# Policy for Development of Water and Sanitation Infrastructure in Paraty, Brazil

by

Eun Chu You

B.S. Civil and Environmental Engineering
University of California, Berkeley (2002)

SUBMITTED TO THE
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ENGINEERING
IN CIVIL AND ENVIRONMENTAL ENGINEERING

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2003



Signature of the Author________________________________________
Department of Civil and Environmental Engineering
May 9, 2003

Certified by________________________________________________
Dr. Donald Harleman
For Professor Emeritus of Civil and Environmental Engineering
Thesis Supervisor

Accepted by________________________________________________
Oral Buyukozturk
Chairman, Departmental Committee on Graduate Studies

**Policy for Development of Water and Wastewater Infrastructure in Paraty, Brazil**

by

Eun Chu You

Submitted to the Department of Civil and Environmental Engineering
on May 15, 2003 in partial fulfillment of the requirements for the degree of
Master of Engineering in Civil and Environmental Engineering

**Abstract**

The purpose of this thesis is to identify and describe Paraty's current problems related to existing water and sanitation systems, and to recommend practical improvements for the mitigation of these problems.

Water quality analysis of Paraty's potable water and surrounding surface waters is central to the evaluation of public health risks, associated with the consumption of ineffectively treated water and exposure to unsanitary disposal of human wastes. Additionally, the study of diarrhea incidence in the City is integral to the measurement of direct health consequences resulting from inadequate water and sanitation.

In addition to poor public health, the consequences of the City's inadequate water and sanitation include: polluted surface waters; damaged aesthetics; loss of amenities; depreciated commercial and intrinsic value of the environment; and deferred nomination process for UNESCO World Heritage Site.

The construction of wastewater collection infrastructure and treatment plant, and new drinking water treatment plant, is recommended for the City.

An increase in water and sewage tariff is suggested as a means of recovering the costs incurred by new water and sanitation improvements. Integrating a cost analysis and a willingness to pay analysis, it was found that the costs could be recovered if water and sewage tariff is priced effectively, based on the distribution of household income and willingness to pay.

Thesis Supervisor: Dr. Donald Harleman
Title: Ford Professor Emeritus of Civil and Environmental Engineering

**Acknowledgements**

I would like to thank the following individuals:

**Dr. Donald Harleman** for his unreserved support. I would like to thank him especially for the weekly meetings, which have been invaluable for the completion of the Brazil Project and this thesis.

**Frederic Chagnon** for all his help, which always came when help was needed most.

**Mr. Ricardo Tsukamoto** for all his help during and after my stay in Paraty.

The **Tsukamoto family** for providing the cutest laboratory, and a wonderful Sunday at the beach.

**Ms. Wilsa Mary S. Barreto**, for generously sharing her work.

My teammates **Claire Kfouri**, **Nancy Choi**, and **Hyo Jin Kweon**, for many unforgettable memories in Paraty and M.Eng room.

The **CEEKA** members for their constant interest and encouragements. I would to thank the CEEKA members especially for making me feel at home and giving me many wonderful memories at MIT.

My sisters **Lisa** and **Sunny You** for being the best sisters and friends anyone can wish for. I would like to also thank my brother **Paul** and his wife **Myung Rye You**.

My parents **Yong Chan** and **Soon Duk You** for their unfailing love.

# TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF TABLES

# CHAPTER 1 - INTRODUCTION TO WATER AND SANITATION

The provision of safe drinking water and the proper treatment and disposal of human waste can achieve large gains in human health, and environmental quality, and hence provides substantial economic returns. Therefore naturally, the provision of adequate drinking water supply and sanitation ranks at the top of priority environmental challenges in Paraty, Brazil, as well as in many parts of the developing world. In this report, drinking water supply refers to a system or service of water collection, drinking water treatment, and water distribution for human consumption. Sanitation is defined as the services or systems of collection, transportation, treatment, and sanitary disposal of wastewater, excreta, or other waste.

## 1.1. Health Consideration

Many studies report that unreliable drinking water quality and supply and the lack of wastewater treatment has a significant impact on health. The use of polluted waters for drinking and bathing causes infectious diseases that kill millions and sicken more than a billion people each year (World Bank, 1992). Thousands of outbreaks of waterborne diseases are caused by the consumption of untreated or improperly treated drinking water (Ford and Colwell, qtd. in Payment and Hunter, 2001).

Water and sanitation-related diseases are transmitted through many pathways, and can be classified into four categories: (i) waterborne diseases, caused by the ingestion of water contaminated by human or animal feces or urine containing pathogenic bacteria or viruses; (ii) water-washed diseases, caused by poor personal hygiene; (iii) water-based diseases, caused by parasites found in intermediate organisms living in water; and (iv) water-related diseases, transmitted by insect vectors that breed in water (Eisenberg et al., 2001). Examples of these diseases are listed in Table 1.1.

| Category | Disease |
|---|---|
| Waterborne diseases | Cholera, typhoid, amoebic and bacillary dysentery, and other diarrheal diseases |
| Water-washed diseases | Scabies, trachoma and flea-, lice-, and tick-borne diseases, in addition to the majority of waterborne diseases, which are also water-washed |
| Water-based diseases | Dracunculiasis, schistosomiasis, and some other helminths |
| Water-related diseases | Dengue, filariasis, malaria, onchocerciasis, trypanosomiasis, and yellow fever |

Table 1.1. Examples of water-related diseases (Bradley, qtd. in Eisenberg, 2000)

The direct health consequence of poor water supply and sanitation is huge. According to the World Health Organization (WHO), approximately one child dies every eight seconds from a water-related disease, and more than 5 million people died each year from illnesses linked to unsafe drinking water or inadequate sanitation (Anon, qtd. in Payment and Hunter, 2001). "Unsafe water is implicated in many cases of diarrheal diseases, which, as a group, kill more than 3 million people, mostly children, and cause about 900 million episodes of illness each year. At any one time more than 900 million people are afflicted with roundworm infection and 200 million with schistosomiasis. Many of these conditions have large indirect health effects – frequent diarrhea, for instance, can leave a child vulnerable to illness and death from other causes" (World Bank, 1992).

Children, the poor, and travelers are most at risk of water and sanitation-related diseases, due to undeveloped or degraded immunity for disease-causing environmental pathogens. Children under 5 years of age are the most vulnerable population, because they are "in a dynamic state of growth" (WHO, "Children"). Also, children are "more exposed to unhealthy conditions and to dangerous substances because they live their lives closer to the ground and, especially in the early years, they are frequently exposed through hand-to-mouth activities" (WHO, "Children"). People from low-income areas are more likely to suffer disease due to increased exposure to pathogens from poor living conditions, and are likely to suffer more severely, once affected by disease, "because of inadequate health-care and social support systems, and from poorer general health due to malnutrition" (Eisenberg et al., 2001). Therefore, not surprisingly, poor children suffer the most, and approximately "one in five children in the poorest parts of the world will not live to their fifth birthday, mainly because of environment-related diseases" (WHO, "Children"). For the third group of vulnerable population, travelers, the risk of infection is higher because they are exposed to new environmental pathogens, to which they do not have acquired immunity due to prior exposure. Most waterborne pathogens have acquired immunity, the protection conferred to a host after exposure to the agent of disease, that is partial and temporary (Eisenberg et al., 2001).

The reduction in water-related illnesses with improvements in water and sanitation is large. "WHO suggest that if sustainable safe drinking water and sanitation services were provided to all, each year there would be 200 million fewer diarrheal episodes, 2.1 million fewer deaths caused by diarrhea, 76,000 fewer dracunculiasis, 150 million fewer schistosomiasis cases and 75 million fewer trachoma cases" (Payment and Hunter, 2001). The effects of improved water and sanitation on the occurrence of related illnesses, studied by the U.S. Agency for International Development (USAID), is summarized in Table 1.2, and the effects on the morbidity from diarrhea, studied by WHO, is summarized in Table 1.3 below. The WHO analysis suggests that the effects of making several kinds of improvements at the same time are roughly additive (Esrey at al., qtd. in World Bank, 1992).

| Disease | Millions of people affected by illness | Median reduction attributable to improvement (%) |
|---|---|---|
| Diarrhea | 900/year | 22 |
| Roundworm | 900 | 28 |
| Guinea worm | 4 | 76 |
| Schistosomiasis | 200 | 73 |

Table 1.2. Effects of improved water and sanitation on water and sanitation-related illnesses (Esrey et al., qtd. in The World Bank, 1992)

| Type of improvement | Median reduction in morbidity (%) |
|---|---|
| Quality of water | 16 |
| Availability of water | 25 |
| Quality and availability of water | 37 |
| Disposal of excreta | 22 |

Table 1.3. Effects of improved water and sanitation on morbidity from diarrhea (Esrey et al., qtd. in The World Bank, 1992)

Some epidemiological evidence suggests that improvements in sanitation are at least as effective in preventing disease as improved water supply (UNICEF et al., 2000). The improvement in wastewater treatment and disposal interrupts the transmission of much fecal-oral disease at its most important source by preventing human fecal contamination of water and soil.

Water and sanitation-related diseases are prevalent in Brazil, where the delivery of drinking water and sanitation services falls far short of the goal of universal coverage. In Brazil, approximately 75% of the total population is served with domestic water connection, and 48% is served with a connection to public sewer system. Among the urban population, which accounts for 78% of the Brazil's total population of 162 million, 91% is served with domestic water connection, and 59% is served with connection to public sewer system. Among the rural population, 20% has domestic water connection, and mere 6% has connection to public sewer system. More alarmingly, only 10% of the total volume of sewage collected from the sewerage systems receives treatment (CEPIS, 2000).

The prevalence of water and sanitation-related diseases, which corresponds to low water and sanitation service coverage, in Brazil is considerable. As much as 32% of all hospital admissions in 1990, were due to diseases related to inadequate sanitation, according to a 1995 report from the Ministry of Planning and Budget of Brazil titled 'Assessment of the Sanitation Sector: Economic and Financial Study' (Csillag and Zorzetto, 2000). This report revealed that as many as 4.5 million hospital admissions, registered by the Ministry of Health from 1987 to 1992, were caused by sanitation-related diseases. The main group of diseases, labeled "poorly defined enteric infection," caused 92% of the cases, and the remaining 8% comprised what are labeled as "other specific enteric infections," as well as typhoid fever, shingellosis, schistosomiasis, and amebiasis. Furthermore, this report remarked that infant mortality is two times higher in households with inadequate sanitation than in households with adequate sanitation, revealing a strong correlation between limited service coverage of water and sanitation and poor public health.

## 1.2 Environmental Quality Consideration

In addition to losses in human health, there are many costs related to environmental degradation, such as losses in productivity, amenity, and the intrinsic value of the environment. The productivity includes both the human productivity that can be lowered by impaired health, and the productivity of many resources, used directly or indirectly by people, that can decline with damage imposed by those uses (World Bank, 1992). Amenity is "a term that describes the many other ways in which people benefit from the existence of an unspoiled environment" (World Bank, 1992). The "intrinsic" value of the environment is separate from its value to human beings, that can only estimated under the notion of amenity values.

The quality of many surface water bodies – such as rivers, streams, and beach waters – have economic values, as fisheries and/or recreational waters, aesthetic value that can add to quality of life, and the intrinsic value, all of which depend on the state of water and sanitation systems.

## 1.3 Economic Consideration

Water is an economic good, with many competing uses, that can be a driving force for social and economic development. In countries where tourism is an important contributor of foreign exchange and employment, the preservation of attractive environment, through proper management of sanitation infrastructure and wastewater treatment facilities, becomes critical for the development of the industry. Polluted environment, such as a beach contaminated with human wastes, and its associated health risks for tourists and local population can easily pose a threat for the development and survival of the tourism industry (San Martin, 2002).

### *Tourism*

Tourism contributes significantly to the economies of developing countries by achieving "three high-priority goals of developing countries: the generation of income, employment, and foreign exchange earnings" (San Martin, 2002). Tourism, classified as exports, accounts for a significant portion of the GDP earnings in the Latin American and Caribbean countries, although this portion is not fully reflected in the domestic income and product accounts of most countries. In Brazil, tourism accounts for approximately 4% of total exports (World Bank, qtd. in San Martin, 2002). In 1997, the Brazilian exports totaled US$ 53 billion (BIT, n.d.). Thus, tourism accounted for approximately US$2 billion of exports in 1997.

Tourism, which does not require sophisticated technology or much skilled training, is a great generator of employment and income. "[In] hotels, which account for about 75 percent of tourism employment (distribution, transport, finance and insurance, and entertainment make up the other 25 percent), [e]very room in a three- or four-star hotel generates one job, for five-star hotels, each room creates 1.3 jobs" (San Martin, 2002). "Even before the 1990s, one job generated by a hotel generated one more job elsewhere in the tourism trade and two in the rest of the economy; thus one job generated an estimated three others" (IDB, qtd. in San Martin, 2002). "It is estimated that in the Latin American and the Caribbean five-star hotels can generate US$5.4 for each dollar spent in their operation. The figure for three- and four-star hotels averages US$4.2" (San Martin, 2002).

## 1.4. Social Consideration

In addition to the economic contributions, there are important social contributions associated with water and sanitation, the most significant of which, aside health, is poverty alleviation.

***Poverty Alleviation***

Water and sanitation infrastructure can promote poverty alleviation by: (i) stimulating economic growth; (ii) converging the poor and rich regions within a country; (iii) increasing agricultural productivity through by improving irrigation; and (iv) improving the health and productivity. "It has been estimated that in Latin America, a 1 percent growth in per capita income reduces the share of the people living in poverty by half a percentage point" suggesting that "any contribution of infrastructure to growth will therefore have a poverty alleviation effect" (San Martin, 2002). "In Argentina and Brazil, recent studies show that lack of access to sanitation and to roads over the last 20 years have been important impediments to convergence [between the poor and the rich regions]" (San Martin, 2002). "With large percentage of the population employed in agriculture in the low-income economies of Latin American countries, investments in irrigation and agriculture more generally and improvements in water management, in particular, can have substantial impacts on rural poverty alleviation" (San Martin, 2002). "Extending coverage rates for water supply and sanitation will affect the living conditions of the poor via better health, and increased potential labor productivity; through considerable cash savings (since their supplies must often be bought extensively, from water trucks, bottled water, etc.); and through reduced time use in bringing the water to the household" (San Martin, 2002).

## 1.5. Institutional Framework in Brazil

Much of the water and sanitation sector in Brazil currently follows the PLANASA (Plano Nacional de Saneamento) model, which is responsible for 80% of water supply and 32% of sewage services for the urban population. Created in 1971, with the goals of improving water supply and sanitation services, PLANASA required each State in Brazil to create its own State-owned public company, from which the municipalities were able to contract services for water and sanitation. The municipalities had the choice of awarding concession contracts to the public company or establishing their own public services, a right granted by the Brazilian Constitution. However, the Federal National Bank of Housing (Banco Nacional de Habitao), under the Ministry of the Interior, did not finance water and sanitation works unless the municipality had joined PLANASA. Although the Federal National Bank of Housing, and PLANASA were abolished in 1986, the PLANASA model remains operational as the backbone of water and sanitation sector in Brazil (US Dept. of Commerce, 1999).

As the concession period from the municipalities to the State companies reaches their end, changes are actively sought. The State companies had shown inadequate performance and low productivity in many cases and had left many consumers, who often viewed their services as unreliable, discontent with their services. The State companies had some typical and common problems, which the World Bank classified into four groups: (i) technical and operational, (ii) commercial and financial, (iii) human and institutional, and (iv) environmental problems. The municipalities are looking for new models or for a new role of the State in providing public services, with the emphasis on decentralization and privatization, as it has occurred in other parts of the world. The service contracts (for pumping stations, sewage treatment plants, metering and reading, for example), and the discussion of private sector participation are becoming more common (US Dept. of Commerce, 1999).

# CHAPTER 2 - INTRODUCTION TO PARATY, BRAZIL

The area of focus for the water and sanitation studies in this report is the City of Paraty, located in the State of Rio de Janeiro, Brazil. Paraty is a historical city, with much natural and cultural charm, that has a potential to grow as a tourist city. However, doubtful drinking water quality and polluted rivers and beach water, which are associated with lack of wastewater treatment, could very well threaten the health of tourists and local population, and hinder the development of the tourism industry. Therefore, a careful study of the City's current state of water supply and sanitation, the extent of environmental degradation, and appropriate response measures are to be studied for the City of Paraty in this report.

## 2.1 Location, Area, Climate, and Population

The City of Paraty is located within the Municipality of Paraty, which is located in the south coast of the State of Rio de Janeiro, Brazil (See Figure 2.1 through 2.3). The Municipality of Paraty covers an area of 930 km$^2$, with the average elevation of 5 meters (Prefeitura, "Patrimony" 3). Embracing the Bay of Ilha Grande (Baia da Ilha Grande), Paraty has the mild climate that is hot in the afternoon most of the year, and receives more than 1.5 m of rainfall each year (Canaldotempo.com).

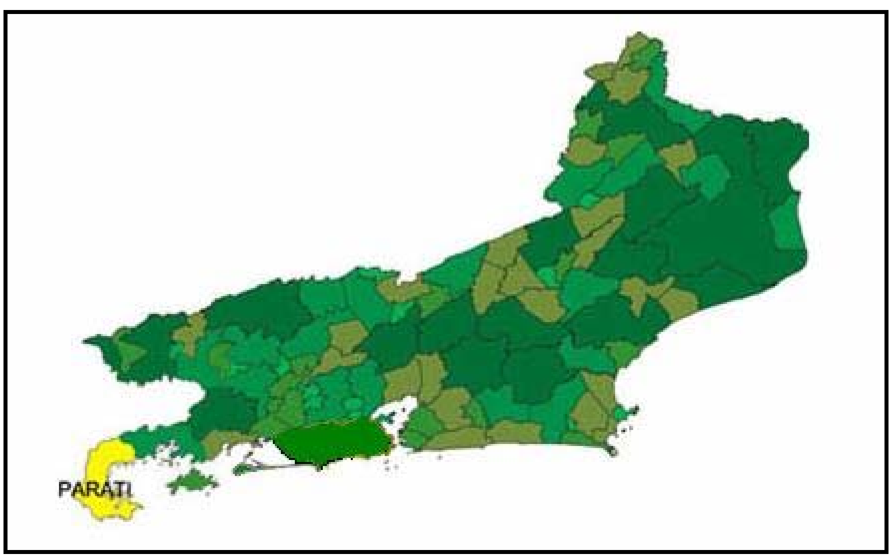


Figure 2.1. Location of Municipality of Paraty in the State of Rio de Janeiro, Brazil

The Municipality of Paraty has a population of 30,000 (Census 2000), approximately 15,000 of which are concentrated in the urban area, in and near the City of Paraty. The other 15,000 are dispersed in smaller rural communities around the Municipality (See Figure 2.2).

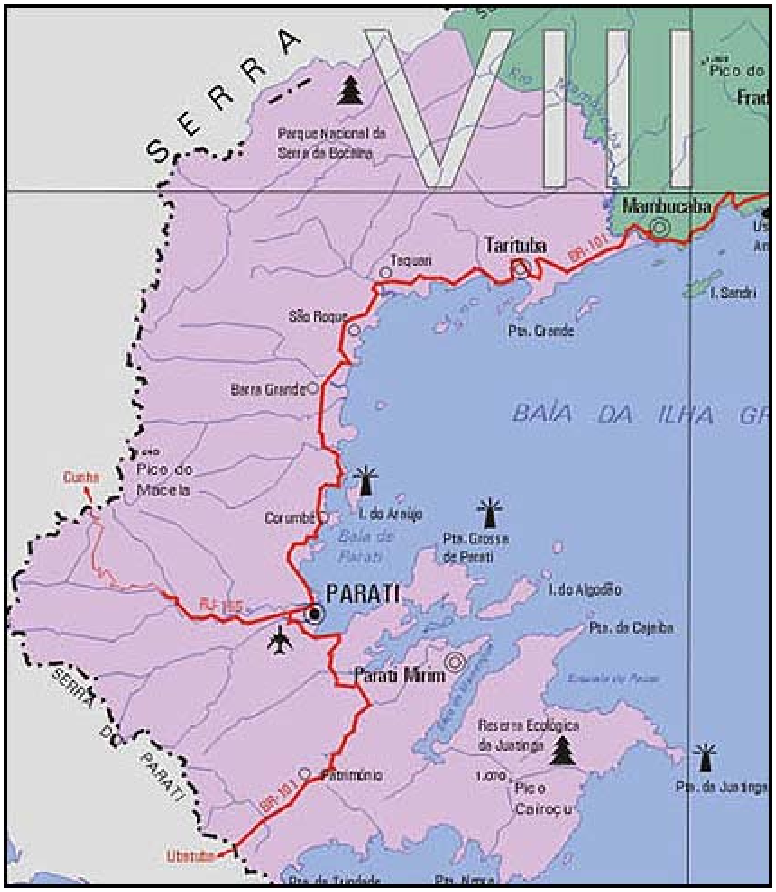


Figure 2.2. Municipality of Paraty (Not to Scale)

## 2.2. City of Paraty

The City of Paraty, which has the highest population density in the Municipality, has two rivers, Pereque River (Rio Pereque-Acu) and Matheus River (Rio Matheus-Nunez), running through it and discharging into the Paraty Bay (Baia Paraty) (See Figure 2.3). Matheus River, in the South, forms the southern boundary of the City, and the northern end of Jabaquara Beach (Praia Jabaquara) forms the northern boundary.

The City can be subdivided into five sections: (1) Historical Center; (2) the Old City; (3) Manguera; (4) Ilha das Cobras; and (5) Jabaquara (See Figure 2.3.b). Paraty's Historical Center, which preserves the authentic colonial architecture, from the 17$^{th}$ century when Paraty was a major staging post for Brazilian gold passing from Minas Gerais to Portugal, is a national monument, considered by UNESCO (United Nations Educational, Scientific and Cultural Organization) to be one of the most important surviving examples of colonial architecture in the world. The streets in the historical center are paved with irregular stones, which form a canal that drains off storm water and allows for the sea to enter and wash the streets at full moon and high tides. Manguera and Ilha das Cobras are the poorer areas of the City. The Old City and Jabaquara consists mainly of inns and other accommodations for tourists, and are generally wealthier areas.

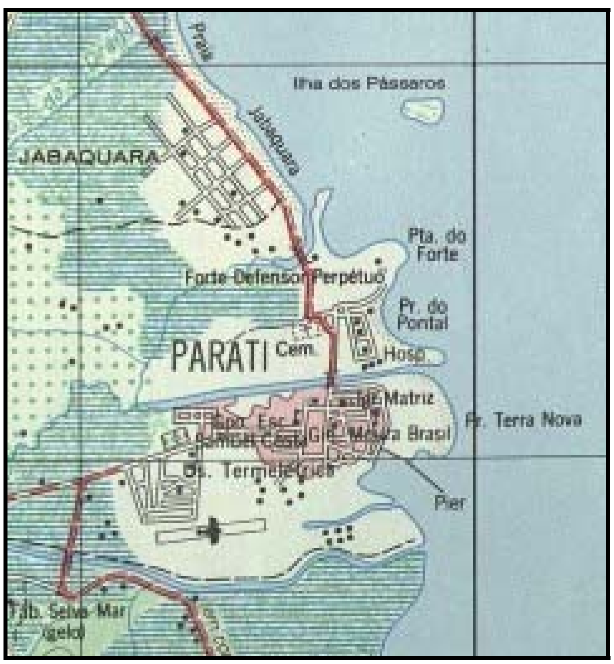


Figure 2.3.a. City of Paraty (Not to Scale)

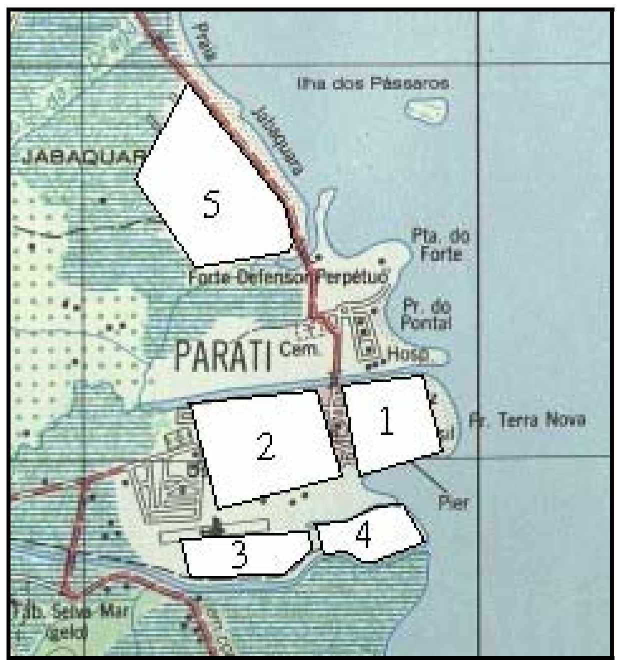


Figure 2.3.b. City of Paraty (Not to Scale)[1]

The City has a total population of approximately 15,000, which increases manifold during summer due to tourism. The increases in population during summer is greatest for the Historical Center, a great tourist attraction, and for Old City and Jabaquara, which are mainly summer

[1] 1) Historical Center; 2) Old City; 3) Mangueira; 4) Ilha das Cobras; and 5) Jabaquara

resort areas. In contrast, population increase is not expected for Mangueira and Ilha das Cobras areas, which are mainly residential areas for the local population.

## 2.3. Tourism Industry

The tourism industry in Paraty is active and strong, and is considered one of the largest contributors to the City and Municipality's economy, next to fishing, trade, and craft (Prefeitura, "Patrimony," 2003). Reflecting the City's thriving tourism industry, are many lodgings and hotels, pubs and restaurants, stores and boutiques, and travel agencies located in the City. Besides the Historical Center, there are many more tourist attractions, some of which include: islands; waterfalls; beaches; natural parks of preservation; museums; historical monuments; military forts; and folkloric parties (Prefeitura, "Patrimony," 2003). The City's location, situated advantageously between the two largest cities in Brazil, Rio de Janeiro and Sao Paulo, helps the tourism industry by allowing tourists to travel conveniently through either of the two cities. Sao Paulo and Rio de Janeiro have the two busiest airports in Brazil, and there were approximately 2.8 million international arrivals in Sao Paulo Airport, and 1 million in Rio de Janeiro Airport, in 2001, according to a poll taken by the Brazilian Tourist Office.

## 2.4. Candidacy for UNESCO World Heritage Site

The well-preserved 17$^{th}$ century colonial architecture in Paraty's Historical Center is the Brazilian national historic monument, and a candidate for UNESCO World Heritage Site. The World Heritage List, a direct result of the adoption of the Convention Concerning the Protection of the World Cultural and National Heritage by UNESCO in 1972, authenticates, in an area or monument, the existence of heritage that belongs to and is important to humanity. To be included in the World Heritage List, sites must satisfy severe selection criteria, following an extensive nominating procedure. A cultural criteria for the World Heritage Site follows: "works of man or the combined works of nature and of man, and areas including archaeological sites which are of outstanding universal value from the historical, aesthetic, ethnological or anthropological points of view" (UNESCO, 1997).

Paraty, which has initiated the nomination process for the UNESCO World Heritage Site, is in the stage of planning the improvements in water and sanitation, which are a few of the requirements specified by ICOMOS (the International Council on Monuments and Sites), one UNESCO's two technical advisory bodies. The current, non-existing, system of wastewater treatment and disposal in Paraty was identified as unsatisfactory, and a system that complies with domestic and international standards is required, in order for Paraty to qualify as a candidate for World Heritage Site.

# CHAPTER 3 – PRESENT CONDITION OF WATER AND SANITATION

## 3.1. Institutional Framework in Paraty

The water and wastewater sector in the Municipality of Paraty is in a state of instability and faced with an uncertain future. Since the concession period, from the Municipality to CEDAE (the Rio de Janeiro State-owned water and sewage company), expired approximately 6 years ago, the Municipality has neither renewed its contract with CEDAE nor completed a full transfer of the control of its water and sanitation systems. While the Municipality remains undecided in its approach toward its repossessed water and sanitation systems, CEDAE continues to provide services without having established a new concession agreement with the Municipality. In the past, CEDAE has made apparent efforts to renew its concession with the Municipality, by making propositions such as: (i) spending R$200,000 for fixing and making operational a partially constructed and abandoned drinking water treatment plant; and (ii) spending R$10 million for the operation and maintenance of potable water treatment and distribution (Lemos Padua, 2003). However no agreement has been reached.

The extent of Municipality's participation in its own water and sanitation sector depends largely on the interests of the individuals in political power. During the seat of previous mayor, Dede, the Municipality had constructed new water supply pipeline, begun the construction of a potable water treatment plant, and measured domestic water consumption using water meters. However, with the election of new mayor in 2000, many of these projects were abandoned while new projects were devised and undertaken. For example, the Municipality had abandoned the construction of the treatment plant, discontinued the reading of water meters, set the tariffs for water and sanitation according to property size, and informally entrusted CEDAE with much of the water and sanitation services since 2001 (Reis, 2003).

## 3.2. Services Coverage

Paraty has a coverage of water supply and sanitation services that is lower than the national average, which is itself far below the desired universal coverage. According to a report prepared by the Municipality of Paraty in 2002, 60% of the total population in Paraty is supplied with public water that is disinfected with chlorine, and 12% is provided with sewage collection, that discharges, untreated, directly to surrounding surface water bodies (Prefeitura, “Laudo,” 2002). This figure is lower than the nationwide average of 75% domestic water connection, and 48% connection to public sewer system.

The disparity is even greater when the coverage in Paraty is compared with the coverage in Rio de Janeiro, one of nation’s largest cities, that is also near Paraty. In Rio de Janeiro, where more than 99% of the population is in the urban area, 90% of the urban population has domestic water supply connection and 84% has connection to public sewer system (CEPIS, 2000). To compare more equitably, it is important to note that approximately 100% of the urban population in Paraty receives water that is disinfected with chlorine, and 0% of the wastewater collected is treated before discharge. In contrast, 77% of the total population in Rio de Janeiro receives effectively disinfected water through the distribution network; and 41% of the total wastewater produced in Rio de Janeiro is treated (CEPIS, 2000).

## 3.3. Existing Potable Water Supply System

Paraty, which receives more than 1.5 m of rainfall each year, is well endowed with an abundant supply of drinking water sources at the mountains. These drinking water sources, most of which are surface waters in the form of streams or rivers, have pristine water quality most of the time. Unfortunately, however, surface waters are easily contaminated with increased amounts of particulate matter in the water after rainstorms, due to erosion of sediments caused by rapid currents. In addition, surface waters are contaminated by the runoffs from upstream areas; so the presence of farms upstream or nearby can easily pollute the waters with fertilizers and animal feces. Therefore, the potable water, with surface waters as its source, has highly variable water quality, and requires the minimum treatment of filtration and disinfection.

Despite these problems of frequent rainstorms and farms located near and upstream of the water intake points, the Municipality of Paraty disinfects only two of its many water sources, those that serve the urban population in the City of Paraty. The disinfection is performed by the addition of chlorine and without filtration or any other form of pretreatment.

In the entire Municipality of Paraty, there are two other systems of potable water that receive treatment, and they are provided by private sectors for private developments. The first system, Condominio Laranjeiras, serves approximately 500 households in Laranjeiras and Vila Oratorio, and the other system, Vila Residencial da Eletronuclear, serves approximately 680 households in private developments in the Mambucaba area (Prefeitura, "Vigilancia," 2001). Both systems are described as conventional treatment with disinfection. The rest of the rural communities in Paraty consume water that is brought from various surface water sources in the mountains, and some groundwater sources.

***Potable Water Infrastructure***

The City of Paraty is supplied with disinfected water that is brought from two surface water sources, called Pedra Branca and Caboclo. The intake points of Pedra Branca and Caboclo are located in the mountains, approximately 7 km and 4 km west of the City, respectively. Pedra Branca withdraws water from Pereque River (Rio Pereque-Acu), which also flows through the City of Paraty further downstream, immediately before discharging into Paraty Bay (Baia Paraty).

Pedra Branca and Caboclo operate in a complementary system, in supplying water to the City of Paraty (See Figure 3.1). The water from Pedra Branca is disinfected with chlorine gas at the source and transported to a reservoir located next to the City of Paraty, where it is combined with the water from Caboclo that has not been chlorinated. The water is disinfected with chlorine gas at the reservoir, before it is distributed to the City of Paraty. The water is not filtered before disinfection. The complementary water supply system, Pedra Branca and Caboclo combined, supplies water to approximately 3,850 households in the City of Paraty as well as the rural areas near the intake points. The average water consumption in the City is approximately 180 L of water per capita per day, according to a report prepared by the Municipal City Hall of Paraty (Prefeitura, "Vigilancia," 2001).

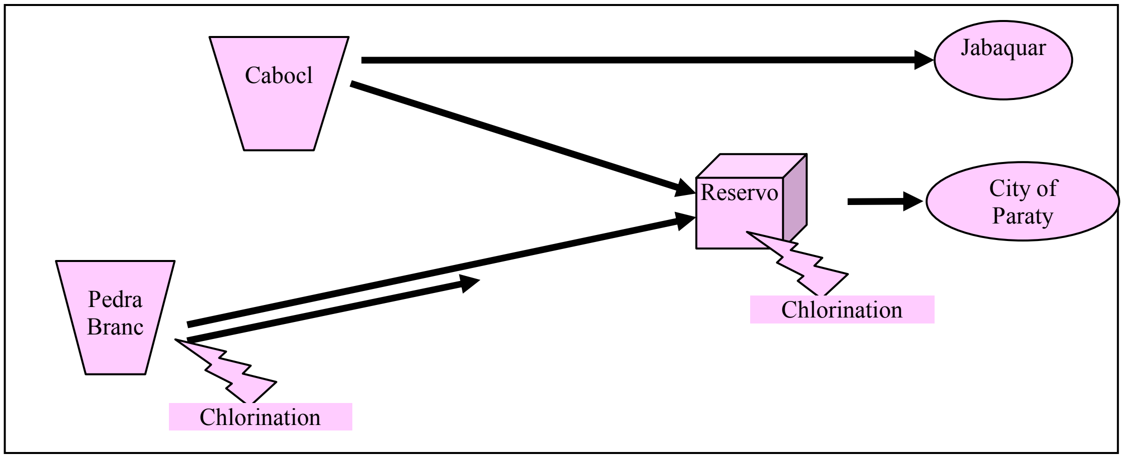


Figure 3.1. Schematic diagram of water supply system for the City of Paraty

Pedra Branca Intake

The water intake system at Pedra Branca, which withdraws water from Pereque River, consists of a concrete dam (W = 23 m, H = 2.1 m), a grit box (L = 6.4 m, W = 1.2 m, H = 2.9 m), also constructed in concrete, and 48 meters of 400 mm intake pipe that connects these two structures. The grit box, located below the dam, captures sand that is mixed with water, and the collected sand is removed from the grit box periodically. Water is disinfected with chlorine gas after it leaves the grit box, before it is taken to the city's reservoir by two 200 mm pipes. One of the two 200 mm pipes is iron pipe, constructed by CEDAE in 1975, and it stretches 6,000 meters from the grit chamber to the City's reservoir. However, the other 200 mm pipe, which is PVC pipe, extends only 3,000 meters and does not connect to the reservoir, although it was built by the City to serve as a duplicate of the iron pipe (Prefeitura, "Laudo," 2002).

