Caribbean Aqua-Terrestrial Solutions

Sewage Solution Mission

Soufriere, DOMINICA

October 27 – 31, 2014

Mission Report (Final)

December 2014

Table of Contents

ANNEXES:

Annex 1: Mission time schedule and encounters

Annex 2: Population development in Soufriere

Annex 3: Questionnaire for Household Survey in Soufriere

Annex 4: Tabular summary of household questionnaire

Annex 5: Selected Photo's

Annex 6: Calculation of cost - CAPEX and OPEX

Annex 7: Dynamic Prime Cost calculation

Annex 8: Assessment of Small Scale Biogas Production

ABBREVIATIONS:

ABR	Anaerobic baffle reactor. Wastewater treatment process that requires no energy-intensive aeration and produces biogas.
BOD5	Bio-chemical oxygen demand. A common parameter to describe the bio-degradable pollution content of water/wastewater
CAPEX	Capital expenditures
CARPHA	Caribbean Public Health Agency
CATS	Caribbean Aqua-Terrestrial Solutions
CH4	Methane
COD	Chemical oxygen demand. A general parameter to describe water pollution
DOWASCO	Dominica Water and Sewerage Company Limited
DPC	Dynamic Prime Cost
FS	Faecal sludge
GIZ	German Agency for International Cooperation
KFW	German Development Bank
OPEX	Operational expenditure
PE	Poly-Ethylene

1. Background

1.1 The Mission in the Context of Aqua-Terrestrial Solutions

St Mark Parish, Dominica is a focus area within the framework of the CATS Programme (Enhancing the Adaptive Capacity of Rural Economies and Natural Resources to Climate Change) operated by CARPHA and GIZ. The negative impact of unregulated sanitary sewage drainage in Soufriere was identified as highly critical. As a consequence, a mission was carried out End of October 2014 to address that issue and formulate solutions[1]. The present report describes the findings (chapters 1+2), makes suggestions for possible solutions (chapter 3) and gives a recommendation (chapter 4).

1.2 Current Situation in Soufriere

Soufriere, located in the Parish of St Mark in the South of Dominica, is inhabited by 364 households with a population of 1,829 (according to the 2011 census, refer also to Annex 2). 433 dwellings are located primarily along the coastal strip and Alumn Stream.

The urban setting is dominated by the topographical features of the terrain – the narrow stretch at the “mouth” of Alumn Stream and steep volcanic slopes of the former craterous rim.

Similar to all natural drainage systems, the Alumn Stream constitutes the lowest point of a catchment of approximately 1,000 acres (4 km²) that is fed by sulphuric spring water and by surface run-off. Due to the underground volcanic influences, the water is acidic and slightly warmer than ambient temperature when it enters the sea.

Considering the high levels of precipitation (2,100 mm/a) the river bed indicates that flow patterns have a mild natural variation within a surprisingly small section area. Both of these factors indicate the high natural retention capacity of landcover and that the soil is still intact.

The condition of the Alumn Stream toward its confluence with the sea is worrying, however. The visit to the project area and the questionnaire completed by some 45 households along the Alumn Stream (refer to chapter 2.1 and Annex 4) have revealed the following:

- Uncontrolled disposal of solid and liquid waste into the water body contribute to the degradation of the banks and the bed of the water body of the last 400 meters before entering into the marine environment.
- Absence of standard sanitary facilities in almost all households leads to a serious influx of pollution

Sporadic clean-up undertaken by the municipality alleviates the problem but does not lead to substantial and certainly not sustainable improvement.

[1] Refer to Annex 1 for the Mission time schedule and the list of participants

The consequences for both, the urban and natural environment include the following:

- Population exposed to health risks directly from the impacts of chemical and microbial contamination and indirectly related to undesired vectors and rodents.
- Chemical and microbiological pollution of the water bodies with negative impact on livelihood activities including tourism and fishing along the coast of Soufriere.
- Odour nuisance and visual eyesores reduce the quality of life of those living next to the Alumn Stream.

2. Approach

Organically developed settlement structures are frequently challenged by modern urban planning requirements prompted by utility services. The small lots along the Alumn Stream with residents of varying social standards face that very challenge. A survey including a questionnaire was therefore conducted to better understand the socio-economic environment, the dimension of the sanitary problem as perceived by the residents, the standards of individual sanitation facilities and the expenses for water and sanitation and, if possible, an indication of the financial capacity of the residents concerned.

