sources.

2.5.2 Historic Water Demand

The Placencia Peninsula water comes from three primary sources: Independence Well, Placencia Resort Well and Private Wells. Various sources of information provided data regarding water supply / consumption rates.

Water supply from the Independence well (which supplies Placencia and Seine Bight Water Boards) has been measured at the well-source, coming into the Peninsula, exiting into the distribution system, and at each of the service meters.

Water Supply from the Placencia Resort Well has been measured at the well-source.

For the purpose of this study, water supply from individually owned wells is estimated, as there are no available records to determine the extent of these sources being used on the Peninsula.

2.5.2.1 Supply Well Readings

Independence Well

Based upon measurements taken by Halcrow at the Peninsula supply well located in Independence, the range of flows from the well to the Peninsula is given in Table 2.5-1 for the time the pump is running. The well is pumped to an open-air wet well in Placencia; the pump runs at a constant head along the system. Therefore, the only change in the system head is due to temporary draw-down of the aquifer at the pump and the tank level. A photograph of the flow reading at the well is provided on Figure 2.5-3. The Independence Well pumping schedule is set up by electronic timer, given in Table 2.5-2. This timer and its "on/off" pump-run device are shown on Figure 2.5-4.

Using an average 280 gallons per minute well flow rate for 16 hours per day well run time, the average daily flow rate for the Independence Well is 187 gpm (0.27 MGD).

Table 2.5-1 Independence Well Supply Flows

Flow Range (gpm)	
Low	250
Average	280
High	310

Figure 2.5-3 Measured Flow at the Independence Well

Table 2.5-2 Independence Supply Well Schedule

Source: Placencia Water Board

Placencia Well Schedule	
Time	**Status**
4:30 AM	ON
12:00 PM	OFF
1:30 PM	ON
10:00 PM	OFF

Figure 2.5-4 Independence Pump Supply Timer

Placencia Hotel Well

A second supply well to the Peninsula is located on the north side of the lagoon, pumping directly to the Placencia Hotel Resort property. Based upon conversations with the well personnel and visual observations, the well has an 8-inch casing, a well pump and a 3-inch PVC discharge line. The buried supply line is about 2 km in length along land and then about 2 km under the lagoon. The pump is a 3hp, 50 gpm Sta-Rite Signature 2000, and provides 40 pounds per square inch (psi) of surface level pressure at the pump at 45 gpm running continuously, for an estimated supply to the Peninsula of 0.06 MGD. The pump capacity verified with published pump curve is shown on Figure 2.5-5.

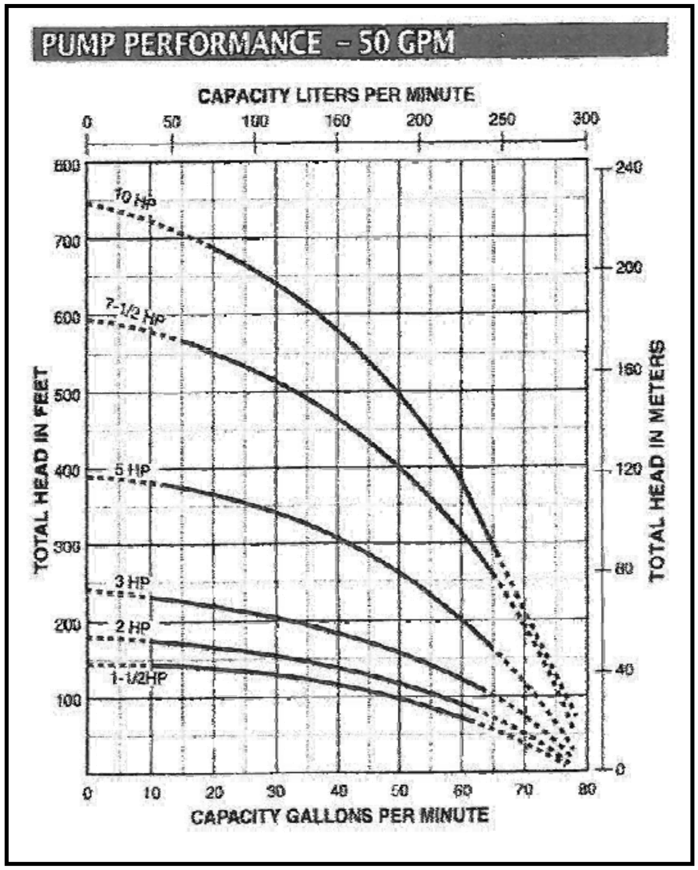


Figure 2.5-5 Placencia Resort Well Pump Curve, Sta-Rite

Individual Wells

There is no available documentation on individual wells in existence or in use on the Peninsula. For the purposes of this study, the estimated consumption of water from individual wells is 5% of the total water consumption. Table 2.5-3 summarizes the estimated water consumption based upon well supply.

Table 2.5-3 Water Consumption per Well Supply, Halcrow

Water Source	ADF (gpm)	ADF (MGD)
Independence Well	187	0.27
Placencia Hotel Well	45	0.06
Individual Wells *	11	0.02
Total	**245**	**0.35**

Note: ADF = average daily flow

* Individual Wells estimated at 5% of total water consumption

2.5.2.2 Bulk Meter Records

There are four bulk water meters located at the Placencia Water Board.

- Bulk meter from the Independence well into the PWB ground storage tank,
- Bulk meter from the PWB ground storage tank to the SB tank, and
- Two bulk meters measuring the water from the PWB ground storage tank to the Placencia system.

Ideally, the single meter entering the wet well should equal the amount of water going through the three meters exiting the wet well. However, the supply line of the Placencia system north of the ground storage tank bypasses the meters and is not measured.

Table 2.5-4 summarizes Bulk Meter records from January 1, 2011 – September 30, 2011 as provided to Halcrow by the Placencia Water Board (PWB). PWB staff read these meters daily. Multiple issues affect the accuracy of this data: the Placencia North meter was not put into service until May 20, 2011 and the Placencia South Meter was out of service from February 22 – May 20, 2011. There are additional anomalies in the readings that indicate likely meter reading errors, but they do not affect the overall data.

Table 2.5-4 Peninsula Bulk Meter Readings

	Independence Supply to PWB Ground Storage Tank		Placencia Village Total (PWB System)		Seine Bight (SBWB System, incl. Coco Plum)		Non-Revenue Water (Measured Supply - Discharge)	
Month	Monthly Sum	Daily Average	Monthly Sum	Daily Average	Monthly Sum	Daily Average	Monthly Sum	Daily Average
Jan-11	7,168,900	231,255	2,396,070	77,293	2,953,380	95,270	1,819,450	58,692
Feb-11	6,475,700	231,275	1,624,420	58,015	2,648,320	94,583	2,202,960	78,677
Mar-11	7,413,900	239,158	10	0	2,967,600	95,729	4,446,290	143,429
Apr-11	7,977,800	265,927	10	0	3,049,820	101,661	4,927,970	164,266
May-11	7,758,900	250,287	1,405,690	45,345	3,229,490	104,177	3,123,720	100,765
Jun-11	7,253,100	241,770	3,551,470	118,382	2,745,280	91,509	956,350	31,878
Jul-11	7,849,500	253,210	3,898,790	125,767	2,949,810	95,155	1,000,900	32,287
Aug-11	8,127,100	262,165	4,017,360	129,592	3,014,800	97,252	1,094,940	35,321
Sep-11	7,091,500	262,648	4,000,390	133,346	3,014,800	94,032	827,620	30,653
Jun-Sep 2011	30,321,200	254,948	15,468,010	126,772	11,724,690	94,487	3,879,810	32,535

Source: Placencia Water Board

Figure 2.5-6 summarizes bulk meter flows for June – September 2011, the only months with complete data records. The Non-Revenue Water shown in the chart is a combination of water losses in the pipe distribution system, misreading of meters and the bulk meters misreading their flows.

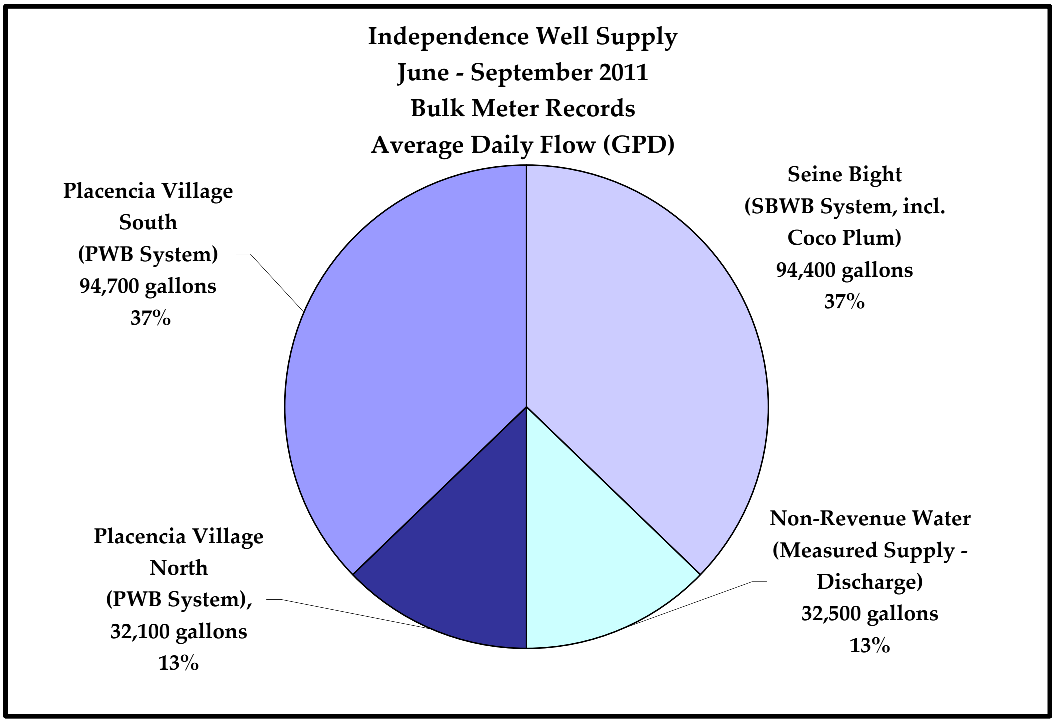


Figure 2.5-6 Bulk Meter Flow Summary

Source: Placencia Water Board

Based upon the Peninsula's supply meter alone, the average flow into the Peninsula during June – September 2011 was 0.255 million gallons per day (MGD) or 177 GPM. However, as shown on Figure 2.5-7, this meter is located immediately downstream of an in-line butterfly valve, which likely causes this meter to under-read the flows into the Peninsula.

Figure 2.5-7 Peninsula Supply Meter

Table 2.5-5 summarizes the water consumption based upon the bulk meter into Peninsula at PWB Ground Storage Tank from June – September 2011.

Table 2.5-5 Water Consumption per Bulk Meter into Peninsula

Water Source	ADF (gpm)	ADF (MGD)
Bulk Meter reading into PWB ground storage tank	177	0.25
Placencia Hotel Well	45	0.06
Individual Wells *	11	0.02
Total	**233**	**0.34**

Source: Placencia Water Board

Table 2.5-6 summarizes the water consumption based upon the bulk meters out of the PWB Ground Storage Tank and to Placencia and Seine Bight from June – September 2011. The difference between these values and those provided above is the Non-Revenue Water.

Table 2.5-6 Water Consumption per Bulk Meters Distributed to System

Water Source	ADF (gpm)	ADF (MGD)
Bulk Meters from PWB Storage Tank into PWB and SBWB systems	154	0.25
Placencia Hotel Well	45	0.06
Individual Wells *	10	0.02
Total	**209**	**0.30**

Source: Placencia Water Board

* Note: Individual Wells estimated at 5% of total water consumption

2.5.2.3 Individual Meter Readings

Halcrow collected records of meter reading data for the Seine Bight water system and Placencia Resort well for February – April 2011 and May 2011. Additionally, Halcrow received individual metering records for the Placencia Water Board from November 2006 – November 2010. The average consumption based upon the 45 months of meter reading data is 99,300 gpd. An increase in water consumption across the 45 months of PWB records would be expected; however, the data does not support this conclusion. The individual metering records are incomplete and are not adequate to estimate total water delivered to customers.

2.5.3 Water Consumption for Feasibility Study

The total amounts of the volume records vary between 0.30 – 0.35 MGD. For the purposes of this study, the estimated average daily flows are based upon the bulk meter supplying the Peninsula (at the well), as shown in Table 2.5-7. As stated earlier, the bulk meter into the PWB storage tank is located directly adjacent to a butterfly valve likely under reads the flows. The bulk meters into the PWB and SBWSL systems are missing some portions of the PWB system north of the storage facility. Individual meter readings are not complete enough to utilize for this value.

Table 2.5-7 Water Consumption for Feasibility Study

Volume Estimation Method	Total Daily Volume (MGD)
Per Independence Well Supply	0.35
Bulk Meter into PWB Storage Tank	0.34
Bulk Meters into PWB and SBWSL Systems	0.30
Individual Meter Readings	N/A
Supply Volume within Feasibility Study	**0.35**
Estimated NRW (see Figure 2.5-6)	**13%**
Consumption Volume within Feasibility Study	**0.30**

2.5.4 Per Capita Water Consumption

In order to determine the amount of water used per person, gallons per-capita per day (gpcd), it is necessary to use the available historic water consumption and estimated population on the Peninsula, accounting for both permanent ('resident') and floating ('tourist') residents.

The floating population in Belize has higher per-capita water consumption than the permanent population. The typical tourist per capita water consumption for regions similar to Belize is 400 L/day (105.7 gpcd)[xi]. For the purpose of this study, the per-capita consumption to be used in the water demand projections is provided in Table 2.5-8.

Table 2.5-8 Per Capita Water Consumption, Halcrow

Type	Population	Total Consumption (MGD)	Per-Capita Consumption (gpd)
Permanent	3,579	0.24	67
Floating	627	0.07	106

2.6 Existing Wastewater Systems

At the present time, there is no centralized wastewater system that services the Placencia Peninsula. The door-to-door survey conducted by Halcrow as a part of this project indicates that each household and business is responsible for its own wastewater handling and disposal. A copy of the survey results is included in Appendix A.3.3 located on a project CD accompanying the final report. The predominant wastewater disposal method is the use of septic tanks and soakage pits. The field survey revealed that a significant number of households (+/-35%) directly discharge into the soil, beach or lagoon. In addition, the survey shows that +/-10% of businesses and +/-5% of hotels also use direct discharge as their disposal practice. Smaller resorts and hotels have septic systems or soakage pits; a few of the larger developments comply with the Department of Environment (DOE) requirements to install and maintain individual packaged wastewater treatment plants, although performance records are not readily available to determine the systems' effectiveness.

In general, the existing septic systems are inappropriate for the environment; pollutants are able to easily move between the groundwater system, the lagoon and the ocean. Placencia's high groundwater levels and the high permeability/porosity of the soils make even a properly designed and constructed septic system a potential health hazard. However, many of the observed existing septic systems in the densely populated areas of Placencia and Seine Bight Villages were not constructed properly and leak directly into the groundwater. These systems are located too close to each other and to homes to effectively function.

During high tides and heavy rains it is likely that contaminated effluent from soakage pits overflows into low-lying residential areas putting residents (and particularly children) at risk from direct exposure to fecal coliforms and other disease-transmitting organisms.

2.6.1 Existing Wastewater Technologies

Direct Discharge of wastewater to the soil surface or a marine environment is a public health hazard as it provides no treatment of the effluent prior to its human or animal contact. The spread of bacteria and excess nutrients within the waste is harmful for the surrounding environment as well. On the Peninsula, a Direct Discharge system is not an effective treatment and disposal method.

In a Soak Pit system, a minimum of two to four feet (2'-4') of unsaturated soil below the facility outflow is required to sufficiently remove effluent bacteria and viruses to treatment standards. Per Table 2.6-1, the highly permeable sandy soils of the Placencia

Peninsula require an even greater unsaturated soil depth. However, the wastewater drains through the sandy soil and enters the high water table (estimated 2'-4') before having adequate time to treat the bacteria and nutrients in the effluent. The waste enters the groundwater prior to effective treatment. On the Peninsula, a Soak Pit system is not an effective treatment and disposal method.

Table 2.6-1 Hydraulic Soil Characteristics

Soil Texture	Permeability in/hr	Percolation min/in
Sand	> 6.0	< 10
Sandy loams	0.2 - 6.0	10-45
Pourous silt loams		
Silty loams		
Clays, compact	< 0.2	> 45
Silt loams		
Silty clay loams		

Source: USEPA Design Manual, "Onsite Wastewater Treatment and Disposal Systems"

In a septic tank system, the tank separates the solids and floatables from the liquid effluent. If the septic tank has an absorption field, the effluent then flows through a distribution box to a leaching facility where it infiltrates into the ground and eventually mixes with the underlying groundwater.

Figure 2.6-1 – Figure 2.6-3 provide generalized schematics of each of these discharge methods as defined by Halcrow for the survey and report. Under the soil and water table prevalent on the Peninsula, a Soak Pit is effectively the same as Direct Discharge (see Section 4.5.4 for further discussion).

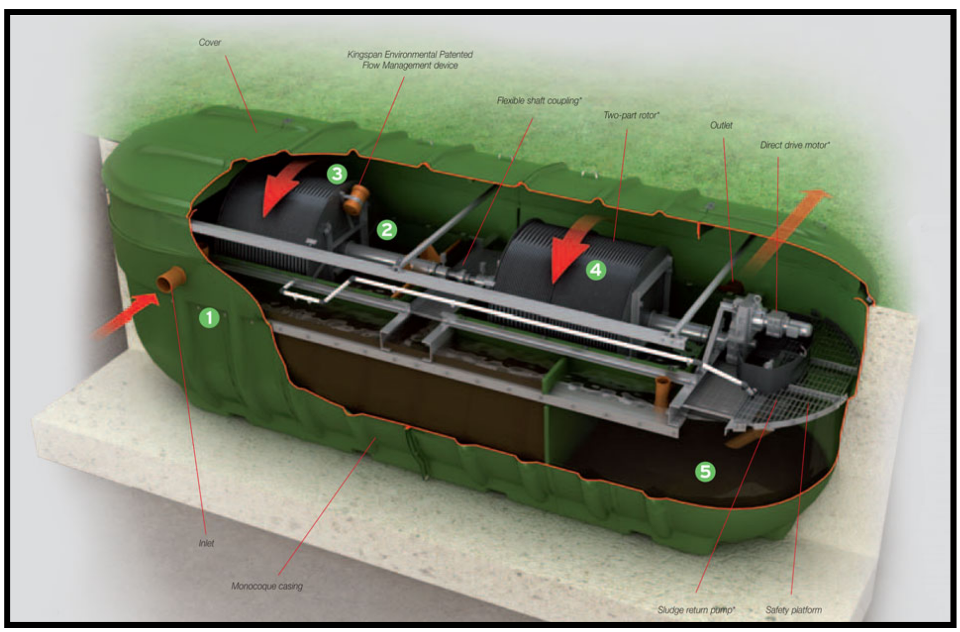


Figure 2.6-1 Wastewater Discharge Method: Wastewater Treatment Plant (WTP)

Source: www.klargester.com/products/BioDisc-BE-BL.htm

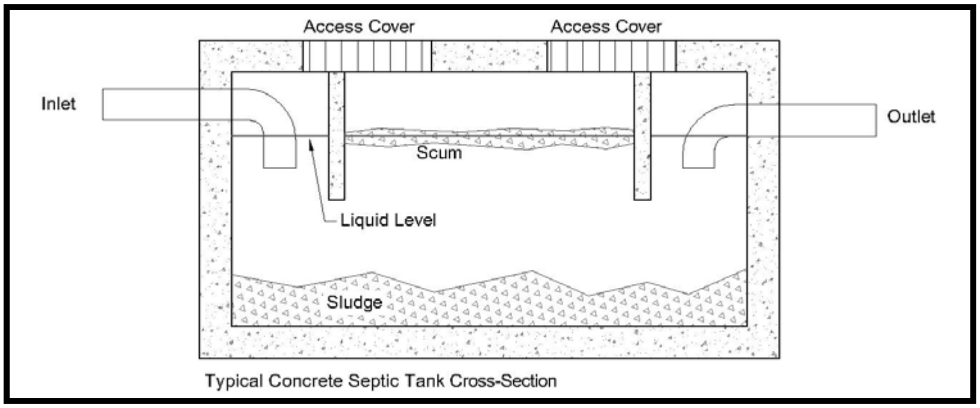


Figure 2.6-2 Wastewater Discharge Method: Septic System, Halcrow

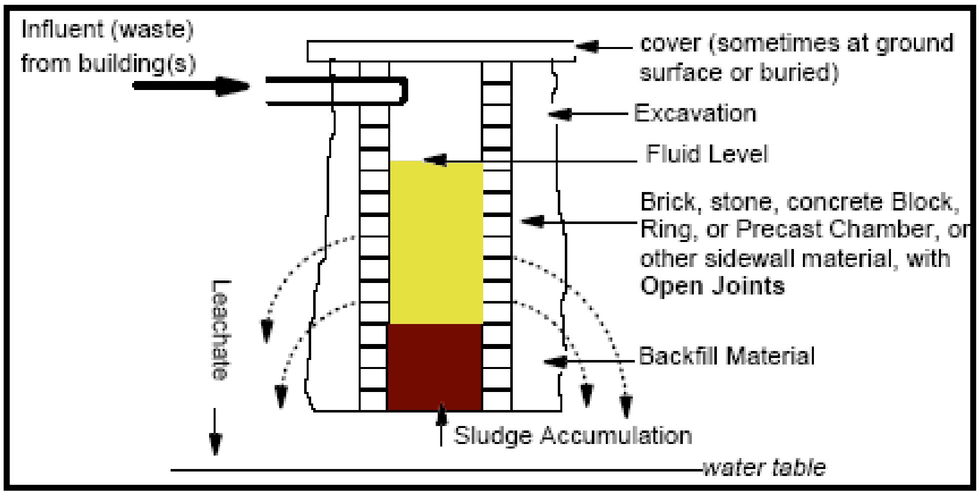


Figure 2.6-3 Wastewater Discharge Method: Soak Pit, Halcrow

2.6.2 Field Survey Results

A portion of the field survey questions centered on the types and locations of different wastewater discharge methods: Septic System, Soak Pit (often in the form of a concrete box structure without a bottom, whereby the effluent soaks into ground), Direct Discharge (emptying effluent directly onto the surface or into a waterway), and Wastewater Treatment Plant. A map of the locations and types of systems is provided on Figure 2.6-4. A copy of the survey results is included in Appendix A.3.3 located on a project CD accompanying the final report.

Figure 2.6-5 – Figure 2.6-7 identify the different methodologies currently used to discharge wastewater from Residences, Businesses and Hotels, respectively. In these summaries, when more than one discharge method was identified at a surveyed location, the least-environmentally appropriate method was utilized for the summary. For this study, the environmentally appropriate wastewater system is valued (from best-quality to least-) as Wastewater Treatment Plant (WTP), Septic System, Soak Pit, and Direct Discharge.

Figure 2.6-4 Project Survey Results – Existing Discharge Locations by Type, Halcrow

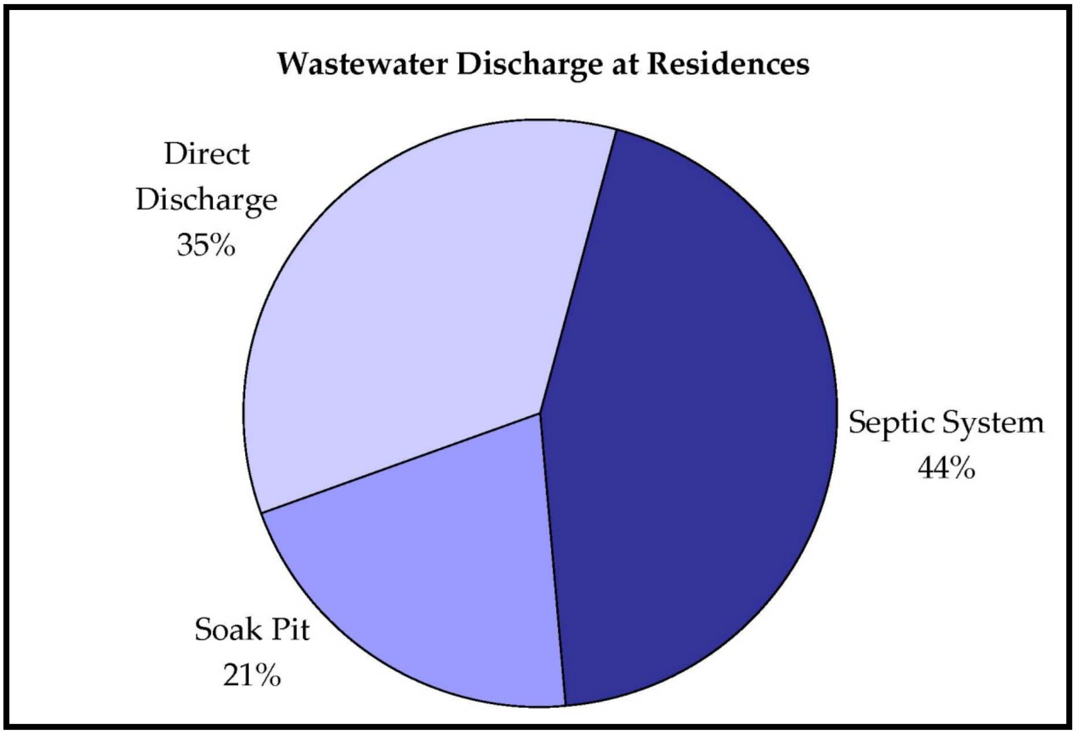


Figure 2.6-5 Survey Results: Residents Current Wastewater Disposal Method, Halcrow

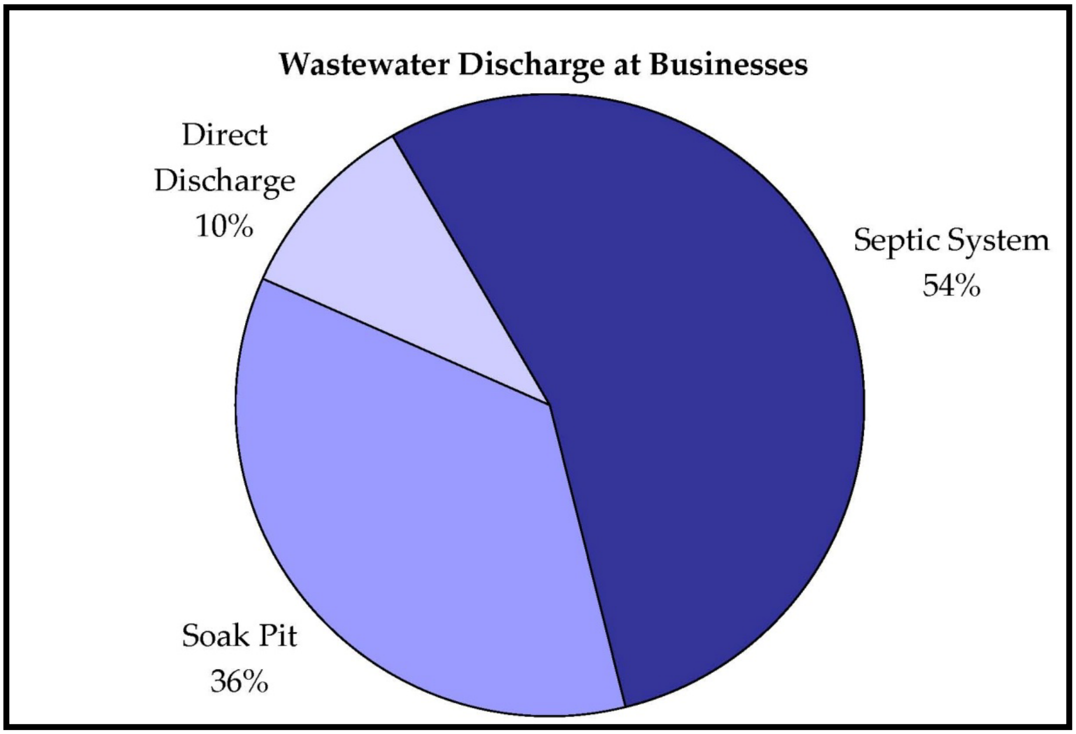


Figure 2.6-6 Survey Results: Businesses Current Wastewater Disposal Method, Halcrow

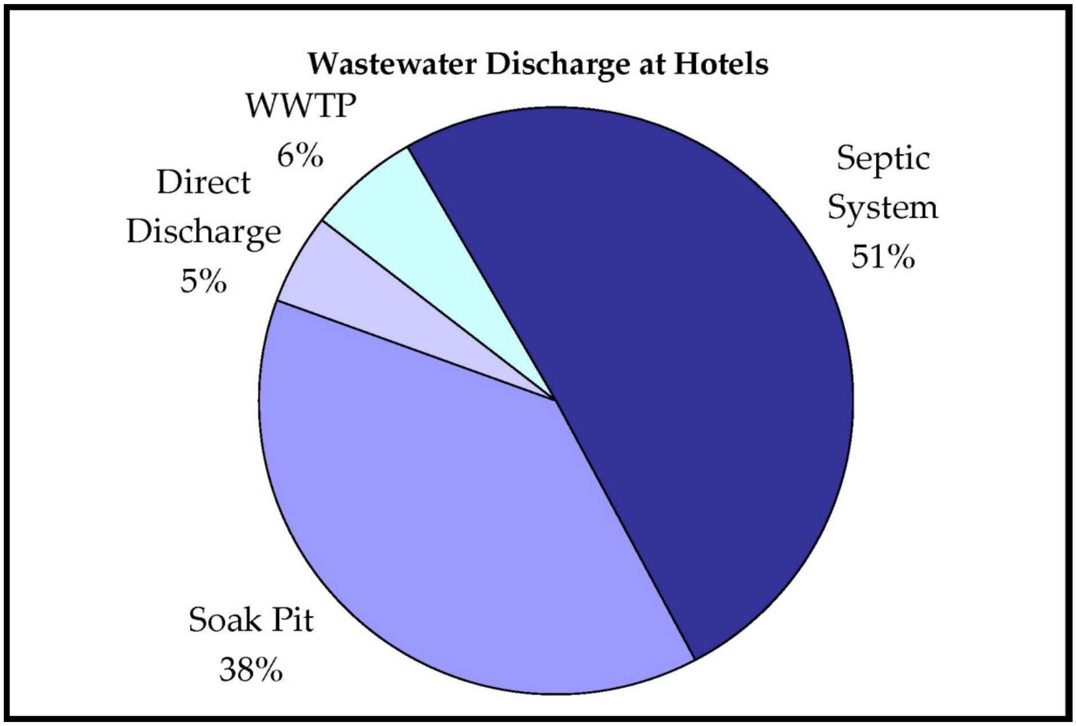


Figure 2.6-7 Survey Results: Hotels Current Wastewater Disposal Method, Halcrow

2.7 Existing Environmental Conditions

2.7.1 Estimated Effluent Characteristics

Table 2.7-1 summarizes the current wastewater volume, bacterial and nutrient loading being created on average each day.

Table 2.7-1 Existing Average Daily Wastewater Loading

Typical Wastewater Characteristics		
BOD_5	300	mg/L
Fecal Coliform	2,000	colonies/L
Nitrogen	20	mg/L
Phosphates	21	mg/L
Total Estimated Wastewater Loading		
Average Daily Flow	0.35	MGD
BOD_5	876	lbs/day
Nitrogen	58	lbs/day
Phosphates	61	lbs/day

2.7.2 Effluent into Environment

Table 2.7-2 summarizes the effective rate of untreated wastewater discharge directly into the environment shown on Figure 2.6-5 – Figure 2.6-7.

Table 2.7-2 Effective Rate of Untreated Wastewater Directly Discharging into Environment

Facility Type	Direct Discharge	Soak Pit	Total Portion of Inadequate Systems Discharging into Environment
Residences	35%	21%	56%
Businesses	10%	36%	46%
Hotels	5%	38%	43%

In each of these cases, little treatment of the effluent occurs before it reaches groundwater. Bacteria are removed through filtration in the subsurface sediments between the leaching point and the groundwater. However, nitrogen, phosphorus, household hazardous wastes, and viruses are not attenuated and may pose a threat to nearby private or public wells, fresh water ponds, or coastal waters. During low tide conditions, groundwater will migrate to the beach interface between the groundwater and the ocean, creating a potential health hazard. As population increases, the potential for contamination and public health issues will increase. Figure 2.7-1 displays the movement of effluent into the ground and groundwater.

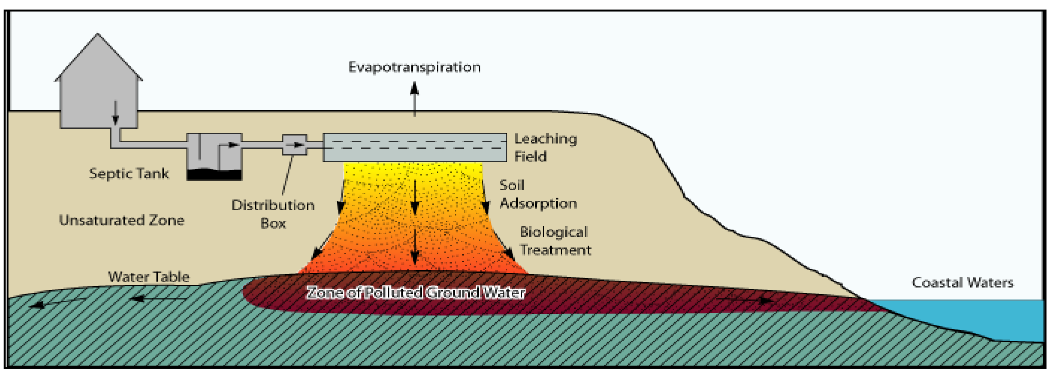


Figure 2.7-1 Movement of Effluent through Soils

The Peninsula's soils are not suited for conventional subsurface soil absorption fields: the sandy soil passes effluent too quickly for treatment and the high water table leaches the untreated effluent into the groundwater and coastal water.

3 Future Conditions

Over the past two decades, the tourism development on the Placencia Peninsula resulted in an increase of the population to an estimated permanent population of around 3,000 persons, to a seasonal high of about 10,000 persons. The provision of a Rudimentary Water System (RWS) allowed the residents to improve their sanitation and hygiene standards, resulting in an increase of the average use of water per person per day. This growth in population and water use has translated into a wastewater problem. Generally assuming that what comes in will go out, and regardless of the sanitation facilities of the particular households, all wastewater will be returned to the environment.

The peninsula has a limited carrying capacity to handle waste and wastewater in an environmentally acceptable way. This is a result of the physical characteristics of the peninsula, which is nothing more than a long and narrow sand spit. Sand does not have a large absorption complex like clay, and excess amounts of nutrients will pass through and end up in the shallow freshwater layer under the peninsula and ultimately be flushed out towards the sea and the lagoon on either side of the peninsula. Filtration time is short and pathogens are not sufficiently killed off, which is confirmed in a recent study that showed the presence of streptococci in the lagoon water.[xii]

The original sanitation method on the peninsula was nothing more than collecting the waste and disposing of it on the shore or in the sea or lagoon. This method is prosaically called the 'honey pot' method and it was still practiced until at least 2003 (Areola, 2003). Other sanitation facilities comprised of pit latrines (improved and non-improved) for households who had not or could not invest in the construction of a flush toilet and septic system. As long as the water table is low or the pit latrine is elevated, this sanitation method that can function (assuming there are no water collection wells nearby). In reality, the groundwater table is often high, resulting in 'flushing out' of the contents of the latrine pit.

Households with flush toilets have built septic tanks (with or without sealed bottom), leach pits, and other constructions that appear to function well, but in reality are slowly polluting the environment. Often, grey water from shower units and kitchen sinks are freely drained into yards, resulting in un-hygienic conditions.

The first hotels built on the Peninsula had small to medium capacities and the most common sanitation facility was a septic tank with a soak-away field. During the last decade, the Department of Environment stopped allowing septic tank systems to be built for tourist accommodations and now require the use of package-plants. Package plants are adequate solutions for primary and secondary wastewater treatment; but the effluent contains high levels of nutrients. If the effluent does not receive some form of tertiary treatments the nutrients can be detrimental to the environment of the lagoon and the sea, where the nutrients ultimately end up.

It is not clear to what extent the Belize Department of Environment monitors the operation and effluent quality of these package plants. In addition, the maintenance and internal quality control provided by each package plant owner/operator may vary from plant to plant.

Taking the above into consideration, the need for an improved sanitation system is clear. A piped wastewater system that will collect all wastewater from the peninsula and properly treat it so it will not negatively affect the quality of the lagoon or the sea will benefit the environment, local and visiting population, and ultimately the peninsula's economy and quality of life.

3.1 Population Projections

As part of this study, Halcrow gathered tourism and population information to help determine the rate and extent of wastewater generation through the year 2040.

3.1.1 Permanent Population

The Belize Population Projections shown on Figure 3.1-1 are from the Statistical Institute of Belize.

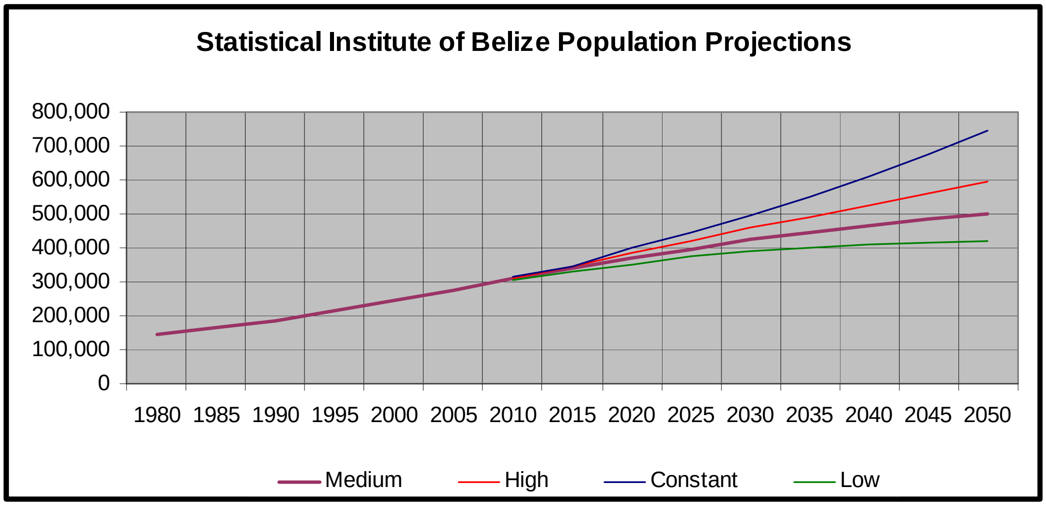


Figure 3.1-1 Belize Population Projections, Statistical Institute of Belize

The Placencia population projections on Figure 3.1-2 are interpolated based upon the current population of the Placencia Peninsula provided by the 2010 Census and the overall country growth rates shown above. This information will be used to determine the permanent peninsula population.

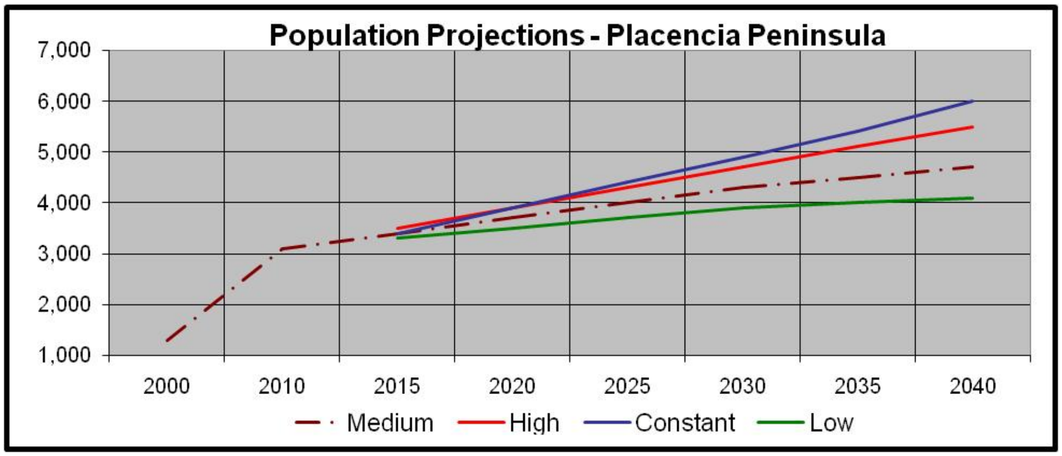


Figure 3.1-2 Placencia Population Projections, Halcrow

3.1.2 Hotel Room Projections

It is anticipated that future growth will not be evenly distributed geographically across the Peninsula. Development trends indicate that the most significant growth is occurring north of Maya Beach. New construction in the northern area include mid rise hotel buildings, luxury condominiums, and a new international airport near Riverdale. In addition, private developers are planning a Cruise Ship terminal in the vicinity of Riverdale north of the Peninsula. Figure 3.1-3 shows the Marina Village area where several two and three story houses and condominiums are currently under construction.

Figure 3.1-3 New Residential Developments in the North Region

Figure 3.1-4 shows the historical hotel room quantities throughout Belize and projected quantities for Placencia. Table 3.1-1 summarizes the hotel room quantities utilized within this study, as documented in Appendix A.2.5. These quantities, along with occupancy rates, are used to project floating populations.

Table 3.1-1 Hotel Room Projections for Study, Halcrow

Area	2010	2015	2020	2025	2030	2035	2040
South Peninsula	620	640	660	680	700	725	750
North Peninsula	109	366	470	700	967	1172	1300
Total Peninsula	**729**	**1006**	**1130**	**1380**	**1667**	**1897**	**2050**

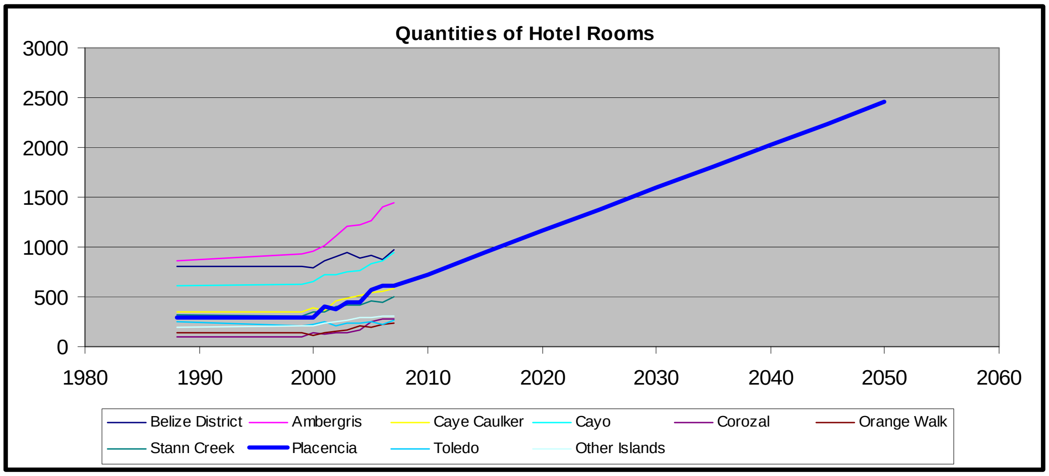
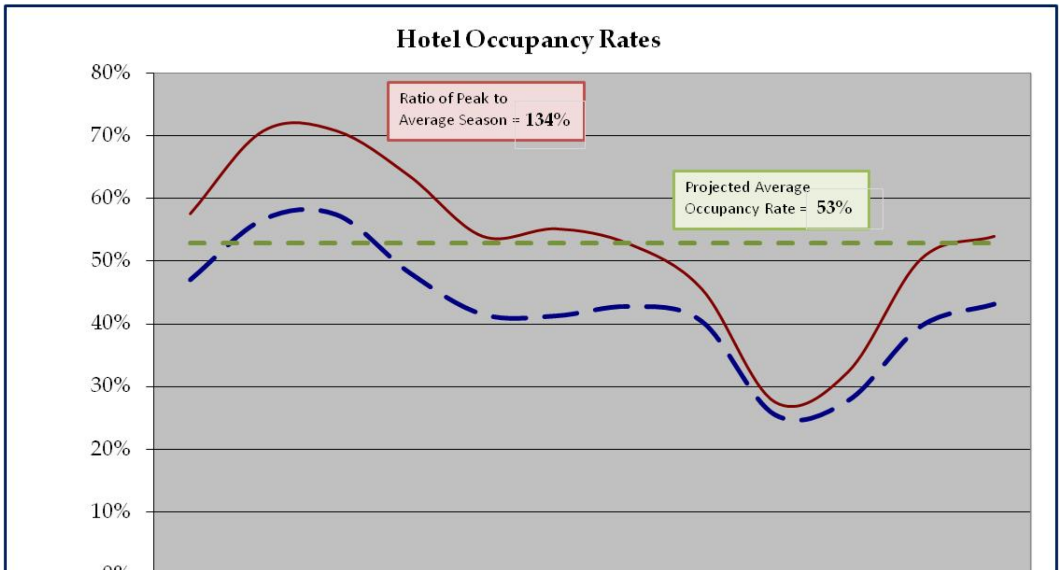


Figure 3.1-4 Hotel Room Quantities, BTB & Halcrow

It is anticipated that the monthly average occupancy rates will increase as the Belize tourist market matures. Estimated occupancy rates for future projections are also provided on Figure 3.1-5. These rates are a 20% increase over the published 2007 rates. The projected average monthly occupancy rate is 53% and peak monthly occupancy rate is 71%.



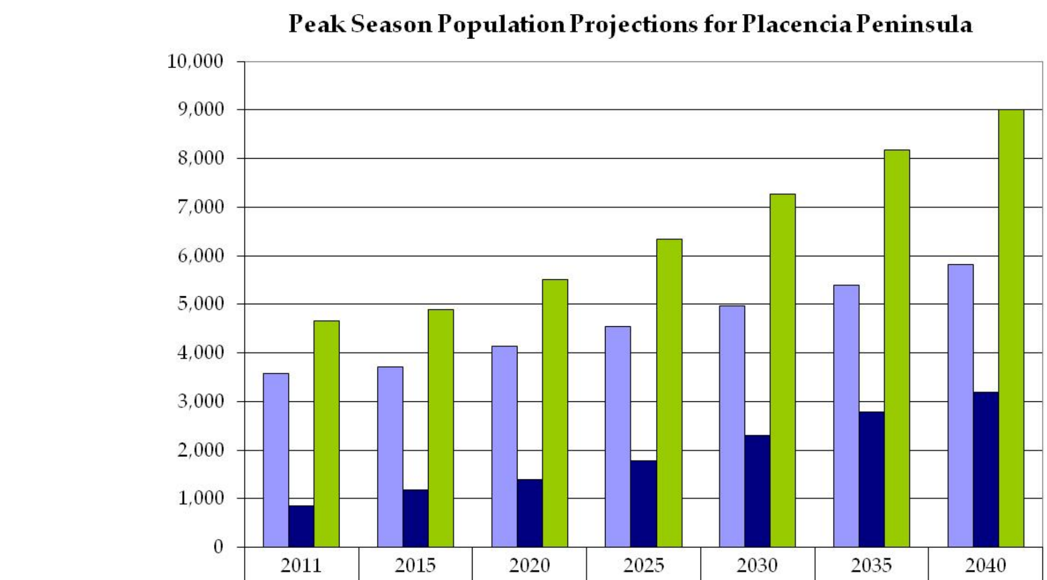
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Historic	47%	57%	57%	48%	42%	41%	43%	40%	26%	28%	40%	43%
Projected	58%	71%	71%	64%	54%	55%	53%	46%	28%	32%	50%	54%
Average	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%	53%

Figure 3.1-5 Hotel Room Occupancy Rates

Source: Historic Occupancy Rates by Belize Tourism Board, 2011. Projections by Halcrow.

3.1.3 Total Projected Population

For the purpose of this study, the 2011 to 2040 population projections are presented on Figure 3.1-6. Equivalent Permanent Population accounts for residents, day laborers and non-hotel visitors.

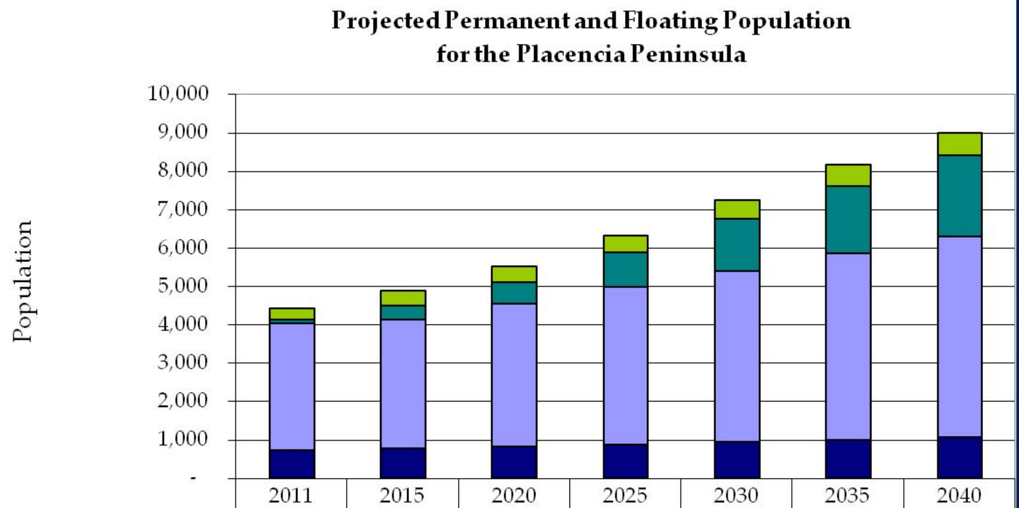


	2011	2015	2020	2025	2030	2035	2040
Equivalent Permanent	3,580	3,711	4,131	4,551	4,971	5,391	5,811
Peak Season Floating	844	1,172	1,384	1,784	2,292	2,778	3,188
Total	4,656	4,882	5,515	6,335	7,263	8,168	8,999

Figure 3.1-6 Permanent and Floating Population Projections

Source: Historic Population by the Belize Tourism Board, 2011. Projections by Halcrow based on data provided by the Statistical Institute of Belize

Figure 3.1-7 summarizes total population projections used for this study; most of the growth in Placencia is expected to take place in the North area. In addition, a significant portion of the future growth can be attributed to visitors or floating population. For the purpose of this study, Halcrow has split the Peninsula into two regions: South and North (see Figure 5.3-1 in Section 5.3.1). The South region is defined as the portion of the Peninsula south of Placencia Resort; from Placencia Resort to Riverdale is the North region.



	2011	2015	2020	2025	2030	2035	2040
Equ. North Permanent	280	371	413	455	497	539	581
Peak North Floating	100	380	544	894	1,349	1,775	2,123
Equ. South Permanent	3,300	3,340	3,718	4,096	4,474	4,852	5,230
Peak South Floating	744	791	840	891	943	1,003	1,065

Figure 3.1-7 Permanent and Floating Population Projections by Region for the Placencia Peninsula

Source: Historic Population by the Belize Tourism Board, 2011. Projections by Halcrow based on data provided by the Statistical Institute of Belize

3.2 Water Consumption

Projected water demands are based upon anticipated population growth and any changes to population water use habits. For a heavy tourist region such as Placencia Peninsula, it will be necessary to look at both 'permanent' (residents) and 'floating' (visitors) population. For this project, there are no anticipated changes in water use consumption rates. Based upon per-capita consumption rates, population projections and occupancy rates, Table 3.2-1 summarizes the total estimated Placencia Peninsula water consumption and Figure 3.2-1 provides the average daily water consumption rates by population type through 2040.

Table 3.2-1 Water Demand Projections

Year	2020	2025	2030	2035	2040
Average Daily Consumption (MGD)	0.42	0.50	0.57	0.65	0.72

Source: Historic Occupancy Rates by Belize Tourism Board, 2011. Projections by Halcrow based on data provided by the Statistical Institute of Belize and Belize Tourism Board

The average daily (AD) and peak season daily (PD) demands do not account for unmetered water uses (leaks, burst, tank overflows, fire abatement, etc.) or fluctuations in water usage due to irrigation demands. The total projected AD water demand for the South and North areas of the Placencia Peninsula are shown on Figure 3.2-2.

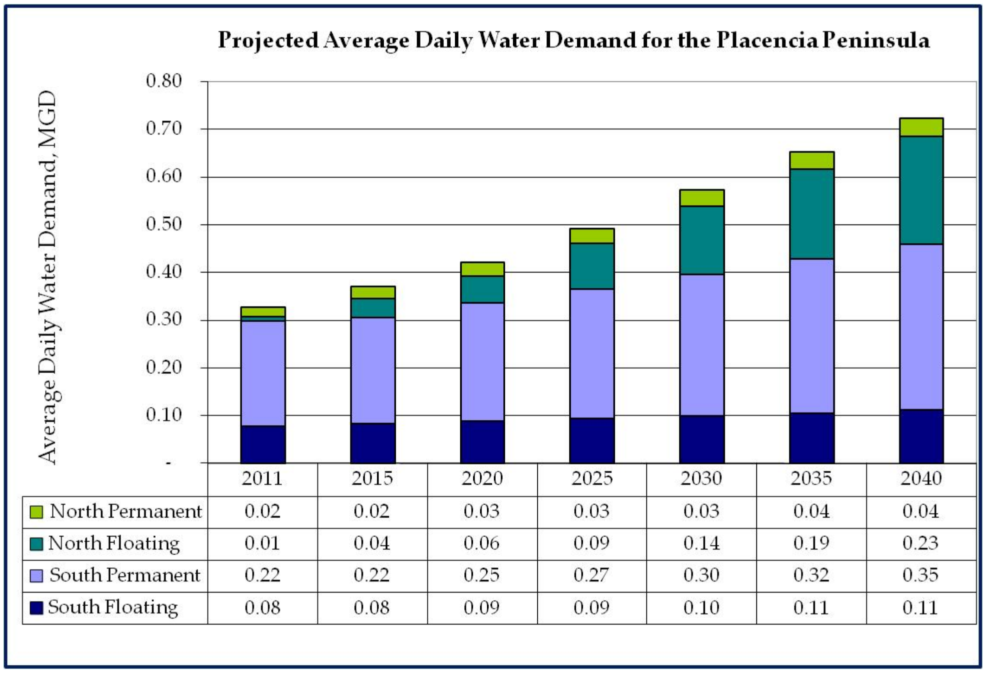


Figure 3.2-1 Projected Average Daily Water Demand by Population Type

Source: Halcrow, based on data provided by the Statistical Institute of Belize (SIB) and Placencia Water Board (PWB)

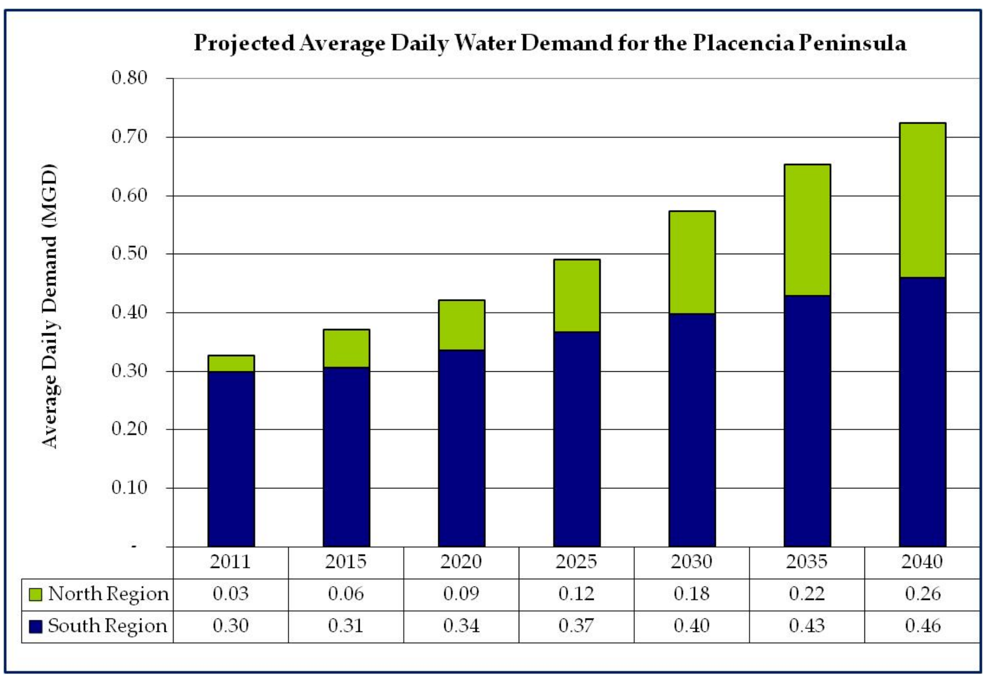
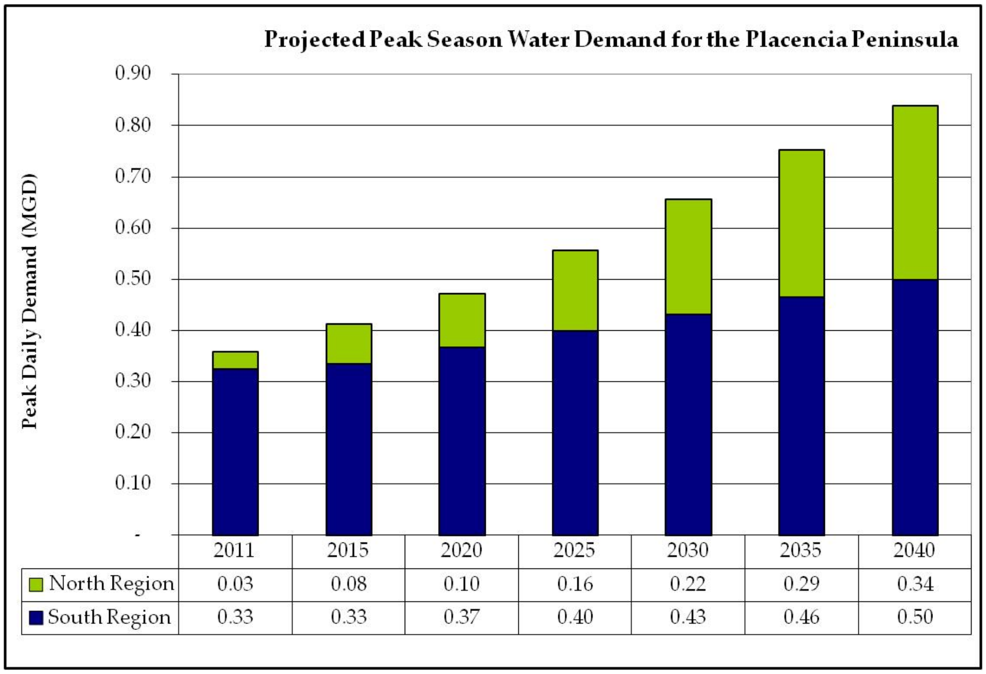


Figure 3.2-2 Projected Average Daily Water Demand Projections by Region

Source: Halcrow, based on data provided by the SIB and PWB

The peak season daily demand is anticipated to occur during peak tourist season. Peak tourist season is estimated at 140% of average tourist season. The peak season daily demand values are calculated as 100% of the permanent population plus 134% of the average floating population. The Peak Season daily demand is shown on Figure 3.2-3.