Caboclo Intake

The water intake system at Caboclo consists of a concrete dam (W=5.3 m, H=1.1 m), a narrow concrete channel (L=17.9 m, W=1.2 m, H=0.8 m), and two stabilizing basins also in concrete, which act as grit boxes. A 150 mm iron pipe stretches 3,000 meters from Caboclo to Jabaquara, and a 150 mm PVC pipe transports water from Caboclo to the City's reservoir. The Caboclo intake system was constructed by the City of Paraty in 1999 (Prefeitura, "Laudo," 2002).

Reservoir

The City's reservoir, which receives chlorinated water from Pedra Branca and raw water from Caboclo, is located on a small hill, near the City of Paraty. The reservoir, built by the CEDAE in 1975, consists of two adjacent tanks, each with dimensions of L=16 m, W=11 m, and H=3.2 m. The total capacity of the reservoir is $10^6$ liters, with the hydraulic residence time of approximately 9 hours. The hydraulic residence time is estimated by assuming that the flow into and out of the reservoir is equal to the daily consumption of 0.7 million gallons, by the City of Paraty.

***System of Disinfection by Chlorination***

The disinfection of water by chlorination, at Pedra Branca and at the City's Reservoir, is performed in a crude, trial-and-error method. The City has no water meter at the reservoir to measure the flow into and out of the reservoir, which varies daily, and thus, no reliable method to determine the required chlorine dosage. In general, an administrator of chlorination adds approximately 200 grams of chlorine gas to the reservoir water each day, after adding an unknown amount of chlorine at the Pedra Branca intake (de Sigueira Baffo, 2003). The administrator adds as much as 400 grams of chlorine gas at the reservoir each day if no chlorine is added at Pedra Branca. The administrator does not measure chlorine demand in the reservoir water, but measures residual chlorine concentration in the City's tap water using a swimming pool kit, to adjust the subsequent day's chlorine dosage using this measurement. For example, if the residual chlorine concentration in the City's tap water were below the target concentration of 0.5 mg/l today, the administrator would increase the chlorine dosage tomorrow. The time lag of 1 day between the measurement and adjustment makes correct chlorine dosage difficult.

The residual chlorine in the City's tap water, measured by the administrator using a swimming pool kit, is approximately 2.5 mg/l on average. However, the residual chlorine concentration varies widely when it is measured with a more precise method. The residual chlorine measured with Hach standard methods, ranges from 0.0 mg/l to 1.5 mg/l. The recommended concentration of residual chlorine in drinking water is 0.5 mg/l for effective disinfection. The residual chlorine concentration in water is discussed further in Section 3.4.

## 3.4. Problems with Potable Water Supply

The potable water supply system for the City of Paraty has a number of problems that must be addressed. The most important problems are: (i) shortage of water supply in the summer; (ii) ineffective disinfection; (iii) inadequate protection of water sources; and (iv) substandard water quality.

***Supply Shortage***

The City experiences water shortage during summer time, when the City's population increases dramatically with tourists. The problem with water shortage has been prevalent in the past, although the situation has improved in the recent years. Despite the abundant amount of source water, which increases in the summer with frequent rainstorms, the supply often does not meet increased demand. It is estimated that the City's population increases manifold in the summer, as much as 3 to 10 times according to some local people. In the past, water shortage in summer was very frequent and some lasted as long as three days (Lemos Padua, 2003). In the more recent years, since the construction of duplicate water supply pipelines, from 1997 to 2000, the water shortage has become less frequent, but has not been eliminated.

Water shortages impose much inconvenience and distress to anyone who experience it. Therefore, water shortages, especially those that last long, have the capacity to generate enormous public discontent, and can affect the local people and tourists alike.

***Ineffective Disinfection***

The disinfection of City's potable water is as unreliable as the method of chlorine addition is imprecise. Due to inaccurate chlorine dosage, the drinking water is distributed with variable amounts of residual chlorine. The residual chlorine in the City's tap water is sometimes undetectable, according to laboratory measurements.

Ineffective disinfection is problematic, mainly because tests of fecal coliform bacteria show that the City's water source is contaminated with fecal matter. Pathogenic fecal coliform bacteria, E-Coli, which occurs naturally in the intestines and feces of most warm-blooded animals, including humans, is a direct result of fecal contamination when found in water, and a clear indication of unsafe water, whereas other types of coliform that are not fecal contamination related, including those commonly found in soil, on the surface of leaves, and in decaying matter, are not necessarily. Some common health effects of bacterial ingestion include abdominal cramps and diarrhea. E-Coli is transmitted through fecal-oral ingestion of the bacteria (i.e. drinking), primary contact recreation (i.e. swimming), or secondary contact (i.e. fishing). Hemorrhagic colitis (HC), is an acute disease caused by E-Coli, which results in severe abdominal cramps, watery diarrhea, and lower intestinal bleeding with occasional vomiting and fever (US Dept of Interior, "Total Coliform" 2001).

***Inadequate Protection of Water Sources***

The City's water sources, Pedra Branca and Caboclo, are not completely isolated from sources of fecal contamination, although they are located at high elevations, and do not have sewage discharged into them. Due to lack of physical barriers around the potable water intake structures, domestic animals, such as chickens and dogs, wander dangerously close to the source waters. In fact, it is highly likely that the fecal contamination of the City's water originates from domestic animals wading around the intake. Therefore, it is important to take measures to protect the City's water sources, by placing fences around the intake structures and the upstream waters, for example.

***Potable Water Quality***

The quality of City's potable water is heavily influenced by the quality of surface waters, from which it is derived, and thus is highly variable. As surface waters often do, the City's potable water quality often falls substandard due to high turbidity after rainstorms, and bacterial contamination. The following is the description and analysis of the City's potable water quality.

In order to characterize the quality of water that people drink in Paraty, and the seriousness of the water quality degradation of the source waters, samples of these waters were collected from numerous locations and tested. Some of the parameters measured are pH, turbidity, suspended solids, free chlorine (potable water only), chemical oxygen demand (ambient waters only), total coliform, and fecal coliform.

Sampling Locations

From January 10 to January 23, 2003, twenty-seven samples of potable water were collected from four locations in and near the City of Paraty. The first sampling location, "Caboclo" was an opening at the top of the city's reservoir, through which the raw water from Caboclo discharged into the reservoir from the end of a 3,000 m pipe. Eight samples of raw water from Caboclo were collected at this location. The second sampling location, "Pedra Branca" was a dam located at the Pedra Branca intake, where five samples of raw water from Pedra Branca were collected before the water was chlorinated. The third sampling location, "Reservoir" was a tap located adjacent to the reservoir, which combined and chlorinated the waters from Pedra Branca and Caboclo. The chlorinated reservoir water was sampled eight times at this location. Finally, the sampling location "Tap Water" was a tap located in the Historical Center of Paraty, supplied with chlorinated water from the reservoir. The tap water was sampled six times, during five times of which the pH, turbidity, suspended solids, and total and fecal coliform bacteria were measured. The free chlorine was measured for only four of the six samples.

Water Quality Parameters

The World Health Organization (WHO) specifies acceptable values of various drinking-water parameters that could be used to gauge the quality of a water sample (WHO, "Health criteria," 1998). Some of these parameters are listed in the following table:

| Parameter | Acceptable Level | Reason |
|---|---|---|
| PH | 6.5-8 | Low pH: corrosion high pH: taste, soapy feel, preferably <8.0 for effective disinfection with chlorine |
| Turbidity | <5 NTU | Appearance; median turbidity 1 NTU for acceptable terminal disinfection |
| Total coliform bacteria | None detectable | |
| Fecal coliform bacteria | None detectable | |
| Residual free chlorine | 0.5 mg/l | Effective disinfection |

Table 3.1. Criteria for acceptable drinking water quality

pH

The waters from all four locations had satisfactory pH, their median pH ranging from 6.6 to 7.0, as illustrated in the Figure 3.2. Although this range is acceptable, pH of tap water measured as low as 5.7, suggesting that the water is slightly acidic and likely to be corrosive. Although there is no health-based guideline proposed for pH, the optimum pH value suggested by the WHO is in the range 6.5-8. It has been shown that the pH should be less than 8 so that chlorination is effective, but greater than 6.5 to prevent corrosion of water mains and pipes in household water systems, which could lead to the contamination of water.

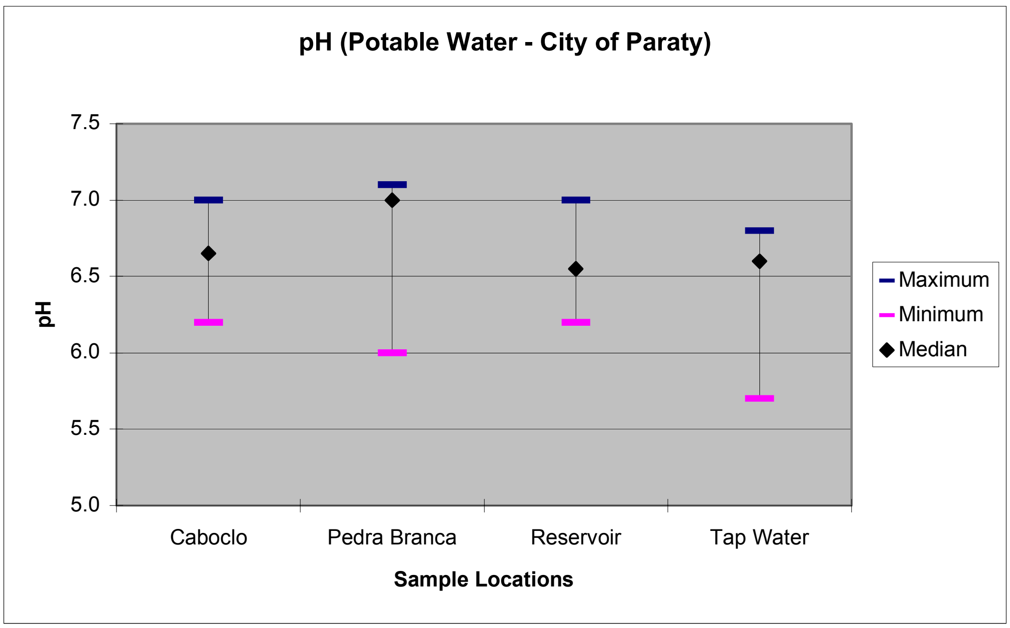


Figure 3.2. pH of the potable water in the City of Paraty

Turbidity

The turbidity of the waters, especially at the tap, was highly variable and unsatisfactory. Of the four sampling locations, only Caboclo had water with turbidity lower than 5 NTU (See Figure 3.3). Turbidity is a water quality that refers to the cloudy appearance of water that is caused by particles or suspended matter that can adsorb harmful contaminants. Although turbid water is not necessarily harmful, it can be an indicator of more serious problems. The turbidity of 5 NTU is the criteria to avoid filtration, and also the threshold of consumer disapproval (WHO, "Health criteria," 1998). With regard to effective disinfection, an even lower level of turbidity of 1 NTU is recommended. Therefore, needless of much discussion, it is clear that the waters in Paraty are unsuitable for safe drinking.

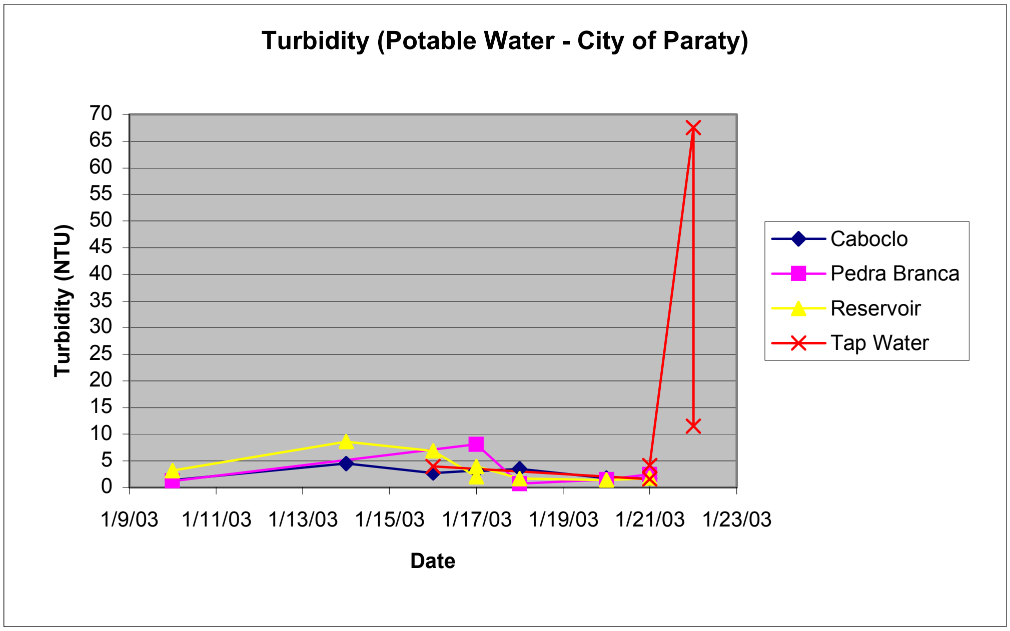


Figure 3.3. Turbidity of the potable water in the City of Paraty

<u>Residual Free Chlorine</u>

The concentration of residual free chlorine in tap water, also highly variable, was sometimes lower than 0.5 mg/l, which is the recommended concentration for effective disinfection (See Figure 3.4). Four samples of tap water were tested for the concentration of residual free chlorine. As illustrated in the Figure 3.4, on Jan. 22$^{nd}$, the residual free chlorine concentration was dangerously close to 0 mg/l.

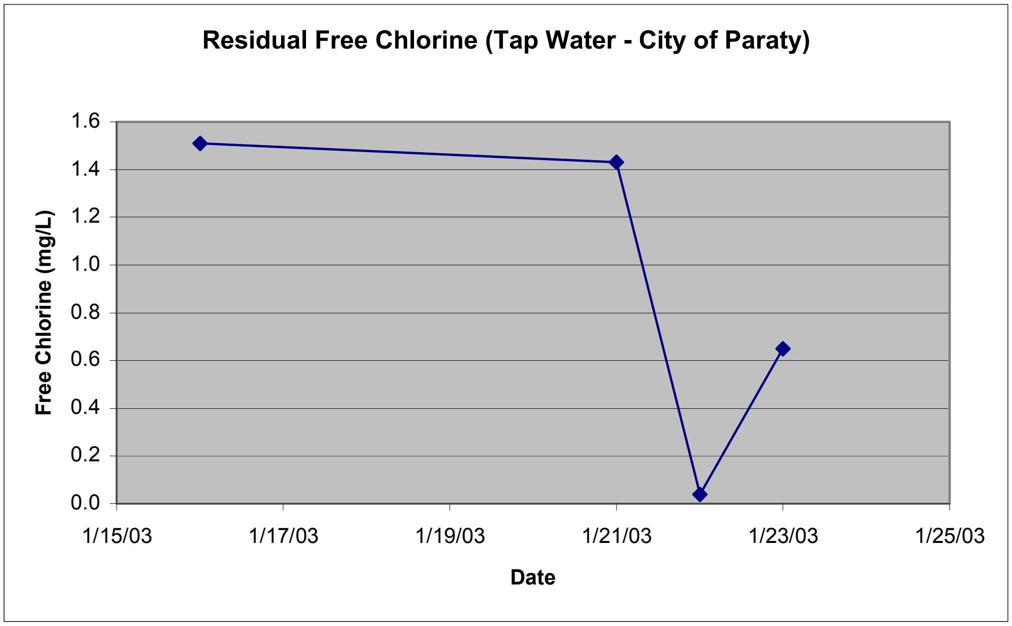


Figure 3.4. Residual free chlorine in the tap water in the City of Paraty

According to this data the sudden drop of the concentration of residual free chlorine corresponded to the sudden increase of turbidity in tap water, and the sudden jump of the concentrations of total coliform and fecal coliform were the consequences of this drop in the free chlorine concentration (See Figure 3.5). The turbidity of the tap water had values below 5 NTU until the January 22, when it suddenly rose to 68 NTU. (Unfortunately no samples were collected from other locations to enhance this data.) At the same time, the residual free chlorine in this sample dropped to an almost undetectable concentration of 0.04 mg/l. Accordingly on this day, the concentration of fecal coliform peaked at 420 colonies/100ml, and the total coliform at greater than 2,400 colonies/100ml.

There are two plausible causes for the sudden decrease of residual free chlorine concentration in the tap water. First, the sudden increase of suspended solids and organic particles in the water, following rainstorms, could have increased the chlorine demand in water, dramatically reducing the residual free chlorine and consequently causing the disinfection to be ineffective. Second, the chlorine addition could have been overdue at the reservoir. One thing is clear: the current method of chlorination, which fails to account for the inconsistencies in flow rate and chemical composition of the highly variable surface water, is ineffective and unreliable.

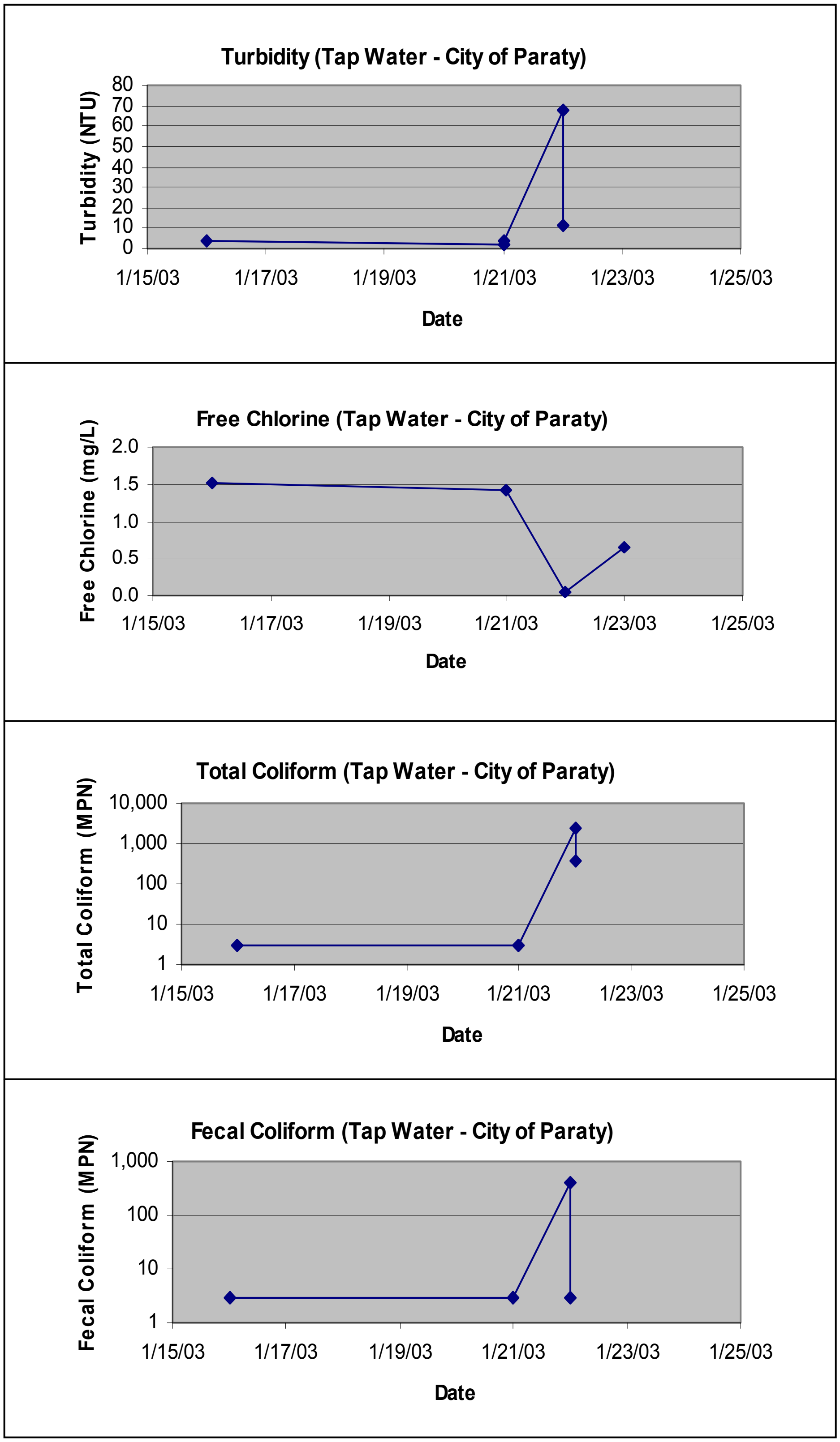


Figure 3.5. Correlation of turbidity, residual free chlorine, total and fecal coliform for the tap water in the City of Paraty

Total Coliform and Fecal Coliform Bacteria

The source water samples from Caboclo and Pedra Branca, had the total coliform concentration of approximately 2,400 colonies/100ml, or greater, and the fecal coliform concentration that was approximately 1/10 of the total coliform concentration (See Figure 3.6). It is clear from this data that the potable water sources are heavily contaminated and that they must be disinfected for safe ingestion. The international drinking water standards require that no fecal coliform bacteria be detectable in any 100 ml sample, for all water intended for drinking. In addition, there must not be any total coliform bacteria detectable in any 100 ml sample of treated water entering a distribution system. However, neither the reservoir water sample, collected immediately after disinfection, nor the tap water sample, collected at the end of the distribution system, complied with these standards. The reservoir water samples consistently had detectable concentrations of total coliform, as well as detectable concentration of fecal coliform on January 20. The tap water samples showed significant concentrations of total coliform and fecal coliform bacteria on January 22.

Summary

This water quality analysis not only asserts that City's present method of disinfection is ineffective, but also that filtration of drinking water before disinfection is necessary in order to remove suspended particulate matter, and the harmful pathogens adsorbed on those particles, from water. The turbidity in drinking water that rises as high as 68 NTU makes filtration obligatory. Chlorination, a method of disinfection that kills organic contaminants in water through the oxidizing ability of chlorine, is ineffective against hard-shelled cysts like those produced by Cryptosporitium, although it can effectively treat biological pathogens like coliform bacteria and lelegionella. Filtration, a method of disinfection, physically removes biological contaminants present in water. The benefits of drinking water filtration are extensive and include: (i) removal of suspended particulate matter; (ii) disinfection by the removal of harmful pathogens adsorbed on those particles; and (iii) reduction of disinfection by-products by the removal of natural organic matter, which are their precursors.

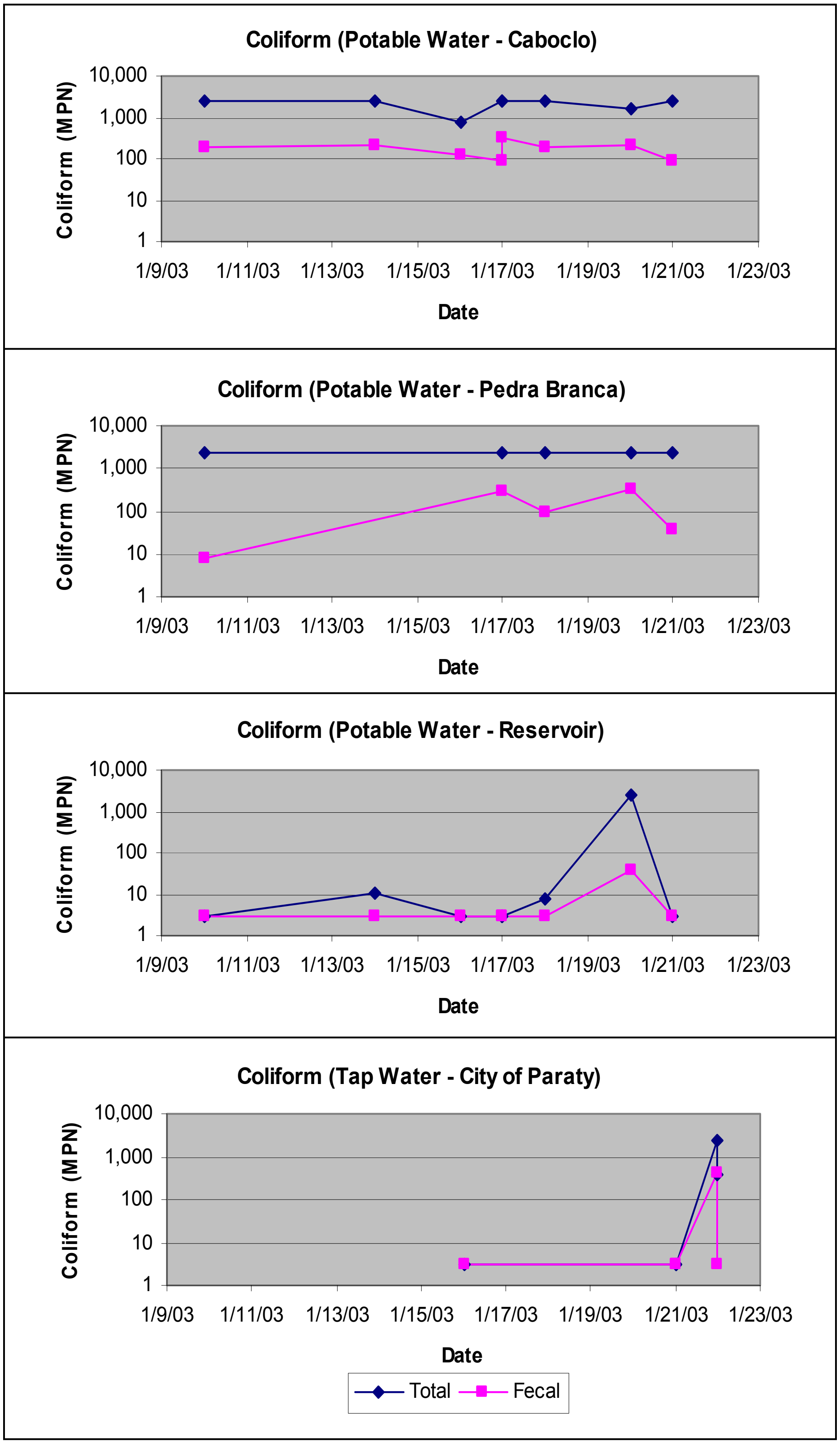


Figure 3.6. Total and fecal coliform in the potable water in the City of Paraty

Additional Sampling Locations in the Municipality of Paraty

The drinking water sources for numerous rural communities, in addition those for the City of Paraty, were sampled and tested for similar physical characteristics and microbial contamination. The communities, from where the drinking water sources were sampled, are: Agua Fria, Barra Grande, Corisco, Patrimonio, Sao Goncalo, Sao Roque, Taquari, Tarituba, and Trindade (See Figure 2.2).

The water quality of potable waters used in the rural communities was measured by the same standards used to gauge the potable water quality in the City. In general, the waters in the rural communities had pH within the 6.5-8.0 range, and turbidity less than 5 NTU (See Figure 3.7 and 3.8). By these parameters, the potable waters in the rural communities were superior to the water in the City. However, these waters had high concentrations of total coliform and fecal coliform bacteria, which made them unsafe to drink (See Figure 3.9 and 3.10). None of these waters were disinfected. The results of water quality analysis, for the city and the rural communities in the Municipality of Paraty, are summarized in Table 3.2:

| Community | No. of Households | Water Quality Parameters | | | | | Conclusion |
|---|---|---|---|---|---|---|---|
| | | Treatment | pH | Turbidity | Total Coliform | Fecal Coliform | |
| City of Paraty | 3850 | Chlorination | Low | High | Present | Present | Unsatisfactory |
| Agua Fria | | None | Normal | Normal | Present | Present | Unsatisfactory |
| Barra Grande | 226 | None | Normal | Normal | Present | Present | Unsatisfactory |
| Corisco | 200 | None | Normal | Normal | Present | Present | Unsatisfactory |
| Patrimonio | 125 | None | Normal | Normal | Present | Present | Unsatisfactory |
| Sao Goncalo | 100 | None | Normal | Normal | Present | Present | Unsatisfactory |
| Sao Roque | 250 | None | Normal | High | Present | Present | Unsatisfactory |
| Taquari | 300 | None | Normal | Normal | Present | Present | Unsatisfactory |
| Tarituba | 107 | None | Normal | Normal | Present | Present | Unsatisfactory |
| Trindade | 250 | None | Normal | Normal | Present | Present | Unsatisfactory |

Table 3.2. Drinking water quality results for the City and rural communities in the Municipality of Paraty

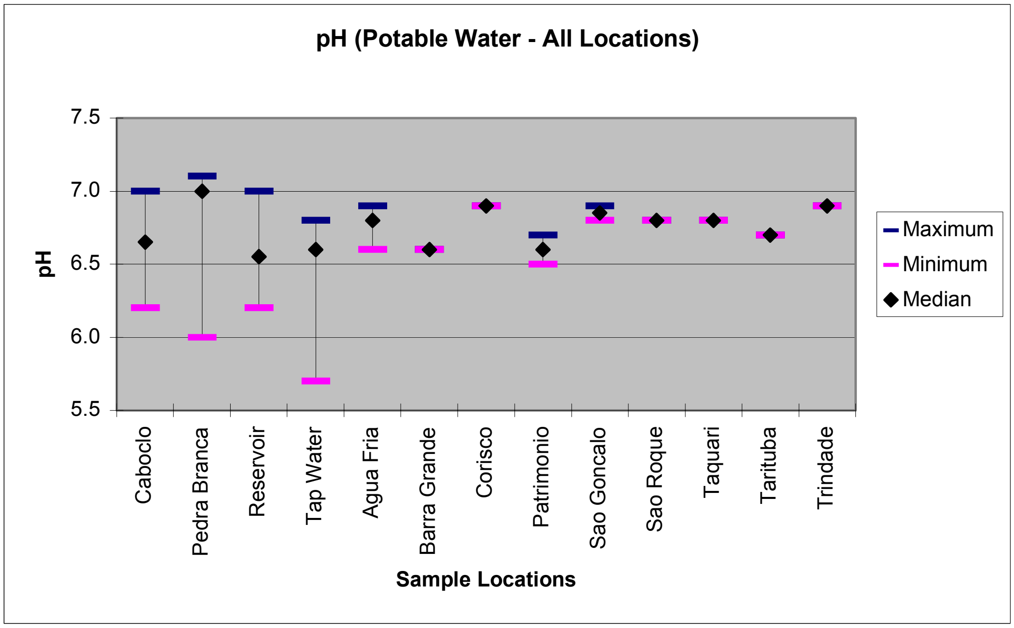


Figure 3.7. pH of potable waters in the Municipality of Paraty

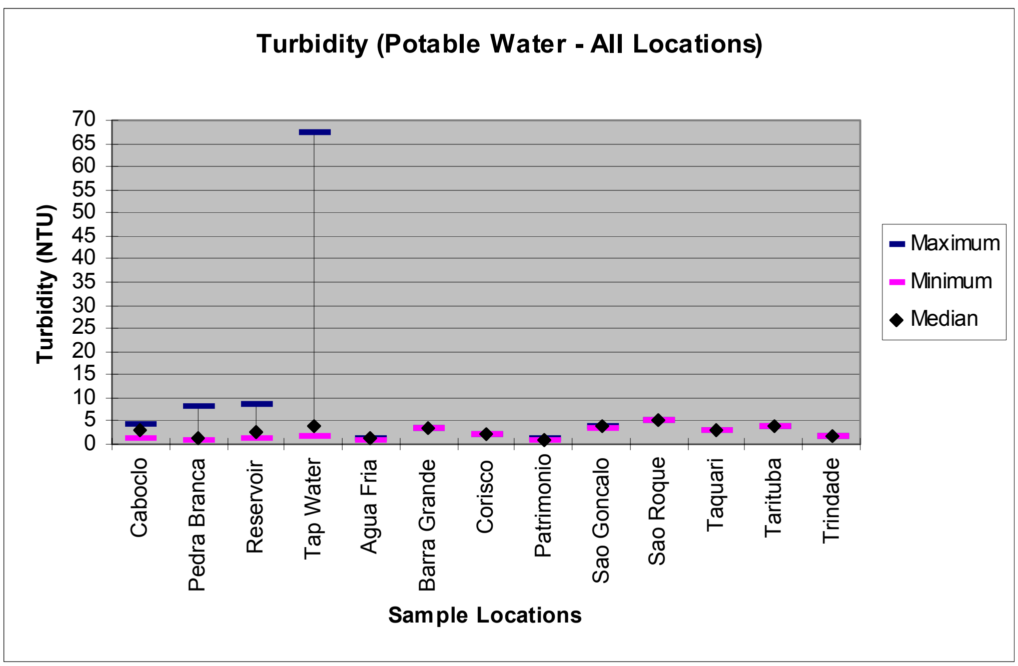


Figure 3.8. Turbidity of potable waters in the Municipality of Paraty

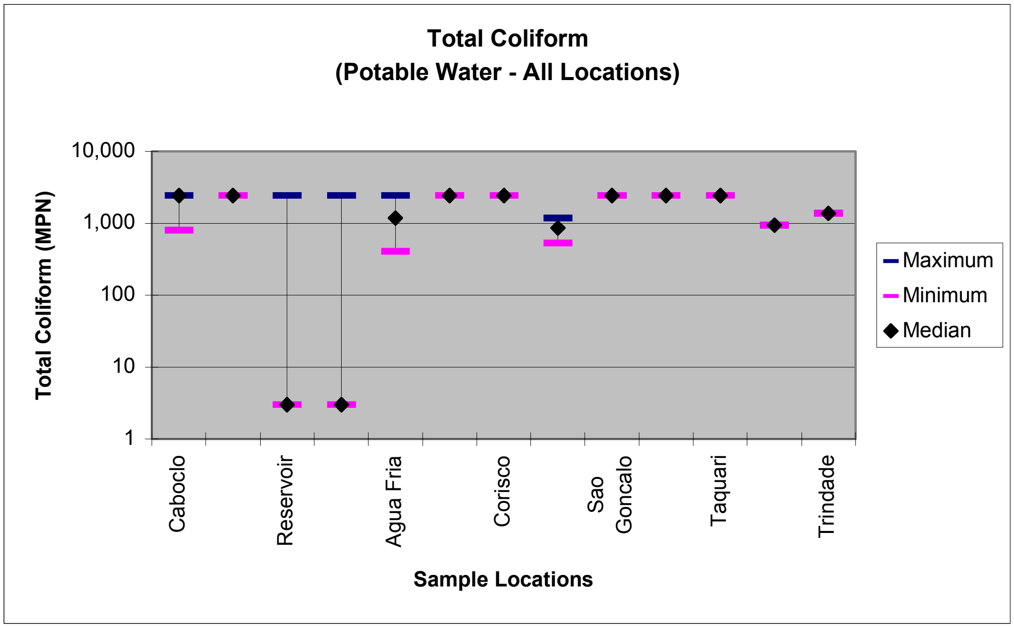


Figure 3.9. Total coliform of potable waters in the Municipality of Paraty

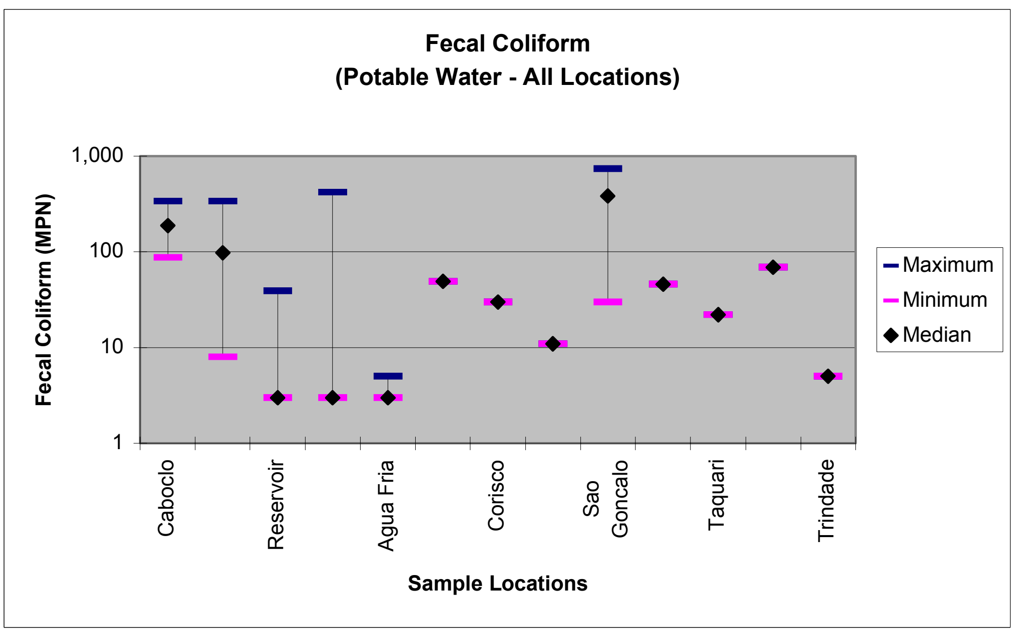


Figure 3.10. Fecal coliform of potable waters in the Municipality of Paraty

Other Water Quality Tests

The Municipality of Paraty determined, from a series of laboratory tests that were performed in the past, that many water sources violated the drinking water standards and were in fact unsafe to drink (See Appendix A-3). Between October 2001 and March 2002, 44 samples of potable water were collected from various locations within the Municipality of Paraty. Three physical characteristics (turbidity, color, and odor), and the tests of total and fecal coliform bacteria were used to determine the quality of the water samples. Of the 44 samples, only 22 samples (17 from the City of Paraty, 3 from Pantanal, and 2 from Ponte Branca) had been chlorinated.