A number of technical options that could be considered in Soufriere were developed after a number of visits to Soufriere and the concerned area along Alumn Stream. It is necessary to mention that the entire area of Soufriere has no access to appropriate sanitary drainage or adequate systems for septage disposal. Interestingly, only few cases of overflowing, leaking “septic” tanks or stagnant grey water in the curb stones could be recalled. This could be attributed to the lower urban density and lower ground water levels in the other residential areas of Soufriere.

Even though sanitation problems may be locally confined to a small neighbourhood in Soufriere, it is essential to look at the urban area and the wider catchment of the Alumn Stream. This is relevant to make sure the adopted solution is:

- Appropriate and to scale. In the context of Soufriere this translates into a solution that is technically feasible and affordable in operation and maintenance for inhabitants and government retained.
- Identified as high priority compared to other solutions. In the context of Soufriere: Other contributors are less critical – e.g. agriculture (a pigsty along Alumn Stream should be removed, refer to Annex 5 for photo documentation).

Solid waste disposal is regarded as equally important as sanitary drainage. Therefore, a full-fledged sanitary upgrade requires solid waste to be adequately addressed as a cornerstone of the Sanitary Concept for Soufriere through a holistic environmental programme including an education dimension targeting the community.

2.1 Results of the questionnaire

The objective of the questionnaire (annex 3) was to provide a basis for decision making.

A total of 45 households were interviewed, which corresponds to more than 10 % of the population of Soufriere and approximately 100% of the residents in the area of interest. The questionnaire is therefore considered to have a certain statistical relevance. The questionnaire was completed by the residents of households in the immediate vicinity of the Alumn Stream, because they were identified as main contributors to the observed degradation of the Alumn Stream.

The tabular summary of the questionnaire is attached in Annex 4.

2.1.1 Residents

Not all interviewees are permanently resident. The typical household has 3.4 residents compared to the national average of 4.5. 20% of the inhabitants are children below the age of 16.

All respondents, with one exception live on their own properties and dispose of $1,500 XCD per month on average.

2.1.2 Water Supply

The piped water, which is produced upstream of Soufriere, is generally available without any supply interruptions. The whole urban area is serviced by a water distribution system. Some pipe alignments are entirely unprotected, exposed to sun or insufficiently fixed to solid underground.

29 out of 31 respondents are connected to the municipal supply provided by DOWASCO. Most households have in-house water taps (28/29) although a significant number also have access to yard taps (11/29). Public taps are used by non-subscribers. Piped water is generally used for all purposes and other sources are employed for irrigation and washing. Rain water is harvested by some households but only used for non-consumption purposes.

2.1.3 Sanitary facilities

Soufriere is primarily equipped with soak pits. These facilities, generally and erroneously referred to as septic tanks, do not retain any wastewater or septage. They are constructed to percolate any liquid waste into the underground. The (most likely) alluvial/sandy soil underground absorbs the wastewater without risk of clogging and pollutes the underground and possibly the water bodies, if travel time is insufficient to ensure decomposition of nutrients and decay of harmful microorganisms.

Only 22 out of 45 households confirmed that they have a toilet. The taboo subject matter is one reason for the reluctance to talk about it. The majority of slightly polluted grey water (sink, shower, dish washing) goes into the Alumn Stream (23/33). When asked about the disposal of black water (highly polluted faeces) 16 out of 29 respondents inform that they use the "septic" tank, whereas the rest (13/29) discharge into the open (mostly the stream). Accordingly, 13 out of 28 respondents are aware that their disposal means is environmentally unfriendly. The negative impact was attributed by all interviewees to:

Dirty stream: 53%	Bad odour: 42%	Visual impact: 36%
Bad for health: 36%	Dirty sea: 31%	Bad for tourism: 24%

2.1.4 Cost of Water and Sanitation

Most of the households (19 out of 24) are equipped with a water meter. 15 out of 19 household who replied to this question confirmed that they pay an average of $32 XCD monthly for water.

DOWASCO charges a flat rate for wastewater management, but this is not applied to residents of Soufriere because these customers have no connection to a sewer system. Yet, none of the households have any cost related to sanitation, because the wastewater holding facilities percolate all wastewater into the subsoil. Water tight septic tanks do not exist in the project area. Consequently, no evacuation costs are incurred for septage haulage or other services.

The questionnaire revealed that 14 out of 19 respondents would be willing to pay for sewerage services (out of whom only 2 interviewees indicated that $30 XCD per month would be a reasonable price).