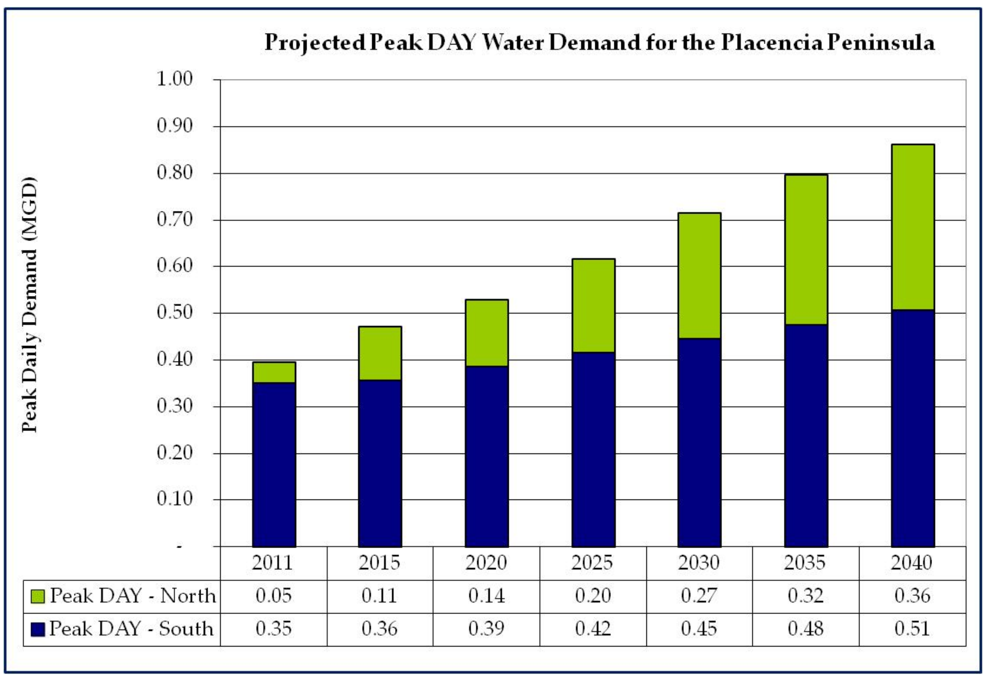
Water demand during holiday weekends when hotels are 100% occupied are shown on Figure 3.2-4. The peak hourly (PH) to average daily demand ratio for this population size is estimated in the range of 3 to 3.5.



	2011	2015	2020	2025	2030	2035	2040
North Region	0.03	0.08	0.10	0.16	0.22	0.29	0.34
South Region	0.33	0.33	0.37	0.40	0.43	0.46	0.50

Figure 3.2-3 Projected Peak Season Daily Water Demand Projections by Region

Source: Halcrow, based on data provided by the SIB and PWB



	2011	2015	2020	2025	2030	2035	2040
Peak DAY - North	0.05	0.11	0.14	0.20	0.27	0.32	0.36
Peak DAY - South	0.35	0.36	0.39	0.42	0.45	0.48	0.51

Figure 3.2-4 Projected Peak Day (100% Occupancy) Water Demand Projections by Region

Source: Halcrow, based on data provided by the SIB and PWB

3.3 Wastewater Generation

Current wastewater disposal practices on the Peninsula consists of almost exclusively on-site systems; therefore, it is not possible to measure the amount of wastewater currently being generated. However, wastewater flows in wastewater systems can be estimated based on the following formula:

- WW = WU – WNR + I/I, where
  - WW = wastewater flow
  - WU = water used
  - WNR = water used and not returned to the wastewater system
  - I/I = infiltration and inflow

Infiltration and inflow (I/I) is a catch-all category that attempts to account for increases in wastewater flows due to illicit connections (eg., storm drains), manhole covers, groundwater infiltration through broken pipes or joints, illegal dumping, etc.

There are several methods to estimate I/I:

- By Pipe Diameter and Length of Sewer, estimated as 500 gpd/inch-diameter/mile of sewer, with ranges from 100 to 10,000.
- By Length of Sewer, estimated as 30,000 gpd/mile sewer, with ranges up to 60,000 in areas of high groundwater.
- By Area Served, estimated in the range of 300 – 1500 gallons/acre/day
- By Percent of Domestic Water Consumption, estimated at 80-90% of water demand returned to wastewater system with 10-40% of demand as I/I.

There are several ways to minimize I/I, including minimizing pipe joints, rock bedding for the pipes, liners, pressure grouting joints, and quality control during construction (air tests).

For the purposes of this overall wastewater generation along the Peninsula, the assumed infiltration and inflow (sinks and sources) to the wastewater collection system preliminary design criteria are shown in Table 3.3-1. However, within the collection system wastewater model performed as a part of the evaluation of collection system alternatives, groundwater infiltration in to the gravity sewer pipes was set at 500 gallons per day per inch pipe diameter per mile of sewer line (gpd/in-mile).

Table 3.3-1 Wastewater Flow Projections based upon Water Consumption

Conversion from Water Consumption to Wastewater Generation	Flow Rate Change
Fraction of Water Consumption Not Returned	-15 %
Infiltration and Inflow Additions	+ 25%
Net Change	**+ 10%**

The estimated wastewater generation rates are based upon growth projections for both permanent and floating populations. For the purpose of this study, it is assumed that all current and future water users on the Peninsula are connected to the proposed wastewater collection system.

Figure 3.3-1 summarizes the average daily dry-weather wastewater flows estimated for the Placencia Peninsula for 2011 to 2040. The Peak Season wastewater flows are shown on Figure 3.3-2. Wastewater generation during holiday weekends when hotels are 100% occupied are shown on Figure 3.3-3.

Sections 4.2 and 5.2 discuss wastewater collection system design criteria that takes into consideration wet weather flows and appropriate Infiltration and Inflow (I/I) rate.

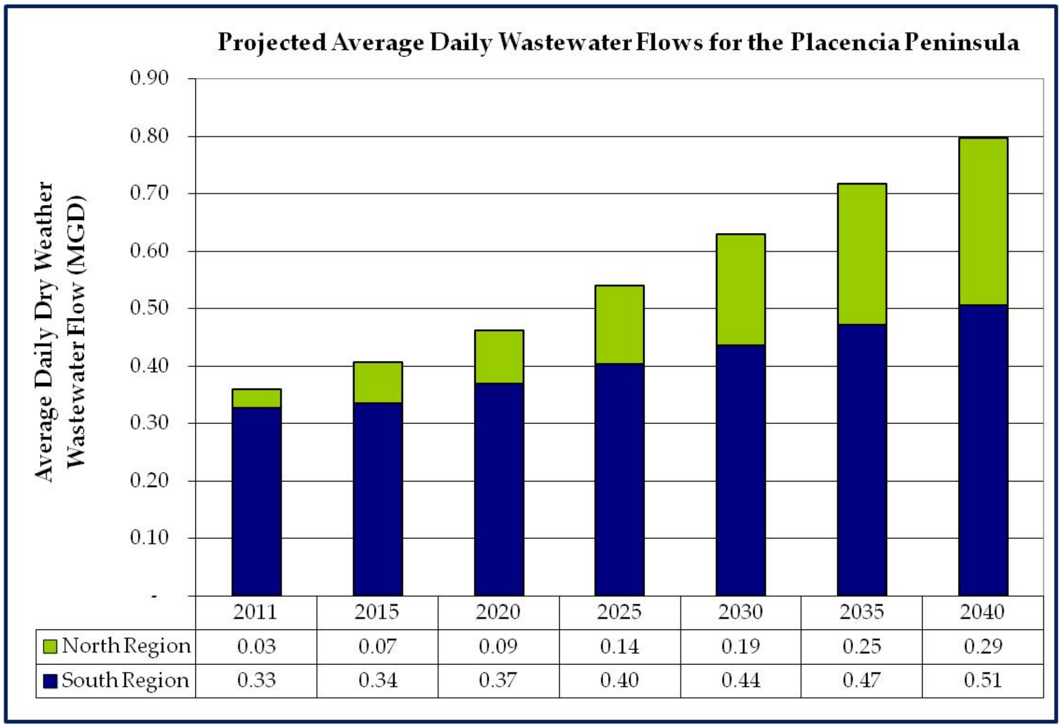
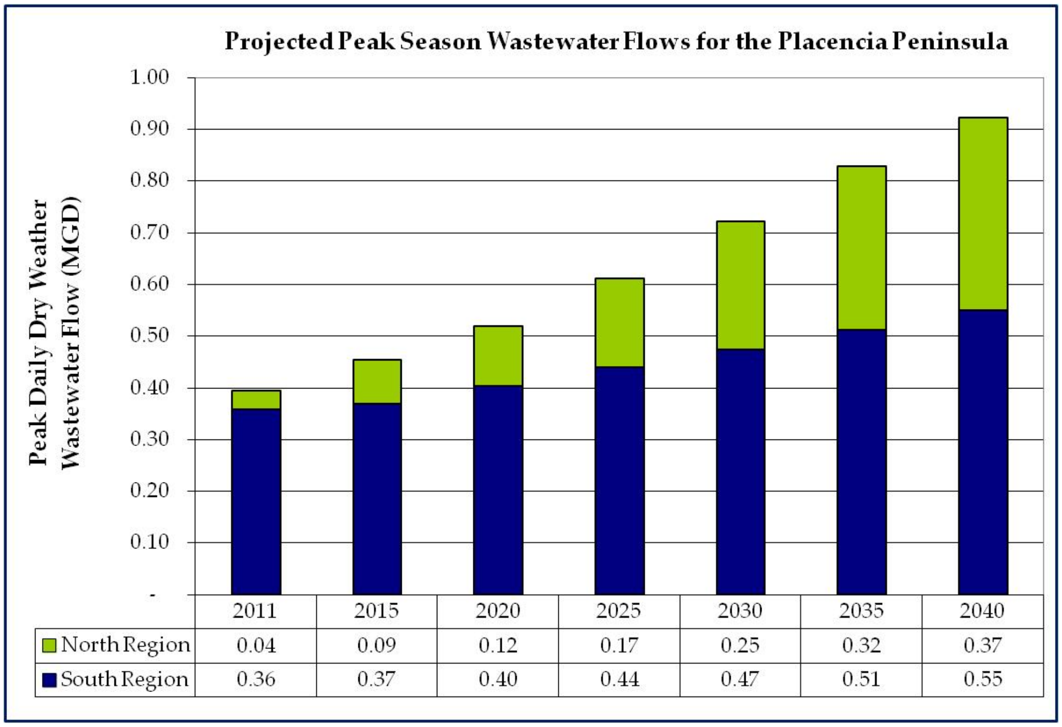


Figure 3.3-1 Average Daily Dry-Weather Wastewater Generation Projections

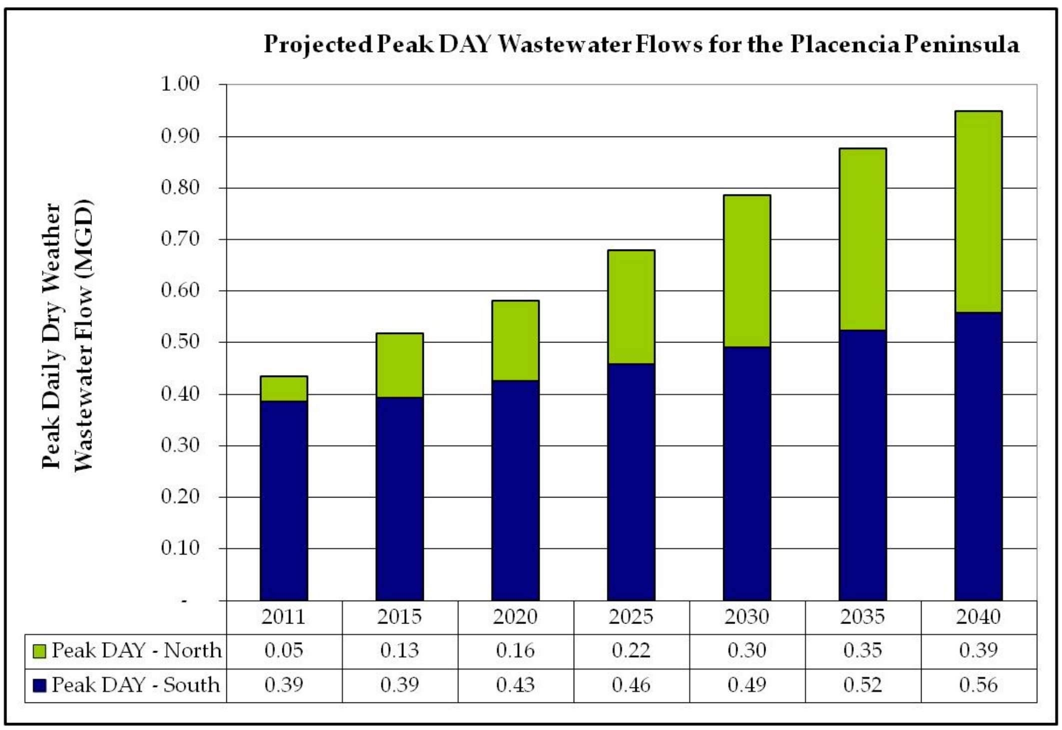
Source: Halcrow, based on data provided by the SIB and PWB



	2011	2015	2020	2025	2030	2035	2040
North Region	0.04	0.09	0.12	0.17	0.25	0.32	0.37
South Region	0.36	0.37	0.40	0.44	0.47	0.51	0.55

Figure 3.3-2 Peak Season Daily Dry-Weather Wastewater Generation Projections

Source: Halcrow, based on data provided by the SIB and PWB



	2011	2015	2020	2025	2030	2035	2040
Peak DAY - North	0.05	0.13	0.16	0.22	0.30	0.35	0.39
Peak DAY - South	0.39	0.39	0.43	0.46	0.49	0.52	0.56

Figure 3.3-3 Peak Day (100% Occupancy) Dry-Weather Wastewater Generation Projections

Source: Halcrow, based on data provided by the SIB and PWB

3.4 Future Environmental Conditions

3.4.1.1 Future Water Demands

Section 3.2 of this report summarizes the anticipated increases in water demand on the Peninsula. However, it has not been determined what amount of drawn water the aquifer can sustain. The Peninsula Citizens for Sustainable Development (PCSD) have stated:

In addition, no government agency has ever addressed the capacity of the Peninsula's water supply to support any specific level of tourism. For example, no one knows where the water comes from, how much of it there is, whether once it's used up, it's gone or whether the supply gets replenished from seasonal rains – or how susceptible the water supply is to being inundated by sea water as sea levels rise. [xiii]

There is an increased awareness of the importance of this aquifer. The owners of the Deep River deep water port plan to straighten and deepen the channel leading to the port. The National Environmental Appraisal Committee, an organization that reviews Environmental Impact Assessments, demanded more extensive research of the potential impacts of these works on this aquifer that stretches under the port facilities. The outcome of this study is not yet available (Boles et al, 2011).

Increase in future demands is a result of the following factors:

- increase in resident population;
- increase in water use by the resident population (for instance: households using a simple latrine will use a water closet model in the future);
- increase in hotel facilities;
- increase in the occupation rate of the accommodations.

For example, the proposed Placencia Marina estimates their daily water demand for its 520 guests and staff during the peak season to be 31,600 gallons, which represents 10% of the present average daily consumption of the peninsula[xiv].

3.4.2 Estimated Effluent Characteristics

Table 3.4-1 summarizes the future wastewater volume, bacterial and nutrient loading being created on average each day.

Table 3.4-1 2040 Wastewater Loading

Typical Wastewater Characteristics			Wastewater Loading	Current	Projected 2040	
Fecal Coliform	2,000	colonies/L	Average Daily Flow	0.36	0.80	MGD
BOD_5	300	mg/L	BOD_5	899	1,988	lbs/day
Nitrogen	20	mg/L	Nitrogen	60	133	lbs/day
Phosphates	21	mg/L	Phosphates	63	140	lbs/day

3.5 Future Conditions Conclusions

There is concern that existing conditions have already exceeded the peninsula ecosystem's capacity to safely assimilate and dilute the generated wastewater. Current treatment and disposal methodologies are not effective: bacteria, viruses and nutrients are leaching through the soils, through the water table and into the surrounding lagoon and sea.

Table 3.4-1 summarized the current and projected wastewater loadings, showing an increase of ~120% in total loads through 2040. These increases will distinctly increase the environmental and public health risks.

4 Design Standards and Technologies

4.1 Collection System Standards

Wastewater collection systems transport wastewater from the points of generation to a point of treatment. These systems are designed based upon sound engineering principles and in accordance with local conditions and projected community growth. The system capacity needs to adequately accommodate incoming peak hydraulic loads and prevent a hydraulic surge or overflow of wastewater from the system.

The following subsections define the collection system standards used during the project study.

4.1.1 Flow Definitions

- Average Daily Flow (ADF): Average flow rate (volume/time) for all contributing sources during a 24-hour dry weather condition period.
- Minimum Flow (MF): Minimum flow rate during 24-hour dry weather condition period. If measurements are not available, MF is estimated at 25% of ADF.
- Design Average Flow: Total of all flows: domestic, commercial, industrial wastewater flows, groundwater infiltration and inflows during wet weather conditions.
- Peak Design Flow (PDF): Anticipated maximum daily flow rate that occurs more than once per year within the collection system. This parameter is used to design the hydraulic capacity of the collection system and treatment plant headworks. PDF is based upon the projected Diurnal Curve for the service area, and is typically 200% - 250% of ADF.
- Diurnal Curve: Temporal variation in wastewater flow rates during different time durations: across a day, during a week, from month to month. Figure 4.1-1 displays the daily diurnal curve used for the purpose of this study. The incremental time step within a diurnal curve is the ratio of the flows during that time step to the ADF. For example, for this diurnal curve, the flows during hour six (6) equal 2.15*ADF.
- Peak Hourly Flow (PHF): Maximum anticipated hydraulic loading within system, PHF = ADF * PF
- Peaking Factor (PF): Ratio of PHF to ADF. For the purpose of this study, the PF is determined using the following formula[xv]:
  - $PF = \dfrac{18 + \sqrt{P}}{4 + \sqrt{P}}$
  - where, P = population in thousands

Figure 4.1-2 shows the PF for Placencia Peninsula's projected population. For example, based upon a projected 2020 population of 5,773, the PF is estimated at 3.19.

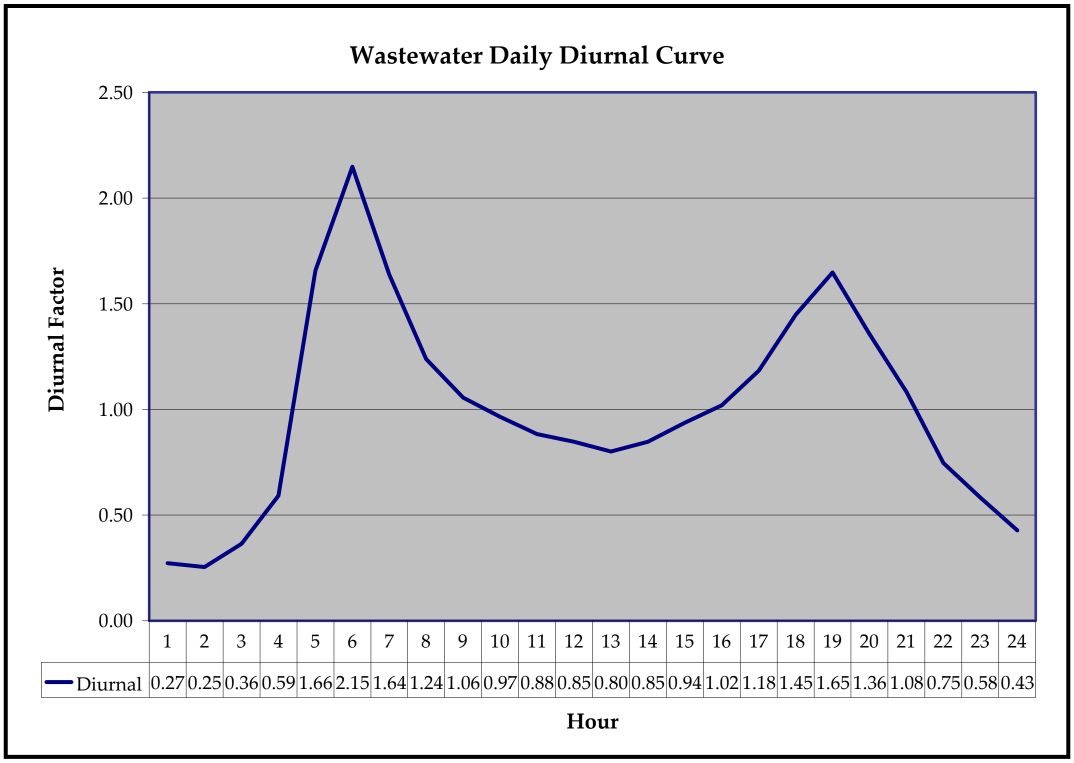


Figure 4.1-1 Daily Diurnal Curve

Source: Halcrow

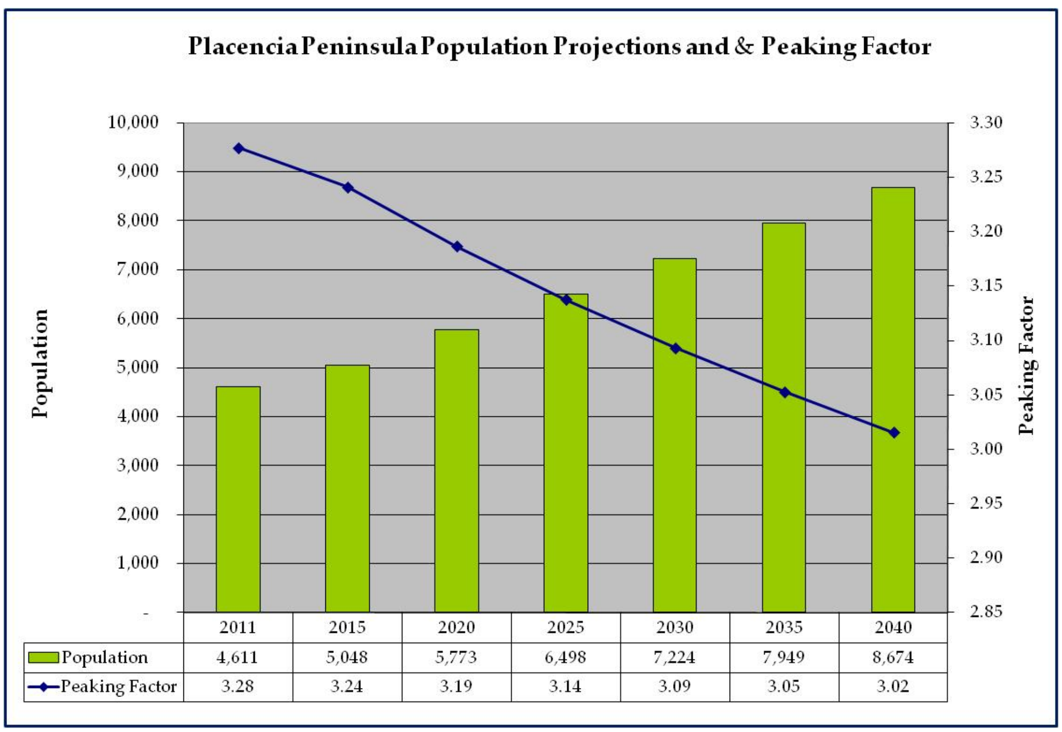


Figure 4.1-2 Population Projections and Peaking Factor

4.1.2 Design Period

In general, wastewater collection systems should be designed for the estimated ultimate population, except when considering portions of the system where capacity can be readily increased. For the purpose of this study, the system is being evaluated at the projected 2025 and 2040 populations.

The 2040 date is listed as the 'build-out' conditions for the Peninsula, when the service area is estimated to reach a fully developed state. The build-out date is valuable in designing the anticipated permanent system infrastructure.

The 2025 date is utilized as an interim build-out stage for the initial design period. This date is used in designing the initial pump capacities. Pumps have a limited life-span, and can be upgraded as the system demand increases.

4.1.3 System Capacity Calculations

- The per capita ADF is based upon the Per Capita Water Consumption rates established in Table 2.5-8. These values do not include Infiltration and Inflow (I/I), which need to be accounted for in the design.
- Sewer laterals and sub-main pipe capacity shall not be less than four (4) times the ADF.
- Calculations – Halcrow used SewerGEMS Sanitary V8i® for designing the wastewater collection system models.

4.1.4 Protection of Water Supplies

There should be no physical connection between a public or private potable water supply system and any portion of the wastewater system which may permit the passage of any wastewater or polluted water into the potable water system. Water main bleeders into sanitary sewers are prohibited. No water pipe should pass through or come in contact with any part of a sewer manhole.

- Horizontal Separation - Whenever possible, sewers should horizontally be laid at least 10 feet from any existing or proposed water main. Should local conditions prevent a lateral separation of 10 feet, a sewer may be laid closer than 10 feet to a water main, if:
  - it is laid in a separate trench; or
  - it is laid in the same trench with the water main located at one side on a bench of undisturbed earth.
  - in either case, the elevation of the crown of the sewer is at least 18 inches below the invert of the water main.
- Vertical Separation - Whenever sewers must cross under water mains, the sewer should be laid at such an elevation that the top of the sewer is at least 18 inches below the invert of the water main. When the elevation of the sewer cannot be buried to meet the above requirement, the water main should be relocated to provide this separation and reconstructed with slip-on or mechanical joint cast-iron pipe for a distance of 10 feet on each side of the sewer. One full length of

water main should be centered over the sewer so that both joints will be as far from the sewer as possible.

- Special Conditions - When it is impossible to obtain the proper horizontal and vertical separation as stipulated above, the water main should be constructed of slip-on or mechanical joint cast-iron pipe and the sewer constructed of mechanical joint cast-iron pipe, schedule 40 PVC or equal, and both services should be pressure tested to assure water-tightness.

Figure 4.1-3 is a typical pipe installation along a roadway section.

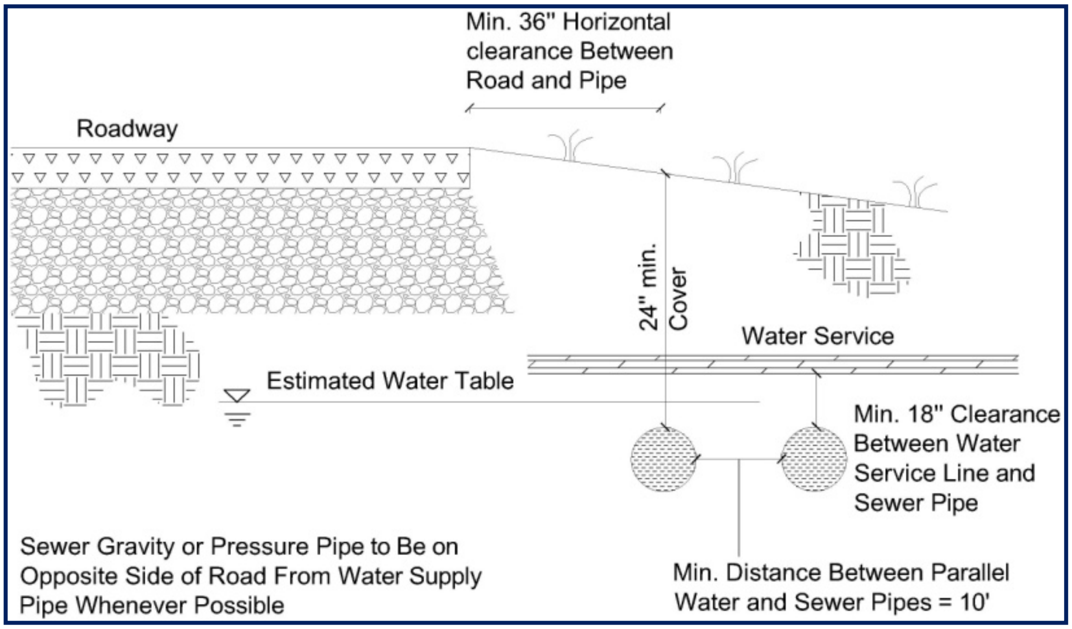


Figure 4.1-3 Typical Pipe Installation Cross-Section along Roadway

4.2 Collection System Design Criteria

4.2.1 Gravity Pipes

- Minimum Size - No community sewer pipe receiving raw wastewater should be less than six inches in diameter; however, eight inch diameter sewers are preferred. Six inch diameter pipes may be used as laterals when
  - there are relatively low flows,
  - a small number of people to be served,
  - future extensions are not anticipated, and
  - the sewer is capable of handling the design flows.

  The operating authority should be made aware of the added possibility of cleaning problems which should require their acceptance of any additional maintenance. Sewers receiving treated or partially treated wastewater and capable of handling the design flows may be four inches in diameter where adequate justification and documentation is provided.

- Depth – Due to the instability of soils and the high water table, sewers inverts should not be more than 6 feet deep. Sewer crowns shall have no less than 2 feet of cover cross-country and no less than 3 feet of cover under roadways.

- Slope – All sewers should be so designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second, based on Manning's formula using an "n" value of 0.011 (for PVC pipe). Based on an "n" value of 0.011, the minimum pipe slopes to be used in the design of the system are listed in Table 4.2-1. However, slopes greater than the ones listed are desirable. Sewers should be laid with uniform slope between manholes.

Table 4.2-1 Minimum Pipe Slopes

Pipe Diameter (in.)	Minimum Slope (ft/100ft)
4	1.05
6	0.60
8	0.40
10	0.28
12	0.22
14	0.17
16	0.14
18	0.12
21	0.10

- Alignment – Sewers 24 inches or less should be laid with straight alignment between manholes except where street or road layouts are such that straight alignment between manholes is impractical, in which case sewers may be curved to conform to the street's curvature. The radius of curvature should not be less than 100 feet and the deflection angle should not exceed the manufacturer's recommendations at any joint or point on the pipe. It is suggested that the sewer curvature be made concentric with the street curvature to simplify layout work as well as locating the lines at a later date. An alignment test such as "balling" must be conducted on curved sewers. The entity responsible for maintenance should be cognizant of the fact that additional maintenance may be necessary and small diameter sewers will require jet-cleaning machines.

- Increasing Size – When a smaller sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to match the crown elevations of both sewers. Generally, sewers should not decrease in size in the downstream direction.
- High Velocity Protection – Where velocities greater than 10 feet per second are attained, sewers should be anchored securely with concrete anchors or equivalent to protect against displacement by erosion and shock. The design should be such to prevent turbulence and deterioration in the receiving manhole.
- Materials, Trenching and Installation – Any generally accepted material for sewers will be given consideration, but the material selected should be adapted to local conditions, such as possibility of septicity, soil characteristics, abrasion and similar problems. Based on the standard practice in Belize, the preferred gravity collection material is PVC. Pipe material will be accounted for in the final design specifications.
- Joints and Infiltration – The method of making joints will be accounted for in the final design specifications. Sewer joints should be designed to minimize infiltration and to prevent the entrance of roots. Post-construction leakage tests should be in the final specifications, including appropriate water or low pressure air testing. The leakage outward or inward (ex-filtration or infiltration) should not exceed 200 gallons per inch of pipe diameter per mile per day for any section of the system. The use of a television camera or other visual methods for inspection prior to placing the sewer in service is recommended.

4.2.2 Manholes

- Unless necessary, manholes should not be located in drainage ways. If any flooding over manholes is anticipated, watertight covers should be installed.
- Manholes should be installed:
  - at the end of each line;
  - at all changes in grade, size, or alignment;
  - at all junctions (intersections); and
  - at distances not greater than 400 feet for sewers 15 inches or less, and not greater than 500 feet for sewers 18 inches to 30 inches.
- The minimum diameter of manholes should be 48 inches.

- The size of the manhole access should be 22 inches or larger in diameter.
- Additional Manhole design requirements include:
  - Flow Channel – The flow channel through manholes should be made to conform in shape and slope to that of the sewer pipes.
  - Watertightness – The final design specifications should include a requirement for inspection of manholes for watertightness prior to placing into service and should not exceed leakage limits for sewers. Watertight manhole covers or raised manhole frames and covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Manholes of brick or segmented block should be waterproofed on the exterior with plaster coatings and supplemented by a bituminous waterproof or epoxy coating where groundwater conditions are unfavorable.
  - Safety and Vandalism – It is recommended that entrance into manholes contain provisions for portable ladders. Consideration should be given for providing a means of ventilation.

4.2.3 Waterway Crossings

- The top of sewers when entering or crossing waterways should be at a sufficient depth below the natural bed to protect the sewer line. The following cover requirements should be met:
  - One foot of cover where the sewer is located in rock.
  - Three feet of cover or more is required in other material depending on size of waterway.
  - In paved channels, immediately below the pavement.
  - Shallow and intermittent streams may require insulating materials.
- Sewer lines should be designed to cross waterways as near to perpendicular as possible with no change in grade. Such sewers should be constructed of (or cased in) cast or ductile iron pipe with mechanical joints or other watertight materials, encasements, and anchored so no changes in alignment or grade will occur.

4.2.4 Pump Stations

The following items should be given consideration in the design of wastewater pumping stations:

Pump Capacity

The pumps (or series of pumps) should have sufficient capacity to pump at least four times the design average flow (ADF) rates for laterals and sub-main sewers, or two and one-half times the peak daily flow (PDF) rate for main sewers, whichever is greater. Each pump(s) should be capable of pumping the peak hourly flow (PHF) rate.

Submersible pumps are preferred for the application. At least two pumps should be provided for each pump station. Where the pumping installation will serve not more than 50 homes, a single unit will be appropriate, provided that the station is designed to permit the installation of a future duplicate unit with no structural changes. A minimum of three (3) pumps should be provided for stations handling flows greater than one (1) million gallons per day (MGD).

When two units are placed in the same station, each pump should have the same capacity, with each pump being capable of handling the PHF. Where three or more units are provided, they should be designed to fit actual flow conditions and must be of such capacity that with any one unit out of service the remaining units will have capacity to handle peak wastewater flows. It is preferable that a standby or ejector pump be provided and available for service at all times.

Pump Standards

Pumps handling raw wastewater should be preceded by readily accessible bar racks with clear openings not exceeding 2-1/2 inches, unless grinder devices are installed to protect the pumps from clogging or damage. Pumps should be capable of passing spheres of at least 3 inches in diameter. Pump suction and discharge openings should be at least 4 inches in diameter.

Turned-down bellmouth inlets are preferred. The pumps should have non-corrosive materials for inner parts. Where turned-down bellmouth inlets are used, the bell should be not more than d/2 and not less than d/3 above the floor of the wet well (where d = minimum liquid in the pump station, as specified by the pump manufacturer). It is recommended that sump and approach channel dimensions be provided as suggested by the pump manufacturer.

Each pump should have an individual intake. Wet well design should be such as to avoid turbulence near the intake. Intake piping should be as straight and short as possible.

The pump should be placed so that under normal operating conditions it will operate under a positive suction head.

The pumps and controls of main pumping stations, and especially pumping stations operated as part of treatment works, should be selected to operate at varying delivery rates to permit the discharge of wastewater from the station to the treatment works at approximately the wastewater flow rate to the pump station.

4.2.5 Wet Wells

Where continuity of pumping operation is important, consideration should be given to dividing the wet well into two sections, properly interconnected, to facilitate repairs and cleaning. The wet well size and control setting should be appropriate to avoid heat buildup in the pump motor due to frequent starting.

Effective Capacity

The effective capacity of the wet well, except for large capacity stations, should be such that one pump will continuously run at least five (5) minutes of every 30 minute period at the minimum flow. The volume of a wet well between start and stop elevations (the effective volume) for a given pump system can be determined by using the formula:

- $V = \frac{T * Q}{4}$ where:
- V = Required effective volume in gallons.
- T = Minimum time of one pumping cycle between successive starts in minutes.
  - Tmin = 20 minutes for pumps > 3,000 gpm
  - Tmin = 10 for pumps < 3,000 gpm, with 15 minutes preferable.
- Refer to pump manufacturer specifications for individual minimum pump cycle times.
- Q = Pump capacity in gallons per minute, for one pump, or the incremental pumping capacity each additional pump.

The wet well floor should have a minimum slope of one to one (1:1) to the hopper bottom. The horizontal area of the hopper bottom should be no greater than necessary for proper installation and function of the pump inlet pipe.

Ventilation

Adequate ventilation should be provided for all pump stations. Wet well ventilation may be either continuous or intermittent. Ventilation, if continuous, should provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. Such ventilation should be accomplished by introduction of fresh air into the wet well by mechanical means.

Flow Measurement

It is desirable to provide suitable devices for measuring wastewater flow at all pumping stations. At a minimum, the discharge piping should be designed to include allowances for installing temporary or permanent flow monitoring devices.

Watertightness

The final design specifications should include a requirement for inspection of wet wells for watertightness prior to placing into service. Watertight lids are to be used wherever the tops may be flooded by street runoff or high water. Manholes of brick or segmented block should be waterproofed on the exterior with plaster coatings and supplemented by a bituminous waterproof or epoxy coating where groundwater conditions are unfavorable.

4.2.6 Station Design

An example of a submersible pump station is provided on Figure 4.2-1. Stations should meet the applicable requirements, including:

Figure 4.2-1 Submersible Pump Station

Pump Removal

Submersible pumps should be readily removable and replaceable without dewatering the wet well and with continuity of operation of the other pump(s).

Operation

Submersible pumps should be capable of unsubmerged operation without damage or reduction of service capability or provision should be made to assure submergence (e.g., backup controls).

Valves

Suitable plug valves should be placed on suction and discharge lines of each pump with the exception of the suction line on submersible and vacuum-primed pumps. A check valve should be mounted in a horizontal position on each discharge line between the shutoff valve and the pump. Valves should not be located in the wet well and shall be suitably protected from weather and vandalism. Valves should be capable of withstanding normal pressure and water hammer.

Controls

Control float tubes should be located so as not to be unduly affected by flows entering the wet well or by the suction of the pumps. Float tubes shall be placed in the wet well at various elevations to ensure that

- ‘All Pumps Off’ float tube to ensure there is a minimum liquid level at pump inlet,
- ‘1st-Pump-On’ float tube to signal for the initial pump to turn on,
- ‘2nd-Pump-On’ float tube to signal for the secondary pump to turn on (during peaks), and

- ‘Emergency Overflow Prevention’ float tube, to notify governing wastewater entity that the station is in danger of wastewater overflow.

In stations with duplicate units, provision should be made to automatically alternate the pumps in use.

As shown on Figure 4.2-2, the stainless steel control panel and alarm system should be located outside the wet well and suitably protected from weather, humidity, flooding and vandalism. Electrical systems and components (e.g. motors, lights, cables, conduits, switchboxes, control circuits, etc.) shall be in enclosed or partially enclosed spaces. Where flammable mixtures may occasionally be present (including raw wastewater wet wells), space should comply with the local electrical code requirements.

Figure 4.2-2 Outdoor Control Panel

Alarm Systems

Alarm systems should be provided for all pumping stations. The alarms should be activated in cases of power failure, pump failure, or any cause of pump station malfunction. Pumping station alarms should be telemetered (SCADA, or equivalent) to a facility or office that is manned 24 hours a day. Where no such facility exists, an audio-visual device should be installed at the station for external observation.

SCADA

It is recommended that each pump station have a telemetry system (SCADA, or equivalent) installed to communicate (at a minimum) all occurrences of the ‘Overflow Prevention’ control float tube being engaged to ensure an immediate response from Operations and Maintenance personnel prior to wastewater overflow. Additional recommended recorded controls include pump on/off times, run times, and power consumption.

Emergency Operation

The objective of emergency operation is to prevent the discharge of raw or partially treated wastewater to any waters and to protect public health by preventing back-up of wastewater and subsequent discharge to basements, streets, and other public and private property. There should be no by-passing of wastewater to the groundwater, surface of the ground or any watercourse. Provision of an emergency power supply for all pumping stations should be made, and may be accomplished by connection of the station to at least two independent public utility sources, or by provision of portable or in-place internal combustion engine equipment which will generate electrical or mechanical energy, or by provision of portable pumping equipment.

Overflows

A high-level wet well overflow to supplement alarm systems and emergency power generation may be provided. Where a high level overflow is utilized, complete retention of all overflows in storage-detention tanks or basins should be provided. Provision should be made to drain or pump the tanks or basins to the station wet well. The overflow basins or tanks should not discharge to the groundwater, surface of the ground, or any watercourse.

Water Supply

There should be no physical connection between any potable water supply and a wastewater pumping station which under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it should be provided with the proper air-gaps and backflow prevention devices. If a non-potable water supply is provided, all outlets should be permanently posted that communicate that the water is not safe for drinking.

Flooding

Wastewater pumping stations should not be subject to flooding. It is important that the stations be readily accessible and fully operational during a twenty-five (25) year flood. A one hundred (100) year flood recurrence interval should be considered in the design for protection of structure and electrical and mechanical equipment from physical damage. The stations should be readily accessible; preferably located off the traffic ways of streets and alleys.

Operations and Equipment Instructions

Wastewater pumping stations and their operators should be supplied with a complete set of operational instructions, including emergency procedures, maintenance schedules, tools and such spare parts as may be necessary.

4.2.7 Force Mains

The following design criteria apply to pressurized-pipe force mains:

Size

Force Mains should be no smaller than 4-inch diameter. Where grinder pumps are provided, force main diameters can be decreased to minimum 2-inch diameter.

Material

The recommended pipe material for pressure pipe force mains in this project is High-Density Polyethylene (HDPE).

Velocity

At design average flow, a minimum velocity of at least two (2) feet per second (fps) should be maintained. The velocity should not exceed eight (8) fps.

Valves

Automatic air release valves should be placed at high points in the force main to prevent air locking. A blow-off should be placed at the low points where gritty material could accumulate and restrict flow through the force main. Access to air release facilities should not be located in traffic-ways.

Termination

Force mains should enter the gravity wastewater system at a point not more than two (2) feet above the flow line of the receiving manhole. The design should be such as to prevent turbulence and deterioration at this point.

Leakage (Ex-filtration)

Force mains should be tested at a minimum pressure of at least 50 percent above the design operating pressure, for at least 30 minutes. Force mains should test leak free.

Maintenance

If the force main is taken out of service for repair or cleaning, the wastewater should be discharged to a storage-detention tank or basin and returned to the wastewater system with no discharge to the groundwater, surface of the ground or any watercourse.

Restraints

Force mains should be restrained at bends to prevent movement occurring from maximum operating pressures or surges.

4.2.8 Collection System Maintenance

One of the primary concerns for a pressure pipe system, especially when there are limited connections into the system, is the settlement and hardening of suspended solids. A minimum of two (2) feet per second flow velocity through the pipes when pump(s) are running is required to re-suspend settled solids (from previous run cycles) and prevent the solids from hardening. For the purpose of this study, this minimum flow velocity was maintained at least one time per day. Pipe sizes are adjusted and pump flow rates chosen to ensure this minimum velocity.

However, given the low population density in various portions of this system, as well as long runs of pressure pipe at the extreme ends of the system, it is recommended for BWSL to develop a 'flushing' schedule at the end-runs of the system, whereby a water truck is emptied into a end-run pump station to trigger the pumps to run for an extended period of time at full flow. A periodic flushing of the system will help prevent solids from hardening at the bottom of the pipe (and decreasing future pipe capacity), as well as decrease odor issues.

4.3 Wastewater Treatment Standards

4.3.1 Permitting Requirements

Per discussions with BWSL, all proposed wastewater collection and treatment systems are to be permitted through the Belize Department of the Environment (DOE). The DOE website provides a checklist to determine if a proposed project requires an Environmental Impact Assessment (EIA). Additional documentation is available outlining the purpose, requirements and timeline for an EIA, if one is determined necessary through the DOE's checklist process.

Upon the approval of a project's EIA, the DOE is responsible for review and permitting of wastewater projects, providing a License to Discharge Effluent as well as monitoring, collecting and analyzing effluent to ensure the treatment facility meets regulatory requirements.

It is not clear from the DOE website whether decentralized individual treatment systems (i.e. septic tanks and absorption fields) are permitted. If these facilities are not currently being designed, reviewed, permitted and inspected, it is recommended to begin doing so.

4.3.2 Treatment System Design Criteria

4.3.2.1 Belize Environmental Standards

In Belize, wastewater effluent treatment standards are regulated under Sections 21 and 45 of the Environmental Protection Act, Chapter 328, revised in 2003, nominally called "Environmental Protection (Effluent Limitations) Regulations". A detailed study of these and other possible regulations is required during final design and permitting of any wastewater treatment facility. A summary of a portion of these regulations is provided below:

- Part 1 (3): "Regulations shall apply to discharges of effluent into any inland waters or the marine environment,"
- Part 1 (6)(1): "Every industry which discharges effluent shall ensure that such effluent can be assimilated by the receiving water into which the effluent is discharged."
- Part 1 (7)(1): "All sewers and wastewater systems shall be maintained and in good working order and sanitary manner to the satisfaction of the Department [of the Environment]."
- Part 4 (12): "No person shall discharge or cause or permit the discharge of any effluent in or on any soil or surface of any land without the prior written permission of the Department [of the Environment]."
- Part 5 (14)(b): "No person shall construct, reconstruct or alter any works for the discharge of any effluent… except under and in accordance with a license for the purpose granted by the Department [of the Environment]…"
- Part 6 (22): "A person who discharges effluent into any inland waters, the marine environment or onto any land shall, in connection with such discharge, install such sampling test point or points inspection chambers, flowmeters, and recording and other apparatus as may, from time to time, be prescribed."

Environmental Protection (Effluent Limitations) Regulations were amended in 2009. A summary of a portion of this amendment is provided below:

- Paragraph 2: "Class I waters" means waters that, due to inherent or unique environmental characteristics or fragile biological or ecological characteristics or human use, are particularly sensitive to the impacts of domestic effluent. Class I waters include, but are not limited to:

  a. Waters containing coral reefs, seagrass beds, or mangroves;
  b. Critical breeding, nursery or forage areas for aquatic and terrestrial life;
  c. Areas that provide habitat for species protected under the Protocol Concerning Specially Protected Areas and Wildlife to the Convention (the SPAW Protocol);
  d. Protected areas listed in the SPAW Protocol; and
  e. Waters used for recreation.

The Placencia Lagoon is classified as a Class I water based upon the definition above.

A Third Schedule of the Environmental Protection (Effluent Limitations) Regulations was added through the 2009 amendment. This schedule details Effluent Standards for discharges from domestic wastewater treatment systems into Class I waters. It is assumed in this report that this Schedule is the effluent standard for this project. The Third Schedule is provided in Table 4.3-1.

Table 4.3-1 Domestic Effluent Limitations for Class I Waters, Belize Dept. of Environment

Parameter	Effluent Limitations
Total Suspended Solids	30 mg/L *
Biochemical Oxygen Demand (BOD5), at 20 °C	30 mg/L
pH	5 – 10
Fats, Oil & Grease	15 mg/L
Fecal Coliform E.coli (freshwater) & Enterococci (saline water)	Fecal Coliform: 200 mpn/100ml, or (a) E.coli: 126 organisms / 100ml, (b) Enterococci: 35 organisms / 100ml
Floatables	Not visible

** Does not include algae from treatment ponds.*

4.3.2.2 International Effluent Standards

Table 4.3-2 summarizes effluent standards by various internationally recognized agencies, along with references for the data source. The published Belize Department of the Environment effluent standards listed above in Table 4.3-1 is to be used in the schematic wastewater treatment system for the purpose of this study. These standards match the United Nations Environment Program, Caribbean Region, protocol. The additional standards provided in this section are for informational purposes only.

Table 4.3-2 Domestic Effluent Limitations, by Standard

Parameter	Effluent Limitations					
	Belize Dept. of Environment[1]	United Nations Environment Programme (Caribbean)[7]	USEPA[2]		European Commission (EU)[5]	World Bank[6]
			Conventional Technologies[3]	Waste Stabilization Ponds[4]		
Biochemical Oxygen Demand (BOD5), at 20 °C (mg/l)	30	30	30 (30-Day avg); 45 (7-Day avg), >85% removal	45 (30-Day avg); 65 (7-Day avg), > 65% removal	25 , 70-90% removal	50
Total Suspended Solids (mg/l)	30 *	30	30 (30-Day avg); 45 (7-Day avg), >85% removal	45 (30-Day avg); 65 (7-Day avg), > 65% removal	60 , 70% removal	50
Chemical Oxygen Demand (COD) (mg/l)	N/A	N/A	25 (30-Day avg); 40 (7-Day avg)	40 (30-Day avg); 60 (7-Day avg)	125 , >75% removal	250
Nitrates (as Nitrogen) (mg/l)	N/A	N/A	N/A	N/A	15 , >70-80% removal	10
Phosphates (mg/l)	N/A	N/A	N/A	N/A	2 , >80% removal	2
pH	5 – 10	5 – 10	6 – 9	6 – 9	N/A	6 – 9
Fecal Coliform	Fecal Coliform: 200 mpn/100ml, **or**	Fecal Coliform: 200 mpn/100ml, **or**	N/A	N/A	N/A	400 mpn/100ml
(a) E.coli (freshwater)	(a) E.coli: 126 organisms / 100ml,	(a) E.coli: 126 organisms / 100ml,	N/A	N/A	N/A	
(b) Enterococci (saline water)	(b) Enterococci: 35 organisms / 100ml	(b) Enterococci: 35 organisms / 100ml	N/A	N/A	N/A	
Residual Chlorine (mg/l)	N/A	N/A	N/A	N/A	N/A	0.2
Fats, Oil & Grease (mg/l)	15	15	N/A	N/A	N/A	10
Floatables	Not visible	Not visible	N/A	N/A	N/A	N/A

* Does not include algae from treatment ponds

1 Belize Environmental Protection Act, amended 2009; Third Schedule

2 USEPA NPDES Permit Writers' Manual (EPA-833-K-10-001), © 2010

3 Technology-based Effluent Limitations for POTWs, Section 5.5.5.1 Secondary Treatment Practices, USEPA

4 Technology-based Effluent Limitations for POTWs, Section 5.5.5.2 Equivalent to Secondary Treatment, USEPA

5 Official Journal of the European Communities, No L 135/40, Council Directive of 21 May 1991 concerning urban wastewater treatment (91/271/EEC)

6 The World Bank; Pollution Prevention and Abatement Handbook, 1998; © 1999; General Environmental Guidelines Table 4

7 United Nations Environment Programme, Caribbean Environment Programme, Report 46 "National Programmes of Action for the Protection of the Coastal and Marine Environment from Land-based Sources of Pollution: The Caribbean Experience", Table 1

4.4 Nutrient Treatment Standards

The effluent treatment standards provided in Section 4.3 do not include nutrient loading (specifically, Total Phosphorus and Total Nitrogen). Belize does not regulate nutrients within domestic wastewater (although it does regulate industrial and commercial activities within the First and Second Schedule of the Environmental Protection (Effluent Limitations) Regulations). Although the nutrient load was not taken into account when the Effluent Limitations were developed, the Caribbean Regional Fund for Wastewater Management (CReW) project has expressed concern about a possible excess nutrient load of the effluent.

The United Nations Environment Programme (Caribbean Environment Programme) "Protection of Coastal and Marine Environment from Land-based Sources of Pollution" (report no. 46) does not provide nutrient limits. Their "Coastal Water Guide and Effluent Guidelines" (technical report no. 8), Annex V, Session II, Group I addresses domestic effluent, but again does not provide nutrient limits. Table 4.4-2 summarizes various nutrient standards throughout Latin America. Belize does not regulate wastewater nutrient loadings.

Given the sensitive ecosystem within the Placencia Lagoon (the eventual destination of the wastewater effluent), a project specific nutrient standard is recommended. The final nutrient standard for this project will need to be determined within the detailed design phase of the project. However, for the purpose of this study, the recommended nutrient effluent standards are provided in Table 4.4-1.

Table 4.4-1 Recommended Nutrient Effluent Standards

Nutrient	Maximum Effluent
Total Phosphorus	3.5 mg/l
Total Nitrogen	5 mg/l

Table 4.4-2 Effluent limitations for Nitrogen and Phosphorus, by Regulatory Entities [xvi]

Parameter	Units (daily)	European Commission [1]	World Bank [2]	Chile [3]	Bolivia [4]	Peru [5]	Brazil [6]	Ecuador [7]	Argentina [8]	Mexico [9]	Colombia [10]	Venezuela [11]	Paraguay [12]	Canada [13]
BOD5	mg/L			33 - 50 [15]	80	250		250	200	200	800[12]	350	250	300
Chlorine (active)	mg/L							0.5						
COD	mg/L				250 - 300	500		500			1500 [14]	900	600	
Fats and Oil	mg/L			150	41202	100	150	100	100	75	100	150	100	150
NH3 - NH4+	mg/L	15	10	80	4	80		40						
pH				5.5 - 9.0	6.9	6 - 8	6 - 10	5 - 9	5.5 - 10	5.5 - 10	5 - 9	6 - 9	5 - 9	
Phosphorus	mg/L	2	2	10 - 45		10		15		20		10		10
Suspended solids (total)	mg/L			300	60	300		220		200	600	400		350
Temperature	°C			35	±5°C [16]	35	40	40	45	< 40	< 40	40	40	

1 Official Journal of the European Communities, No L 135/40, Council Directive of 21 May 1991 concerning urban wastewater treatment (91/271/EEC)

2 The World Bank; Pollution Prevention and Abatement Handbook, 1998; © 1999; General Environmental Guidelines Table 4

3 Chilean Ministry of Public Works, NORMA DE EMISION PARA LA REGULACION DE CONTAMINANTES ASOCIADOS A LAS DESCARGAS DE RESIDUOS INDUSTRIALES LIQUIDOS A SISTEMAS DE ALCANTARILLADO, 1998

4 CONGRESO NACIONAL DE BOLIVIA, LEY N°1333 DEL MEDIO AMBIENTE,REGLAMENTACIÓN DE LA LEY N°1333 DEL MEDIO AMBIENTE REGLAMENTO EN MATERIA DE CONTAMINACIÓN HÍDRICA, 1992

5 Ministry of Housing, APRUEBAN LÍMITES MÁXIMOS PERMISIBLES(LMP) A LAS DESCARGAS DE AGUAS RESIDUALES EN LOS SISTEMAS DE RECOLECCIÓN DE ALCANTARILLADO SANITARIO

6 DO LANÇAMENTO DE EFLUENTES LÍQUIDOS NA REDE COLETORA DE ESGOTOS – DEC 18.328 DE 18.06.97, 1997

7 Congreso Nacional, CODIFICACIÓN 2004-019, LEY DE GESTIÓN AMBIENTAL

8 National Decree 674 of 1989. Decreto reglamentario de la Ley 13.577 de Obras Sanitarias de la Nación.

9 Secretaría de Medio Ambiente, Recursos Naturales y Pesca. 1996. Norma official mexicana NOM-002-ECOL-1996

10 Decree 1594 of 1984.Water usages and wastewater disposal

11 Decreto No. 883 de 1995. Normas para la clasificación y el control de la calidad de los cuerpos de agua y vertidos o efluentes líquidos.

12 Reglamento de Calidad en la Prestación del Servicio Permisionarios

13 Derek Coronado, Regulating Water Pollution in Ontario's Municipalities – Windsor's Sewer use by law, values for the city of Toronto page2

14 Environmental District Department. Resolution 3957 of 2009.Technical norm, for wastewater discharges management and control in public wastewater for the capital district

15 Transformed the monthly value to daily by using 30 days. The value declared in the norm was monthly between 1000 mg/lt - 1500 mg/lt

16 Variation temperature with respect to the reception body

4.5 Wastewater Treatment Technologies

There are several treatment technologies (or combinations of technologies) that can provide cost-effective solutions for specific treatment applications. These processes are discussed in the following sub-sections and summarized in Table 4.5-1. Design considerations for secondary treatment systems are summarized in Table 4.5-2.

Table 4.5-1 Wastewater Treatment Process Comparison of Applicable Technologies

Process	Typical Range			Sludge Management	Comments
	Capacity	BOD5 & TSS Removal Efficiency	Effluent Quality of BOD5 & TSS		
	MGD	%	mg/l		
Conventional Activated Sludge	> 5	90 - 98	10 - 30	Generates primary and secondary sludge at a rate of 0.15 to 0.70 Kg per Kg of BOD5 removed.	More applicable for population centers of over 200,000 people. More cost-effective in areas of scarce land availability or of high cost of land.
Extended Aeration Activated Sludge Process	0.3 to 20	85 - 95		Generates secondary sludge at a rate of 0.15 to 0.3 Kg per Kg of BOD5 removed.	Applicable for communities of 200,000 or less. Area requirement about the same as conventional activated sludge.
Stabilization Ponds	0.02 to 20	85 - 95		Sludge is accumulated and degraded in the pond. Typical sludge dredging occurs every seven to ten years.	Very little maintenance required. Good in tropical and subtropical climates. Large area requirements compared to the activated sludge process.
Extended Aeration Lagoons/Oxidation Ditch	0.3 to 25	85 - 95		Generates sludge at a rate of 0.05 to 0.15 Kg per Kg of BOD5 removed.	Suitable for areas where land cost and availability is not a problem. Similar to stabilization ponds but requires mechanical equipment for aeration.

* Excluding land cost

Table 4.5-2 Wastewater Treatment Design Considerations

Process	Typical Range				Sludge Production
	Capacity	BOD5 Loading	Detention Time	Side Water Depth	
	MGD		days	ft	
Conventional Activated Sludge	> 5	0.15 to 0.70, kg 1 of BOD_5 per kg of MLVSS	0.15 to 0.60	7 to 16	Generates primary and secondary sludge at a rate of 0.15 to 0.70 Kg per Kg of BOD5 removed.
Extended Aeration Activated Sludge Process	0.3 to 18.5	.05 to 0.15 kg of BOD_5 per kg of MLVSS	0.75 to 5	5 to 10	Generates secondary sludge at a rate of 0.15 to 0.3 Kg per Kg of BOD5 removed.
Package Extended Aeration Plants	0.02 to 1.5	.05 to 0.15 kg of BOD_5 per kg of MLVSS	0.75 to 5	3 to 8	Same as Extended Aeration.
Stabilization Ponds	0.02 to 20	20-300 kg BOD_5 per hectare per day	12 to 180	3 to 8	Sludge is accumulated and degraded in the pond. Typical sludge dredging occurs every seven to ten years.
Extended Aeration Lagoons / Oxidation Ditch	0.3 to 25	8-320 kg BOD_5 per 1000 m3 per day	7 to 20	5 to 10	Generates sludge at a rate of 0.05 to 0.15 Kg per Kg of BOD5 removed.

MLVSS Mixed Liquor Volatile Suspended Solids

4.5.1 Conventional (Mechanical) Wastewater Treatment Systems

The two processes most commonly used as conventional treatment systems to provide biochemical oxidation (secondary treatment) to organic material in wastewater are activated sludge and extended aeration processes.

Conventional Activated Sludge

The Conventional Activated Sludge Process is typically used in larger municipal wastewater treatment plants (>10 MGD) and consists of primary treatment followed by aeration, final sedimentation, and disinfection. In this type of process, air is bubbled through the wastewater and biomass mixture (mixed liquor) in aeration tanks. The air provides mixing and oxygen for micro-organisms, causing adsorption, flocculation and oxidation of the organic matter. A schematic of this process is provided on Figure 4.5-1.

The current and anticipated wastewater generation for the entire Placencia Peninsula does not match the particular strengths of this type of treatment system. An Activated Sludge system is a managed system with large amounts of electrical use on a small land area. The Placencia project has plenty of available land, while electricity is relatively expensive. Based upon a peninsula-wide system scope, this system type is not being considered for the purposes of this study.