Of the 44 samples, 28 samples (64%) were determined to be of unsatisfactory quality by at least one of these parameters. Ten samples (23%) had high concentration of particulate matter; 1 sample (2%) had yellow color. No sample had any detectable odor. Twenty-five samples (57%) had total coliform bacteria, and 20 of these samples were contaminated with fecal coliform bacteria. The presence of total coliform bacteria, with 89% occurrence, was the principal cause for unsatisfactory water quality.

Of the 28 samples that had unsatisfactory water quality, 6 samples (21%) had been chlorinated for disinfection. Four out of the 6 chlorinated samples were declared unsatisfactory due to the presence of detectable amounts of coliform bacteria, revealing that the disinfection was not effective. Two samples from the City of Paraty had both total and fecal coliform bacteria present, and two had only total coliform present. Two more chlorinated water samples (collected from Pantanal and Ponte Branca) had no coliform bacteria, suggesting that the chlorination had been effective, but were declared unsatisfactory due to the high concentration of suspended solids.

Although 100% of potable water in the City of Paraty was chlorinated, 4 out of the 17 samples collected in the City (24%) were declared unsatisfactory, due to microbial contamination as well as high concentration of suspended solids.

***Conclusion***

Numerous water quality analyses reveal that many rural communities in the Municipality of Paraty, as well as the City of Paraty, consume drinking water that fails to comply with international drinking water regulations. Two principal causes of substandard water quality are high turbidity and bacterial contamination. The rural communities, which currently do not treat their drinking water, must disinfect their drinking water at the least, with chlorine addition for example.

The City of Paraty must adopt various measures to improve the quality of its drinking water. In addition to procuring a sufficient supply of drinking water to meet demand at all times, the City must better protect its drinking water at the sources, and treat the water by filtration and disinfection. The drinking water must be filtered in order to reduce the turbidity in water, which frequently rises to unacceptable levels after rainstorms, and a more precise method of chlorination must be adopted in order to make disinfection of drinking water more effective.

## 3.5. Existing Wastewater Disposal System

Reflecting the City's preference of drinking water system to drinking water system, Paraty has a very low percentage (12%) of connection to public sewer system, which lacks sewage treatment. As a consequence, large quantities of untreated sewage is discharged into two rivers, Pereque-Acu and Matheus-Nunez, that pass through the City; Jabaquara beach, a popular spot for swimming that is situated North of the City within walking-distance; and Paraty Bay. It is estimated that approximately 2,600 $m^3$ of wastewater is discharged into these water bodies on average, and as much as 7,900 $m^3$ of is discharged in the highly populated summer season.

***Wastewater Infrastructure***

The City has short networks of sewerage pipe connections, which are mainly used to transport sewage from individual households into the nearest receiving water body. The sewerage network is incomplete and run-down, and its exact structure and location is unknown, due to the misplacement of the plans containing such information.

The incomplete, and often broken, sewerage pipes lead to an additional problem of polluting the streets with wastewater in the high tides. As the City sits at a low altitude, near sea level, with a high water table, large parts of the Historical Center is flooded with seawater periodically during high tidal periods. During these times, wastewater leaks out of broken sewerage pipes and floods the streets mixed with seawater, before it can discharge into the Bay with reversing tides.

***Storm water Infrastructure***

While the City has some wastewater collection infrastructure, it has no storm water infrastructure. The streets in the City are lined with cobblestones, in shapes of a canal, in V or U-shapes. In congruence with this design, the storm water drains into the Bay naturally by gravity.

## 3.6. Problems with Wastewater Disposal

The two major problems associated with Paraty's current mode of wastewater disposal are: (i) environmental degradation resulting from direct discharge of sewage into surrounding water bodies, and from tidal inflows that flood the streets with sewage and seawater mixture; and (ii) health consequences resulting from exposure to such environment. The latter will be discussed in Section 3.7.

***Environmental Degradation***

The pollution of surface water bodies, such as rivers and beaches, due to untreated sewage, result in increased health risks, loss of aesthetics and other amenities, and violation of their intrinsic values. For those water bodies intended for recreational use, the health risks are very high when they are polluted with fecal matter. Many environmental regulatory agencies limit the amount of fecal contamination allowed in recreational water bodies for this reason. For example, the maximum concentration of fecal coliform bacteria in beach waters, where people swim, is 200 colonies/100ml, and those waters exceeding this limit are required to prohibit these recrational activities. Therefore, the environmental degradation results in limited recreational activities and diminished commercial value of the water body.

The loss of aesthetics, due to the discoloration of water and the odor, which becomes more unpleasant in the summer, also contribute to the diminishment of water body's commercial value. The damage to aesthetics also reduces the amenities value and intrinsic value of the water body.

The environmental degradation not only occurs in the water bodies, due to direct discharge of wastewater, but also in the streets due to the tidal flows that flood the streets with sea water and sewage mixture. Similar costs apply to this mode of environmental degradation.

### *Quality of Surrounding Water Bodies*

Surface water bodies near the City of Paraty are heavily polluted from human activities. In order to characterize the quality of these surface water bodies, samples were collected from numerous locations and tested. The following is the description and analysis of the surrounding surface water bodies in the City.

#### Sampling Locations

Water samples were collected from Jabaquara Beach, Matheus-Nunez River, and Pereque-Acu River (referred as "Jabaquara Beach," "Matheus River," and "Pereque River," respectively), and tested. Samples were also collected from an open ditch (designated "Sewer Stream") that carries raw sewage through Mangueira and discharges into the Paraty Bay. Jabaquara Beach water was sampled 11 times, at the knee level near the most populated places. Matheus River, Pereque River, and Sewer Stream waters were sampled 7, 9, and 4 times, respectively. The Matheus River water was sampled at the riverbank, near small boats. The Pereque River water was sampled from a bridge, at the center of the river's cross-section. The Sewer Stream water was sampled similarly at the middle of the cross-section, from a walkway crossing the ditch.

#### Water Quality Parameters

The water quality parameters tested are pH, turbidity, suspended solids, chemical oxygen demand (COD), total coliform, and fecal coliform bacteria concentrations. The water quality measurements for Jabaquara Beach samples are compared against surface water criteria for coastal waters designated for aquatic life, recreation, navigation, and industrial water supply (See Table 3.3). Similarly, the water quality measurements for Pereque River and Matheus River samples are compared against surface water criteria for waters designated for aquatic life, recreation, navigation, and industrial and agricultural water supply (See Table 3.4). The Sewer Stream samples, on the other hand, are compared to the raw sewage sampled in the City of Paraty (See Table 3.5).

| Beach | |
|---|---|
| | **Coastal water standards, EPA Connecticut** |
| **Designated Use** | Habitat for marine fish and other aquatic life and wildlife; shell fish harvesting; recreation; navigation; and industrial water supply |
| **pH** | 6.8-8.5 |
| **Turbidity (NTU)** | None other than of natural origin |
| **Total suspended solids (mg/l)** | None other than of natural origin |
| **Fecal coliform bacteria (colonies/100 ml)** | Geometric mean of 200/100 ml for summer primary contact recreation |

Table 3.3. Beach water quality criteria

| River | | | |
|---|---|---|---|
| | **Interim national river water quality standards, Malaysia** | **Water quality constituents and standards, EPA Kansas** | **Surface water standards, EPA Connecticut** |
| **Designated Use** | Aquatic life; recreation | Aquatic life; recreation | Habitat for fish and other aquatic life and wildlife; recreation; navigation; and industrial and agricultural water supply |
| **pH** | 6.0-9.0 | 6.5-8.5 | 6.5-8.0 |
| **Turbidity (NTU)** | 50 | 9.9 | <5 NTU over ambient conditions |
| **Total suspended solids (mg/l)** | 50 | | <10 mg/l over ambient conditions |
| **COD (mg/l)** | 25 | | |
| **Total coliform bacteria (colonies/100ml)** | 5,000 | | |
| **Fecal coliform bacteria (colonies/100ml)** | 100 | Geometric mean of 200/100 ml for summer primary contact recreation; 2000/100 ml for winter primary contact recreation or secondary contact recreation | |

Table 3.4. River water quality criteria

| Raw Sewage | |
|---|---|
| **pH** | 6.8 |
| **Turbidity (NTU)** | 128 |
| **Suspended solids (mg/l)** | 117 |
| **COD (mg/l)** | 412 |
| **Total coliform bacteria (colonies/100ml)** | 3,280,000 |
| **Fecal coliform bacteria (colonies/100ml)** | 460,000 |

Table 3.5. Quality of raw wastewater in the City of Paraty (Kfouri and Kweon)

pH

All four water samples had pH near 7 (See Figure 3.11). The samples from Jabaquara Beach and Pereque River fluctuated significantly from 6 to 8, while the samples from Matheus River and Sewer Stream stayed within the much narrower range of 6.5 to 7.4. The acceptable range of pH for beach waters is 6.8-8.5, and the pH of the water samples from Jabaquara Beach was at the lower end of this range. The more strict range of pH for the surface waters is 6.5-8.0. The samples from Matheus River and Sewer Stream were safely within this range, while the samples from Pereque River were at the lower end of this range.

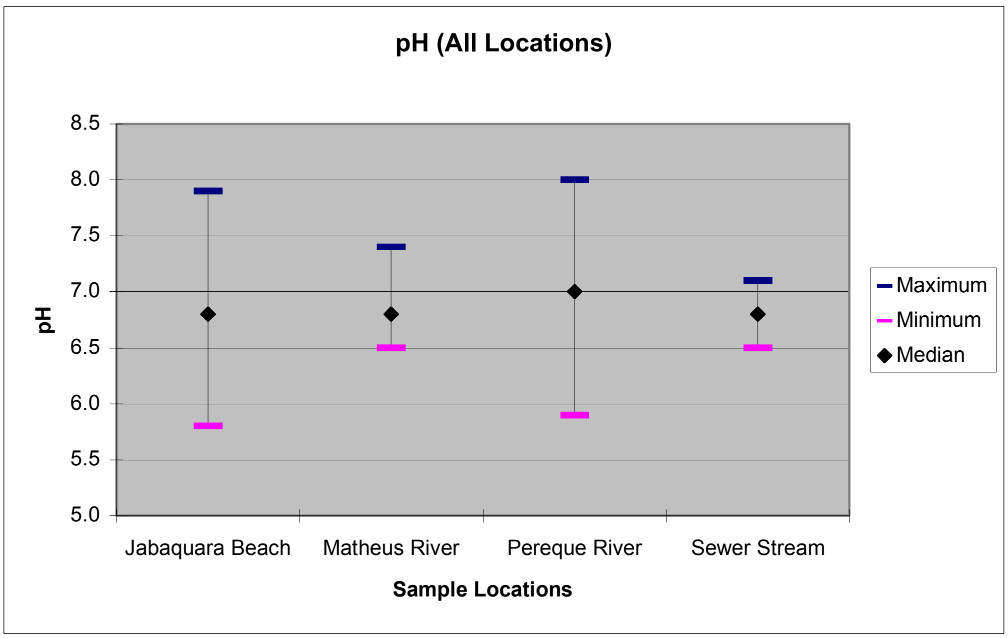


Figure 3.11. pH of the surrounding water bodies

Turbidity

The turbidity of the waters from Jabaquara Beach, Matheus River, and Pereque River were safely below 50 NTU (See Figure 3.12). The median turbidity was approximately 20 NTU for Jabaquara Beach, and approximately 10 NTU for Matheus River and Pereque River. The acceptable level of turbidity for safe aquatic life and recreation is approximately 10 NTU (State of Kansas). The median turbidity for the two rivers suggests that they are often, but not always, acceptable for safe aquatic life and recreation. The turbidity of Sewer Stream ranged from 30 NTU to 90 NTU, with the median of 41 NTU. The Sewer Stream had turbidity that is much higher than those of the rivers or the beach, but smaller than the turbidity of the raw sewage, which was 128 NTU.

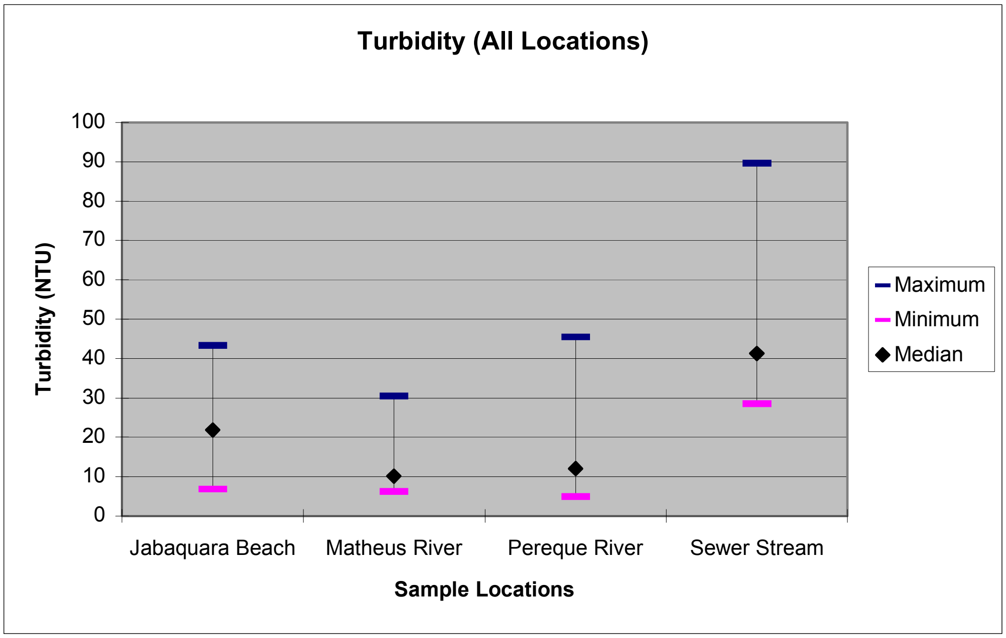


Figure 3.12. Turbidity of the surrounding water bodies

Suspended Solids

Similar observations were made with the analysis of suspended solids in the water. The amounts of suspended solids in the water samples from Jabaquara Beach, Matheus River, and Pereque River ranged from 5 mg/l to 40 mg/l, with the median of approximately 20 mg/l. This level of suspended solids in water is acceptable for all aquatic life and recreational activities under Malaysian standards. The US EPA standards are more stringent and require that the suspended solids do not exceed 10 mg/l over the ambient condition. If the upstream river waters, Caboclo and Pedra Branca, which are also potable water sources, represent the "ambient condition," the ambient suspended solids concentration is approximately 5 mg/l, and could be as high as 10 mg/l. Therefore the median concentration of suspended solids in the surface waters must not exceed 15 mg/l, and the maximum concentration of suspended solids must not exceed 20 mg/l. According to these standards, Jabaquara Beach, Matheus River, and Pereque River water quality are unsatisfactory, with their single sample maximums of 42 mg/l, 29 mg/l and 38 mg/l. The Sewer Stream showed levels of suspended solids that are unacceptable for aquatic recreation, indicating heavy contamination from domestic sewer discharge (See Figure 3.13). The raw sewage had approximately 120 mg/l of suspended solids, and the samples of Sewer Stream had approximately 56 mg/l of suspended solids, that could be as high as 102 mg/l.


Figure 3.13. Suspended solids of the surrounding water bodies

As the similar values of turbidity and suspended solids suggest, there is a strong correlation between turbidity and suspended solids (See Figure 3.14 and 3.15). The correlation can be explained by the fact that both turbidity and suspended solids were measured using photometric method, which measures the amount of light scattered by the impurities present in water.

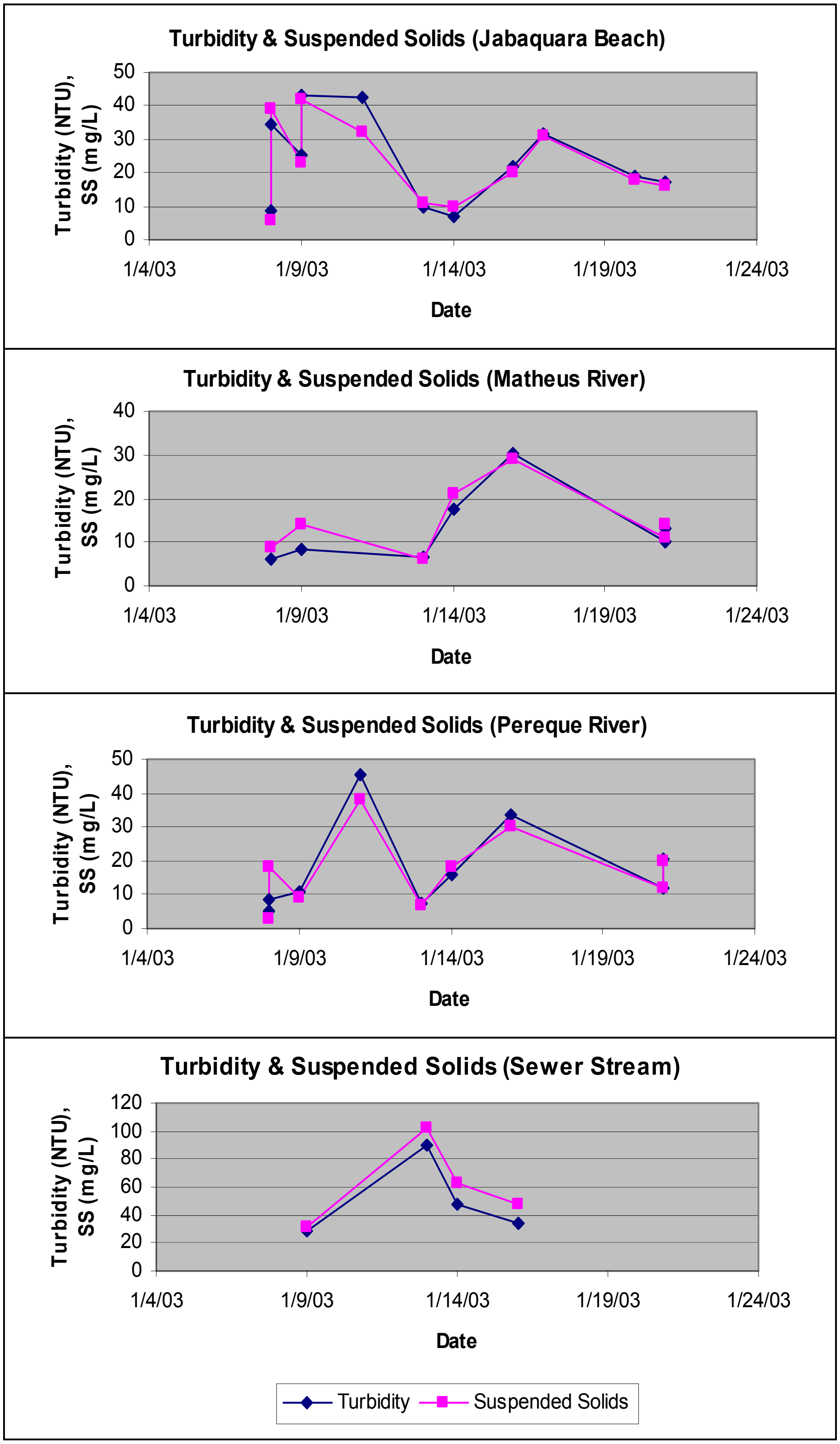


Figure 3.14. Correlation of turbidity and suspended solids

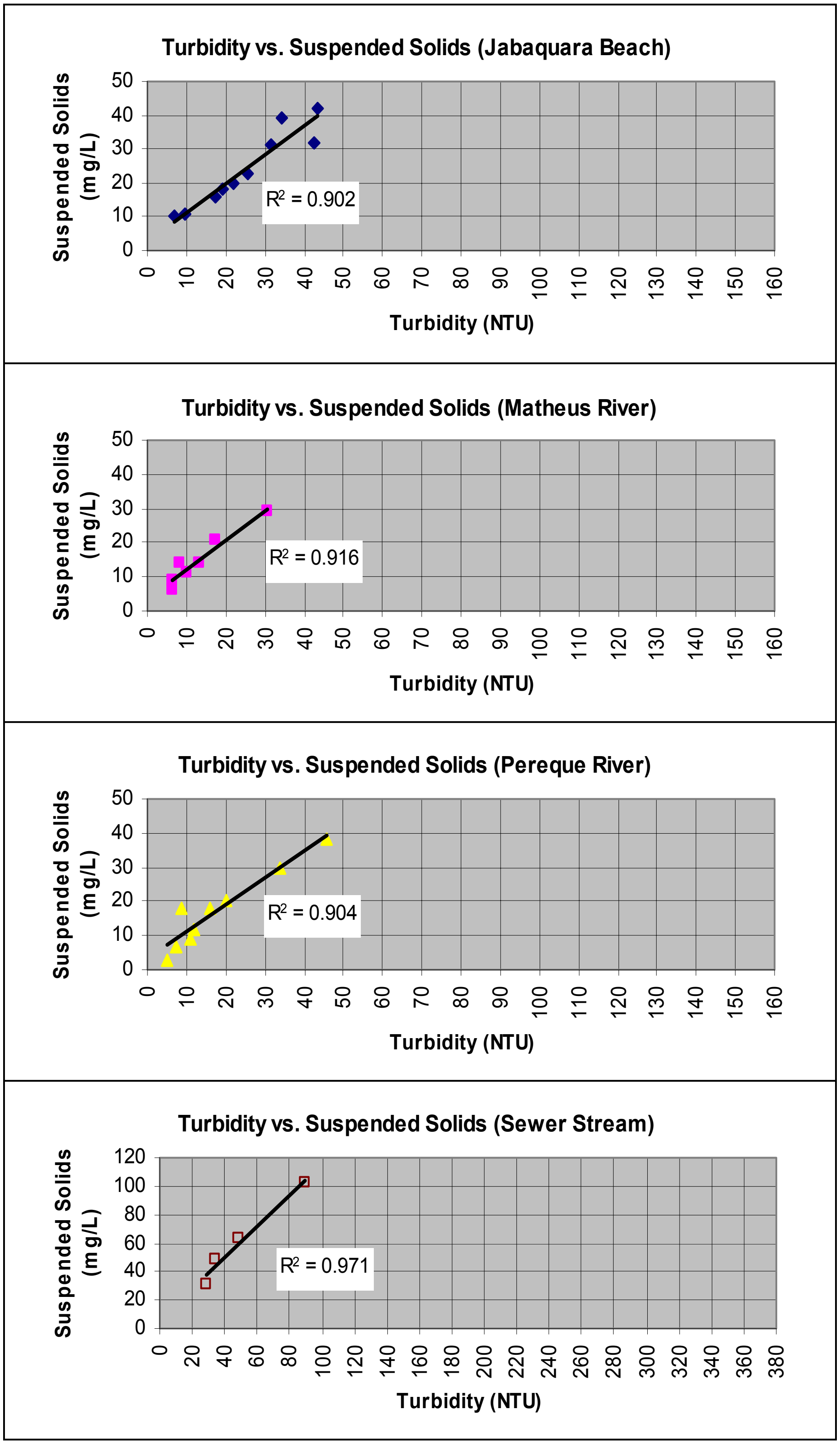


Figure 3.15. Correlation of turbidity and suspended solids

COD

All water samples had unacceptable levels of chemical oxygen demand (COD). According to the Malaysian river water quality standards, maximum COD level for aquatic life and recreational activities is 25 mg/l. However, the median COD concentrations in water samples from Jabaquara Beach, Matheus River, Pereque River, and Sewer Stream are 120 mg/l, 85 mg/l, 21 mg/l, and 280 mg/l, respectively (See Figure 3.16). The maximum COD level in Matheus River is as high as 800 mg/l, most likely due to oil spills from small boats anchored at the riverbank. Although the median COD level in Pereque River is less than 25 mg/l, its maximum COD level is as high as 230 mg/l. The COD level in Sewer Stream is a bit lower than that of raw sewage, which is approximately 400 mg/l. The US EPA does not list maximum COD level acceptable for aquatic life because the dissolved oxygen (DO) is deemed more applicable.

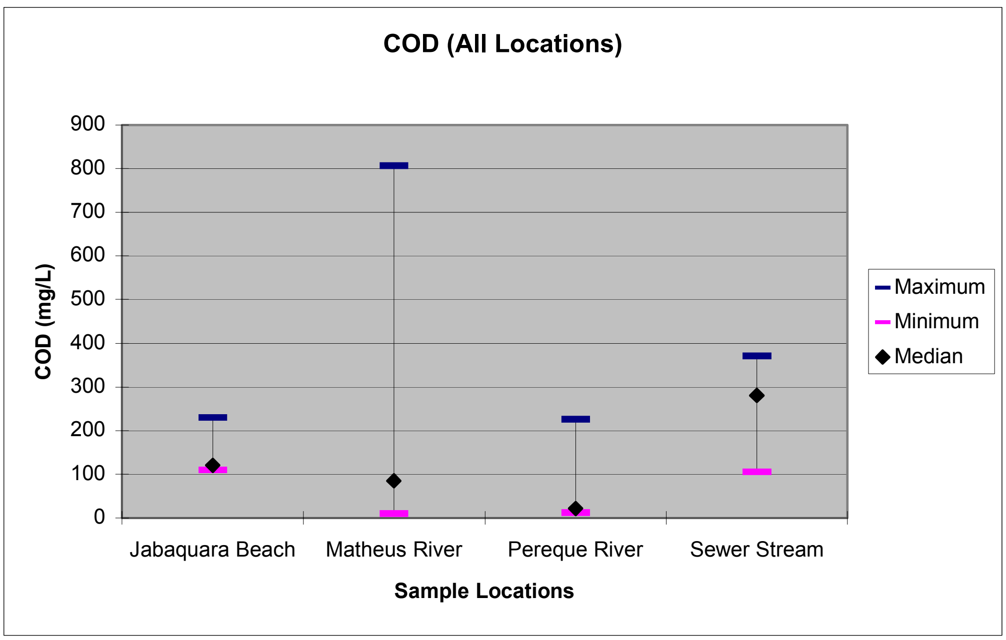


Figure 3.16. COD of the surrounding water bodies

Fecal Coliform bacteria

The concentration of fecal coliform bacteria is an important water quality parameter in determining the feasibility of the intended uses of the water bodies, especially for those water bodies intended for primary contact recreation. Primary contact recreation is defined as when the body is immersed in surface water to the extent that some inadvertent ingestion of water is probable such as boating or swimming. Secondary contact recreation is defined as recreation where ingestion of the surface water is not probable such as wading, fishing, or hunting (KDHE, 2001). A geometric mean of 200 colonies/100ml of fecal coliform is acceptable for waters intended for summer primary contact recreation, and 2,000 colonies/100ml for winter primary contact recreation and secondary contact recreation. Jabaquara Beach, which is intended for summer primary contact recreation, has median fecal coliform concentration of 160 colonies/100ml, and maximum of 600 colonies/100ml. Therefore Jabaquara Beach is not adequate for primary contact recreation (See Figure 3.17). Pereque River and Matheus River have median fecal coliform concentration of 36,000 colonies/100ml and 6,300 colonies/100ml, respectively, reflecting heavy fecal contamination caused by direct discharge of domestic sewage into these rivers. Neither river is adequate for secondary contact recreation. The sewer stream has fecal coliform concentration of 1,600,000 colonies/100ml, which is typical of raw sewage. Unsurprisingly, all waters exceed the maximum total coliform concentration of 5,000 colonies/100 ml is allowed in surface waters (See Figure 3.18).

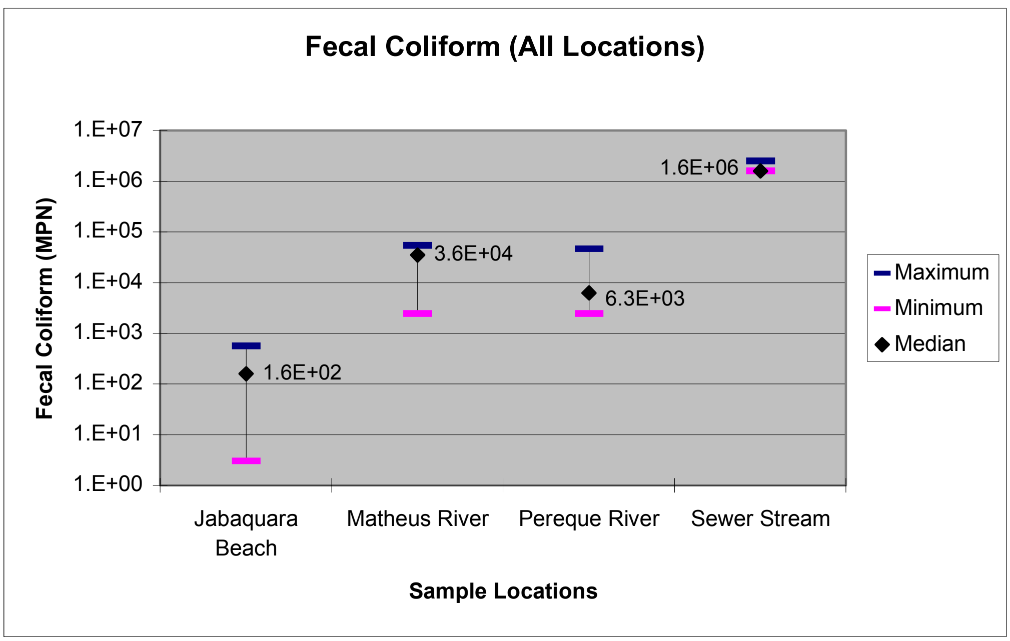

Figure 3.17. Fecal coliform of the surrounding water bodies

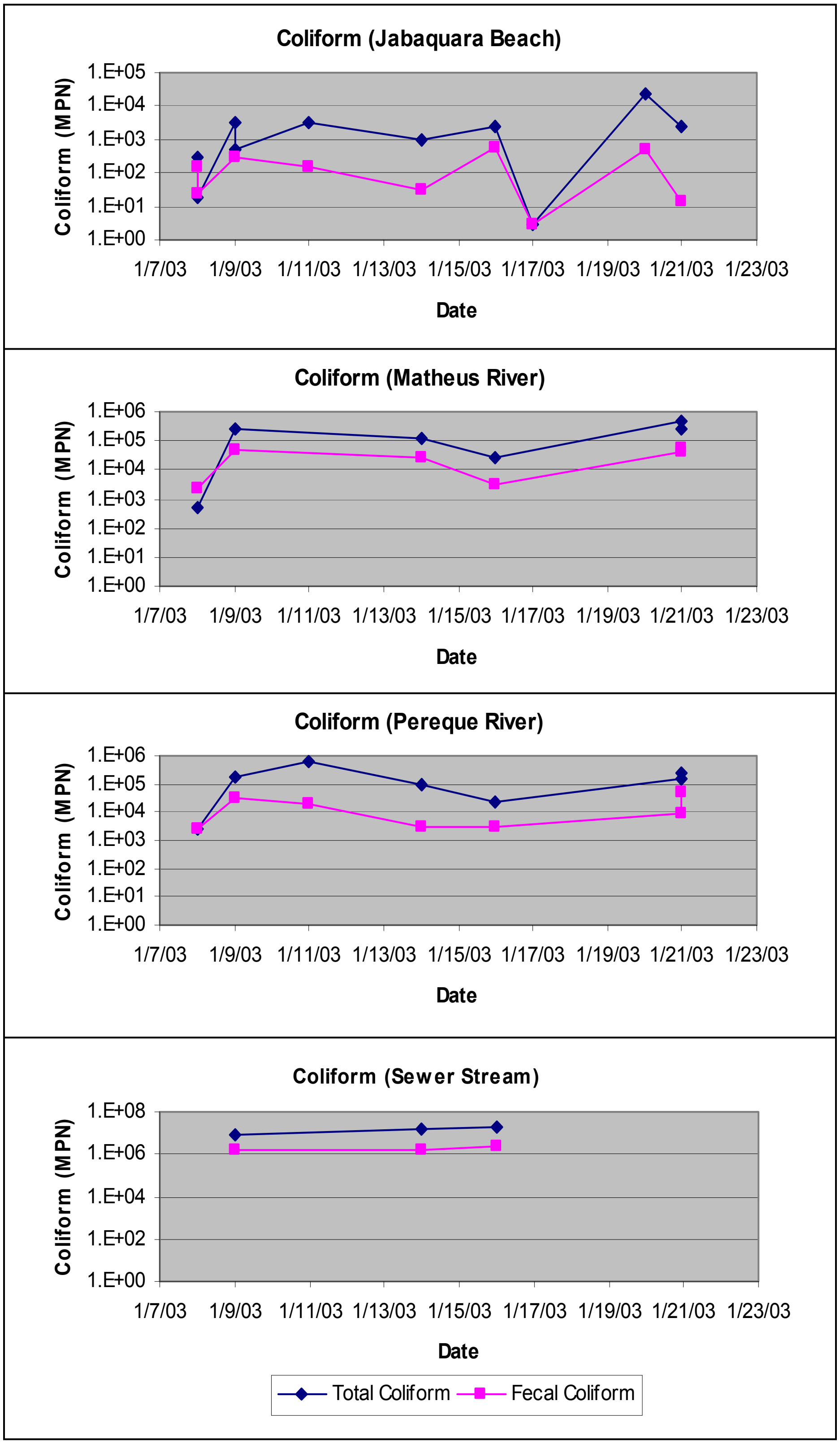


Figure 3.18. Total coliform of the surrounding water bodies

Summary

All four surface water bodies show fecal coliform concentrations that suggest contamination from sewer discharge. Among the four, Jabaquara Beach shows the least amount of contamination, most likely benefited by tidal dilution. Matheus River and Pereque River are approximately equally contaminated, and Sewer Stream shows characteristics of diluted raw sewage.