3. Options for Wastewater Drainage and Treatment

The term “drainage” generally refers to the evacuation of all kinds of undesired water accumulating on private property. It is therefore assumed in the following that rain water is strictly kept out of the alternative drainage concepts presented hereafter. (On a general note: evacuation of rain water into wastewater drainage systems might be convenient for the users, but will only result in oversized – and thus more expensive – conveyors, storage volumes and treatment facilities and should be avoided by all means and everywhere).

When looking at the remaining, much smaller quantities of waste water the following distinctions should be made, as briefly outlined earlier:

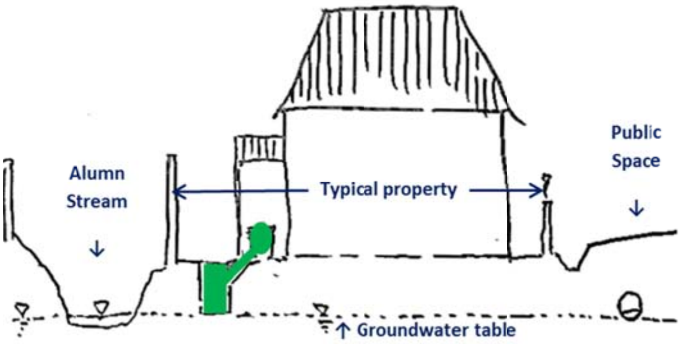
- Grey water: is the largest amount of waste water that originates from typical household processes and personal hygiene.
- Yellow water: is a small faction of wastewater that consists of urine.
- Black Water: is the faction that contains faeces. This small quantity is critical and should be kept out of the environment until it is fully stabilized and all health risks are neutralized. This is generally the case after 6 to 12 months.

The treatment of wastewater generally refers to the faecal matter that is in most cases diluted into wastewater. Natural biological processes are employed to treat wastewater or faecal waste.

3.1 Drainage Options

The typical arrangement of wastewater facilities in the project area next to the Alumn Stream is governed by limitations in space as shown in the cross-sectional sketch bellow:

- Currently existing sanitary facilities are typically located behind the property towards Alumn Stream.
- High ground water table provides little space for gravity pipes installations which require a gradient of 2% for in-house installation to ensure flushing.



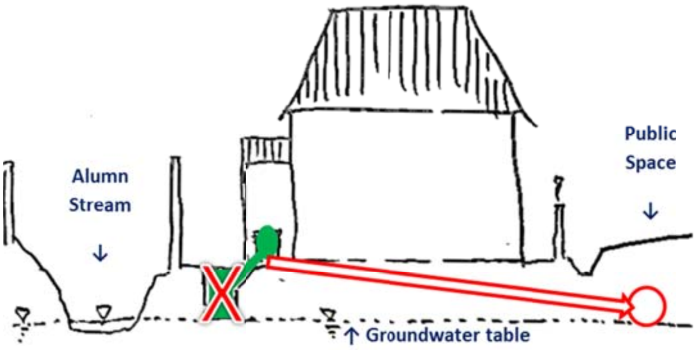
- Little space for the installation of sanitation facilities between Alumn Stream and the property.

The above factors challenge cost efficient construction and easy access for operation and maintenance.

3.1.1 Conventional (gravity) Sewerage

The conventional sewerage is the most common application when it comes to wastewater drainage in the world. Few areas in Roseau are equipped with gravity sewers which connect to a pre-treatment facility and an outfall pipe of 500 meters into the Caribbean Sea.

As concerns the arrangement in the project area in Soufriere the gravity sewer has to be laid in public space, meaning roads and passages. Both banks and the bed of Alumn Stream have to be ruled out for structural reasons. Safety measures to secure the pipes (on both sides of the stream) would be too large (and too expensive) and would further reduce the small hydraulic profile of stream.



This solution requires the provision of approximately:

- 770 meters of Polyethylene (PE) pipe with diameters ranging from 200 mm to 300 mm and a short section 150 mm pressure pipe. All works are assumed to take place in soft soil and manholes are provided at a distance of 30 meters on average.
- On average 15 meters of in-house piping has to be provided per household.
- A lifting station at the low point of the sewer system that conveys the water to the treatment site.

- It is assumed that some houses have to be equipped with a small lifting station because a gravity connection to the sewerage is not possible.