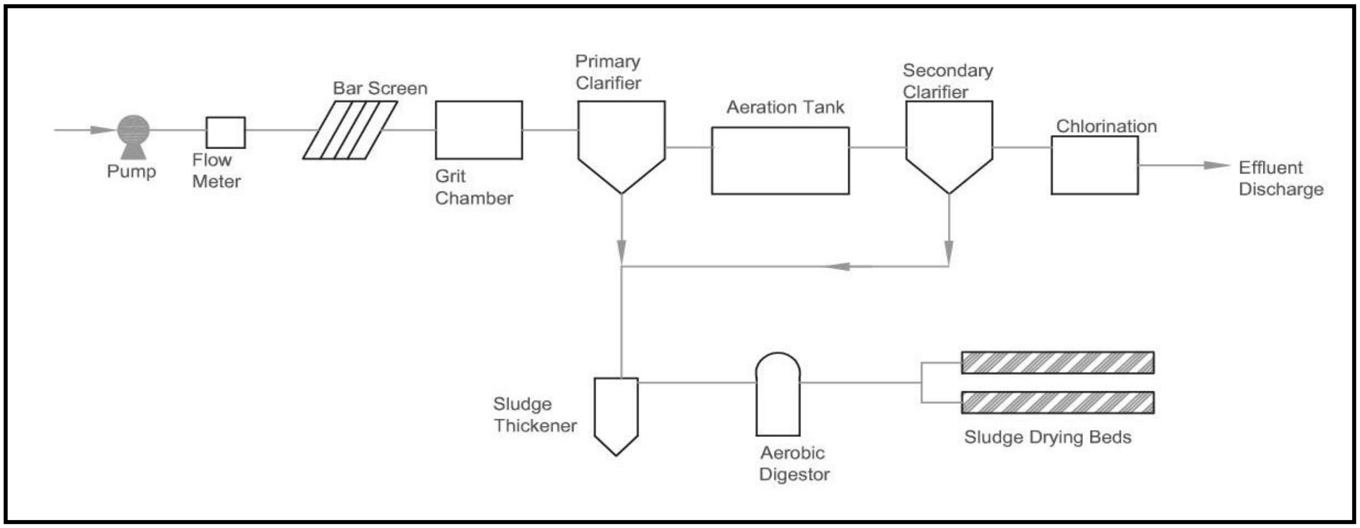


Figure 4.5-1 Conventional Activated Sludge Process

Extended Aeration

Extended Aeration Process is a variation of the activated sludge process often used for small communities (< 5 MGD). The extended aeration process operates by providing sufficient aeration time for the decomposition of most of the sludge from the organic material removed by the process. This provides a considerable reduction in the amount of sludge solids produced. While some attempts have been made to operate extended aeration plants without separate sludge wasting facilities, this usually has resulted in excess solids carryover in the effluent. It is therefore recommended that solids handling facilities be provided. The well-stabilized sludge produced in this process is often put directly on drying beds without prior treatment. Primary sedimentation is usually omitted from the process to simplify sludge treatment and disposal.

An advantage of extended aeration plants is that they are easily converted to the conventional activated sludge process during a plant expansion, which generally provides more economical treatment at higher flow rates. These systems can be built on a relatively small footprint, but require constant electricity and a solid waste handling unit.

Package Plants

Another common treatment system for small communities is the packaged extended aeration activated sludge plants. These prefabricated treatment units can be assembled in place in an area where construction materials and skilled labor are not readily available or cost-effective.

If the scope and service area of the overall project is small enough, a pre-fabricated activated sludge package plant may be the appropriate solution for the portion of the Peninsula being served. This would be a short term solution, as the increasing population and stresses on the local environment will require a larger-scale service area to treat a greater portion of the Peninsula's wastewater. This system type is not being considered for the purposes of this study.

Aerated Lagoon & Oxidation Ditch

An aerated lagoon or aerated basin is a holding and/or treatment pond or lagoon provided with artificial aeration to promote the biological oxidation of wastewaters. As with extended aeration plants, aerated lagoons are often favored for small communities because of their simplicity and ease of operation. There are many methods for aerating a lagoon or basin:

- Motor-driven floating surface aerators
- Motor-driven submerged aerators
- Motor-driven fixed-in-place surface aerators
- Injection of compressed air through submerged diffusers

Aeration Lagoons and/or Oxidation Ditches are often favored for small communities because of their simplicity and ease of operation. Completely mixed Aerated Lagoons / Oxidation Ditches are essentially extended aeration activated sludge systems without settling basins or solids recycle. Solids in the pond are maintained in virtually complete suspension and pass out with the effluent. BOD_5 removals are relatively low due to the BOD_5 demand of the suspended organic solids, but soluble BOD_5 removals are typically greater than 85 percent, depending on the detention time. Typically, ammonia conversion to nitrates of approximately 50 percent has been reported for detention times of approximately 2.5 days. Total nitrogen removal, however, is low due to the absence of denitrification. These systems typically require disinfection of the effluent prior to discharge or reuse. The aerated lagoons can be designed with secondary facultative lagoons and maturation ponds.

Two Aerated Lagoon schematics are provided on Figure 4.5-2 and Figure 4.5-3; an Oxidation Ditch schematic is provided on Figure 4.5-4.

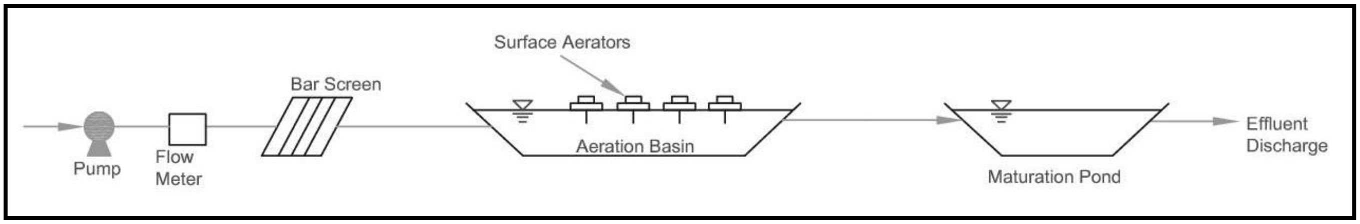


Figure 4.5-2 Aerated Lagoon Schematic

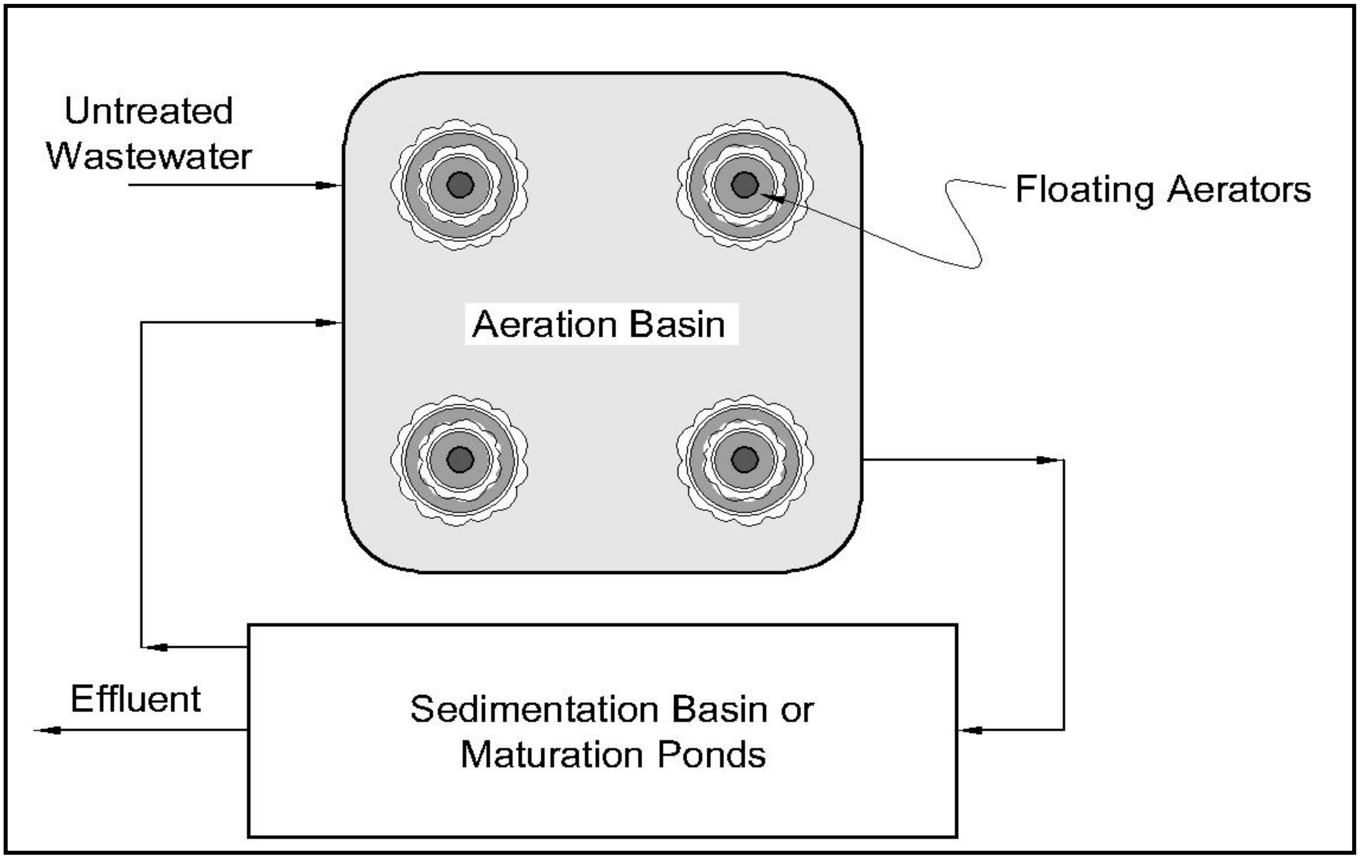


Figure 4.5-3 Aerated Lagoon Schematic

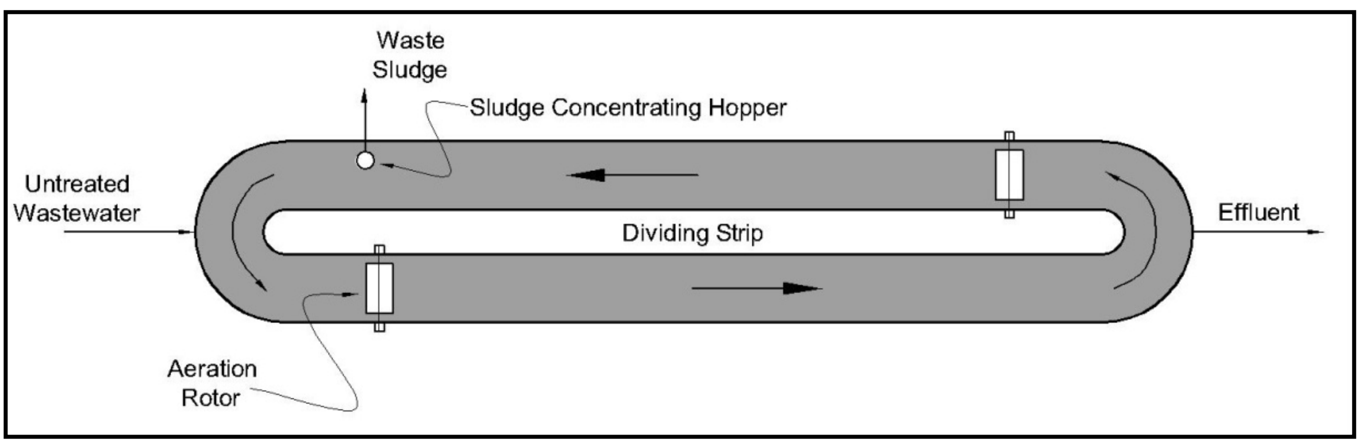


Figure 4.5-4 Oxidation Ditch Schematic

4.5.2 Natural Wastewater Treatment

Waste Stabilization Ponds

Stabilization Pond treatment offers several advantages over more complex mechanical treatment plants. If properly designed and adequately operated, stabilization pond treatment systems offer a simple, reliable, and low maintenance means of achieving a high degree of wastewater treatment. Apart from the inherent simplicity of treatment of the liquid phase, adequate design of the sludge storage capacity virtually eliminates the problems of sludge disposal. Sludge produced in these systems is contained and degraded anaerobically (methane fermentation) within the stabilization ponds themselves, requiring desludging only after extended operating periods. There are several types of stabilization ponds, including:

Facultative Lagoons

Facultative Lagoons or Ponds are the simplest of all natural wastewater treatment systems and consist of large shallow ponds (depth of 3.3 to 6.6 ft. or 1 to 2m) with an aerobic zone (containing dissolved oxygen) close to the surface and a deeper, anaerobic zone (with no dissolved oxygen) at the pond bottom. Facultative Lagoons are partially aerobic and partially anaerobic. Photosynthesis and surface reaeration provide oxygen for aerobic stabilization in upper layers. They favor algae growth along with the growth of aerobic, anaerobic, and facultative microorganisms. Such ponds are predominantly aerobic during daylight, as well as during some hours of the night. During the remaining night hours, the pond bottom waters may turn anaerobic. Benthic deposits are generally anaerobic beyond the first few millimeters from the sludge-water interface. Nitrogen removal depends on residence time, pH, and temperature in the pond. There is some phosphorus removal through uptake by algae.

There are two types of facultative lagoons: primary facultative lagoons that receive raw wastewater, and secondary facultative lagoons receiving settled wastewater from a primary lagoon. In primary facultative lagoons, the functions of anaerobic and secondary facultative ponds are combined. Facultative Lagoons are designed for Five-Day Biochemical Oxygen Demand (BOD_5) removal on the basis of low surface loading. The BOD loading range of 90 to 320 lbs/acre/day or 100 to 400 kg/ha/day at temperatures above 20°C or 68°F. Algae grow in the facultative lagoons using the sunlight, producing oxygen through photosynthesis which they transfer to the water. The oxygen is used by aerobic and facultative bacteria to further break down the organic matter via aerobic digestion (oxidation) transforming the organic matter into water and carbon dioxide (CO_2). The algal production of oxygen occurs near the surface of aerobic ponds to the depth to which light can penetrate. Additional oxygen can be introduced by wind due to vertical mixing of the water. Dissolved oxygen is unable to be maintained at the lower layers if the pond is too deep or the organic loading is too high. Additionally, facultative lagoons can remove over 99.9% of the fecal coliform bacteria contained in the raw wastewater. In fact, the system design in tropical climates is driven by the pathogen decay rather than the BOD_5. The principle mechanisms of coliform bacteria decay in these systems are the facultative bacteria and sunlight.

Maturation ponds, or polishing ponds, generally follow the secondary facultative lagoons. The maturation ponds are primarily designed for additional removal of pathogens, nutrients and possibly algae. They are shallow 3 to 5 ft deep (0.9 – 1.6 m) in order to allow light penetration to the bottom and ensure aerobic conditions through the entire pond depth. The organic loading on the maturation pond is calculated on the assumption that at least 80% of the BOD_5 has been removed during preceding treatment. In addition, as a complete process, the facultative lagoons followed by the maturation ponds serve to:

- Further treat wastewater through sedimentation and aerobic oxidation of organic material;
- Reduce odor;
- Reduce pathogen microorganisms;
- Store residues as bottom sludge;
- Produce a high quality effluent that can be discharged to surface waters or reused for agricultural purposes.

A Facultative Lagoon schematic is provided on Figure 4.5-5. Figure 4.5-6 is an aerial photograph of a Facultative Lagoon treatment plant project Halcrow designed in Chichiriviche, Venezuela. Figure 4.5-7 provides a general estimate of the area requirements for a Facultative Lagoon system based upon the required treatment capacity of the WWTP.

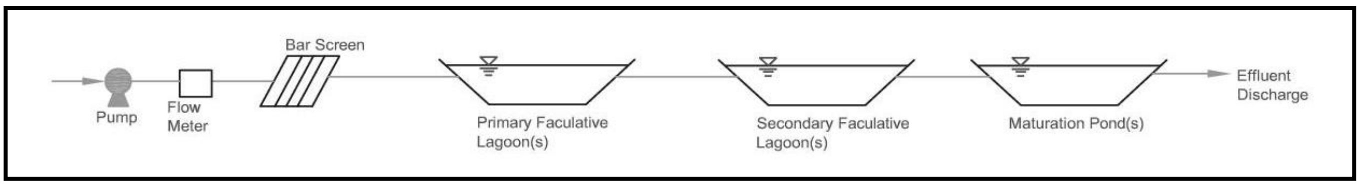


Figure 4.5-5 Facultative Pond followed by a Maturation Pond

Figure 4.5-6 Aerial View of the Chichiriviche Lagoons (Google-Earth)

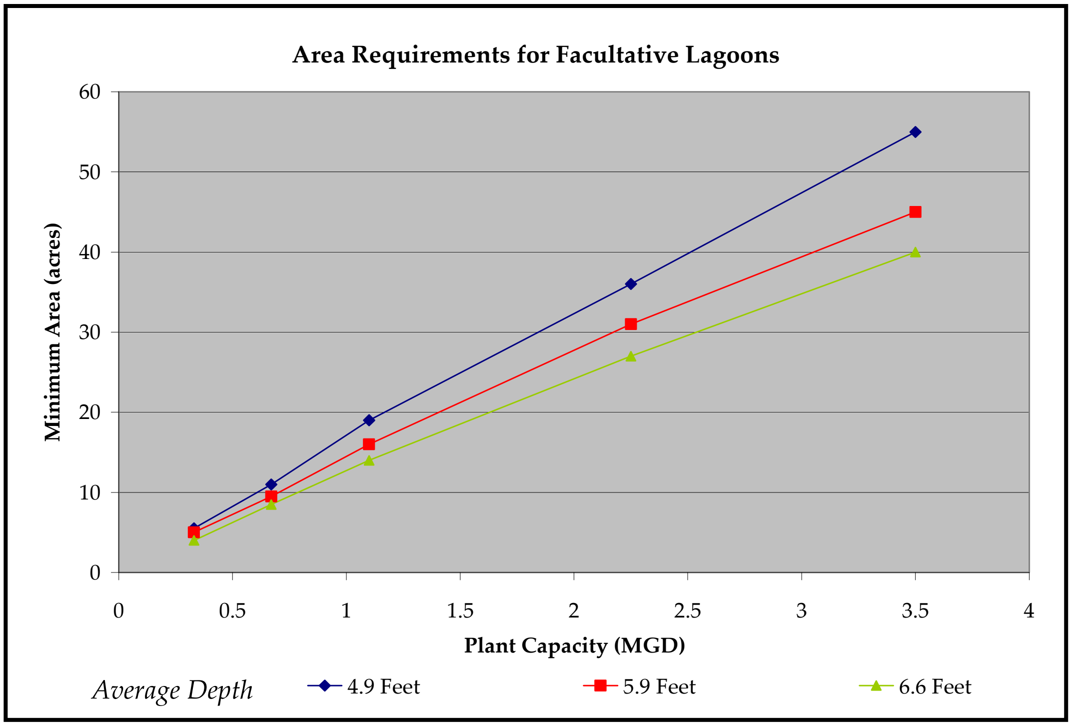


Figure 4.5-7 Area Requirements for Facultative Lagoons, Halcrow

Macrophyte Treatment Systems

Floating macrophyte species, with their large root systems, are very efficient at nutrient stripping (Nitrogen and Phosphorus reductions up to 80% have been achieved). Although several genera have been used in pilot schemes, including Salvinia, Spirodella, Lemna and Eichornia (O'Brien 1981), Eichornia crassipes (water hyacinth) has been studied in much greater detail. In tropical regions, water hyacinth doubles in mass about every 6 days and a macrophyte pond can increase in mass by more than 220 lb/acre (dry weight). Apart from any physical removal processes which might occur (especially sedimentation), the aquatic vascular plants serve as living substrates for microbial activity, removing BOD and nitrogen and achieving reductions in phosphorus, heavy metals and some organics through plant uptake.

The addition of a macrophyte stage in the Lagoon system assimilates, concentrates and stores contaminants on a short-term basis. The plant material must be harvested from the lagoon to permanently remove stored contaminants from the pond treatment system. A Facultative Lagoon schematic with the addition of Macrophyte treatment is provided on Figure 4.5-8.

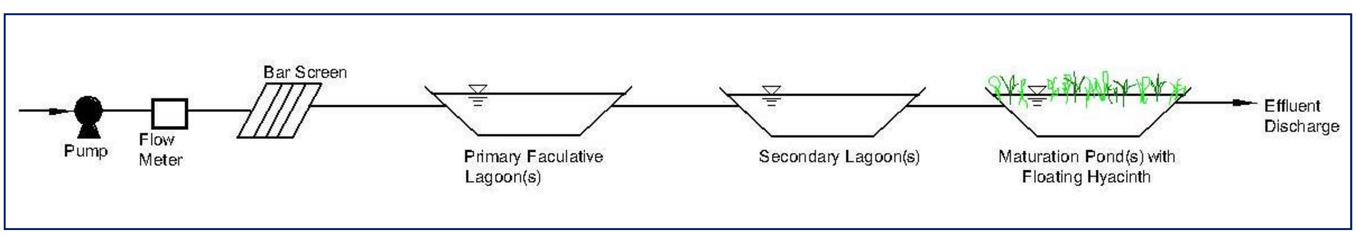


Figure 4.5-8 Natural Treatment System with Nutrient Removal by a Hyacinth Lagoon

Constructed Wetland Systems

Natural and artificial wetlands and marshes have been used to treat raw wastewater and partially-treated effluents. Natural wetlands are usually unmanaged, whereas artificial systems are especially designed to maximize performance by providing the optimum conditions for emergent macrophyte growth. Reed beds serve as an example of this system; key features of reed bed treatment systems are:

- Rhizomes of the reeds grow vertically and horizontally in the soil or gravel bed, opening up 'hydraulic pathways'.
- Wastewater BOD and nitrogen are removed by bacterial activity; aerobic treatment takes place in the rhizosphere, with anoxic and anaerobic treatment taking place in the surrounding soil.
- Oxygen passes from the atmosphere to the rhizosphere via the leaves and stems of the reeds through the hollow rhizomes and out through the roots.
- Suspended solids in the wastewater are aerobically composted in the above-ground layer of vegetation formed from dead leaves and stems.
- Nutrients and heavy metals are removed by plant uptake.

The growth rate and pollutant assimilative capacity of emergent macrophytes such as Phragmites communis and Scirpus lacstris are limited by the culture system, wastewater loading rate, plant density, climate and management factors.

High tissue nitrogen concentrations have been found in plants cultured in nutrient enriched (wastewater) systems and in plants analyzed in the early stages of growth. Maximum storage of nutrients by emergent macrophytes was found to be in the range 180-1400 lb N/ac and 36-335 lb P/ac in Florida (Reddy and DeBusk 1987). More than 50 percent of the nutrients were stored in below-ground portions of the plants, tissues difficult to harvest to achieve effective nutrient removal. However, because emergent macrophytes have more supportive tissue than floating macrophytes, they might have greater potential for storing the nutrients over a longer period. Consequently, frequent harvesting might not be as necessary to achieve maximum nutrient removal although harvesting above-ground biomass once a year should improve overall nutrient removal efficiency.

4.5.3 Hybrid Wastewater Treatment Technologies

A combination of the systems listed above (or other treatment systems) can be utilized to ensure a successful treatment operation.

4.5.4 Decentralized Wastewater Treatment

An onsite decentralized treatment and disposal system is required for facilities outside the service area of a communal wastewater collection system. Per the USEPA Design Manual,

"Subsurface soil absorption has been used almost exclusively for onsite disposal of wastewater because of its ability to meet the public health and environmental criteria without the necessity for complex design or high costs. A properly designed, constructed and maintained subsurface absorption system performs reliably over a long period of time with little attention. This is because of the large natural capacity of the soil to assimilate the wastewater pollutants." [xvii]

When required to consider an onsite treatment and disposal system, the following design strategy is necessary to determine which type of system will successfully serve the treatment and disposal needs of the facility while securing against public health hazards and ensuring environmental quality:

- Wastewater Characterization – estimated daily volume in the short and long term, including peak inflows.
- Initial Site Evaluation – review all available information regarding soils, geology, topography, climate and other physical site features.
- Initial Disposal Option Evaluation – determine effective disposal options based upon site information and the use of Table 4.5-3.
- Detailed Site Evaluation – including individual property evaluation (facility and system layout, area, slope) and soil survey (texture, saturation, hydraulic characteristics)
- Selection of Treatment Component and Disposal Method
- System Design

4.5.4.1 Placencia Soil Characteristics

The following criteria characterize the soil situation on Placencia Peninsula:

- Very Rapid Soil Permeability
- Deep Depth to Bedrock
- Shallow Depth to Water Table
- 0 – 5% Slope

Per Table 4.5-3, Mounds, Fill Systems, Evaporation Lagoons (lined) and Evapotranspiration Beds/Trenches (lined) are suitable disposal methods for properties meeting these soil characteristics. Evaporation Lagoons (lined) and Evapotranspiration Beds/Trenches (lined) require a large amount of space and an open wastewater system; it is not likely that these systems would be acceptable on the Peninsula. Fill Systems are similar to Mounds; for the purpose of the study, given the similarity between Fill Systems and Mounds, Mounds will be considered the suitable disposal method for decentralized systems on the Peninsula, where such systems are required.

Table 4.5-3 USEPA Disposal Method Selection Matrix [xviii]

Method	Site Constraints											
	Soil Permeability			Depth to Bedrock			Depth to Water Table		Slope			Small Lot Size
	Very Rapid	Rapid – Moderate	Slow – Very Slow	Shallow and Porous	Shallow and Non-Porous	Deep	Shallow	Deep	0-5%	5-15%	0.15	
Trenches		X	X[2]			X		X	X	X	X	X
Beds		X				X		X	X			X
Pits		X				X		X	X	X	X	X
Mounds	X	X	X	X	X	X	X	X	X	X		
Fill Systems	X	X[1]	X[1]	X	X	X	X	X	X	X	X	X[4]
Sand-Lined Trenches or Beds	X	X	X[2]			X		X	X	X[3]	X[3]	X[4]
Artificially Drained Systems		X				X		X	X	X[3]	X[3]	X[4]
Evaporation Infiltration Lagoons		X	X[5]			X		X	X			
Evaporation Lagoons (lined) [4,5]	X	X	X	X	X	X	X	X	X			
ET Beds or Trenches (lined) [4,5]	X	X	X	X	X	X	X	X	X	X[6]		
ETA Beds or Trenches [4]		X	X			X		X	X	X	X	X

X System can function effectively with that constraint
1 Only where surface soil can be stripped to expose sand or sandy loam material
2 Construct only during dry soil conditions. Use trench configuration only.
3 Trenches only.
4 Flow reduction suggested
5 High Evaporation potential required
6 Recommendation for south-facing slopes only.

4.5.4.2 Onsite Disposal System - Mounds

Mound systems are specifically suited for properties with high water tables. The system is artificially elevated above the natural soil surface in a specifically-suited fill material. Raising the mound allows a greater depth to the (high) water table. A minimum of two foot (2′) depth to water table from original ground surface is required. A mound system schematic is provided on Figure 4.5-9.

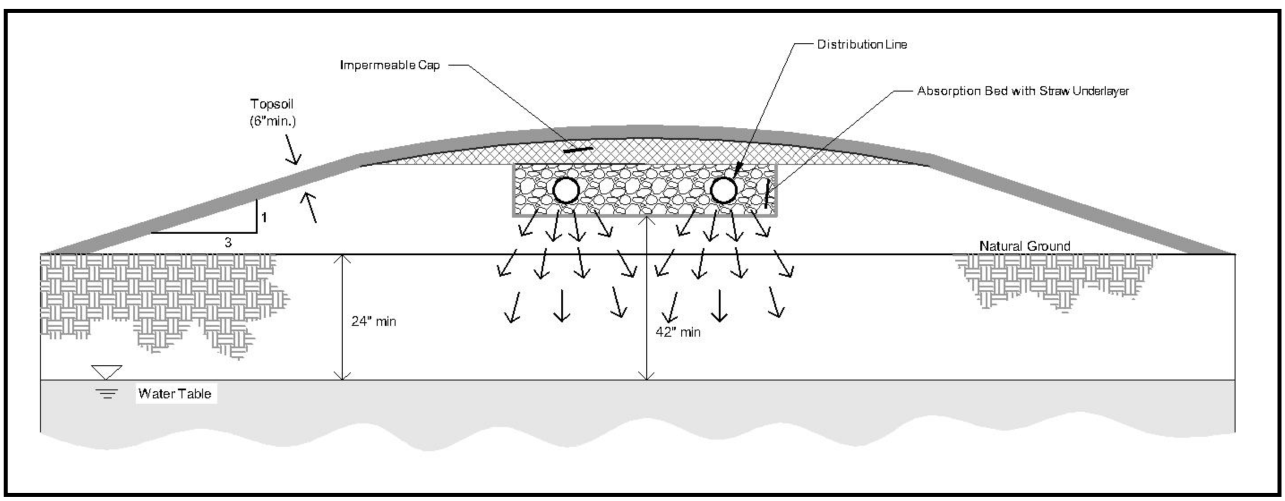


Figure 4.5-9 Mound System Schematic Detail

Sandy soils typically infiltrate 1.2 gallons per day per square foot (gpd/ft^2) of absorption bed. Each facility needs to determine its anticipated wastewater loading. For a typical household of four, an estimated 260 gpd of wastewater is generated, requiring 220 ft^2 of absorption field (typically, 12' x 19'). This area calculation does not include the slopes around the mound perimeter. A minimum horizontal separation is required to protect the absorption field and its surrounding features (see Table 4.5-4).

Table 4.5-4 Mound System Horizontal Separation [xix]

Feature	Horizontal Separation (ft)	
	Minimum	Ideal Minimum
Water Supply Well	50	100
Surface Water, Springs	50	100
Escarpments	10	20
Property Boundary	5	10
Building Foundation	10	20

For mound systems being used by multiple facilities, additional care needs to be taken to more accurately estimate both the quantities and qualities of the flow entering the system. An alternating bed system is recommended to ensure a failed bed area can be rehabilitated while the other bed area is in use.

4.5.4.3 Onsite Treatment System – Septic Tank

The onsite effluent requires treatment prior to disposing the wastewater into a mound disposal system. The most common and relatively simple treatment option is the installation of a Septic Tank between the facility and the disposal system. Per USEPA Onsite Wastewater Treatment and Disposal Systems Design Manual,

"Septic Tanks are buried, watertight receptacles designed and constructed to receive wastewater from a home, to separate solids from the liquid, to provided limited digestion of organic matter, to store solids, and to allow the clarified liquid to discharge for further treatment and disposal." [xx]

Tank volume is typically sized based upon the number of bedrooms being served (250 gallons per bedroom, with 750 gallon minimum). For non-residential facilities, a detailed estimate of anticipated water use is required. A grease trap to capture and store fats and floatable solids is recommended to be placed between the facility and the septic tank. A septic tank schematic is provided on Figure 4.5-10.

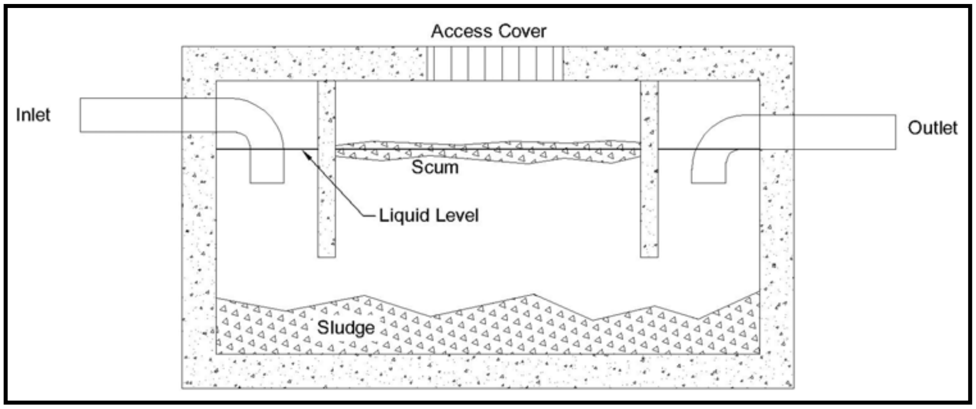


Figure 4.5-10 Septic Tank cross-section

4.5.5 Wastewater Effluent Reuse and Disposal Alternatives

4.5.5.1 Marine Discharge

Marine discharge involves the direct discharge of treated effluent exiting a wastewater treatment facility into sea waters, typically at the seabed elevation and a minimum distance from the seashore.

Municipal wastewater systems using marine discharge typically provide only primary wastewater treatment with the expectation that the assimilation of the effluent with the surrounding seawater will both dilute the effluent characteristics and possibly provide additional treatment.

The primary advantages of a marine discharge system are:

- Expense – passive discharge into sea typically replaces secondary treatment
- Dilution and dispersion of pollutants and pathogens, as well as managed exposure distance between effluent and the public.

Concerns regarding marine discharge include accumulation of toxins, sludge accumulation and grease agglomeration, each of which can negatively affect the success of dilution and dispersion. In addition, marine discharge could also impact the marine reefs in the vicinity of the discharge.

4.5.5.2 Surface Water Discharge

Surface water discharge involves the direct discharge of treated effluent exiting a wastewater treatment facility into surface waters (streams, wetlands, lake, etc), typically at the bottom of the waterway and a minimum distance from the shoreline. Municipal wastewater systems using surface water discharge may provide only primary wastewater treatment or may perform secondary treatment as well, depending on the local governing jurisdictional standards.

For surface water discharge systems that do not provide secondary treatment, the advantages and disadvantages are comparable to those listed within the marine discharge section above. For surface water discharge systems that provide secondary treatment prior to discharge, the primary advantages of a surface water discharge system are the removal of the effluent from the treatment system, the overall dilution and dispersion of the effluent within the surface water, and the additional treatment done by the receiving body of water. This only applies to systems that use disinfection with chlorine.

Concerns regarding surface water discharge include the effects of residual chlorination as well as nutrient buildup at the point of discharge. The ratio of the discharged effluent volume to the receiving water body volume is an important consideration in a successful surface water discharge application.

4.5.5.3 Land Application Discharge

The three basic approaches to land application are irrigation, overland flow, and infiltration-percolation. Irrigation and infiltration of pretreated municipal wastewater have been the most widely used types of land application. Recently, municipal plants have begun experimenting with overland flow. Industrial wastewater, generally preceded by screening or settling, has been applied using all three methods, with the choice usually governed by the type of soil in the disposal area. Table 4.5-5 summarizes the treatment qualities of the three primary land application discharge approaches. Table 4.5-6 summarizes the discharge method's capacity for water reclamation. Table 4.5-7 summarizes land application system requirements and general system characteristics.

Table 4.5-5 Treatment Objectives for Land Application Approaches [xxi]

Post-Secondary Treatment Objective	Type of Land Application Approach		
	Irrigation	Overland flow	Infiltration, Percolation, Evaporation
BOD_5 & TSS Removal	90-99 percent	90-99 percent	90-99 percent
Nitrogen Removal	85-90 percent	70-90 percent	0-80 percent
Phosphorus Removal	80-99 percent	50-60 percent	70-95 percent
Agricultural Crops	Excellent	Fair	Poor
Direct Recycle to Land	Complete	Partial	Complete
Groundwater Recharge	0-30 percent	0-10 percent	Up to 90 percent
Use in Cold Climates	Fair [a]	-- [b]	Excellent

a Conflicting Data - Irrigation in Woods is acceptable, on Croplands is marginal
b Insufficient data

Table 4.5-6 Land Application Capacity for Water Reclamation [xxii]

Used as a Treatment Process with an intent to Recover Treated Water	Type of Land Application Approach		
	Irrigation	Overland flow	Infiltration, Percolation, Evaporation
	Impractical	50-60 percent recovery	Up to 90 percent recovery

Table 4.5-7 Land Application Requirements and Characteristics [xxiii]

Factor	Type of Land Application Approach		
	Irrigation	Overland flow	Infiltration, Percolation, Evaporation
Liquid-loading rate	0.5 - 4.0 in/wk	2.0 - 5.5 in/wk	4 - 200 in/wk
Annual application	2 - 8 ft/yr	8 - 24 ft/yr	18 - 500 ft/yr
Land required for 250,000 gallon/day	40 - 150 acres, plus buffer zones	12 - 40 acres, plus buffer zones	0.5 - 15 acres, plus buffer zones
Application techniques	Spray or surface	Usually spray	Usually surface
Soils	Moderately permeable soils with good productivity when irrigated	Slowly permeable soils such as clay-loam and clay	Rapidly permeable soils such as sands, loamy sands, and sandy loams
Probability of influencing groundwater	Moderate	Slight	Certain
Needed depth to groundwater	+/- 5 ft	Undetermined	+/- 15 ft
Wastewater losses	Predominantly evaporations or deep percolation	Predominantly surface discharge, but some evaporation and percolation	Evaporation and percolation to groundwater

Irrigation

Three basic land application irrigation methods are flood, ridge and furrow, and spray. Flood irrigation is the inundation of land with several inches of water. Ridge and furrow irrigation consists of applying water by gravity flow into furrows, with crops grown on the ridges. Spray irrigation consists of either portable or solid-set sprinklers.

The type of irrigation system used depends on soil permeability, crop, topography, and economics. Typically, irrigation disposal systems are restricted to operation in the growing season, with storage required for the remaining months. With Belize's tropical climate, this system may be available for year-round use.

Important factors in an irrigation system design are liquid loading (inches per week) and nitrogen loading (pounds per acre per year). Market value, management requirements and specific responses to wastewater components are to be considered when determining the appropriate crop; common crop choices are grasses with high uptakes of water and nitrogen and low maintenance requirements.

Treatment of the wastewater predominately occurs in the first 1.5 to 4 feet of soil. Removal levels, where monitored, are significant. BOD_5, TSS, and bacteria removal rates normally reach 99 percent. With loamy soils, heavy metals, phosphorus and viruses have been found to be almost completely removed by absorption. Nitrogen is taken up by plant growth; where the crop is harvested, removals have been up to 90 percent depending on leaching rate and type of crop grown.

The practice of land application of wastewater by irrigation differs from the water reclamation practice of agricultural reuse in one basic respect. The primary objective of land application of wastewater is treatment and disposal with concurrent protection of the groundwater. Therefore, crops are chosen not so much for their profitability and marketability as for their uptake of both water and nutrients. A discussion of wastewater reuse through agricultural irrigation is found in Section 4.5.5.4. Table 4.5-8 summarizes the factors necessary to assess when analyzing a property for irrigation application.

Table 4.5-8 Site Selection Factors and Criteria for Irrigation [xxiv]

Factor	Criterion
Soil Type	Loamy soils preferable, but most soils from sands to clays are acceptable.
Soil drainability	Well-drained (more than 2 in/day) soil preferred
Soil depth	Uniformly at least 4 to 6 ft throughout site
Depth to groundwater	Minimum of 5 ft
Groundwater control	May be necessary to ensure treatment if water table is less than 10 ft from surface
Groundwater movement	Velocity and direction must be determined
Slopes	Up to 15 percent are acceptable with or without terracing
Underground formations	Should be mapped and analyzed with respect to interference with groundwater or percolating water movement
Isolation	Moderate isolation from public preferable, the degree depending on wastewater characteristics, method of application, and crop
Distance from source of wastewater	Economics

Overland Flow

Unlike irrigation and infiltration systems, overland flow functions more as a land treatment process than a land disposal process. Overland flow has been used widely in the United States on food-processing wastes and experimentally on municipal wastewater. Soils of low permeability are unsuitable for irrigation or infiltration but they are ideal for overland flow. Also, a high water table will reduce the soil filtering function with the irrigation or infiltration processes but will have little or no effect on overland flow treatment. This system utilizes the soil surface layer, surface organic mat, plants, and microorganisms. The groundwater table should be deeper than two feet so that the health of the plants is not damaged by water-logging.

Land used for overland flow should have a slope of between 2 and 6 percent, so that the wastewater will flow in a sheet over the ground surface. Grass is planted to provide a habitat for the bacteria which help purify the wastewater. As runoff is expected, provision must be made to dispose of this effluent.

Overland flow systems are generally designed on the basis of liquid-loading rates, although an organic-loading or detention-time criterion may also be considered. The process is essentially biological, with a minimum contact time between bacteria and wastewater required for adequate treatment. Like irrigation, overland flow is typically a seasonal operation, requiring storage during some of the winter months in cold climates. With Belize's tropical climate, this system may be available for year-round use.

Important management practices in overland flow include maintaining the proper hydraulic loading cycle (periods of application followed by resting), and active biota and growing grass. Hydraulic loading cycles used successfully have ranged from 6 to 8 hours of spraying followed by 6 to 18 hours of drying. More frequent cycles have also been successful. Periodic cutting of the grass with or without removal is important, but the effects of harvesting on organic oxidation have not been fully demonstrated.

As shown in Table 4.5-5, treatment of wastewater by overland flow is only slightly less complete than that achieved by irrigation.

Infiltration, Percolation and Evaporation

Land application for wastewater disposal through infiltration, percolation and evaporation (IPE) has been used for many years for treatment and recharge of groundwater. Hydraulic contributions to the groundwater are substantial.

Very coarse sands and gravels are not ideal, since the wastewater is permitted to pass too rapidly through the top few feet of soil where most biological and chemical action takes place. BOD_5, TSS and bacteria are almost completely removed in most cases, as is noted in Table 4.5-5. Nitrogen removals, on the other hand, are generally poor unless specific operating procedures are designed to optimize denitrification. Careful management of the hydraulic loading cycle has resulted in nitrogen removals of up to 80 percent in presently operating, high-rate systems. Infiltration-percolation systems have generally proved to be less reliable than irrigation and overland flow systems from the standpoint of environmental effects, but the poorly performing systems have been those which have not been monitored and/or managed properly.

The principal advantage in the use of infiltration-percolation is that it requires much less land area than irrigation or overland flow and can be used on a year round basis, while its principal disadvantage is a lesser degree of treatment achieved in the surface soils and a requirement for highly permeable soils.

4.5.5.4 Effluent Reuse

The reclamation of water from wastewater has been practiced for many years, and many examples can be cited of the use of reclaimed community wastewater for virtually every purpose for which water is employed. The rising cost of new and supplemental sources of water supply has in recent years intensified the interest in this subject.

As distinguished from wastewater treatment and disposal, the reclamation of water is for a specific use, and therefore must be selective as to the quantity and quality of wastewater to be used. A water reclamation plant should therefore operate independently of the wastewater disposal system to the extent that a shutdown of the reclaiming operation will not adversely affect the disposal operation. Where the effluent quality for wastewater disposal must be equal to the quality required for water reuse, plant design and operation may be based solely on disposal requirements. In this case the entire plant output may be considered as reclaimed water to be used or discharged at the discretion of the operating agency.

To be feasible, water reclamation must produce a usable product to meet a specific need at a cost which the consumer is willing to pay. For cases where reclaimed water would replace a present water use, the cost needs to be evaluated on the basis of the present cost of water to the consumer. For cases where a new use is established, the cost of reclaimed water will have to be evaluated on the basis of its actual value to the consumer.

Potential uses for reclaimed water include:

- Agricultural,
- Industrial,
- Recreational,
- Domestic, and
- Groundwater Recharge.

Groundwater recharge is not properly an end use in itself, but rather a method of adding reclaimed water to the area water resources in a manner that makes it available for future use.

Agricultural Reuse

The most common type of reuse in the United States is agricultural irrigation reuse (with over 500 U.S. communities in practice). The city of Cheyenne, Wyoming, has been operating such a system since 1881 and Fresno, California since 1891. Controlling factors for this technique are treatment level requirements, site selection, irrigation methods, loading rates, and management and cropping practices. Table 4.5-8 summarizes the site selection factors and criteria. Soil permeability is perhaps the primary factor. The minimum depth to groundwater should be five feet (5’) to prevent water logging and ensure aerobic conditions. If the groundwater is within five feet (5’) of the surface, control procedures such as underdrains or wells may be required.

The average yearly amount of water applied to agriculture lands varies between 60” – 108”. Bacteriological quality requirements for agricultural use of reclaimed water should be determined on a case-by-case basis. Present practice in other countries requires, as a minimum, treatment equivalent to that which can be achieved by sedimentation, biological oxidation, and disinfection for effluents discharged to irrigation canals. Typical international bacteriological effluent quality sets the maximum fecal coliform concentration at 50 organisms or less per 100 milliliters. In general, it can be said that the potential for agricultural reuse should be investigated carefully when requirements for treatment and discharge equal or exceed quality requirements for irrigation.

Industrial Reuse

Future possibilities for the industrial use of reclaimed water will have to be evaluated individually, considering the quality of water required for a specific application and the cost of producing reclaimed water of the required quality. It may be assumed that the degree of treatment required would be at least equal to 95 percent BOD removal plus disinfection. As there are serious public health implications involved in the construction of duplicate potable and non-potable water distribution systems which would be necessary to deliver small quantities of reclaimed water to multiple industrial users, the most promising industrial reuse applications are those involving a large single-point use.

Recreational Reuse

When reclaimed water is to be used for recreational purposes, specific treatment and disposal requirements are to be formulated based upon the extent of physical contact (and potential for ingestion) anticipated by recreational users. Such activities may have intimate contact (swimming, bathing), casual contact (boating, fishing, golf course irrigation) or minimal (fountains, aquaculture).

Domestic Reuse

Reclamation of water from wastewater for domestic and other urban purposes represents the most advanced form of urban water reuse and is the one most difficult to support technically, politically, and psychologically. Direct domestic use of reclaimed wastewater effluent has been practiced only in a few cases throughout the world. Windhoek, Southwest Africa, a metropolitan area of 250,000 inhabitants, currently meets a portion of its water needs by recycling about one-third of its effluent, after advanced treatment, for reuse in the municipal supply system. Acceptance has been good, and, as a result, South Africa is investigating increasing this approach to meet growing water needs.

It is highly unlikely that this form of water reclamation would be justifiable in the foreseeable future for Belize. If current water supplies fail to meet the future needs of the area, the first steps would be to substitute reclaimed water for the supplies used for industrial, agricultural, recreational, and land beautification purposes. Only then should consideration be given to the reclamation of wastewater effluent for general domestic purposes. Based upon present knowledge and expectations, it is concluded that this form of reclamation is not to be considered in detail for many years, if at all.

Groundwater Recharge

Groundwater recharge could be accomplished by spreading, infiltration, downward percolation, or by pressure injection into recharge wells. Certain wastewater chemical constituents and the land area available for surface spreading are usually the limiting factors to reclamation by this procedure, the continuous rate of ground infiltration which can be achieved being of primary concern. Surface spreading requires a permeable formation overlying or hydraulically leading to the groundwater aquifer to be recharged. The hydraulic capacity of the subsurface formation must be equal or exceed the infiltrative capacity of the surface formation. With wastewater, the infiltrative capacity at the soil-water interface governs, and, with continuous application, infiltration rates decline to low values. The reported range of these values is remarkably narrow regardless of the hydraulic capacity of the formation. The technology of recharge by spreading, therefore, entails geology and hydrology in locating sites over suitable formations, and the techniques of constructing and operating recharge facilities in a way to obtain maximum, rather than equilibrium, infiltration rates. The technology for recharge of groundwater aquifers by injection through deep wells or bores has been well developed for clean waters, but little definitive information is usable for wastewater operations. The petroleum industry has developed the technique for returning oil-field brine to very deep formations, thereby aiding oil recovery and disposing of the brine. That technique has been extended to the disposal of small quantities of high strength or toxic trade wastes.

The deliberate recharge of treated wastewater to groundwater basins by either surface methods or injection requires overcoming a number of technical problems. The mechanical problems of clogging the soil pores with suspended material in treated effluent would complicate effluent recharge from a conventional wastewater treatment plant by direct injection through a well, even if such disposal were desirable.

4.5.5.5 Installation and Maintenance Costs

Installation and maintenance costs of land application systems depend on many variables which makes it difficult to develop cost curves. Some cost variables include:

- Distance from the treatment plant to the land application site,
- Effluent flow,
- Equipment used for effluent distribution, and
- Method of effluent distribution and application.

5 Evaluation of Alternatives

5.1 Wastewater Load Allocation

For the purpose of establishing the estimated geographic location of generated wastewater, an overlay of the per capita waste generation with the projected population density is required.

For the purpose of this study, it is assumed that all facilities will be connected to the wastewater collection and treatment system. While this may not be a reality in the short-term, it is an important goal in the long term. If a facility receives water from an outside source and has access to a collection system, it ought to connect to the connection system and pay applicable tariffs.

5.1.1 Wastewater Load by Land Category

Portions of land throughout the Placencia peninsula generate variable wastewater loadings. For the purpose of this study, Table 5.1-1 summarizes general land use categories outside the villages and estimated wastewater loadings.

Table 5.1-1 Placencia Peninsula Wastewater Load Densities - General

Land Category	Facility Density (unit/acre)	Pop'n Density	Wastewater Load (by Pop'n Type) (gpcd)	Wastewater Load (by Land Category) (gpd/acre)
Low Density Residential	0.17 homes	3 persons / home	73	37
Medium Density Residential	0.34 homes			75
Low Density Tourist	2.5 rooms	2 persons/room	117	583
Medium Density Tourist	5.0 rooms			1,166

The mixture of property type as well as the increase in population density in the two village areas necessitated individualized density categories within the villages. Table 5.1-2 summarizes the village areas used to develop load densities.

Table 5.1-2 Peninsula Wastewater Load Densities – Villages

Land Category	Land Area (acres)	2040 Mixed Type Pop'n	Wastewater Load (by location) (gpcd)	Wastewater Load (by Land Category) (gpd/acre)
Placencia Village	170	3,050	88	1,578
Seine Bight Village	67	1,600	78	1,863

5.1.2 Load Allocation

To estimate the geographic location of generated wastewater, load density categories were assigned to land tracts along the peninsula. The land tracts used in this study were established by the Halcrow team and do not directly correspond to tax parcels. A Peninsula Land Category Map is shown on Figure 5.1-1.

Based upon land area, load density category, and population projections, a Load Allocation Map was created of the estimated geographic location of generated wastewater for both years 2011 and 2040, as shown on Figure 5.1-2 and Figure 5.1-3. The load allocation data is included Appendix B.1.2.

For example, tract R2_01 on Figure 4.3-3 has a land area of 55 acres and is assigned a Medium Density Residential load category. Therefore, the estimated wastewater generation based upon a Land Use Category loading rate of 73 gpd/acre at full build out (year 2040) is 4,015 gpd.

For the purpose of the project's wastewater model, the total waste loading for each tract was evenly distributed into each manhole located within the tract. Each tract has a minimum of one manhole.

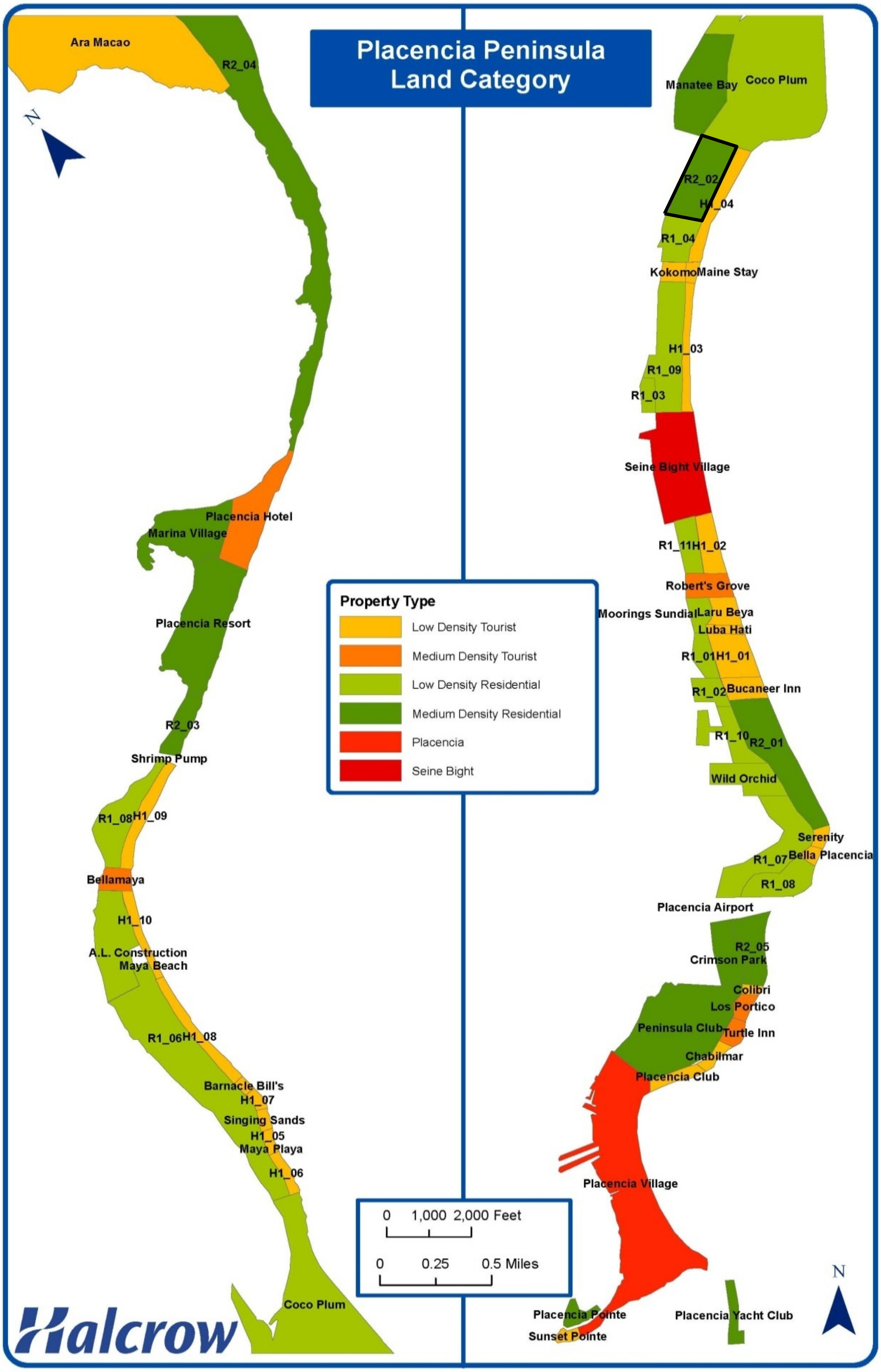


Figure 5.1-1 2011 Placencia Land Category Map

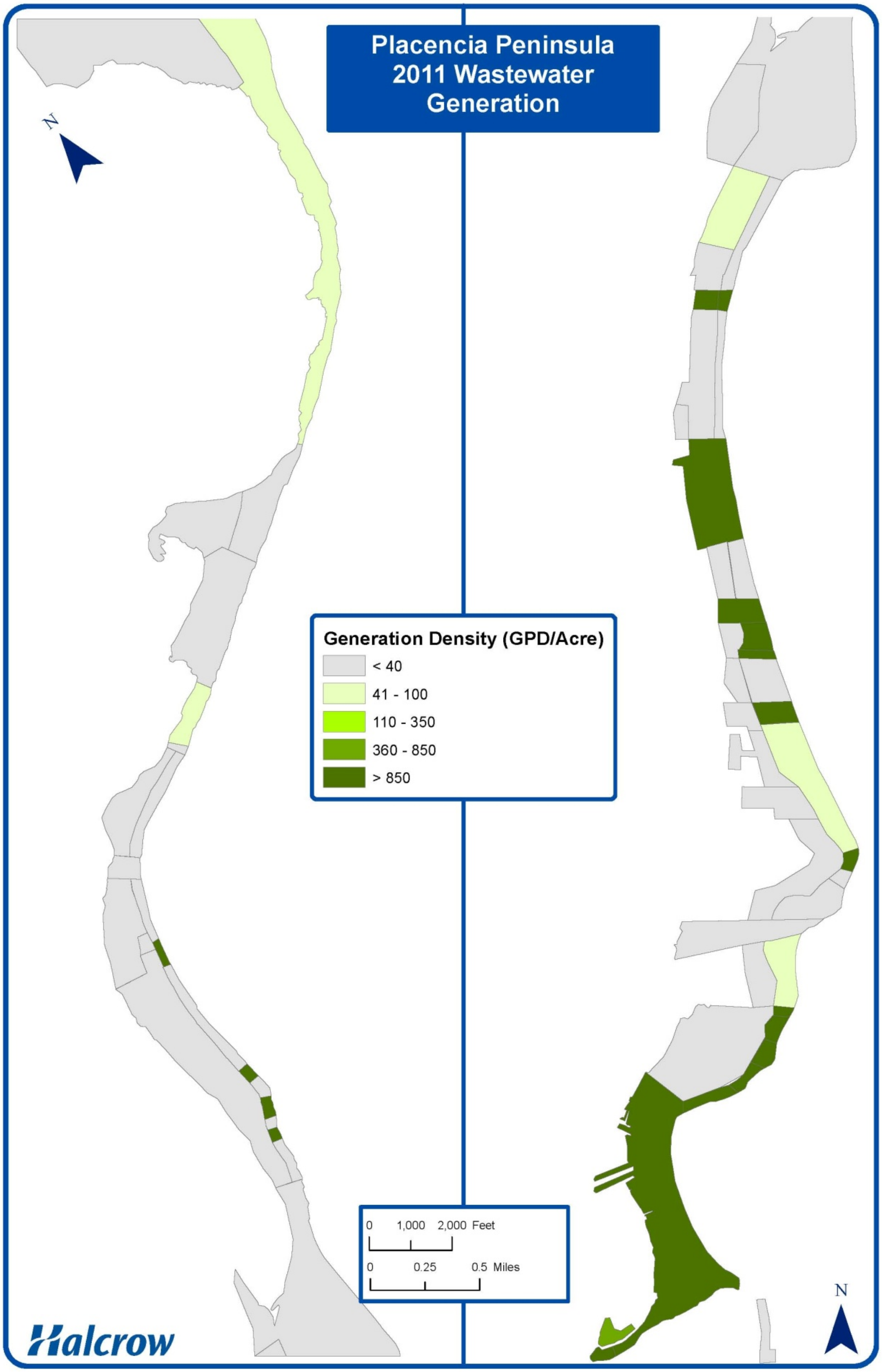


Figure 5.1-2 2011 Placencia Wastewater Generation Map

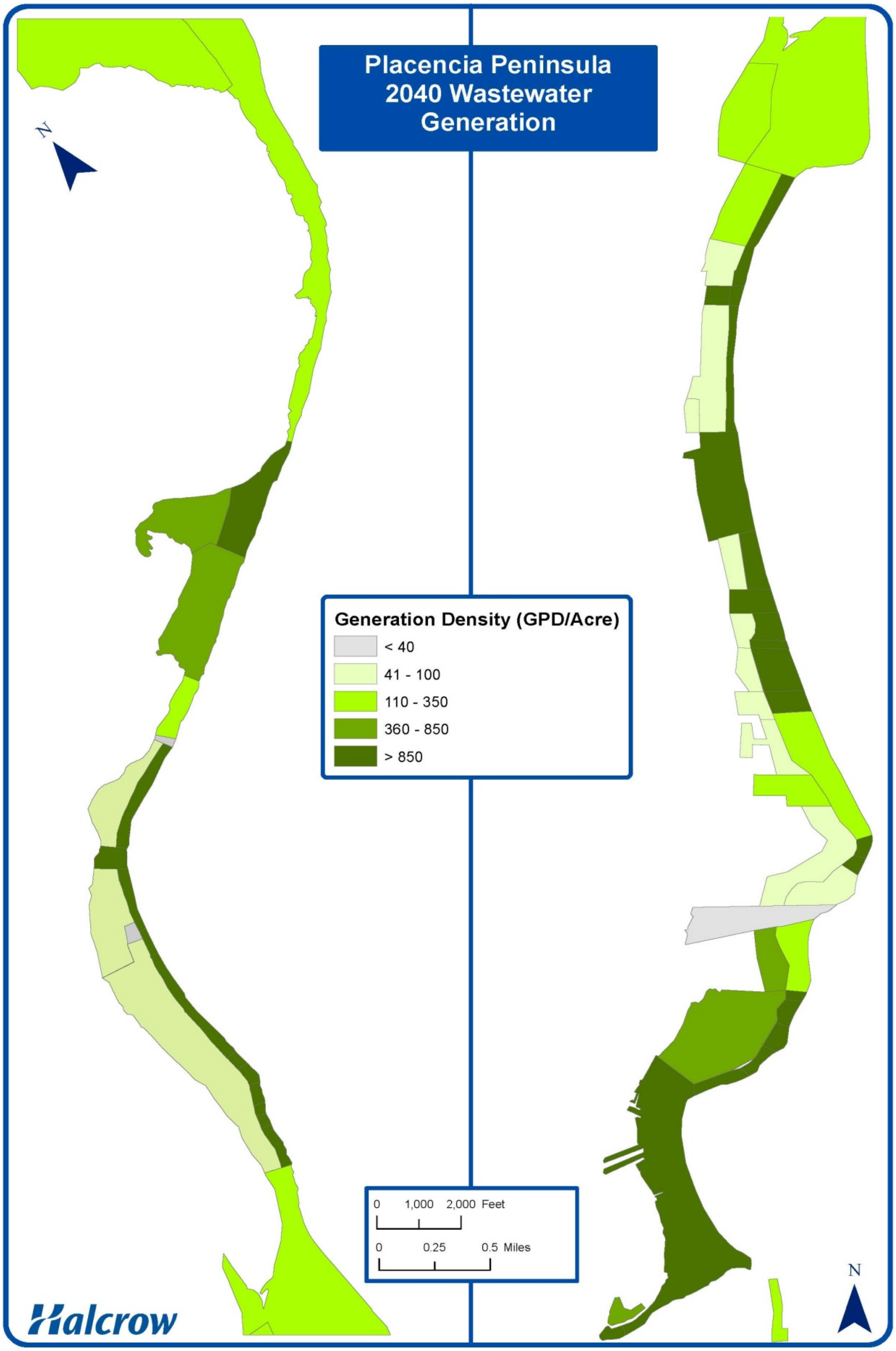


Figure 5.1-3 2040 Placencia Wastewater Generation Map

5.2 Wastewater Collection Model

SewerGEMS Sanitary V8i® was used to create alternative wastewater collection system models to help determine the:

- Service Area
  - Macro-level: extent of area to be served
  - Cluster-level: extent of individual wastewater clusters
  - Micro-level: connections to individual facilities (was not considered in model)
- Sizes
  - Gravity Pipe
  - Pressure Force Main Pipe
  - Pumps
- Schematic Location of:
  - Manholes
  - Pump Stations
  - Pump run times for the purpose of establishing electrical requirements.