Jabaquara Beach, a popular recreational water body where people swim, that is within walking distance from the City of Paraty, is inadequate for primary recreation, which includes swimming. Jabaquara Beach water has a slightly low pH, adequate levels of turbidity and suspended solids, and high COD.

Neither Matheus Rivers nor Pereque River is adequate for secondary recreation, due to high levels of fecal contamination. Matheus River showed acceptable pH, but especially high COD level that is most likely due to oil spills from small boats anchored at the riverbank. Pereque River had pH that is in the lower end of the acceptable range, and low COD that is within acceptable range most of the time. The turbidity and suspended solids for both Rivers suggest that they are often, but not always, in the safe range for aquatic life.

### ***Conclusion***

From the water quality analysis above, it is evident that the City's current mode of wastewater disposal degrades its surface waters, rendering Jabaquara Beach unsafe for swimming, and Matheus River and Pereque River unsafe for all aquatic sports. The uncontrolled disposal of wastewater damages the aesthetics of the rivers, and reduces the commercial value of the environment. The source of pollution must be controlled in order to preserve the environment from further degradation, and therefore an appropriate treatment and discharge of the City's wastewater is critical. The collection and treatment of wastewater is expected to limit pollution of the surface waters, as well as the streets, in the City of Paraty.

## 3.7. Problems with Public Health - Diarrhea

A direct consequence of poor potable water quality and polluted environment is the negative impact on public health. Of many different diseases and illnesses, diarrhea is the most widely studied public health problem that is associated with poor water and sanitation.

### *Incidence*

A total of 443 diarrhea cases were recorded at local hospital and health clinics in the Municipality of Paraty, from Sept. 1, 2002 to Dec. 28, 2002, according to an epidemiological study conducted by Wilsa Mary S. Barreto (Barreto, 2003). Of these 443 cases, 228 cases (51%) were of those individuals living in the City of Paraty, 204 cases (46%) of individuals living in the rural areas, and 11 cases (2%) of individuals from outside. Among the 228 people from the City of Paraty, 60% were from Mangueira and Ilha das Cobras, the poorer parts of the City.

| Area | Population | Number of diarrhea cases | | | Probability of diarrhea incidence per person |
|---|---|---|---|---|---|
| | | | In 4 months | In 1 year | |
| Urban | 1,5000 | 51% | 228 | 680 | 4.6% |
| *Mangueira and Ilha das Cobras* | *7,500* | *60%* | *137* | *410* | *5.5%* |
| *Other* | *7,500* | *40%* | *91* | *270* | *3.6%* |
| Rural | 1,5000 | 46% | 204 | 610 | 4.1% |
| Other | | 2% | 11 | 30 | |
| **Municipality Total** | **30,000** | **100%** | **443** | **1,300** | **4.4%** |

Table 3.6. Number of diarrhea cases within Municipality of Paraty by location[1]

Approximately 111 diarrhea cases are treated in the health clinics each month, and approximately 1,330 cases are treated each year, if the incidence of diarrhea is assumed constant throughout the year. Furthermore, each person in the Municipality of Paraty has greater than 4% probability of suffering from diarrhea each year, if each person is assumed to suffer from diarrhea not more than once a year. The probability is greatest for the urban poor, those living in Mangueira and Ilha das Cobras, who have greater than 5% likelihood of suffering from diarrhea in a year.

[1] Number of diarrhea cases, which were registered at local hospital and health clinics between September 1, 2002 and December 28, 2002.

More importantly, the number of diarrhea cases reported above does not account for all diarrhea cases in Paraty, but only those that received care at the local hospital and health clinics. The actual number of diarrhea cases is expected to be much higher, because many people treat their illnesses at home.

It is expected that the poor and the rural population are less likely to visit health clinics, due to lack of time and money. Even though basic health services are provided free of charge in Paraty, the time required to go to health clinics can be costly. This cost of time is especially significant for the poor and those living in rural areas, farther away from the health clinics. Therefore, the numbers of diarrhea cases in the poorer areas (Mangueira and Ilha das Cobras), and the rural areas are likely to be much higher than the numbers reported.

The higher proportion of diarrhea cases in the City than in the rural areas suggests that: (i) the disinfection of City's drinking water is often ineffective; (ii) adequate sanitation is as important as, if not more than, clean drinking water supply. Although the common sense expects the number of diarrhea cases to be lower for the urban population, which drinks disinfected drinking water, than for the rural population, which does not, the study indicates that this is not so. In fact, the incidence of diarrhea for the urban population is higher at 4.6% than the 4.1% for the rural population. It is likely that the disinfection of City's drinking water with chlorine addition is ineffective and therefore does not benefit the urban population. The test of residual chlorine concentration in City's drinking water, which indicated zero residual chlorine concentration, reinforces this speculation.

It is also likely that environmental pollution, which is more serious in the City than the in rural areas, accounts for larger number of diarrhea cases in the urban population. The City, occupied by half of the Municipality's population, discharges large quantities of untreated sewage everyday, severely polluting its waters. In contrast, the rural areas have smaller population density, and their sewage disposal is likely to be in better control. Therefore, the more polluted environment in the City could account for its higher diarrhea incidence, suggesting furthermore that adequate sanitation is as important as the supply of clean drinking water.

### *Morbidity*

As much as 9% of diarrhea cases studied were serious, with two or more signs of serious dehydration, which can be life-threatening without proper and timely treatment. Approximately 7% of diarrhea cases showed two or more signs of dehydration that were less serious, and 57% of the cases were mild with no sign of dehydration. The seriousness of these diarrhea cases was determined from the types of medical treatment (i.e. "Plans") received by the patients. The age distribution of the patients was not studied.

| | Plan A | Plan B | Plan C | Plan Ign. | Sum |
|---|---|---|---|---|---|
| Total Number of Cases (by Plan Type) = | 254 | 31 | 41 | 117 | 443 |
| Percent of Cases (by Plan Type) = | 57% | 7% | 9% | 26% | 100% |
| Plan A: No sign of dehydration | | | | | |
| Plan B: Two or more signs of dehydration | | | | | |
| Plan C: Two or more signs, including one which shows serious dehydration | | | | | |

Table 3.7. Number of diarrhea cases within Municipality of Paraty by morbidity

### *Conclusion*

Diarrhea, a widely studied indicator of water and sanitation-related diseases, is prevalent in both the urban and the rural areas of Paraty. According to this study of diarrhea incidence in Paraty, the most severely affected areas are Mangueira and Ilha das Cobras, the more densely populated, low-income areas within the City of Paraty.

It is assumed that a significant proportion of diarrhea cases is caused by waterborne pathogens, although it is difficult to estimate the exact proportion that is caused by the consumption of poorly disinfected drinking water, or by the contact with polluted surface waters (Payment and Hunter, 2001). For the City of Paraty, it is speculated that both the ineffectively disinfected drinking water, and the highly polluted surface waters are the causes of diarrhea and other water and sanitation related diseases.

## 3.8. Other Problems

In addition to the problems associated with potable water supply, wastewater disposal, and related health consequences, Paraty suffers from the following problems that are typical and common in many developing areas: (i) commercial and financial problems; and (ii) technical and operational problems (World Bank qtd. in US Dept. of Commerce, 1999).

***Commercial and Financial***

The commercial and financial problems observed in the City of Paraty are: (i) limited consumption metering; (ii) billing based on property value or lot size, regardless of the amount of water consumed; (iii) under-priced water; and (iv) commercial losses that reflect the high levels of unaccounted-for water.

The City of Paraty, which provides connection to public water supply to nearly 100 % of its population, has water meters connected to only 44% of those water connections (Prefeitura, "Laudo," 2002). In addition, these water meters, which were read in the past, are no longer read. The City claims that it lacks personnel to read the water meters, and that many water meters are broken or malfunctioning.

The City currently sets tariffs for water and sewage according to property size, since the consumption metering has been discontinued. On average, small houses in Mangueira or Ilha das Cobras, are billed approximately R$3 to R$5 per month, and larger houses in the Historical Center and Jabaquara are billed approximately R$7 per month. Commercial entities are billed much more; a bakery would be billed R$100 each month, for example. On the other hand, farms, which are often the largest users of water, are supplied with water free of charge (Reis, 2003).

The City's current tariff for domestic and agricultural water consumption is under-priced. For example, monthly billing of R$7 per month per household is much lower than R$0.73 per $m^3$ of water consumed, and R$0.87 per $m^3$ of sewage discharged, which are average volumetric tariff charged by CEDAE (US Dept. of Commerce, 1999). Assuming that a household consists of an average of 4 people, and that each person consumes 180 liters of water each day, each household consumes approximately 22 $m^3$ each month. Therefore, the City's current tariff of R$7 per month per household is equal to R$0.32 per $m^3$ of water consumed, much lower than the amount that is charged in most of the State.

The City's suffers from commercial loss (unaccounted-for water) due to poorly enforced billing. Currently, approximately 30% of the bills invoiced are not collected, and the uncollected bills amounts to approximately R$190,000 each year (Prefeitura, "Laudo," 2002). The Municipality of Paraty is currently making efforts to increase the percentage of collected bills to 80% over the next 10 years, and to 85% in 5 additional years, by installing water meters and holding every household accountable for its consumption (Reis, 2003).

| Year | Tot Collected (R$) | Tot Invoiced (R$) | % Collected | Annual Loss (R$) |
|---|---|---|---|---|
| 2000 | 505,000 | 730,000 | 69 | 225,000 |
| 2001 | 540,000 | 750,000 | 72 | 210,000 |
| 2002 | 415,000 | 556,000 | 75 | 141,000 |
| **Average** | **487,000** | **679,000** | **72** | **192,000** |

Table 3.8. Tariffs for water and sanitation invoiced and collected by the City of Paraty

### *Technical and Operational*

Inadequate preventive and regular maintenance of water and wastewater infrastructure is the main technical and operational problem that is observed in Paraty. The inadequate maintenance of water supply infrastructure is evident from the large quantities of water loss due to leakage from broken supply pipes. The inadequate maintenance of the few wastewater infrastructure that exist is also observed from the leakage of sewage in the streets.

## 3.9. Summary of Problems

City of Paraty currently suffers from poor public health, polluted surface waters, and degraded aesthetics and commercial value of the environment, all of which are the consequences of poor water and sanitation systems. In addition, the City's goal of becoming a UNESCO World Heritage Site has been deferred due to the lack of functioning sanitation system in the Historical Center. In order to mitigate these problems, improve the quality of life, and foster economic growth in the City, the City's water and wastewater infrastructure must be improved.

Areas of improvement in the potable water supply are: (i) treatment of drinking water, (ii) protection of drinking water sources, and (iii) procurement of sufficient drinking water supply. It is evident that the City's potable water must be filtered and better disinfected in order to make it safe for drinking, and that the drinking water sources must be isolated in order to prevent accidental contamination of the source waters. Furthermore, to improve the quality of life for the local population, as well as the tourists, water shortages must be eliminated.

Areas of improvement in wastewater supply are: (i) collection of wastewater collection, and (ii) treatment of wastewater. New wastewater infrastructure must be put in place to collect sewage, and a new wastewater treatment plant must be constructed in order to treat the wastewater before it can be safely discharged into the surrounding waters.

# CHAPTER 4 - WATER AND SANITATION IMPROVEMENTS

This chapter recommends water and sanitation improvements that are necessary to mitigate Paraty's current water and sanitation-related problems, which were identified and described in detail in the preceding chapter. The population/area(s) to service, the type(s) of improvement, and the time(s) of development are considered. The costs of improvements are estimated and the City's capacity to recover these costs is analyzed by estimating new water and sewage tariff, and the people's willingness to pay.

## 4.1. Initial Considerations

Although the hope is to achieve universal coverage, providing adequate water and sanitation services to all, this cannot be achieved at once. Therefore, it is necessary to determine which community to service first, with which service, and when to develop these services, adhering to Paraty's objectives and priorities. It is assumed that there is, at the base of Paraty's objectives and priorities, a goal to provide water and sanitation services to the maximum number of people with the least amount of time and money.

### *Population/Area(s) to Service*

Urban vs. Rural

The wastewater infrastructure and treatment plant is to be constructed for the City, rather than for other rural communities in the Municipality, because the City has a more serious and imminent need for sanitation improvements. While the City suffers from severe environmental degradation, which exposes large numbers of local people and tourists to considerable health risks, due to uncontrolled discharge of human wastes, it is assumed that rural communities, which have smaller population density, have better control of their wastes and are thus in a healthier condition. More importantly, sewage collection and treatment in rural areas is seldom economically feasible, and hence the use of septic tanks is recommended and commonly used in rural areas.

While sanitation improvements in the City are justified thus, the improvement of the City's drinking water treatment is justified by Paraty's objective to service a larger number of people with less time and money. It is evident, from the water quality analysis, that both the urban and the rural communities are in need of better drinking water treatment. The rural communities need of disinfection for their drinking water, at the least, which they do not have, and the City, which does have disinfection, needs a more reliable method of disinfection, and treatment by filtration, because its water quality often falls substandard. Given this situation of similar needs, the drinking water treatment project for the City is preferred from the social and economic perspective.

The drinking water treatment for the City is preferred to those for rural communities due to the differences in population. The largest rural community in the Municipality of Paraty does not have more than 300 to 400 households (1200 to 1400 persons), while the City holds more than 3,800 households. This means that one water and sanitation project in the City services approximately 10 times the population of a rural community. Conversely, more than 10 separate water and wastewater treatment facilities in different rural communities are needed to service the equivalent urban population. Moreover, one large project costs less than 10 smaller projects with 1/10 its capacity, due to economy of scale, and are typically more profitable than smaller projects. Therefore, it is justifiable to service the larger of two communities when two communities have similar needs.

The City's water and sanitation improvements are also valid from the health perspective. According to the study of diarrhea incidence in the Municipality of Paraty, there was a higher number of diarrhea cases in the City, than in the rural communities, and the low-income areas of the City, Mangueira and Ilha das Cobras, had the highest diarrhea incidence per capita. Therefore, the water and sanitation projects are most critical in the City, especially in Mangueira and Ilha das Cobras.

Jabaquara

Jabaquara is excluded from the City's development of wastewater collection infrastructure and treatment plant, due to geographic constraints. Because Jabaquara is located North of Pereque

River, separated from the rest of the City by a hill and a narrow band of water, transporting its wastewater to the City's treatment plant, to be located in Ilha das Cobras, would be too costly. Therefore, a separate wastewater system is recommended for Jabaquara.

On the other hand, Jabaquara can be included in the City's drinking water supply system, to receive treated drinking water from the City's future drinking water treatment plant, which is to be located on a hill, next to the City's existing reservoir. Although Jabaquara currently brings its drinking water directly from Caboclo intake, rather than from the City's reservoir, a supply pipe could be constructed to connect Jabaquara to the future treatment plant. The water would flow downhill by gravity from the future treatment plant to Jabaquara, which has an elevation near sea level.

***Development Priorities***

Due to high capital costs involved with water and sanitation developments, it is often economical to divide the development projects into a number of stages, and undertake one project, or one section of a project, at a time. A project of the highest priority would be developed in stage 1, followed by projects of lower priority (i.e. those projects, the time of completion of which are of less consequence).

Water Supply vs. Sanitation

In the City of Paraty, the need of wastewater collection and treatment is considered more serious and imminent than the need for better drinking water treatment, for the following two reasons: (i) a functioning wastewater collection and treatment system at the Historical Center is necessary in the near future for the qualification of UNESCO World Heritage Site; and (ii) while there is a drinking water alternative, the bottled water, there is no alternative for wastewater collection and treatment. Therefore, in a situation where the undertaking of both water and wastewater projects is not economically feasible, the City is to commence its wastewater project first.

Wastewater Collection Infrastructure vs. Wastewater Treatment Plant

The construction of wastewater collection infrastructure and the wastewater treatment plant is to be undertaken concurrently, since one is useless without the other.

## 4.2. Recommendations

The previous chapter identified the following improvements, which are essential in the City of Paraty: (i) a wastewater infrastructure and a treatment plant for the collection and treatment of wastewater; and (ii) a drinking water treatment plant with filtration and disinfection, for better treatment of drinking water.

***Wastewater Collection System***

A gravity sewer system is recommended for the collection of wastewater (Choi, 2003). In a gravity sewer system, wastewater is transported by gravity flow to treatment facilities. The gravity flow is maintained by the slopes of the sewer pipes, which are designed to maintain the minimum "self-cleansing" velocity of approximately 0.6 m/s. Due to the slopes required and the depth of the sewer pipes, gravity sewers often require lift station pumps to transport wastewater from low to high points, so that flow can proceed by gravity again. Gravity sewer systems generally require less maintenance than other sewer collection systems, such as a low-pressure force main system. In addition, a gravity system can handle large variations in flow, and is readily adaptive for growth and change within the sewer district (Pleasanton, 2001).

***Wastewater Treatment Plant***

A chemically enhanced primary treatment (CEPT) plant is recommended for the treatment of the City's wastewater (Kfouri and Kweon, 2003). CEPT is the process by which chemical coagulants are added to primary sedimentation basins in order to enhance the treatment efficiency (i.e. removal of solids, organic matter, and nutrients from the wastewater). CEPT costs minimally more than primary treatment, and half as much as secondary treatment, but its efficiency is highly competitive with biological secondary treatment. "CEPT is ideal for a coastal city since the removal of total suspended solids is very high, and the decrease in biochemical oxygen demand is sufficient so as not to impact oxygen concentrations in the ocean" (Chagnon, 2002).

The CEPT plant is to be located in an empty lot in Ilha das Cobras (See Area 1 in Figure 4.1).

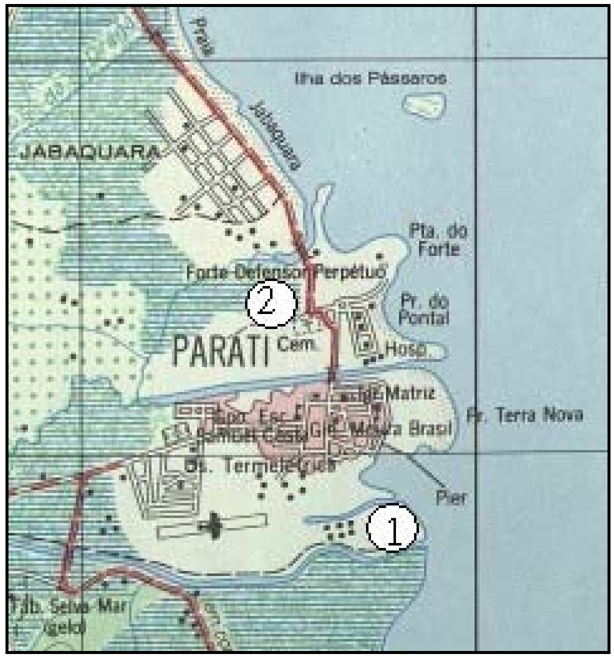


Figure 4.1. Possible location of wastewater treatment plant and drinking water plant [1]

***Drinking Water Treatment Plant***

Different alternatives of filtration and disinfection are to be considered by the City of Paraty, for the treatment of the City's drinking water. Some of the treatment options include conventional filtration, direct filtration, slow sand filtration, and diatomaceous earth (DE) filtration. The descriptions of each follow:

Conventional Filtration

The conventional filtration consists of rapid mix coagulation, flocculation, sedimentation, and gravity filtration. Common filter media include sand, dual-media and tri-media. Conventional filtration is the most widely used technology for treating surface water supplies for turbidity and microbial contaminants, and has the advantage that it can treat a wide range of water qualities. However, it has the disadvantage that it requires advanced operator skill and has high monitoring requirements (US EPA, "Small System," 1997).

[1] 1=Location of wastewater treatment plant; 2=Location of drinking water treatment plant.

Direct Filtration

Direct filtration is conventional filtration minus the sedimentation step. In-line filtration is the simplest form of direct filtration and consists of filters preceded by direct influent chemical feed and static mixing. In general, direct filtration requires low turbidity raw water and is attractive because of its low cost relative to conventional treatment. However, similar to conventional filtration, direct filtration requires advanced operator skill and has high monitoring requirements. The performance of direct filtration is extremely sensitive to the proper management of the coagulation chemistry, and if the coagulation step is disrupted or improperly executed, the removal efficiencies for turbidity and microbial contaminants decrease dramatically in a matter of minutes (US EPA, "Small System," 1997).

Slow Sand Filtration

Slow sand filtration employs a sand filter with a large cross-sectional area, which results in a low filtration rate. Slow sand filtration also employs a biological slime layer, called the "schumutzdecke," which develops over time on top of the sand. The schumutzdecke assists in the removal of suspended organic materials and microorganisms, by biodegradation and other biological processes, instead of relying solely on simple filtration or physico-chemical sorption. An advantage of slow sand filtration is that no backwashing is necessary for slow sand filters. When a predetermined duration, headloss or effluent turbidity is reached, the top few centimeters of the sand are scraped off. Other advantages of slow sand filtration include its low maintenance requirements (since it does not require backwashing and requires less frequent cleaning) and the fact that its efficiency does not depend on actions of the operator. A disadvantage of slow sand filtration is that large systems have large land requirements. Slow sand filters are simple, and easily used by small systems (US EPA, "Small System," 1997).

Diatomaceous Earth (DE) Filtration

Diatomaceous earth (DE) filtration involves a filter cake build-up on a fabric filter element or septum. The DE is a powdery, siliceous material that, on a particle level, is porous, multi-shaped, angular, and varies in width between 5 and 60 microns. The DE filter cake is subject to cracking and must be supplemented by a continuous body feed of diatomite to maintain porosity of the filter. Problems inherent in maintaining the filter cake have limited the use of DE filtration. The advantage of DE is that it does not require coagulants. A disadvantage is that advanced operator skill is required for filtration efficiency (US EPA, "Small System," 1997).

<u>Summary</u>

Land area permitting, the slow sand filtration would be the optimal system for the City of Paraty, since it is cost-effective and does not require advanced operator skills. However, the City should compare the different alternatives of filtration, described above, and select a system that best satisfies the City's needs. In the cost analysis, which is to follow, the conservative costs of a conventional filtration plant are used.

The most convenient location for the drinking water treatment plant is next to the City's reservoir, since this is where the waters from two sources, Pedra Branca and Caboclo, are combined, disinfected, and distributed to the City (See Area 2 in Figure 4.1).

***Development Sequence***

The wastewater collection infrastructure and treatment plant are to be constructed concurrently in three stages for the City of Paraty, excluding the Jabaquara area. The Historical Center is to be developed in the first stage; Mangueira and Ilha das Cobras in the second stage; and the Old City and rest of the City in the third stage. Each development stage is to last approximately 2 years. The incremental development of the CEPT plant is made possible by its ease of implementation and expansion.

The drinking water treatment plant, with the capacity for the entire City of Paraty including Jabaquara, is to be constructed in one stage, since its expansion is likely to be more difficult. The drinking water treatment plant will be constructed after the completion of the wastewater collection infrastructure and treatment plant. However, since there is an immediate need for a more precise method of chlorination, the drinking water disinfection system is to be upgraded immediately, with a flow meter and an automated chlorinator, for example. In addition, the drinking water intake points are to be fenced around the perimeter, in order to protect the integrity of the drinking water.

The earliest feasible time for the construction of drinking water treatment plant is to be determined by comparing the costs of constructing the drinking water treatment plant at different years after the completion of the wastewater infrastructure developments. Four scenarios of development sequence are considered, as shown in Table 4.1:

| | Year0 | Year1 | Year2 | Year3 | Year4 | Year5 | Year6 | Year7 | Year8 | Year9 | Year10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Scenario 1 | WW 1 | WW 2 | WW 3 | DW | | | | | | | |
| Scenario 2 | WW 1 | | WW 2 | | WW 3 | | DW | | | | |
| Scenario 3 | WW 1 | | WW 2 | | WW 3 | | | DW | | | |
| Scenario 4 | WW 1 | | WW 2 | | WW 3 | | | | DW | | |

Table 4.1. Four scenarios of development sequence for wastewater and drinking water infrastructure[1]

Scenario 1 assumes an accelerated project, in which all development is completed in a four-year period, each development stage lasting one year. Scenarios 2, 3 and 4 estimate that each development stage lasts two years. Scenario 2 assumes that all developments will be completed in 8 years, during which time the completion of each development stage is immediately followed by the development of the subsequent stage. Scenario 3 assumes one year of no development between the completion of the development of wastewater infrastructure and the development of drinking water treatment plant, and Scenario 4 assumes two years of no development.

## 4.3. Design Parameters

Two important parameters in the design of the wastewater collection infrastructure and treatment plant, and the drinking water treatment plant are the population in the City of Paraty, and an average consumption of water per capita. The flow demand for the wastewater infrastructure and treatment plant, and the drinking water treatment plant are estimated from these two parameters:

Daily flow = (Daily water consumption per capita) x (Population)

[1] WW1 = development stage 1 of wastewater infrastructure and treatment plant; WW2 = development stage 2; WW3 = development stage 3; and DW = development of drinking water treatment plant

### *Population*

The population in the City of Paraty is assumed to increase in the summer. The rough estimates of the average annual population, and summertime population are listed in Table 4.2 below:

| Area | Average | Summertime Increase | Peak (Summer) |
|---|---|---|---|
| Jabaquara (excluded from WW design) | 1,500 | 3x | 4,500 |
| Historical Center | 3,000 | 3x | 9,000 |
| Mangueira | 4,500 | 1x | 4,500 |
| Ilha das Cobras | 3,000 | 1x | 3,000 |
| Old City | 3,000 | 3x | 9,000 |
| **Total Urban Population** | **15,000** | | **30,000** |

Table 4.2. Average annual population and the peak summertime population for the City of Paraty

As indicated in the table above, most areas in the City are expected to experience a 3-fold increase in population during summer. However, the population in Mangueira and Ilha das Cobras is expected to remain constant since these areas are primarily residential areas for the local people. The annual population growth rate is approximately 0.8%, estimated from the average growth rate in the State of Rio de Janeiro (CEPIS, 2002).

### *Consumption*

The design flow for the wastewater and the drinking water systems are estimated from the daily potable water consumption of 180 liters per capita (Prefeitura, "Laudo," 2002). The amount of wastewater produced is assumed to be approximately equal to the potable water consumption. The flow demand for different stages of development for the wastewater collection infrastructure and treatment plant and for the one-stage development of the drinking water treatment plant are estimated below:

| Development Stage | Development Area | Design Flow (m^3/day) |
|---|---|---|
| WW 1 | Historical Center | 1,620 |
| WW 2 | Mangueira and Ilha das Cobras | 1,350 |
| WW 3 | Old City | 1,620 |
| DW | City of Paraty including Jabaquara | 5,400 |

Table 4.3. Summertime average daily flow for water and wastewater treatment design for the City of Paraty[1]

[1] Design flow corresponds to summertime average flow.

## 4.4. Cost Analysis

***Project Cost***

The capital cost and operation and maintenance (O&M) costs of the wastewater infrastructure and treatment plant and the drinking water treatment plant are derived from a number sources. All costs are assumed to be linear with flow capacity, and a conversion rate of US$1.00 = R$1.00 is used to convert US costs to Brazilian costs. The exchange rate of US Dollar to Brazilian Real is approximately US$1.00 = R$3.11 (X-rates.com, 2003). However, the cost of equipments and labor in Brazil is assumed to be approximately 1/3 of the cost in the US (Tsukamoto, 2003). Therefore, the true value of US$1.00 is approximately equal to the value of R$1.00.

Wastewater Collection and Treatment

The capital cost of wastewater collection infrastructure includes: piping, pump stations, manholes, and associated construction costs. The capital and O&M costs of wastewater infrastructure are estimated from US costs (Choi, 2003).

The capital cost of wastewater treatment includes: CEPT tanks, chlorination and dechlorination chambers, sludge dewatering units and drying beds, and associated construction costs. The O&M cost includes: chemical costs for CEPT and disinfection, as well as sludge treatment and disposal costs. The costs of CEPT and sludge treatment and disposal are Brazilian costs adapted from Tatui-CEAGESP Wastewater Treatment Facility, Brazil (Cabral et al., 1999). The disinfection cost of the wastewater effluent, including chlorination and dechlorination, is US cost adapted from the US EPA (US EPA, qtd. in Kfouri and Kweon, 2003). The capital cost and O&M cost of wastewater collection infrastructure and treatment plant are summarized in Table 4.4 below:

| **Total Cost for Wastewater Collection Infrastructure and Treatment Plant** | | |
|---|---|---|
| WW Infrastructure CC | 2,720 | R$1000 |
| WW Treatment CC | 1,292 | R$1000 |
| **Total WW Capital Cost** | **4,011** | **R$1000** |
| WW Infrastructure O&M Cost | 436 | R$1000/yr |
| WW Treatment O&M Cost | 35 | R$1000/yr |
| **Total WW Annual O&M Cost** | **472** | **R$1000/yr** |

Table 4.4. Total capital cost and O&M cost for wastewater collection infrastructure and treatment plant

Drinking Water Treatment

The capital and O&M costs of a conventional drinking water treatment plant, consisting of rapid mixing, flocculation, sedimentation, chlorination, filtration, contact basin, chemical feed systems, and finished water storage, are adapted from typical US costs estimated by US EPA (US EPA, 1999). The cost for a new finished water storage tank is included since the City's existing reservoir, constructed in 1975, is rundown and approaching the end of its lifetime. The following costs are neglected due to lack of information: (i) current O&M cost for chlorination; (ii) capital cost and O&M cost for interim upgrade of drinking water disinfection system; (iii) all costs associated with drinking water infrastructure.

The capital cost and O&M cost of a new drinking water treatment plant with conventional filtration and chlorination are summarized in Table 4.5 below:

| **Total Cost for Drinking Water Treatment Plant** | |
|---|---|
| DW Treatment CC | 1,057 R$1000 |
| **Total DW Capital Cost** | **1,057 R$1000** |
| DW Treatment O&M Cost | 395 R$1000/yr |
| **Total DW Annual O&M Cost** | **395 R$1000/yr** |

Table 4.5. Total capital cost and O&M cost for drinking water treatment plant

***Financial Analysis***

The above costs are incorporated into four scenarios of development sequence, shown in Table 4.1, and evaluated assuming a project life of 30 years and annual interest rates of 5% and 10% (See Appendix D). Equivalent uniform annual cost (EUAC), defined as the amount of money which, paid in equal annual installments over the life of a project, would pay for the project, is referred as average annual cost in this analysis. Average annual cost and benefit/cost ratio of the projects are computed and used to determine the minimum water and sewage tariff required to fully recover costs, as well as the earliest feasible time for the construction of drinking water treatment plant.

Break-Even Tariff for Water and Sewage

In the following analysis, the break-even tariff for water and sewage, which reflects the minimum amount of revenue required to fully recover the costs, is estimated by setting the City's annual revenue to equal the average annual cost (i.e. by setting the benefit/cost ratio equal to 1). An important consideration in this computation is that the break-even tariffs are computed accounting for the fact that the City collects only 70% of its invoiced tariffs (See Section 3.8). The break-even tariffs for water and sewage, for the four scenarios of development sequence listed in Table 4.1, are summarized in Table 4.6 below:

| Development Sequence Scenario | Annual Cost (R$1000) | | Annual Revenue (R$1000) | | Water and Sewage Tariff (R$/m^3) | |
|---|---|---|---|---|---|---|
| | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% |
| **1** | 1,086 | 1,226 | 1,086 | 1,226 | 1.57 | 1.78 |
| **2** | 976 | 1,058 | 976 | 1,058 | 1.42 | 1.53 |
| **3** | 955 | 1,030 | 955 | 1,030 | 1.38 | 1.49 |
| **4** | 934 | 1,004 | 934 | 1,004 | 1.35 | 1.46 |

Table 4.6. Equivalent uniform annual cost and break-even tariff for water and sewage

According to this financial analysis, the annual cost is greatest for Scenario 1, in which all developments, including wastewater infrastructure and treatment plant and drinking water treatment plant, are completed within a period of 4 years. Under Scenario 1, an average water and sewage tariff, required to fully recover the project costs, is R\$1.57/m$^3$ at 5% annual interest rate, and R\$1.78/m$^3$ at 10% annual interest rate. The annual cost decreases with extended duration of water and wastewater developments, and the minimum water and sewage tariff decreases correspondingly.

Economic Feasibility of Projects when Water and Sewage Tariff = R\$1.60/m$^3$

The economic feasibility of the projects is also analyzed for the case that uses average water and sewage tariffs previously determined by CEDAE. CEDAE charges an average tariff of R\$0.73/m$^3$ for drinking water, and R\$0.87/m$^3$ for sewage (US Dept. of Commerce, 1999). The combined tariff is R\$1.60/m$^3$. The average annual revenue is estimated from the sum of water and sewage tariffs collected each year, which is approximately 70% of the invoiced tariffs. The benefit/cost ratio, an important indicator of the economic feasibility of the projects, is estimated by dividing revenues by costs. The average annual revenue and the benefit/cost ratios are listed in Table 4.7 below:

| Development Sequence Scenario | Annual Cost (R$1000) | | Annual Revenue (R$1000) | | Benefit/Cost Ratio | |
|---|---|---|---|---|---|---|
| | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% |
| **1** | 1,086 | 1,226 | 1,209 | 1,185 | 1.1 | 1.0 |
| **2** | 976 | 1,058 | 1,209 | 1,185 | 1.2 | 1.1 |
| **3** | 955 | 1,030 | 1,209 | 1,185 | 1.3 | 1.2 |
| **4** | 934 | 1,004 | 1,209 | 1,185 | 1.3 | 1.2 |

Table 4.7. Benefit/cost ratio for water and sewage tariff = R$ 1.60/m^3

According to this analysis, the water and sewage tariff of R$1.60/m$^3$ produces an average annual revenue of R$1.2 million at annual interest rates of 5% and 10%, and the benefit/cost ratios that range from 1.0 to 1.3. Therefore, all four scenarios of development sequence are economically feasible, at either interest rates, when the tariff for water and sewage is equal to R$1.60/m$^3$.

***Summary***

The minimum water and sewage tariff required for full recovery of costs, which include the costs of operation, maintenance, and administration as well as current debt service obligations, is approximately R$1.80/m$^3$ when the annual interest rate is 10%. This tariff is approximately equivalent to R$38/household-month for a 4-person household, and about 5 to 10 times the City's current tariff for residential use. At the same time, it is about 1/10 of the City's current tariff for commercial use.

## 4.5. Willingness to Pay Analysis

Although the study of willingness to pay (WTP) for improvements in water and sanitation was not performed in the City of Paraty, due to limited time and resources, it can be estimated based on a number of economic indicators.

***Assumptions***

The basic underlying assumption in this study is that the WTP is approximately equal to the sum of the existing water and sewage tariff paid, the cost of bottled drinking water purchased, and the minimum wage lost due to water and sanitation-related illnesses:

WTP = existing tariff + cost of bottled drinking water + minimum wage lost to illness

***Distribution of Income***

Since the WTP is closely related to household income, it is estimated separately for the low-income households in Mangueira and Ilha das Cobras, and for the mid- to high-income households in Historical Center, and Old City. The WTP in the low-income areas is expected to be lower than that in the high-income areas. The WTP in Jabaquara, which is a relatively high-income community, is estimated separately, since its sanitation system will not be connected with the City's public sewer system.