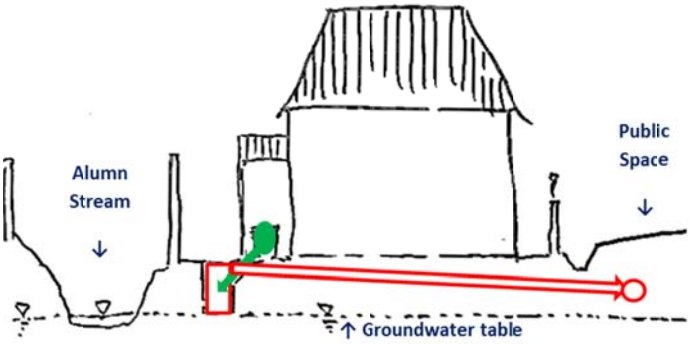
For further details of this technical option please refer to Annex 6 – D1. Cost estimates for capital expenditures (Capex) and operation and maintenance cost (Opex) are presented. Besides the financial aspect, this option has a number of advantages and disadvantages which need to be taken into account. The main environmental benefit will be achieved by decommissioning the soak pits.

Pro's	Con's
- Diameters of sewer are large enough to cope with regular wastewater and maintain sufficient flow velocity. - Terrain in most sections shows sufficient slope. - Little maintenance, if well-constructed. - Soak Pits must be abolished (filled with rubble or excavation material) to avoid unintended use and instability.	- High in cost, because large diameters at large depth are required. - Risk of wastewater exfiltration and groundwater infiltration. - Requires the involvement of a well-organised sewerage department. - Significant pipe laying in private property resulting in damaged floor. These costs have to be covered by the concerned household.

3.1.2 Simplified (condominial or small-bore) Sewerage

Simplified sewerage is a technology that was developed in the 1980s for low-income areas and is mostly used in Brazil. It incorporates elements of community engagement (condominio) to increase user ownership and reduce cost. Additionally, the choice of material and shallow pipe laying are important factors which help reduce costs for the case of Soufriere.

The simplified sewerage will involve the following:



- 770 meters of small diameter Polyethylene pipe. Diameters are expected to vary form 150 mm to 200 mm. As in the case of the conventional sewerage a 150 mm PE pressure pipe of 150 m length is required. All works are assumed to be executed by a local contractor and will take place in soft soil and with inspection chambers (manholes) at a distance of 30 meters on average.
- A lifting station at the low point of the sewer system that conveys the water to the treatment site.
- A small conveyor evacuation truck with 500 litres capacity.
- The technology only works with septic tanks in place. In absence of an assessment of all concerned septic tanks it has been assumed that 50% of the structures need to be replaced and the other 50% have to be rehabilitated (re-lining to achieve water tightness). The overflow will be conveyed through a service pipe to the simplified sewerage

underneath the road. On average 15 meters of piping has to be provided to connect the septic tank to the sewerage.

- It is assumed that some houses have to be equipped with a small lifting station because a gravity connection to the sewerage is not possible.

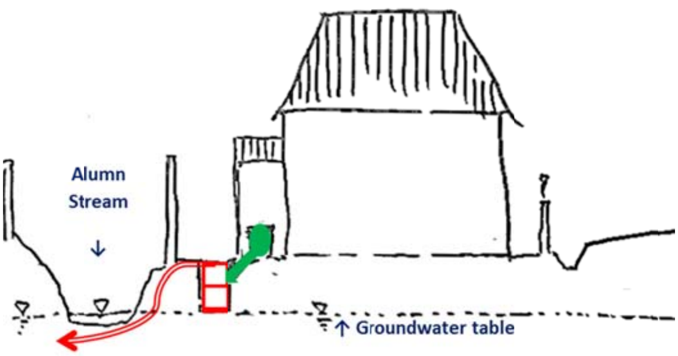
Annex 6 – D2 provides more details on quantities and specific Capex and Opex of that option. The advantages and disadvantages of this option are presented below. The environmental benefit will materialize once the soak pits are either replaced or rehabilitated.

Pro's	Con's
- Sewers can be built and repaired with standard building materials. - Construction can provide short-term employment to unskilled local labourers. - Can be laid at a shallower depth and shallower gradient than conventional sewers. - Lower capital costs than conventional sewers; less operating costs.	- Requires a real septic tank, which incurs regular emptying (once per year). - Repairs and removals of blockages are more frequent than with conventional gravity sewer. - The septic tanks may overflow, if not de-slugged regularly. - Wastewater exfiltration and groundwater infiltration can still occur and is generally difficult to identify. - Requires support from a well-organised sewerage department.