5.2.1 System Characteristics

The wastewater generation within the model was established using:

- Peak Daily Flow determined using the daily diurnal curve shown on Figure 4.1-1.
- Peak Hourly Flow determined using the peaking factor equation from Section 4.1.
- Population Projections for years 2025 and 2040 from Section 3.1.
- Wastewater Load Allocation from Section 5.1.2 and included in Appendix B.1.2.

5.2.2 Model Loads

The wastewater load allocation was initially input within the model based upon the 2040 population and estimated wastewater generation. These loads were used to determine permanent infrastructure, pipe and wet well sizes.

A second load allocation was performed based upon the 2025 population and its reduced estimated wastewater generation (+/- 80% of 2040 loading). These loads were used to size system pumps. Pump life is estimated at 15 years, and can be upgraded as needed to meet increased population demands.

5.2.3 Model Assumptions

The following assumptions were used in creating the project wastewater model. These assumptions will require additional validation during the final detail design process of the project and in the development of construction documents.

Elevations

- A topographic map of the Peninsula was not available for this study. Prior to final detail project design, a full topographic survey of the Peninsula will be required, including ground elevations throughout the project limits as well as connection points at each facility being connected to system.
- Prior to final detail project design, a flood study of the Peninsula will be required to ensure no overflows (or at least decrease the potential of flooding) occur into the

system. This report does not give consideration for flood elevations, as there are no known elevations at this time.

- Given the flat terrain and near-sea level elevations, ALL elements in the model were set at a ground elevation of 6′ above mean sea level (msl) throughout the entire project.
- Based upon Halcrow's previous experience digging below grade to install a flow meter on buried pipe at the Placencia Water Board, the water table is estimated at 3′ msl.
- For each cluster, the most upstream gravity invert is set at 4.0′ msl, with 2′ cover. This generic assumption will have to be analyzed on a case by case basis during final design to ensure that adjacent properties' wastewater can effectively drain by gravity into the collection system.
- For each cluster, the lowest gravity invert is set at about zero foot (0′) msl.
- When the length of gravity line sloping from its upstream extent reaches the downstream extent, a pump station is required.
- These assumptions were used to establish individual wastewater clusters, with each cluster draining into a pump station.

Wet Wells

- Initial Volume:
  - Base Elevation: -4.5′
  - Lowest Water Elevation (pump shut off): -3.5′ (1.0′ minimum liquid depth)
  - Pump On Elevation: -0.5′
  - Working Depth (from pump on to pump off): 3.0′
  - Diameter: 5′ (ideally prefabricated fiberglass or concrete structure)
- Increased Sizing:
  - As inflow volume increases, diameters increase from 6′ to 8′ and base elevation lowers from -5 to -8′, increasing the working volume through an increased cross-section and increased working depth.
  - Wet Wells less than or equal 6′ diameter were modeled as circular structures. Larger wet wells were modeled as square structures.

Infiltration

Groundwater infiltration into the gravity sewer pipes was set in the model at 500 gallons per day per inch pipe diameter per mile of sewer line (gpd/in-mile).

5.3 Wastewater Collection Alternatives

A key factor in the success of a functioning wastewater system is the collection and delivery of the generated wastewater from the decentralized homes, businesses and resorts throughout the peninsula to the treatment facility.

One of the distinct challenges for this collection system is the length of land the pipes must traverse to connect the properties to the system relative to the quantity of facilities being served. The Peninsula has a low population density, which increases the relative cost per individual for a constructed solution.

A primary goal in the schematic design of the wastewater collection system is to minimize the depth of the system below ground. The Peninsula's sandy soils increase the challenge and expense of stable excavation, especially in areas where there is not adequate room to 'lay back' the excavated slopes to a stable and safe degree. In addition, the high water table increases the expense of excavation and the permanent challenge of groundwater infiltration into the pipe and wet well systems.

The peninsula is too large and too flat to build a single traditional gravity-based wastewater collection system. Based upon the model assumptions laid out in Section 5.2, there is a limited sized area that can be served by gravity alone. These 'gravity wastewater clusters' are geographically based, and are consistent throughout all collection alternatives. Each cluster will need to be re-evaluated during final detail design based upon a more accurate horizontal location of properties being served, topographic survey, and a final determination of the minimum and maximum pipe cover.

Once a cluster is defined and a low point within its bounds is determined, a wastewater pump station will need to be installed at the local cluster low point to 'lift' the wastewater through mechanical pumps and move it to or towards the wastewater treatment plant (WWTP). Section 5.3.3 explores how to effectively move wastewater to the WWTP in a cluster-based system.

5.3.1 Service Area

When analyzing the Peninsula's wastewater load density (wastewater generation per land area), the existing loads are currently heavily weighted in the southern half with the anticipated increased loads occurring in the northern half of the Peninsula in the future. For the purpose of this study, the Peninsula was split into two (2) regions based upon geography and the wastewater generation differences (existing versus anticipated). A map delineating the two regions is shown on Figure 5.3-1.

The South Region is defined from Placencia Village northwards to the southern border of Placencia Resort. The North Region is defined from the Placencia Resort property on the south end to Ara Macao property on the north end.

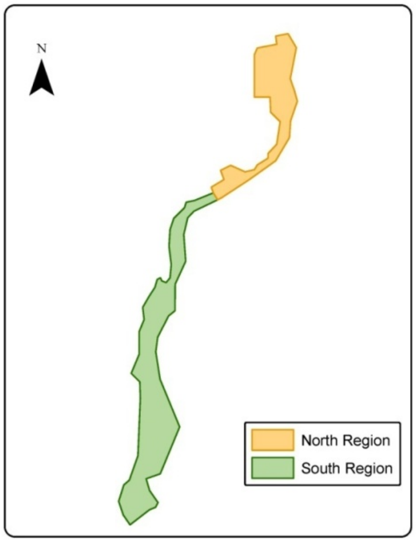


Figure 5.3-1 Service Area Region Map

The different wastewater generation characteristics of the two regions need to be considered in determining the most appropriate wastewater collection alternatives.

5.3.1.1 South Region

The hotel properties in this region are generally small cabana-style or small resorts. While this region will continue to grow, its build out is more clearly defined. In general, properties are either built on or have distinct plans for their build out. There are no major vacant parcels available for large-scale resort expansion.

5.3.1.2 North Region

This land mass is anticipated to expand via large tracts of resort-style property through a private-investor business model. Major developments at Placencia Resort / Hotel and Ara Macao will clearly change the wastewater characteristics of the Peninsula, *when and if they are developed and populated*. However, the North Region's land area is currently relatively vacant. In addition, per the assessments on file with the Department of the Environment, these larger resorts have in-house wastewater collection and treatment 'package plants' either in-place or anticipated to be installed as required upon development.

Table 5.3-1 summarizes basic information on the two regions.

Table 5.3-1 Service Area Summary Chart

Service Area	Land Area	Permanent Population Share	Current Hotel Rooms
Complete South Region	55% +/- 1,490 acres	95%	+/- 82%
North Region	45% +/- 1,250 acres	5%	+/- 18%

5.3.2 Key Facility Locations

Wastewater Treatment Plant

For the purposes of this study, four locations were assessed for the construction and operation of a wastewater treatment facility: across the Lagoon from Seine Bight Village, north of the Peninsula adjacent to Ara Macao, and within/adjacent to both Placencia and Seine Bight Villages. These potential locations are assessed within the collection alternatives in Section 5.3.3 and 5.4.1 as well as within the Environmental Feasibility Assessment in Section 8.2.

Collection Pump Station to WWTP

Alternatives that pump wastewater from the South Region of the Peninsula under the Placencia Lagoon and onto the mainland have a central collection pump station that delivers the wastewater to the WWTP located just south of Seine Bight. This location was chosen because the Placencia Lagoon is relatively narrow at this point (to decrease the length of the underwater pipe crossing) and it is also relatively centralized within the South Region.

5.3.3 Primary Collection Alternatives

5.3.3.1 Pump to Adjacent Cluster

The simplest system for moving wastewater from gravity-based clusters to the WWTP is by pumping each cluster directly into the gravity system of its neighboring cluster thus moving wastewater from cluster to cluster until it is finally pumped to the WWTP. Figure 5.3-2 is a schematic of this type of system.

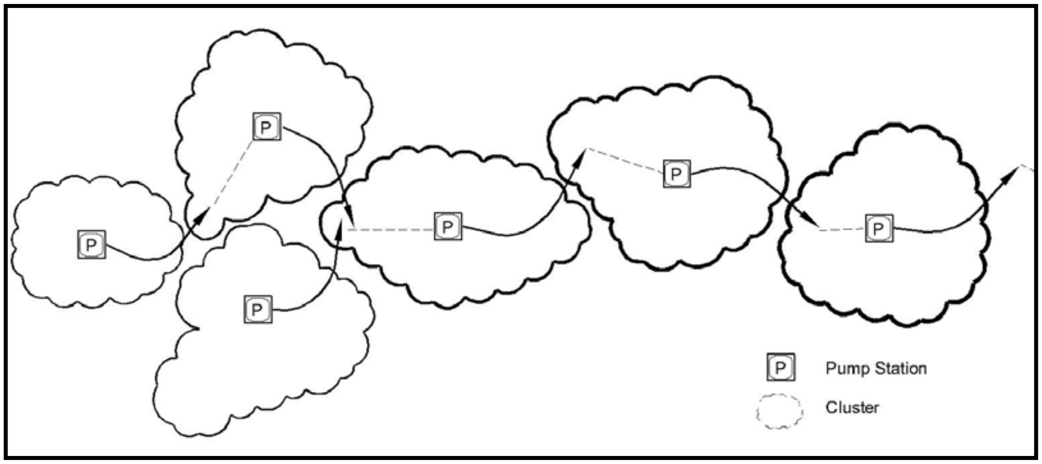


Figure 5.3-2 Cluster to Cluster Collection Concept

The advantage of this system is that each cluster pumps over short distances (only to the next cluster) and the cluster systems are hydraulically disconnected (the pump for each cluster acts independently of other clusters' pumps).

The disadvantage of this system is that the same wastewater is being pumped multiple times (the volume from the 5th cluster is being pumped by the 5th, 4th, 3rd, 2nd and 1st pump station), which requires increased wet well volume, gravity pipe sizes, and the required pump sizes.

Collection Alternative #1

Listed as "Collection Alternative #1" within the project's wastewater model, two separate 'cluster to cluster' systems pump into a collection pump station that then pumps the wastewater to the WWTP. Figure 5.3-3 is a schematic of this collection alternative. A map of this collection alternative is included in Appendix B.3. A summary of the major aspects of the collection alternative is included in Table 5.3-2.

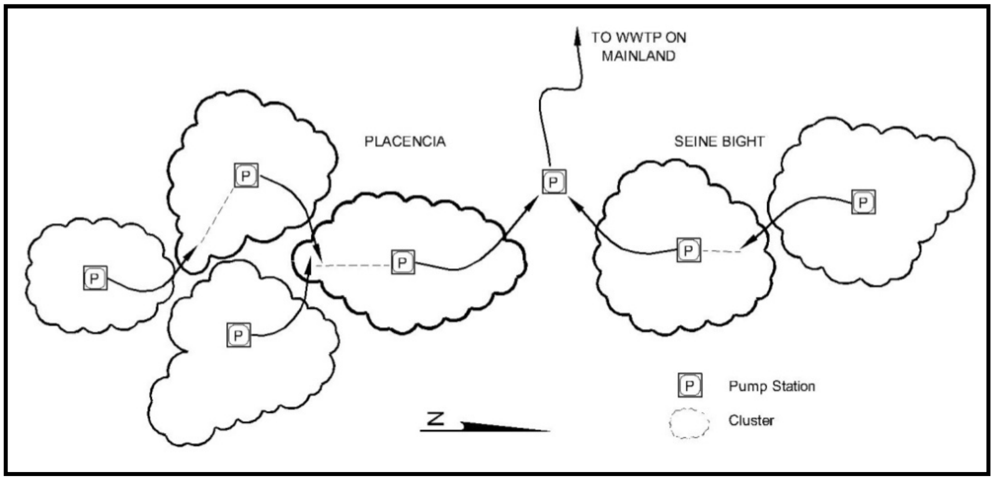


Figure 5.3-3 Collection Alternative #1 – Cluster to Cluster Model

Table 5.3-2 Collection Alternative #1 Component Summary

Scenario #1 Full Peninsula Summary		
Item	Qty	Units
Facility Connections	1,100	each
Gravity Pipe	96,400	linear feet
Pressure Pipe	87,300	linear feet
Pump Stations	39	each

5.3.3.2 Pump to Common Force Main

A second option for moving wastewater from gravity-based clusters to the WWTP is to provide a single force main from the furthest pump station to the collection pump station that every cluster ties directly into. Figure 5.3-4 is a schematic of this type of system.

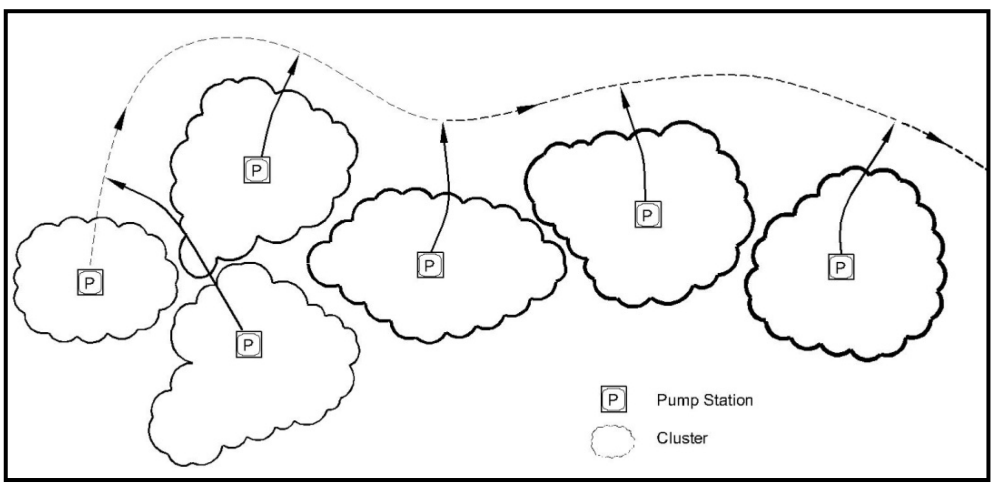


Figure 5.3-4 Common Force Main Collection Concept

The advantage of this system is that each cluster only pumps the wastewater generated within its cluster (wastewater is pumped only one time) and the wet wells are relatively small.

The disadvantage of this system is that the clusters are hydraulically connected (the pumps from each cluster are pushing against each other), which requires more detailed analysis during design and a higher standard of quality control during construction, maintenance and operation.

Collection Alternative #2

Listed as "Collection Alternative #2" within the project's wastewater model, separate 'common force main' systems pump into a collection pump station that pumps the wastewater to the WWTP. Figure 5.3-5 is a schematic of this collection alternative. A map of this collection alternative is included in Appendix B.3. A summary of the major aspects of the collection alternative is included in Table 5.3-3.

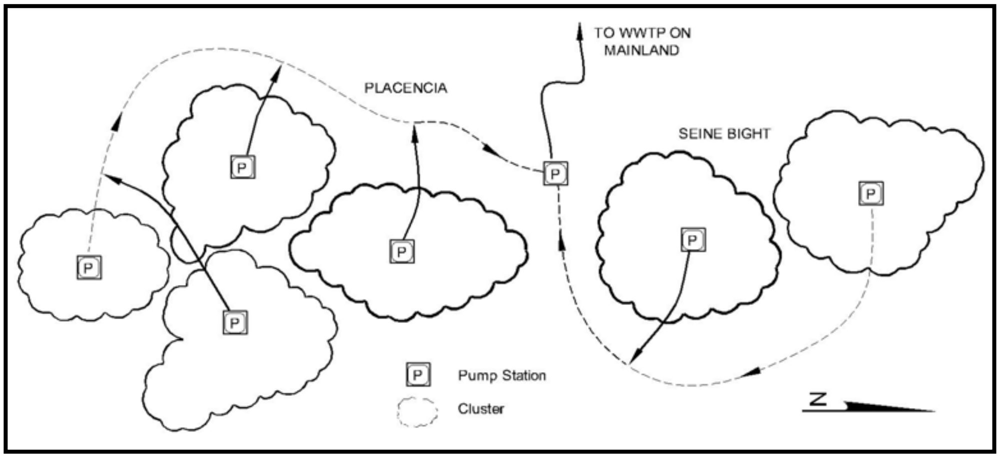


Figure 5.3-5 Collection Alternative #2 – Common Force Main Model

Table 5.3-3 Collection Alternative #2 Component Summary

Scenario #2 Full Peninsula Summary		
Item	Qty	Units
Facility Connections	1,100	each
Gravity Pipe	96,400	linear feet
Pressure Pipe	96,050	linear feet
Pump Stations	39	each

Collection Alternative #3

A second Common Force Main alternative was developed in the model looking at using 'parallel' force mains to separate flow. In Collection Alternative #2, a single force main runs from the extreme north and south end of the system to the final pump station and then into the WWTP. Alternative #3 looked at running multiple force mains to determine the cost differences between increased infrastructure (the parallel pipes) versus the smaller pumps (as each station would not have to pump against as much common force main flow). Figure 5.3-6 is a schematic of this collection alternative. A map of this collection alternative is included in Appendix B.3. A summary of the major aspects of the collection alternative is included in Table 5.3-4.

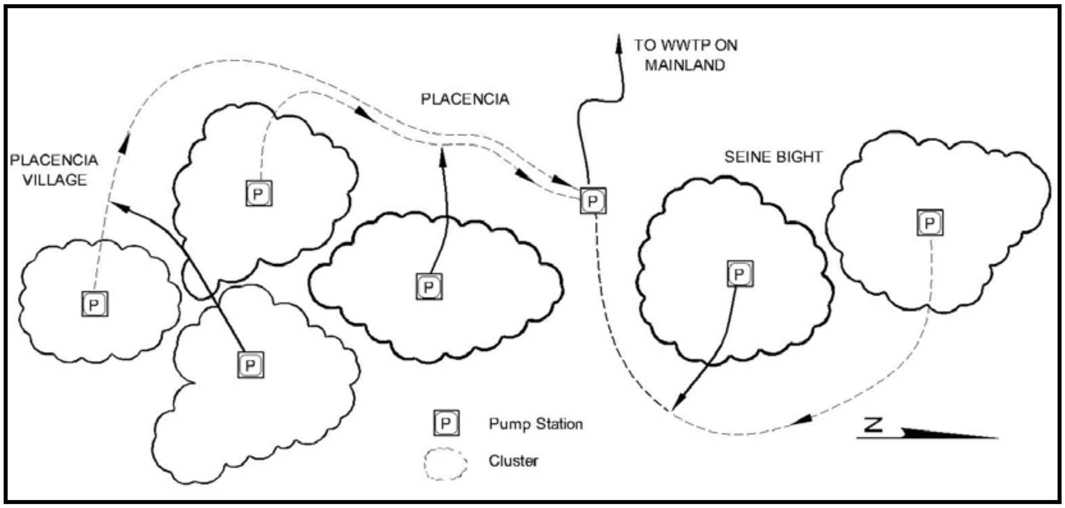


Figure 5.3-6 Collection Alternative #3 – Common Force Main Model

Table 5.3-4 Collection Alternative #3 Component Summary

Scenario #3 Full Peninsula Summary		
Item	Qty	Units
Facility Connections	1,100	each
Gravity Pipe	96,400	linear feet
Pressure Pipe	114,550	linear feet
Pump Stations	39	each

5.3.4 Individual Grinder Pumps

The preceding Collection System alternatives are based upon individual facilities connecting to the collection system by gravity. These measures are low maintenance alternatives for property owners and do not require the consumption of electricity. However, there may be circumstances where constructing a typical gravity sewer connection to a facility is either cost or physically challenging (for example, a facility very isolated from the collection system or facilities in very close proximity to each other where construction will be difficult).

A typical grinder pump connection involves gravity outflow from a facility(-ies) to drain to a small wet well (often a pre-cast manhole with lid) with a pump and a small diameter (2½") pressure line to a nearby collection system manhole. Multiple facilities can utilize a common grinder pump/wet well.

The costs associated with a grinder pump system involves the individual facility connections, manhole, grinder pump and pressure line. The typical coast for a grinder pump installed ranges from US$500-$1,000 and would have an anticipated life cycle of 7-10 years in a salt-water environment.

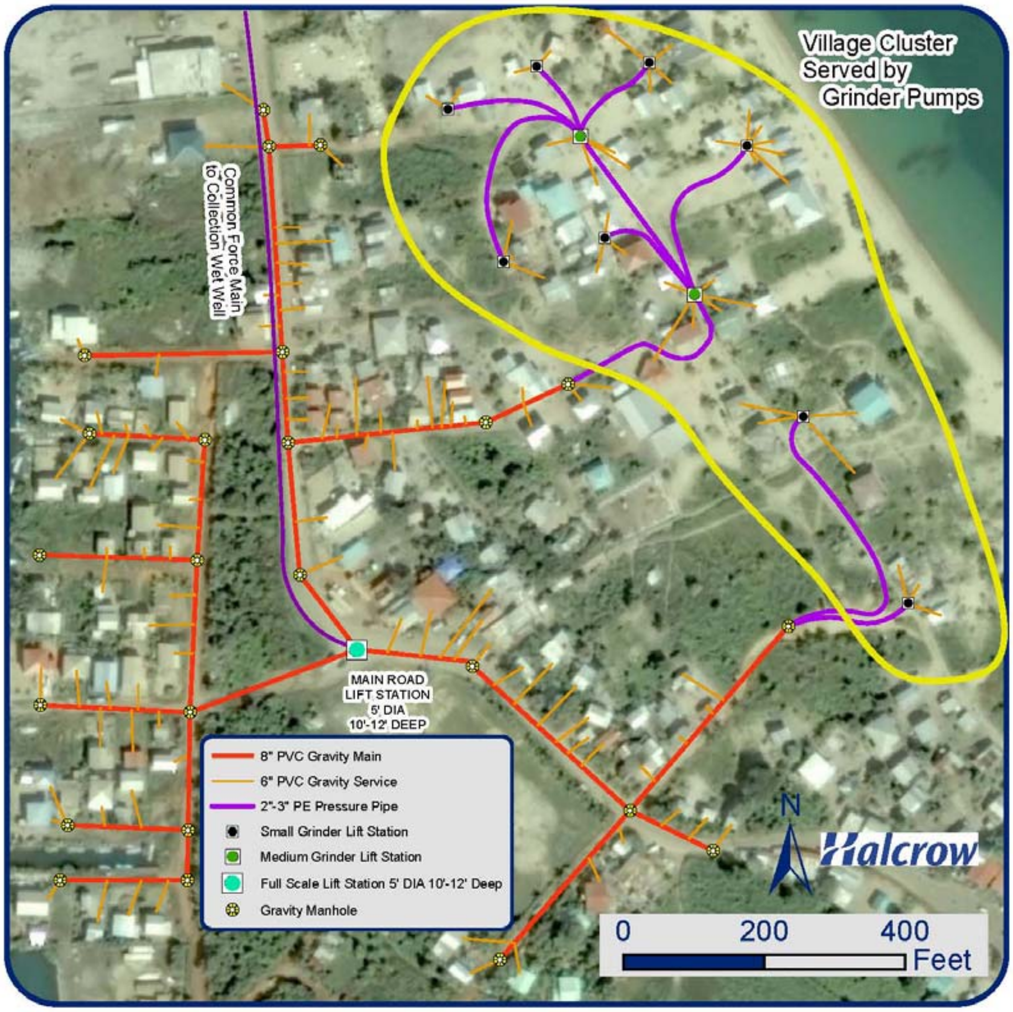
5.3.4.1 Grinder Pump Systems Cost Analysis

For the purpose of this Feasibility Study, and as an example on how to evaluate similar situations during the detailed design phase of the project, a portion of Placencia Village was analyzed to compare a gravity cluster with single lift station (Collection Alternative #2 above) with a grinder system for the same service area. For both alternatives, facilities on or immediately adjacent to the main road are served by a trunk gravity collection system with a typical lift station as outlined in Collection Alternative #2 (red pipes and main road lift station in Figure 5.3-7 and Figure 5.3-8). However, the facility connections that are off the main road and are along the beach pose a greater physical (and therefore financial) challenge to connect a typical gravity system with its relatively deep pipe and manhole installation. This area (outlined in yellow) has been selected as an example and was analyzed for two optional conveyance systems:

- Mostly gravity conveyance cluster with typical lift station and force main pumping to adjacent cluster;
- Grinder pump conveyance cluster with grinder pumps connected to each facility, and a larger collection grinder pump pumping to adjacent cluster;

Alternative Collection Technology Cluster	
	Gravity Alternative
Gravity Pipe (ft)	470
Pressure Pipe (ft)	330
Pump Station	1
Manholes	8
Quantity of Services	38

Figure 5.3-7 Wastewater Collection Example with Mostly Gravity Conveyance System



Alternative Collection Technology Cluster	
	Grinder Alternative
Length of Pipe (ft)	746
Pump	
Medium Grinder	2
Small Grinder	8
Quantity of Services	38

Figure 5.3-8 Wastewater Collection Example with Shared Grinder Pump Conveyance System

Cost estimates within this analysis follow the same methodology utilized for the overall Collection System alternatives. However, labor costs for pipe installation were increased to account for the challenge of installing the pipe in the tight spaces. Cost estimates for the two example options are summarized in Table 5.3-5 and provided in Appendix C.4.

Table 5.3-5 Cost Comparison of Gravity Cluster and Grinder Pump Systems

Collection System	Placencia Village Cluster off the Main Road serving 38 facilities, estimated 190 persons	
Capital Improvements	Collection Alternative #2	Grinder Pump Alternative
Initial Capital Costs (US$)	$210,000	$120,000
Annualized CIP (US$)	**$14,300**	**$8,200**
Operations and Maintenance		
Annualized O&M (US$)	**$4,000**	**$6,700**
Total Annualized Expenses:	**$18,300**	**$14,900**
Estimated Accounts:	*38*	
Annual Cost per Service	$482	$392

During the detailed design phase of the project, the Consultant will evaluate the most cost effective solution for cluster areas with limited accessibility for gravity conveyance systems. Cost estimates for grinder systems will depend on the quantity of facilities connecting to the pump and the distance from the pump to the collection system. For the example scenarios analyzed above, the grinder system was approximately 20% less expensive by annual costs than the typical gravity collection with pump station alternative. As shown in Appendix C.4, the cost difference is primarily due to the cost increases due to the challenge of physically constructing the system, which varies across the Peninsula.

Wherever a grinder system is considered along the Peninsula, a more complete analysis will be required during the detailed design phase of the project to make a more accurate assessment of the installation challenges, and the costs between the alternative collection systems.

For the purpose of the overall project costs within this study, it is assumed that installing grinder pumps as needed does not affect the overall project budget. If grinder pumps are chosen during the detailed design phase of the project, the decision will be primarily made based upon the physical challenge of installing the gravity collection system.

5.3.4.2 Grinder Pump System Implementation Considerations

Installing grinder pumps to facilitate wastewater collection may be considered when facilities are not more readily suited for typical gravity collection connections. When implementing a grinder system, the following need to be considered:

- System ownership, operation and maintenance, and pump replacement responsibilities: by either the individual property owner(s) or by the utility that provides the service.
- Need to develop a contingency plan to manage wastewater during periods of electrical power outage (i.e. storm events).

While grinder pumps are options for facility connections, they require electrical connections and maintenance and will require specific agreements between BWSL and individual property owners. It is recommended to use these systems sparingly.

5.3.5 Engineers Without Borders Collection Concepts

In Section 3.4 of the "Wastewater System Feasibility Study for Placencia Peninsula, Belize" report prepared by Engineers Without Borders (EWB) – Sacramento Valley Professional Chapter and dated June 2006, three (3) wastewater collection alternatives were presented and analyzed. Capital cost estimates for the preferred collection system paired with three (3) treatment solutions are provided in the report (estimated at US$ 10M – 12M). However, the costs are not broken down by scope (collection or treatment); therefore these costs cannot be directly compared with the wastewater collection system alternatives provided in this report. A summary of the EWB report is included below.

5.3.5.1 EWB Collection Alternative #1 – Gravity Collection System

This alternative is comparable to the gravity-based system with the "cluster" concept presented in each of Halcrow's collection alternatives above. It is not clear from the Engineers Without Borders (EWB) report whether they considered a single gravity-based system or a series of smaller clusters as outlined in Section 5.3.3.1.

Based upon the high water table and concerns for groundwater infiltration into the gravity pipe, EWB did not consider this system as a viable alternative for the Peninsula.

5.3.5.2 EWB Collection Alternative #2 – Vacuum Collection System

A vacuum system uses pressure within a pipe system to 'pull' wastewater from various cisterns to a pump station or WWTP. Some quantity of facilities would gravity drain into a local cistern, where the wastewater would be 'sucked' into the pressure-pipe system.

Based upon anticipated maintenance costs and lack of local knowledge of this system type, EWB did not consider this system as a viable alternative for the Peninsula.

5.3.5.3 EWB Collection Alternative #3 – Pressure Wastewater

This alternative is an expansion of the Individual Grinder Pump Alternative provided above, with every facility having its own grinder pump that connects to a pressure pipe to be pushed to a pump station or WWTP. The pressure pipe concept is comparable to Collection Alternatives #2 and #3. This solution requires an electrical connection for every facility.

EWB recommends this alternative for the Peninsula.

5.3.5.4 Halcrow's Assessment of EWB Collection Alternatives

The three (3) alternatives provided by EWB are appropriate to consider for this type of project. Alternative #1 is a traditional gravity wastewater system. EWB is understandably concerned about groundwater infiltration into the gravity pipe (see Sections 3.3 and 5.2). However, if proper material is selected, specifications are written and followed, and the installation is effectively performed, this system is a low-maintenance solution that allows facilities to tie into the system without long-term expense to the individual property owner and a clear demarcation of responsibility between the governing wastewater entity and the property owner.

Alternative #2 requires stable and relatively large amounts of power to provide consistent suction pressure on the system. It also requires consistent maintenance. This system is ideal for low-density, hilly property, but is not an appropriate design solution for the Peninsula.

Alternative #3 is a growing design solution in the United States. EWB's recommended product manufacturer (eOne) has a strong and successful history as the leader in this technology. The primary concern for this system is the individual pump system that each facility (wastewater connection) must install and maintain (including electrical costs). The system blurs the 'line' between the governing wastewater entity's and the individual property owner's responsibility.

5.3.6 Collection Challenges

There are logistical, physical and legal challenges and responsibilities to ensure that the wastewater is effectively collected for treatment.

5.3.6.1 Physical Challenges

While this study looks at the conceptual collection system, there will be physical challenges 'on the ground' that will need to be thought through on a case-by-case basis. There are constraints as to how deep the pipe system can be built as well as objects (trees, buildings, utilities, etc.) that will have to be avoided throughout the project construction. Every facility tie-in to the wastewater system will have to be analyzed; in addition, work will have to take place on some of the buildings in order to connect to the system.

5.3.6.2 Legal Challenges

The Peninsula is dominated by private property, with many property tracts not having a direct access to a public right-of-way. This is especially true in both Placencia and Seine Bight villages. It will be necessary to determine property ownership and obtain the necessary approvals (easements or land purchases) prior to the installation of many portions of the collection system. Depending on the extent of the public right of way, additional construction easements or land purchases may be required in order to build the collection trunk line.

For the purpose of this study, including wastewater generation volumes and system schematic designs, it has been assumed that all facilities will be mandated to connect to the constructed collection system. The decision of whether to create and enforce a mandatory connection to the system will carry additional legal challenges.

5.3.6.3 Land Purchase

Each system option requires some amount of land to be purchased. Selection, negotiation and purchase of the land may play a major role in which alternative is chosen and in the final detail design.

5.3.6.4 Hurricanes

It is recommended that a flood study be performed during the Final Design to determine the historic surge and flooding extents. When possible, all pump station openings are to be raised above the flood elevation. If a station is inundated via a large storm or hurricane event, BWSL is to have emergency procedures to bring the station back online within a reasonable time frame, depending on the severity of the flooding event.

5.4 Wastewater Treatment Alternatives

The purpose of this project is to provide the Peninsula population a safe and effective wastewater treatment system, protecting public health and maintaining a healthy environment. Ideally, the entire population would be connected to this system. The system design assumes that all existing and future wastewater generators within the proposed service area connect to the collection system and are brought to the treatment system.

Potential exceptions to this requirement are:

- Resort facilities with active wastewater treatment plants that are permitted and in compliance with DOE regulations. While these facilities may not connect to the system as it is brought on-line, it is recommended that they continue to treat their wastewater to DOE standards. If a facility is not able to consistently meet these standards, it is recommended that they connect to the central system. In the long-term, it is preferable for these facilities to discharge into the central system to ensure long-term treatment quality.

- For locations too far removed from adjacent collection systems, it is generally financially or physically impractical to connect to the central system. In these circumstances, efforts need to be made to ensure that their individual decentralized systems are compliant with DOE regulations and the intent of the overall project through the installation of a functioning septic tank and absorption field as detailed in Section 4.5.4.

Depending on the quantity of these tie-in exceptions, it may be necessary to relook at the collection system analysis and the treatment system schematic design. These exceptions will likely effect the project's economic analysis, changing both the capital costs and the projected service income of the overall project.

5.4.1 Treatment Facility Location

Selecting a location for the Wastewater Treatment and potential Disposal Facility requires balancing various stakeholder interests:

- Land Area – the required land area varies depending on the type of wastewater treatment and nutrient removal facility constructed. The availability and expense of this land purchase, as well as any infrastructure required to access this land, needs to be taken into account in determining a final WWTP location.
- Adjacent Parcels – consideration must be given to the neighbors of the proposed facility, and to their potential concerns.
- Expense of Wastewater Transport – moving wastewater from the generation points (primarily in the two villages) to the WWTP has an associated cost. This is specifically true when considering pumping the wastewater under the Placencia Lagoon to the mainland or to the northern end of the Peninsula.

As indicated in Section 5.3.1, the Peninsula was divided into two regions based upon the geographic location of the current population and the anticipated population.

- The South Region is defined from Placencia Village to the southern border of Placencia Marina.

- The North Region is defined from Placencia Marina north to the Ara Macao property.

However, the south region generates an estimated 91 percent of the current wastewater and the large wastewater generators in the north region are currently served by in-house wastewater collection and treatment 'package plants' already in-place. The centroid of wastewater is in the southern region, between the two villages.

The following locations for treatment and disposal facilities have been considered during this study:

1. South Region Mainland – Collection Alternatives #1, #2 and #3 from Section 5.3 all assume that the wastewater is being collected at a central point on the Peninsula (just south of Seine Bight) and then pumped under the lagoon to the mainland. The facility would be located far away from high-value land, and the crossing location could be chosen to minimize the length the wastewater is required to travel (decreasing pumping costs) along the peninsula.
    a. Independence Village may choose to tie into the proposed treatment facility.
2. North Region Mainland – at the north end of the Peninsula, along the western boundary of the Ara Macao property.
3. Placencia Airport – adjacent to the Placencia airport on the Lagoon side.
4. Seine Bight Village – on a property along the south side of the village.

Based upon the physical constraints of the peninsula as well as the value of the land for permanent residence and tourist facilities, it may be that the installation of a treatment facility on the Peninsula is not a physically reasonable or cost effective design solution.

These treatment locations specified within the collection alternatives can be adjusted as further feedback is provided and project assessment occurs. The final location of the WWTP can be adjusted within each of the collection alternatives without altering their individual effectiveness. The primary change centers on pump expense, depending on how far the wastewater is pumped from its source to the WWTP.

5.4.1.1 Analysis of South and North WWTP Locations

It does not seem likely that the WWTP will be constructed on the Peninsula. The land requirements are likely cost prohibitive, and social acceptance is likely low. There are various advantages and disadvantages to locating the WWTP and Nutrient Removal facility at both the South and North locations. Figure 5.4-1 shows the estimated location for both the South and North WWTP.

South Advantages

- Land is free from the central government and available for the project
- Relatively close to the center of the Peninsula
- Relatively close to the centroid of the wastewater generation
- Removed from the population

South Disadvantages

- Across the Lagoon, which limits access to boat crossings
- Wastewater is piped under the Lagoon, which presents monitoring challenges

North Advantages

- Proximity to agricultural plantations for potential effluent reuse
- Accessible by road (to be constructed)
- Avoids the pipe crossing under the Lagoon

North Disadvantages

- Public land is not available. Land would not likely need to be purchased.
- Location is at the opposite end of the Peninsula from the main wastewater generation source (Placencia Village).
- Increased pumping expenses to move wastewater to site.

The advantage of either location in regards to effluent reuse for agricultural purposes is unknown at this time. There are potential effluent-purchasers near both locations. A market-analysis of potential purchasers would need to be completed to determine which location is most suited for this consideration.

An environmental assessment of these locations is provided in Section 8.2.

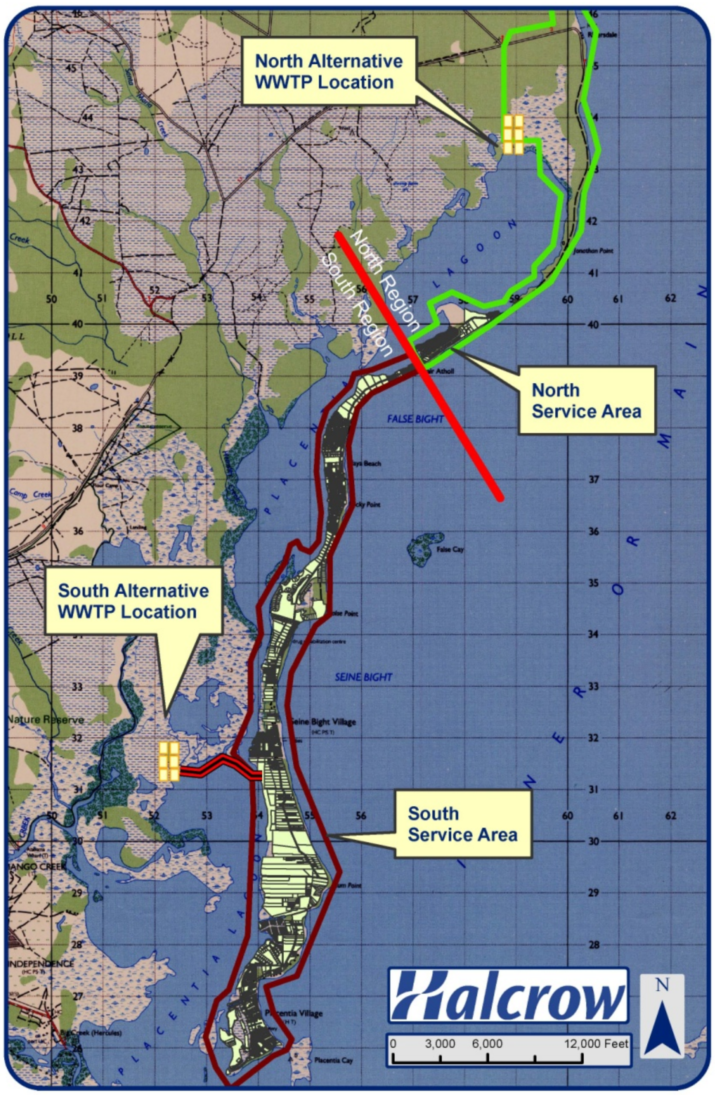


Figure 5.4-1 Treatment Facility Location Options: South and North

5.4.1.2 Lagoon Crossing

The South WWTP location requires that the effluent be pumped under and across the Placencia Lagoon. Crossing water-bodies with pressurized pipes is a common construction method; the water supply line for the Peninsula crosses the Lagoon from Independence Village. However, there are some considerations that must be made to ensure that the crossing is effective and environmentally safe through the project life cycle.

It is recommended that the crossing be made with scour-resistant, thickened-wall High Density Polyethylene Pipe (HDPE) compliant with *PAS 1075: Pipes made from Polyethylene for alternative installation techniques* using fused joints and being anchored along the Lagoon bottom at pre-determined intervals to ensure that the pipe does not float or slide. If properly installed, the risk of leaks into the Lagoon is minimal. Pipe crossing burial and anchoring details are provided in Appendix C.5.

To monitor for leaks, a SCADA alarm system can be installed at the treatment plant headworks to monitor the incoming pressure to compare against the outgoing pressure at the main Peninsula pump station to ensure that the correct pressure differential exists and to set an alarm if this differential falls out of an established range (which would indicate a leak out of the pipe). In addition, fecal coliform testing can be performed periodically on the Lagoon water along the extent of the force main crossing.

5.4.2 Treatment Technology Alternatives

Section 4.5 discussed the various wastewater treatment technologies considered by Halcrow for this study, which include:

- Alternative #1: Facultative Lagoons with Maturation Ponds
- Alternative #2: Aerated Lagoon with Maturation Pond
- Alternative #3: Extended Aeration System

For the purpose of this study, the location of the WWTP (either South or North) does not effect the evaluation of the various treatment alternatives. The technologies can be effectively employed in either location.

5.4.3 Engineers Without Borders Treatment Concepts

In the Section 3.4 of “Wastewater System Feasibility Study for Placencia Peninsula, Belize” report prepared by Engineers Without Borders (EWB) – Sacramento Valley Professional Chapter and dated June 2006, four (4) wastewater treatment alternatives were presented and analyzed. Capital cost estimates for the preferred collection system paired with three (3) treatment solutions are provided in the report (estimated at US$ 10M – 12M). However, the costs are not broken down by scope (collection or treatment); these costs cannot be directly compared with the wastewater collection system alternatives provided by Halcrow in this report. A summary of the EWB report is included below.

5.4.3.1 EWB Treatment Alternative #1 – Facultative Pond

This Natural Treatment System alternative is comparable to the Facultative Pond presented in Section 4.5.2. This treatment system type is not chosen as the preferred alternative within the EWB report, although no reason is given for this choice.

5.4.3.2 EWB Treatment Alternative #2 – Aerated Lagoons

This Hybrid Treatment System alternative is comparable to the Aerated Lagoon system presented in Section 4.5.3. The advantage of this treatment system is based upon its smaller land size and being less odorous than the Facultative Pond.

5.4.3.3 EWB Treatment Alternative #3 – Package Plant

This Conventional Treatment System alternative is comparable to the Package Plant system presented in Section 4.5.1. The advantage of this treatment system is its small footprint, although it requires a relatively large amount of electricity.

5.4.3.4 EWB Treatment Alternative #4 – Constructed Wetlands

In practice, the treatment methodology of a Constructed Wetland alternative is most comparable to the Facultative Lagoon system presented in Section 4.5.2 although the system is difficult to manage over the long term and is not provided as an alternative by Halcrow. This treatment system is presented within the EWB report as the 'selected alternative' for recommendation by EWB.

5.4.3.5 Halcrow's Assessment of EWB Treatment Alternatives

The four (4) alternatives provided by EWB are appropriate to consider for this type of project. Alternatives #1 – #3 directly coincide with alternatives provided by Halcrow. Alternative #4 (Constructed Wetlands) is EWB's recommended alternative; however, Halcrow does not recommend this alternative because of the difficulty in managing and maintaining a Constructed Wetland system. A few additional concerns regarding this system:

- Potential mosquito breeding ground in shallow portions of pond;
- Difficulty managing vegetative growth;
- Potential for hydraulic shortcuts, whereby influent wastewater develops channels through and passes out of the system quicker than required to provide proper treatment;
- Larger land requirement than all other options.

5.4.4 Treatment Challenges

There are logistical, physical and legal challenges and responsibilities to ensure that the wastewater is effectively treated.

5.4.4.1 Physical Challenges

The primary wastewater treatment challenge is the area's proximity to water: surface water and groundwater. The location and design of both the centralized system and individual decentralized systems will need to take this into account.

Depending on the location of the centralized treatment system, it may be necessary to extend transportation infrastructure to the property.

5.4.4.2 Legal Challenges

The primary legal concern for this project is ensuring that existing facilities either tie into the proposed collection system for treatment or install and maintain a permitted individual treatment system (septic tank and absorption field).

5.4.4.3 Land Purchase

Selection, negotiation and purchase of the land may play a major role in which alternative is chosen and in the final detail design. It is recommended that the treatment facility site be located as high an elevation above potential flooding concerns as reasonable.

5.4.4.4 Hurricanes

It is recommended that a flood study be performed during the Final Design to determine the historic surge and flooding extents. The WWTP site is to be constructed above the 100-year flood zones. However, if the WWTP station is inundated via a large storm or hurricane event, BWSL is to have emergency procedures to bring the facility back online within a reasonable time frame, depending on the severity of the flooding event.

For the facultative lagoon WWTP alternative, a flood event can be handled with relatively minimal expense, as there are little to no mechanical processes involved.

5.5 Effluent Reuse and Disposal Alternatives

As discussed in Section 4.4, Belize does not legislatively require advanced treatment for the removal of nutrients from domestic wastewater. However, given the sensitive environmental context of the Peninsula as well as the role this project may have for future projects in the greater Caribbean region, initial minimum standards for nutrient removal have been initially established as shown on Table 4.4-1.

5.5.1 Effluent Reuse Strategy

The proposed long-term effluent disposal strategy is to make the treated effluent available for agricultural reuse. Prior to completing the implementation of this option, a market research needs to be conducted in order to evaluate this option and determine the willingness to pay and capacity to receive treated effluent by nearby farmers. Figure 5.5-1 presents a map of the neighboring farms and a schematic of the potential expansion of the discharge system to these properties.

Expansion of the discharge system would require purchase agreements with the property owners as well as additional capital improvements, including:

- Pipeline to the agricultural customers;
- Electrical supply installed at the treatment facility;
- Pump system installed at the treatment facility; and,
- Flow meter(s) to determine the quantity of effluent distributed to agricultural customers, and
- Contingency and environmental mitigation plan for wet-weather discharges during times when irrigation customers do not have a need for the treated effluent.

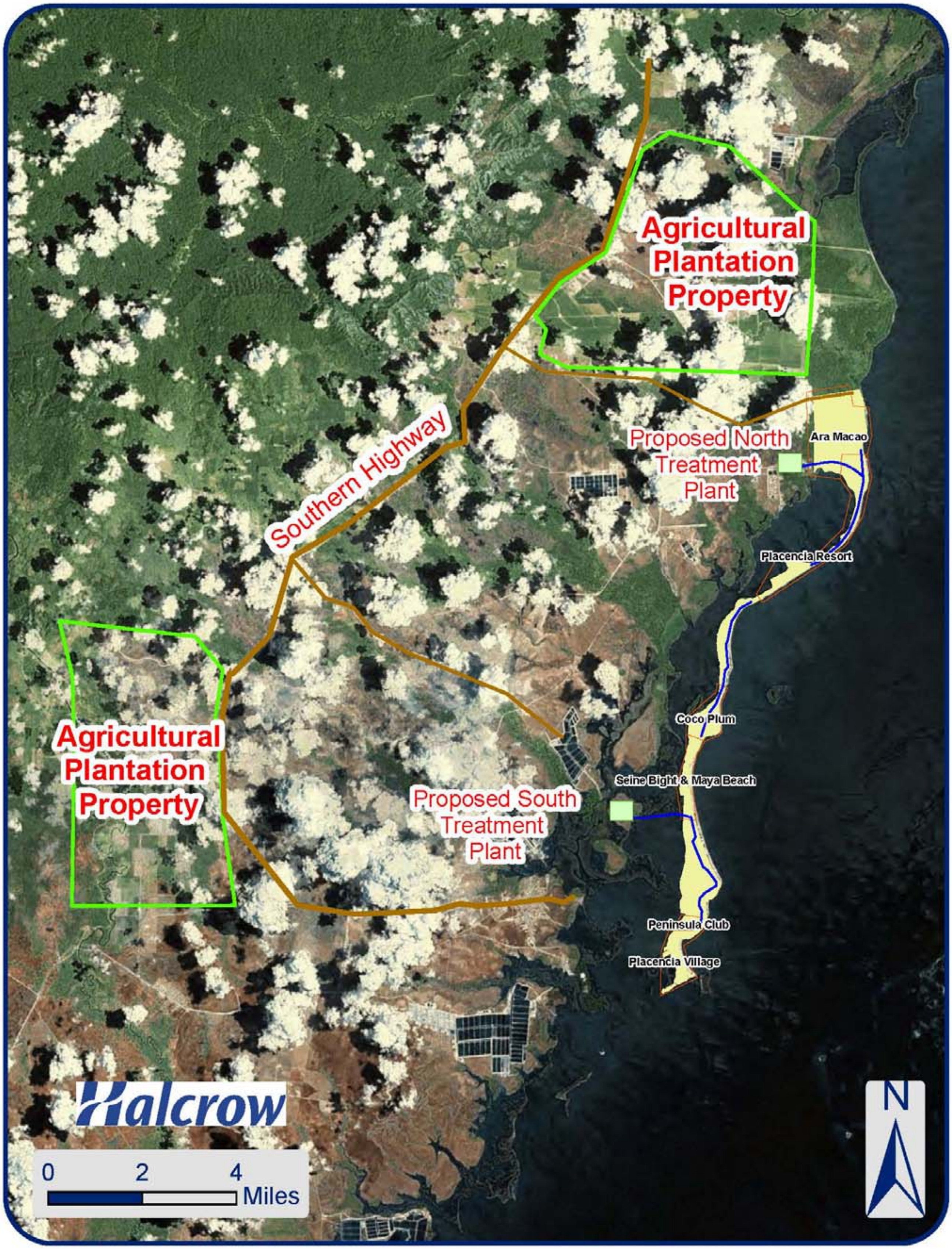


Figure 5.5-1 Effluent Discharge to Agricultural Irrigation

5.5.1.1 Preliminary Effluent Reuse Analysis

As previously indicated, an effluent market analysis will be necessary to determine necessary details needed for a proper evaluation of this option, including the final location of potential effluent customers. Figure 5.5-2 summarizes the major components of the agricultural reuse system.

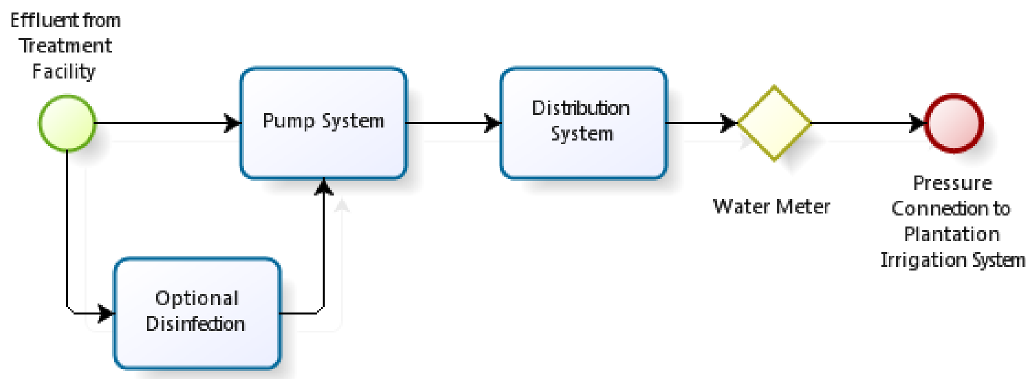


Figure 5.5-2 Agricultural Reuse System Process Flow Diagram

Effluent Market Analysis Schematic Scope of Work

This analysis should include a local information survey, at a minimum:

- Potential Customers
  - Create an inventory of potential users and locate them on GIS;
  - Determine current and future water needs (demand) for each user;
  - Determine existing water sources that the treated effluent would supplement;
  - Estimate existing water source reliability as a available irrigation redundancy (i.e., potable water availability in the absence of reclaimed water);
  - Determine estimated timing of irrigation needs (seasonal, year round, daily and hourly demand variations);
  - Determine necessary water pressure;
  - Project future land use trends that could eliminate reclaimed water use such as converting farm lands to urban and commercial development;
  - Inform potential users of applicable regulatory requirements, projected quality of wastewater at various level of treatment compared to fresh water sources;
- Regulatory Parameters
  - Finalize water quality objectives and regulatory requirements;
  - Use World Health Organization Recycled Water Regulations or reference, or other applicable regulations;
  - Determine ordinances or regulatory enforcement needed to be established by the Government to make the program work;
  - Establish permitted uses based on various level of treatment;
  - Cooperate with wholesale and retail water agencies or water boards;
- Economic Analysis
  - Determine cost of existing source of water and fertilizers as a baseline for current user expenses;

  - Establish willingness to pay by end user;
  - Determine break-even and profit-based reclaimed water tariff and pricing;
  - Estimate potential monetary savings on reclaimed water, payback period and return on investment;
  - Estimate timeframe to begin using reclaimed water;

Preliminary Effluent Reuse Assessment

The following assumptions are made for this preliminary assessment:

- The infrastructure (pipe and pump system) from the Treatment Facility to receiving agricultural plantation(s) is to be built and maintained by BWSL.
- The purchasing client willing and able to purchase 75% of the treated effluent, accounting for wet-weather events, when irrigation is not needed. This assumption is utilized in the initial tariff analysis provided in Section 11.7.
- Belize regulations allow use of treated effluent for Agricultural irrigation.
- This analysis focuses on the economic considerations for effluent reuse. Future considerations need to be made regarding environmental and socio-economic factors.
- The Government of Belize and the Department of Environment will consider new regulatory requirements necessary to incentivize use of treated effluent for irrigation.

Additional operational considerations for the effluent reuse system include:

- World Health Organization[xxv] recommended microbiological quality guidelines for wastewater use in agriculture, Category A crops (including likely to be eaten uncooked) provides a maximum fecal coliform limit at <1,000 MPN/100ml.
- The treatment facility technologies analyzed within this study all reduce fecal coliform counts to below this threshold; however, this factor will require regular monitoring at the proposed treatment facility to ensure it is met.
- Disinfection system may be added at the treatment facility prior to distributing effluent to plantation to eliminate fecal content on produce.
- The nutrient loading within the treated effluent will likely be one of the primary drivers behind the effluent's commercial value. Nitrogen (and to a lesser extent, Phosphorus) within the effluent will help to supplement the fertilizer requirements of the customers, decreasing their net fertilizer expenses.
  - A major factor in purchasing party's willingness to pay for the effluent is based upon the nutrient loading in the effluent.
  - The customers will want assurance that the effluent is consistent in quality and quantity.

In preparing an initial agricultural reuse conceptual design, the following preliminary assumptions were made:

- Length from the treatment facility to the plantation: 2.5 miles, the estimated distance from the proposed north treatment facility location and the neighboring banana plantation to its north;
- Pressure at the delivery point to the plantation: 30 psi;
- Duplex pump station at treatment facility using a storage pond constructed downstream of the maturation pond as a 'wet well';

- Storage provided in storage pond for five (5) consecutive days (about 3 MG).
- Effluent is metered at the Plantation;
- Construction estimate does not include bringing electrical power to the treatment facility site;

Initial conceptual design calculations and cost estimates are included in Appendix E.1.

Environmental Impact of Effluent Reuse

A complete environmental analysis of an effluent reuse system will be based upon the specific design and implementation of the system. However, generalized benefits include:

- Reduction of water withdrawal from surface and subsurface sources;
- Reduction of required additive fertilizer;
- Reduction of effluent disposal into Placencia Lagoon ecosystem, with subsequent concerns regarding nutrient loadings

5.5.2 Effluent Disposal Strategy

During the final design, a study of the fate and transport of nutrients and baseline conditions should be conducted to determine if the Placencia Lagoon and mangrove system has the assimilative capacity to handle the proposed nutrient loadings. The information from this study is important in determining which of the proposed nutrient treatment alternatives is most environmentally appropriate for this system.

Each of the three treatment technologies evaluated within this study (see Section 5.4) have varying degrees of nutrient removal capacity within the treatment system. The nutrient reduction capacity of the treatment facility has a direct correlation to the nutrient treatment requirements of the tertiary treatment system.

Initial Nutrient Reduction: Facultative Lagoon

Figure 5.5-3 shows the natural process of nutrient reduction within a facultative lagoon system. Figure 5.5-4 and Figure 5.5-5 provide a summary of the total phosphorus and nitrogen removal, respectively, for BWSL' Belize City and San Pedro facultative lagoon systems. These facilities are designed for primary and secondary treatment only. The nutrient uptake is a by-product of these treatment systems.