<u>Mangueira and Ilha das Cobras</u>

The average current tariff for water and sewage in Mangueira and Ilha das Cobras is approximately R$3/household-month.

It is assumed that half of the Mangueira and Ilha das Cobras population buys bottled water for drinking. Or, it is assumed that the entire Mangueira and Ilha das Cobras population buys bottled water for approximately half of the month, on average. Additionally, it is assumed that each person drinks 2 liters of water each day. Therefore, in Mangueira and Ilha das Cobras, a 4-person household, which consumes 240 liters of water each month for drinking, buys 120 liters of the bottled water each month. Since a 20-liter bottle of water purchased and delivered to individual households costs R$3 in Paraty, the cost of bottled water is approximately R$18/household-month.

Due to a comparatively high diarrhea incidence in Mangueira and Ilha das Cobras, it is assumed that an income-earning member in each household loses a day of work each month due to a water-related illness of his/her own or that of his/her child. Assuming that the monthly minimum wage in Mangueira and Ilha das Cobras is approximately equal to the monthly minimum wage of R$240 in Brazil, the cost of minimum wage lost to water and sanitation-related illness is approximately R$8/household-month.

WTP (Mangueira and Ilha das Cobras) = 3 + 18 + 8 = R$29/household-month

The WTP, for the Mangueira and Ilha das Cobras population, is approximately R$29/household-month.

Historical Center and Old City

Since the tariff for water and sewage in the City is currently determined from property value (i.e. lot size), and the houses in Historical Center, and Old City are generally larger, the average monthly tariff is higher for the households in these areas. The average monthly tariff for water and sewage in Historical Center, and Old City is approximately R$7/household.

It is assumed that mid- to high-income households drink only bottled water. Therefore, each household in Historical Center and Old City purchases approximately 240 liters of bottled water, and the cost of bottled water is approximately $R36/household-month.

It is assumed that the minimum wage in Historical Center, and Old City is generally higher than the minimum wage in Mangueira and Ilha das Cobras. However, it is also assumed that the population in these areas are less afflicted by water and sanitation-related illnesses. These two assumptions considered, it is estimated that the loss of wage due to water and sanitation-illnesses in these areas is also approximately R$8/household-month.

WTP (Historical Center, and Old City) = 7 + 36 + 8 = R$51/household-month

The WTP, for the Historical Center and Old City population, is approximately R$51/household-month.

Jabaquara

Since Jabaquara is a relatively high-income community, with tourism as its major industry, the WTP of its population is expected to be similar to that of the Historical Center and Old City population. However, the WTP of the Jabaquara population is assumed to be approximately half of that for the Historical Center and Old City population, since it will be provided with only half of the service, which is the supply of treated drinking water.

WTP (Jabaquara) = WTP (Historical Center, and Old City)/2 = R$26/household-month

The WTP, for the Jabaquara population, is approximately R$26/household-month.

***Willingness to Pay***

The WTP is approximately R$29/household-month for the low-income population in Mangueira and Ilha das Cobras, $51/household-month for the mid- to high-income population in Historical Center and Old City, and R$26/household-month for the Jabaquara population, who will receive only the treated drinking water.

The WTP varies widely between the low-income population and the mid- to high-income population, and the difference is approximately R$22/household-month, almost 80% of the WTP of the low-income population. The WTP of the low-income population is approximately R$9/household-month lower than the break-even water and sewage tariff, and the WTP of the mid- to high-income population is approximately R$13/household-month higher.

## 4.6. Water and Sewage Tariff

The water and sewage tariff must be designed to reflect the people's WTP, which varies with income distribution, because the WTP of the low-income population is below the minimum water and sewage tariff required for full cost recovery. Examples of income-based tariffs include "lifeline" tariffs, and lump-sum credits provided to qualifying low-income households. Lifeline tariffs, which are reduced tariffs applicable to low-income consumers, provide the low-income consumers with a predetermined amount of service to meet a minimum quality of life.

Lifeline tariffs or other income transfers to low-income households are motivated and justified by a goal to achieve "fairness," even though they are in conflict with "equity." Tariffs are fair when they are perceived to be just and equitable by consumers and the general public. Many members of the public believe that it is fair to charge lower prices to low-income households, even though equity precludes non-cost-related differences in tariff as well as any other arbitrary distinctions among users (Boland, 1992).

In this study, a separate tariff for water and sewage is designed for each income group based on the study of WTP. For example, water and sewage tariff of R$1.40/m$^3$, corresponding to R$29 /household-month, is charged for the low-income households in Mangueira and Ilha das Cobras; R$2.40/m$^3$, corresponding to R$51/household-month, is charged for the mid- to high-income households in Historical Center and Old City; and R$1.20/m$^3$, corresponding to R$26/household-month, is charged to mid- to high-income households in Jabaquara. This design of water and sewage tariff is feasible as shown in Table 4.8:

| Area | Population | Adjusted Water and Sewage Tariff | | Annual Revenue | Target Annual Revenue |
|---|---|---|---|---|---|
| Mangueira, and Ilha das Cobras | 7,500 | 29 R$/hh-mo | 1.40 R$/m^3 | 475 R$1000 | |
| Historical Center, and Old City | 6,000 | 51 R$/hh-mo | 2.40 R$/m^3 | 626 R$1000 | |
| Jabaquara | 1,500 | 26 R$/hh-mo | 1.20 R$/m^3 | 78 R$1000 | |
| **Total** | | | | **1,228 R$1000** | **1,226 R$1000** |

Table 4.8. Water and sewage tariff adjusted according to income distribution[1]

The above tariffs are substantially higher than the existing tariffs of approximately R$3/household-month in Mangueira and Ilha das Cobras, and R$7/household-month in other parts of the City. Sudden increase in water and sewage tariffs of this magnitude is likely to "shock" the users, and thus appropriate interim tariffs must be designed for one or more steps to phase in the final design tariff.

## 4.7. Benefits

The benefits associated with water and sanitation improvements are numerous and substantial, although it is difficult to associate these benefits with monetary values for cost-benefit analysis. Some of the benefits include:

(i) Disease reduction and improved human productivity;

(ii) Healthier environment, improved aesthetics, and associated increase in amenities, economic values, and intrinsic values of the environment;

[1] hh= household; mo=month

(iii) Encouraged tourism, poverty alleviation, and general economic growth; and
(iv) UNESCO World Heritage Site candidacy, and associated distinction and merit.

## 4.8. Summary

Following improvements are proposed for the mitigation of the City's current water and sanitation-related problems:
(i) Gravity sewer system for the collection of wastewater;
(ii) Chemically enhanced primary treatment (CEPT) plant for the treatment of wastewater; and
(iii) Drinking water treatment plant for a better treatment of potable water.

The wastewater collection infrastructure and treatment plant are to be constructed concurrently in three stages for the City of Paraty, excluding the Jabaquara area. The Historical Center is to be developed in the first stage; Mangueira and Ilha das Cobras in the second stage; and the Old City and rest of the City in the third stage. Each development stage is to last approximately 2 years, and the completion of each stage is to initiate an immediate start of the subsequent stage.

The drinking water disinfection system is to be upgraded immediately, with a flow meter and an automated chlorinator, and the drinking water intake points are to be fenced around the perimeter, in order to protect the source waters. The drinking water treatment plant, with the capacity for the entire City of Paraty including Jabaquara, is to be constructed in one stage, immediately following the third stage of wastewater infrastructure development.

The total capital costs and O&M costs associated with the above improvements are as follows:

| Total Capital Costs and O&M Costs for Water and Sanitation Improvement Projects | |
|---|---|
| Total WW Collection Infrastructure and Treatment Plant CC | R$ 4 million |
| Total WW Collection and Treatment Annual O&M Cost | R$ 0.5 million/yr |
| Total DW Treatment Plant CC | R$ 1 million |
| Total DW Treatment Annual O&M Cost | R$ 0.4 million/yr |

Table 4.9. Total capital cost and O&M cost for water and sanitation improvement projects

The total annual cost is approximately R$1.2 million, with the capital cost amortized over a 30-year project life at 10% annual interest rate. The minimum water and sewage tariff required for full recovery of this annual cost is approximately R$1.80/$m^3$ or R$38/household-month.

The willingness to pay (WTP) varies between different areas of the City according to household income. WTP is approximately R$29/household-month for the low-income population in Mangueira and Ilha das Cobras, $51/household-month for the mid- to high-income population in Historical Center and Old City, and R$26/household-month for the Jabaquara population, who will receive only the treated drinking water.

Designing a separate water and sewage tariff for each income group, based on the study of WTP, water and sewage tariff is R$1.40/$m^3$ for Mangueira and Ilha das Cobras population, R$2.40/$m^3$ for Historical Center and Old City population, and R$1.20/$m^3$ for Jabaquara population. Since these tariffs can be seen as a substantial increase from the existing tariffs, appropriate interim tariffs are to be designed and implemented in one or more steps to phase in the final design tariff.

Finally, the construction of wastewater collection infrastructure and treatment plant, and drinking water treatment plant is expected to bring substantial benefits in public health, environmental quality, and aesthetics in the city, and hence provide large economic gains.

# CHAPTER 5 - PROPOSED POLICY

City of Paraty currently suffers from inadequate water and sanitation systems, the consequences of which include: poor public health; polluted surface waters; damaged aesthetics; loss of amenities; and depreciated commercial and intrinsic value of the environment. In addition, the City's objective of becoming a UNESCO World Heritage Site has been deferred due to the lack of functioning sanitation system in the Historical Center.

***Problems***

The potable water supply system for the City of Paraty has a number of problems that must be addressed, including: (i) shortage of water supply in the summer; (ii) ineffective disinfection; (iii) inadequate protection of water sources; and (iv) substandard water quality.

Numerous water quality analyses revealed that the quality of City's potable water is heavily influenced by the quality of surface waters, from which it is derived, and often fails to comply with international drinking water standards due to high turbidity after rainstorms, and bacterial contamination. These analyses also indicated that the City's present method of disinfection is ineffective, and that filtration of drinking water before disinfection is necessary in order to remove suspended particulate matter, and the harmful pathogens adsorbed on those particles, from water.

Due to the lack of wastewater collection and treatment, the City of Paraty suffers from serious environmental degradation and associated health consequences. The environmental degradation in the City results from the direct discharge of untreated sewage into surrounding water bodies, and from the tidal inflows that flood the streets with sewage and seawater mixture.

Four surface water bodies, Jabaquara Beach, Matheus River, Pereque River, and an open ditch of sewer stream, were tested for water quality. According to the water quality analyses, Jabaquara Beach was found to be unsafe for swimming, and Matheus River and Pereque River unsafe for all aquatic sports, due to high fecal contamination. In addition, Sewer stream was found to have the water quality of a diluted sewage.

The uncontrolled disposal of wastewater damages the aesthetics of the rivers, and reduces the commercial value of the environment. The source of pollution must be controlled in order to preserve the environment from further degradation, and therefore an appropriate treatment and discharge of the City's wastewater is critical.

Poor public health is a direct consequence of inadequate potable water quality and polluted environment. Diarrhea, a widely studied indicator of water and sanitation-related diseases, was found to be prevalent in both the urban and the rural areas of Paraty, especially in Mangueira and Ilha das Cobras, the more densely populated, low-income areas within the City of Paraty.

It is assumed that a significant proportion of diarrhea cases is caused by waterborne pathogens, although it is difficult to estimate the exact proportion that is caused by the consumption of poorly disinfected drinking water, or by the contact with polluted surface waters. For the City of Paraty, it is speculated that both the ineffectively disinfected drinking water, and the highly polluted surface waters are the causes of diarrhea and other water and sanitation related diseases.

***Improvements***

Following improvements are proposed for the mitigation of the City's current water and sanitation-related problems identified above:

(i) Gravity sewer system for the collection of wastewater;

(ii) Chemically enhanced primary treatment (CEPT) plant for the treatment of wastewater; and

(iii) Drinking water treatment plant for a better treatment of potable water.

The wastewater collection infrastructure and treatment plant are to be constructed concurrently in three stages for the City of Paraty, excluding the Jabaquara area. The Historical Center is to be developed in the first stage; Mangueira and Ilha das Cobras in the second stage; and the Old City and rest of the City in the third stage. Each development stage is to last approximately 2 years, and the completion of each stage is to initiate an immediate start of the subsequent stage.

The drinking water disinfection system is to be upgraded immediately, with a flow meter and an automated chlorinator, and the drinking water intake points are to be fenced around the perimeter, in order to protect the source waters. The drinking water treatment plant, with the capacity for the entire City of Paraty including Jabaquara, is to be constructed in one stage, immediately following the third stage of wastewater infrastructure development.

In order to fully recover costs of water and sanitation improvements, annual revenue of R$1.2 million must be collected from water and sewage tariffs. The following water and sewage tariffs, which are based on willingness to pay (WTP), are to be billed for each income group: R$1.40/$m^3$ for Mangueira and Ilha das Cobras population; R$2.40/$m^3$ for Historical Center and Old City population; and R$1.20/$m^3$ for Jabaquara population. Since these tariffs can be seen as a substantial increase from the existing tariffs, appropriate interim tariffs are to be designed and implemented in one or more steps to phase in the final design tariff.

Finally, the construction of wastewater collection infrastructure and treatment plant, and drinking water treatment plant is expected to bring numerous and substantial benefits to the City, which include: improvements in public health, environmental quality, and aesthetics in the city, as well as increases in productivity and economic value of the environment. It is also expected that these water and sanitation improvements will encourage tourism and promote general economic growth, providing large economic returns.

## APPENDIX A – Water Quality Test Data

**Water Quality Test Data for Drinking Water Samples from the City of Paraty**

| Sample # | Location | Detail | Date | Collection Time | Turbidity (NTU) | SS (mg/L) | pH | Chlorine Free Cl (mg/L) | Chlorine Tot Cl (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 14 | Caboclo | | 1/10/2003 | 5:40 PM | 1.4 | 1 | 6.2 | | |
| 18 | Caboclo | At reservoir | 1/13/2003 | 10:20 AM | 2.9 | 3 | 6.9 | | |
| 23 | Caboclo | At reservoir | 1/14/2003 | 10:00 AM | 4.5 | 8 | 6.6 | | |
| 29 | Caboclo | At reservoir | 1/16/2003 | 9:30 AM | 2.7 | 3 | 6.6 | | |
| 37 | Caboclo | At reservoir | 1/17/2003 | 12:00 PM | 3.2 | 1 | 6.7 | | |
| 42 | Caboclo | At reservoir | 1/17/2003 | 4:00 PM | 3.1 | 3 | 6.4 | | |
| 46 | Caboclo | At reservoir | 1/18/2003 | 12:45 PM | 3.5 | 7 | 7.0 | | |
| 51 | Caboclo | At reservoir | 1/20/2003 | 11:05 AM | 1.8 | 2 | 6.8 | | |
| 56 | Caboclo | At reservoir | 1/21/2003 | 12:00 PM | 1.7 | 3 | 6.9 | | |
| 13 | Pedra Branca | | 1/10/2003 | 5:00 PM | 1.2 | 2 | 6.0 | | |
| 41 | Pedra Branca | | 1/17/2003 | 3:45 PM | 8.1 | 7 | 6.4 | | |
| 45 | Pedra Branca | | 1/18/2003 | 12:05 PM | 0.7 | 3 | 7.1 | | |
| 50 | Pedra Branca | | 1/20/2003 | 10:50 AM | 1.5 | 2 | 7.0 | | |
| 55 | Pedra Branca | | 1/21/2003 | 11:30 AM | 2.5 | 3 | 7.1 | | |
| 15 | Reservoir | After chlorination | 1/10/2003 | 6:00 PM | 3.2 | 3 | 6.2 | | |
| 24 | Reservoir | After chlorination | 1/14/2003 | 10:05 AM | 8.6 | 10 | 6.4 | | |
| 30 | Reservoir | After chlorination | 1/16/2003 | 9:40 AM | 6.9 | 6 | 6.4 | 0.15 | |
| 38 | Reservoir | After chlorination | 1/17/2003 | 12:10 PM | 2.0 | 1 | 6.6 | 3.40 | 8.30 |
| 43 | Reservoir | After chlorination | 1/17/2003 | 4:05 PM | 4.0 | 4 | 6.5 | | |
| 47 | Reservoir | After chlorination | 1/18/2003 | 12:50 PM | 1.7 | 7 | 6.8 | 0.01 | 0.13 |
| 52 | Reservoir | After chlorination | 1/20/2003 | 11:10 AM | 1.4 | 3 | 7.0 | 0.58 | 0.2 |
| 57 | Reservoir | After chlorination | 1/21/2003 | 12:00 PM | 1.8 | 2 | 7.0 | | |
| 35 | Tap Water | | 1/16/2003 | 4:40 PM | 4.0 | 3 | 5.7 | 1.51 | |
| 61 | Tap Water | | 1/21/2003 | 2:00 PM | 1.6 | 2 | 6.8 | 1.43 | 1.59 |
| 64 | Tap Water | | 1/21/2003 | 5:30 PM | 4.1 | 5 | 6.7 | | |
| 65 | Tap Water | | 1/22/2003 | 10:00 AM | 67.5 | 44 | 6.6 | 0.04 | 0.15 |
| 66 | Tap Water | | 1/22/2003 | 10:10 AM | 11.5 | 7 | 6.6 | | |
| 76 | Tap Water | | 1/23/2003 | 5:10 PM | | | | 0.65 | 0.77 |

**Water Quality Test Data for Drinking Water Samples from the City of Paraty (Cont'd)**

| Coliform | | | | |
|---|---|---|---|---|
| **Total Count** | **Fecal MPN** | **Fecal Count** | **Total MPN** | **Weather** |
| 96 | > 2424 | 50 | 188 | sunny, 4 days after heavy rain |
| | | | | cloudy, cool, 1 day after rain |
| 96 | > 2424 | 54 | 213 | cloudy, rained the night before |
| 88 | 794 | 38 | 127 | sunny, partly cloudy, rained the night before |
| 95 | 2424 | 28 | 87 | really sunny, rained lightly night before |
| 96 | > 2424 | 69 | 339 | started raining |
| 96 | > 2424 | 50 | 188 | rained heavily the night before |
| 94 | 1696 | 53 | 206 | sunny, rained very lightly the night before |
| 96 | > 2424 | 29 | 90 | very sunny, before rain |
| 96 | > 2424 | 3 | 8 | sunny, 4 days after heavy rain |
| 96 | > 2424 | 65 | 298 | started raining |
| 96 | > 2424 | 31 | 98 | rained heavily the night before |
| 96 | > 2424 | 69 | 339 | sunny, rained very lightly the night before |
| 95 | 2424 | 14 | 39 | very sunny, before rain |
| 1 | 3 | 0 | < 3 | sunny, 4 days after heavy rain |
| 4 | 11 | 0 | < 3 | cloudy, rained the night before |
| 0 | < 3 | 0 | < 3 | sunny, partly cloudy, rained the night before |
| 0 | < 3 | 0 | < 3 | really sunny, rained lightly night before |
| 0 | < 3 | 0 | < 3 | started raining |
| 3 | 8 | 0 | < 3 | rained heavily the night before |
| 95 | 2424 | 14 | 39 | sunny, rained very lightly the night before |
| 0 | < 3 | 0 | < 3 | very sunny, before rain |
| 0 | < 3 | 0 | < 3 | sunny, partly cloudy, rained the night before |
| 0 | < 3 | 0 | < 3 | very sunny, before rain |
| 0 | < 3 | 0 | < 3 | immediately after storm |
| 96 | > 2424 | 75 | 418 | sunny, before rain |
| 71 | 362 | 0 | < 3 | sunny, before rain |
| | | | | sunny, day after rain |

**Water Quality Test Data for Drinking Water Samples from Rural Communitites within Municipality of Paraty**

| Sample # | Location | Detail | Date | Collection Time | Turbidity (NTU) | SS (mg/L) | pH | Chlorine Free Cl (mg/L) | Chlorine Tot Cl (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 36 | Agua Fria | | 1/17/2003 | 11:45 AM | 1.5 | 2 | 6.6 | | |
| 49 | Agua Fria | | 1/20/2003 | 10:15 AM | 0.8 | 4 | 6.8 | | |
| 54 | Agua Fria | | 1/21/2003 | 11:15 AM | 1.5 | 2 | 6.9 | | |
| 72 | Barra Grande | | 1/22/2003 | 6:45 PM | 3.4 | 5 | 6.6 | | |
| 44 | Corisco | | 1/18/2003 | 11:00 AM | 2.1 | 4 | 6.9 | | |
| 48 | Patrimonio | | 1/20/2003 | 10:00 AM | 1.2 | 3 | 6.7 | | |
| 75 | Patrimonio | | 1/23/2003 | 4:00 PM | 0.8 | 1 | 6.5 | | |
| 68 | Sao Goncalo | | 1/22/2003 | 5:45 PM | 4.1 | 4 | 6.8 | | |
| 69 | Sao Goncalo | From Reservoir | 1/22/2003 | 5:50 PM | 3.4 | 7 | 6.9 | | |
| 71 | Sao Roque | | 1/22/2003 | 6:30 PM | 5.3 | 7 | 6.8 | | |
| 70 | Taquari | | 1/22/2003 | 6:10 PM | 3.2 | 6 | 6.8 | | |
| 67 | Tarituba | | 1/22/2003 | 5:15 PM | 3.7 | 3 | 6.7 | | |
| 74 | Trindade | | 1/23/2003 | 3:50 PM | 1.9 | 2 | 6.9 | | |

**Water Quality Test Data for Drinking Water Samples from Rural Communitites within Municipality of Paraty (Cont'd)**

| Coliform | | | | |
|---|---|---|---|---|
| **Total Count** | **Fecal MPN** | **Fecal Count** | **Total MPN** | **Weather** |
| 74 | 403 | 1 | 3 | really sunny, rained lightly night before |
| 92 | 1174 | 0 | < 3 | sunny, rained very lightly the night before |
| 96 | > 2424 | 2 | 5 | very sunny, before rain |
| 96 | > 2424 | 17 | 49 | rained heavily |
| 96 | > 2424 | 11 | 30 | rained heavily the night before |
| 92 | 1174 | 4 | 11 | sunny, rained very lightly the night before |
| 81 | 534 | 4 | 11 | sunny, day after rain |
| 96 | > 2424 | 11 | 30 | rained heavily |
| 96 | > 2424 | 87 | 740 | rained heavily |
| 96 | > 2424 | 16 | 46 | rained heavily |
| 96 | > 2424 | 8 | 22 | rained heavily |
| 90 | 938 | 23 | 69 | rained heavily |
| 93 | 1370 | 2 | 5 | sunny, day after rain |

**Results of Water Quality Analysis performed by the Municipality of Paraty from October 2001 to March 2002**
**For Drinking Water Sampled from Various Communities within the Municality of Paraty**

| Location | Date (dd/mm/yy) | Time | Treatment | Turbidity/ Suspended Solids (ss) | Color | Odor | Total Coliform | Fecal Coliform | Conclusion |
|---|---|---|---|---|---|---|---|---|---|
| Barra Grande | 17/10/01 | 15:30 | None | high ss | none | none | present | present | not satisfactory |
| Barra Grande | 23/01/02 | 15:55 | None | clear | none | none | present | present | not satisfactory |
| Campinho | 06/02/02 | 16:27 | None | clear | none | none | present | present | not satisfactory |
| Campinho | 19/12/01 | 16:10 | None | clear | none | none | present | present | not satisfactory |
| Corisquinho | 06/02/02 | 17:35 | None | cloudy | none | none | present | present | not satisfactory |
| Corisquinho | 19/12/01 | 17:20 | None | clear | none | none | present | present | not satisfactory |
| Corumbe | 17/10/01 | 16:05 | None | clear | none | none | present | present | not satisfactory |
| Corumbe | 23/01/02 | 16:25 | None | clear | none | none | present | present | not satisfactory |
| Grauna | 06/03/02 | 15:25 | None | high ss | none | none | present | absent | not satisfactory |
| Grauna | 17/10/01 | 15:45 | None | clear | none | none | present | present | not satisfactory |
| Grauna | 23/01/02 | 16:10 | None | high ss | none | none | present | present | not satisfactory |
| Pantanal | 06/02/02 | 18:15 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Pantanal | 06/03/02 | 14:56 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Pantanal | 17/10/01 | 16:28 | Chlorination | high ss | none | none | absent | absent | not satisfactory |
| Paraty City | 17/10/01 | 13:30 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 06/02/02 | 18:50 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 19/12/01 | 18:35 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 19/12/01 | 18:50 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 23/01/02 | 16:43 | Chlorination | clear | none | none | present | present | not satisfactory |
| Paraty City | 06/02/02 | 18:25 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 19/12/01 | 18:25 | Chlorination | high ss | none | none | present | absent | not satisfactory |
| Paraty City | 17/10/01 | 15:10 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 06/03/02 | 17:45 | Chlorination | clear | none | none | present | absent | not satisfactory |
| Paraty City | 17/10/01 | 15:00 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 23/01/02 | 15:35 | Chlorination | clear | none | none | present | present | not satisfactory |
| Paraty City | 06/03/02 | 17:10 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 23/01/02 | 17:05 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 06/02/02 | 18:40 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 06/03/02 | 14:35 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 17/10/01 | 14:35 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Paraty City | 23/01/02 | 16:55 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Pastiba | 19/12/01 | 18:00 | None | high ss | none | none | absent | absent | not satisfactory |
| Patrimonio | 06/02/02 | 16:34 | None | clear | none | none | present | present | not satisfactory |
| Patrimonio | 19/12/01 | 15:40 | None | clear | none | none | present | present | not satisfactory |
| Pedras Azuis | 06/02/02 | 16:12 | None | clear | none | none | present | present | not satisfactory |
| Pedras Azuis | 19/12/01 | 16:40 | None | cloudy | yellow | none | present | present | not satisfactory |
| Ponte Branca | 06/02/02 | 17:55 | Chlorination | clear | none | none | absent | absent | satisfactory |
| Ponte Branca | 19/12/01 | 17:40 | Chlorination | high ss | none | none | absent | absent | not satisfactory |
| Taquari | 06/03/02 | 15:45 | None | clear | none | none | present | absent | not satisfactory |
| Taquari | 18/10/01 | 7:00 | None | clear | none | none | present | present | not satisfactory |
| Tarituba | 06/03/02 | 16:00 | None | clear | none | none | present | absent | not satisfactory |
| Tarituba | 18/10/01 | 7:40 | None | clear | none | none | present | present | not satisfactory |
| Trindade | 06/02/02 | 16:55 | None | clear | none | none | present | present | not satisfactory |
| Trindade | 19/12/01 | 15:20 | None | high ss | none | none | present | present | not satisfactory |

**Water Quality Test Data for Surface Water Samples from the City of Paraty**

| Sample # | Location | Date | Collection Time | Turbidity (NTU) | SS (mg/L) | pH | COD (mg/L) |
|---|---|---|---|---|---|---|---|
| 1 | Jabaquara Beach | 1/8/2003 | 10:20 AM | 8.6 | 6 | 6.8 | ~~1.4E+03~~ |
| 5 | Jabaquara Beach | 1/8/2003 | 5:20 PM | 34.5 | 39 | 7.9 | > ~~1.7E+03~~ |
| 10 | Jabaquara Beach | 1/9/2003 | 4:15 PM | 25.5 | 23 | 5.8 | ~~1.1E+03~~ |
| 11 | Jabaquara Beach | 1/9/2003 | 4:20 PM | 43.3 | 42 | 6.1 | > ~~1.7E+03~~ |
| 16 | Jabaquara Beach | 1/11/2003 | 2:00 PM | 42.4 | 32 | 6.8 | ~~7.3E+01~~ |
| 19 | Jabaquara Beach | 1/13/2003 | 10:40 AM | 9.7 | 11 | 6.6 | > ~~1.7E+03~~ |
| 25 | Jabaquara Beach | 1/14/2003 | 10:15 AM | 6.8 | 10 | 7.7 | 1.2E+02 |
| 31 | Jabaquara Beach | 1/16/2003 | 10:00 AM | 21.8 | 20 | 6.8 | 1.1E+02 |
| 40 | Jabaquara Beach | 1/17/2003 | 3:20 PM | 31.4 | 31 | 7.7 | 2.3E+02 |
| 53 a | Jabaquara Beach | 1/20/2003 | 12:20 PM | 19.2 | 18 | 6.7 | |
| 53 b | Jabaquara Beach | | | | | | |
| 60 a | Jabaquara Beach | 1/21/2003 | 12:05 PM | 17.3 | 16 | 6.8 | |
| 60 b | Jabaquara Beach | | | | | | |
| 3 | Matheus River | 1/8/2003 | 3:40 PM | 6.2 | 9 | 6.5 | 8.1E+02 |
| 8 a | Matheus River | 1/9/2003 | 10:50 AM | 8.2 | 14 | 6.6 | 3.1E+02 |
| 8 b | Matheus River | | | | | | |
| 21 | Matheus River | 1/13/2003 | 11:25 AM | 6.5 | 6 | 6.8 | 7.9E+01 |
| 27 | Matheus River | 1/14/2003 | 11:00 AM | 17.4 | 21 | 7.4 | 3.2E+01 |
| 33 | Matheus River | 1/16/2003 | 10:30 AM | 30.4 | 29 | 7.0 | 8.5E+01 |
| 58 a | Matheus River | 1/21/2003 | 12:20 PM | 10.2 | 11 | 6.8 | 8.6E+01 |
| 58 b | Matheus River | | | | | | |
| 62 | Matheus River | 1/21/2003 | 3:30 PM | 13.4 | 14 | 6.6 | 1.0E+01 |
| 2 | Pereque River | 1/8/2003 | 10:40 AM | 4.9 | 3 | 6.4 | 5.7E+01 |
| 6 | Pereque River | 1/8/2003 | 5:45 PM | 8.8 | 18 | 5.9 | 1.2E+01 |
| 12 a | Pereque River | 1/9/2003 | 4:50 PM | 10.8 | 9 | 6.6 | 3.3E+01 |
| 12 b | Pereque River | | | | | | |
| 17 | Pereque River | 1/11/2003 | 2:20 PM | 45.5 | 38 | 7.3 | 2.6E+01 |
| 20 | Pereque River | 1/13/2003 | 10:50 AM | 7.4 | 7 | 7.4 | 1.7E+01 |
| 26 | Pereque River | 1/14/2003 | 10:35 AM | 16.0 | 18 | 8.0 | 1.4E+01 |
| 32 | Pereque River | 1/16/2003 | 10:15 AM | 33.8 | 30 | 7.4 | 2.1E+01 |
| 59 a | Pereque River | 1/21/2003 | 12:45 PM | 12.0 | 12 | 7.0 | 1.6E+01 |
| 59 b | Pereque River | | | | | | |
| 63 | Pereque River | 1/21/2003 | 3:50 PM | 20.3 | 20 | 6.5 | 2.3E+02 |
| 9 a | Sewer Stream | 1/9/2003 | 11:00 AM | 28.5 | 31 | 6.5 | ~~1.1E+03~~ |
| 9 b | Sewer Stream | | | | | | - |
| 22 | Sewer Stream | 1/13/2003 | 11:30 AM | 89.6 | 102 | 6.8 | 2.8E+02 |
| 28 | Sewer Stream | 1/14/2003 | 11:15 AM | 48.2 | 63 | 7.1 | 3.7E+02 |
| 34 | Sewer Stream | 1/16/2003 | 10:40 AM | 34.4 | 48 | 6.8 | 1.1E+02 |
| | Raw Sewage | 1/23/2003 | | 128.0 | 117 | 6.8 | 4.1E+02 |

**Water Quality Test Data for Surface Water Samples from the City of Paraty (Continued)**

| Coliform | | | | | |
|---|---|---|---|---|---|
| **Dilution by** | **Total Count** | **Total MPN** | **Fecal Count** | **Fecal MPN** | **Weather** |
| | 66 | 3.1E+02 | 45 | 1.6E+02 | sunny, 2 days after heavy rain |
| | 7 | 1.9E+01 | 9 | 2.5E+01 | sunny, 2 days after heavy rain |
| 10^(-2) | 11 | 3.0E+03 | 0 | < 3.0E+02 | sunny, 3 days after heavy rain |
| 10^(-2) | 2 | 5.0E+02 | 0 | < 3.0E+02 | sunny, 3 days after heavy rain |
| 10^(-1) | 66 | 3.1E+03 | 6 | 1.6E+02 | started raining |
| | | | | | cloudy, cool, 1 day after rain |
| 10^(-1) | 32 | 1.0E+03 | 0 | < 3.0E+01 | cloudy, rained the night before |
| | 96 | > 2.4E+03 | 82 | 5.6E+02 | sunny, partly cloudy, rained the night before |
| | 0 | < 3.0E+00 | 1 | 3.0E+00 | started raining |
| | 96 | > 2.4E+03 | 60 | 2.6E+02 | sunny, rained very lightly the night before |
| 10^(-1) | 96 | > 2.4E+04 | 25 | 7.6E+02 | sunny, rained very lightly the night before |
| | 16 | 4.6E+01 | 3 | 8.0E+00 | very sunny, before rain |
| 10^(-1) | 96 | > 2.4E+03 | 7 | 1.9E+01 | very sunny, before rain |
| | 79 | 4.9E+02 | 96 | > 2.4E+03 | sunny, 2 days after heavy rain |
| 10^(-1) | 96 | > 2.4E+04 | 96 | > 2.4E+04 | sunny, 3 days after heavy rain |
| 10^(-2) | 96 | > 2.4E+05 | 79 | 4.9E+04 | sunny, 3 days after heavy rain |
| | | | | | cloudy, cool, 1 day after rain |
| 10^(-3) | 35 | 1.1E+05 | 10 | 2.8E+04 | cloudy, rained the night before |
| 10^(-3) | 9 | 2.5E+04 | 0 | < 3.0E+03 | sunny, partly cloudy, rained the night before |
| 10^(-2) | 96 | > 2.4E+05 | 58 | 2.4E+04 | very sunny, before rain |
| 10^(-3) | 78 | 4.7E+05 | 21 | 6.2E+04 | very sunny, before rain |
| 10^(-2) | 96 | > 2.4E+05 | 81 | 5.3E+04 | immediately after storm |
| | 96 | > 2.4E+03 | 96 | > 2.4E+03 | sunny, 2 days after heavy rain |
| | 96 | > 2.4E+03 | 96 | > 2.4E+03 | sunny, 2 days after heavy rain |
| 10^(-3) | 38 | 1.3E+05 | 11 | 3.0E+04 | sunny, 3 days after heavy rain |
| 10^(-4) | 9 | 2.5E+05 | 1 | 3.0E+04 | sunny, 3 days after heavy rain |
| 10^(-3) | 83 | 5.9E+05 | 7 | 1.9E+04 | after rain, rapid flow |
| | | | | | cloudy, cool, 1 day after rain |
| 10^(-3) | 29 | 9.0E+04 | 1 | 3.0E+03 | cloudy, rained the night before |
| 10^(-3) | 8 | 2.2E+04 | 0 | < 3.0E+03 | sunny, partly cloudy, rained the night before |
| 10^(-2) | 91 | 1.0E+05 | 45 | 1.6E+04 | very sunny, before rain |
| 10^(-3) | 50 | 1.9E+05 | 1 | 3.0E+03 | very sunny, before rain |
| 10^(-2) | 96 | > 2.4E+05 | 78 | 4.7E+04 | immediately after storm |
| 10^(-4) | 84 | 6.2E+06 | 45 | 1.6E+06 | sunny, 3 days after heavy rain |
| 10^(-5) | 32 | 1.0E+07 | 6 | 1.6E+06 | sunny, 3 days after heavy rain |
| | | | | | cloudy, cool, 1 day after rain |
| 10^(-5) | 44 | 1.6E+07 | 6 | 1.6E+06 | cloudy, rained the night before |
| 10^(-5) | 50 | 1.9E+07 | 9 | 2.5E+06 | sunny, partly cloudy, rained the night before |
| | | 3.3E+06 | | 4.6E+05 | |