3.1.3 Vacuum Sewerage

High groundwater tables and flat terrain provide the ideal preconditions for a vacuum sewerage. The technology is mostly used in coastal areas were sewerage infrastructure, such as pipes, manholes and lifting stations have to cope with risk of buoyancy. Vacuum sewerage can provide a number of advantages which outweigh the disadvantages usually related to high-tech solutions.

Vacuum sewerage is a system that collects wastewater on household level in small retention/storage tanks. The location of the existing soak pits can be used to install this storage tank. Once the wastewater level has reached a certain level, a vacuum (negative pressure) that is maintained in the system conveys this specific batch of wastewater to take it to a vacuum station that is located at the low point of the project area. Wastewater batches can be easily transported for hundreds of meters with a velocity of up to 6 m/s. In Soufriere a vacuum solution would consist of the following components:



- 17 vacuum tanks, which should be shared among the 45 houses of the project area.
- 6 metres of lateral service pipe per household, adding up to 270 metres of 90 mm PE pipe.

- 1,000 metres of 150 mm PE pipe along the Alumn Stream and in the small pathways on the right bank of the stream.
- 1 central vacuum station with a control panel in addition to
- 150 meters of pressure pipe to the treatment site.

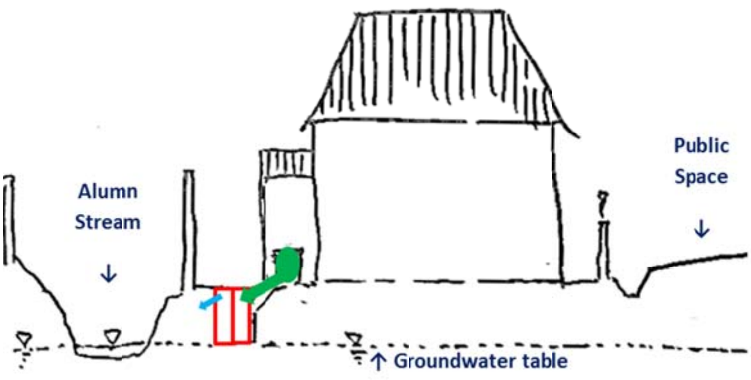
Capex and Opex for the vacuum sewerage solution are presented in Annex 6 – D3. The desired environmental improvement will be achieved once all inhabitants use the proposed facilities instead of soak pits and direct disposal into the stream.

Advantages and disadvantages of the vacuum option are shown in below table.

Pro's	Con's
- Can be laid irrespective of terrain or slope. - To avoid pipe laying on private property an alignment along the Alumn Stream is envisaged; therefore no in-house pipe laying is needed. - Requires very little water to operate. - No risk of infiltration or exfiltration. - Can be laid at a very shallow depth.	- Requires the soak pit to be either used to hold the vacuum tank or to be decommissioned. - Requires professional support in case of technical problems and the involvement of a well-organised sewerage department that is able to deal with blockages/clogging. - Requires 24/7 electricity at the central vacuum station to build up the vacuum in the system at all times. - High capital costs.

3.1.4 On-site Sanitation (improved Septic Tank)

In contrast to a sewerage-based solution the on-site sanitation suggests that the treatment takes place on-site. The concept proposed assumes that standard facilities are provided on the individual properties which cope with sanitation standards and environmental requirements. The facilities which are currently in use are "useless" because all sludge seeps into the underground and further into the groundwater (which communicates with the Alumn Stream). The proposed concept suggests therefore the replacement of the existing facilities with standard septic tanks which consist of several compartments. The first compartment retains the sludge volume for one year (appr. 200 litres for the average household size in Soufriere). A biological degradation of the faecal sludge is taking place in that very chamber. The two following compartments are required to retain settleable matter. These compartments need to be emptied every 5-10 years. Perforated pipes may be provided to improve the percolation into the underground, but soil conditions generally seem to cope well.



The investments related to this solution are the following:

- 45 Septic Tanks. All sanitation facilities such as soak pits and others, will be replaced with Standard Septic Tanks. Where no such facilities exist a new Standard Septic Tank will be provided. The cost estimate does not provide for perforated pipes.
- 1 evacuation truck with a capacity of 500 litres. The vehicle is equipped with a long hose pipe that reaches from the road into the septic tank. The vehicle is also small enough to make it into the narrow passages in the project area.