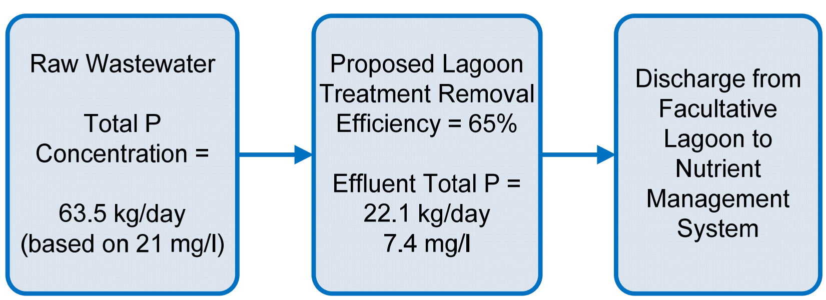
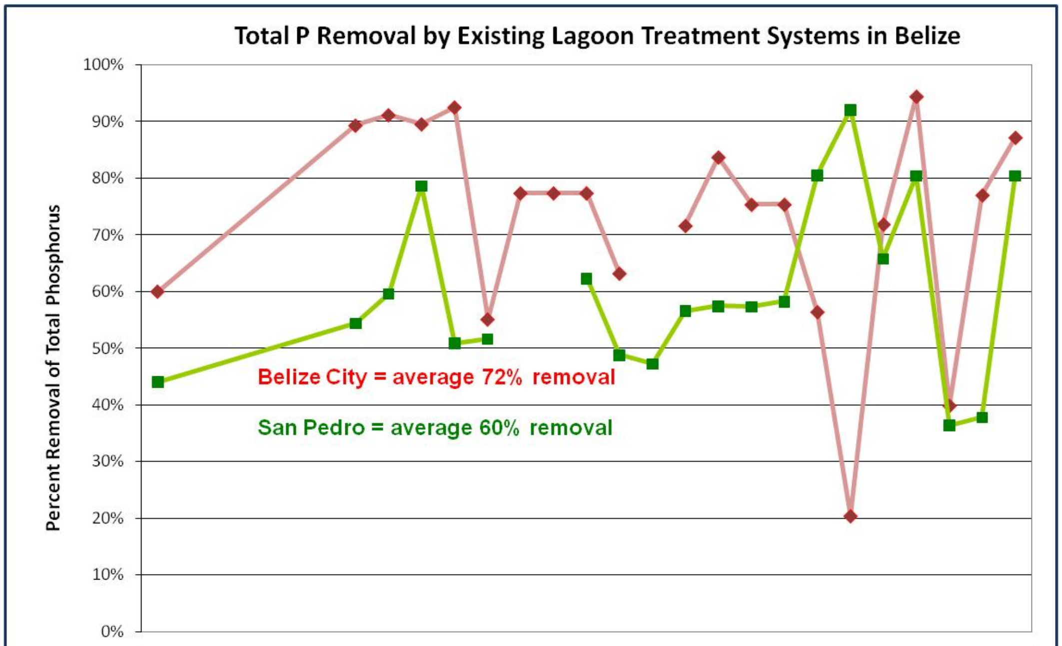
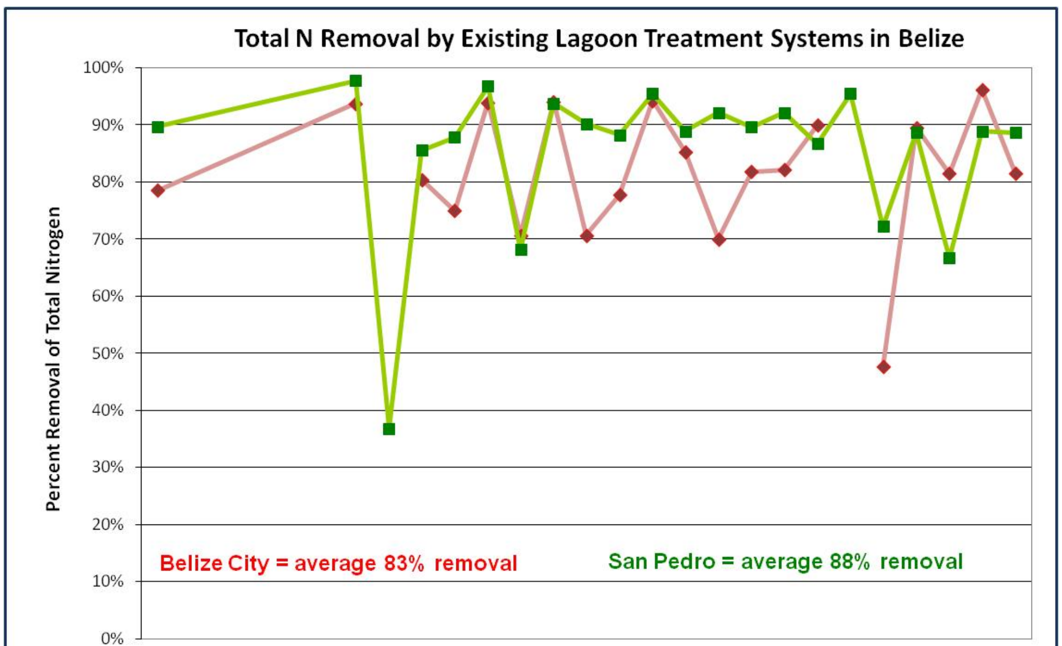


Figure 5.5-3 Nutrient Uptake within Facultative Lagoons



	S-09	M-10	A-10	M-10	J-10	J-10	A-10	S-10	O-10	N-10	D-10	J-11	F-11	M-11	A-11	M-11	J-11	J-11	A-11	S-11	O-11	N-11
BELIZE CITY	60%	89%	91%	90%	93%	55%	77%	77%	77%	63%		72%	84%	75%	75%	56%	20%	72%	94%	40%	77%	87%
SAN PEDRO	44%	54%	60%	79%	51%	52%			62%	49%	47%	57%	57%	57%	58%	81%	92%	66%	80%	36%	38%	80%

Figure 5.5-4 Phosphate Removal within BWSL Systems, 2009-2011



	S-09	M-10	A-10	M-10	J-10	J-10	A-10	S-10	O-10	N-10	D-10	J-11	F-11	M-11	A-11	M-11	J-11	J-11	A-11	S-11	O-11	N-11
BELIZE CITY	79%	94%		80%	75%	94%	71%	94%	71%	78%	94%	85%	70%	82%	82%	90%		48%	90%	82%	96%	82%
SAN PEDRO	90%	98%	37%	86%	88%	97%	68%	94%	90%	88%	95%	89%	92%	90%	92%	87%	95%	72%	89%	67%	89%	89%

Figure 5.5-5 Nitrates Removal within BWSL Systems, 2009-2011

Based on previous investigations conducted on similar facultative lagoons/maturation ponds systems and BWSL records from their Belize City and San Pedro facultative lagoon systems, the anticipated total phosphorus and nitrogen removal mechanisms of the proposed treatment system are provided in Table 5.5-1. Phosphate precipitation can be enhanced by chemicals addition, but this is not initially recommended.

Table 5.5-1 Nutrient Removal within Facultative Lagoon and Maturation Pond System

Nutrient	Anticipated % Removal
Total Phosphorus	65%
Total Nitrogen	85%

The nutrient reduction is accomplished through the natural processes occurring within the primary and secondary treatment systems. The main mechanism of phosphorous and nitrogen removal will be through algae uptake. Table 5.5-2 summarizes the anticipated tertiary treatment capacity of a Facultative Lagoon treatment system.

Table 5.5-2 Nutrient Removal Summary, Facultative Lagoon System

Nutrient	Proposed Disposal Standards	Influent	Facultative Lagoon Removal	Effluent
Phosphorus	3.5 mg/l	21 mg/l	65%	< 7 mg/l
Nitrogen	5 mg/l	20 mg/l	85%	< 3 mg/l

Utilizing the facultative lagoon system as a partial treatment system for nutrient removal does not require any additional capital improvement or operations and maintenance costs; it is a natural process within the primary and secondary lagoon treatment system.

These reduction numbers need to be further validated during the final design phase of the project as the nutrient management system is developed. At a minimum:

- BWSL should continue monitoring the nutrient removal efficiency of the existing treatment systems in Belize City and San Pedro, to validate the assumed removal efficiencies, and
- A research study should be conducted as part of the final design to determine the baseline conditions of nutrients in the Placencia Lagoon and the nutrient uptake rates of local mangrove systems. This action should not affect the overall project schedule. The study should be conducted prior to the final determination of the effluent disposal scope and in parallel with the site survey activities.

Alternative #2 Aerated Lagoon - Nutrient Reduction

The Aerated Lagoons with a Maturation Pond alternative are estimated to take in ~40% of the nutrient uptake of an equivalent Facultative Lagoon system (based upon a comparison of surface areas between the two alternatives), summarized in Table 5.5-3. Phosphate precipitation can be enhanced by chemicals addition, but this not initially recommended.

Table 5.5-3 Nutrient Removal within Aerated Lagoon and Maturation Pond System

Nutrient	Anticipated % Removal
Total Phosphorus	25%
Total Nitrogen	33%

The nutrient reduction is accomplished through the natural processes occurring within the primary and secondary treatment system. The main mechanism of phosphorous and nitrogen removal will be through algae uptake. Table 5.5-4 summarizes the anticipated tertiary treatment capacity of an Aerated Lagoon treatment system.

Table 5.5-4 Nutrient Removal Summary, Aerated Lagoon System

Nutrient	Proposed Disposal Standards	Influent	Aerated Lagoon Removal	Effluent
Phosphorus	3.5 mg/l	21 mg/l	25%	< 16 mg/l
Nitrogen	5 mg/l	20 mg/l	33%	< 14 mg/l

Utilizing the facultative lagoon system as a partial treatment system for nutrient removal does not require any additional capital improvement or operations and maintenance costs; it is a natural process within the primary and secondary lagoon treatment system.

Alternative #3 Extended Aeration - Nutrient Reduction

The Extended Aeration alternative has negligible nutrient uptake. The nutrient removal system that follows the wastewater treatment system will need to account for the full influent nutrient loading in its design.

5.5.2.1 Nutrient Treatment via Nutrient Ponds

Nutrient-removal ponds can be constructed to provide further uptake of nutrients from the effluent prior to disposal. The effect of these ponds is presented on Figure 5.5-6. These ponds' sole purpose is to remove nutrients via floating plant species (namely, Water Hyacinth, genus Eichhornia, a native plant to Central America). Nutrient uptake is directly related to the surface area of active plants, which in turn is based upon the size of the pond. The required pond size varies depending on the WWTP system technology and nutrient concentrations entering the pond system. The ponds are relatively shallow (12" – 18"), just deep enough to sustain the plant species.

Within this alternative, measures must be taken to harvest the plants from the system to ensure that newer growth continuously takes in the nutrients. A drying area will be required to store the harvested material. A material disposal method must also be taken into account. A market may be found in neighboring agricultural businesses to utilize this plant material, which will be rich in nutrients.

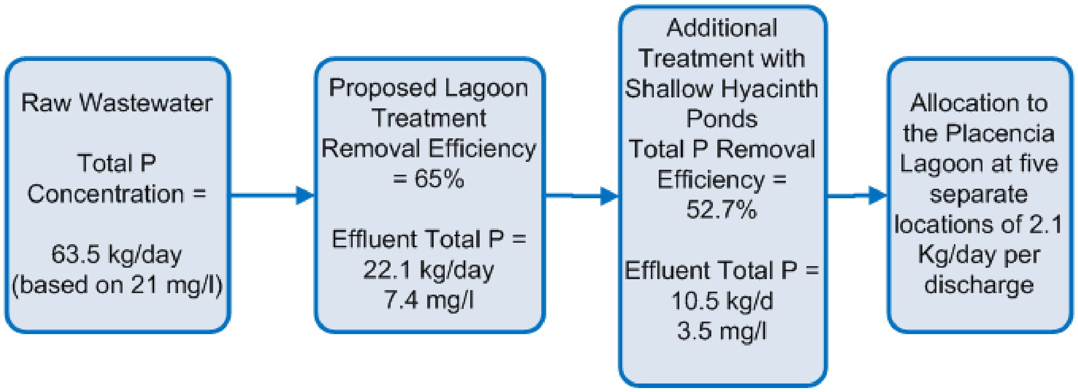


Figure 5.5-6 Nutrient Management through Nutrient Ponds

5.5.2.2 Nutrient Treatment via Infiltration, Percolation and Evaporation

As discussed in Section 4.5.5.3, the release of treated effluent onto a designated property for Infiltration, Percolation and Evaporation (IPE) is an effective disposal option. The effluent would be released into the pine groves and savannah surrounding the treatment facility. Depending on the topography of the property, a pump system may be required to achieve this alternative.

The Infiltration, Percolation and Evaporation (IPE) Land Application system disperses the effluent across a designated property constructed to absorb the effluent volume. Nutrient uptake occurs through plant absorption and other natural processes. The effect of these ponds is presented on Figure 5.5-7.

Table 5.5-5 estimates the land required to effectively absorb the treated effluent for an IPE system based upon a liquid-loading rate of 21 inches/week (see Table 4.5-7). If this alternative is chosen during the detailed design and construction phase of the project, a detailed analysis of the soil, vegetative and groundwater conditions at the project site to ensure this assumption is valid. The land area includes 30% additional land buffer to account for the wet season and other considerations.

Table 5.5-5 Infiltration Percolation and Evaporation Field Land Requirements

Infiltration, Percolation and Evaporation Field Land Requirements		
Item	Qty	Unit
Average Daily Flow	0.80	MGD
	0.92	
Peak Season Flow	2.8	acre-feet / day
Weekly Application	21	inches
Required IPE Field area during Peak Season	10	acres
Additional Land Buffer for Wet Season	30%	
Design IPE Field Area	14	acres

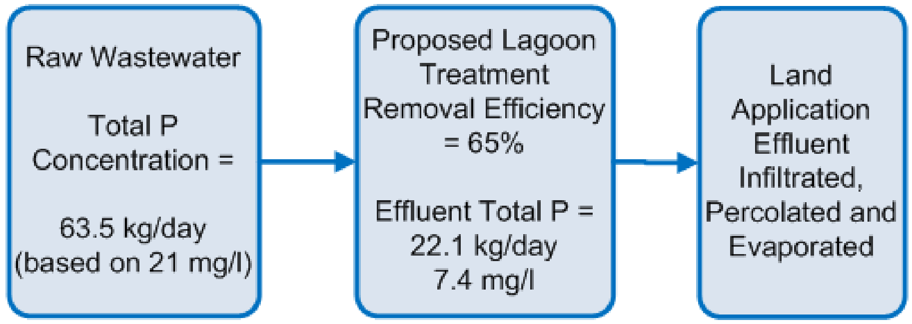


Figure 5.5-7 Nutrient Management through IPE Fields

5.5.2.3 Nutrient Treatment via Water Hyacinth in Maturation Ponds

As discussed in Section 4.5.2 and shown on Figure 4.5-8, a floating Water Hyacinth garden can be grown within the maturation pond of the lagoon system. These plant species are specifically suited to take up the nutrients within the wastewater.

The primary advantage of this system is its nutrient absorption. However, the system requires continual maintenance to ensure that the plants do not overgrow the pond system, including scheduled harvesting and removal from the pond.

If plants are used within the treatment, measures must be taken to harvest the plants from the system to ensure that newer growth continuously takes in the nutrients. A drying area will be required to store the harvested material. A material disposal method must also be taken into account. A market may be found in neighboring agricultural businesses to utilize this material, which will be rich in nutrients.

The addition of hyacinth within the third-stage 'maturation pond' of the facultative lagoon system provides a potential opportunity for nutrient uptake within the wastewater treatment system. The advantage of this system is it's relatively low cost. Additional capital costs are limited to preparing a drying area for harvested hyacinth. Operation and maintenance costs involve the payroll addition of harvesters. Table 5.5-6 summarizes the anticipated tertiary treatment capacity of the proposed facultative lagoon treatment system.

Table 5.5-6 Nutrient Removal Summary, Water Hyacinth within Maturation Pond

Nutrient	Proposed Disposal Standards	Influent	Hyacinth in Maturation Pond Removal	Effluent
Phosphorus	3.5 mg/l	21 mg/l	70%	< 7 mg/l
Nitrogen	5 mg/l	20 mg/l	85%	< 3 mg/l

The addition of hyacinth to the maturation pond has a negligible effect on the nutrient concentrations. While hyacinths uptake nutrients, they also block out the light within the pond and decrease the capacity of the algae to uptake nutrients. Given the information above, this alternative does not meet the project's standards for Phosphorus. Therefore, within this feasibility study, it is not the preferred tertiary treatment option.

5.5.3 Surface Water Discharge

As discussed in Section 4.5.5.2, Surface Water Discharge is a means of disposing of secondary-treated effluent if it is determined that the dispersion of the effluent into the larger body of water is adequate.

If a surface discharge is employed, it is recommended that the treated effluent be allocated to various discharge locations near the WWTP facility. This will achieve two purposes:

- More effective dispersion of nutrient compounds; and
- Utilization of the mangrove wetlands uptake of excess nutrients from the effluent.

The final design for the disposal system will need to take into account the results of the Lagoon study recommended above to ensure that the effluent does not negatively influence the Lagoon ecosystem.

6 Economic Analysis of Alternatives

As with any infrastructure project, it is desirable to maximize the effective service while minimizing its costs. Knowing that the infrastructure is to be owned, operated and maintained by the governing wastewater entity, it is necessary to analyze a project's costs beyond initial construction and look at the yearly expenses associated with its operation and maintenance.

6.1 Unit Costs

The project cost estimates utilized budgetary quotes for materials provided by U.S. manufacturers, as well as the unit costs shown below. Typical costs used for projects of this scale were increased to account for the challenges of working in the Placencia Peninsula and Lagoon environment, including a shallow water table, sandy soils and potentially working on the mainland side of the Lagoon.

6.1.1 Construction Labor Rates

Table 6.1-1 summarizes the construction labor rate used for the study's cost estimates.

Table 6.1-1 Construction Labor Rates

Construction Labor Costs (US$)	
Minimum Wage - Manual Worker (**BZ$**):	$2.25
Minimum Wage - Manual Worker (**US$**):	$1.13
Est. Crewman Wage:	$3.94
Est. Foreman Wage:	$6.19
Hourly Crew (4 crew +1 foreman) Wage:	$21.94
Operation & Profit:	100%
Hourly Rate for Crew:	$43.88
Daily Rate for Crew:	$438.75
Hourly Rate for Equipment:	$30.00
Daily Rate for Equipment:	$300.00
Hourly Rate for Crew & Equipment:	$73.88
Day Rate for Crew & Equipment:	$738.75

6.1.2 Pipe Installation Costs

The largest component of the Collection System costs involves the laying of both gravity and pressure pipes. Pipe material costs were determined from manufacturer quotes, plus shipping and import tariffs. The labor component of pipe installation is shown in Table 6.1-2.

Table 6.1-2 Pipe Install Cost per Linear Foot

Construction Labor Costs (US$)	
Day Rate for Crew & Equipment:	$738.75
Pipe Lay per Day (l.f.):	100
Install Cost per L.F.:	**$7.39**

6.1.3 Employment Costs

Table 6.1-3 summarizes the employment labor rate used within the study's cost estimates for Operation and maintenance costs.

Table 6.1-3 Employment Labor Rates

Employment Labor Costs (US$)	Yearly Cost
Operation Supervisor	$21,100
Foreman	$14,000
Field Technician	$10,500
Lagoon Operator	$12,300
Customer Service Supervisor	$21,100
Department Lead	$25,400
Customer Representative	$10,500
Cashier	$7,700

6.1.4 Electrical Operation Costs

The cost estimates for electrical operation were determined from sample pump station electrical bills provided by Placencia and Seine Bight Water Boards. Table 6.1-4 summarizes the input factors in determining electrical costs.

Table 6.1-4 Electrical Utility Cost Factors

Associated Cost	Rate
Monthly Charge, per account (one account per pump station)	BZ$ 100.00
Unit Electrical Cost	BZ$ 0.44 / kWh
General Sales Tax (GST)	12.5%

6.2 Economic Analysis of Collection System Alternatives

6.2.1 Final Service Area

The purpose of this project is to provide wastewater service for as much of the Placencia Peninsula as possible, from Placencia Village to Riversdale, stretching approximately 15 miles in length.

It is recommended that the final design cover the full extent of the Peninsula. A cost estimate for this full system is provided in Appendix C.1. A cost-benefit analysis can be made at that time based upon the final cost estimates and construction bids to determine which portions of the collection system is a part of the initial phase of the project.

Future expansions of the system can be made as additional funds are available and as additional properties are developed. The availability of fully developed design plans will help ensure that incremental system expansions are in line with the overall scope of the system. It is important to plan how the system will expand when future development occurs, providing reasonable connection points for developers to tie their portion of the system into. An in-place strategy will help the region's development (and developers) accommodate their tracts' wastewater generation with the desires and intent of the governing entity. As densification occurs, infrastructure expansion can be financed through the development process.

6.2.2 Interim Service Area

Given the limited funds for project construction, the distinct difference in population density between the regions, and the difference in short-term needs, current project efforts are focused on the South Region.

Another concern regarding the North Region is the varied estimates of its build out. The magnitude of development and subsequent population estimates vary by as much as 100%, making it very difficult to appropriately design a system to manage the wastewater.

For the purpose of this study, the following analysis is based upon connecting

- all existing facilities in the South Region
- a central trunk line through the north region, connecting facilities readily available, and
- connecting the homes in Riversdale.

As stated above, the final determination of which facilities are initially connected is to be made during the final design and construction bidding phases of the project.

6.2.3 Collection System Electrical Expenses

The primary difference in Operations and Maintenance costs between the different collection alternatives is found in the power expense. For each collection alternative, the wastewater model determined the total pump run times for a peak season day for each pump. Total electricity usage was calculated based upon pump-run time and pump horsepower. Figure 6.2-1 summarizes the estimated electrical bills for the pump stations for each collection alternative.

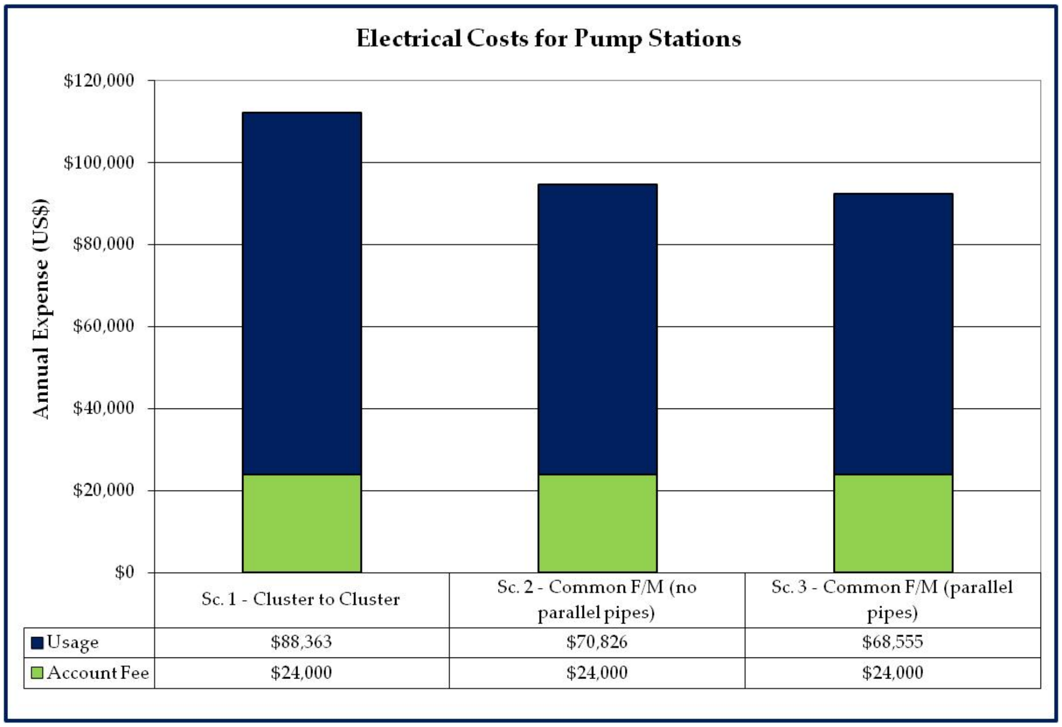


Figure 6.2-1 Annual Electrical Expenses by Collection Alternative

6.2.4 Collection System Cost Estimate

Table 6.2-1 summarizes the initial cost estimates for the various collection system alternatives defined in Section 5.3. These estimates are based upon the initial design considerations used for the early stage of the feasibility study.

Table 6.2-1 Collection Alternative Initial Cost Estimates

Collection System	Full Peninsula Service Area		
	Initial Cost Estimate		
Capital Improvements	Sc #1 - Cluster to Cluster	Sc. #2 - Common Force Main (no parallel)	Sc. #3 - Common F/M (parallel)
Initial Capital Costs (US$)	$9,720,000	$10,040,000	$10,470,000
Annualized CIP (US$)	**$660,000**	**$680,000**	**$710,000**
Operations and Maintenance			
Annualized O&M (US$)	**$350,000**	**$340,000**	**$340,000**
Total Annualized Expenses:	**$1,010,000**	**$1,020,000**	**$1,050,000**

Note: Annualized CIP based upon 20 year loan at 3.5%

6.2.5 Preferred Collection System Alternative

The overall annual expense for each of these alternatives is effectively the same. Each alternative has various construction, operation and cost advantages and disadvantages. The final design will likely incorporate some aspect of each of these alternatives, based upon the localized needs and circumstances of various portions of the system. For example, in the densely populated areas found in the villages, a single common force main has the advantage of keeping the individual pump stations small. In the sparsely populated portions of the South Region, a cluster to cluster design may prove simpler to design and operate. In the North Region, where the initial population and flows are low, the initial force main will need to be a small pipe-diameter. However, if the tourist growth predicted in the North Region materializes, a second larger diameter parallel force main may be necessary in the future.

For the purpose of this study, Scenario #2's collection system model was used in economic analysis. Table 6.2-2 summarizes the complete as well as initial service area (as discussed in Sections 6.2.1and 6.2.2) system cost estimate. The reduced scale system delays the connection of some portions of the system based upon the limited capital funds during initial construction. Case by case decisions will be made during the detailed design and construction phases of the project as to exactly which properties are initially connected to the system. These estimates were used in the remainder of the economic analysis.

Table 6.2-2 Collection System Final Cost Estimates

Collection System	Full Penninsula (Placencia Village to Riversdale) Service Area	
Capital Improvements	Initial Recommended 92% Coverage Service Area	100% Peninsula Coverage Service Area
Initial Capital Costs (US$)	$7,570,000	$9,850,000
Annualized CIP (US$)	**$510,000**	**$670,000**
Operations and Maintenance		
Annualized O&M (US$)	**$280,000**	**$340,000**
Total Annualized Expenses:	**$790,000**	**$1,010,000**

Note: Annualized CIP based upon 20 year loan at 3.5%

As mentioned in Section 5.3.4 on page 125, there may be circumstances where individual grinder pump systems will be the most economic or physically viable alternative for connecting a facility to the collection system. This alternative requires a higher degree of maintenance, a continual electrical supply and requires additional consideration for wastewater storage during extended power outages; therefore, it is not a preferred alternative for the system as a whole. Example facilities that are likely candidates for this alternative include:

- Facilities very isolated from the proposed collection system, being a long distance away and not having neighboring facilities to 'share' the expense of extending the collection system to the facility
- Facilities in 'tight' spaces, particularly in Placencia Village, where extending a typical gravity sewer pipe may be very difficult to achieve.

As shown in Section 5.3.4, installing a grinder pump system can provide cost savings over the traditional gravity system with centralized pump station. However, these systems require continual management and their implementation need to take this into consideration. The preferred alternative is to serve all facilities along and immediately adjacent to the main road with a gravity collection system. However, when a facility is physically distant from the main road, or its connection particularly challenging, then a grinder pump installation may be considered as the preferred collection alternative.

6.2.6 Land Easements and Acquisition

The challenges of finding and purchasing land for pump stations will likely affect the final design of the collection. Procuring temporary construction and permanent pipe easements must be taken into account during the design phase as well. The alternative wastewater collection systems provided in this study do not detail out the specific land easements and acquisition needs for the systems. The detailed base information (survey, tax parcels, right-of-ways) was not available at the time of this study.

6.2.7 Non-Cost Criteria

Environmental Impact

Each wastewater system alternative needs to be reviewed to identify any potential negative impacts, determine to what extent these impacts can be mitigated, and ensure that whatever collection system is pursued to final design, construction and operation effectively protects and promotes a vibrant ecological community. Section 8 will focus on this consideration.

Stakeholder Input

Halcrow encouraged stakeholders input in weighing the costs and benefits of these alternatives, looking at both the near- and long-term needs of the Peninsula with a commitment to quality of life and ecological sustainability. Public acceptance of the infrastructure is vital to project success.

Socio-Economic Impacts

Within the confines of stakeholders input, the constructed wastewater system will impact the social and economic realities of the residents and visitors of the Placencia Peninsula. It will be important to balance the expense of constructing, operating and maintaining the system with the improvements and potential for expansion that said system will provide for the local community.

6.3 Economic Analysis of Treatment Facility Alternatives

6.3.1 Treatment System Electrical Expenses

The various wastewater treatment alternative technologies are discussed in detail in Section 4.5. The primary difference in the operations and maintenance expenses for each of these scenarios is whether the systems require consistent electrical power – the Facultative Lagoons do not require power; the Aerated Lagoons and Extended Aeration systems do require power. Figure 6.3-1 summarizes the estimated pump station electrical power expense for each scenario. The methods for determining the electrical expenses are summarized in Table 6.1-4 of Section 6.1.4.

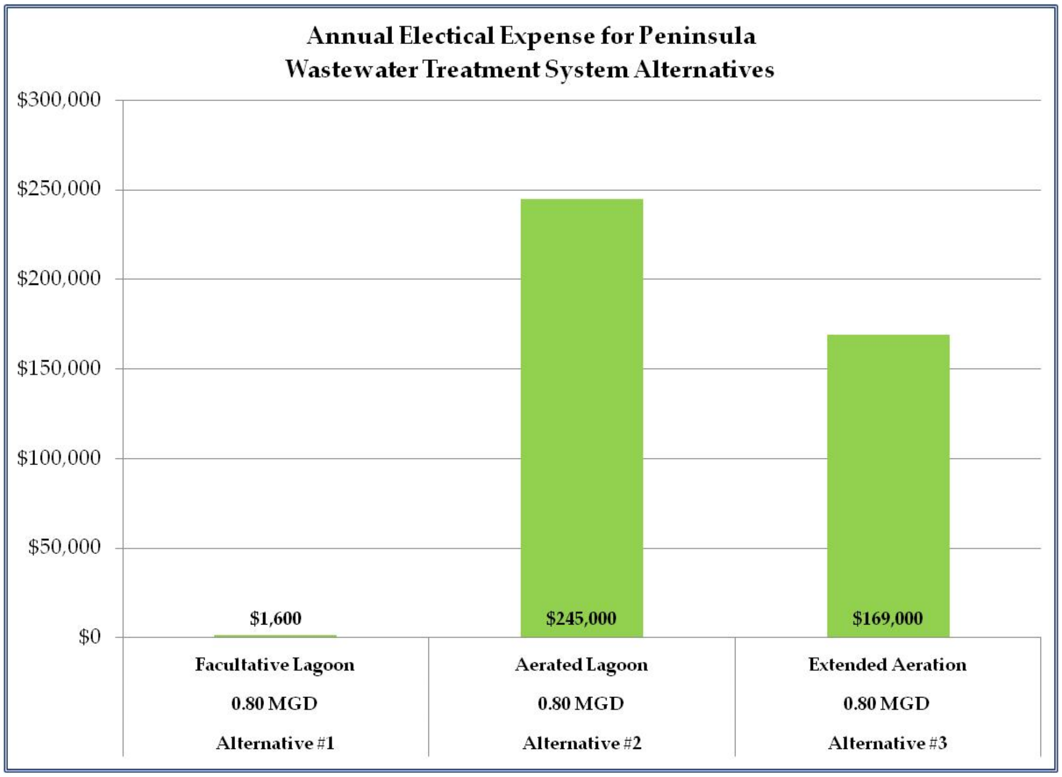


Figure 6.3-1 Annual Power Expenses by Scenario

6.3.2 Treatment System Location

All cost estimates provided for this study are based upon the treatment facility being located on the property outlined in Section 0, Crown land available from the Belize government to BWSL that is across the Placencia Lagoon from Seine Bight Village. However, as discussed in Section 5.4.1, an alternative location is at the north end of the Peninsula.

To compare the alternative locations, the difference in the estimated costs between constructing and operating a facility at each location needs to be utilized. Within the economic analysis, moving the WWTP from the South to the North would require the follow updates to the project costs:

- Capital Costs
    - +/- 10 miles of force main pipe would reverse flow (from southbound to northbound flow) and their size would need to be increased. Estimated expense: US$400,000
    - Eliminate the Lagoon Crossing. Estimated savings: US$300,000
    - Construction of the WWTP on the mainland would likely incur a 5% construction cost savings due to ease of construction. Estimated savings: US$125,000
    - Total Capital Cost Savings: US$25,000
    - Annualized savings (20 years, 3.5%) = US$2,000
- Operation and Maintenance
    - Electrical expense for pumping the wastewater the additional distance to the north facility, as shown in Table 6.3-1.

Table 6.3-1 Electrical Expenses, pumping South to North

Pump South to North		
ADD (2011-2040):	0.41	MGD
Length	10	miles
Diameter	10	inches
Req'd HP	21	
Daily Electricity	157	kWh
Yearly Electricity	57,150	kWh
Yearly Costs	**$15,000**	**US $**

The total additional annualized expense for all collection scenarios with the WWTP at the north end of the Peninsula and not across the Lagoon is estimated at US$13,000. Given the overall project budget (US$10M) and the current cost estimate's level of precision, this additional expense does not affect the overall project analysis and should not be a determining factor in making the final decision regarding the WWTP location.

However, this analysis does not take into account land purchase expenses at either location. Land purchase expenses for all alternatives needs be taken into account in the final economic analysis.

The final location of the treatment facility is to be determined during the detailed design phase of the project from either:

- Crown land on the mainland directly across Placencia Lagoon from Seine Bight village;
- Land at the north end of the Peninsula; or
- An as yet unidentified suitable property.

Project design team (led by BWSL, who will own and operate the facility) will need to finalize the treatment facility location in the early stage of the design process, as this decision will affect the final collection system design and influence the final determination of which effluent reuse and disposal strategy is most appropriate at this site.

6.3.3 Treatment Alternative Cost Estimate

Table 6.3-2 and Figure 6.3-2 provide a summary of the overall capital improvement costs, yearly annual amortization costs, and operations and maintenance annual costs for each treatment system alternative as detailed in Section 5.4.

Based upon the economic ranking of these treatment alternatives as well as the relative ease of operating said facility, the preferred treatment facility is a Facultative Lagoon with Maturation Pond as detailed as Treatment Alternative No. 1 in Section 5.4.2.

The costs estimates provided below do not take into account the cost of land purchase, which may drastically affect the overall project costs.

Table 6.3-2 Wastewater Treatment System Cost Estimates

Financing Summary	Wastewater Treatment		
	Alternative #1	Alternative #2	Alternative #3
	0.80 MGD	0.80 MGD	0.80 MGD
Capital Improvements	Facultative Lagoon	Aerated Lagoon	Extended Aeration
Total Capital Costs (US$)	$2,890,000	$2,100,000	$2,100,000
Annualized CIP (US$)	$200,000	$140,000	$140,000
Operations and Maintenance			
Total O&M (US$)	$50,000	$300,000	$220,000

Note: Annualized CIP based upon 20 year loan at 3.5%

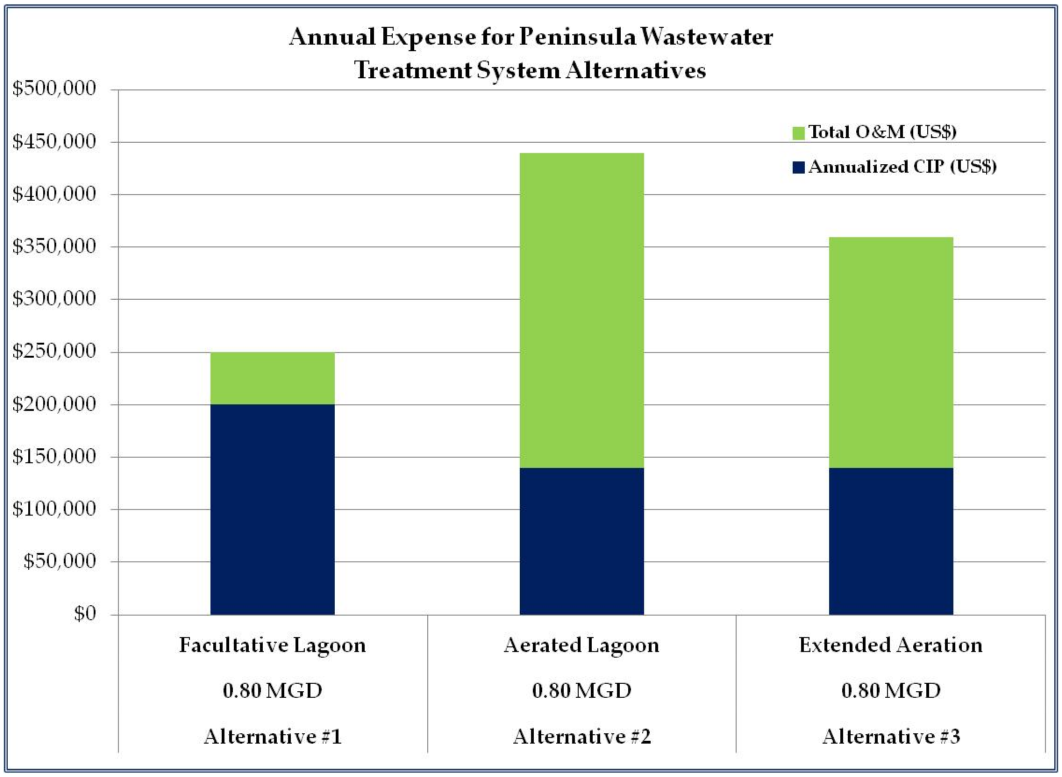


Figure 6.3-2 Wastewater Treatment Cost Estimates

6.3.4 Land Easements and Acquisition

The challenges of finding and purchasing land for the WWTP will likely affect the final design of the treatment system. The detailed base information (survey, tax parcels, right-of-ways) necessary to perform as a site specific treatment plant layout was not available at the time of this study.

6.3.5 Non-Cost Criteria

Environmental Impact

Each wastewater treatment system alternative needs to be reviewed to identify any potential negative impacts, determine to what extent these impacts can be mitigated, and ensure that whatever alternative system is pursued to final design, construction and operation effectively protects and promotes a vibrant ecological community.

Stakeholders Input

Halcrow encourages stakeholders input in weighing the costs and benefits of these alternatives, looking at both the near- and long-term needs of the Peninsula with a commitment to quality of life and ecological sustainability. Public acceptance of the infrastructure is vital to project success.

Socio-Economic Impacts

Within the confines of stakeholders input are the impacts that the constructed wastewater treatment system will have on the social and economic realities of the residents and guests of the Placencia Peninsula. It will be important to balance the expense of constructing, operating and maintaining the system with the improvements and potential for expansion that said system will provide for the local community.

6.4 Economic Analysis of Effluent Reuse and Disposal Alternatives

The cost of the tertiary treatment (nutrient removal) system needs to be accounted for in the overall economic assessment of the wastewater treatment system. As detailed in Section 5.5, the treatment technologies have various levels of passive nutrient removal, which in turn can affect the scale of the required nutrient removal system.

As stated in Section 5.5, the alternatives for the disposal of treated effluent are through:

- An agricultural reuse system,
- Nutrient treatment ponds following disposal into the Lagoon, or
- Infiltration, Percolation and Evaporation fields.

6.4.1 Agricultural Reuse System

Final considerations for the disposal of effluent through an agricultural reuse system require an Effluent Market Analysis to determine if there is an available market for the purchase of treated effluent at a rate that justifies the expense of the system’s construction, operation and maintenance (see Section 10.8, page 236, for reuse market analysis scope). If the market for the sale of effluent is strong enough, there is some potential to reduce the tariff costs for the water and wastewater users on the Peninsula (as outlined in Section 0). Table 6.4-1 summarizes the project area requirements and cost estimates for the reuse system. Section The system cost estimate is included in Appendix E.1.

An agricultural reuse system is a supplement to one of the permanent nutrient treatment and disposal system alternatives provided below. A permanent treatment and disposal system needs to be built alongside a reuse system in case the reuse market changes, including:

- Weather conditions preclude the need for irrigation;
- Less expensive alternative irrigation and fertilizer sources;
- Receiving customer(s) choosing to not purchase effluent;
- Receiving customer(s) shutting down operations completely.

The preferred and most cost-effective combination of effluent disposal options is to have the effluent reuse system and the Infiltration, Percolation and Evaporation overland flow disposal.

Table 6.4-1 Effluent Reuse System Cost Estimates

Financing Summary	Effluent Reuse System
Capital Improvements	Same system for Treatment Alt: #1, 2 & 3
Minimum Surface Area (acres)	3
Total Capital Costs (US$)	$695,000
Annualized CIP (US$)	$90,000
Operations and Maintenance	
Total O&M (US$)	$28,000
Total Annualized Expenses:	**$118,000**

Note: Annualized CIP based upon 10 year loan at 5%

6.4.2 Nutrient Treatment via Nutrient Ponds

Nutrient uptake within the nutrient pond is based upon the surface area of the pond(s). The following cost estimates are based upon the estimated 2040 wastewater flows and the passive nutrient removal capacity of the various treatment technologies as shown in Section 5.5 and Appendix E.2. These cost estimates do not account for land expenses; however, land expenses are accounted for in the system alternatives economic matrices provided in Table E-4 and Table 6.5-1.

The major portion of the O&M budget involves a vegetative management crew. The ponds themselves require minimal maintenance.

6.4.3 Nutrient Treatment via IPE Field

While the size of the nutrient pond is based upon the anticipated uptake capacity of the pond vegetation, the scale of the infiltration, percolation and evaporation field (IPE) system is based upon the capacity of the receiving land to effectively absorb the effluent. Therefore, the required IPE field land area and cost estimates are consistent for each of the WWTP alternatives. Table 6.4-2 and Figure 6.4-1 summarizes the anticipated cost estimate for the construction and operation of an IPE Land Application system. Detailed cost estimates are included in Appendix E.3. These cost estimates do not account for land expenses; however, land expenses are accounted for in the system alternatives economic matrices provided in Table E-4 and Table 6.5-1.

The major portion of the O&M budget involves pumping from the WWTP to the IPE field property. The saturation grounds themselves require minimal maintenance. An allowance is made in the cost estimate to drill and test monitoring wells around the perimeter of the IPE field to ensure that the groundwater is not affected by the effluent dispersion.

Table 6.4-2 Effluent Disposal Facility Size Requirements and Cost Estimates

Financing Summary	Effluent Disposal System Alternatives			
	0.80 MGD			0.80 MGD
Capital Improvements	Treatment Alt. #1: Facultative Lagoon	Treatment Alt. #2: Aerated Lagoon	Treatment Alt. #3: Extended Aeration	Same system for Treatment Alt: #1, 2 & 3
Minimum Surface Area (acres)	17	35	41	14
Total Capital Costs (US$)	$570,000	$920,000	$1,040,000	$490,000
Annualized CIP (US$)	$40,000	$60,000	$70,000	$30,000
Operations and Maintenance				
Total O&M (US$)	$70,000	$80,000	$80,000	$40,000
Total Annualized Expenses:	**$110,000**	**$140,000**	**$150,000**	**$70,000**

Note: Annualized CIP based upon 20 year loan at 3.5%

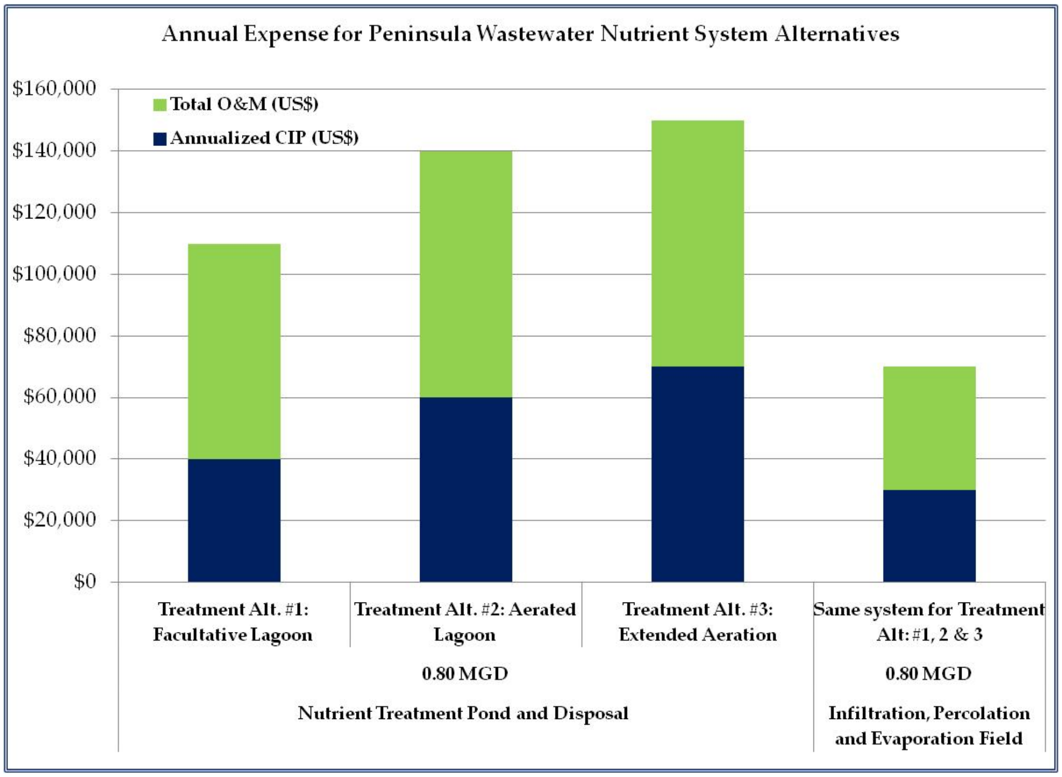


Figure 6.4-1 Effluent Disposal Cost Estimates

6.4.4 Nutrient Treatment via Water Hyacinth in Maturation Ponds

As discussed in Section 5.5.2.3, the addition of Water Hyacinth to the Maturation Ponds within either the Facultative or Aerated Lagoon alternatives will not provide effective nutrient removal, and is therefore not an option considered in this study.

6.4.5 Preferred Effluent Reuse and Disposal Alternative

If it is shown through an Effluent Market Analysis that the treated effluent can be distributed to a local agent (plantation farmer, aquiculture farmer, landscaped property, or similar customer) at a cost-effective price for the system, then it is recommended that this alternative be pursued to supplement a permanent effluent treatment and disposal system. As stated above, if the wholesale rate of sold effluent has a high enough value, it is possible to supplement the overall system costs and potentially reduce the tariff rates for the Placencia Peninsula water and wastewater customers. However, if the future analysis of agricultural reuse system results show that the system cannot sustain itself economically, and is required to be supplemented by the Placencia Peninsula water and wastewater users, then this alternative should not be given a high level of consideration.

Also, as previously indicated, a permanent effluent disposal system is required for the project; the most cost effective option is an IPE Land Application system. However, the final decision regarding which alternative is to be utilized should be based upon which one is best suited to the final design, the land available for the project, and stakeholders input.

Therefore, for the purpose of the economic analysis within this report, the IPE Land Application Field cost estimates are utilized. The preliminary expenses and cost recovery analysis associated with the Agricultural Reuse system are provided as a separate economic analysis in Section 11.7.

6.5 Preferred Wastewater System

As stated in Section 6.2, the various collection system alternatives are effectively the same cost. Therefore, the preferred collection system for final design and implementation is the combination of the various collection methodologies that is most appropriate in a site specific situation as determined during the detailed design phase of the project. For example:

- In the village areas, gravity collection system with each facility connected by gravity directly into the system, with a common pump station collecting clustered areas;
    - Some facilities may be connected via a grinder pump system, if it is determined that a typical gravity pipe installation is not physically viable;
- Hotel facilities between villages may collect their waste in an onsite wet well and pump directly into the pressure force main running in front of their property along the main road, sharing a 'common force main';
- In the sparsely populated areas, individual facilities may install a small individual grinder pump to move that facility's effluent to a nearby gravity collection system manhole or pump station wet well.

A summary of the wastewater treatment and nutrient treatment system costs across the entire Placencia Peninsula is provided in Table 6.5-1. This summary is for the collection system (Section 5.3), wastewater treatment (Section 5.4) and nutrient treatment (Section5.5) systems. The same capital improvement and operation and maintenance costs for the collection system were utilized within each of these scenarios.

Wastewater Treatment Alternative No. 1 (Facultative Lagoon) on the Mainland with a Nutrient Alternative No. 2 (IPE Land Application) is the most economically beneficial system alternative. Facultative Lagoons are more expensive to construct but simple and inexpensive to operate and maintain.

Table 6.5-1 Collection, Wastewater & Nutrient Treatment Systems Cost Estimates & Annualized Expenses

Wastewater System Cost Estimate Matrix															
92% Collection System		Capital Costs	$7,225,000												
		CReW Grant	($5,000,000)												
		Total Annual Expense *	$431,000												
Wastewater Treatment Alternatives				Alternative 1 Facultative Lagoon (0.80MGD)				Alternative 2 Aerate Lagoon (0.80MGD)				Alternative 3 Extended Aeration (0.80MGD)			
				Across Lagoon on Crown Land (Req'd Land: 50 acres)		North of Peninsula (no Lagoon crossing) (Req'd Land: 50 acres)		Across Lagoon on Crown Land (Req'd Land: 61 acres)		North of Peninsula (no Lagoon crossing) (Req'd Land 61 acres)		Across Lagoon on Crown Land (Req'd Land: 65 acres)		North of Peninsula (no Lagoon crossing) (Req'd Land 65 acres)	
				Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *	Capital Costs	Total Annual Expense *
Wastewater Treatment				$2,890,000	$246,000	$2,890,000	$246,000	$2,100,000	$443,000	$2,100,000	$443,000	$2,100,000	$363,000	$2,100,000	$363,000
Effluent Disposal Alternatives			Lagoon Crossing	$345,000	$23,000			$345,000	$23,000			$345,000	$23,000		
Nutrient Alternative 1	Nutrient Pond w Facultative Lagoon	Capital Costs	$570,000	$11,030,000		$10,685,000									
		Total Annual Expense *	$119,000		$819,000		$796,000								
	Nutrient Pond w Aerated Lagoon	Capital Costs	$920,000					$10,590,000		$10,245,000					
		Total Annual Expense *	$143,000						$1,040,000		$1,017,000				
	Nutrient Pond w Extended Aeration	Capital Costs	$1,040,000									$10,710,000		$10,365,000	
		Total Annual Expense *	$111,000										$928,000		$905,000
Alt. 2	Infiltration, Percolation and Evaporation Land Application	Capital Costs	$490,000	**$10,950,000**		**$10,605,000**		$10,160,000		$9,815,000		$10,160,000		$9,815,000	
		Total Annual Expense *	$73,000		**$773,000**		**$750,000**		$970,000		$947,000		$890,000		$867,000

Notes: Annualized CIP based upon 20 year loan at 3.5%

Per request of BWSL, land costs were not included within this analysis

Recommended 92% Collection System costs per Table 6.2-2

** Total Annual Expense includes the CReW Grant to offset capital costs, Capital Improvement Loan repayment plus Operation and Maintenance Budget; does not include Water System operational, BWSL corporate, or future system capital improvement expenses.*

6.5.1 Preferred Collection System

As expressed in Section 5.3.1, it is the intent of the project to provide wastewater service to the full extent of the Peninsula. However, if economic considerations prevent that goal from being completely fulfilled in the short term, it is recommended that focus be placed on the more densely populated areas of the Peninsula. Collecting the wastewater discharge in these areas has economic value (more service connections per land area) and environmental value (ensuring that the portions of the Peninsula with the highest concentration of wastewater flows are treated).

Table 6.5-2 summarizes the population density estimates for the year 2025, based upon the region's area and population projections as defined in this project report.

Table 6.5-2 Population Density

Region	2025 Population	Land Area (acres)	Population Density (persons per acre)
South Region	5,180	1,490	3.5
North Region	1,120	1,250	0.9
Placencia Village *	2,650	170	15.5
Seine Bight Village *	1,500	67	22.3

** Villages are located within and account in the South Region quantities*

Table 6.5-3 summarizes the cost estimate difference between connecting a majority of the existing facilities on the Peninsula to the collection system versus building the complete infrastructure at this time. The incremental cost of connecting the last portion of the facilities is considerably higher than the majority of the system (US$2.3M for ~100 accounts; US$23,000 per additional account). This preliminary cost estimate will be updated during the final design phase of the project, when detailed survey information is available and specific decisions on each facility connection can be made. However, it is likely that some portions of the Peninsula may not be connected during the initial stage of the project, and will be connected as the Peninsula population density increases.

Table 6.5-3 Collection System Final Cost Estimates

Collection System	Full Penninsula (Placencia Village to Riversdale) Service Area	
Capital Improvements	Initial Recommended 92% Coverage Service Area	100% Peninsula Coverage Service Area
Initial Capital Costs (US$)	$7,570,000	$9,850,000
Annualized CIP (US$)	**$510,000**	**$670,000**
Operations and Maintenance		
Annualized O&M (US$)	**$280,000**	**$340,000**
Total Annualized Expenses:	**$790,000**	**$1,010,000**
Estimated Accounts:	*1,000*	*1,100*
Annual Cost per Service	$790	$918

Expansion of the collection system will be predicated by an increase in the available customers in the service area; there needs to be an increase in the quantity of system users to make the system expansion economically viable. The initial capital costs for the expansion can be paid by the developer who is building the new facilities, or through a wastewater 'tap' fee for new facilities.

BWSL should work with the various government agencies involved with the approval of development projects to develop wastewater system requirements for new developments that integrate with BWSL' long-term goals.

6.5.2 Preferred Treatment Technology

The economic assessment provided in Section 6.3 of this report shows that the most cost-effective treatment system alternative is Facultative Lagoon technology. The cost savings center on energy use; a facultative lagoon requires no electricity, while aerated systems require constant use of electrical power.

Advantages

Alternative No. 1 is the lowest present cost to operate. The facultative lagoon system is 'passive' and does not require full-time active-presence operation. A mechanized system requires increased operation and maintenance to ensure it continually works as designed.

The facultative system can be built in phases; the system can be expanded based upon the actual increases of flows. Another method to expand system capacity is to add aeration units to the first cell (pond), which is a relatively low cost option, although this expansion would require continuous electrical power.

Disadvantages

Facultative Lagoons require a large land lot to build upon. Land availability and access is a major factor in determining this final feasibility of this system.

6.5.3 Preferred Nutrient Treatment System

As stated in Section 6.4, both Nutrient Ponds and Infiltration, Percolation and Evaporation Land Application (IPE) systems are acceptable systems for this project and the preferred wastewater treatment technology. Based upon economic considerations, the IPE system is the preferred option. However, it is recommended that the final decision for this system be made during the final design phase of the project, based upon the results of the recommended Lagoon Nutrient Fate and Transport Study as well as the specific conditions of the project site.

6.5.4 Preferred Wastewater System Cost Summary

Table 6.4-4 summarizes the cost estimates for the preferred wastewater system:

- Collection System based upon site specific conditions during detailed design,
- Facultative Lagoon and Maturation Ponds on the Mainland, and
- Infiltration, Percolation and Evaporation Land Application System.

Table 6.5-4 Wastewater System Cost Estimate

Preferred Wastewater System Cost Estimate (US$)	
Initial Capital Costs	$10,950,000
Annualized CIP	$740,000
Annualized O&M	$370,000
Total Annual Budget	**$1,110,000**

Notes: Annualized CIP based upon 20 year loan at 3.5%

While the initial capital costs exceed the proposed budget of US$10M, the final design can be tailored to meet this budget requirement.

6.5.5 Summary of Preferred Wastewater System

- Build the Initial Collection System, connecting as many facilities as possible within the full-infrastructure areas and making it as easy as possible for facilities to connect to the pressure pipe system in the less-dense portions of the Peninsula.

- Enact Legislation which stipulates that:
  - Any new structure within the overall service area must connect to the collection system;
  - Any upgrade/expansion to an existing facility within the service area requires connecting to the collection system.

6.5.6 Water Supply and Distribution System Improvements

While this is out of the scope of this project, it has been made clear to Halcrow by the Peninsula residents that the water supply is precarious; at a minimum, the perception by the citizen population is that the well water source may not be adequate to meet the growing needs of the community. Their concern is whether the water demand is sustainable. In addition, the water distribution system is near its capacity. It is recommended that BWSL conduct a Regional Water Supply Study to plan out the growth of the water system over the same time period being analyzed by this Wastewater System study. Placencia citizens have indicated that water supply is one of their top concerns in each public meeting.

7 Conceptual Design for the Preferred Wastewater Management System

7.1 Collection Service Area

The most common wastewater collection system is by means of conventional gravity-based wastewater connections from each facility to the system. The preferred wastewater collection system for the Placencia Peninsula is described in Section 0. This system will consist of:

- A cluster-to-cluster and common force main collection system from Placencia Village to Riversdale,
- The collection infrastructure to connect the entire Placencia and Seine Bight village areas, as well as for the more densely populated neighboring areas (including Maya Beach and Riversdale),
- A pressure pipe force main is to be pumped across the Placencia Lagoon to a treatment facility to be built on the mainland. This pipe segments will be sealed and anchored to the bottom of the lagoon.
- A pump station in Riversdale at the north end of the system will provide a means to manually flush out the force main pipes from any settled solids until there is adequate inflows to perform the function naturally (see Section 4.2.8 for maintenance standards).

For this system:

- The full collection system is to be designed during the final design to provide a road map for future expansion,
- Provisions will be made to allow future properties along the system to ‘tie-in’ to either via gravity or through individual facility pump systems.

The final extent of exactly which existing facilities are connected to the initial system and which will be connected in the future will be determined during final detailed design plans, based upon project costs and BWSL determinations. The technical design of the collection system must make the final determination as to how the various clusters will be grouped together, based on local existing arrangement of properties and available space for the pipes.

The collection system will consist of the following units:

- Gravity Pipe: to collect the wastewater from each individual property to the pressure pipe
- Manholes to allow maintenance of the system
- Facility Connections: to connect the property with the gravity pipe
- Force main Pressure Pipe: to pump the wastewater to another wet well or to the treatment system
- Cleanouts: units to allow cleaning the gravity pipe system
- Air & Vacuum Valves: release air accumulated in the force main and to prevent negative pressure
- Plug Valves: flow control valve use for wastewater
- Lift or Pump Stations (incl. two pumps, wet well, valve pit and controls) to pump wastewater from one area to another through a force main

A detailed map of the service area, including the extent of gravity pipe system is provided in Figure 7.1-1 and Figure 7.1-2 as well as in Appendix B.3. These maps reflect the collection system layout utilized for bill of quantities and cost estimating purposes.

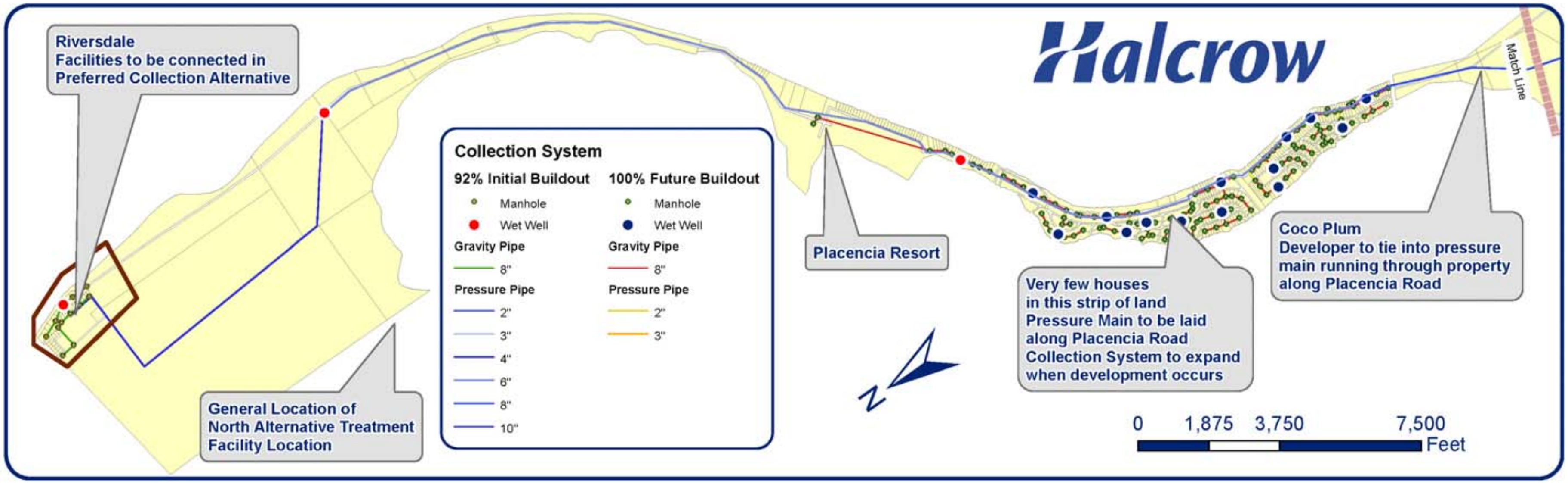


Figure 7.1-1 Collection System Schematic, Page 1 of 2

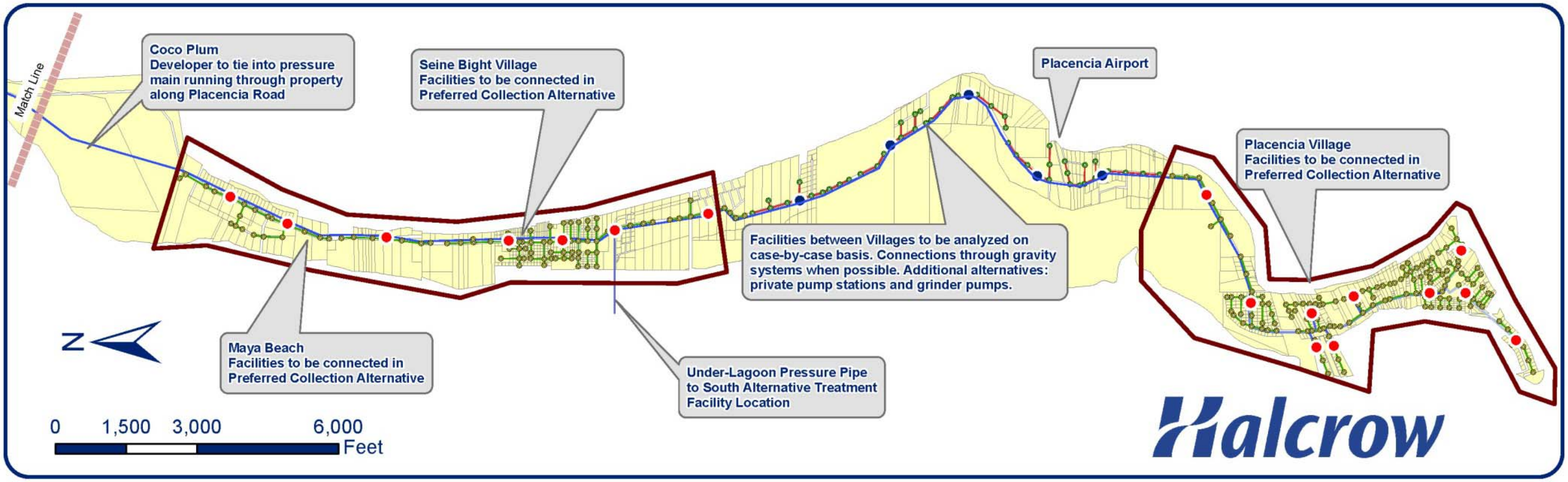


Figure 7.1-2 Collection System Schematic, Page 2 of 2

7.2 Treatment System Technology

The primary goals of the proposed wastewater treatment system are to:

- Provide primary and secondary treatment to the wastewater effluent from the Placencia Peninsula collection system,
- Require minimal operating cost,
- Have minimal technical operation requirements, and
- Be readily expandable, either through replication of the system on the property (another series of treatment cells) or through the addition of aeration treatment.