# APPENDIX B – Diarrhea Incidence Data

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**In the Low-Income Urban Areas**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Ilha das Cobras | Urban | 2 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Ilha das Cobras | Urban | 1 |
| 39 | 9/22/2002 | 9/28/2002 | ESF | Ilha das Cobras | Urban | 8 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Ilha das Cobras | Urban | 3 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Ilha das Cobras | Urban | 5 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Ilha das Cobras | Urban | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Ilha das Cobras | Urban | 1 |
| 43 | 10/20/2002 | 10/26/2002 | | Ilha das Cobras | Urban | 11 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Ilha das Cobras | Urban | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Ilha das Cobras | Urban | 10 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Ilha das Cobras | Urban | 2 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Ilha das Cobras | Urban | 7 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Ilha das Cobras | Urban | 7 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Ilha das Cobras | Urban | 3 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Ilha das Cobras | Urban | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Ilha das Cobras | Urban | 6 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Mangueira | Urban | 2 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Mangueira | Urban | 2 |
| 37 | 9/8/2002 | 9/14/2002 | PSF | Mangueira | Urban | 1 |
| 39 | 9/22/2002 | 9/28/2002 | ESF | Mangueira | Urban | 1 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Mangueira | Urban | 1 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Mangueira | Urban | 6 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Mangueira | Urban | 2 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Mangueira | Urban | 5 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Mangueira | Urban | 5 |
| 44 | 10/27/2002 | 11/2/2002 | PSF | Mangueira | Urban | 2 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Mangueira | Urban | 11 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Mangueira | Urban | 4 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Mangueira | Urban | 4 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Mangueira | Urban | 4 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Mangueira | Urban | 4 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Mangueira | Urban | 6 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Mangueira | Urban | 3 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Mangueira | Urban | 2 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Mangueira | Urban | 3 |
| | | | | **Total (Urban, Poor)=** | | **137** |
| | | | | **Percent (Urban, Poor)=** | | **60%** |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**In the Mid-to-High-Income Urban Areas**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Cabore | Urban | 1 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Cabore | Urban | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Cabore | Urban | 1 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Cabore | Urban | 2 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Centro | Urban | 1 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Centro | Urban | 2 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Centro | Urban | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Centro | Urban | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Centro | Urban | 1 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Centro | Urban | 1 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Chacara | Urban | 1 |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**In the Mid-to-High-Income Urban Areas (Continued)**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Chacara | Urban | 1 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Chacara | Urban | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Chacara | Urban | 4 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Chacara | Urban | 2 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Chacara | Urban | 4 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Chacara | Urban | 7 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Chacara | Urban | 2 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Chacara | Urban | 3 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Chacara | Urban | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Chacara | Urban | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Chacara | Urban | 5 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Chacara da Saudade | Urban | 1 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Fatima | Urban | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Fatima | Urban | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Fatima | Urban | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Jabaquara | Urban | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Jabaquara | Urban | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Jabaquara | Urban | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Jabaquara | Urban | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Jabaquara | Urban | 4 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Jabaquara | Urban | 2 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Parque Imperial | Urban | 2 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Parque Imperial | Urban | 1 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Patitiba | Urban | 2 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Patitiba | Urban | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Patitiba | Urban | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Patitiba | Urban | 2 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Patitiba | Urban | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Patitiba | Urban | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Patitiba | Urban | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Patitiba | Urban | 2 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Pontal | Urban | 1 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Pontal | Urban | 1 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Pontal | Urban | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Pontal | Urban | 3 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Pontal | Urban | 1 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Pontal | Urban | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Pontal | Urban | 1 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Portal | Urban | 1 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Portao de Ferro | Urban | 1 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Portao de Ferro | Urban | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Portao de Ferro | Urban | 3 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Portao de Ferro | Urban | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Portao de Ferro | Urban | 1 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Portao de Ferro | Urban | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Ribeirinho | Urban | 1 |
| | | | | **Total (Urban, Other)=** | | **91.00** |
| | | | | **Percent (Urban, Other)=** | | **40%** |

| | |
|---|---|
| **Total (Urban) =** | **228** |
| **Percent (Urban) =** | **51%** |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**In the Rural Areas**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Angra dos Reis | Rural | 1 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Barra Grande | Rural | 1 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Barra Grande | Rural | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Barra Grande | Rural | 2 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Boa Vista | Rural | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Cabral | Rural | 2 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Cabral | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Cabral | Rural | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Cachaus | Rural | 1 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Cajaiba | Rural | 2 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Cajaiba | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Cajaiba | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Campinho | Rural | 2 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Canhanheiro | Rural | 1 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Condodo | Rural | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Corisco | Rural | 2 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Corisco | Rural | 2 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Corisco | Rural | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Corisco | Rural | 1 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Corumbe | Rural | 2 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Corumbe | Rural | 1 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Corumbe | Rural | 2 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Corumbe | Rural | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Corumbe | Rural | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Corumbe | Rural | 2 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Corumbe | Rural | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Corumbe | Rural | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Grauna | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Grauna | Rural | 2 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Grauna | Rural | 2 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Ignorado | Rural | 1 |
| 40 | 9/29/2002 | 10/5/2002 | ESF | Ilha do Araujo | Rural | 39 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Ilha do Araujo | Rural | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Ilha do Araujo | Rural | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Joatinga | Rural | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Joatinga | Rural | 1 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Juatinga | Rural | 2 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Laranjeiras | Rural | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Laranjeiras | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Laranjeiras | Rural | 1 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Mamangua | Rural | 1 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Mamanqua | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Matadouro | Rural | 1 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Matadouro | Rural | 2 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Matadouro | Rural | 1 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Olaria | Rural | 2 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Olaria | Rural | 1 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Pantanal | Rural | 1 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Pantanal | Rural | 1 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Pantanal | Rural | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Pantanal | Rural | 1 |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**In the Rural Areas (Continued)**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Pantanal | Rural | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Pantanal | Rural | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Pantanal | Rural | 2 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Pantanal | Rural | 2 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Pantanal | Rural | 1 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Paraty Mirim | Rural | 1 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Paraty Mirim | Rural | 1 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Paraty Mirim | Rural | 2 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Paraty Mirim | Rural | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Paraty Mirim | Rural | 1 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Paraty Mirim | Rural | 2 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Paraty Mirim | Rural | 1 |
| 36 | 9/1/2002 | 9/7/2002 | PSF | Patrimonio | Rural | 2 |
| 37 | 9/8/2002 | 9/14/2002 | PSF | Patrimonio | Rural | 2 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Patrimonio | Rural | 2 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Patrimonio | Rural | 1 |
| 36 | 9/1/2002 | 9/7/2002 | PSF | Pedras Azuis | Rural | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Pedras Azuis | Rural | 2 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Pedras Azuis | Rural | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Penha | Rural | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Penha | Rural | 2 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Penha | Rural | 1 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | Ponta Grossa | Rural | 2 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Ponta Grossa | Rural | 1 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Ponta Grossa | Rural | 2 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Ponta Negra | Rural | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Ponta Negra | Rural | 3 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Ponte Branca | Rural | 1 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | Ponte Branca | Rural | 1 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Ponte Branca | Rural | 1 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | Ponte Branca | Rural | 2 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Ponte Branca | Rural | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Ponte Branca | Rural | 1 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Ponte de Cimento | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Portao da Cajaiba | Rural | 1 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | Portao Vermelho | Rural | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Pouso do Casaiba | Rural | 1 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Praia do Sono | Rural | 1 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | Praia Grande | Rural | 1 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | Praia Grande | Rural | 1 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Praia Grande | Rural | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Praia Grande | Rural | 1 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Praia Grande | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Praia Grande | Rural | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Prainha | Rural | 2 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Rio dos Meros | Rural | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Rio dos Meros | Rural | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Rio Pequeno | Rural | 1 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | Sao Goncalo | Rural | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Sao Goncalo | Rural | 2 |
| 38 | 9/15/2002 | 9/21/2002 | ESF | Sao Roque | Rural | 1 |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**In the Rural Areas (Continued)**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | Sao Roque | Rural | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Sao Roque | Rural | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Sao Roque | Rural | 2 |
| 41 | 10/6/2002 | 10/12/2002 | PSF | Sertao do Taquari | Rural | 7 |
| 42 | 10/13/2002 | 10/19/2002 | PSF | Sertao Qinho | Rural | 1 |
| 38 | 9/15/2002 | 9/21/2002 | ESF | Taquari | Rural | 2 |
| 42 | 10/13/2002 | 10/19/2002 | PSF | Taquari | Rural | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Taquari | Rural | 3 |
| 38 | 9/15/2002 | 9/21/2002 | ESF | Tarituba | Rural | 8 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Tarituba | Rural | 1 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | Tijuca | Rural | 1 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | Trindade | Rural | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Trindade | Rural | 2 |
| 42 | 10/13/2002 | 10/19/2002 | PSF | Vila da Penha | Rural | 1 |
| 36 | 9/1/2002 | 9/7/2002 | PSF | Vila Oratoria | Rural | 1 |
| 38 | 9/15/2002 | 9/21/2002 | ESF | Vila S Vincente | Rural | 1 |
| | | | **Total (Rural) =** | | | **204** |
| | | | **Percent (Rural) =** | | | **46%** |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**From outside population**

| Week No. | Start Date | End Date | U.Saude | Location | Description | No. Cases |
|---|---|---|---|---|---|---|
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | Externo | Other | 1 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | Externo | Other | 1 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | Externo | Other | 1 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | Outro Municipio | Other | 1 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | Outro Municipio | Other | 1 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | Outro Municipio | Other | 5 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | Sao Paulo | Other | 1 |
| | | | **Total (Other) =** | | | **11** |
| | | | **Percent (Other) =** | | | **2%** |

| | |
|---|---|
| **Total =** | **443** |

**Number of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**Summary by Location**

| | | No. Cases | Percent |
|---|---|---|---|
| **Urban =** | | **228** | **51%** |
| | Ilha das Cobras, Mangueira = | 137 | 60% |
| | Other = | 91 | 40% |
| **Rural =** | | **204** | **46%** |
| **Other =** | | **11** | **2%** |
| | | | |
| **Total =** | | **443** | **100%** |

**Morbidity of Diarrhea Cases in the Municipality of Paraty From September 1 to December 28, 2002**
**Summary by Diagnosis (Type of Treatment Plan)**

| Week No. | Start Date | End Date | U.Saude | Plan A | Plan B | Plan C | Plan Ign | Sum |
|---|---|---|---|---|---|---|---|---|
| 36 | 9/1/2002 | 9/7/2002 | PSF | 4 | | | | 4 |
| 36 | 9/1/2002 | 9/7/2002 | HMSPA | 6 | 1 | 2 | 2 | 11 |
| 37 | 9/8/2002 | 9/14/2002 | HMPA | 5 | 1 | | 5 | 11 |
| 37 | 9/8/2002 | 9/14/2002 | PSF | 3 | | | | 3 |
| 38 | 9/15/2002 | 9/21/2002 | HSPA | 4 | | | 5 | 9 |
| 38 | 9/15/2002 | 9/21/2002 | ESF | 12 | | | | 12 |
| 39 | 9/22/2002 | 9/28/2002 | ESF | 9 | | | | 9 |
| 39 | 9/22/2002 | 9/28/2002 | HMSPA | 6 | 2 | | 2 | 10 |
| 40 | 9/29/2002 | 10/5/2002 | ESF | 39 | | | | 39 |
| 40 | 9/29/2002 | 10/5/2002 | HMSPA | 1 | 2 | 3 | 13 | 19 |
| 41 | 10/6/2002 | 10/12/2002 | PSF | 3 | 4 | | | 7 |
| 41 | 10/6/2002 | 10/12/2002 | HMSPA | 4 | | 1 | 4 | 9 |
| 42 | 10/13/2002 | 10/19/2002 | PSF | 3 | | | | 3 |
| 42 | 10/13/2002 | 10/19/2002 | HMSPA | 10 | | 1 | 12 | 23 |
| 43 | 10/20/2002 | 10/26/2002 | | 11 | | | | 11 |
| 43 | 10/20/2002 | 10/26/2002 | HMSPA | 12 | 5 | 1 | 6 | 24 |
| 44 | 10/27/2002 | 11/2/2002 | PSF | 2 | | | | 2 |
| 44 | 10/27/2002 | 11/2/2002 | HMSPA | 16 | | 10 | | 26 |
| 45 | 11/3/2002 | 11/9/2002 | HMSPA/PSF | 24 | | 4 | 13 | 41 |
| 46 | 11/10/2002 | 11/16/2002 | Hospital/PSF | 5 | 2 | 3 | 12 | 22 |
| 47 | 11/17/2002 | 11/23/2002 | HMSPA/PSF | 10 | 2 | 3 | 4 | 19 |
| 48 | 11/24/2002 | 11/30/2002 | HMSPA/ESF | 6 | 12 | 3 | 14 | 35 |
| 49 | 12/1/2002 | 12/7/2002 | HMSPA/ESF | 17 | | 5 | 4 | 26 |
| 50 | 12/8/2002 | 12/14/2002 | HMSPA/ESF | 12 | | 2 | 6 | 20 |
| 51 | 12/15/2002 | 12/21/2002 | HMSPA/ESF | 11 | | | 7 | 18 |
| 52 | 12/22/2002 | 12/28/2002 | HMSPA/ESF | 19 | | 3 | 8 | 30 |
| **Total Number of Cases (by Plan Type) =** | | | | **254** | **31** | **41** | **117** | **443** |
| **Percent Number of Cases (by Plan Type) =** | | | | **57%** | **7%** | **9%** | **26%** | **100%** |

| |
|---|
| Plan A: No sign of dehydration |
| Plan B: Two or more signs of dehydration |
| Plan C: Two or more signs, including one that shows serious dehydration |

## APPENDIX C – Financial Data

**Monthly Water and Sewage Tariff Invoiced and Collected by the City of Paraty from January 2000 to November 2002**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2000** | R$ 49,000 | R$ 39,000 | R$ 57,000 | R$ 46,000 | R$ 32,000 | R$ 31,000 | R$ 46,000 | R$ 38,000 | R$ 23,000 | R$ 41,000 | R$ 40,000 | R$ 63,000 |
| **2001** | R$ 65,000 | R$ 21,000 | R$ 74,000 | R$ 66,000 | R$ 37,000 | R$ 34,000 | R$ 43,000 | R$ 45,000 | R$ 38,000 | R$ 33,000 | R$ 39,000 | R$ 48,000 |
| **2002** | R$ 30,000 | R$ 29,000 | R$ 42,000 | R$ 37,000 | R$ 48,000 | R$ 34,000 | R$ 44,000 | R$ 35,000 | R$ 45,000 | R$ 35,000 | R$ 35,000 | |
| | | | | | | | | | | | | |

| Year | Tot Collected | Tot Invoiced | Collected | Loss |
|---|---|---|---|---|
| **2000** | **R$ 505,000** | **R$ 730,000** | **69%** | **R$ 225,000** |
| **2001** | **R$ 543,000** | **R$ 750,000** | **72%** | **R$ 207,000** |
| **2002** | **R$ 414,000** | **R$ 556,000** | **75%** | **R$ 142,000** |
| **Mean=** | **R$ 487,000** | **R$ 679,000** | **72%** | **R$ 192,000** |

**Information about State Water and Sewer Companies in Brazil**

| State Company | State | State Population (1000) | State Municipalities | Water Connections (1000) | Sewage Connections (1000) | Water network (km) | Sewage Network (km) | Water Coverage (%) | Sewage Coverage (%) | Water Produced (1000 m^3) | Unaccounted-for Water (%) | Water Average Tariff (R$/m^3) | Sewage Average Tariff ($R/m^3) | Employees | Muncipalties Operated by State Company | Company Income, 1997 (US$ million) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CASAN | Santa Catarina | 4,715 | 293 | 740,381 | 42,161 | 12,484 | 499 | 88 | 8 | 253,455 | 33 | 1.17 | 0.98 | 2,549 | 215 | 208 |
| ***CEDAE*** | ***Rio de Janeiro*** | ***13,276*** | ***63*** | ***1,453*** | ***612*** | ***14,527*** | ***4,586*** | ***79*** | ***46*** | ***1,809,144*** | ***52*** | ***0.73*** | ***0.87*** | ***9,703*** | ***63*** | ***1,127*** |
| CESAN | Espirito Santo | 2,786 | 77 | 364 | 68 | 4,666 | 993 | 98 | 15 | 214,710 | 37 | 0.77 | 0.57 | 1,205 | 52 | 117 |
| COPASA | Minas Gerais | 16,215 | 800 | 2,093 | 774 | 26,810 | 7,703 | 97 | 76 | 727,200 | 33 | 0.72 | 0.69 | 9,566 | 423 | 480 |
| CORSAN | Rio Grande do Sul | 9,638 | 423 | 1,327 | 94 | 17,431 | 1,183 | 95 | 10 | 486,187 | 45 | 1.31 | 0.98 | 5,428 | 315 | 343 |
| COSAMA | Amazonas | 2,438 | 62 | 268 | 18 | 2,330 | 257 | 70 | 6 | 137,730 | 59 | 0.96 | 1.43 | 1,242 | 48 | 56 |
| SABESP | Sao Paulo | 32,536 | 645 | 4,601 | 3,276 | 93,020 | 27,818 | 99 | 73 | 2,489,472 | 30 | 0.84 | 0.94 | 19,129 | 370 | 2,706 |
| SANEMAT | Mato Grosso | 2,330 | 126 | 309 | 53 | 6,480 | 616 | 67 | 11 | 167,508 | 53 | 0.98 | 0.64 | 1,257 | 90 | N/A |
| SANEPAR | Paranaln | 7,198 | 396 | 1,717 | 432 | 32,394 | 7,152 | 99 | 30 | 510,213 | 28 | 0.93 | 0.77 | 4,198 | 319 | 439 |
| SANESUL | Mato Grosso do Sul | 1,923 | 77 | 381 | 40 | 5,754 | 506 | 94 | 10 | 142,560 | 47 | 0.78 | 0.61 | 1,445 | 69 | 84 |
| **Average** | | | | | | | | **89** | **28** | | **42** | **0.92** | **0.85** | | | |

# APPENDIX D – Financial Analysis

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 years | |
| **Interest Rate** | 5% /year | 10% /year |
| **Population** | 15,000 capita | |
| **Average Water Tariff (Reference)** | 0.73 R$/m^3 | 15.37 R$/household-month |
| **Average Sewage Tariff (Reference)** | 0.87 R$/m^4 | 18.32 R$/household-month |
| **Tariff Collected/Billed** | 70% | |

| DESIGN PARAMETERS: POPULATION | | | |
|---|---|---|---|
| **Area** | **Average** | | **Peak (Summer)** |
| *Jabaquara* | *1,500 capita* | *3* | 4500 *capita* |
| Historical Center | 3,000 capita | 3 | 9000 capita |
| Mangueira | 4,500 capita | 1 | 4500 capita |
| Ilha das Cobras | 3,000 capita | 1 | 3000 capita |
| Old City | 3,000 capita | 3 | 9000 capita |
| **Total Urban Population** | **15,000 capita** | | **30,000 capita** |
| **Population Growth Rate** | 0.8% /year | | |

| DESIGN PARAMETERS: OTHER | |
|---|---|
| **Household** | 3.9 capita |
| **Consumption** | 0.18 m^3/capita*day |

**CALCULATION OF COSTS FOR WW TREATMENT AND INFRASTRUCTURE**

| **DESIGN PARAMETERS: POPULATION** | | | |
|---|---|---|---|
| **Area** | **Average** | | **Peak (Summer)** |
| Jabaquara | 1,500 capita | 3 | 4,500 capita |
| Historical Center | 3,000 capita | 3 | 9,000 capita |
| Mangueira | 4,500 capita | 1 | 4,500 capita |
| Ilha das Cobras | 3,000 capita | 1 | 3,000 capita |
| Old City | 3,000 capita | 3 | 9,000 capita |
| **Total Urban Population** | **15,000 capita** | **0** | **30,000 capita** |
| **Population Growth Rate** | **0.8% /year** | | |

| **DESIGN PARAMETERS: OTHER** | |
|---|---|
| **Household** | 3.9 capita |
| **Consumption** | 0.18 m^3/capita*day |

| **COSTS PARAMETERS** | |
|---|---|
| Exchange Rate Brazilian to US | 3 R$/US$ |
| Buying Power in US to in Brazil Ratio | 0.3 |
| **US Cost to Brazilian Cost Conversion Factor** | 1.0 R$/US$ |

| **WW DEVELOPMENT STAGES** | |
|---|---|
| **Development Stage 1: Historical Center** | |
| Design Population for Dev. Stage 1 | 9,000 capita |
| **Development Stage 2: Mangueira + Ilha das Cobras** | |
| Design Population for Dev. Stage 2 | 7,500 capita |
| **Development Stage 3: Old City** | |
| Design Population for Dev. Stage 3 | 9,000 capita |

**CALCULATION OF COSTS FOR WW TREATMENT AND INFRASTRUCTURE**

**Development Stage 1: Historical Center**

| **DESIGN PARAMETERS: Stage 1** | |
|---|---|
| **Design Population** | 9,000 capita |
| **Design Flow for WW Treatment CC** | 3,240 m^3/day |
| **Design Flow for WW Infrastructure CC** | 1,620 m^3/day |
| **Design Flow for WW O&M** | 1,620 m^3/day |

| **COSTS: Stage 1** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CEPT CC (2x) | 1,810 | R$1000 | for flow of | 14,000 | m^3/d | 0.23 | 419 | R$1000 | for flow of | 3,240 | m^3/d |
| Disinfection CC (2x) | 1,810 | R$1000 | for flow of | 14,000 | m^3/d | 0.23 | 419 | R$1000 | for flow of | 3,240 | m^3/d |
| Sludge treatment CC (2x) | 320 | R$1000 | for flow of | 14,000 | m^3/d | 0.23 | 74 | R$1000 | for flow of | 3,240 | m^3/d |
| **WW Treatment CC** | | | | | | | **912** | **R$1000** | | | |
| CEPT O&M | 10 | R$1000/yr | for flow of | 14,000 | m^3/d | 0.12 | 1.2 | R$1000/yr | for flow of | 1,620 | m^3/d |
| Disinfection of effluent O&M | 6 | US$1000/yr | for flow of | 1,000 | m^3/d | 1.62 | 10 | R$1000/yr | for flow of | 1,620 | m^3/d |
| Sludge treatment and disposal O&M | 12 | R$1000/yr | for flow of | 14,000 | m^3/d | 0.12 | 1.4 | R$1000/yr | for flow of | 1,620 | m^3/d |
| **WW Treatment O&M** | | | | | | | **13** | **R$1000/yr** | | | |
| Piping, pump stations, manholes, and other | 1,000 | US$1000 | for flow of | 1,620 | m^3/d | 1.00 | 1,026 | R$1000/yr | for flow of | 1,620 | m^3/d |
| **WW Infrastructure CC** | | | | | | | **1,026** | **R$1000** | | | |
| Piping, pump stations, manholes, and other | 150 | US$1000/yr | for flow of | 1,620 | m^3/d | 1.00 | 154 | R$1000/yr | for flow of | 1,620 | m^3/d |
| **WW Infrastructure O&M** | | | | | | | **154** | **R$1000/yr** | | | |

**CALCULATION OF COSTS FOR WW TREATMENT AND INFRASTRUCTURE**

**Development Stage 2: Mangueira and Ilha das Cobras**

| **DESIGN PARAMETERS: Stage 2** | | |
|---|---|---|
| **Additional Population** | 7,500 | capita |
| **Design Flow for WW Treatment & Infrast. CC** | 1,350 | m^3/day |
| **Design Flow for WW O&M** | 2,970 | m^3/day |

| **COSTS: Stage 2** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CEPT CC | 1,810 | R$1000 | for flow of | 14,000 | m^3/d | 0.10 | 175 | R$1000 | for flow of | 1,350 | m^3/d |
| Disinfection CC | 1,810 | R$1000 | for flow of | 14,000 | m^3/d | 0.10 | 175 | R$1000 | for flow of | 1,350 | m^3/d |
| Sludge treatment CC | 320 | R$1000 | for flow of | 14,000 | m^3/d | 0.10 | 31 | R$1000 | for flow of | 1,350 | m^3/d |
| **WW Treatment CC** | | | | | | | **380** | **R$1000** | | | |
| CEPT O&M | 10 | R$1000/yr | for flow of | 14,000 | m^3/d | 0.21 | 2.1 | R$1000/yr | for flow of | 2,970 | m^3/d |
| Disinfection  of effluent O&M | 6 | US$1000/yr | for flow of | 1,000 | m^3/d | 2.97 | 18 | R$1000/yr | for flow of | 2,970 | m^3/d |
| Sludge treatment and disposal O&M | 12 | R$1000/yr | for flow of | 14,000 | m^3/d | 0.21 | 2.5 | R$1000/yr | for flow of | 2,970 | m^3/d |
| **WW Treatment O&M** | | | | | | | **23** | **R$1000/yr** | | | |
| Piping, manholes, and other | 900 | US$1000 | for flow of | 1,620 | m^3/d | 0.83 | 770 | R$1000/yr | for flow of | 1,350 | m^3/d |
| **WW Infrastructure CC** | | | | | | | **770** | **R$1000** | | | |
| Piping, pump stations, manholes, and other | 150 | US$1000/yr | for flow of | 1,620 | m^3/d | 1.83 | 282 | R$1000/yr | for flow of | 2,970 | m^3/d |
| **WW Infrastructure O&M** | | | | | | | **282** | **R$1000/yr** | | | |

**CALCULATION OF COSTS FOR WW TREATMENT AND INFRASTRUCTURE**

**Development Stage 3: Old City and other areas**

| **DESIGN PARAMETERS: Stage 3** | | |
|---|---|---|
| **Additional Population** | 9,000 | capita |
| **Design Flow for WW Infrastructure CC** | 1,620 | m^3/day |
| **Design Flow for WW O&M** | 4,590 | m^3/day |

| **COSTS: Stage 3** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **WW Treatment CC** | | | | | | | **0** | **R$1000** | | | |
| CEPT O&M | 10 | R$1000/yr | for flow of | 14,000 | m^3/d | 0.33 | 3.3 | R$1000/yr | for flow of | 4,590 | m^3/d |
| Disinfection of effluent O&M | 6 | US$1000/yr | for flow of | 1,000 | m^3/d | 4.59 | 28.3 | R$1000/yr | for flow of | 4,590 | m^3/d |
| Sludge treatment and disposal O&M | 12 | R$1000/yr | for flow of | 14,000 | m^3/d | 0.33 | 3.9 | R$1000/yr | for flow of | 4,590 | m^3/d |
| **WW Treatment O&M** | | | | | | | **35** | **R$1000/yr** | | | |
| Piping,manholes, and other | 900 | US$1000 | for flow of | 1,620 | m^3/d | 1.00 | 924 | R$1000/yr | for flow of | 1,620 | m^3/d |
| **WW Infrastructure CC** | | | | | | | **924** | **R$1000** | | | |
| Piping, pump stations, manholes, and other | 150 | US$1000/yr | for flow of | 1,620 | m^3/d | 2.83 | 436 | R$1000/yr | for flow of | 4,590 | m^3/d |
| **WW Infrastructure O&M** | | | | | | | **436** | **R$1000/yr** | | | |

**CALCULATION OF COSTS FOR DW TREATMENT AND INFRASTRUCTURE**

**With Development**

| **DESIGN PARAMETERS: With Development** | | |
|---|---|---|
| **Design Population** | 30,000 | capita |
| **Design Flow for WW CC** | 5,400 | m^3/day |
| **Design Flow for WW O&M** | 5,400 | m^3/day |

| **COSTS: With Development** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Conventional treatment and Chlorine disinfection | 1,300 | US$1000 | for flow of | 6,813 | m^3/d | 0.79 | 1,057 | R$1000 | for flow of | 5,400 | m^3/d |
| **DW Treatment CC** | | | | | | | **1,057** | **R$1000** | | | |
| Conventional treatment and Chlorine disinfection | 486 | US$1000/yr | for flow of | 6,813 | m^3/d | 0.79 | 395 | R$1000/yr | for flow of | 5,400 | m^3/d |
| **DW Treatment O&M** | | | | | | | **395** | **R$1000/yr** | | | |
| **DW Infrastructure CC** | Neglected due to lack of information | | | | | | **0** | **R$1000** | | | |
| **DW Infrastructure O&M** | Neglected due to lack of information | | | | | | **0** | **R$1000/yr** | | | |

| COSTS | | | |
|---|---|---|---|
| **WW Treatment CC (Stage 1)** | 912 | R$1000 | |
| **WW Treatment O&M (Stage 1)** | 13 | R$1000/year | |
| **WW Infrastructure CC (Stage 1)** | 1,026 | R$1000 | |
| **WW Infrastructure O&M (Stage 1)** | 154 | R$1000/year | |
| | | | |
| **WW Treatment CC (Stage 2)** | 380 | R$1000 | |
| **WW Treatment O&M (Stage 2)** | 23 | R$1000/year | |
| **WW Infrastructure CC (Stage 2)** | 770 | R$1000 | |
| **WW Infrastructure O&M (Stage 2)** | 282 | R$1000/year | |
| | | | |
| **WW Treatment CC (Stage 3)** | 0 | R$1000 | |
| **WW Treatment O&M (Stage 3)** | 35 | R$1000/year | |
| **WW Infrastructure CC (Stage 3)** | 924 | R$1000 | |
| **WW Infrastructure O&M (Stage 3)** | 436 | R$1000/year | |
| | | | |
| **DW Treatment CC (w/o development)** | 0 | R$1000 | |
| **DW Treatment O&M (w/o development)** | 0 | R$1000/year | Neglected due to lack of information |
| **DW Infrastructure CC (w/o development)** | 0 | R$1000 | |
| **DW Infrastructure O&M (w/o development)** | 0 | R$1000/year | Neglected due to lack of information |
| | | | |
| **DW Treatment CC (w/ development)** | 1,057 | R$1000 | |
| **DW Treatment O&M (w/ development)** | 395 | R$1000/year | |
| **DW Infrastructure CC (w/ development)** | 0 | R$1000 | Neglected due to lack of information |
| **DW Infrastructure O&M (w/ development)** | 0 | R$1000/year | Neglected due to lack of information |

**COST ANALYSIS**

**CALCULATION OF WATER AND SEWAGE TARIFF REQUIRED WHEN BENEFIT:COST RATIO = 1.**

| Scenario | Equivalent Uniform Annual Cost (R$1000) | | Equivalent Uniform Annual Benefit (R$1000) | | Break-Even Water and Sewage Tariff (R$/m^3) | | NPV of Annual Net Benefit | | NPV of Annual Cash Flow (R$1000) | | IRR of Annual Cash Flow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% |
| 1 | 1,086 | 1,226 | 1,086 | 1,226 | 1.57 | 1.78 | 0 | 0 | 95 | 222 | 5% | 11% |
| 2 | 976 | 1,058 | 976 | 1,058 | 1.42 | 1.53 | 0 | 0 | 6 | 157 | 5% | 11% |
| 3 | 955 | 1,030 | 955 | 1,030 | 1.38 | 1.49 | 0 | 0 | -7 | 149 | 5% | 11% |
| 4 | 934 | 1,004 | 934 | 1,004 | 1.35 | 1.46 | 0 | 0 | -20 | 142 | 5% | 11% |

**WATER AND SEWAGE TARIFF (R$/m^3)**

| Scenario | I = 5% | I = 10% |
|---|---|---|
| 1 | | |
| 2 | 1.42 | 1.53 |
| 3 | 1.38 | 1.49 |
| 4 | 1.35 | 1.46 |

**ANALYSIS OF WATER AND SEWAGE TARIFF = R$ 1.60/ m^3**

| Scenario | Equivalent Uniform Annual Cost (R$1000) | | Equivalent Uniform Annual Benefit (R$1000) | | Benefit:Cost Ratio | | NPV of Annual Net Benefit | | NPV of Annual Cash Flow (R$1000) | | IRR of Annual Cash Flow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% | I = 5% | I = 10% |
| 1 | 1,086 | 1,226 | 1,209 | 1,185 | 1.1 | 1.0 | 1,899 | (391) | 1903 | -134 | 9% | 9% |
| 2 | 976 | 1,058 | 1,209 | 1,185 | 1.2 | 1.1 | 3,583 | 1,197 | 3418 | 1245 | 18% | 18% |
| 3 | 955 | 1,030 | 1,209 | 1,185 | 1.3 | 1.2 | 3,915 | 1,463 | 3722 | 1479 | 20% | 20% |
| 4 | 934 | 1,004 | 1,209 | 1,185 | 1.3 | 1.2 | 4,232 | 1,705 | 4011 | 1692 | 22% | 22% |