As discussed in Section 0, the preferred wastewater treatment system is a Facultative Lagoon and Maturation Pond system. A facultative lagoon system does not require electricity to operate, which is a distinct advantage in operating costs and with utility down-time (power outages) concerns. Any proposed utility building can be powered by either a generator, batteries or through solar panels.

Figure 7.2-1 presents a schematic profile of a facultative lagoon system. The system consists of two series of three (3) ponds in parallel, each series sized to hold the incoming wastewater effluent for about +/- 25 days (year 2040 projected loadings). The effluent is treated via natural processes, utilizing sunlight and algae and aerobic and anaerobic bacteria. The effluent will be allocated to multiple locations (to be determined during final design) and discharged to the adjacent mangrove wetlands.

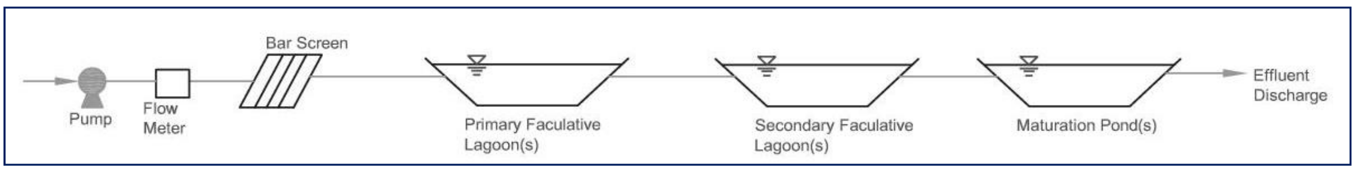


Figure 7.2-1 Facultative Lagoon Process Schematic

A schematic facultative lagoon site layout is provided on Figure 7.2-2 as well as in Appendix F.1. Additional construction details are provided in Appendix F.

The proposed facultative and maturation ponds will effectively reduce the amount of fecal coliform bacteria, the Biochemical Oxygen Demand (BOD_5), and Total Suspended Solids (TSS) to levels below the standards regulated within the Third Schedule of the Environmental Protection (Effluent Limitations) Regulations, 2009 amendment: discharge of domestic wastewater to class I waters (Placencia Lagoon), as shown in Table 4.3-1.

Table 7.2-1 presents a summary of the treatment site area. A detailed, site specific design will be conducted during the final detailed design stage of the project, including a topographic and geotechnical survey and flood study to establish final elevations and dirt moving volumes. A summary spreadsheet of the conceptual treatment design is provided in Appendix D.1.

The facultative lagoon and maturation ponds were selected as the preferred option for the treatment of wastewater based on the following criteria:

- low operating costs
- minimal technical requirements
- future expansion of the capacity is possible, either by increasing the number of lagoons and ponds or by changing the treatment methods

Table 7.2-1 Proposed Treatment Facility Summary

Facultative Lagoon Treatment Facility Conceptual Design Summary		
Item	Qty	Unit
Average Daily Flow	0.80	MGD
Peak Daily Flow	1.60	
Number of Cells in Series	3	ponds
Number of Cells in Parallel	2	
Total Number of Cells	6	
Project Area		
Width	394	feet
Length	1,568	
Area	15	acres
Pond Sizing		
First Cell in Series		
Top Width	165	feet
Top Length	559	
Depth	8.5	
Water Volume	509,270	ft^3
Detention Time	9.5	days
Second Cell in Series		
Top Width	165	feet
Top Length	559	
Depth	7.4	
Water Volume	428,658	ft^3
Detention Time	8.0	days
Third Cell in Series		
Top Width	165	feet
Top Length	352	
Depth	5.9	
Water Volume	203,504	ft^3
Detention Time	3.8	days
Total Water Volume	**2,282,864**	**ft^3**
Total Detention Time	**21**	**days**

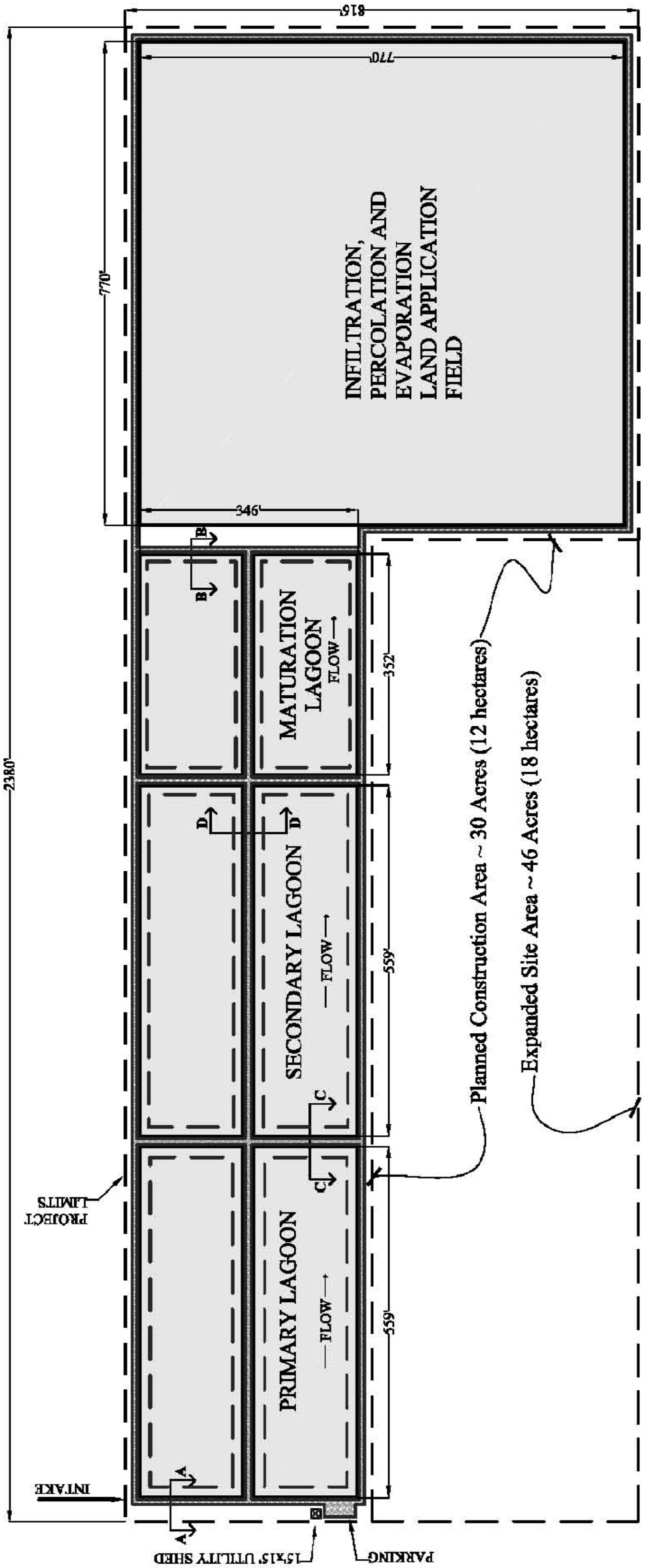


Figure 7.2-2 Facultative Lagoon System Schematic Site Plan

7.2.1 Treatment Facility Location

Within the context of this study, as shown in Figure 7.2-3, four (4) different locations for the treatment facilities were considered. These locations were analyzed within the Environmental Feasibility Assessment in Section 8.2. Of the four (4) potential treatment facility locations analyzed within this study, two (2) locations are considered potentially suitable: north of the peninsula and west of Riversdale and west of Seine Bight on the mainland side of the lagoon. The remaining two (2) locations (in or near the two villages) were not deemed feasible by the environmental consultant because of:

- limited space available for the ponds that would limit or eliminate the possibility to expand the capacity of the treatment technologies
- unsuitable soil and groundwater conditions, which would raise the costs of construction.

The west mainland site has been selected as the preferred option based upon its proximity to the generated wastewater and an initial evaluation of both properties. This property was found to have a better terrain for the construction of the treatment ponds. The preferred location is outlined in yellow on Figure 7.2-4 and Figure 7.2-5. This property has been listed as "Crown" land, available for free to BWSL for use as a treatment facility. A visual inspection of this property was conducted by Halcrow and BWSL in September 2011 via boat. The property is above the lagoon high water mark and is solid ground (pine trees were observed, indicating a high ground area). An additional site visit was made by a Halcrow representative in November 2011. Section 8.2 provides additional information regarding the proposed facility location.

Figure 7.2-3 Four Potential Treatment Facility Locations along Placencia Peninsula / Lagoon

The property is listed as consisting of +/-50 acres; it is anticipated around 30 acres of land are required to build the treatment facility and nutrient land application field. The remainder of the property should provide adequate space for future expansion, if necessary. It is recommended that the property line be extended to the furthest extent of possible legal ownership against the Placencia Lagoon to ensure that there is no future development between the facility and the Lagoon and that the released treated effluent has a direct, unimpeded path to the Lagoon.

Access to the property will be by boat, via Seine Bight, Placencia, or Independence Village. While a road could possibly be extended to the property from the mainland, the expense and construction challenge of the project is unnecessary, particularly in regards to a bridge crossing over the creek shown as a purple line to the west of the site.

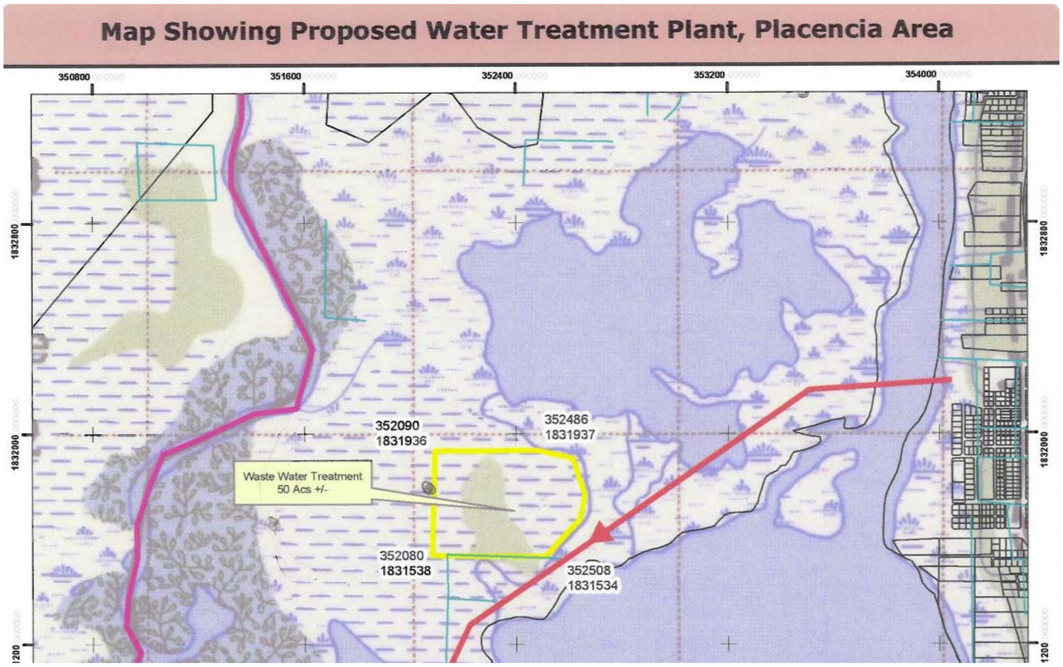


Figure 7.2-4 Wastewater Treatment Plant Location – GIS Map

A comprehensive topographic survey of the property will be performed during the detailed design phase of the project. The survey data will be used to establish the hydraulic profile of the lagoons and to determine access to the facility and appropriate discharge locations from the facility to the mangrove wetlands. A geotechnical soil survey will be performed to determine the structural soil capacity.

Figure 7.2-5 Wastewater Treatment Plant Location – Aerial Imagery

7.3 Nutrient Treatment System

Infiltration, Percolation and Evaporation (IPE) Land Application Systems are specifically sized to handle the design flows based upon the site characteristics (soil type, terrain, proximity to water table). An initial effluent application rate was utilized for the conceptual design. The final application rate is to be determined through field studies within the detailed design phase of this project. Table 7.3-1 summarizes the alternative. The conceptual design spreadsheet and cost estimate for this facility is provided in Appendix E.3.

During the final design, a site-specific survey will be made to determine the most beneficial waste allocation design to determine the most appropriate means of effluent disposal. Any release into the Lagoon system will likely involve dissipating through multiple discharge locations to diminish the discharge loading effects.

Table 7.3-1 IPE Land Application System Summary

Infiltration, Percolation and Evaporation Field Land Requirements		
Item	Qty	Unit
Average Daily Flow	0.80	MGD
Peak Season Flow	0.92	MGD
	2.8	acre-feet / day
Weekly Application	21	inches
Required IPE Field area during Peak Season	10	acres
Additional Land Buffer for Wet Season	30%	
Design IPE Field Area	14	acres

7.4 Land Requirements

The estimated land requirements for the wastewater system project are provided in Table 7.4-1. These are the minimum land area requirements, not including buffers or expansion areas.

Table 7.4-1 Wastewater System Land Requirements

Preferred Wastewater System Land Requirements (acres)	
Operations Facility	0.5
Collection System: Pump Stations	0.1
Collection System: Easements	2.3
Treatment Facility	14.2
Effluent Disposal Facility	
IPE Field Alternative:	13.6
Nutrient Field Alternative:	21.0
Total Project Acreage:	**31 - 38**

7.5 Required Facilities

The following facilities are required for the wastewater system project:

- Treatment Facility, as detailed above, including
  - Tool Shed / Utility Building to be located on Treatment Facility property
  - Boat dock and gravel road to facility
- Pump Stations – Figure 7.5-1 is a schematic of a typical pump station site plan.
- Operations Facility, including BWSL local office, administration, billing, customer service, and technical services.
  - Equipment Storage Warehouse to be located at or near Operations Facility

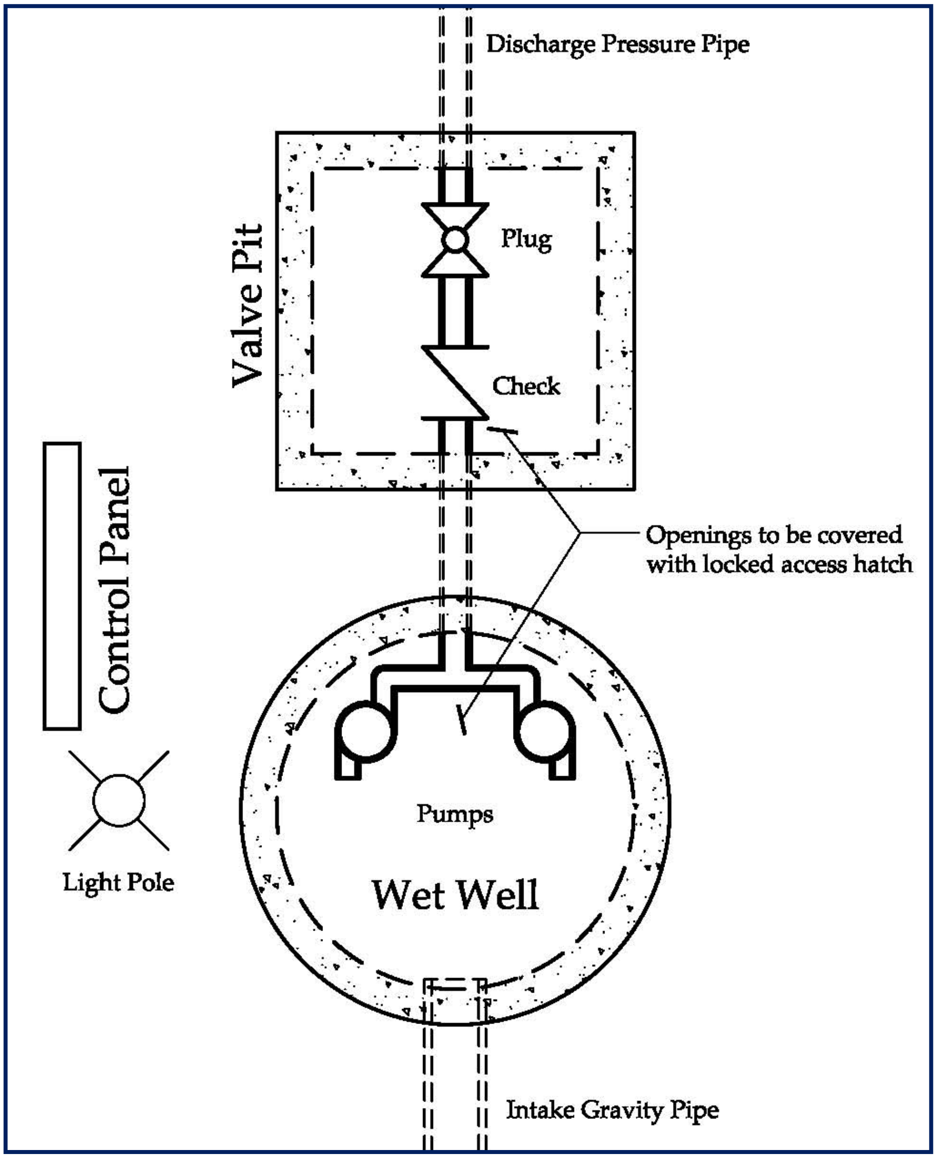


Figure 7.5-1 Typical Pump Station Layout

7.5.1 Household Connections

It is anticipated and budgeted that each facility being connected to the collection system will require some amount of plumbing work to transfer the wastewater from the current disposal method to the new collection pipe system.

However, as determined through the survey conducted as part of this project, as well as discussions with local citizens, some homes do not have toilet facilities. For these homes, it is recommended that BWSL enter into an agreement with the homeowner to build a simple toilet and sink bathhouse and connect these structures to the collection system. A schematic detail is provided in Figure 7.5-2. An estimated quantity of facilities needed and cost estimate for the work is included within the Collection System cost estimate provided in Appendix C.

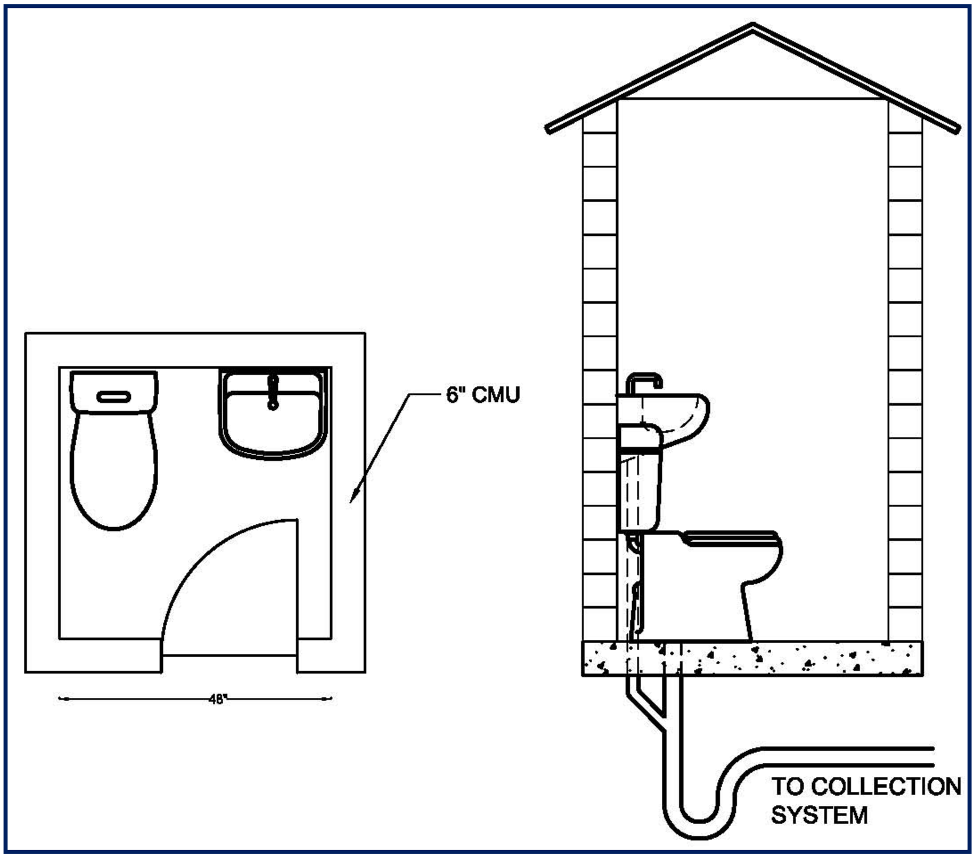


Figure 7.5-2 Bathhouse Schematic Detail

8 Environmental Feasibility Assessment

8.1 Preferred Wastewater Management System Results

Table 8.1-1 summarizes the anticipated influent and effluent characteristics of the wastewater system.

Table 8.1-1 Estimated 2040 Wastewater Nutrient Loading Reduction

Total 2040 Estimated Wastewater		Influent	Effluent	Reduction
Average Daily Flow	MGD	0.8		
	mg/L	300	< 30	
BOD_5	lbs/day	2,000	< 70	> 95%
Fecal Coliform	MPN/100ml	6.5 x 10^6	< 200	> 99.99%
	mg/L	20	< 3	
Total Nitrogen	lbs/day	133	< 20	~ 85%
	mg/L	21	< 5	
Total Phosphorous	lbs/day	140	< 35	~ 75%

8.2 Ecology of Candidate Treatment System Locations

The following sites have been selected as alternatives for the wastewater treatment ponds (see Sections 5.4.1 and 0). These descriptions are based on a field survey conducted on November 30, 2011. Figure 8.2-1 shows the four potential treatment facility locations evaluated for this study. Additional locations may be evaluated during the final design.

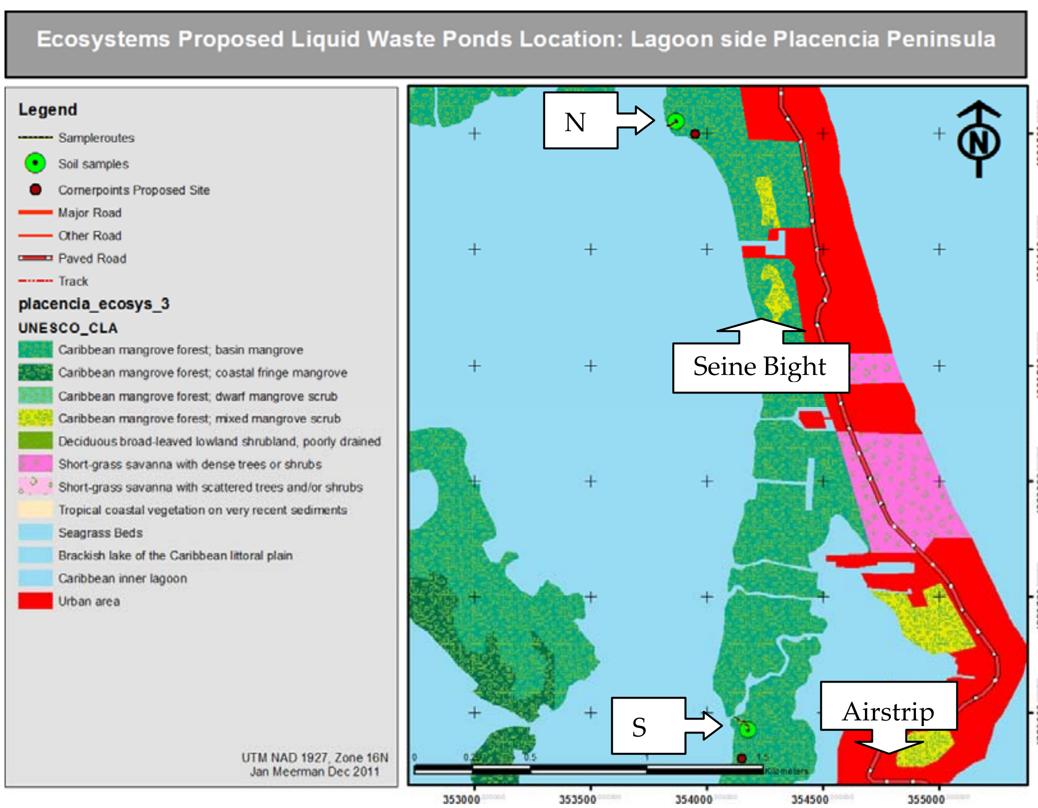


Figure 8.2-1 Evaluated Treatment Plant Locations

8.2.1 Peninsula Treatment Facility Locations

Table 8.2-1 summarizes information regarding the Placencia Village treatment facility site. Figure 8.2-2 is a series of four photographs taken during the project team's visit to the site.

Table 8.2-1 Placencia Village Treatment Site's Ecology Observations

Observation Category	Site Information
Site	Adjacent to Placencia Airstrip
UTM	354,166E 1,828,921N
Date	Nov 30, 2011
Location	On the west side of peninsula, behind airstrip, next to a newly dug channel, indicating scheduled development
Elevation above Lagoon	0 m
Vegetation	Medium *Rhizophora mangle* - Red Mangrove (Basin Mangrove)
Soil	Peat
Groundwater Level	0 cm
Soil Sample Description	Wet and loosely consolidated mangrove peat to a depth of 1.5m. Locals informed the team that sand can be found at a depth of > 2m

Placencia Village Site: Medium Sized Red Mangrove

Placencia Village Site: Sampling

Placencia Village Site: Recently Dug Canal Nearby

Placencia Village Site: Mangrove Peat

Figure 8.2-2 Placencia Village Treatment Facility Site Visit Pictures

Table 8.2-2 summarizes information regarding the Seine Bight Village treatment facility site. Figure 8.2-3 is a series of four photographs taken during the project team's visit to the site.

Table 8.2-2 Seine Bight Treatment Site Ecology Observations

Observation Category	Site Information
Site	West of Seine Bight Village
UTM	353,882E 1,831,543N
Date	Nov 30, 2011
Location	On the west side of peninsula, just behind Seine Bight. Next to a newly cleared area with active development activities.
Elevation above Lagoon	0 m

Observation Category	Site Information
Vegetation	Medium *Rhizophora mangle* - Red Mangrove (Basin Mangrove)
Soil	Peat
Groundwater Level	0 cm
Soil Sample Description	Wet and loosely consolidated mangrove peat to a depth of 1.5m. Locals informed the team that sand can be found at a depth of > 2m

Seine Bight Village Site: Freshly Cleared Red Mangrove

Seine Bight Village Site: Sampling

Seine Bight Village Site: Freshly Created Access Road

Seine Bight Village Site: Mangrove Peat

Figure 8.2-3 Seine Bight Village Treatment Facility Site Visit Pictures

8.2.2 Mainland Treatment Facility Location

As shown on Figure 8.2-4, the preferred site is located west of the Placencia Lagoon. Three soil samples were taken here on locations called "South", "Central" and "West".

Mainland-South Site

Table 8.2-3 summarizes information regarding the Mainland-South treatment facility site. Table 8.2-4 lists the observed vegetative species at the site. Figure 8.2-5 is a series of photographs from the site visit.

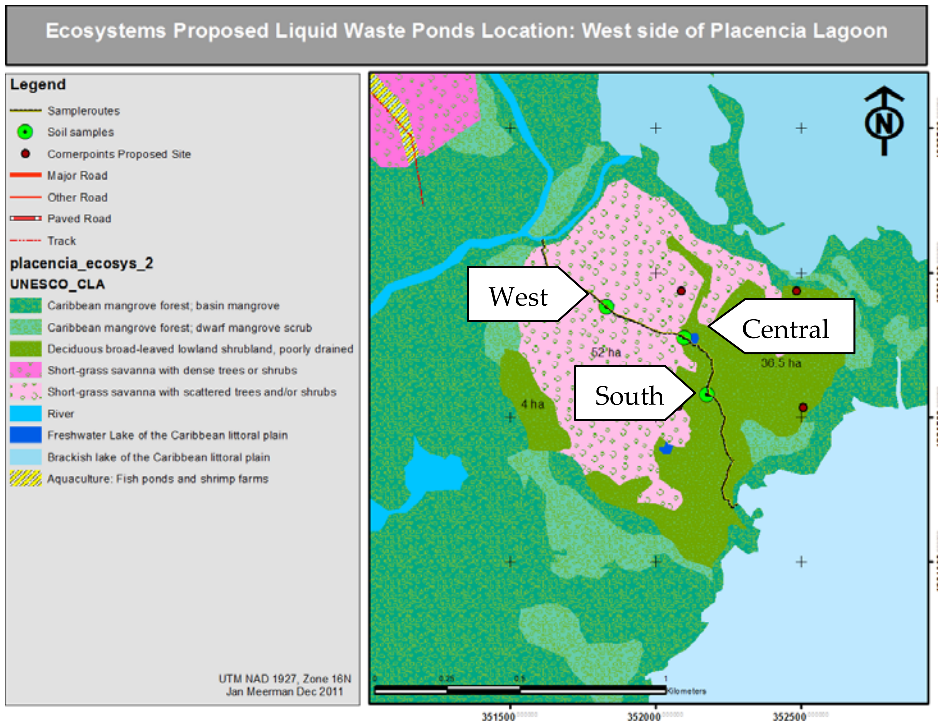


Figure 8.2-4 Mainland Treatment Facility Location Map

Table 8.2-3 Mainland-South Treatment Site's Ecology Observations

Observation Category	Site Information
Site	Mainland-South
UTM	352,173E 1,831,585N
Date	Nov 30, 2011
Location	On a "peninsula" on the west side of Placencia Lagoon. Scrub forest with recent (2011) fire damage.
Elevation above Lagoon	0.5 – 3 m approximate
Vegetation	Scrub forest with the following species recorded:
Soil	Clay with distinct hog wallow relief indicating wetting and drying cycles.

Observation Category	Site Information
Groundwater Level	30 cm
Soil Sample Description	Various layers of sandy clay. Drilled to 1.2 m where a hard stony layer was encountered. Top 20 cm dense greenish-gray clay with some humus 20 - 100 cm: yellow sandy clay. 100 - 120 cm: yellow mottled clay with white veins and red gravel like clay conglomerates.

Table 8.2-4 Observed Mainland South Treatment Site Vegetative Species

Family	Species	Family	Species
Anacardiaceae	*Metopium brownei*	Lycopodiaceae	*Lycopodiella cernua*
Aquifoliaceae	*Ilex quianensis*	Malpighiaceae	*Byrsonima crassifolia*
Arecaceae	*Acoelorraphe wrightii*	Melastomataceae	*Miconia ciliata*
Asclepidaceae	*Metastelma schlechtendalii*	Melastomataceae	*Mouriri exilis*
Chrysobalanaceae	*Chrysobalanus icaco*	Melastomataceae	*Tococca guianensis*
Clusiaceae	*Calophyllym brasiliense*	Mimosoideae	*Inga pinetorum*
Clusiaceae	*Clusia sp*	Myricaceae	*Myrica cerifera*
Clusiaceae	*Symphonia globulifea*	Myrtaceae	*Eugenia aeruginea*
Cyperaceae	*Scleria bracteata*	Myrtaceae	*Eugenia sp*
Dilleniaceae	*Doliocarpus dentatus*	Myrtaceae	*Eugenia sp2*
Dilleniaceae	*Doliocarpus dentatus*	Myrtaceae	*Psidium guinense*
Erythroxylaceae	*Erythroxylon guatemalense*	Ochnaceae	*Ouratea nitida*
Fagaceae	*Quercus oleoides*	Rhizophoraceae	*Casipourea guianensis*
Gentianaceae	*Coutoubea spicata*	Vochysiaceae	*Vochysia hondurensis*

Mainland South: Dense Scrubland

Mainland South: Cutgrass as Most Abundant Species

Mainland South: Soil Sample

Mainland South: Yellow Mottled Clay with White Veins and Red Gravel like Clay Conglomerates

Figure 8.2-5 Mainland-South Treatment Facility Site Visit Pictures

Mainland-Central Site

Table 8.2-5 summarizes information regarding the Mainland-Central treatment facility site.Table 8.2-6 lists the observed vegetative species at the site. Figure 8.2-6 is a series of photographs from the site visit.

Table 8.2-5 Mainland-Central Treatment Site Ecology Observations

Observation Category	Site Information
Site	Mainland-Central (preferred location)
UTM	352,094E 1,831,767N
Date	Nov 30, 2011
Location	On a "peninsula" on the west side of Placencia Lagoon. One of the highest points of the peninsula near a small rain-fed lake.
Elevation above Lagoon	3-4m estimated
Vegetation	Transition from open savannah to scrub forest. Abundant *Acoelorraphe wrightii* palms.
Soil	Clay with distinct hog wallow relief indicating wetting and drying cycles.
Groundwater Level	5 cm
Soil Sample Description	Soil sample description: Various layers of sandy clay. Drilled to 1.2 m where a hard stony layer was encountered Top 30 cm very wet muddy clay with peat and root fragments 30 - 50 cm: wet gray sandy clay. 50 - 100 cm: white-gray sandy clay. 100 120 cm: Dense gray clay with red mottling and isolated red "baked clay" fragments

Table 8.2-6 Observed Mainland Central Treatment Site Vegetative Species

Family	Species
Arecaceae	*Acoelorraphe wrightii*
Chrysobalanaceae	*Chrysobalanus icaco*

Mainland central: Open Savanna to Dense Scrub Land

Mainland Central: Soil Sample

Mainland Central: White-Gray Sandy Clay

Mainland Central: Dense Gray Clay Red Mottling

Figure 8.2-6 Mainland-Central Treatment Facility Site Visit

Mainland-West Site

Table 8.2-7 summarizes information regarding the Mainland-West treatment facility site. Table 8.2-8 lists the observed vegetative species at the site. Figure 8.2-7 is a series of photographs from the site visit.

Table 8.2-7 Mainland-West Treatment Site Ecology Observations

Observation Category	Site Information
Site	Mainland-West
UTM	351,822E 1,831,887N
Date	Nov 30, 2011
Location	On a "peninsula" on the west side of Placencia Lagoon. Open savanna
Elevation above Lagoon	3-4m estimated
Vegetation	Open savanna vegetation with sedges.
Soil	Sandy clay with hog wallow relief indicating wetting and drying cycles.
Groundwater Level	50 cm
Soil Sample Description	Soil sample description: Various Types of silty sand with red gravel and "corned beef" clay at the bottom. Top 20 cm: brown/grey sandy clay with roots etc. 20 - 50 cm: light gray sand with some clay. 50 - 70 cm: yellow sand 70-80 cm: Gray sand/clay with red mottling and red stony clay particles 80- 130 cm: pale yellow very sandy clay

Table 8.2-8 Observed Mainland West Treatment Site Vegetative Species

Family	Species	Family	Species
Arecaceae	*Acoelorraphe wrightii*	Letibiculariaceae	*Utricularia sp*
Dilleniaceae	*Curatela americana*	Letibiculariaceae	*Utricularia subulata*
Droseraceae	*Drosera cappilaris*	Lycopodaceae	*Lycopodiella caroliniense*
Letibiculariaceae	*Utricularia amethystina*	Polygalaceae	*Polygala adenophora*
Letibiculariaceae	*Utricularia juncea*	Xyridaceae	*Xyris ambigua*

Mainland West: Open Savanna

Mainland West: Open Savanna

Mainland West: Soil Sample

Mainland West: Yellow Sand

Figure 8.2-7 Mainland-West Treatment Facility Site Visit

8.2.3 North Treatment Facility Location

As shown on Figure 8.2-8, the North site is located on the mainland towards the very northern end of the Placencia Lagoon. Table 8.2-9 summarizes information regarding the North treatment facility site. Table 8.2-10 lists the observed vegetative species at the site. Figure 8.2-9 is a series of photographs from the site visit.

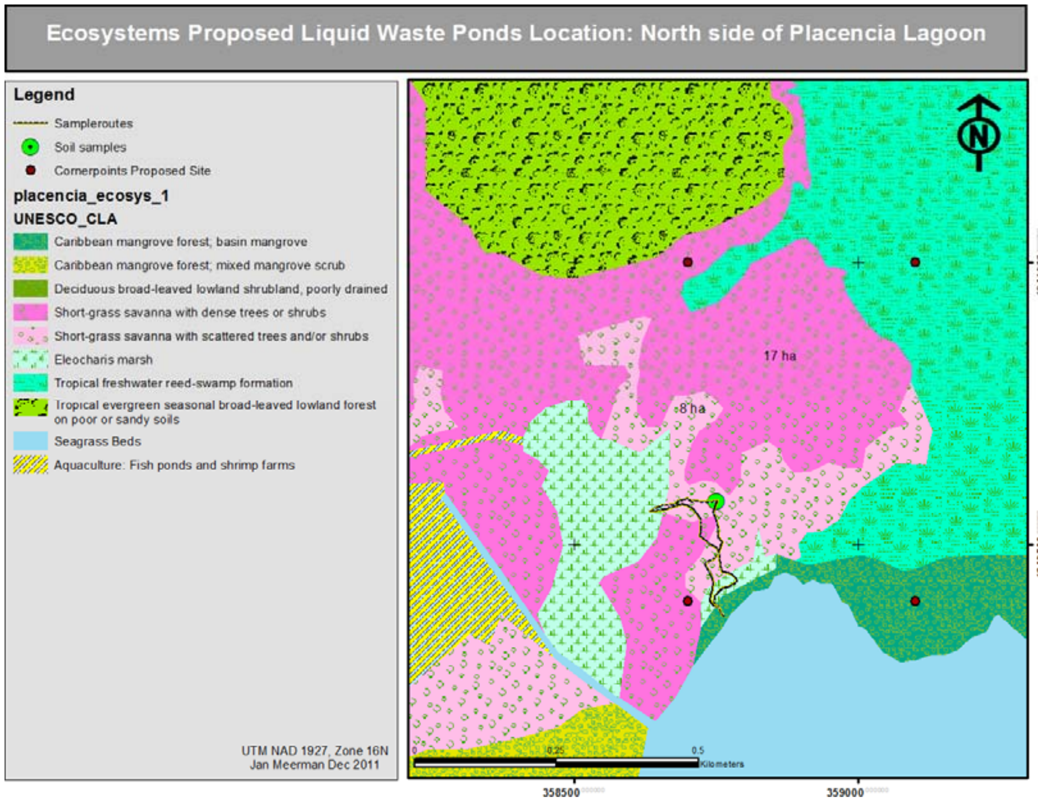


Figure 8.2-8 North Treatment Facility Location Map

Table 8.2-9 North Treatment Site Ecology Observations

Observation Category	Site Information
Site	North (Laguna Madre Shrimp farm Belize Ltd)
UTM	358,739E 1,843,570N
Date	Nov 30, 2011
Location	Immediately north of the extreme north end of Placencia Lagoon and south of the Riversdale road. Savanna, mangrove and other wetlands
Elevation above Lagoon	< 1 m estimated
Vegetation	Very wet, open savanna.
Soil	Clay with some hog wallow relief indicating cycles of wetting and drying

Observation Category	Site Information
Groundwater Level	5 cm
Soil Sample Description	Various Types of silty sand with red gravel and "corned beef" clay at the bottom. Top 20 cm: gray sandy clay with roots and plant particles 20 - 40 cm: Bright yellow sandy clay 40 - 110 cm: Very wet pale gray sand 110 - 120 cm: Yellow Sandy clay with red mottling and some reddish clay lumps.

Table 8.2-10 Observed North Site Vegetative Species

Family	Species
Arecaceae	*Acoelorraphe wrightii*
Blechnaceae	*Blechnum serrulatum*
Caesalpinioideae	*Chamaecrista desvauxii (=bartlettii)*
Cyperaceae	*Fimbristylis dichotoma?*
Cyperaceae	*Fimbristylis sp*
Dilleniaceae	*Curatela americana*
Droseraceae	*Drosera cappilaris*
Gentianaceae	*Schultesia brachyptera*
Letibiculariaceae	*Utricularia juncea*
Malpighiaceae	*Byrsonima crassifolia*
Myricaceae	*Myrica cerifera*
Passifloraceae	*Passiflora urbaniana*
Pinaceae	*Pinus caribbaea*
Sterculiaceae	*Melochia spicata*
Xyridaceae	*Xyris sp*

North: Open, Very Wet Savanna

North: Open Savanna

North: Soil Sample

North: Yellow Sandy Clay

Figure 8.2-9 North Treatment Facility Site Visit

8.3 Policy, Legal and Administrative Framework

8.3.1 IDB Operational Policies

The InterAmerican Development Bank (IDB) has developed a set of Operational Policies (OP). Any proposal that is to be funded by the IDB has to follow the standards set out in these OP.

The OP applicable to the proposed wastewater collection, treatment and disposal system for the Placencia Peninsula are:

- Environment and Safeguard Compliance Policy (OP 703)
- Disclosure of information (OP 102)
- Involuntarily Resettlement (OP 710)
- Disaster Risk Management (OP 704)

Environment and Safeguard Compliance Policy (OP 703)

This OP requires that such facility be subject to an Environmental and Social Analysis (ESA) and the preparation of an Environmental and Social Management plan to ensure its safe construction and operation.

Disclosure of information (OP 102)

The Bank seeks to maximize access to the information that it produces and will therefore disclose any information not contained on a list of exceptions. The policy is predicated not on a list of information that it chooses to disclose but rather on a clear definition of information that it will not disclose.

Involuntarily Resettlement (OP 710)

This policy covers any involuntary physical displacement of people caused by a Bank project.

Disaster Risk Management (OP 704)

Bank-financed public and private sector projects will include the necessary measures to reduce disaster risk to acceptable levels as determined by the Bank on the basis of generally accepted standards and practices.

When significant risks due to natural hazard are identified at any time throughout the project preparation process, appropriate measures should be taken to establish the viability of the project, including the protection of populations and investments affected by Bank financed activities. Alternative prevention and mitigation measures that decrease vulnerability must be analyzed and included in project design and implementation, as applicable.

8.3.2 The Environmental Protection Act

The Environmental Protection Act Chapter 328, Revised Edition 2000, entrusted the Department of the Environment with a broad range of functions relating to the protection of the environment, including the assessment of water pollution, the coordination of activities relating to the discharge of wastes, the licensing of activities that may cause water pollution, the registration of sources of pollution and the carrying out of research and investigations as to the causes, nature and extent of water pollution, and the necessary prevention and control measures.

8.3.3 Environmental Impact Assessment

In Environmental Impact Assessment (Amendment) Regulations, 2007. S.I. No. 24 of 2007 schedule II, projects are listed that may require an environmental impact assessment or limited level environmental study depending on the location and the size of the project. "Wastewater treatment plant" is listed under part 20d.

Guidelines are listed under Schedule III to be used by permitting and/or licensing agencies to determine when a project is to be sent to DOE for an Environmental Clearance. Applicable guidelines to the proposed project include:

- all applications for development in coastal areas;
- all applications for development near or in ecologically sensitive areas like swamps, marshes, mangrove, lagoon; and,
- all applications for development within or in close proximity to critical habitats for protected, threatened or endangered species of flora and fauna

8.3.4 Pollution Regulations

Pollution Regulations, 1996. S.I. No. 56 of 1996, under Part XI, noise abatement is regulated. Under the second schedule maximum noise level and duration of the noise is defined.

8.3.5 Environmental Protection

Environmental Protection (Effluent Limitations) (Amendment) Regulations, S.I. 102 of 2009, under the third schedule, the effluent limits of the discharge from domestic wastewater treatment systems into Class I waters is determined, as shown Table 4.3-1.

8.4 Project Environmental Considerations

Construction and operation of the proposed wastewater system created various environmental impacts, as discussed below.

8.4.1 Land Systems and Agricultural Value

8.4.1.1 Peninsula

Soils at the peninsula will hardly be affected by the wastewater collection system. All pipelines are underground, only the pump houses and the wet wells will require some land. The agricultural value of the soils of the peninsula is very low. The impact on available land for residential use is larger; see Section 8.4.6 on social matters.

8.4.1.2 Mainland

Soils at the preferred location for the construction of treatment ponds have a low agricultural value. Although the preferred site may have a potential for shrimp farming, the total areal of this patch with higher grounds is a limitation for the establishment of such an enterprise.

8.4.1.3 Impacts and Recommended Mitigation and Monitoring

As shown on Table 8.4-1, no mitigation measures or monitoring efforts are proposed to mitigate the negative impacts of the construction of the wastewater collection and treatment facilities on lands with a high agricultural value.

Table 8.4-1 Environmental Impacts of the Proposed Wastewater System: Land and Agricultural Systems

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost per Env. Benefit
Digging trenches	Removal vegetation	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Disturbing landscaped gardens	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Removal fences	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Disturbance soil	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Need access to private yards	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Dust production	Negative	Direct	Short	Avoidable	Reversible	Small	Low
	Noise production	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Open trenches dangerous for traffic	Negative	Indirect	Short	Avoidable	Reversible	Medium	Low
	Blocking of traffic	Negative	Indirect	Short	Avoidable	Reversible	Medium	Low
	Breaking of water and other utility lines	Negative	Indirect	Short	Avoidable	Reversible	Medium/High	Medium
	Unsightly sight after completion	Negative	Direct	Short	Avoidable	Reversible	Small	Low
Placing sub-marine pipe through lagoon	Removal marine/coastal vegetation	Negative	Direct	Short	Unavoidable	Irreversible	Small	Low
	Increase siltation	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
	Obstruction boating traffic	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
Construction access road to the wastewater treatment site	Private land acquisition	Negative	Direct	Long	Unavoidable	Irreversible	Medium	Medium
	Removal natural vegetation	Negative	Direct	Short	Unavoidable	Reversible	Medium	Low
	Trucking movements to haul in road fill	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
	Disturbance natural drainage	Negative	Indirect	Long	Avoidable	Irreversible	Medium	Medium
	Excavation of road fill material	Negative	Indirect	Short	Unavoidable	Irreversible	Medium	Medium
Prepare wastewater treatment site	Private land acquisition	Negative	Direct	Long	Unavoidable	Irreversible	High	High
	Removal natural vegetation	Negative	Direct	Short	Unavoidable	Irreversible	Medium	Medium
	Dumping of waste soil	Negative	Direct	Short	Unavoidable	Irreversible	Medium	Medium
	Increase siltation resulting from earth works	Negative	Indirect	Short	Avoidable	Reversible	Small	Low
	Quarrying for lining material (when applicable)	Negative	Direct	Short	Unavoidable	Irreversible	Medium	Medium
	Dust production	Negative	Indirect	Short	Avoidable	Reversible	Small	Low
	Noise production	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
Installing individual pumps (where applicable)	Cost price pump units	Negative	Direct	Short	Unavoidable	Irreversible	High	High
	Connecting costs	Negative	Direct	Short	Unavoidable	Irreversible	Medium	Medium
	Operation costs pump	Negative	Direct	Long	Unavoidable	Irreversible	Small/Medium	Medium
	Maintenance schedule	Negative	Direct	Long	Unavoidable	Irreversible	Small	Medium
Building centralized pump stations	Land requirements	Negative	Direct	Short	Unavoidable	Irreversible	Small	Low
	Traffic obstructions	Negative	Indirect	Short	Avoidable	Reversible	Small	Low
	Noise	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
	Unsightly sight after completion	Negative	Direct	Short	Avoidable	Reversible	Small	Low
Operational phase wastewater system	Improved water quality of lagoon and sea	Uncertain - needs	Direct	Long	N.A.	Depending on success of project	High	?
	Smelly wastewater ponds	Negative	Indirect	Long	Avoidable	Reversible	Medium	Medium
	Wastewater ponds become mosquito breeding	Negative	Indirect	Long	Avoidable	Reversible	High	High

8.4.2 Flora and Fauna

8.4.2.1 Peninsula

Most natural vegetation of the peninsula has already been altered or will be changed in the nearby future. The bulk of the natural vegetation on the peninsula is found on the lagoon side, nearly exclusively consisting of mangroves. Therefore, works on the peninsula will have little impact on the natural environmental apart from the site where the underwater pipe carrying the wastewater will enter the lagoon. In this pond, a small section of the shore vegetation will need to be removed to enable installation of the pipe.

8.4.2.2 Mainland

The preferred location of the treatment ponds is covered with natural vegetation of "Short-grass Savanna with Scattered Trees" and "Deciduous Broad-leaved Lowland Shrubland". These vegetation types are very common in the coastal plains. Of the approx. 88 acres (combined), 30 acres or 40% is needed for the treatment ponds. During construction of the ponds, a larger acreage will be affected to allow heavy machinery access to the site.

Access to the location will be by overwater transport using barges. A landing has to be constructed which will be used in the future by maintenance crews. The construction of a road from the southern highway to the pond location would increase the costs of the project considerably since several bridges would need to be constructed.

One of the options for tertiary treatment of the effluents is to direct the discharge water through the surrounding vegetation where the nutrients are absorbed by the natural vegetation and adsorbed by soil particles. To avoid a one-point release, some minor earth works may be needed to guide the discharge water over a larger land surface

8.4.2.3 Impacts and Recommended Mitigation and Monitoring

The location on the peninsula where the pipe enters the lagoon has to remain accessible for any maintenance crew and re-vegetation of this site is not recommended. Additional space that was cleared to allow the construction crews to carry out their work and that is not needed to allow maintenance crews access to the pipe, can be re-planted with suitable plants, for instance mangroves. Table 8.4-2 – Table 8.4-4 summarize the environmental impact, recommended mitigation and monitoring for flora and fauna.

Table 8.4-2 Environmental Impact of Wastewater System: Flora and Fauna

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost per Env. Benefit
Digging trenches	Removal natural vegetation	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
Construction of access to the	Removal natural vegetation	Negative	Direct	Long	Unavoidable	Irreversible	Medium	Low
Prepare wastewater treatment site including construction of ponds	Removal natural vegetation	Negative	Direct	Long	Unavoidable	Irreversible	High	High
Operational phase wastewater system	Improved water quality of lagoon, restoration of the natural sea grass beds in the lagoon	Positive	Direct	Long	N.A.	N.A.	Small	Inherit System

Table 8.4-3 Environmental Mitigation Recommendations: Flora and Fauna

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional responsibilities	Cost Estimate	Comments
Digging trenches	Removal natural vegetation, in especial the mangrove vegetation on the lagoon shore (where the underwater pipe will be)	Replant mangrove at sites where no future activities are to be expected	Construction company	US$ 10/square yard replanted area	Collaborate with local organizations (for example S.E.A. and P.C.S.D.) that are already involved in replanting mangrove
Construction of access to the treatment site where heavy equipment will be disembarked	Removal of the natural vegetation, in especial the mangrove vegetation on the lagoon shore	Construct a permanent landing site to avoid wide scale destruction of the mangrove and other wetland plants, This landing site will be used for maintenance activities in the future	Design of the landing site will be part of the technical design	Depending on the design and local needs for fill	
Prepare wastewater treatment site including construction of ponds	Natural vegetation will be permanently removed where the treatment ponds will be constructed. Natural vegetation around these ponds will be temporarily effected during construction activities	After completion of the treatment ponds, restore the natural profile of the surrounding effected land in order to restore natural drainage patterns. Depending on the effected vegetation, some replanting of Acoelorraphe is recommended	Construction company	Location Dependent; US$3/palm @ 1 palm per 10 squ.yard	Collaborate with local organizations (for example S.E.A. and P.C.S.D.) that are already involved in replanting mangrove efforts.

Table 8.4-4 Environmental Monitoring Recommendations: Flora and Fauna

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Parameters to be monitored	Location	Methods and equipment	Frequency	Responsibilities	Cost (US$)
Digging trenches	Removal natural vegetation, in especial the mangrove vegetation on the lagoon shore (where the underwater pipe will be)	Replant mangrove at sites where no future activities are to be expected	Replanting of mangroves was done after construction of the underwater pipe was completed	Site where the underwater pipe leading from the central wet well is entering the lagoon	Visual inspection, photography	One month after completion of the underwater pipe; six months later to monitor if the replant effort was successful	Report on the replant effort and the level of survival of the replanted vegetation	US$ 100 per visit and report writing, including use of camera
Construction of access to the treatment site where heavy equipment will be disembarked	Removal of the natural vegetation, in especial the mangrove vegetation on the lagoon shore	Construct a permanent landing site to avoid wide scale destruction of the mangrove and other wetland plants, This landing site will be used for maintenance activities in the future	Access to the treatment pond site happens by using the landing site, no use of alternative sites	Mainland, treatment pond site	Visual inspection, photography	Monthly during construction activities, more frequent when it is noticed that alternative sites are used	Report on proper use of the constructed landing site	US$ 100 per visit and report writing, including use of camera
Prepare wastewater treatment site	Natural vegetation will be permanently removed where the treatment ponds will be constructed. Natural vegetation around these ponds will be temporarily effected during construction activities	After completion of the treatment ponds, restore the natural profile of the surrounding effected land in order to restore natural drainage patterns. Depending on the effected vegetation, some replanting of tachiste palms is needed	Restoration of land surface to a natural profile, replanting efforts if appropriate	Mainland, treatment pond site	Visual inspection, photography	One month after completion of the ponds; six months later to monitor if the replant (if needed) was successful	Report on the rehabilitation of the soil, replanting efforts and survival of the plants	US$ 100 per visit and report writing, including use of camera

8.4.3 Hydrology

8.4.3.1 Construction phase

During the construction phase of the ponds, the local drainage pattern of the site will be affected by the heavy machinery involved in the activities. The construction of the ponds requires the excavation of soil material, which may be of unsuitable quality for the construction of the impoundment system.

8.4.3.2 Operational phase

The wastewater collection and treatment facility will reduce the amount of wastewater that is released by the individual sanitation systems located throughout the peninsula by inadequate individual systems. The present systems pollute the groundwater and the open water environment (sea and lagoon) with their bacteriological and nutrients contents. The proposed system will adequately treat the wastewater, reducing the bacteriological contents and the Biochemical Oxygen Demand (BOD_5) within the standards set by the Effluent Limitation Regulations S.I. 102 of 2009.

Reduction of the nutrient load will happen in the so-called tertiary treatment phase. After receiving primary and secondary treatment in the ponds, the effluent will be directed to an area where the effluent is discharged in a vegetated zone. Plants will absorb the nutrients (such as nitrogen and phosphorus) and soil particles will absorb them, lowering the nutrient load of the treated wastewater. The terrain is landscaped in such a way that point release in the open water is prevented.

Due to low density and distance from the main pipe, a certain amount of properties will not be connected to the system, at least not immediately. The negative effect will be that uncontrolled disposal of wastewater will continue at these locations. The amount of developments that will be affected is unclear at this stage, but needs to be assessed in the final design. However, the quantity and thereby the impact is expected to be minimal and easily mitigated by mandating the construction of proper septic systems at these locations.

8.4.3.3 Impacts and Recommended Mitigation and Monitoring

Construction of the system, in particular the treatment ponds, will have a negative impact on the hydrology of the August Creek watershed and the lagoon. Many adverse impacts are avoidable through proper management and most are reversible with proper cleaning up activities after the construction activities have been completed. Monitoring of the construction activities are for a limited period only.

Ultimately, the system results in a reduction of the pollution by domestic wastewater system, in particular the reduction of the E-coli level of the lagoon water and reduction of N and P loads of the water.

The effectiveness of the treatment system is monitored by regular water testing of the effluents that are discharged from the tertiary treatment phase. The level of effluent should be well within the limits set by Effluent Limitation Regulations S.I. 102 of 2009. However, these Effluent Limitation Regulations do not set any limitation to the nutrient load of the effluent. Most industries do have a limit for the N and P contents of their effluent namely 10 mg/l for N and 5 mg/l for P. Monitoring of the quality of the effluent will be an ongoing activity.

Table 8.4-5– Table 8.4-7 summarize the environmental hydrological impacts, recommended mitigation and monitoring

Table 8.4-5 Environmental Impacts of the Proposed Wastewater System: Hydrological

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost / Benefit
Construction of the ponds	Excavation of soil material and disposing of it	Negative	Direct	Long	Unavoidable	Irreversible	Large	Cost
	Disruption of natural drainage patterns	Negative	Direct	Short	Unavoidable	Reversible	Medium	Cost
	Compacting of soil, reducing its infiltration capacity	Negative	Direct	Short	Unavoidable	Reversible	Medium	Cost
Operational phase	Replacement of the diffuse wastewater discharge by	Positive	Direct	Long	N.A.	N.A.	Large	Benefit
	Point release of nutrients	Negative	Direct	Long	Avoidable	Reversible	Large	Cost
	Point release of bacteria	Negative	Direct	Long	Avoidable	Reversible	Large	Cost

Table 8.4-6 Environmental Mitigation Recommendations: Hydrological

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional responsibilities	Cost Estimate	Comments
Construction of the ponds	Excavation of soil material and disposing of it	Investigate if excavated material can be used for the construction of the impoundment	Project design team	Part of the design	
		Dispose material at a location where it is not blocking any natural waterway	Project design team: locate an appropriate site	Part of the design and construction contract	
			Contractor: execution of the task		
	Disruption of natural drainage patterns	After finishing of the construction phase, rehabilitate the drainage patterns of the surrounding lands	Contractor	Part of the contract	
	Compacting of soil, reducing its infiltration capacity	After finishing of the construction phase, rehabilitate soil of the surrounding lands	Contractor	Part of the contract	
Operational phase	Point release of nutrients	Proper design of the tertiary treatment location to avoid point release of the treated wastewater	Project design team: design diffuse release system	Part of the design and construction contract	
			Contractor: execution of the task		
	Point release of bacteria	Proper design of the tertiary treatment location to avoid point release of the treated wastewater	Project design team: design diffuse release system Contractor: execution of the task	Part of the design and construction contract	

Table 8.4-7 Environmental Monitoring Recommendations: Hydrological

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Parameters to be monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Pond Construction	Excavation of soil material and disposing of it	Dispose material at a location where it is not blocking any natural waterway	Inspection of the disposed material site	Mainland, treatment ponds site	Visual inspection, photography	One month after completion of the ponds; six months after completion of the ponds to confirm consolidation of the situation	Document the disposal site	$ 200 per visit
	Disruption of natural drainage patterns	After finishing of the construction phase, rehabilitate the drainage patterns of the surrounding lands	Inspection of the drainage of the area	Mainland, treatment ponds site	Visual inspection, photography	One month after completion of the ponds; six months after completion of the ponds to confirm consolidation of the situation	Document the drainage of the area	Carry out during soil disposal site monitoring
	Compacting of soil, reducing its infiltration capacity	After finishing of the construction phase, rehabilitate soil of the surrounding lands	Inspection of the drainage of the area, for instance newly created areas with standing water	Mainland, treatment ponds site	Visual inspection, photography	One month after completion of the ponds; six months after completion of the ponds to confirm consolidation of the situation	Document the drainage of the area	Carry out during soil disposal site monitoring
Operational phase	Point release of nutrients and organic load	Proper design of the tertiary treatment location to avoid point release of the treated wastewater	BOD5, N and P	In the August and Mango Creeks: upstream and downstream of the discharge area	Management of treatment system sets up water test laboratory unit in Placencia village	Monthly	Document BOD5, N and P, & Report to management of the treatment ponds and DoE	Collecting efforts $ 200 per trip, reagents $ 10 per trip, in conjunction with coli testing
	Point release of bacteria	Proper design of the tertiary treatment location to avoid point release of the treated wastewater	E-coli (total coliform testing)	In the August and Mango Creeks: upstream and downstream of the discharge area	Management of treatment system sets up water test laboratory unit in Placencia village	Monthly	Document E-coli levels & Report to management of the treatment system and DoE	Collecting efforts $ 200 per trip, reagents $ 10 per trip, in conjunction with coli testing

8.4.4 Air and Noise Pollution

The whole project will do little to create air and noise problems. Most possible problems will arise during the construction phase due to the effect of equipment used. Mitigation and Monitoring are limited to these aspects of the project.

Table 8.4-8 – Table 8.4-10 summarize the air and noise environmental impacts, recommended mitigation and monitoring.

Table 8.4-8 Environmental Impacts of the Proposed Wastewater System: Air and Noise

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost per Environ. Benefit
Digging trenches	Dust production	Negative	Direct	Short	Avoidable	Reversible	Small	Low
	Noise production	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
Prepare wastewater treatment site	Dust production	Negative	Indirect	Short	Avoidable	Reversible	Small	Low
	Noise production	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low

Table 8.4-9 Environmental Mitigation Recommendations: Air and Noise

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional Responsibilities	Cost Estimate	Comments
Digging trenches	Dust production	If needed, use sprinkler system (vehicle) to wet the soil	Contractor	Part of contract	Cooperation with land owner
	Noise production	Use properly maintained machinery, adhere to noise pollution regulations.	Contractor	Part of contract	
		No use of heavy machinery before 7 am and after 6 pm			
Prepare wastewater treatment site	Dust production	Wet the road surface and other surface to minimize dust production	Contractor	Part of contract	
	Noise production	Use properly maintained machinery, adhere to noise pollution regulations	Contractor	Part of contract	
		No use of heavy machinery before 7 am and after 6 pm			
Building centralized pump stations	Noise	Use properly maintained machinery, adhere to noise pollution regulations	Contractor	Part of contract	
		No use of heavy machinery before 7 am and after 6 pm			
Operational phase wastewater system	Smelly wastewater ponds	Proper design, implementation and management of the ponds	Engineer, BWS	Part of operational costs	

Table 8.4-10 Environmental Monitoring Recommendations: Air and Noise

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Parameters to be monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Digging Trenches	Dust production	If needed, use sprinkler system (vehicle) to wet the soil	Excessive dust production Dust plume higher than 5 yards	Where excavation activities are taking place at that time	Visual	When needed	Reporting: activity schedule of the watering truck: when and where active	Develop activity logbook, $300
	Noise production	Use properly maintained machinery, adhere to noise pollution regulations. No use of heavy machinery before 7 am and after 6 pm	Adhere to the noise levels as stipulated in Pollution regulations, 1996. S.I. 56 of 1996	At construction sites	Noise level measurements with dB meter	At random	Report, including construction site activities and noise levels at certain distances	Equipment US$ 80 Monitoring US$ 20/day
Prepare wastewater treatment site	Dust production	Wet the road surface and other surface to minimize dust production	Road visibility remains at a minimum of 100 yards	Access road (where on peninsula)	Visibility check after a truck passes	During dry weather	Reporting: activity schedule of the watering truck: when and where active	US$ 200/visit
	Noise production	Use properly maintained machinery, adhere to noise pollution regulations No use of heavy machinery before 7 am and after 6 pm	Adhere to the noise levels as stipulated in Pollution regulations, 1996. S.I. 56 of 1996	Access road (where on peninsula)	dB meter	Spot checks	Reporting recorded sound levels with number plate of vehicles	US$ 200/visit

8.4.5 Archaeology

8.4.5.1 Institute of Archaeology Consultation

No Archaeological sites as traditionally understood (residential and/or ceremonial sites) have been found along the shores of the Lagoon. MacKinnon and Kepecs (1989) described 16 locations along the lagoon where pre-historic salt making locations were discovered. The remains encountered during their investigations were temporary campsites with few mounds, which they described as refuse disposal sites. No stone foundations and rock-filled centers of traditionally house mounds were encountered, neither any burial activity. Other remains found were fragments of salt vessels and fired clay cylinders, both used during the salt production process.

It is possible that new salt winning camps are present in the underground, but if so, these would be buried under layers of sediment. The greatest impact of the proposed activities is the potential destruction of artifacts that might have shed a new light on the salt making practices of the Mayas.

New archaeological finds on the Placencia peninsula are not expected; since the area has been relatively well researched and large parts of the peninsula have already been developed over the years.

8.4.5.2 Impacts and Recommended Mitigation and Monitoring

After the final location of the treatment ponds has been identified, the Institute of Archaeology (IOA) will be contacted to determine the level of input required to complete a Rapid Archaeological Survey. This survey will become an integral part of the Environmental Impact Assessment which has to be completed before the actual construction of the wastewater collection and treatment system will start. Furthermore, when archaeological and/or historical remains are encountered during the actual construction activities, works at that locality has to be halted and the IOA has to be informed of the finds. After the IOA has investigated the discoveries, it will provide clearance to continue the construction works.

Table 8.4-11 – Table 8.4-13 summarize the archaeological impacts, recommended mitigation and monitoring.

Table 8.4-11 Environmental Impacts of the Proposed Wastewater System: Archaeology

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost per Environ. Benefit
Digging of Trenches Construction of Wet Wells Excavation of treatment ponds	Destruction of archaeological and historical remains	Negative	Direct	Long	Unavoidable	Irreversible	Small	Low

Table 8.4-12 Environmental Mitigation Recommendations: Archaeology

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional Responsibilities	Cost Estimate
Digging of Trenches Construction of Wet Wells	Destruction of archaeological and historical remains	Conduct Rapid Archaeological Sur vey at the identified site for the treatment ponds	BWSL	US$ 15,000
Excavation of treatment ponds		Instruct the construction crew in recognizing archaeological and historical remains and how to handle if these remains are encountered during excavation work	BWSL	Half a workday for the senior staff and heavy equipment operators US$ 1,000
		During excavation phase of the treatment ponds, an IoA approved supervisor is overlooking the works		US$ 1,500

Table 8.4-13 Environmental Monitoring Recommendations: Archaeology

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Parameters to be monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Digging trenches	Destruction of archaeological and historical remains	Instruct the construction crew in recognizing archaeological and historical remains and how to handle if these remains are encountered during excavation work	Discovery of archaeological and historical remains	Peninsula	Visual checks; laminated identification sheets, GPS unit, basic digital camera	During the excavation works of the trenches	Document location of the remains with GPS unit and camera. Inform the Institute of Archaeology.	Equipment (identification sheet, camera and GPS): US$ 500; Labor BZ$3,000/month
Construction of wet wells, pump houses	Destruction of archaeological and historical remains	Instruct the construction crew in recognizing archaeological and historical remains and how to handle if these remains are encountered during excavation work	Discovery of archaeological and historical remains	Peninsula	Visual checks; laminated identification sheets, GPS unit, basic digital camera	During the excavation works of the foundation of the buildings and wet wells	Document location of the remains with GPS unit and camera. Inform the Institute of Archaeology.	Equipment (identification sheet, camera and GPS): US$ 500; Labor BZ$3,000/month
Excavation of treatment ponds	Destruction of archaeological and historical remains	Instruct the construction crew in recognizing archaeological and historical remains and how to handle if these remains are encountered during excavation work	Discovery of archaeological and historical remains	Location of the treatment ponds on the mainland	Visual checks; laminated identification sheets, GPS unit, basic digital camera	During the excavation of the treatment ponds	Document location of the remains with GPS unit and camera. Inform the Institute of Archaeology	Equipment (identification sheet, camera and GPS): US$ 500; Labor BZ$3,000/month

8.4.6 Social Impacts

Proper sanitation facilities will improve the quality of life of the population by improving the hygienic conditions and resolving the problem of grey wastewater that oftentimes is often disposed of into houshold's yard.

An improved way of handling human waste will offer the people healthier living conditions whereby the amount of water borne diseases will be reduced.

Tourism will also be positively affected, as the peninsula will be able to boast of a healthy clean environment without persons running the risk of encountering contaminated waters.

The water quality of the lagoon and the sea will be safeguarded from excess nutrient levels and potential pathogens originating from human waste. The lagoon and the sea are the ultimate natural resources that are the cornerstone of local economic activities like the artisanal fishing industry and the tourism industry.

Providing proper sanitation is also a very cost effective way of providing assistance to the local and national economy. Evaluation of the costs and benefits of water and sanitation improvements estimated that the economic return from improved sanitation is about US$10 for every US$1 invested.[xxvi]

A factor of some concern is that some households will not want or be able to connect to the system due to the costs of installing proper sanitation. The issue can be mitigated by establishing a program that assists needy households with the installation of proper sanitary facilities. However, the possible magnitude of this potential problem is unknown.

Table 8.4-14 – Table 8.4-16 summarize the social impacts, recommended mitigation and monitoring.

Table 8.4-14 Social and Economic Impacts of the Proposed Wastewater System

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost per Environ. Benefit
Construction access road to the wastewater treatment site	Private land acquisition	Negative	Direct	Long	Unavoidable	Irreversible	Medium	Medium
	Trucking movements to haul in road fill	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
	Excavation of road fill material	Negative	Indirect	Short	Unavoidable	Irreversible	Medium	Medium
Prepare wastewater treatment site	Private land acquisition	Negative	Direct	Long	Unavoidable	Irreversible	High	High
	Dust production	Negative	Indirect	Short	Avoidable	Reversible	Small	Low
	Noise production	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
Installing individual pumps - only potentially applicable in case distant connections are made after the main construction phase - does not apply to the overall project	Cost price pump units	Negative	Direct	Short	Unavoidable	Irreversible	Small	Low
	Connecting costs	Negative	Direct	Short	Unavoidable	Irreversible	Small	Low
	Operation costs pump	Negative	Direct	Long	Unavoidable	Irreversible	Small	Low
	Maintenance schedule	Negative	Direct	Long	Unavoidable	Irreversible	Small	Low
Building centralized pump stations	Land requirements	Negative	Direct	Short	Unavoidable	Irreversible	Small	Low
	Traffic obstructions	Negative	Indirect	Short	Avoidable	Reversible	Small	Low
	Noise	Negative	Indirect	Short	Unavoidable	Reversible	Small	Low
	Unsightly sight after completion	Negative	Direct	Short	Avoidable	Reversible	Small	Low
Operational phase wastewater system	Costs of improving individual sanitation facilities to flush toilets	Negative	Indirect	Short	Unavoidable	Irreversible	Medium	Medium
	Extra costs for users system	Negative	Direct	Long	Unavoidable	Irreversible	Small	Medium
	Health benefits	Positive	Direct	Long	N.A.	N.A.	High	High benefit
	Improvement of living conditions	Positive	Direct	Long	N.A.	N.A.	High	High benefit
	Economic benefits through improved tourism opportunities	Positive	Direct	Long	N.A.	N.A.	High	High benefit
	Improved water quality of lagoon and sea	Positive	Direct	Long	N.A.	Depending on success of project	High	High benefit
	Smelly wastewater ponds	Negative	Indirect	Long	Avoidable	Reversible	Medium	Medium
	Wastewater ponds become mosquito breeding grounds	Negative	Indirect	Long	Avoidable	Reversible	Small (due to distance)	High
Not everyone in south portion connected due to distance from main pipe	Uncontrolled disposal of waste water	Negative	Direct	Long	Unavoidable	Reversible	Small	Low
People refusing to connect due to costs	Uncontrolled disposal of waste water, effectively negating the benefits of the projects	Negative	Direct	Long	Avoidable	Reversible	Medium??	Medium
Failure of system: power failure	System not working	Negative	Indirect	Short	Avoidable	Reversible	Medium	Low
Failure of system: broken pipes	System not working	Negative	Indirect	Short	Unavoidable	Reversible	Medium	Low
	Spillage/leakage of wastewater on land	Negative	Indirect	Short	Avoidable	Irreversible	Medium	Low
Failure of system as result of hurricane impact: power failure	System not working	Negative	Indirect	Short to medium	Unavoidable	Irreversible	Medium	Low to Medium
Failure of system as result of hurricane impact: pipe failure on land	Spillage/leakage of wastewater on land (potentially washed into marine environment)	Negative	Indirect	Short to medium	Unavoidable	Irreversible	Medium	Low to Medium
Failure of system as result of hurricane impact: pipe failure 10	System not working	Negative	Indirect	Short to medium	Unavoidable	Irreversible	Medium	Low to Medium
Failure of system as result of hurricane impact: wastewater pond system damaged	System not working	Negative	Indirect	Short to medium	Unavoidable	Irreversible	Medium to large	Medium to Highs
Removal old sanitation systems	Contaminated septic contents/soil	Negative	Indirect	Short	Unavoidable	NA	Small	Low
	Construction rubble	Negative	Direct	Short	Unavoidable	Reversible	Small	Low
	Release of pathogens in the environment	Negative	Indirect	Short	Unavoidable	Irreversible	Small	Low

Table 8.4-15 Recommended Mitigation for Social and Economic Impacts

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional Responsibilities	Cost Estimate	Comments
Digging trenches	Disturbing landscaped gardens	After closing trenches, re-distribute topsoil and replant with ornamental plants	Contractor	Part of contract	Cooperation with land owner
	Removal fences	After closing trenches, restore fences	Contractor	Part of contract	Cooperation with land
	Disturbance soil	After closing trenches, re-distribute topsoil	Contractor	Part of contract	Cooperation with land
	Need access to private yards	Ask permission from landowner and land user to enter private	Contractor	Part of contract	Cooperation with land owner
		All authorized employees carry identification cards			
		Develop grievance mechanism			
		Open hotline (telephone)			
	Dust production	If needed, use sprinkler system (vehicle) to wet the soil	Contractor	Part of contract	Cooperation with land
	Noise production	Use properly maintained machinery, adhere to noise pollution	Contractor	Part of contract	
		No use of heavy machinery before 7 am and after 6 pm			
	Open trenches dangerous for traffic	Demarcate open trenches, if needed with lights in the night	Contractor	Part of contract	
	Blocking of traffic	Guarantee access to premises by covering open trenches with steel covers for the night	Contractor	Part of contract	
		Businesses remain accessible, day and night			
	Breaking of water and other utility lines	Liaise with water board about location of the water pipes	Contractor, BWSL, Water board(s), BEL	Part of contract	
		Liaise with BEL about standby crew for repair on power lines			
		Liaise with land owners about other underground utility lines			
		Have repair kit (tools and materials) available to make immediate repairs if needed			
	Unsightly situation after completion	After completion of trenches, remove all construction materials, refill trenches	Contractor	Part of contract	
		One month after filling trenches, verify the level of fill, if soil has caved in, make needed fill to level ground			
Construction access road to the wastewater treatment	Private land acquisition	Long term lease of private land to guarantee access to treatment site or acquisition of private land	BWSL	Land acquisition price	
		Government land: establish road reserve			
Prepare wastewater treatment site	Private land acquisition (only applicable in case a currently non-preferred site is chosen)	The process of land acquisition has to be finalized before development of sewage ponds can start	BWSL	Land acquisition price	
	Dust production (only applicable in case a currently non-preferred site is chosen)	Wet the road surface and other surface to minimize dust production	Contractor	Part of contract	
	Noise production	Use properly maintained machinery, adhere to noise pollution	Contractor	Part of contract	
		No use of heavy machinery before 7 am and after 6 pm			

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional Responsibilities	Cost Estimate	Comments
Building centralized pump stations	Land requirements	First option is to locate these pump stations on national land. If national land is not available at the proper locations, land acquisition will have to take place.	BWSL, Contractor,	Environmental Impact Assessment	Cost estimate needs to be added after final design
		Location of the pump houses must not conflict with other (future) developments on the peninsula	Consultant	Engineering cost	
	Traffic obstructions	Construction of the central pump station is not to interfere with traffic	BWSL, Contractor,	Engineering cost	Cost estimate needs to be added after final design
	Noise	Use properly maintained machinery, adhere to noise pollution	Contractor	Part of contract	
		No use of heavy machinery before 7 am and after 6 pm			
	Unsightly situation after completion	Inspect finished pump houses to ensure proper clean up of the construction materials etc. around the buildings	Contractor	Part of contract	
		Landscape surrounding areas after completion of the pump			
Operational phase wastewater system	Costs of improving individual sanitation facilities to flush toilets	Outfit low income families with a pre-fabricated flush toilet unit, to replace pit latrines	User, BWSL	Part of individual running costs	
		Advocate the use of water saving devices and water saving			
		Develop technical assistance package to educate population about proper sanitation facilities			
	Extra costs for users system	Develop a prop-poor rate users fee structure	User, BWSL	Part of individual running costs	
		Develop a fee structure that allows small users affordable fees			
	Diffuse and uncontrolled discharge of effluents changed into a controllable point release	Connection to the wastewater system should be mandatory, monitor this	User, BWSL	Part of individual running costs	
	Smelly wastewater ponds	Proper design, implementation and management of the ponds	BWSL	Part of operational costs	
	wastewater ponds become mosquito breeding grounds	Use of certain fish species that prey on mosquito larvae	BWSL	Part of operational costs	
Not everyone in south portion connected due to distance from main pipe	Uncontrolled disposal of waste water	Require/Install proper septic systems	Regulatory body + property owner	Cost of installation of septic depending on size development	Expected to be limeted in extend.
People refusing to connect due to costs	Uncontrolled disposal of waste water, effectively negating the benefits of the projects	Assistance to low income households	BWSL	Cost of installing flush toilet outhouses and similar	Magnitude to be identifed in final design
Failure of system: power	System not working	Back-up generator(s) to power pump houses	BWSL	Part of operational costs	
Failure of system: broken pipes	System not working	Stand by crew (24/7) to make needed repairs	BWSL	Part of operational costs	
		Hotline for failure reports			
	Spillage/leakage of wastewater on land	Stand by crew (24/7) to make needed repairs	BWSL	Part of operational costs	
		Hotline for failure reports			
Failure of system as result of hurricane impact: power	System not working	Back-up generator(s) to power pump houses	BWSL	Part of operational costs	
Removal old sanitation systems	Contaminated septic contents/soil	Develop a plan for cleanup campaign, decide site by site the preferred option for the de-commissioning of the existing	BWSL	Part of operational costs	
	Construction rubble	Use construction waste to fill in redundant latrine and leach pits	BWSL	Part of operational costs	

Table 8.4-16 Recommended Monitoring for Social and Economic Impacts

Project Activity	Potential Environmental Impacts	Proposed Mitigation Measures	Parameters to be Monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Digging trenches	Disturbing landscaped gardens	After closing trenches, re-distribute topsoil and replace with ornamental plants	Leveling soil, replanted with appropriate ornamental plants. Baseline will be digital pictures of	Local NGO	Personal visit at the site, Digital Camera	Baseline before start of activities. Once: after completion of the	Baseline + final report including photographs	Initial costs camera U$ 200; $ 20 per houselot
	Removal fences	After closing trenches, restore fences	Restoration of the fences. Baseline will be digital pictures of yards before start of works	Local NGO	Personal visit at the site, Digital Camera	Once: after completion of the trenches	Personal visit at the site, Digital Camera	
	Need access to private yards	Ask permission from landowner and land user to enter private yards	Documentation of communication filed per connection	Contractor	Computer files and hard copy files	Permission: for all privately owned land	Contractor	Database development: $5,000
		All authorized employees carry identification cards	Signed forms allowing crew access to property					
		Develop grievance mechanism	One file containing grievance documentation and follow-up					
		Open hotline (telephone)	Logbook of any calls made to hotline and follow-up actions					
	Dust production	If needed, use sprinkler system (vehicle) to wet the soil	Excessive dust production Dust plume higher than 5 yards	Local NGO	Visual	When needed	Reporting: activity schedule of the watering truck: when and	Develop activity logbook $ 300.--
	Noise production	Use properly maintained machinery, adhere to noise pollution regulations.	Adhere to the noise levels as stipulated in Pollution regulations, 1996. S.I. 56 of 1996	Local NGO	Noise level measurements with dB meter	At random	Report, including construction site activities and noise levels at certain distances	Equipment $ 100. Monitoring $ 20/day
		No use of heavy machinery before 7 am and after 6 pm						
	Open trenches dangerous for traffic	Demarcate open trenches, if needed with lights in the night	Open trenches are sign posted?	Local NGO	Personal visit at the site, Digital Camera	When needed	Report including photographs	Initial costs camera $ 200; $ 20 per open trench
	Blocking of traffic	Guarantee access to premises by covering open trenches with steel covers for the night	Access to house lots remain open during evening hours	Local NGO	Personal visit at the site, Digital Camera	When needed	Report including photographs	Initial costs camera $ 200; $ 20 per open trench
		Businesses remain accessible, day and night	Access to businesses remain open during the day and night					
	Breaking of water and other utility lines	Liaise with water board about location of the water pipes	Contractor has a set of blueprints outlining the water mains and other underground utility lines	Contractor	Visual	When needed	One time, at the start of the project	Liaison costs (telephone etc)
		Liaise with BEL about standby crew for repair on power lines	Contractor has telephone numbers of involved utility companies (BEL, water board, cable companies)					
		Liaise with land owners about other underground utility lines	Contractor has repair kits for water mains					
		Have repair kit (tools and materials) available to make immediate repairs if needed	Other utility companies have repair equipment available at the peninsula					
	Unsightly situation after completion	After completion of trenches, remove all construction materials, refill trenches	Remove all construction materials, rubbish. Leveling soil	Local NGO	Personal visit at the site, Digital Camera	Twice: first time after closing trenches, second time after closing trenches	Report including photographs	Initial costs camera $ 200; $ 50 per 100 yard length of pipe
		One month after filling trenches, verify the level of fill, if soil has caved in, make needed fill to level ground						
	Obstruction boating traffic	Place signs to regulate boat traffic	Sign posting upcoming activities	Local NGO	Measuring depth with 'stick', Measuring tape, depth sounder	3 times: first before activities start during low tide, second during construction during low tide, third after placing	Report of findings	Measuring stick, depth sounder.

Project Activity	Potential Environmental Impacts	Proposed Mitigation Measures	Parameters to be Monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Construction access road to the wastewater treatment site	Private land acquisition	Long term lease of private land to guarantee access to treatment site or acquisition of private land	Present private land: Lease or title to land needed for the access road has to be obtained before any construction activity starts	Funding agency	NA	Start project	Copy of title/lease has to be submitted to the funding agency	NA
		Government land: establish road reserve	Present GOB land: establish road reserve				Documentation (map) of road reserve has to be submitted to funding agency	
Construction access road to the wastewater treatment site	Trucking movements to haul in road fill	The amount of fill needed to construct the access road, is one of the parameters that has to be taken into consideration when the access road trajectory is to be determined	Evaluation of the different options for access roads	Independen t consultant	Assessment matrix with evaluation of the different options taking into account costs, traffic movements, disturbance of local vegetat,	Once, before access road trajectory is surveyed	Assessment matrix (part of the EIA)	Part of the EIA
Prepare wastewater treatment site	Private land acquisition	The process of land acquisition has to be finalized before development of sewage ponds can start	Present private land: Lease or title to land needed for the treatment ponds has to be obtained before any construction activity starts	Funding agency	NA	Start project	Copy of title/lease has to be submitted to the funding agency	NA
	Dust production	Wet the road surface and other surface to minimize dust production	Road visibility remains at a minimum of 100 yards	Local NGO	Visibility check after a truck passes	During dry weather	Reporting: activity schedule of the watering truck: when and	$ 200/visit
	Noise production	Use properly maintained machinery, adhere to noise pollution regulations	Adhere to the noise levels as stipulated in Pollution regulations, 1996. S.I. 56 of 1996	Local NGO	dB meter	Spot checks	Reporting recorded sound levels with number plate of vehicles	$ 200/visit
		No use of heavy machinery before 7 am and after 6 pm						
	Connecting costs	The connecting costs should be included in the total price of the	Provision, installation of individual pump does not come at a cost of individual households	Funding agency	Sample survey	After delivery of the project	reporting	$ 500/ developing and carrying out of sample survey
		For new housing developments: these costs should be included in the lot price, land developer is responsible for the connection of the houses to the wastewater system						
Building centralized pump stations	Land requirements	First option is to locate these pump stations on national land.	Secure national land , or Negotiate long term lease or through land acquisition	Funding agency	NA	Once: before the planning phase of the project	Copy of the title, or declaration of national land, or land acquisition procedure has been	$1,000
		Location of the pump houses must not conflict with other (future) developments on the peninsula	Concur with local authorities about landownership neighbouring lots, concur with neighbours about future development plans	Executing agency	Development plans	Once, before the planning phase of the project	Report writing including copies of development plans	$2,000
Building centralized pump stations	Traffic obstructions	Construction of the central pump station is not to interfere with traffic	Use of proper traffic signs, roads and streets remain accessible	Local NGO	Visual check	Once a week	Report, including pictures	$ 50/week
	Noise	Use properly maintained machinery, adhere to noise pollution regulations	Adhere to the noise levels as stipulated in Pollution regulations, 1996. S.I. 56 of 1996	Local NGO	dB meter	Spot checks	Report	Meter $50, monitoring $ 20/day
		No use of heavy machinery before 7 am and after 6 pm						
	Unsightly situation after completion	Inspect finished pump houses to ensure proper clean up of the construction materials etc.	Removal of all construction waste	Local NGO	Visual check	One time after completion pump house	Report, including pictures	$ 100/pump house
		Landscape surrounding areas after completion of the pump house	Landscaping of the immediate surroundings of the pump house	Local NGO	Visual check	Two times: first after completion of the landscaping, second two months to monitor the survival of the plants	Report, including pictures	$ 200/month

Project Activity	Potential Environmental Impacts	Proposed Mitigation Measures	Parameters to be Monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Operational phase wastewater system	Costs of improving individual sanitation facilities to flush toilets	Outfit low income families with a pre-fabricated flush toilet unit, to replace pit latrines	Low-income households receive a pre-fab toilet unit	Local NGO	Qualified low-income households receive a unit	One time	Report	$ 800per household
		Advocate the use of water saving devices and water saving etiquette	Maintain a list with households to ensure that all households have been approached	Local NGO	Contact all listed households	Several times during the construction and the first months of operational	Report	$5,000
		Develop technical assistance package to educate population about proper sanitation facilities	Maintain a list with households to ensure that all households have been approached	Local NGO	Contact all listed households	Several times during the construction and the first months of operational	Report	$5,000
	Extra costs for users system	Develop a pro-poor rate users fee structure Develop a fee structure that allows small users affordable fees	Fee structure is staged, with an affordable fee for reasonable minimum use for low income households	Executing agency	Development of the fee structure for the Placencia service area	One time	NA	NA
	Diffuse and uncontrolled discharge of effluents changed into a controllable	Connection to the wastewater system should be mandatory, monitor this	Monitor the presence of household wastewater connections and the disconnection of individual systems	Executing agency	Visual check	One check for existing structures; buildings under construction when needed	Report writing	$ 10,000 one time effort
Operational phase wastewater system	Smelly wastewater ponds	Respond to reports of 'smelly' ponds by applying the correct procedures of management of the ponds	Occurrence of smelly ponds	Local NGO	Visual, olfactory checks	Depends on reporting	Grievance mechanism	NA
	wastewater ponds become mosquito breeding grounds	Use of local fish species that prey on mosquito larvae	Presence of mosquito larvae in the wastewater ponds	Local NGO	Adequate sample nets	Rainy season, once a month	Report writing	$ 100/month
	Discharge of effluents in class I water body (Lagoon)	Water quality testing	Periodically testing water quality of the lagoon near wastewater	DoE	Testing of water samples on appropriate	Quarterly	Reporting	$ 600/3 months
Failure of system: power failure	System not working	Back-up generator(s) to power pump houses	Monthly testing of the back-up generator, including check on amount of fuel, sufficient for 48	Executing agency	Emergency simulation exercise	Once a month	Report writing	$ 300/month
Failure of system: broken pipes	System not working	Stand by crew (24/7) to make needed repairs Hotline for failure reports	Time lapse between report of failure and repair	Executing agency	Data base	When needed	Proper reporting by the managing agency	NA
	Spillage/leakage of wastewater on land	Stand by crew (24/7) to make needed repairs Hotline for failure reports	Time lapse between report of failure and repair	Executing agency	Data base	When needed	Proper reporting by the managing agency	NA
Failure of system as result of hurricane impact: power failure	System not working	Back-up generator(s) to power pump houses	Monthly testing of the back-up generator, including check on amount of fuel, sufficient for 48	Executing agency	Emergency simulation exercise	Once a month	Report writing	$ 300/month
Failure of system as result of hurricane impact: pipe failure on land	Spillage/leakage of wastewater on land (potentially washed into marine environment)	Logistics in place that shuts off the present wastewater system and emergency response plan to repair the wastewater system	Presence of a hurricane emergency response plan	Executing agency	Updated emergency response plan	Annual review of emergency response plan	Report writing	NA

8.4.7 Transportation

All locations on the peninsula are in more or less proximity of a road.

The preferred location for the WWTP is on the mainland, about 6 miles from the nearest highway. No road access to the WWTP exists and constructing a new road to the site is considered cost prohibitive.

Access to the site will therefore be by boat/barge, via Seine Bight, Placencia or Independence village on the mainland. A permanent landing site will need to be established. This landing site will serve both during the construction phase as well as for access during the maintenance phase.

The exact location for this landing site will be decided as part of the design phase following a detailed survey, including a geotechnical soil survey, to determine the structural soil capacity. In addition, local lagoon conditions are important, as it needs to facilitate access for different kinds of vessels. The landing site may potentially include a pier or jetty to allow access to deeper waters.

The environmental impacts of creating access to the WWTP are essentially limited to destruction of the shore vegetation which exists of a fringe of mangrove and other wetland vegetation.

Table 8.4-17 – Table 8.4-19 summarize the transportation impacts, recommended mitigation and monitoring.

Table 8.4-17 Environmental Impacts of the Proposed Wastewater System: Transportation

Project Activity	Potential Environmental Impacts	Positive / Negative	Direct / Indirect	Short / Long Term	Avoidable / Unavoidable	Reversible / Irreversible	Magnitude	Cost / Benefit
Creating access to the WWTP on the mainland	Destruction of wetland vegetation	Negative	Direct	Long term	Avoidable	Irreversible	Medium	High
Creating access to the WW	Creation of landing site	Negative	Direct	Long term	Unavoidable	Irreversible	Small	Low

Table 8.4-18 Recommended Mitigation for Transportation Impacts

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Institutional Responsibilities	Cost Estimate	Comments
Creating access to the WWTP on the mainland	Destruction of wetland vegetation	Construction of a permanent landing and access road to the WWTP	Determine appropriate location and design: technical design team.	Depending on the design	
			Construction: construction company		

Table 8.4-19 Recommended Monitoring for Transportation Impacts

Project Activity	Potential Environmental Impacts	Proposed mitigation measures	Parameters to be monitored	Location	Methods and Equipment	Frequency	Responsibilities	Cost (US$)
Creating access to the WWTP on the mainland	Destruction of wetland vegetation	Construction of a permanent landing and access road to the WWTP	No additional landing sites are used	Local organization	Visual check, photography	Once a week	Weekly reports	$ 100/ visit

8.5 Conclusions and Recommendations

The overall conclusion of the Environmental Impact Analysis is that the project as a whole presents substantial benefits to both the biological and human environment. Particularly, the reduction of the pathogen load on the peninsula itself will have benefits for public health extending into benefits for the tourism industry, which serves as the economic mainstay for the peninsula.

The current methods of wastewater disposal, combined with high ground water levels and highly permeable soils (in the non-mangrove areas) no doubt have negative effects on the surrounding marine habitats, including the Placencia Lagoon. The lagoon is a critical habitat for the endangered West-Indian Manatee which relies on the seagrass beds in the lagoon. The principal risk to these seagrass beds is formed by algae blooms as a result of eutrophication. Is it not clear to what extent this eutrophication is the result of residential wastewater inflow, as no data exists. However these concerns for eutrophication initially led to a concern that the proposed wastewater treatment project would simply replace a diffuse nutrient input with a point based nutrient input.

For these reasons, a tertiary treatment of the wastewater effluent was proposed in order to further reduce the nutrient discharge. The proposed tertiary treatment by means of a water hyacinth pond is the preferred treatment option.

An additional concern on the socio-economic level is that low income households would not be able to invest in proper sanitary facilities and thus not be able to connect to the wastewater system. A technical and or financial assistance program is recommended to mitigate this concern.

9 Development Impact

9.1 Development Impact Assessment

Developmental impact analyses ask whether projects make a difference, how they make a difference, and for whom. According to the World Bank Group's International Finance Corporation (IFC), a Developmental Impact Assessment is a tool to help stakeholders think through a project and understand who may gain and who may lose as a result of the project. This helps to identify pertinent issues and to determine whether a project has an overall positive or negative effect for the population it will serve.

Developmental impacts are important in determining the success of investments in developing countries. For example, the IFC, U.S. Trade and Development Agency (USTDA), and the U.S. Overseas Private Investment Corporation (OPIC), among others, use objective measurements to demonstrate the developmental success of their programs. It is important to consider the potential impacts of projects on host country job creation, worker training, local procurement, and social responsibility, among others.

This Feasibility Study was funded by the USTDA. With regard to developmental impact, matters of primary interest to USTDA include: "*Infrastructure (including any positive environmental impacts), Human Capacity Building (including jobs and training), Technology Transfer and Productivity Improvements and Market-Oriented Reforms*." USTDA also encourages "*other host country economic development benefits, such as financial revenue enhancements and others where appropriate*."[xxvii]

The USTDA quantifies and publishes its achievements in promoting:

- Infrastructure and industrial improvements
- The adoption of market-oriented reforms
- The creation of ten or more jobs or the training of ten or more people
- The transfer of technology or increased productivity.[xxviii]

The proposed Placencia Peninsula Wastewater System Improvements project will contribute to reaching USTDA's goals.

9.2 Infrastructure Advancement

A primary measurement of developmental success is the degree to which a project results in infrastructure improvements for the service of the local community.

With respect to infrastructure improvements, the Placencia Peninsula, Belize, Wastewater Collection and Treatment System have the following potential developmental benefits:

- The collection of wastewater from residents, commercial businesses and hotels significantly decreases the volume of untreated wastewater being disposed directly into the groundwater and leaching into the surrounding ocean and lagoon. Table 9.2-1 summarizes the estimated daily reduction of waste into the environment for the 2040 build out year.
- The removal of wastewater from the currently used localized disposal systems will decrease odor issues and public health hazard concerns and help ensure that the Peninsula's tourist industry continues to prosper.
- The project will have a positive impact on the property values and tourism development.
- As a pilot project, it will also provide a model for other areas of Belize and the Caribbean region for the development of wastewater systems.
- The project's economic analysis contributes to the Caribbean Regional Fund for Wastewater Management (CReW) revolving fund for future infrastructure projects within Belize.

Table 9.2-1 Estimated Wastewater Loading Reduction for 2040

Total 2040 Estimated Wastewater		Influent	Effluent	Reduction
Average Daily Flow	MGD	0.8		
BOD_5	mg/L	300	< 30	> 95%
	lbs/day	2,000	< 70	
Fecal Coliform	MPN/100ml	6.5×10^6	< 200	> 99.99%
Total Nitrogen	mg/L	20	< 3	~ 85%
	lbs/day	133	< 20	
Total Phosphorous	mg/L	21	< 5	~ 75%
	lbs/day	140	< 35	

9.3 Market-Oriented Reforms

In part, USTDA measures a successful grant on the degree to which the investment leads to market-oriented reforms. Market-oriented reforms impact suppliers, customers, the community, neighbors, and contributions to government revenues.

The Placencia Peninsula, Belize, Wastewater System Improvements project will introduce alternative treatment technologies and a large-scale application of improved materials and equipment technologies to Belize.

9.3.1 Impact on Suppliers

The project will benefit suppliers of professional services, construction services, equipment, and materials in the following categories:

- Professional Services: Final design services for the project will incorporate detailed Land Surveying and Legal Land Title, Civil Site Engineering, Electrical Engineering Pump Control design, and Construction Administration.
- Construction Services: Multiple contractors are to be involved, including trenching and laying pipe, making wastewater connections to existing facilities, installing wet wells and pump stations, grading operations for the construction of the wastewater lagoons.
- Construction Materials: Piping, Pumps, Valves, Pre-fabricated Wet Wells and Electrical Panels are to be imported and transported to the Peninsula. Manholes and larger Wet Wells are to be constructed from concrete on-site, utilizing local materials. The wastewater treatment facility will include a utility shed.
- Operations Materials: Generators, Trucks and Spare Pumps are to be imported and transported to the Peninsula.
- Utility: The local Electrical Utility will increase its supply to the Peninsula via service to the wastewater pump stations.

9.3.2 Impact on Customers

The primary positive impacts on consumers are:

- The new collection system will eliminate on-site wastewater disposal and the associated contamination of soils and groundwater.
- Decrease in odors and potential public health hazards.
- Improved customer confidence in the ecological sustainability of the Peninsula, translating to improved tourist experiences, particularly in the long-term.

9.3.3 Impact on Community

The addition of a wastewater collection and treatment system can make the Placencia Peninsula more attractive for new tourism, residential and commercial investment. Improved potable water quality and reliability can improve the community's public health.

9.3.4 Impact on Neighbors

The project will ideally serve as a demonstration project for communities throughout Belize and the greater Caribbean region, providing sustainable wastewater collection and treatment at a reasonable billing tariff for the community's citizens.

Concepts and equipment examples include:

1. Facultative Lagoon wastewater treatment system, with passive treatment methodologies requiring limited oversight and electricity;
2. HDPE fused-end pipe to decrease the infiltration of groundwater into the wastewater collection system;
3. Fiberglass pre-fabricated wet wells, with simple construction installation and maintenance; and
4. Provision of standby power generators to improve system reliability.

9.3.5 Impact on Taxes

The design and construction of the project will generate contributions to the Belize Government in the form of Environmental Impact Taxes and some minor portion of embedded Import Tariffs. Per discussions among the Project Team, General Sales Tax and typical Import Tariffs are exempt for this project (see Effective Import Tariff Rate in Table 11.2-1) (these exemptions must be applied for prior to purchase / import).

Once the proposed systems are in operation, they will continue to generate contributions to the Belize Government in the form of General Sales Tax through the billing system and occasional Environmental Impact Taxes and Import Tariffs during system maintenance and upgrades.

9.4 Potential US Exports to Belize

Based on the results of the feasibility study, Table 9.4-1 presents a summary of potential equipment and services that can possibly be exported to Belize from the United States. The table also includes an estimate of the probability of the exports coming from US vendors. The HDPE pressure pipe, Fiberglass Wet Wells, Valves, and Submersible Pumps and Controls have the highest probability of being exported from the United States, primarily because these products are not produced in most local markets. Other listed items have strong competition from neighboring Latin American vendors and service providers (particularly Mexico). In addition, miscellaneous construction materials and services have a very low probability of being exported to Belize for this project. Therefore, such items are not included in the estimate.

Table 9.4-1 Value of Potential US Exports to Belize

Import Item	Import Value $US	Estimated Probabilty of Export from U.S.
Professional Design Services & Construction Oversight	$1,100,000	85%
Gravity Pipe (PVC)	$730,000	25%
Pressure Pipe (HDPE)	$800,000	90%
Pressure Pipe Equipment	$20,000	90%
Valves	$110,000	90%
Flow Meters	$30,000	90%
Submersible Pumps, Control Panels & Fiberglass Wet Wells	$650,000	90%
Pond Geomembrane	$170,000	90%
Construction Equipment	$200,000	50%
Operation Vehicles	$75,000	25%
Boat & Motor	$30,000	25%
Generators	$60,000	25%
Total:	**$3,980,000**	**72%**

A list of potential US Exporters to Belize is presented in Table 9.4-2.

Table 9.4-2 Potential U.S. Exporters to Belize

Name	Address	Phone / Fax
PIPE		
ADS	4640 Trueman Boulevard Hilliard, OH 43026	(800) 821-6710 (614) 658-0204
JM Eagle	9 Peach Tree Hill Road Livingston, NJ 07039	(973) 535-1633
Charlotte Pipe	P.O. Box 35430 Charlotte, NC 28235	(800) 438-6091 (800) 553-1605
VALVES		
U.S. Pipe Valve & Hydrant Division	500 W. Eldorado Street Decatur, IL 62522	(800) 871-2194 (217) 425-7382
U.S. Pipe & Foundry Company	Birmingham, AL 35202	(866) 347-7473 (205) 254-7165
Water Works Supply Corporation	869 Eastern Avenue Maldren, MA 02148	(781) 322-1238 (781) 322-0739
SEWAGE PUMPS		
ITT Flygt	90 Horizon Drive Suwanee, GA 30024	(770) 932-4320 (770) 932-4321
The Gorman Rupp International Company	600 S. Airport Road Mansfield, OH 44903	(419) 755-1352 (419) 755-1266
WET WELLS		
Riley & Company Fiberglass	5491 Benchmark Lane Sanford, FL 32773	(888) 317-4481 (407) 265-9967
Romtec Utilities	18240 North Bank Road Roseburg, OR 97470	(541) 496-0804
CONTROLS		
Automation Direct	3505 Hutchinson Road Cumming, GA 30040	(800) 633-0405 (770) 889-7876
Revere Control Systems	2240 Rocky Ridge Road Birmingham, AL 35216	(205) 824-0004 (205) 824-0439
ICS Healy-Ruff Company	13005 16th Avenue North, Ste 100 Plymouth, MN 55331	(763) 559-0568 (763) 559-2187
SCADA		
Automation Direct	3505 Hutchinson Road Cumming, GA 30040	(800) 633-0405 (770) 889-7876
Revere Control Systems	2240 Rocky Ridge Road Birmingham, AL 35216	(205) 824-0004 (205) 824-0439
ICS Healy-Ruff Company	13005 16th Avenue North, Ste 100 Plymouth, MN 55331	(763) 559-0568 (763) 559-2187
GE Digital Energy - MDS	175 Science Parkway Rochester, NY 14620	(585) 242-9600 (585) 242-9620
STANDY GENERATORS		
Automation Direct	3505 Hutchinson Road Cumming, GA 30040	(800) 633-0405 (770) 889-7876
Caterpillar	330 Lee Industrial Blvd Austell, GA 30168	(800) 282-1562 (770) 941-2300
Cummins Power	5125 Hwy 85 Atlanta, GA 30349	(404) 762-0151
ELECTROMAGNETIC FLOW METERS		
EMCO	6567 B Industrial Way Alpharetta, GA 30004	(770) 475-2242
Sensus	8601 Six Forks Road, Suite 300 Raliegh, NC 27615	(800) 638-3748

9.5 Human Capacity Building

USTDA measures success in this category as "*the creation of ten or more jobs or the training of ten or more people*." It is difficult to quantify job creation, as this may be measured simply by counting new positions in existing organizations, new positions in new organizations or keeping positions that may have otherwise been eliminated.

The Placencia Peninsula, Belize, Wastewater Collection and Treatment System project can result in both short-term and long-term impacts on the workforce, requiring existing skill sets as well as new skills that must be learned to complete some tasks successfully.

9.5.1 Employment

In the short term (design and construction), the labor in all trades and professions (excluding marketing, manufacture, transport of equipment and supplies) is estimated as shown in Table 9.5-1.

Table 9.5-1 Potential Short-Term Job Creation

Task	Labor, person-years
Professional Services	
Land Surveying	1.6
Establishment of Legal Title	0.3
Civil Engineering	2.5
Construction Administration	3.3
Construction Services	
Sewer Pipe Installation	21
Facility Connections	6
Pump Station Installation	1
Wastewater Treatment Plant Construction	6
Supplier Services	
Total Estimated Material Purchases	6

The Placencia Wastewater System project will likely create jobs as follows:

- Professional services firms (engineering, soil science, land surveying, financial services, etc.) will maintain staff positions or increase staff numbers to prepare projects for construction and to provide construction observation.
- Construction firms will need to hire workers in appropriate trades – laborers, equipment operators, technicians, etc.
- Suppliers will either maintain staff positions or increase staff numbers to meet demands for materials, etc.

- Belize Water Services (BWSL) will either: (a) maintain staff positions, reassign staff members to new positions, or (b) hire additional staff to monitor and control project development, from design through construction to startup and acceptance.

In the long term, demand may continue or increase throughout Belize for skills in laying HDPE pipe; for installing, calibrating and maintaining electronic and electrical equipment (pumps, controls, monitoring equipment, etc.); and for installing, maintaining and operating lagoon wastewater treatment systems.

Locally, the project will require new staff positions and new skills at BWSL, new service capabilities in the private sector, or both. Table 9.5-2 summarizes potential long-term employment opportunities provided as a direct result of this project.

Table 9.5-2 Potential Long-Term Job Creation

Role
Belize Water Services (BWSL)
Local Department Manager
Customer Service Supervisor
Customer Representative
Cashiers - 2
Operations Supervisor
Electrician / Mechanic
Field Supervisor
Field Technicians – 2 or 3
Lagoon Operator
Private Sector
Landscape Maintenance Crew – 2

9.5.2 Wages

There are two factors to consider with respect to wages:

1. Payrolls will likely grow as a result of the stimulus provided by the projects described herein (at least in the short term); and
2. In general, compensation improves with skills.

It is anticipated that wages and salaries will grow at a rate of 3 percent per annum and that the introduction of new skills will raise wages in some trades.

9.5.3 Training

The proposed projects will bring training in the following areas:

- HDPE Pipe Fusion and Pipe Laying
- Confined Space Sewer Installation
- Pump Installation, Operation and Maintenance
- Pump Instrumentation and Controls
- Standby Power System Operation, Maintenance, and Controls
- Facultative Lagoon Wastewater Treatment System Operation and Maintenance.

9.5.4 Work Environment

The Placencia Peninsula, Belize, Wastewater Collection and Treatment System project will result in improvements in the work environment:

- Public Health – the reduction of wastewater in the localized environment (including the neighboring fishing and swimming water bodies) directly decreases public health hazards.
- Environmental – the reduction of untreated wastewater in the localized environment improves the health of the ecological environment.
- Residents – the proposed project will improve the living conditions of the more densely populated residential areas, specifically in the two villages (Placencia and Seine Bight), where a large majority of residents live in a small portion of the land space.
- Tourists – the proposed project will improve the quality of the tourist encounter with Belize, improving their experience and encouraging a continued relationship between the tourist and the country.

9.6 Technology Transfer and Productivity Improvements

The project is expected to result in significant technology transfer and productivity enhancement through the largest wastewater infrastructure project Belize has undertaken in a generation. The installation of new materials (HDPE) specifically designed to withstand infiltration in installations below the water table, as well as facultative lagoon treatment systems will be employed, serving as a model for other communities that are experiencing similar infrastructure needs.

The project is not expected to result in any market-related reform or human capacity building.

10 Implementation Plan

10.1 Administration Organizational Chart

The final determination of the organizational chart for the administration of the Placencia Wastewater System will be made by the Belize Water System (BWSL), who has similar facilities in multiple locations throughout Belize. A schematic organization chart is provided on Figure 10.1-1 below.

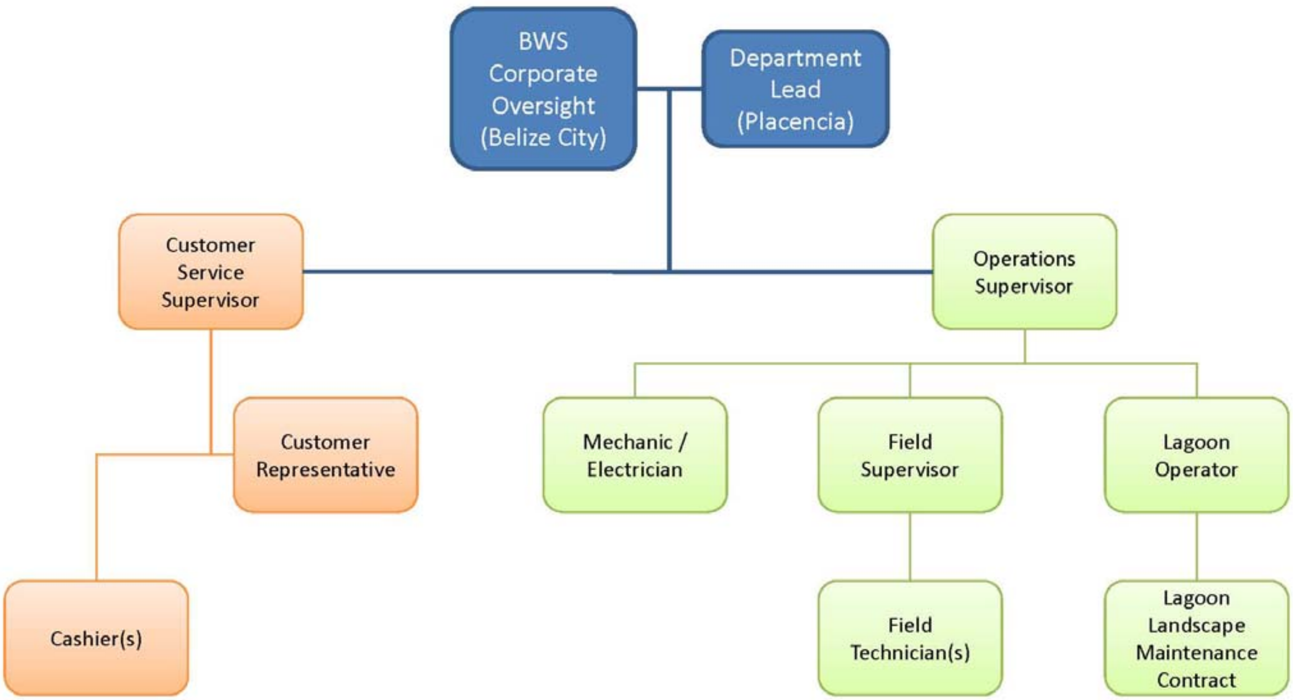


Figure 10.1-1 Administration Organization Chart

10.2 Implementation Plan

This section presents Halcrow's recommendations for an implementation plan to assist Belize Water Services (BWSL) for the proposed wastewater system improvements for the Placencia Peninsula. The information presented in this section is based on data and findings collected during the previous tasks for this project and documented in previous deliverables.

10.2.1 BWSL Construction Oversight

It is recommended that BWSL creates documentation for each property owner involved within the geographic scope of the project. This document, to be signed by the property owner in acknowledgement and agreement, includes:

- Allowing access to the property during design,
- Allowing access to the property during construction,
- Allowing BWSL to connect the property's building(s) to the wastewater system, and
- Acknowledging that the wastewater connection will incur wastewater tariffs.

10.2.2 Wastewater Collection System

The Wastewater Collection and Treatment System project for the Placencia Peninsula consists of the installation of +/- 10 miles of gravity pipe and +/- 18 miles of pressure pipe collection system across the Placencia Peninsula. The purpose of the collection system is to connect all existing buildings within the wastewater service area to the collection system to eliminate localized on-site wastewater disposal. A service area map of the proposed wastewater collection system is provided in Appendix B.3.

Based upon population projections provided in Section 3.1, the proposed collection system piping, manholes and facility connections are sized for full build out conditions and will not need upgrading to larger pipe sizes.

The initial pumps are to be sized for a 15-year life, with the expectation that pump stations can upgrade to larger capacity pumps as needed.

Wet wells are generally sized to provide no more than 45 minutes of run time during the peak wastewater generation hour during peak season at full population build out. The practical result of this is that the wet wells have capacity for population increases beyond stated projections, for potential power outages, or for other unforeseen circumstances.

The current service area is schematic in nature, based upon information available at the time of the study. The final service area will be adjusted during final design based upon updated information on recently constructed structures, topographic elevations, BWSL policy and local input. It is assumed that the final service area will provide coverage for at least as much a population base as what is provided in this study. The final determination of service area limits is to be made during the detailed design and construction bid phase of the project, based upon more accurate information regarding where existing facilities are located as well as the whether the construction bids are within the overall project budget. The majority of the population (and wastewater generation) occurs in the Village areas, which will be included within the final service area. The initial connection of more remote locations will be made on a case by case basis by the project design team and stakeholders.

Table 10.2-1 provides a summary of the effective service area across the entire Placencia Peninsula, estimating what portion of the population is being served by the system.

Table 10.2-1 Effective Population Coverage, by Future Milestones

Effective Service Area		South Region		North Region	
		Residents	Tourists	Residents	Tourists
2015	Peak Season Population	3,340	791	371	380
	Portion of Population connected to System	85%	85%	25%	50%
	Population with Treated Wastewater	2,839	673	93	190
	Effectively Served Population	78%			
2025	Peak Season Population	4,096	891	455	894
	Portion of Population connected to System	90%	100%	50%	85%
	Population with Treated Wastewater	3,686	891	228	760
	Effectively Served Population	88%			
2040	Peak Season Population	5,230	1,065	581	2,123
	Portion of Population connected to System	95%	100%	85%	100%
	Population with Treated Wastewater	4,968	1,065	494	2,123
	Effectively Served Population	96%			

10.2.3 Wastewater Pump System

The construction project includes the installation of a series of submersible pumps to carry the generated wastewater from local cluster wet wells to the collection wet well and then to the wastewater treatment plant.

Pumps

Each pump station is to be fitted with two separate and identical submersible pumps specifically designed to carry wastewater under the individual conditions of each station. A list of the pump sizes is provided in Appendix C.2. The secondary pump within the station is to serve as a backup during maintenance of the primary pump.

Controls

Each pump station is to be fitted with an electronic control system to identify when the pump(s) need to turn on and off in order to ensure that the wastewater does not overflow the wetwell or back up into the collection pipe system.

SCADA

Supervisory Control and Data Acquisition (SCADA) is a monitoring and communication installed alongside the individual control mechanisms for each pump station designed to communicate between the individual pump station and a centralized control facility (ideally, the utility office). A functioning SCADA system monitors, records and communicates information of interest to a system operator: pump on and off times, electricity usage, rates of incoming wastewater, etc. A SCADA system can also invoke “alarm settings” to notify the central control facility of a problematic condition (such as a backup of wastewater). This information may be utilized to better understand and manage a system, particularly given the large quantity of wastewater lift stations that may be built length of the Peninsula.

Flow Meter

At the headworks of the treatment plant (where the wastewater enters the plant), a flow metering device is to be installed to measure and record flows into the station in real time. This data will help treatment plant operators ensure that the treatment facility is working within its design parameters, as well as provide historical data on the quantity of wastewater the Peninsula is creating, which will help in planning future expansion of the system, as needed.

10.2.4 Wastewater Treatment System

The construction project includes the construction of two parallel sets of three ponds working in series as a Facultative Lagoon Treatment System. The treatment facility is to be located on a portion of Crown Property across the Placencia Peninsula from Seine Bight Village. The plant is sized to adequately treat the anticipated 2040 wastewater flows, with multiple options for expansion beyond that timeframe.

The plant will provide primary and secondary treatment, ensuring that the effluent leaving the facility meets the Belize Department of Environment standards. The effluent will be ideal for irrigation purposes. It is recommended that BWSL work with local agricultural operations to determine if there is a market need for nutrient rich irrigation water.

The initial effluent disposal is to be released into the surrounding mangroves. The final design of this disposal will be based upon a field survey of the property, a field assessment of the size and health of the surrounding mangrove, and a conservative determination of the mangrove's uptake of the effluent nutrients. The goal of this design process is to ensure that the Placencia Lagoon is not stressed by the input of a concentrated nutrient load by the treatment facility.

Treatment Facility Expansion

The facility design provided in this study is sized to handle the projected wastewater flows through the year 2040. If and when flow rates are consistently higher than the design flows, an expansion of the treatment capacity will be required. This can be accomplished by expanding the treatment volume of the facultative lagoon system through the construction of additional series ponds running in parallel with the initial two series, or by adding aeration units to the primary treatment pond, increasing the speed of the treatment process and allowing more wastewater to effectively pass through the system in a given amount of time.

10.3 Investment Requirements

The investment requirements for the wastewater project are summarized in Table 10.3-1.

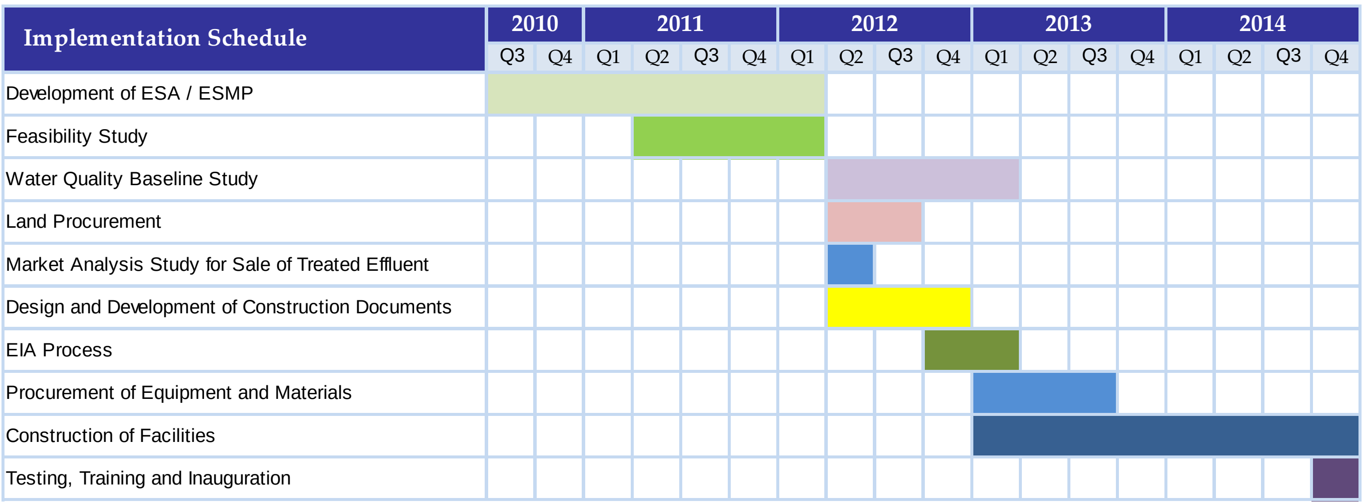
Table 10.3-1 Project Funding Requirements

Project Scope	Implementation Costs	Year One		Year Two		Year Three	
		%	Amount	%	Amount	%	Amount
Collection System							
Professional Design Services	$ 494,000	70%	$ 345,800	15%	$ 74,100	15%	$ 74,100
Materials	$ 930,000	30%	$ 279,000	60%	$ 558,000	10%	$ 93,000
Installation	$ 1,119,300	30%	$ 335,790	60%	$ 671,580	10%	$ 111,930
Pumping System							
Professional Design Services	$ 266,000	70%	$ 186,200	15%	$ 39,900	15%	$ 39,900
Materials	$ 1,858,300	10%	$ 185,830	80%	$ 1,486,640	10%	$ 185,830
Installation	$ 1,006,000	10%	$ 100,600	60%	$ 603,600	30%	$ 301,800
Treatment System							
Professional Design Services	$ 206,000	70%	$ 144,200	15%	$ 30,900	15%	$ 30,900
Materials	$ 750,735	0%	$ -	70%	$ 525,515	30%	$ 225,221
Installation	$ 999,504	0%	$ -	60%	$ 599,703	40%	$ 399,802
Nutrient Management System							
Professional Design Services	$ 52,000	70%	$ 36,400	15%	$ 7,800	15%	$ 7,800
Materials	$ 42,000	0%	$ -	70%	$ 29,400	30%	$ 12,600
Installation	$ 122,000	0%	$ -	60%	$ 73,200	40%	$ 48,800
Operations							
Land & Facilities	$ 802,000	50%	$ 401,000	50%	$ 401,000	0%	$ -
Startup Equipment	$ 245,000	10%	$ 24,500	50%	$ 122,500	40%	$ 98,000
Contingency							
Contingency	$ 1,139,000	10%	$ 113,900	20%	$ 227,800	70%	$ 797,300
Total:	**$ 10,032,000**	**21%**	**$ 2,153,000**	**54%**	**$ 5,452,000**	**24%**	**$ 2,427,000**

10.4 Implementation Schedule

The proposed project implementation schedule is shown in Table 10.4-1. It is estimated by the Project Team that the project can be completed in less than three years.