**BENEFIT:COST RATIO WHEN WATER AND SEWAGE TARIFF = R$1.60/m^3**

| Scenario | I = 5% | I = 10% |
|---|---|---|
| 1 | | |
| 2 | 1.2 | 1.1 |
| 3 | 1.3 | 1.2 |
| 4 | 1.3 | 1.2 |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 5% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 2 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 3 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 4 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 5 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 6 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 7 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 1,086 | R$1000 | | |
| **Total Amount to Bill** | 1551 | R$1000 | | |
| **Water & Sewage Tariff** | 1.57 | R$/m^3 | 33 | R$/household-month |
| **Water& Sewage Tariff**<br>(Previously set by CEDAE) | 1.60 | R$/m^3 | 34 | R$/household-month |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | 95 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! |
| 367 | 1,086 | 586 | 719 | (1,316) | (230) | #NUM! |
| 566 | 1,086 | 1,135 | 520 | (1,229) | (143) | #NUM! |
| 801 | 1,086 | 1,477 | 285 | (1,529) | (443) | #NUM! |
| 1,197 | 1,086 | 1,440 | (111) | (867) | 219 | #NUM! |
| 1,197 | 1,086 | 1,401 | (111) | (867) | 219 | #NUM! |
| 1,197 | 1,086 | 1,360 | (111) | (867) | 219 | #NUM! |
| 1,197 | 1,086 | 1,317 | (111) | (867) | 219 | #NUM! |
| 1,197 | 1,086 | 1,272 | (111) | (867) | 219 | #NUM! |
| 1,197 | 1,086 | 1,225 | (111) | (867) | 219 | -12% |
| 1,197 | 1,086 | 1,176 | (111) | (867) | 219 | -9% |
| 1,197 | 1,086 | 1,124 | (111) | (867) | 219 | -6% |
| 1,197 | 1,086 | 1,069 | (111) | (867) | 219 | -4% |
| 1,197 | 1,086 | 1,012 | (111) | (867) | 219 | -3% |
| 1,197 | 1,086 | 951 | (111) | (867) | 219 | -2% |
| 1,197 | 1,086 | 888 | (111) | (867) | 219 | -1% |
| 1,197 | 1,086 | 822 | (111) | (867) | 219 | 0% |
| 1,197 | 1,086 | 752 | (111) | (867) | 219 | 1% |
| 1,197 | 1,086 | 679 | (111) | (867) | 219 | 2% |
| 1,197 | 1,086 | 602 | (111) | (867) | 219 | 2% |
| 1,197 | 1,086 | 521 | (111) | (867) | 219 | 3% |
| 1,197 | 1,086 | 436 | (111) | (867) | 219 | 3% |
| 1,197 | 1,086 | 347 | (111) | (867) | 219 | 4% |
| 1,197 | 1,086 | 254 | (111) | (867) | 219 | 4% |
| 1,197 | 1,086 | 156 | (111) | (867) | 219 | 4% |
| 1,197 | 1,086 | 53 | (111) | (867) | 219 | 4% |
| 1,197 | 1,086 | (55) | (111) | (867) | 219 | 5% |
| 1,197 | 1,086 | (169) | (111) | (867) | 219 | 5% |
| 1,197 | 1,086 | (288) | (111) | (867) | 219 | 5% |
| 1,197 | 1,086 | (413) | (111) | (867) | 219 | 5% |
| 1,197 | 1,086 | (545) | (111) | (867) | 219 | 5% |
| **$16,693** | **$16,693** | | **($0)** | | **$95** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 10% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 2 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 3 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 4 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 5 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 6 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 7 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 1,226 | R$1000 | | |
| **Total Amount to Bill** | 1752 | R$1000 | | |
| **Water & Sewage Tariff** | 1.78 | R$/m^3 | 37 | R$/household-month |
| **Water& Sewage Tariff** (Previously set by CEDAE) | 1.60 | R$/m^3 | 34 | R$/household-month |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | 222 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! |
| 494 | 1,226 | 506 | 732 | (1,316) | (90) | #NUM! |
| 731 | 1,226 | 1,052 | 496 | (1,229) | (3) | #NUM! |
| 1,009 | 1,226 | 1,374 | 217 | (1,529) | (303) | #NUM! |
| 1,405 | 1,226 | 1,333 | (178) | (867) | 359 | #NUM! |
| 1,405 | 1,226 | 1,288 | (178) | (867) | 359 | #NUM! |
| 1,405 | 1,226 | 1,239 | (178) | (867) | 359 | -16% |
| 1,405 | 1,226 | 1,184 | (178) | (867) | 359 | -9% |
| 1,405 | 1,226 | 1,124 | (178) | (867) | 359 | -5% |
| 1,405 | 1,226 | 1,058 | (178) | (867) | 359 | -1% |
| 1,405 | 1,226 | 986 | (178) | (867) | 359 | 1% |
| 1,405 | 1,226 | 906 | (178) | (867) | 359 | 3% |
| 1,405 | 1,226 | 818 | (178) | (867) | 359 | 4% |
| 1,405 | 1,226 | 721 | (178) | (867) | 359 | 6% |
| 1,405 | 1,226 | 615 | (178) | (867) | 359 | 7% |
| 1,405 | 1,226 | 498 | (178) | (867) | 359 | 7% |
| 1,405 | 1,226 | 370 | (178) | (867) | 359 | 8% |
| 1,405 | 1,226 | 228 | (178) | (867) | 359 | 8% |
| 1,405 | 1,226 | 73 | (178) | (867) | 359 | 9% |
| 1,405 | 1,226 | (99) | (178) | (867) | 359 | 9% |
| 1,405 | 1,226 | (287) | (178) | (867) | 359 | 10% |
| 1,405 | 1,226 | (494) | (178) | (867) | 359 | 10% |
| 1,405 | 1,226 | (722) | (178) | (867) | 359 | 10% |
| 1,405 | 1,226 | (972) | (178) | (867) | 359 | 10% |
| 1,405 | 1,226 | (1,248) | (178) | (867) | 359 | 10% |
| 1,405 | 1,226 | (1,551) | (178) | (867) | 359 | 11% |
| 1,405 | 1,226 | (1,885) | (178) | (867) | 359 | 11% |
| 1,405 | 1,226 | (2,252) | (178) | (867) | 359 | 11% |
| 1,405 | 1,226 | (2,655) | (178) | (867) | 359 | 11% |
| 1,405 | 1,226 | (3,099) | (178) | (867) | 359 | 11% |
| 1,405 | 1,226 | (3,588) | (178) | (867) | 359 | 11% |
| **$11,560** | **$11,560** | | **($0)** | | **$222** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 5% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | | | | | 0 | 126 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 201 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 6 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 7 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 976 | R$1000 | | |
| **Total Amount to Bill** | 1395 | R$1000 | | |
| **Water & Sewage Tariff** | 1.42 | R$/m^3 | 30 | R$/household-month |
| **Water& Sewage Tariff** (Previously set by CEDAE) | 1.60 | R$/m^3 | 34 | R$/household-month |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | 6 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! |
| 293 | 976 | 551 | 684 | (166) | 810 | #NUM! |
| 367 | 976 | 1,188 | 609 | (1,316) | (340) | #NUM! |
| 506 | 976 | 1,718 | 470 | (305) | 671 | -23% |
| 566 | 976 | 2,214 | 410 | (1,229) | (252) | #NUM! |
| 733 | 976 | 2,568 | 244 | (472) | 505 | -11% |
| 801 | 976 | 2,872 | 175 | (1,529) | (553) | #NUM! |
| 1,197 | 976 | 2,795 | (220) | (867) | 109 | #NUM! |
| 1,197 | 976 | 2,714 | (220) | (867) | 109 | -22% |
| 1,197 | 976 | 2,630 | (220) | (867) | 109 | -15% |
| 1,197 | 976 | 2,541 | (220) | (867) | 109 | -10% |
| 1,197 | 976 | 2,448 | (220) | (867) | 109 | -7% |
| 1,197 | 976 | 2,350 | (220) | (867) | 109 | -5% |
| 1,197 | 976 | 2,247 | (220) | (867) | 109 | -3% |
| 1,197 | 976 | 2,139 | (220) | (867) | 109 | -2% |
| 1,197 | 976 | 2,025 | (220) | (867) | 109 | -1% |
| 1,197 | 976 | 1,906 | (220) | (867) | 109 | 0% |
| 1,197 | 976 | 1,781 | (220) | (867) | 109 | 1% |
| 1,197 | 976 | 1,650 | (220) | (867) | 109 | 1% |
| 1,197 | 976 | 1,512 | (220) | (867) | 109 | 2% |
| 1,197 | 976 | 1,367 | (220) | (867) | 109 | 2% |
| 1,197 | 976 | 1,215 | (220) | (867) | 109 | 3% |
| 1,197 | 976 | 1,055 | (220) | (867) | 109 | 3% |
| 1,197 | 976 | 888 | (220) | (867) | 109 | 4% |
| 1,197 | 976 | 712 | (220) | (867) | 109 | 4% |
| 1,197 | 976 | 527 | (220) | (867) | 109 | 4% |
| 1,197 | 976 | 333 | (220) | (867) | 109 | 4% |
| 1,197 | 976 | 129 | (220) | (867) | 109 | 5% |
| 1,197 | 976 | (84) | (220) | (867) | 109 | 5% |
| 1,197 | 976 | (309) | (220) | (867) | 109 | 5% |
| 1,197 | 976 | (545) | (220) | (867) | 109 | 5% |
| **$15,009** | **$15,009** | | **($0)** | | **$6** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 10% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | | | | | 0 | 206 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 328 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 6 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 7 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| Annual Revenue Req'd | 1,058 | R$1000 | | |
| Total Amount to Bill | 1511 | R$1000 | | |
| Water & Sewage Tariff | 1.53 | R$/m^3 | 32 | R$/household-month |
| Water& Sewage Tariff<br>(Previously set by CEDAE) | 1.60 | R$/m^3 | 34 | R$/household-month |
| NPV of Net Benefit | 0 | R$1000 | | |
| NPV of Net Cash Flow | 157 | R$1000 | | |
| Benefit:Cost Ratio | 1 | | | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! |
| 372 | 1,058 | 460 | 686 | (166) | 891 | #NUM! |
| 494 | 1,058 | 1,069 | 564 | (1,316) | (258) | #NUM! |
| 633 | 1,058 | 1,601 | 425 | (305) | 753 | -15% |
| 731 | 1,058 | 2,089 | 327 | (1,229) | (171) | -24% |
| 897 | 1,058 | 2,458 | 161 | (472) | 586 | -3% |
| 1,009 | 1,058 | 2,752 | 48 | (1,529) | (471) | #NUM! |
| 1,405 | 1,058 | 2,681 | (347) | (867) | 191 | -10% |
| 1,405 | 1,058 | 2,602 | (347) | (867) | 191 | -4% |
| 1,405 | 1,058 | 2,515 | (347) | (867) | 191 | -1% |
| 1,405 | 1,058 | 2,420 | (347) | (867) | 191 | 2% |
| 1,405 | 1,058 | 2,315 | (347) | (867) | 191 | 4% |
| 1,405 | 1,058 | 2,200 | (347) | (867) | 191 | 5% |
| 1,405 | 1,058 | 2,073 | (347) | (867) | 191 | 6% |
| 1,405 | 1,058 | 1,933 | (347) | (867) | 191 | 7% |
| 1,405 | 1,058 | 1,780 | (347) | (867) | 191 | 8% |
| 1,405 | 1,058 | 1,611 | (347) | (867) | 191 | 8% |
| 1,405 | 1,058 | 1,425 | (347) | (867) | 191 | 9% |
| 1,405 | 1,058 | 1,220 | (347) | (867) | 191 | 9% |
| 1,405 | 1,058 | 996 | (347) | (867) | 191 | 10% |
| 1,405 | 1,058 | 748 | (347) | (867) | 191 | 10% |
| 1,405 | 1,058 | 476 | (347) | (867) | 191 | 10% |
| 1,405 | 1,058 | 177 | (347) | (867) | 191 | 10% |
| 1,405 | 1,058 | (152) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (514) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (913) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (1,351) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (1,833) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (2,363) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (2,946) | (347) | (867) | 191 | 11% |
| 1,405 | 1,058 | (3,588) | (347) | (867) | 191 | 11% |
| **$9,972** | **$9,972** | | **($0)** | | **$157** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 5% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | | | | | 0 | 126 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 201 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 261 | 35 | 436 | 0 | 472 |
| 7 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 8 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 955 | R$1000 | | |
| **Total Amount to Bill** | 1,364 | R$1000 | | |
| **Break-even Tariff** | 1.38 | R$/m^3 | 29 | R$/household-month |
| **Water& Sewage Tariff** | 1.60 | R$/m^3 | 34 | R$/household-month |
| (Previously set by CEDAE) | | | | |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | -7 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! |
| 293 | 955 | 530 | 662 | (166) | 788 | #NUM! |
| 367 | 955 | 1,144 | 587 | (1,316) | (361) | #NUM! |
| 506 | 955 | 1,650 | 449 | (305) | 650 | -25% |
| 566 | 955 | 2,121 | 389 | (1,229) | (274) | #NUM! |
| 733 | 955 | 2,449 | 222 | (472) | 483 | -13% |
| 733 | 955 | 2,794 | 222 | (472) | 483 | -3% |
| 801 | 955 | 3,087 | 153 | (1,529) | (574) | #NUM! |
| 1,197 | 955 | 2,999 | (242) | (867) | 88 | -17% |
| 1,197 | 955 | 2,907 | (242) | (867) | 88 | -11% |
| 1,197 | 955 | 2,810 | (242) | (867) | 88 | -8% |
| 1,197 | 955 | 2,709 | (242) | (867) | 88 | -6% |
| 1,197 | 955 | 2,602 | (242) | (867) | 88 | -4% |
| 1,197 | 955 | 2,490 | (242) | (867) | 88 | -2% |
| 1,197 | 955 | 2,373 | (242) | (867) | 88 | -1% |
| 1,197 | 955 | 2,250 | (242) | (867) | 88 | 0% |
| 1,197 | 955 | 2,120 | (242) | (867) | 88 | 0% |
| 1,197 | 955 | 1,984 | (242) | (867) | 88 | 1% |
| 1,197 | 955 | 1,841 | (242) | (867) | 88 | 2% |
| 1,197 | 955 | 1,691 | (242) | (867) | 88 | 2% |
| 1,197 | 955 | 1,534 | (242) | (867) | 88 | 3% |
| 1,197 | 955 | 1,369 | (242) | (867) | 88 | 3% |
| 1,197 | 955 | 1,195 | (242) | (867) | 88 | 3% |
| 1,197 | 955 | 1,013 | (242) | (867) | 88 | 4% |
| 1,197 | 955 | 822 | (242) | (867) | 88 | 4% |
| 1,197 | 955 | 621 | (242) | (867) | 88 | 4% |
| 1,197 | 955 | 410 | (242) | (867) | 88 | 4% |
| 1,197 | 955 | 188 | (242) | (867) | 88 | 5% |
| 1,197 | 955 | (44) | (242) | (867) | 88 | 5% |
| 1,197 | 955 | (288) | (242) | (867) | 88 | 5% |
| 1,197 | 955 | (545) | (242) | (867) | 88 | 5% |
| **$14,677** | **$14,677** | | **($0)** | | **($7)** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 10% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | | | | | 0 | 206 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 328 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 426 | 35 | 436 | 0 | 472 |
| 7 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 8 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 1,030 | R$1000 | | |
| **Total Amount to Bill** | 1,471 | R$1000 | | |
| **Break-even Tariff** | 1.49 | R$/m^3 | 31 | R$/household-month |
| **Water& Sewage Tariff** | 1.60 | R$/m^3 | 34 | R$/household-month |
| (Previously set by CEDAE) | | | | |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | 149 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! |
| 372 | 1,030 | 431 | 658 | (166) | 863 | #NUM! |
| 494 | 1,030 | 1,010 | 536 | (1,316) | (287) | #NUM! |
| 633 | 1,030 | 1,508 | 397 | (305) | 724 | -18% |
| 731 | 1,030 | 1,958 | 299 | (1,229) | (199) | -30% |
| 897 | 1,030 | 2,286 | 132 | (472) | 558 | -5% |
| 897 | 1,030 | 2,647 | 132 | (472) | 558 | 4% |
| 1,009 | 1,030 | 2,932 | 20 | (1,529) | (500) | -5% |
| 1,405 | 1,030 | 2,850 | (375) | (867) | 163 | -1% |
| 1,405 | 1,030 | 2,759 | (375) | (867) | 163 | 2% |
| 1,405 | 1,030 | 2,660 | (375) | (867) | 163 | 3% |
| 1,405 | 1,030 | 2,551 | (375) | (867) | 163 | 5% |
| 1,405 | 1,030 | 2,431 | (375) | (867) | 163 | 6% |
| 1,405 | 1,030 | 2,299 | (375) | (867) | 163 | 7% |
| 1,405 | 1,030 | 2,154 | (375) | (867) | 163 | 8% |
| 1,405 | 1,030 | 1,994 | (375) | (867) | 163 | 8% |
| 1,405 | 1,030 | 1,819 | (375) | (867) | 163 | 9% |
| 1,405 | 1,030 | 1,625 | (375) | (867) | 163 | 9% |
| 1,405 | 1,030 | 1,413 | (375) | (867) | 163 | 10% |
| 1,405 | 1,030 | 1,179 | (375) | (867) | 163 | 10% |
| 1,405 | 1,030 | 922 | (375) | (867) | 163 | 10% |
| 1,405 | 1,030 | 639 | (375) | (867) | 163 | 10% |
| 1,405 | 1,030 | 328 | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (15) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (391) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (806) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (1,261) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (1,762) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (2,314) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (2,920) | (375) | (867) | 163 | 11% |
| 1,405 | 1,030 | (3,588) | (375) | (867) | 163 | 11% |
| **$9,706** | **$9,706** | | **($0)** | | **$149** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 5% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |

| **Year** | | **WW Treat CC** | **WW Infrast CC** | **DW Treat CC** | **Total CC** | **Total CC Amortized** | **WW Treat O&M** | **WW Infrast O&M** | **DW Treat O&M** | **Total O&M** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | | | | | 0 | 126 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 201 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 261 | 35 | 436 | 0 | 472 |
| 7 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 8 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 934 | R$1000 | | |
| **Total Amount to Bill** | 1,335 | R$1000 | | |
| **Break-even Tariff** | 1.35 | R$/m^3 | 29 | R$/household-month |
| **Water& Sewage Tariff** (Previously set by CEDAE) | 1.60 | R$/m^3 | 34 | R$/household-month |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | -20 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! |
| 293 | 934 | 509 | 642 | (166) | 768 | #NUM! |
| 367 | 934 | 1,102 | 567 | (1,316) | (382) | #NUM! |
| 506 | 934 | 1,585 | 428 | (305) | 629 | -27% |
| 566 | 934 | 2,032 | 368 | (1,229) | (295) | #NUM! |
| 733 | 934 | 2,335 | 202 | (472) | 463 | -16% |
| 733 | 934 | 2,653 | 202 | (472) | 463 | -4% |
| 733 | 934 | 2,988 | 202 | (472) | 463 | 2% |
| 801 | 934 | 3,270 | 133 | (1,529) | (595) | -8% |
| 1,197 | 934 | 3,171 | (263) | (867) | 67 | -6% |
| 1,197 | 934 | 3,067 | (263) | (867) | 67 | -5% |
| 1,197 | 934 | 2,958 | (263) | (867) | 67 | -3% |
| 1,197 | 934 | 2,843 | (263) | (867) | 67 | -2% |
| 1,197 | 934 | 2,722 | (263) | (867) | 67 | -1% |
| 1,197 | 934 | 2,596 | (263) | (867) | 67 | 0% |
| 1,197 | 934 | 2,463 | (263) | (867) | 67 | 0% |
| 1,197 | 934 | 2,324 | (263) | (867) | 67 | 1% |
| 1,197 | 934 | 2,177 | (263) | (867) | 67 | 2% |
| 1,197 | 934 | 2,024 | (263) | (867) | 67 | 2% |
| 1,197 | 934 | 1,862 | (263) | (867) | 67 | 2% |
| 1,197 | 934 | 1,693 | (263) | (867) | 67 | 3% |
| 1,197 | 934 | 1,515 | (263) | (867) | 67 | 3% |
| 1,197 | 934 | 1,328 | (263) | (867) | 67 | 3% |
| 1,197 | 934 | 1,132 | (263) | (867) | 67 | 4% |
| 1,197 | 934 | 926 | (263) | (867) | 67 | 4% |
| 1,197 | 934 | 710 | (263) | (867) | 67 | 4% |
| 1,197 | 934 | 483 | (263) | (867) | 67 | 4% |
| 1,197 | 934 | 244 | (263) | (867) | 67 | 4% |
| 1,197 | 934 | (6) | (263) | (867) | 67 | 5% |
| 1,197 | 934 | (269) | (263) | (867) | 67 | 5% |
| 1,197 | 934 | (545) | (263) | (867) | 67 | 5% |
| **$14,360** | **$14,360** | | **($0)** | | **($20)** | |

| FINANCIAL ANALYSIS PARAMETERS | | |
|---|---|---|
| **Project Life** | 30 | years |
| **Interest Rate** | 10% | /year |
| **Population** | 15,000 | capita |
| **Population Growth Rate** | 0.8% | /year |
| **Household** | 3.9 | capita |
| **Consumption** | 0.18 | m^3/capita*day |
| **Tariff Collected/Billed** | 70% | |
| | | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | | | | | 0 | 206 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 328 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 426 | 35 | 436 | 0 | 472 |
| 7 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 8 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| TARIFF REQUIRED TO BREAK-EVEN AT YEAR 30 | | | | |
|---|---|---|---|---|
| **Annual Revenue Req'd** | 1,004 | R$1000 | | |
| **Total Amount to Bill** | 1,434 | R$1000 | | |
| **Break-even Tariff** | 1.46 | R$/m^3 | 31 | R$/household-month |
| **Water& Sewage Tariff** | 1.60 | R$/m^3 | 34 | R$/household-month |
| (Previously set by CEDAE) | | | | |
| **NPV of Net Benefit** | 0 | R$1000 | | |
| **NPV of Net Cash Flow** | 142 | R$1000 | | |
| **Benefit:Cost Ratio** | 1 | | | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** |
|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! |
| 372 | 1,004 | 406 | 632 | (166) | 837 | #NUM! |
| 494 | 1,004 | 956 | 510 | (1,316) | (312) | #NUM! |
| 633 | 1,004 | 1,423 | 371 | (305) | 699 | -20% |
| 731 | 1,004 | 1,838 | 273 | (1,229) | (225) | #NUM! |
| 897 | 1,004 | 2,129 | 107 | (472) | 532 | -8% |
| 897 | 1,004 | 2,449 | 107 | (472) | 532 | 2% |
| 897 | 1,004 | 2,800 | 107 | (472) | 532 | 8% |
| 1,009 | 1,004 | 3,075 | (5) | (1,529) | (525) | 2% |
| 1,405 | 1,004 | 2,981 | (401) | (867) | 137 | 4% |
| 1,405 | 1,004 | 2,879 | (401) | (867) | 137 | 5% |
| 1,405 | 1,004 | 2,766 | (401) | (867) | 137 | 6% |
| 1,405 | 1,004 | 2,642 | (401) | (867) | 137 | 7% |
| 1,405 | 1,004 | 2,505 | (401) | (867) | 137 | 8% |
| 1,405 | 1,004 | 2,355 | (401) | (867) | 137 | 8% |
| 1,405 | 1,004 | 2,190 | (401) | (867) | 137 | 9% |
| 1,405 | 1,004 | 2,008 | (401) | (867) | 137 | 9% |
| 1,405 | 1,004 | 1,808 | (401) | (867) | 137 | 10% |
| 1,405 | 1,004 | 1,588 | (401) | (867) | 137 | 10% |
| 1,405 | 1,004 | 1,346 | (401) | (867) | 137 | 10% |
| 1,405 | 1,004 | 1,080 | (401) | (867) | 137 | 10% |
| 1,405 | 1,004 | 787 | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | 465 | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | 110 | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (280) | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (708) | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (1,180) | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (1,699) | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (2,269) | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (2,897) | (401) | (867) | 137 | 11% |
| 1,405 | 1,004 | (3,588) | (401) | (867) | 137 | 11% |
| **$9,464** | **$9,464** | | **($0)** | | **$142** | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 5% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| **Year** | | **WW Treat CC** | **WW Infrast CC** | **DW Treat CC** | **Total CC** | **Total CC Amortized** | **WW Treat O&M** | **WW Infrast O&M** | **DW Treat O&M** | **Total O&M** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 2 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 3 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 4 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 5 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 6 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 7 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| EUANB (Annual Revenue) | 1,209 | R$1000 |
| NPV of Net Benefit | 1,899 | R$1000 |
| NPV of Net Cash Flow | 1,903 | R$1000 |
| IRR of Net Cash Flow | 9% | |
| Benefit:Cost Ratio | 1.1 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 367 | 1,113 | 613 | 745 | (1,316) | (204) | #NUM! | 15,120 | 993,384 | 1.60 |
| 566 | 1,121 | 1,199 | 555 | (1,229) | (107) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 801 | 1,130 | 1,588 | 329 | (1,529) | (399) | #NUM! | 15,360 | 1,009,152 | 1.60 |
| 1,197 | 1,139 | 1,609 | (58) | (867) | 272 | #NUM! | 15,480 | 1,017,036 | 1.60 |
| 1,197 | 1,148 | 1,641 | (49) | (867) | 281 | #NUM! | 15,600 | 1,024,920 | 1.60 |
| 1,197 | 1,157 | 1,683 | (40) | (867) | 290 | -23% | 15,720 | 1,032,804 | 1.60 |
| 1,197 | 1,166 | 1,736 | (31) | (867) | 299 | -16% | 15,840 | 1,040,688 | 1.60 |
| 1,197 | 1,174 | 1,800 | (22) | (867) | 307 | -10% | 15,960 | 1,048,572 | 1.60 |
| 1,197 | 1,183 | 1,877 | (14) | (867) | 316 | -7% | 16,080 | 1,056,456 | 1.60 |
| 1,197 | 1,192 | 1,966 | (5) | (867) | 325 | -4% | 16,200 | 1,064,340 | 1.60 |
| 1,197 | 1,201 | 2,069 | 4 | (867) | 334 | -1% | 16,320 | 1,072,224 | 1.60 |
| 1,197 | 1,210 | 2,185 | 13 | (867) | 343 | 1% | 16,440 | 1,080,108 | 1.60 |
| 1,197 | 1,219 | 2,316 | 22 | (867) | 352 | 2% | 16,560 | 1,087,992 | 1.60 |
| 1,197 | 1,227 | 2,463 | 31 | (867) | 360 | 3% | 16,680 | 1,095,876 | 1.60 |
| 1,197 | 1,236 | 2,625 | 39 | (867) | 369 | 4% | 16,800 | 1,103,760 | 1.60 |
| 1,197 | 1,245 | 2,805 | 48 | (867) | 378 | 5% | 16,920 | 1,111,644 | 1.60 |
| 1,197 | 1,254 | 3,002 | 57 | (867) | 387 | 6% | 17,040 | 1,119,528 | 1.60 |
| 1,197 | 1,263 | 3,218 | 66 | (867) | 396 | 6% | 17,160 | 1,127,412 | 1.60 |
| 1,197 | 1,272 | 3,454 | 75 | (867) | 405 | 7% | 17,280 | 1,135,296 | 1.60 |
| 1,197 | 1,280 | 3,710 | 84 | (867) | 413 | 7% | 17,400 | 1,143,180 | 1.60 |
| 1,197 | 1,289 | 3,988 | 92 | (867) | 422 | 8% | 17,520 | 1,151,064 | 1.60 |
| 1,197 | 1,298 | 4,289 | 101 | (867) | 431 | 8% | 17,640 | 1,158,948 | 1.60 |
| 1,197 | 1,307 | 4,614 | 110 | (867) | 440 | 8% | 17,760 | 1,166,832 | 1.60 |
| 1,197 | 1,316 | 4,963 | 119 | (867) | 449 | 9% | 17,880 | 1,174,716 | 1.60 |
| 1,197 | 1,325 | 5,339 | 128 | (867) | 458 | 9% | 18,000 | 1,182,600 | 1.60 |
| 1,197 | 1,333 | 5,743 | 137 | (867) | 466 | 9% | 18,120 | 1,190,484 | 1.60 |
| 1,197 | 1,342 | 6,175 | 145 | (867) | 475 | 9% | 18,240 | 1,198,368 | 1.60 |
| 1,197 | 1,351 | 6,638 | 154 | (867) | 484 | 9% | 18,360 | 1,206,252 | 1.60 |
| 1,197 | 1,360 | 7,133 | 163 | (867) | 493 | 9% | 18,480 | 1,214,136 | 1.60 |
| 1,197 | 1,369 | 7,662 | 172 | (867) | 502 | 9% | 18,600 | 1,222,020 | 1.60 |
| **$16,693** | **$18,592** | | **$1,899** | | **$1,903** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| Project Life | 30 | years | Consumption | 0.18 | m^3/capita*day |
| Interest Rate | 10% | /year | Tariff Collected/Billed | 70% | |
| Population | 15,000 | capita | Water& Sewage Tariff | 1.60 | R$/m^3 |
| Population Growth Rate | 0.8% | /year | (Previously set by CEDAE) | | |
| Household | 3.9 | capita | | | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 2 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 3 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 4 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 5 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 6 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 7 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| NPV= | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| EUANB (Annual Revenue) | 1,185 | R$1000 |
| NPV of Net Benefit | (391) | R$1000 |
| NPV of Net Cash Flow | (134) | R$1000 |
| IRR of Net Cash Flow | 9% | |
| Benefit:Cost Ratio | 1.0 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 494 | 1,113 | 392 | 619 | (1,316) | (204) | #NUM! | 15,120 | 993,384 | 1.60 |
| 731 | 1,121 | 822 | 391 | (1,229) | (107) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 1,009 | 1,130 | 1,025 | 121 | (1,529) | (399) | #NUM! | 15,360 | 1,009,152 | 1.60 |
| 1,405 | 1,139 | 862 | (266) | (867) | 272 | #NUM! | 15,480 | 1,017,036 | 1.60 |
| 1,405 | 1,148 | 692 | (257) | (867) | 281 | #NUM! | 15,600 | 1,024,920 | 1.60 |
| 1,405 | 1,157 | 513 | (248) | (867) | 290 | -23% | 15,720 | 1,032,804 | 1.60 |
| 1,405 | 1,166 | 325 | (239) | (867) | 299 | -16% | 15,840 | 1,040,688 | 1.60 |
| 1,405 | 1,174 | 128 | (230) | (867) | 307 | -10% | 15,960 | 1,048,572 | 1.60 |
| 1,405 | 1,183 | (81) | (221) | (867) | 316 | -7% | 16,080 | 1,056,456 | 1.60 |
| 1,405 | 1,192 | (302) | (213) | (867) | 325 | -4% | 16,200 | 1,064,340 | 1.60 |
| 1,405 | 1,201 | (536) | (204) | (867) | 334 | -1% | 16,320 | 1,072,224 | 1.60 |
| 1,405 | 1,210 | (785) | (195) | (867) | 343 | 1% | 16,440 | 1,080,108 | 1.60 |
| 1,405 | 1,219 | (1,049) | (186) | (867) | 352 | 2% | 16,560 | 1,087,992 | 1.60 |
| 1,405 | 1,227 | (1,331) | (177) | (867) | 360 | 3% | 16,680 | 1,095,876 | 1.60 |
| 1,405 | 1,236 | (1,633) | (168) | (867) | 369 | 4% | 16,800 | 1,103,760 | 1.60 |
| 1,405 | 1,245 | (1,956) | (160) | (867) | 378 | 5% | 16,920 | 1,111,644 | 1.60 |
| 1,405 | 1,254 | (2,302) | (151) | (867) | 387 | 6% | 17,040 | 1,119,528 | 1.60 |
| 1,405 | 1,263 | (2,675) | (142) | (867) | 396 | 6% | 17,160 | 1,127,412 | 1.60 |
| 1,405 | 1,272 | (3,075) | (133) | (867) | 405 | 7% | 17,280 | 1,135,296 | 1.60 |
| 1,405 | 1,280 | (3,507) | (124) | (867) | 413 | 7% | 17,400 | 1,143,180 | 1.60 |
| 1,405 | 1,289 | (3,973) | (116) | (867) | 422 | 8% | 17,520 | 1,151,064 | 1.60 |
| 1,405 | 1,298 | (4,477) | (107) | (867) | 431 | 8% | 17,640 | 1,158,948 | 1.60 |
| 1,405 | 1,307 | (5,023) | (98) | (867) | 440 | 8% | 17,760 | 1,166,832 | 1.60 |
| 1,405 | 1,316 | (5,614) | (89) | (867) | 449 | 9% | 17,880 | 1,174,716 | 1.60 |
| 1,405 | 1,325 | (6,256) | (80) | (867) | 458 | 9% | 18,000 | 1,182,600 | 1.60 |
| 1,405 | 1,333 | (6,953) | (71) | (867) | 466 | 9% | 18,120 | 1,190,484 | 1.60 |
| 1,405 | 1,342 | (7,711) | (63) | (867) | 475 | 9% | 18,240 | 1,198,368 | 1.60 |
| 1,405 | 1,351 | (8,535) | (54) | (867) | 484 | 9% | 18,360 | 1,206,252 | 1.60 |
| 1,405 | 1,360 | (9,434) | (45) | (867) | 493 | 9% | 18,480 | 1,214,136 | 1.60 |
| 1,405 | 1,369 | (10,413) | (36) | (867) | 502 | 9% | 18,600 | 1,222,020 | 1.60 |
| **$11,560** | **$11,169** | | **($391)** | | **($134)** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 5% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | | | | | 0 | 126 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 201 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 6 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 7 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| EUANB (Annual Revenue) | 1,209 | R$1000 |
| NPV of Net Benefit | 3,583 | R$1000 |
| NPV of Net Cash Flow | 3,418 | R$1000 |
| IRR of Net Cash Flow | 18% | |
| Benefit:Cost Ratio | 1.2 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 293 | 1,113 | 688 | 820 | (166) | 946 | #NUM! | 15,120 | 993,384 | 1.60 |
| 367 | 1,121 | 1,476 | 754 | (1,316) | (195) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 506 | 1,130 | 2,174 | 624 | (305) | 825 | -10% | 15,360 | 1,009,152 | 1.60 |
| 566 | 1,139 | 2,856 | 573 | (1,229) | (90) | -13% | 15,480 | 1,017,036 | 1.60 |
| 733 | 1,148 | 3,414 | 415 | (472) | 676 | 4% | 15,600 | 1,024,920 | 1.60 |
| 801 | 1,157 | 3,940 | 355 | (1,529) | (372) | -4% | 15,720 | 1,032,804 | 1.60 |
| 1,197 | 1,166 | 4,106 | (31) | (867) | 299 | 3% | 15,840 | 1,040,688 | 1.60 |
| 1,197 | 1,174 | 4,289 | (22) | (867) | 307 | 7% | 15,960 | 1,048,572 | 1.60 |
| 1,197 | 1,183 | 4,490 | (14) | (867) | 316 | 9% | 16,080 | 1,056,456 | 1.60 |
| 1,197 | 1,192 | 4,709 | (5) | (867) | 325 | 11% | 16,200 | 1,064,340 | 1.60 |
| 1,197 | 1,201 | 4,949 | 4 | (867) | 334 | 13% | 16,320 | 1,072,224 | 1.60 |
| 1,197 | 1,210 | 5,210 | 13 | (867) | 343 | 14% | 16,440 | 1,080,108 | 1.60 |
| 1,197 | 1,219 | 5,492 | 22 | (867) | 352 | 15% | 16,560 | 1,087,992 | 1.60 |
| 1,197 | 1,227 | 5,797 | 31 | (867) | 360 | 15% | 16,680 | 1,095,876 | 1.60 |
| 1,197 | 1,236 | 6,126 | 39 | (867) | 369 | 16% | 16,800 | 1,103,760 | 1.60 |
| 1,197 | 1,245 | 6,481 | 48 | (867) | 378 | 16% | 16,920 | 1,111,644 | 1.60 |
| 1,197 | 1,254 | 6,862 | 57 | (867) | 387 | 17% | 17,040 | 1,119,528 | 1.60 |
| 1,197 | 1,263 | 7,271 | 66 | (867) | 396 | 17% | 17,160 | 1,127,412 | 1.60 |
| 1,197 | 1,272 | 7,710 | 75 | (867) | 405 | 17% | 17,280 | 1,135,296 | 1.60 |
| 1,197 | 1,280 | 8,179 | 84 | (867) | 413 | 17% | 17,400 | 1,143,180 | 1.60 |
| 1,197 | 1,289 | 8,680 | 92 | (867) | 422 | 18% | 17,520 | 1,151,064 | 1.60 |
| 1,197 | 1,298 | 9,215 | 101 | (867) | 431 | 18% | 17,640 | 1,158,948 | 1.60 |
| 1,197 | 1,307 | 9,786 | 110 | (867) | 440 | 18% | 17,760 | 1,166,832 | 1.60 |
| 1,197 | 1,316 | 10,395 | 119 | (867) | 449 | 18% | 17,880 | 1,174,716 | 1.60 |
| 1,197 | 1,325 | 11,042 | 128 | (867) | 458 | 18% | 18,000 | 1,182,600 | 1.60 |
| 1,197 | 1,333 | 11,731 | 137 | (867) | 466 | 18% | 18,120 | 1,190,484 | 1.60 |
| 1,197 | 1,342 | 12,463 | 145 | (867) | 475 | 18% | 18,240 | 1,198,368 | 1.60 |
| 1,197 | 1,351 | 13,240 | 154 | (867) | 484 | 18% | 18,360 | 1,206,252 | 1.60 |
| 1,197 | 1,360 | 14,065 | 163 | (867) | 493 | 18% | 18,480 | 1,214,136 | 1.60 |
| 1,197 | 1,369 | 14,941 | 172 | (867) | 502 | 18% | 18,600 | 1,222,020 | 1.60 |
| **$15,009** | **$18,592** | | **$3,583** | | **$3,418** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 10% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| **Year** | | **WW Treat CC** | **WW Infrast CC** | **DW Treat CC** | **Total CC** | **Total CC Amortized** | **WW Treat O&M** | **WW Infrast O&M** | **DW Treat O&M** | **Total O&M** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | | | | | 0 | 206 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 328 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 6 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 7 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 8 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| **EUANB (Annual Revenue)** | 1,185 | R$1000 |
| **NPV of Net Benefit** | 1,197 | R$1000 |
| **NPV of Net Cash Flow** | 1,245 | R$1000 |
| **IRR of Net Cash Flow** | 18% | |
| **Benefit:Cost Ratio** | 1.1 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 372 | 1,113 | 514 | 741 | (166) | 946 | #NUM! | 15,120 | 993,384 | 1.60 |
| 494 | 1,121 | 1,193 | 627 | (1,316) | (195) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 633 | 1,130 | 1,810 | 498 | (305) | 825 | -10% | 15,360 | 1,009,152 | 1.60 |
| 731 | 1,139 | 2,399 | 408 | (1,229) | (90) | -13% | 15,480 | 1,017,036 | 1.60 |
| 897 | 1,148 | 2,890 | 251 | (472) | 676 | 4% | 15,600 | 1,024,920 | 1.60 |
| 1,009 | 1,157 | 3,326 | 147 | (1,529) | (372) | -4% | 15,720 | 1,032,804 | 1.60 |
| 1,405 | 1,166 | 3,420 | (239) | (867) | 299 | 3% | 15,840 | 1,040,688 | 1.60 |
| 1,405 | 1,174 | 3,532 | (230) | (867) | 307 | 7% | 15,960 | 1,048,572 | 1.60 |
| 1,405 | 1,183 | 3,663 | (221) | (867) | 316 | 9% | 16,080 | 1,056,456 | 1.60 |
| 1,405 | 1,192 | 3,817 | (213) | (867) | 325 | 11% | 16,200 | 1,064,340 | 1.60 |
| 1,405 | 1,201 | 3,995 | (204) | (867) | 334 | 13% | 16,320 | 1,072,224 | 1.60 |
| 1,405 | 1,210 | 4,200 | (195) | (867) | 343 | 14% | 16,440 | 1,080,108 | 1.60 |
| 1,405 | 1,219 | 4,433 | (186) | (867) | 352 | 15% | 16,560 | 1,087,992 | 1.60 |
| 1,405 | 1,227 | 4,699 | (177) | (867) | 360 | 15% | 16,680 | 1,095,876 | 1.60 |
| 1,405 | 1,236 | 5,001 | (168) | (867) | 369 | 16% | 16,800 | 1,103,760 | 1.60 |
| 1,405 | 1,245 | 5,341 | (160) | (867) | 378 | 16% | 16,920 | 1,111,644 | 1.60 |
| 1,405 | 1,254 | 5,724 | (151) | (867) | 387 | 17% | 17,040 | 1,119,528 | 1.60 |
| 1,405 | 1,263 | 6,155 | (142) | (867) | 396 | 17% | 17,160 | 1,127,412 | 1.60 |
| 1,405 | 1,272 | 6,637 | (133) | (867) | 405 | 17% | 17,280 | 1,135,296 | 1.60 |
| 1,405 | 1,280 | 7,177 | (124) | (867) | 413 | 17% | 17,400 | 1,143,180 | 1.60 |
| 1,405 | 1,289 | 7,779 | (116) | (867) | 422 | 18% | 17,520 | 1,151,064 | 1.60 |
| 1,405 | 1,298 | 8,450 | (107) | (867) | 431 | 18% | 17,640 | 1,158,948 | 1.60 |
| 1,405 | 1,307 | 9,197 | (98) | (867) | 440 | 18% | 17,760 | 1,166,832 | 1.60 |
| 1,405 | 1,316 | 10,028 | (89) | (867) | 449 | 18% | 17,880 | 1,174,716 | 1.60 |
| 1,405 | 1,325 | 10,950 | (80) | (867) | 458 | 18% | 18,000 | 1,182,600 | 1.60 |
| 1,405 | 1,333 | 11,974 | (71) | (867) | 466 | 18% | 18,120 | 1,190,484 | 1.60 |
| 1,405 | 1,342 | 13,109 | (63) | (867) | 475 | 18% | 18,240 | 1,198,368 | 1.60 |
| 1,405 | 1,351 | 14,366 | (54) | (867) | 484 | 18% | 18,360 | 1,206,252 | 1.60 |
| 1,405 | 1,360 | 15,758 | (45) | (867) | 493 | 18% | 18,480 | 1,214,136 | 1.60 |
| 1,405 | 1,369 | 17,298 | (36) | (867) | 502 | 18% | 18,600 | 1,222,020 | 1.60 |
| **$9,972** | **$11,169** | | **$1,197** | | **$1,245** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 5% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| **Year** | | **WW Treat CC** | **WW Infrast CC** | **DW Treat CC** | **Total CC** | **Total CC Amortized** | **WW Treat O&M** | **WW Infrast O&M** | **DW Treat O&M** | **Total O&M** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | | | | | 0 | 126 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 201 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 261 | 35 | 436 | 0 | 472 |
| 7 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 8 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| EUANB (Annual Revenue) | 1,209 | R$1000 |
| NPV of Net Benefit | 3,915 | R$1000 |
| NPV of Net Cash Flow | 3,722 | R$1000 |
| IRR of Net Cash Flow | 20% | |
| Benefit:Cost Ratio | 1.3 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 293 | 1,113 | 688 | 820 | (166) | 946 | #NUM! | 15,120 | 993,384 | 1.60 |
| 367 | 1,121 | 1,476 | 754 | (1,316) | (195) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 506 | 1,130 | 2,174 | 624 | (305) | 825 | -10% | 15,360 | 1,009,152 | 1.60 |
| 566 | 1,139 | 2,856 | 573 | (1,229) | (90) | -13% | 15,480 | 1,017,036 | 1.60 |
| 733 | 1,148 | 3,414 | 415 | (472) | 676 | 4% | 15,600 | 1,024,920 | 1.60 |
| 733 | 1,157 | 4,009 | 424 | (472) | 685 | 12% | 15,720 | 1,032,804 | 1.60 |
| 801 | 1,166 | 4,573 | 364 | (1,529) | (364) | 9% | 15,840 | 1,040,688 | 1.60 |
| 1,197 | 1,174 | 4,780 | (22) | (867) | 307 | 11% | 15,960 | 1,048,572 | 1.60 |
| 1,197 | 1,183 | 5,005 | (14) | (867) | 316 | 13% | 16,080 | 1,056,456 | 1.60 |
| 1,197 | 1,192 | 5,251 | (5) | (867) | 325 | 15% | 16,200 | 1,064,340 | 1.60 |
| 1,197 | 1,201 | 5,517 | 4 | (867) | 334 | 16% | 16,320 | 1,072,224 | 1.60 |
| 1,197 | 1,210 | 5,806 | 13 | (867) | 343 | 17% | 16,440 | 1,080,108 | 1.60 |
| 1,197 | 1,219 | 6,118 | 22 | (867) | 352 | 18% | 16,560 | 1,087,992 | 1.60 |
| 1,197 | 1,227 | 6,455 | 31 | (867) | 360 | 18% | 16,680 | 1,095,876 | 1.60 |
| 1,197 | 1,236 | 6,817 | 39 | (867) | 369 | 19% | 16,800 | 1,103,760 | 1.60 |
| 1,197 | 1,245 | 7,206 | 48 | (867) | 378 | 19% | 16,920 | 1,111,644 | 1.60 |
| 1,197 | 1,254 | 7,624 | 57 | (867) | 387 | 19% | 17,040 | 1,119,528 | 1.60 |
| 1,197 | 1,263 | 8,071 | 66 | (867) | 396 | 19% | 17,160 | 1,127,412 | 1.60 |
| 1,197 | 1,272 | 8,549 | 75 | (867) | 405 | 20% | 17,280 | 1,135,296 | 1.60 |
| 1,197 | 1,280 | 9,060 | 84 | (867) | 413 | 20% | 17,400 | 1,143,180 | 1.60 |
| 1,197 | 1,289 | 9,606 | 92 | (867) | 422 | 20% | 17,520 | 1,151,064 | 1.60 |
| 1,197 | 1,298 | 10,188 | 101 | (867) | 431 | 20% | 17,640 | 1,158,948 | 1.60 |
| 1,197 | 1,307 | 10,807 | 110 | (867) | 440 | 20% | 17,760 | 1,166,832 | 1.60 |
| 1,197 | 1,316 | 11,466 | 119 | (867) | 449 | 20% | 17,880 | 1,174,716 | 1.60 |
| 1,197 | 1,325 | 12,167 | 128 | (867) | 458 | 20% | 18,000 | 1,182,600 | 1.60 |
| 1,197 | 1,333 | 12,912 | 137 | (867) | 466 | 20% | 18,120 | 1,190,484 | 1.60 |
| 1,197 | 1,342 | 13,703 | 145 | (867) | 475 | 20% | 18,240 | 1,198,368 | 1.60 |
| 1,197 | 1,351 | 14,543 | 154 | (867) | 484 | 20% | 18,360 | 1,206,252 | 1.60 |
| 1,197 | 1,360 | 15,433 | 163 | (867) | 493 | 20% | 18,480 | 1,214,136 | 1.60 |
| 1,197 | 1,369 | 16,377 | 172 | (867) | 502 | 20% | 18,600 | 1,222,020 | 1.60 |
| **$14,677** | **$18,592** | | **$3,915** | | **$3,722** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 10% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| **Year** | | **WW Treat CC** | **WW Infrast CC** | **DW Treat CC** | **Total CC** | **Total CC Amortized** | **WW Treat O&M** | **WW Infrast O&M** | **DW Treat O&M** | **Total O&M** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | | | | | 0 | 206 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 328 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 426 | 35 | 436 | 0 | 472 |
| 7 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 8 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| **EUANB (Annual Revenue)** | 1,185 | R$1000 |
| **NPV of Net Benefit** | 1,463 | R$1000 |
| **NPV of Net Cash Flow** | 1,479 | R$1000 |
| **IRR of Net Cash Flow** | 20% | |
| **Benefit:Cost Ratio** | 1.2 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 372 | 1,113 | 514 | 741 | (166) | 946 | #NUM! | 15,120 | 993,384 | 1.60 |
| 494 | 1,121 | 1,193 | 627 | (1,316) | (195) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 633 | 1,130 | 1,810 | 498 | (305) | 825 | -10% | 15,360 | 1,009,152 | 1.60 |
| 731 | 1,139 | 2,399 | 408 | (1,229) | (90) | -13% | 15,480 | 1,017,036 | 1.60 |
| 897 | 1,148 | 2,890 | 251 | (472) | 676 | 4% | 15,600 | 1,024,920 | 1.60 |
| 897 | 1,157 | 3,439 | 260 | (472) | 685 | 12% | 15,720 | 1,032,804 | 1.60 |
| 1,009 | 1,166 | 3,939 | 156 | (1,529) | (364) | 9% | 15,840 | 1,040,688 | 1.60 |
| 1,405 | 1,174 | 4,102 | (230) | (867) | 307 | 11% | 15,960 | 1,048,572 | 1.60 |
| 1,405 | 1,183 | 4,291 | (221) | (867) | 316 | 13% | 16,080 | 1,056,456 | 1.60 |
| 1,405 | 1,192 | 4,508 | (213) | (867) | 325 | 15% | 16,200 | 1,064,340 | 1.60 |
| 1,405 | 1,201 | 4,754 | (204) | (867) | 334 | 16% | 16,320 | 1,072,224 | 1.60 |
| 1,405 | 1,210 | 5,035 | (195) | (867) | 343 | 17% | 16,440 | 1,080,108 | 1.60 |
| 1,405 | 1,219 | 5,352 | (186) | (867) | 352 | 18% | 16,560 | 1,087,992 | 1.60 |
| 1,405 | 1,227 | 5,710 | (177) | (867) | 360 | 18% | 16,680 | 1,095,876 | 1.60 |
| 1,405 | 1,236 | 6,113 | (168) | (867) | 369 | 19% | 16,800 | 1,103,760 | 1.60 |
| 1,405 | 1,245 | 6,564 | (160) | (867) | 378 | 19% | 16,920 | 1,111,644 | 1.60 |
| 1,405 | 1,254 | 7,070 | (151) | (867) | 387 | 19% | 17,040 | 1,119,528 | 1.60 |
| 1,405 | 1,263 | 7,635 | (142) | (867) | 396 | 19% | 17,160 | 1,127,412 | 1.60 |
| 1,405 | 1,272 | 8,265 | (133) | (867) | 405 | 20% | 17,280 | 1,135,296 | 1.60 |
| 1,405 | 1,280 | 8,967 | (124) | (867) | 413 | 20% | 17,400 | 1,143,180 | 1.60 |
| 1,405 | 1,289 | 9,749 | (116) | (867) | 422 | 20% | 17,520 | 1,151,064 | 1.60 |
| 1,405 | 1,298 | 10,617 | (107) | (867) | 431 | 20% | 17,640 | 1,158,948 | 1.60 |
| 1,405 | 1,307 | 11,581 | (98) | (867) | 440 | 20% | 17,760 | 1,166,832 | 1.60 |
| 1,405 | 1,316 | 12,650 | (89) | (867) | 449 | 20% | 17,880 | 1,174,716 | 1.60 |
| 1,405 | 1,325 | 13,835 | (80) | (867) | 458 | 20% | 18,000 | 1,182,600 | 1.60 |
| 1,405 | 1,333 | 15,147 | (71) | (867) | 466 | 20% | 18,120 | 1,190,484 | 1.60 |
| 1,405 | 1,342 | 16,599 | (63) | (867) | 475 | 20% | 18,240 | 1,198,368 | 1.60 |
| 1,405 | 1,351 | 18,205 | (54) | (867) | 484 | 20% | 18,360 | 1,206,252 | 1.60 |
| 1,405 | 1,360 | 19,981 | (45) | (867) | 493 | 20% | 18,480 | 1,214,136 | 1.60 |
| 1,405 | 1,369 | 21,943 | (36) | (867) | 502 | 20% | 18,600 | 1,222,020 | 1.60 |
| **$9,706** | **$11,169** | | **$1,463** | | **$1,479** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 5% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 126 | | | | |
| 1 | | | | | 0 | 126 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 201 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 201 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 261 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 261 | 35 | 436 | 0 | 472 |
| 7 | | | | | 0 | 261 | 35 | 436 | 0 | 472 |
| 8 | DW | | | 1,057 | 1,057 | 330 | 35 | 436 | 0 | 472 |
| 9 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 330 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 330 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| EUANB (Annual Revenue) | 1,209 | R$1000 |
| NPV of Net Benefit | 4,232 | R$1000 |
| NPV of Net Cash Flow | 4,011 | R$1000 |
| IRR of Net Cash Flow | 22% | |
| Benefit:Cost Ratio | 1.3 | |

| Total Cost | Revenue | NPV | Net Benefit | Total Cost = CC+O&M | Net Cash Flow = R-(CC+O&M) | IRR | Population | Consumption | Tariff |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 126 | | (126) | (126) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 293 | 1,113 | 688 | 820 | (166) | 946 | #NUM! | 15,120 | 993,384 | 1.60 |
| 367 | 1,121 | 1,476 | 754 | (1,316) | (195) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 506 | 1,130 | 2,174 | 624 | (305) | 825 | -10% | 15,360 | 1,009,152 | 1.60 |
| 566 | 1,139 | 2,856 | 573 | (1,229) | (90) | -13% | 15,480 | 1,017,036 | 1.60 |
| 733 | 1,148 | 3,414 | 415 | (472) | 676 | 4% | 15,600 | 1,024,920 | 1.60 |
| 733 | 1,157 | 4,009 | 424 | (472) | 685 | 12% | 15,720 | 1,032,804 | 1.60 |
| 733 | 1,166 | 4,642 | 433 | (472) | 694 | 17% | 15,840 | 1,040,688 | 1.60 |
| 801 | 1,174 | 5,247 | 373 | (1,529) | (355) | 15% | 15,960 | 1,048,572 | 1.60 |
| 1,197 | 1,183 | 5,496 | (14) | (867) | 316 | 17% | 16,080 | 1,056,456 | 1.60 |
| 1,197 | 1,192 | 5,766 | (5) | (867) | 325 | 18% | 16,200 | 1,064,340 | 1.60 |
| 1,197 | 1,201 | 6,059 | 4 | (867) | 334 | 19% | 16,320 | 1,072,224 | 1.60 |
| 1,197 | 1,210 | 6,375 | 13 | (867) | 343 | 19% | 16,440 | 1,080,108 | 1.60 |
| 1,197 | 1,219 | 6,715 | 22 | (867) | 352 | 20% | 16,560 | 1,087,992 | 1.60 |
| 1,197 | 1,227 | 7,082 | 31 | (867) | 360 | 20% | 16,680 | 1,095,876 | 1.60 |
| 1,197 | 1,236 | 7,475 | 39 | (867) | 369 | 21% | 16,800 | 1,103,760 | 1.60 |
| 1,197 | 1,245 | 7,897 | 48 | (867) | 378 | 21% | 16,920 | 1,111,644 | 1.60 |
| 1,197 | 1,254 | 8,349 | 57 | (867) | 387 | 21% | 17,040 | 1,119,528 | 1.60 |
| 1,197 | 1,263 | 8,833 | 66 | (867) | 396 | 21% | 17,160 | 1,127,412 | 1.60 |
| 1,197 | 1,272 | 9,349 | 75 | (867) | 405 | 21% | 17,280 | 1,135,296 | 1.60 |
| 1,197 | 1,280 | 9,900 | 84 | (867) | 413 | 22% | 17,400 | 1,143,180 | 1.60 |
| 1,197 | 1,289 | 10,488 | 92 | (867) | 422 | 22% | 17,520 | 1,151,064 | 1.60 |
| 1,197 | 1,298 | 11,113 | 101 | (867) | 431 | 22% | 17,640 | 1,158,948 | 1.60 |
| 1,197 | 1,307 | 11,779 | 110 | (867) | 440 | 22% | 17,760 | 1,166,832 | 1.60 |
| 1,197 | 1,316 | 12,487 | 119 | (867) | 449 | 22% | 17,880 | 1,174,716 | 1.60 |
| 1,197 | 1,325 | 13,239 | 128 | (867) | 458 | 22% | 18,000 | 1,182,600 | 1.60 |
| 1,197 | 1,333 | 14,038 | 137 | (867) | 466 | 22% | 18,120 | 1,190,484 | 1.60 |
| 1,197 | 1,342 | 14,885 | 145 | (867) | 475 | 22% | 18,240 | 1,198,368 | 1.60 |
| 1,197 | 1,351 | 15,783 | 154 | (867) | 484 | 22% | 18,360 | 1,206,252 | 1.60 |
| 1,197 | 1,360 | 16,736 | 163 | (867) | 493 | 22% | 18,480 | 1,214,136 | 1.60 |
| 1,197 | 1,369 | 17,744 | 172 | (867) | 502 | 22% | 18,600 | 1,222,020 | 1.60 |
| **$14,360** | **$18,592** | | **$4,232** | | **$4,011** | | | | |

| FINANCIAL ANALYSIS PARAMETERS | | | | | |
|---|---|---|---|---|---|
| **Project Life** | 30 | years | **Consumption** | 0.18 | m^3/capita*day |
| **Interest Rate** | 10% | /year | **Tariff Collected/Billed** | 70% | |
| **Population** | 15,000 | capita | **Water& Sewage Tariff** | 1.60 | R$/m^3 |
| **Population Growth Rate** | 0.8% | /year | (Previously set by CEDAE) | | |
| **Household** | 3.9 | capita | | | |

| Year | | WW Treat CC | WW Infrast CC | DW Treat CC | Total CC | Total CC Amortized | WW Treat O&M | WW Infrast O&M | DW Treat O&M | Total O&M |
|---|---|---|---|---|---|---|---|---|---|---|
| | | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 |
| 0 | WW1 | 912 | 1,026 | 0 | 1,938 | 206 | | | | |
| 1 | | | | | 0 | 206 | 13 | 154 | 0 | 166 |
| 2 | WW2 | 380 | 770 | 0 | 1,150 | 328 | 13 | 154 | 0 | 166 |
| 3 | | | | | 0 | 328 | 23 | 282 | 0 | 305 |
| 4 | WW3 | 0 | 924 | 0 | 924 | 426 | 23 | 282 | 0 | 305 |
| 5 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 6 | | | | 0 | 0 | 426 | 35 | 436 | 0 | 472 |
| 7 | | | | | 0 | 426 | 35 | 436 | 0 | 472 |
| 8 | DW | | | 1,057 | 1,057 | 538 | 35 | 436 | 0 | 472 |
| 9 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 10 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 11 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 12 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 13 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 14 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 15 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 16 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 17 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 18 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 19 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 20 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 21 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 22 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 23 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 24 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 25 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 26 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 27 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 28 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 29 | | | | | | 538 | 35 | 436 | 395 | 867 |
| 30 | | | | | | 538 | 35 | 436 | 395 | 867 |
| **NPV=** | | | | | | | | | | |

| PROJECT WORTH WHEN USING WATER AND SEWERAGE TARIFF SET BY CEDAE | | |
|---|---|---|
| **EUANB (Annual Revenue)** | 1,185 | R$1000 |
| **NPV of Net Benefit** | 1,705 | R$1000 |
| **NPV of Net Cash Flow** | 1,692 | R$1000 |
| **IRR of Net Cash Flow** | 22% | |
| **Benefit:Cost Ratio** | 1.2 | |

| **Total Cost** | **Revenue** | **NPV** | **Net Benefit** | **Total Cost = CC+O&M** | **Net Cash Flow = R-(CC+O&M)** | **IRR** | **Population** | **Consumption** | **Tariff** |
|---|---|---|---|---|---|---|---|---|---|
| R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | R$1000 | | | m^3/yr | R$/m^3 |
| 206 | | (206) | (206) | (1,938) | (1,938) | #NUM! | 15,000 | 985,500 | 1.60 |
| 372 | 1,113 | 514 | 741 | (166) | 946 | #NUM! | 15,120 | 993,384 | 1.60 |
| 494 | 1,121 | 1,193 | 627 | (1,316) | (195) | #NUM! | 15,240 | 1,001,268 | 1.60 |
| 633 | 1,130 | 1,810 | 498 | (305) | 825 | -10% | 15,360 | 1,009,152 | 1.60 |
| 731 | 1,139 | 2,399 | 408 | (1,229) | (90) | -13% | 15,480 | 1,017,036 | 1.60 |
| 897 | 1,148 | 2,890 | 251 | (472) | 676 | 4% | 15,600 | 1,024,920 | 1.60 |
| 897 | 1,157 | 3,439 | 260 | (472) | 685 | 12% | 15,720 | 1,032,804 | 1.60 |
| 897 | 1,166 | 4,051 | 268 | (472) | 694 | 17% | 15,840 | 1,040,688 | 1.60 |
| 1,009 | 1,174 | 4,621 | 165 | (1,529) | (355) | 15% | 15,960 | 1,048,572 | 1.60 |
| 1,405 | 1,183 | 4,862 | (221) | (867) | 316 | 17% | 16,080 | 1,056,456 | 1.60 |
| 1,405 | 1,192 | 5,135 | (213) | (867) | 325 | 18% | 16,200 | 1,064,340 | 1.60 |
| 1,405 | 1,201 | 5,445 | (204) | (867) | 334 | 19% | 16,320 | 1,072,224 | 1.60 |
| 1,405 | 1,210 | 5,794 | (195) | (867) | 343 | 19% | 16,440 | 1,080,108 | 1.60 |
| 1,405 | 1,219 | 6,188 | (186) | (867) | 352 | 20% | 16,560 | 1,087,992 | 1.60 |
| 1,405 | 1,227 | 6,629 | (177) | (867) | 360 | 20% | 16,680 | 1,095,876 | 1.60 |
| 1,405 | 1,236 | 7,124 | (168) | (867) | 369 | 21% | 16,800 | 1,103,760 | 1.60 |
| 1,405 | 1,245 | 7,676 | (160) | (867) | 378 | 21% | 16,920 | 1,111,644 | 1.60 |
| 1,405 | 1,254 | 8,293 | (151) | (867) | 387 | 21% | 17,040 | 1,119,528 | 1.60 |
| 1,405 | 1,263 | 8,980 | (142) | (867) | 396 | 21% | 17,160 | 1,127,412 | 1.60 |
| 1,405 | 1,272 | 9,745 | (133) | (867) | 405 | 21% | 17,280 | 1,135,296 | 1.60 |
| 1,405 | 1,280 | 10,595 | (124) | (867) | 413 | 22% | 17,400 | 1,143,180 | 1.60 |
| 1,405 | 1,289 | 11,539 | (116) | (867) | 422 | 22% | 17,520 | 1,151,064 | 1.60 |
| 1,405 | 1,298 | 12,587 | (107) | (867) | 431 | 22% | 17,640 | 1,158,948 | 1.60 |
| 1,405 | 1,307 | 13,748 | (98) | (867) | 440 | 22% | 17,760 | 1,166,832 | 1.60 |
| 1,405 | 1,316 | 15,033 | (89) | (867) | 449 | 22% | 17,880 | 1,174,716 | 1.60 |
| 1,405 | 1,325 | 16,456 | (80) | (867) | 458 | 22% | 18,000 | 1,182,600 | 1.60 |
| 1,405 | 1,333 | 18,031 | (71) | (867) | 466 | 22% | 18,120 | 1,190,484 | 1.60 |
| 1,405 | 1,342 | 19,771 | (63) | (867) | 475 | 22% | 18,240 | 1,198,368 | 1.60 |
| 1,405 | 1,351 | 21,695 | (54) | (867) | 484 | 22% | 18,360 | 1,206,252 | 1.60 |
| 1,405 | 1,360 | 23,819 | (45) | (867) | 493 | 22% | 18,480 | 1,214,136 | 1.60 |
| 1,405 | 1,369 | 26,165 | (36) | (867) | 502 | 22% | 18,600 | 1,222,020 | 1.60 |
| **$9,464** | **$11,169** | | **$1,705** | | **$1,692** | | | | |

## REFERENCES


1. Barreto, Wilsa Mary S. Epidemiological Study Data of Diarrhea in Municipality of Paraty. 2002.

2. Blumenthal, Ursula J., Jay M. Fleisher, Steve A. Esrey, and Anne Peasey. “Epidemiology: a tool for the assessment of risk.” Water Quality: Guidelines, Standards, and Health: Assessment of Risk and Risk Management for Water-Related Infectious Disease. London, UK: IWA Publishing, 2001. 135-160. World Health Organization.

3. BIT (Brazillian Incentrive & Tourism). “Business Essentials – Economy: Historical perspective.” n.d. <http://www.bitourism.com/countryinfo/business/business_economy.asp>.

4. Boland, John J. “Pricing Urban Water: Principles and Compromises.” Water Resources Update. Summer 1992: 7-10.

5. Brazilian Tourist Office. “International Arrivals and Departures by City.” 2002 <http://www.brazil.org.uk/page.php?cid=1193>.

6. Cabral, Christian, Frederic Chagnon, and Domagoj Gotovac. Alternative Designs for the Upgrade of the Tatui-CEAGESP Wastewater Treatment Facility using Chemically Enhanced Primary treatment. Master of Engineering Project Report, Massachusetts Institute of Technology: June 1999.

7. Canaldotempo.com (The Weather Channel). “Tempo Local – Paraty, Brazil.” 2003 <http://br.weather.com/weather/local/BRXX3898>.

8. CEPIS (Pan American Center for Sanitary Engineering and Environmental Sciences). “Assessment of Drinking Water and Sanitation 2000 in the Americas.” 2000 <http://www.cepis.ops-oms.org/enwww/eva2000/brasil/informe.html>.

9. Chagnon, Frederic. “An Introduction to Chemically Enhanced Primary Treatment” Cambridge, MA: MIT, 2002 <http://www.efm.leeds.ac.uk/CIVE/Sewerage/articles/Introduction_to_CEPT.pdf>.

10. Commonwealth of Pennsylvania, Department of Environmental Protection. “Drinking water treatment technologies for groundwater systems under the direct influence of surface water.” Harrisburg, PA: October 2001 <http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/WSM_DWM/Technol/Trt_GUDI.pdf>.

11. Csillag, Claudio and Ricardo Zorzetto. “Turning Point: Environmental Health in Brazil.” Environmental Health Perspectives. Volume 108. Number 11. November 2000 <http://ehpnet1.niehs.nih.gov/docs/2000/108-11/focus.html>.

12. De Sigueira Baffo, Sergio Mauricio. Personal Interview. January 2003.

13. Eisenberg, Joseph N. S., Jamie Bartram, and Paul R. Hunter. “A public health perspective for establishing water-related guidelines and standards.” Water Quality: Guidelines, Standards, and Health: Assessment of Risk and Risk Management for Water-Related Infectious Disease. London, UK: IWA Publishing, 2001. 229-256. World Health Organization.

14. Fateen, Shaheerah A., Natalia Olive, and Jennifer K. Stout. Chemically Enhanced Primary Treatment in Alfenas, Brazil: CEPT plant design, sludge management strategy, and reservoir impact analysis. Master of Engineering Project Report, Massachusetts Institute of Technology: June 2002.

15. Furtado, Georgina, Office of Mayor. Personal Interview. January 2003.

16. Hutton, Guy. “Cosiderations in evaluating the cost-effectiveness of environmental health interventions.” Geneva: WHO, 2000

<http://www.who.int/environmental_information/Disburden/WSH00-10/WSH00-10TOC.htm>.

17. Hutton, Guy. "Economic evaluation and priority setting in water and sanitation interventions." Water Quality: Guidelines, Standards, and Health: Assessment of Risk and Risk Management for Water-Related Infectious Disease. London, UK: IWA Publishing, 2001. 333-359. World Health Organization.

18. "Interim national river water quality standards for Malaysia." n.p.: n.d <http://agrolink.moa.my/did/river/sgklang/sgklang_wqi.htm>.

19. KDHE (Kansas Department of Health and Environment). "Kansas Water-Water Quality Standards." Kansas: 2001 <http://ks.water.usgs.gov/Kansas/rtqw/parameter.html#TSS>.

20. Kfouri, Claire, and Hyo Jin Kweon, Seawater as a Coagulant Substitute and Effects on Disinfection in Chemically Enhanced Primary Treatment: A case study of Paraty, Brazil and Deer Island, Boston. Master of Engineering Thesis, Massachusetts Institute of Technology: June 2003.

21. Lemos Padua, Edneia Maria, Director of Public Works (1999-2000). Personal Interview. January 2003.

22. Payment, Pierre, and Paul R. Hunter. "Endemic and epidemic infectious intestinal disease and its relationship to drinking water." Water Quality: Guidelines, Standards, and Health: Assessment of Risk and Risk Management for Water-Related Infectious Disease. London, UK: IWA Publishing, 2001. 61-88. World Health Organization.

23. Pleasanton Sewer Feasibility Board. "Bear Lake – Pleasanton Wastewater Feasibility Study." Bear Lake, MI: 2001 <http://www.bearlakemichigan.org/sewer/feasibility1.html>.

24. Prefeitura Municipal de Paraty (Municipal City Hall of Paraty). "Laudo de Avaliacao Tecnica e Economico – Financeiro." Paraty, Brazil: January 2002.

25. Prefeitura Municipal de Paraty (Municipal City Hall of Paraty). "Paraty: A patrimony of life." Paraty, Brazil: 2003.

26. Prefeitura Municipal de Paraty (Municipal City Hall of Paraty). "Vigilancia da Qualidade da Agua de Consumo Humano – VQACH." Paraty, Brazil: 2001.

27. Reis, Renato. Financial Secretary for the Municipality of Paraty. Personal Interview. January 2003.

28. San Martin, Orlando. "Water Resources in Latin America and the Caribbean: Issues and Options." February 2002 <http://www.iadb.org/sds/doc/ENV-OSanMartin-WaterResourcesinLaC.pdf>.

29. Secretaria Municipal de Saude (Municipal Secretary of Health). "SIAB – Sistema de Informacao de Atencao Basica: Consolidado das familias cadastradas do ano de 2003 do modelo general." Paraty, Brazil: January 2003.

30. State of Connecticut, Department of Environmental Protection. Connecticut Water Quality Standards. Connecticut: 2002 <http://dep.state.ct.us/wtr/wq/wqs.pdf>.

31. Tsukamoto, Ricardo. Personal Interview. January 2003.

32. UNESCO. "Criteria for the inclusion of properties in the World Heritage List." 1997 <http://whc.unesco.org/criteria.htm >.

33. UNICEF, WHO, and WSSCC. "Global Water Supply and Sanitation Assessment 2000 Report." 2000 <http://www.who.int/water_sanitation_health/Globassessment/GlobalTOC.htm>.

34. U.S. Department of Commerce. “Brazil – Water and Wastewater Concession Opps. – Market Assessment.” 13 January 1999. <http://strategis.ic.gc.ca/SSGF/dd73927f.html>.

35. U.S. Department of Interior, Bureau of Reclamation. “Total Coliform and E-Coli: Factsheet.” September 21, 2001 <http://www.usbr.gov/water/media/pdfs/TC&Ecoli.pdf>.

36. U.S. EPA (Environmental Protection Agency). “Appendix B – Selected Costs of Alternative Disinfection Systems” EPA Guidance Manual: Alternative Disinfectants and Oxidants. EPA, April 1999 <http://www.epa.gov/safewater/mdbp/pdf/alter/app_b.pdf>.

37. U.S. EPA. “Small System Compliance Technology List for the Surface Water Treatment Rule.” EPA, August 1997 <http://www.epa.gov/safewater/regs/swtrsms.pdf>.

38. WHO (World Health Organization). “Children are among the most vulnerable to environmental threats.” n.d. <http://www.who.int/heca/advocacy/publications/HECIbr2.pdf>.

39. WHO (World Health Organization). “Cholera and epidemic-prone diarrhoeal diseases.” 2003 <http://www.who.int/csr/disease/cholera/en/>.

40. WHO (World Health Organization). “Health criteria and other supporting information.” Guidelines for Drinking-Water Quality. 2nd ed. Vol. 2. 1996. 940-949. and Addendum to Vol. 2 1998. 281-283. <http://www.who.int/water_sanitation_health/GDWQ/Summary_tables/Sumtab.htm>.

41. World Bank, The. Environmental Priorities for Development and Sanitation and Clean Water. n.p.: 1992.

42. X-rates.com. “Exchange Rates.” 2003 <http://www.x-rates.com/>.