Table 10.4-1 Project Implementation Schedule



10.5 Potential Funding Sources

The potential sources of funding for the project include:

1. Inter-American Development Bank (IDB);
2. Caribbean Regional Fund for Wastewater Management (CReW);
3. Belize Water Services (BWSL);
4. Public-Private Partnership between BWSL and Local Developers; and
5. Private Banks.

It will need to be determined by the project stakeholders which parties will be responsible for additional income, if the project exceeds the current budget.

10.5.1 Inter-American Development Bank

The Inter-American Development Bank (IDB) is the largest source of development financing to central governments, municipalities, private firms and non-governmental organizations in the 26 countries throughout Latin America and the Caribbean, providing loans, grants, technical assistance and research support.

To be eligible for IDB funding, a project must:

- Be located in an IDB borrowing member country,
- Contribute effectively to the economic and social development of the regional member countries,
- Be technically, economically, and environmentally sound, financially secure, and take place in an adequate legal and institutional framework,
- Help to maintain the IDB's reputation as a financial agency in international markets. [xxix]

The IDB tailors each project to the needs of the client and to the specific situation of the country, region and sector. The IDB can fund up to 90 percent of the total project cost for the long-term capitalization of the project company, depending on the member country status. Belize is in Country Group D, with the percentage of total cost financing at 90 percent.

At the time of the report, the IDB is working with the Belize Ministry of Finance (MOF) and Belize Water Services (BWSL) to receive a loan of US$5,000,000 for the purpose of wastewater treatment and disposal improvements within the Placencia Peninsula.

10.5.2 Caribbean Regional Fund for Wastewater Management

The Caribbean Regional Fund for Wastewater Management (CReW) is a regional extension of the United Nations Environmental Program (UNEP), working to improve the wastewater effluent standards within the Caribbean region.

At the time of the report, the IDB, MOF and BWSL are working with CReW to receive a grant of US$5,000,000 for the purpose of wastewater treatment and disposal improvements within the Placencia Peninsula. This money is to be utilized as 'seed' money for the Placencia project, and then to be recovered by the project tariff system for the purpose of providing continued wastewater effluent infrastructure improvements throughout Belize. The purpose of the grant is for the money to cycle through multiple projects throughout Belize, improving the wastewater effluent and disposal quality, decreasing the destructive environmental effects of untreated wastewater disposal, and improving the quality of life of Belizean citizens.

10.5.3 Belize Water Services

Belize Water Services (BWSL) will be overseeing the design and construction of the Placencia Wastewater System and will inherit the system upon its start-up. As part of the agreement to expand its service area to the Peninsula, BWSL will provide US$1,400,000 for operational capital to ensure the project has positive cash flow through the initial years of service. If the project capital improvement budget exceeds the current funding budget, some portion of this money may be needed to cover the additional project expenses.

10.5.4 Public-Private Partnership

The funding mechanisms listed above are intended to be adequate for the design, construction and start-up of a wastewater system throughout the the Peninsula. System expansion may require BWSL to enter into a Public-Private Partnership (PPP) with the primary developers of this region. The purpose of the partnership would be to provide a feasible economic means to expand the system in an area with a relatively small population density. The PPP contractual relationship should provide a means to:

- Private party to install appropriate infrastructure within BWSL' long-term vision of use;
- Turn over the ownership and maintenance of the infrastructure of built infrastructure to BWSL;

- Share billing tariffs between both parties to allow adequate cost-recovery for the private party infrastructure installation as well as BWSL operation and maintenance.

10.5.5 Private Banks

One funding source option for BWSL is to borrow a fraction of the loan amount from private banks. However this option may incur high interest charges and may be publicly unpopular for BWSL.

10.6 Funding Strategy

The proposed funding strategy is to maximize the use of low-interest, long-term debt and minimize the commitment of internal cash flows for this proposed expansion and investment program. The lenders to the project must look to the revenues to be received by BWSL from the various tourist, commercial, and residential customers along the Placencia Peninsula as the main basis for loan repayment over time.

10.6.1 Cash Flow Analysis

A cash flow analysis is provided in Appendix G.3, detailing out the project income and expenses from 2012 through 2040. The analysis is based upon projected water and wastewater demands, a proposed tariff system, and the effective collections rate, ensuring that the project has positive cash flow throughout its the life cycle. The analysis shows the repayment of all project loans within the agreed upon terms; it also shows that the project secures long-term profits for BWSL.

10.6.2 CReW Funding

As indicated in Section 10.5.2, a portion of the project funding is obtained through a CReW grant. The purpose of this grant is to serve as continual ‘seed’ money for future wastewater infrastructure improvement projects within Belize. The project cash flow analysis ensures that the CReW funds will be made available for future projects.

10.6.3 Funding Security

The security which investors and lenders will be offered to secure their funding commitments to the project, financial and otherwise, is termed the “security package.” The security package comprises the set of interlocking agreements and contracts that bind and safeguard the interests of Belize Water Services and possibly the Government of Belize to perform those tasks and duties that will collectively lead to a successfully implemented project. Recourse available to lenders will be limited to the provisions of agreements comprising the security package, the benefit of which will be assigned to the lenders.

10.7 Training Requirements

After the project facilities and equipment has been installed, tested, adjusted and placed in satisfactory operating condition, the Construction Manager shall schedule and organize classroom and field instruction to the Owner's operating personnel in the use and maintenance of the facilities. The Construction Manager shall provide the Owner formal written notice of the proposed instruction period at least two weeks prior to commencement of the instruction period. Scheduled training shall be at a time mutually acceptable to the Owner and the Construction Manager. During this instruction period, the Construction Manager shall answer any questions from the operating personnel.

An organizational chart of the Construction Manager's training responsibilities is on Figure 10.7-1. A list of recommended courses as well as minimum training time is provided in Table 10.7-1.

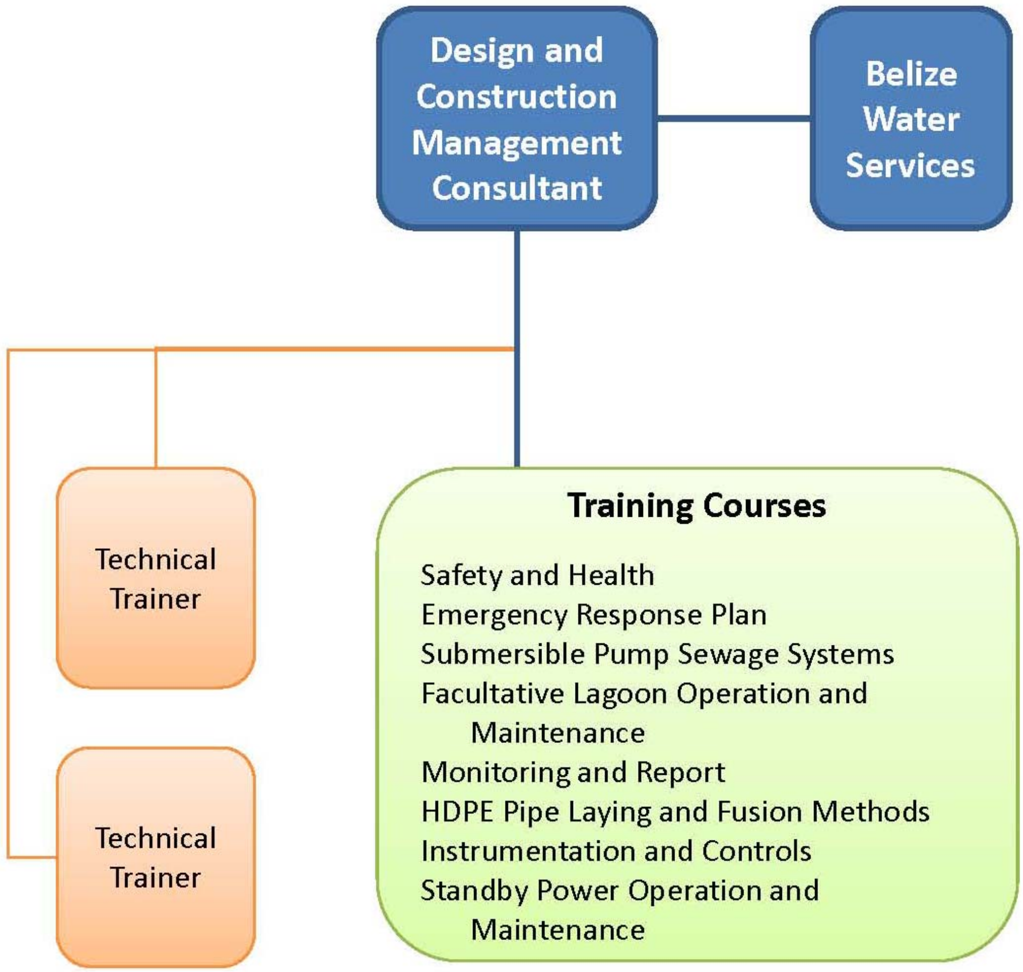


Figure 10.7-1 Facilities Training Organization Chart

Table 10.7-1 Applicable Training Courses

Training Courses	Min. Time (days)
Safety and Health in Wastewater Systems	3
Developing an Emergency Response Plan	3
HDPE Pipe Laying and Fusion Methods	2
Submersible Wastewater Pumping Systems	
Controls, Start-Up and Operation of Pumping Systems	2
Pump Maintenance & Repair	2
Standby Power Operation and Maintenance	1
Wastewater Treatment Plant Operation	
Understanding the Facultative Lagoon System and Operation	2
Lagoon Maintenance and Troubleshooting Procedures	1
Disposal Inspection Procedures	1
Monitoring and Reporting	1

10.8 Reuse Market Analysis

As discussed in Sections 5.5.1 and 6.4.1, a market analysis will be needed to determine if there is sustainable market potential for the sale of wastewater effluent for irrigation purposes. This analysis should include a local information survey, at a minimum:

- Potential Customers
  - Create an inventory of potential users and locate them on GIS;
  - Determine current and future water needs (demand) for each user;
  - Determine existing water sources that the treated effluent would supplement;
  - Estimate existing water source reliability as a available irrigation redundancy (i.e., potable water availability in the absence of reclaimed water);
  - Determine estimated timing of irrigation needs (seasonal, year round, daily and hourly demand variations);
  - Determine necessary water pressure;
  - Project future land use trends that could eliminate reclaimed water use such as converting farm lands to urban and commercial development;
  - Inform potential users of applicable regulatory requirements, projected quality of wastewater at various level of treatment compared to fresh water sources;
- Regulatory Parameters
  - Finalize water quality objectives and regulatory requirements;

  - Use World Health Organization Recycled Water Regulations or reference, or other applicable regulations;
  - Determine ordinances or regulatory enforcement needed to be established by the Government to make the program work;
  - Establish permitted uses based on various level of treatment;
  - Cooperate with wholesale and retail water agencies or water boards;
- Economic Analysis
  - Determine cost of existing source of water and fertilizers as a baseline for current user expenses;
  - Establish willingness to pay by end user;
  - Determine break-even and profit-based reclaimed water tariff and pricing;
  - Estimate potential monetary savings on reclaimed water, payback period and return on investment;
  - Estimate timeframe to begin using reclaimed water;

11 Financial Plan

The project funding mechanisms are provided in Table 11.2-1. These funds are to be used to develop the construction design documents and implement the capital improvement construction of a wastewater collection, treatment and nutrient management system for the Placencia Peninsula, from Placencia Village in the south through Riversdale in the north.

As stated in 6.2.5, based upon limited funding and current needs, the collection system will not likely be initially installed to every tax parcel/lot on the Peninsula, particularly in areas where no homes yet exist. The infrastructure is to be designed for the full Peninsula, and a plan put in place to ensure proper system expansion as homes are built.

The treatment facility and nutrient management facility is to be designed and constructed for the full estimated 2040 Peninsula population.

11.1 Capital Costs

Based upon Table 6.5-1 and the preferred collection, treatment and nutrient management system summarized in Section 0, the estimated capital improvement costs for this project based upon the information at the time of this study is US$10,950,000.

11.1.1 Capital Cost Savings

This cost estimate will be updated throughout the final design phase of the project as specific decisions are made and the project scope is finalized. If it is determined that the projected capital costs exceed the available funds, then the project scope will need to be assessed to look for cost savings opportunities.

Staging the construction of the treatment facility and/or the effluent reuse/disposal facility is not likely cost effective. Reducing the size and treatment capacity of these facilities would have a minimal effect on the overall project costs, and require system expansion within the project timeframe. It is recommended that these systems are designed and constructed for the 2040 design loads.

The collection system, however, can be more readily adjusted in size and cost. A primary goal of this project is to provide sanitary sewer service to every facility on the Peninsula. However, given the limited funds available, the final collection system will need to determine which facilities are most efficiently served. This concept was developed in Section 6.2; the initial recommended service area is estimated to connect 92% of the total existing facilities.

The following potential cost savings would not directly decrease the service area (and quantity of connected users) of the collection system:

- US$884,000 is provided in the budget as "Contingencies" to account for unforeseen expenses. Any project of this size will have unforeseen expenses; however, effective project management including tight cost controls will help reduce this amount.

- US$296,000 is provided in the budget for road repair after completion of the project. Much of the collection piping will run parallel and cross the Placencia road. Reducing disturbance of this roadway will help reduce the repair costs.
- US$234,000 is provided in the budget for a BWSL facility on the Peninsula. Any decrease in this expense would reduce the project costs.
- Isolate material and equipment procurement into a separate contract package to be conducted directly by BWSL on behalf of the Contractor. Based upon an estimated US$2.9M material and equipment imports value, a 10% Contractor mark-up on procured items (a conservative value) yields US$290,000 savings.

If additional cost savings are required for the project, a reduction in the project service area (how many facilities are tied to the system) will be required. Potential cost savings include:

- Eliminating facility connections for properties that are determined to have adequate sanitary facilities (working package plants or septic systems).
- Eliminating facility connections for properties that are particularly isolated, where a relatively large amount of sewer infrastructure would be required for a single facility connection.
- For facilities that are particularly isolated, exchanging the preferred gravity sewer connection for a small grinder pump system with a pressure pipe connection from the facility to the collection system.
    - This type of connection is Engineer Without Borders' preferred collection system (see Section 5.3.5). Halcrow does not prefer this alternative across the extent of the Peninsula; however, it may prove an effective compromise for isolated facilities.
    - A cost analysis comparing the preferred collection system with a grinder system in a sample area of Placencia Village is provided in Section 5.3.4 starting on page 125. In this analysis, a grinder system is shown to be a cost effective alternative to the preferred collection alternative when necessary.
    - If this collection method is utilized, BWSL will need to develop an agreement with the property owner to determine operation, maintenance and cost responsibilities between the two parties.
- Perform the detailed engineering design the complete collection system for all existing facilities on the Peninsula. Break the system up to bid in phases based upon priorities. Award as many of the contracts as is within the overall project budget.

The project team will need to determine which parties will be responsible for any expenses that exceed the project budget.

11.2 Financial Assumptions

Table 11.2-1 summarizes the assumptions made by Halcrow in this financial analysis. Any changes to these assumptions will cause changes to the overall financial model and may adjust the recommended solutions. These values need to be assessed by the Ministry of Finance and additional project stakeholders.

The total final cost of the capital improvements will not be known until the project scope is finalized, detailed designs are completed and the project is bid for construction. The loan values listed below and the tariff system with accompanying cash flow analysis were performed under the assumption that the full value of the potential loan is utilized for the project. If the project comes in under this full budget, the tariff system and cash flow analysis may be changed to reflect these cost savings.

Table 11.2-1 Project Financial Assumptions

Item	Unit	Value
Taxes Within Project Scope		
General Sales Tax	%	EXEMPT
Environmental Impact Tax (on all imports)	%	2.0
Material Import Tariffs (on all imports, excepting vehicles)	%	EXEMPT
Vehicle Import Tariffs	%	EXEMPT
Effective Rate of Import Tariff through purchase of materials within Belize wholesalers who have already paid typical tariff	**%**	**1.0**
Loan #1: CReW grant to Belize Government, in turn loaned to BWSL		
Loan #1 Amount	US$	5,000,000
Loan #1 Term	Years	20
Loan Deferment	Years	Upon Project Completion
Loan Rate	%	3.5
Grant #1 IDB to BWSL for Project Detailed Design		
Grant #1 Amount	US$	700,000
Grant #2 IDB loan to Belize Government, in turned granted to BWSL		
Grant #2 Amount	US$	5,000,000
Collection Efficiency		
Collection to Billing Ratio	%	95

11.3 Water Consumption

The proposed tariff structure for the wastewater system is connected to the metered water consumption for the system users. With a conservation based rate structure (where a gallon of water used costs varying amounts depending on the overall water use), it is necessary to estimate how much water each account will use and develop a projected system income based upon individual account water use and associated tariff system.

Figure 11.3-1 summarizes the historic water consumption rate by accounts for Placencia Water Board customers from December 2009 – November 2010. The average volume used per account is 5,000 gallons per month. However, a number of large users skew the average; the typical user (median amount) averages 3,150 gallons per month.

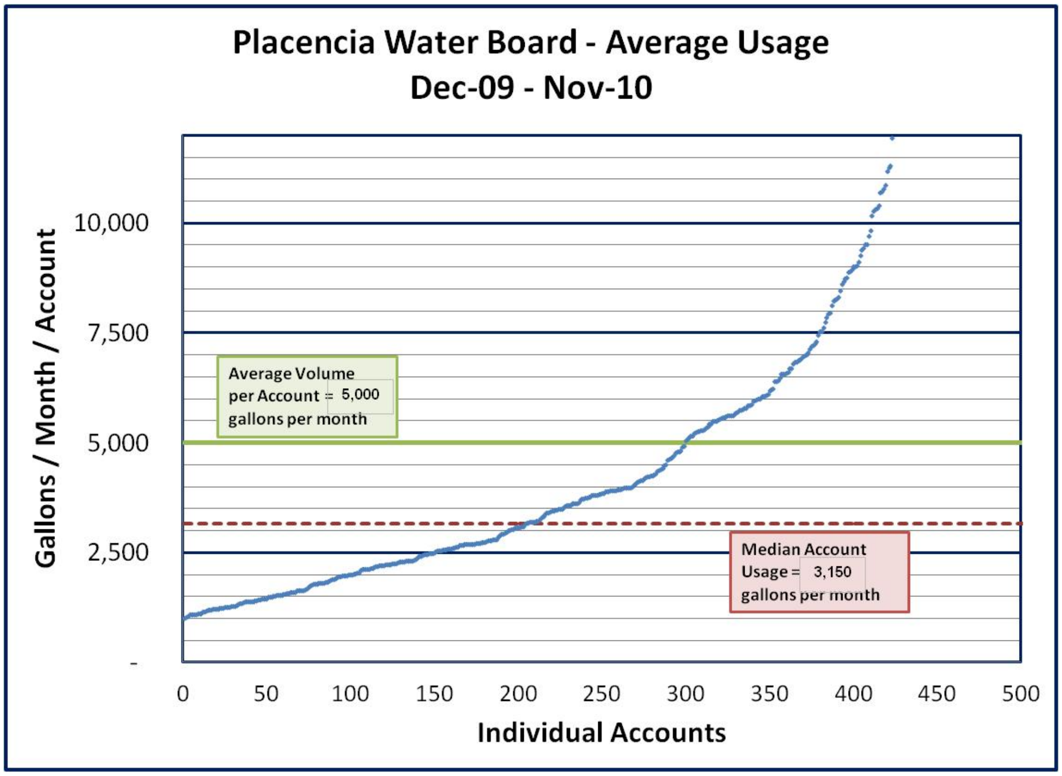


Figure 11.3-1 Historic Water Use Records

Table 11.3-1and Figure 11.3-2 summarize the distribution of accounts by monthly water consumption using BWSL' Belize City district ranges. For example, for all accounts (domestic and commercial), 17% of the historic record accounts averaged between 2,001 – 3,000 gallons per month.

In the cash flow model, the existing accounts average water consumption was *lowered* from the historic readings to account for the lower-consumption Seine Bight users as well as an anticipated decrease in water use with the introduction of the wastewater tariff. These values are shown under "Cash Flow Model: Existing Accts" column. For example, in the cash flow model to estimate the income from existing facilities, 8% of all accounts average between 5,001 – 6,000 gallons per month.

However, for proposed metered accounts (new growth anticipated through 2040), the water consumption per account is *increased* from the historic rates; new homes and hotels will likely utilize more water per facility. New accounts within the cash flow model utilize the "Cash Flow Model: Proposed Accts" water consumption breakdown. For example, for new facilities within the cash flow model, 15% of the accounts utilize >8,001 gallons per month. Note: the proposed growth consumption breakdown is more conservative than the current historic records. It is possible that average water use is higher than predicted here, with a stronger income stream from metered water sales.

Table 11.3-1 Water Use Records: Historic and Projected

Customer Accounts by Monthly Usage		Historic Records: Domestic	Historic Records: Commercial	Historic Records: All Accounts	Cash Flow Model: Existing Accts	Cash Flow Model: Future Accts
FROM	TO	Percent of Accounts, by Usage				
0	1,000	12%	12%	12%	15%	10%
1,001	2,000	19%	18%	19%	20%	14%
2,001	3,000	19%	9%	17%	17%	15%
3,001	4,000	14%	13%	14%	14%	20%
4,001	5,000	7%	5%	7%	7%	10%
5,001	6,000	6%	11%	7%	8%	8%
6,001	7,000	4%	7%	5%	6%	5%
7,001	8,000	3%	3%	3%	3%	3%
> 8,001		16%	22%	17%	10%	15%
		100%	100%	100%	100%	100%

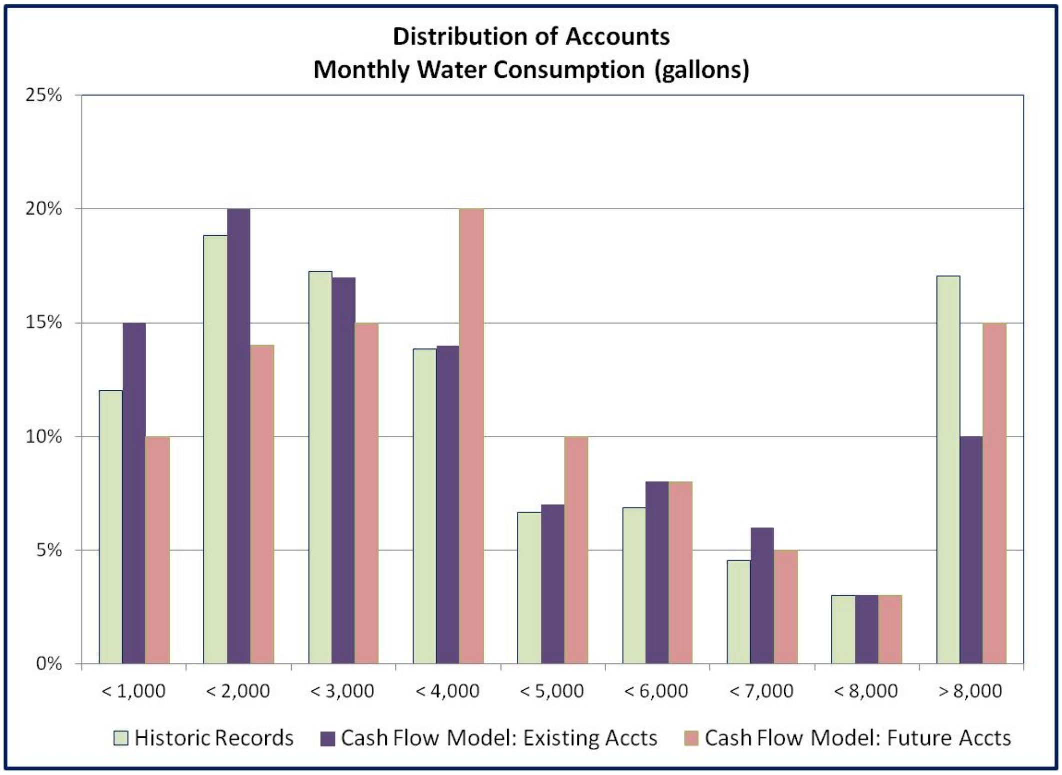


Figure 11.3-2 Distribution of Accounts, by Water Usage

11.4 Tariff System

In order to sustain the physical and social improvements made from providing wastewater collection and treatment to the Placencia Peninsula, as well as to serve as a model for system expansion for Belize and the greater region, the improved wastewater system must be able to sustain its costs, repay its initial debts, and be able to provide long-term system wide maintenance and appropriate expansion. A tariff (billing) system based upon a positive cash flow analysis needs to be established that takes into account the anticipated system expenses and income.

The proposed tariff system groups both water consumption and wastewater generation, utilizing the currently measured monthly water consumption amounts as the basis for the overall billing structure. It is recommended that all accounts have a base charge for a minimum use (1,000 gallons / month) as well as a conservation rate structure with increasing rates for increasing amounts of water usage (cost per gallon increases as the customer uses more water).

Halcrow initially recommended two separate rate structures: one for Residences (Domestic) and the second for all classes of businesses (Commercial / Hotel). However, per discussions with BWSL, a single rate structure system is the current standard throughout their service districts and needs to be utilized in this study.

A detailed listing of the proposed tariff rate structure is provided in Appendix G.1, specifying out the base charge and incremental rates by year (2012 – 2040) and monthly water consumption.

11.4.1 Tariff System Summary

The following summarize inputs into the tariff system:

- Base Charge for Water Service Account: US$4.00/month (BZ$8.00/month), which covers 0 – 1,000 gallons per month
- Water is billed in a Conservation Rate structure, whereby the cost per gallon increases in 1,000 gallon increments.
- Per-Gallon rate charges to increase by 5% every five (5) years (1% inflation per year), starting in year 2019 (the 5th year of the wastewater system)
- For facilities with wastewater connections:
    - Wastewater Collection and Treatment Surcharge: 50% of water consumption portion of bill.
- New meters within the system are to pay “Infrastructure Fees” comparable to the fees currently utilized by BWSL in the Belize City district
    - Water Infrastructure Fee: BZ$ 150.00
    - Wastewater Infrastructure Fee: BZ$ 1,695.00

11.4.2 Tariff Rates

The tariff rates shown below were utilized alongside the other forms of income to develop a cash flow analysis of the project to ensure that the project is economically feasible. The final tariff rates are to be developed by Belize Water Services and approved by the Public Utilizes Commission.

Table 11.4-1 displays the conservation rate structure utilized within this cash flow analysis for the feasibility study.

Table 11.4-1 Proposed Tariff Rate Structure

Monthly Usage		Base Charge	Water Rate	Water & Sewer
FROM	TO		BZ$	BZ$
0	1,000		$8.00	$12.00
1,001	2,000	Cost Per Additional Gallon	$0.016	$0.024
2,001	3,000		$0.019	$0.029
3,001	4,000		$0.022	$0.033
4,001	5,000		$0.025	$0.038
5,001	6,000		$0.028	$0.042
6,001	7,000		$0.031	$0.047
7,001	8,000		$0.034	$0.051
>8,001			$0.038	$0.057

Figure 11.4-1 shows a comparison of the proposed Placencia rate structure with the BWSL systems in Belize City, Belmopan, San Pedro and Caye Caulker (note: Caye Caulker is water only). Table 11.4-2 specifically compares the proposed Placencia rate structure with the structure utilized in Belize City.

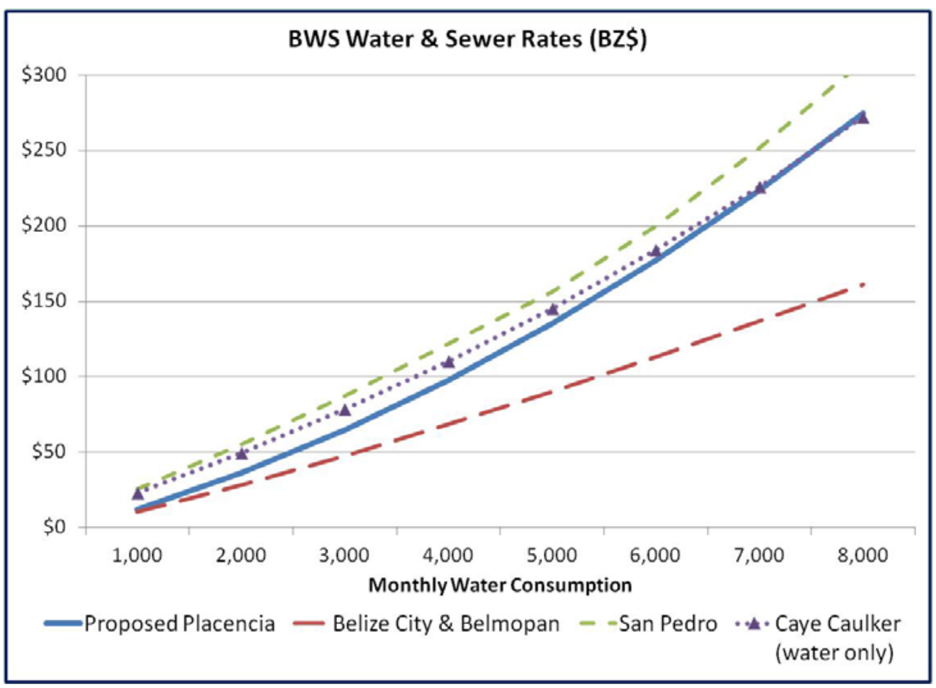


Figure 11.4-1 Comparison BWSL Rate Structures

Table 11.4-2 Comparison of proposed Placencia rates with Belize City, Belmopan and San Pedro rates

	Belize City & Belmopan Water & Wastewater			San Pedro Water & Wastewater			Placencia Water & Wastewater		
(a) < 1,001 gallons / month	BZ$	$	10.34	BZ$	$	25.27	BZ$	$	12.00
(b) > 1,001 & < 2,000	BZ$	$	17.81	BZ$	$	29.87	BZ$	$	24.00
	BZ$/gal	$	0.0178	BZ$/gal	$	0.0299	BZ$/gal	$	0.0240
(.c) > 2,000 & < 3,000	BZ$	$	19.54	BZ$	$	32.17	BZ$	$	28.50
	BZ$/gal	$	0.0195	BZ$/gal	$	0.0322	BZ$/gal	$	0.0285
(d) > 3,000 & < 4,000	BZ$	$	20.68	BZ$	$	34.46	BZ$	$	33.00
	BZ$/gal	$	0.0207	BZ$/gal	$	0.0345	BZ$/gal	$	0.0330
(e) > 4,000 & < 5,000	BZ$	$	21.83	BZ$	$	34.46	BZ$	$	37.50
	BZ$/gal	$	0.0218	BZ$/gal	$	0.0345	BZ$/gal	$	0.0375
(f) > 5,000 & < 6,000	BZ$	$	22.98	BZ$	$	43.66	BZ$	$	42.00
	BZ$/gal	$	0.0230	BZ$/gal	$	0.0437	BZ$/gal	$	0.0420
(g) > 6,000 & < 7,000	BZ$	$	23.55	BZ$	$	51.70	BZ$	$	46.50
	BZ$/gal	$	0.0236	BZ$/gal	$	0.0517	BZ$/gal	$	0.0465
(h) > 7,000 & < 8,000	BZ$	$	24.13	BZ$	$	57.44	BZ$	$	51.00
	BZ$/gal	$	0.0241	BZ$/gal	$	0.0574	BZ$/gal	$	0.0510
(i) > 8,000	BZ$	$	24.70	BZ$	$	63.19	BZ$	$	57.00
	BZ$/gal	$	0.0247	BZ$/gal	$	0.0632	BZ$/gal	$	0.0570

Monthly		Belize City & Belmopan Water & Wastewater				San Pedro Water & Wastewater				Placencia Water & Wastewater			
onsumption Amount is:		nthly Bill is:				Monthly Bill is:				Monthly Bill is:			
Over:	But Not Over:	BZ$			Of Excess Over:	BZ$			Of Excess Over:	BZ$			Of Excess Over:
0	1,000	$ 10	plus	$ -	0	$ 25	plus	$ -	0	$ 12	plus	$ -	0
1,000	2,000	$ 10	plus	$ 0.0178	1,000	$ 25	plus	$ 0.0299	1,000	$ 12	plus	$ 0.0240	1,000
2,000	3,000	$ 28	plus	$ 0.0195	2,000	$ 55	plus	$ 0.0322	2,000	$ 36	plus	$ 0.0285	2,000
3,000	4,000	$ 48	plus	$ 0.0207	3,000	$ 87	plus	$ 0.0345	3,000	$ 65	plus	$ 0.0330	3,000
4,000	5,000	$ 68	plus	$ 0.0218	4,000	$ 122	plus	$ 0.0345	4,000	$ 98	plus	$ 0.0375	4,000
5,000	6,000	$ 90	plus	$ 0.0230	5,000	$ 156	plus	$ 0.0437	5,000	$ 135	plus	$ 0.0420	5,000
6,000	7,000	$ 113	plus	$ 0.0236	6,000	$ 200	plus	$ 0.0517	6,000	$ 177	plus	$ 0.0465	6,000
7,000	8,000	$ 137	plus	$ 0.0241	7,000	$ 252	plus	$ 0.0574	7,000	$ 224	plus	$ 0.0510	7,000
8,000	and over	$ 161	plus	$ 0.0247	8,000	$ 309	plus	$ 0.0632	8,000	$ 275	plus	$ 0.0570	8,000

Table 11.4-3 summarizes the monthly water and wastewater bill, by total monthly consumption, based upon the proposed tariff rate structure.

Table 11.4-3 Water and Wastewater Bill, by Monthly Water Consumption

Monthly Consumption	Proposed Placencia	Belize City & Belmopan	San Pedro	Caye Caulker (water only)
	Bill (BZ$)	Bill (BZ$)	Bill (BZ$)	Bill (BZ$)
1,000	$12	$10	$25	$23
2,000	$36	$28	$55	$49
3,000	$65	$48	$87	$78
4,000	$98	$68	$122	$110
5,000	$135	$90	$156	$145
6,000	$177	$113	$200	$184
7,000	$224	$137	$252	$226
8,000	$275	$161	$309	$272

11.4.2.1 Willingness to Pay

As a part of the survey conducted by Halcrow during this project, participants were asked to report what monthly tariff they were willing to pay for a quality water and wastewater system. Figure 11.4-2 – Figure 11.4-4 summarize how much a Resident, Business and Hotel would be willing to pay in a total monthly bill for a combined Water and Wastewater service. The proposed rate structure provided within this study is in line with the survey responses.

The rate structure is specifically designed to be as affordable as possible for low consumption users (see Social Indicators in Table 11.6-2), while weighing more heavily on large-scale users.

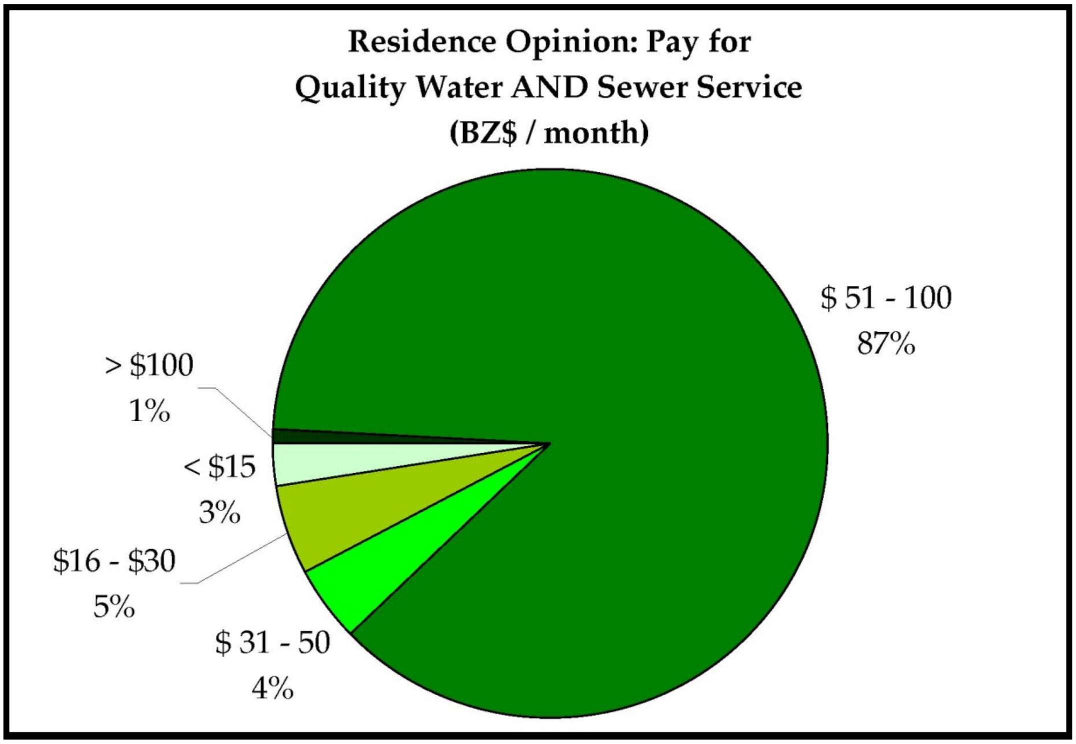


Figure 11.4-2 Survey Results: Residents Pay for Water & Wastewater, Halcrow

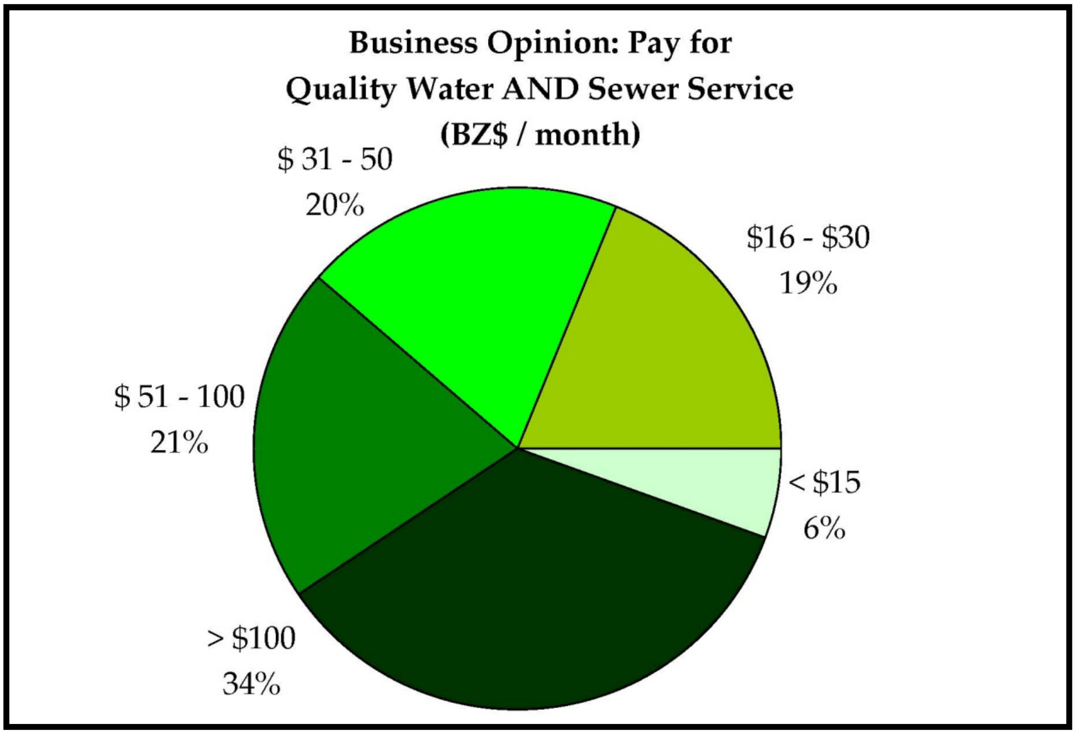


Figure 11.4-3 Survey Results: Business Pay for Water & Wastewater, Halcrow

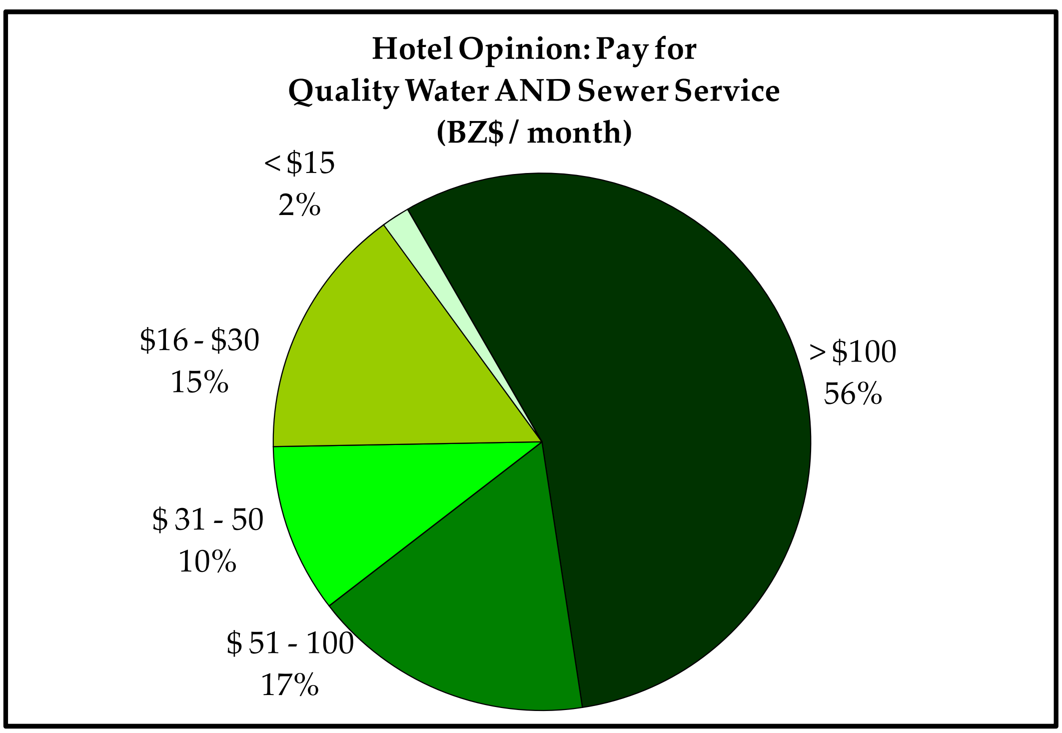


Figure 11.4-4 Survey Results: Business Pay for Water & Wastewater, Halcrow

11.5 Cash Flow Analysis

Based upon the financial assumptions listed in Section 11.2, the proposed tariff structure summarized within Section 11.4.1, along with the project capital improvement and operation and maintenance costs summarized in Table 6.5-4, a positive cash flow (cumulative cash accrual) is maintained throughout the project life cycle (through year 2040). A detailed cash flow spreadsheet of the income and expenses through the project life cycle is provided in Appendix G.3.

Figure 11.5-1 displays the cash flow by year, with Net Income (water / wastewater billing, grants, and loans), Total Expenses (operations and maintenance, BWSL corporate overhead, capital improvements, and loan repayments), and Net Cash Flow (Net Income minus Total Expenses).

Per the Cash Flow Analysis in Appendix G.3, the US$5,000,000 CReW loan is paid back across years 2015 – 2034 (20 years) at US$355,000 / year. The in-kind support from BWSL-Corporate, as well as their expenses for the general overhead of the system is paid through a 15% of net operations income ('billing') budget line item to BWSL-Corporate.

Figure 11.5-2 displays the cumulative cash flow for the project. It is important that the system does not have any period of negative cash flow ('no money on hand'). The system experiences its minimum cash flow from year 2018 - 2023, as it finishes paying down the construction loans. The system is consistently profitable from 2023 onwards.

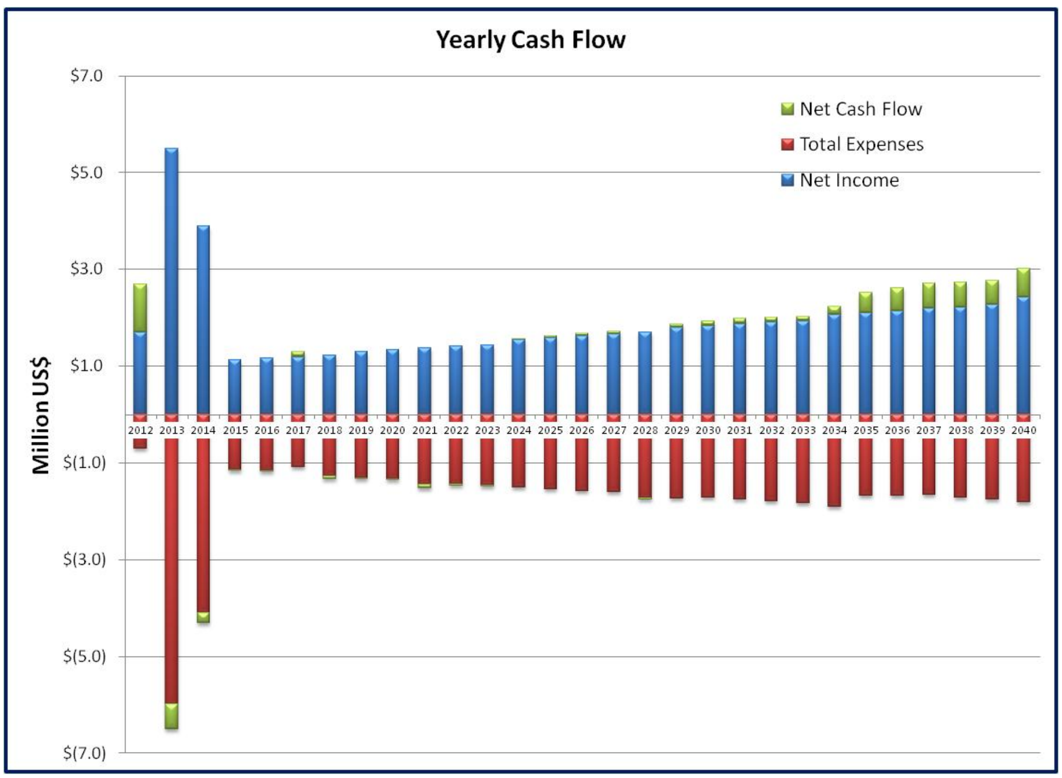


Figure 11.5-1 Cash Flow, by Year

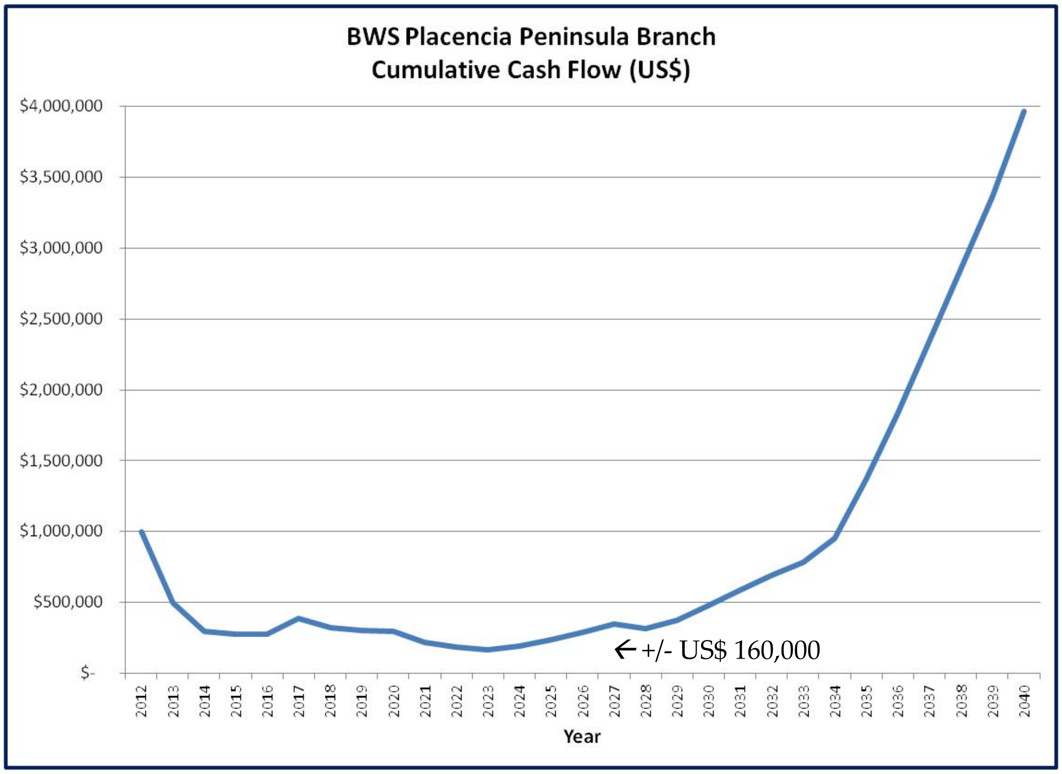


Figure 11.5-2 Cumulative Cash Flow

11.6 Project Success Indicators

The Placencia Peninsula Wastewater System project meets distinct environmental and social needs, and will contribute to the future economic success of the Peninsula by helping to ensure that the environment continues to serve as a pleasant community for local citizens as well as being conducive to a successful tourist experience. In addition, the project's financial indicators are positive: it maintains positive cash flow, repays the CReW loan for the purpose of continued infrastructure investment within Belize, and provides a source of profit income for Belize Water System (BWSL). Table 11.6-1 summarizes the financial indicators.

Table 11.6-1 Project Financial Indicators

Financial Indicators	million US$	
Short-Term Equity (1st 5 years - 2012 - 2016)	$	0.3
Long-Term Equity (2017 - 2040)	$	3.7
Net Equity (2012 - 2040)	$	4.0

In addition, the proposed tariff structure is suitable to the resident citizens within the community. The price increases from the current water service rates are minimal, and the anticipated yearly expense for typical users is within acceptable limits (as a portion of overall household income). Per Figure 11.3-2, approximately 40-50% of all accounts use less than 3,000 gallons per month. Based upon this consumption rate, Table 11.6-2 summarizes these social indicators for the year 2017.

Table 11.6-2 Project Social Indicators

Social Indicators		BZ$
2017 Residential Customer Tariff - Water & Wastewater		
Minimum Monthly Charge	$	12
Monthly Charge - 3,000 Gallons	$	65
Yearly Charge - 3,000 Gallons per Month	$	774
World Bank, World Development Indicators, Per Capita Income	$	7,480
Placencia Peninsula Local Income Factor		120%
Wage Earners per Household (account)		1.5
Estimated Average Income per Household (in 2017)	$	16,000
Water & Sewerage Service Cost as portion of Income		4.8%

* Note: Per United Nations Children's Fund (UNICEF) web publications[xxx]

- 2009 Gross National Income per Capita is US$3,740,
- Per capita annual growth rate (1990) of 2.2%
- Assuming a 1.5 person working household, and
- A 20% above-national average income for Placencia Residents.

11.7 Effluent Reuse

As shown in Sections 5.5.1 and 6.4.1, an initial analysis has been performed within this study to estimate the costs associated with the construction, operation and maintenance of an agricultural reuse system that distributes treated wastewater effluent to irrigation customers.

11.7.1 System Funding

Given the anticipated restrictions in the overall scope of the collection system due to the limited capital improvement funds for the project, it is not recommended to include the expense of the irrigation reuse system within the initial project budget. If it is determined to proceed with this phase of the system, additional funding for this project needs to be acquired. Funding alternatives include:

- Public-Private partnership with local Plantations, funded through private bank;
- Corporate monies directly from BWSL;

The expenses associated with this system are not included within the overall wastewater system expenses and accompanying cash flow analysis.

11.7.2 Effluent Sales

As provided within the system assumptions in Section 5.5.1, the estimated effluent sold is 75% of the total treated effluent, based upon the average annual wastewater flows projected in Section 3.3. This reduced sales figure is based upon estimated wet-weather conditions that preclude the need by the plantation users for irrigated water. When treated effluent is not sold, it is to be disposed through the nutrient disposal system.

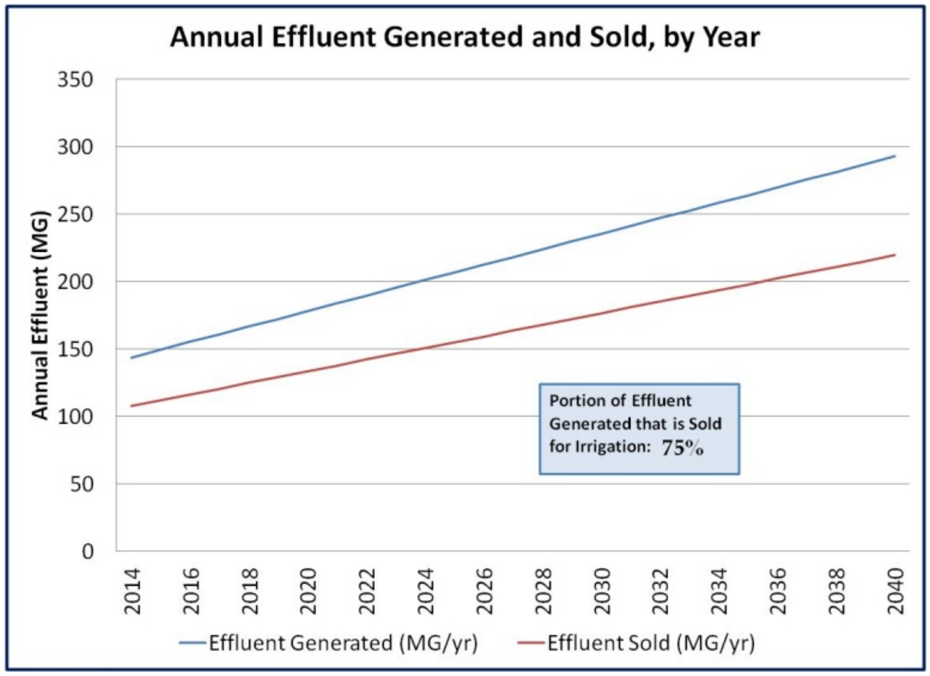


Figure 11.7-1 Treated Effluent Generated and Sold, by year

11.7.3 Effluent Tariff

Based upon the estimated system capital costs, operation and maintenance costs, and projected effluent volume sold, the system costs about US$1.20-$2.00 per 1,000 gallons (US$0.30-$0.50 per cubic meter) delivered and sold (see Appendix E.1 for initial system design and cost estimate and Appendix G.4 for tariffs) was established for effluent sales to irrigation users.

This is the minimum rate for the system to sustain its costs. There is potential that effluent sales can supplement the overall costs for the Placencia Wastewater System and therefore reduce the tariff rates for Placencia water and wastewater users. Prior to finalizing any potential water/wastewater tariff reductions, an Effluent Market Analysis study to determine the irrigation users' willingness to pay.

11.7.4 Effluent Cash Flow Analysis

Based upon the proposed tariff structure summarized within Section 11.7.3, along with the project capital improvement and operation and maintenance costs summarized in Table 6.4-2, a positive cash flow (cumulative cash accrual) is maintained throughout the project life cycle (through year 2040). A detailed cash flow spreadsheet of the income and expenses through the project life cycle is provided in Appendix G.4.

Figure 11.7-2 displays the cash flow by year, with Net Income (effluent billing and loans), Total Expenses (operations and maintenance, BWSL corporate overhead, capital improvements, and loan repayments), and Net Cash Flow (Net Income minus Total Expenses).

Per the Cash Flow Analysis in Appendix E.1, the US$700,000 loan is paid back across years 2015 – 2024 (10 years) at US$100,000 / year. The loan term was decreased from 20 years (utilized through the wastewater system loans) to 10 years to compensate for the increase in overall project risks. The in-kind support from BWSL-Corporate, as well as their expenses for the general overhead of the system is paid through a 15% of net operations income ('billing') budget line item to BWSL-Corporate.

Figure 11.7-3 displays the cumulative cash flow for the project. It is important that the system does not have any period of negative cash flow ('no money on hand'). The system experiences its minimum cash flow from year 2018 - 2023, as it finishes paying down the construction loans. The system is consistently profitable from 2023 onwards.

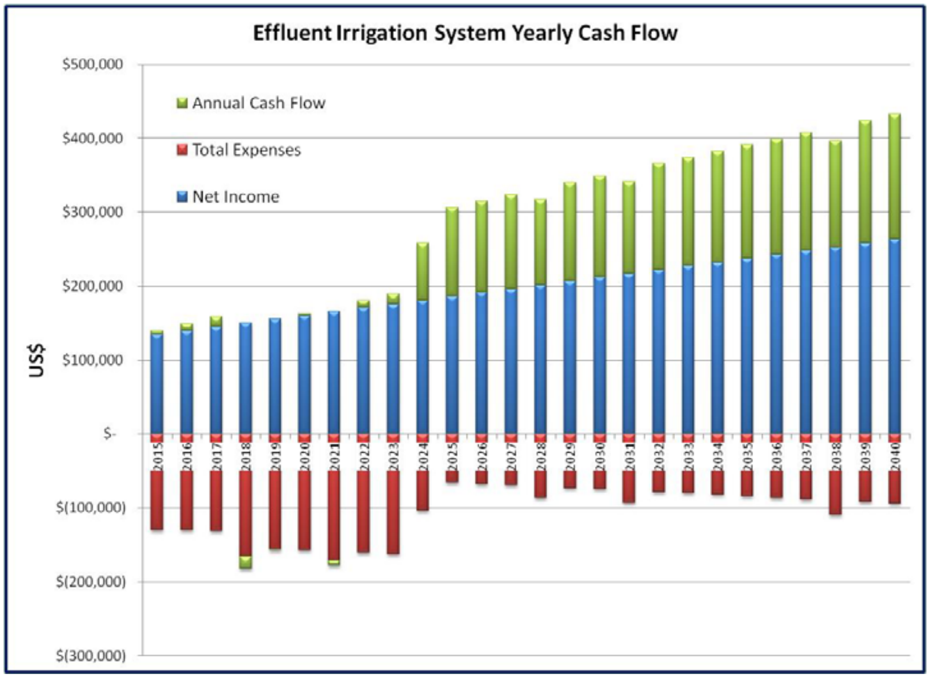


Figure 11.7-2 Effluent Reuse Cash Flow, by Year

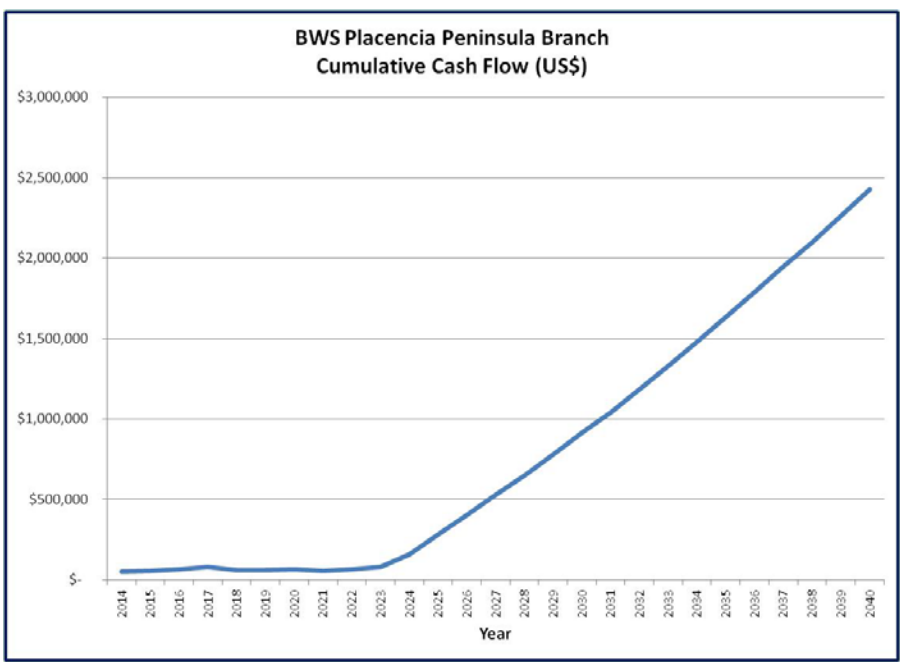


Figure 11.7-3 Effluent Reuse System Cumulative Cash Flow

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