Details of the capital expenditures and the recurrent operation and maintenance cost are presented in Annex 6 – D4. Alumn Stream will improve and the reported nuisance will be achieved once the standardized septic tanks are in use. The effluent that is emitted from these facilities is safe enough to be discharged into the underground.

The advantages and disadvantages which are attributed to septic tanks in the context of the project area in Soufriere are listed hereafter.

Pro's	Con's
- Fits best to the prevailing urban arrangement with dwellings being located in immediate vicinity of Alumn Stream. - Shows acceptable treatment results. - Very moderate capital and low operation cost. - Construction will provide employment to local labourers/plumbers. - Moderately organised sewerage department will manage easily to register and certify the septic tanks prior to commissioning.	- Requires emptying once a year. - Due to percolation into the underground environmental performance is considered to be lower than a well-functioning sewer system.

3.2 Treatment Options

All four drainage options, D1 to D4 convey different quantities of waste to the treatment stage. These quantities are estimated in below table and are used to look into sizing the treatment options.

Drainage Option	Quantity and quality of waste	Chosen Treatment Option
D1, D2, D3	16 m^3 per day wastewater containing some 50 litres of faecal sludge. The expected pollution, expressed as Bio-chemical Oxygen Demand (BOD5) concentration is in the range of 600 mg/l and the Chemical Oxygen Demand (COD) is expected to reach 1,150 mg/l.	T1 : Wastewater Treatment Plant: Settling Tank followed by an Anaerobic Baffled Reactor and Horizontal Gravel Filter. The sludge is dried on sludge drying beds.
D4	150 litres or 0.15 m^3 per day of faecal sludge with concentrations of pollution load of 67 g BOD5/l and 130 g COD/l respectively.	T2 : Faecal Sludge Treatment Facility consisting of an Anaerobic Baffled Reactor and Horizontal Gravel Filter. The sludge is dried on sludge drying beds.

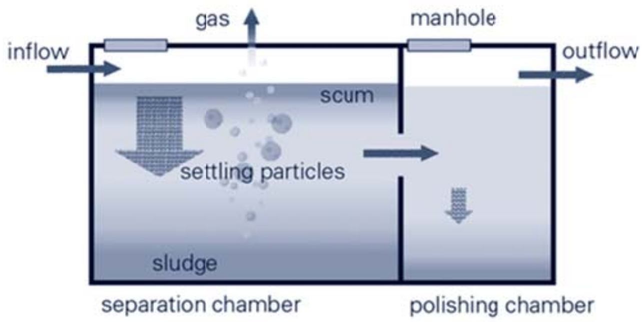
In the following the different components of the treatment processes are introduced to provide an understanding for the specific tasks of each component in the process and the operational requirements of that treatment step.

3.2.1 Settling tank

The first component of the wastewater treatment process receives the wastewater from the pumping station that is provided by Drainage Options 1 to 3.

Some treatment processes rely on oxygen transfer to induce the growth of biomass (in fact bacteria) which consumes the nutrients contained in faecal sludge and converts it into more bacteria. These processes require energy to dissolve oxygen into the water and produce sludge which has to be disposed after the treatment.

Other processes do not need oxygen for the treatment. These so-called anaerobic processes employ a different kind of bacteria which converts the faecal sludge into methane and inert sludge. This process is considered here because it is lower in operation costs and produces less sludge.



The settling tank constitutes the first stage of the anaerobic treatment process and it primarily takes settleable matter out of the process. At this point anaerobic activity is already taking place.

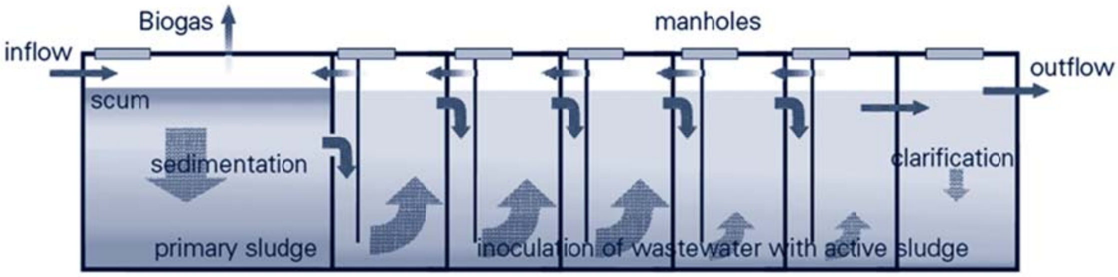
This treatment step has four different outputs:

- Water, which still contains substantial polluting substances and which flows by gravity into the next reactor.
- Sludge, which is taken through to the sludge drying beds. (Volume in the order of 15 m^3/year)
- Scum, is lighter than the wastewater and therefore floats on top. It could develop a solid layer that needs to be removed and safely discharged on a solid waste landfill. (Expected volume per year in the order of 2m^3/year)
- Methane, which could be used. In the case of Soufriere the use of methane gas could be considered. It is not accounted for in the cost estimate however. (Methane volume per year depends on a number of parameters, such as size of the tank, temperature, BOD5 load. The volume is expected to be in the range of 150$m^3$$CH_4$/year). Please refer to Annex 8 for more details.

3.2.2 Anaerobic Baffle Reactor

This treatment step (ABR) must be considered as the actual wastewater treatment unit. The wastewater that comes from the settling tank is being forwarded first into a settling compartment which is then followed by vertical cascades that force the water down to contact the layer of active sludge sitting on the floor of each compartment. The bacterial matter or sludge will then consume the remaining nutrients, primarily carbon and, to a lower degree, nitrogen and phosphorous and convert them to biomass and methane.

The number of cascades may vary, but should not be less than three.



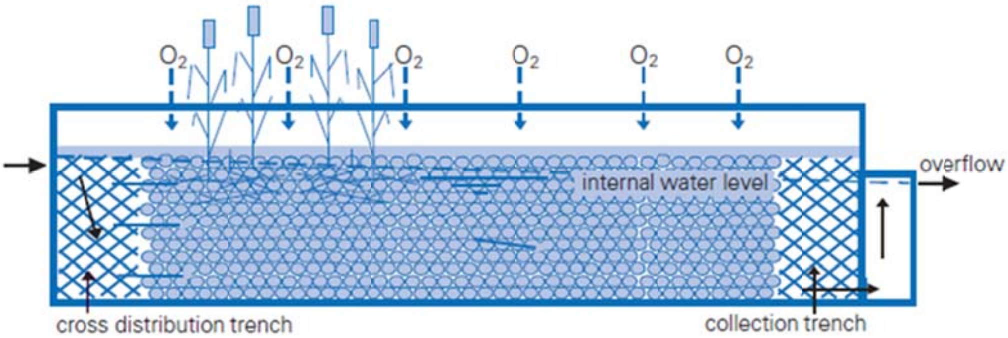
Again, four different outputs are expected at this stage:

- Water, which still contains some polluting substances and which flows to the horizontal gravel filter.
- Sludge, that has to be taken to the sludge drying beds. (30 m³/year).
- Approximately 0.5 m³ of scum per year.
- 800 m³ Methane (CH4) per year. The total exploitable quantity of methane in Soufriere could be in the range of roughly 1,000 m³ per year, equivalent to 600 litres of diesel fuel.

3.2.3 Horizontal Gravel Filter

The horizontal gravel filter receives water from the ABR. The water flows by gravity through the layers of gravel to achieve the final treatment of the water. So far the water is free of dissolved oxygen. It is now exposed to air and helps develop a biofilm on the surface of the gravel that will further extract dissolved nutrients from the water.

Plants, generally species of reed, may grow on top to further consume nutrients contained in the water.



The following is expected out of this treatment stage:

- Approximately 16 m³ per day of treated wastewater (effluent) exit the treatment process towards the effluent pumping station. The expected treatment efficiency should be in excess of 90% (BOD5 removal).
- Reeds and other plants which grow on top have to be harvested regularly.

3.2.4 Discharge Pumping Station

The treatment site will be located close to the sea. It is therefore necessary to convey the effluent in a safe manner into the sea. Effluent water has to be dissolved into the saline sea water at a safe distance from the shore. A pumping station and a 50 m outfall pipe with a small diffusor for 0.7 m³/hour and 5 meter pressure head would be recommended.

3.2.5 Sludge Drying Bed

Approximately 18 m³ of sludge have to be dried every year, requiring a number of identical sludge drying beds. These need to be covered to not hamper the drying process. The sludge is expected to be of good quality with a high content of Nitrogen and Phosphorous, because the treatment process is not designed to eliminate these substances. Additionally, it should be low in critical pollutants, such as heavy metals or hydrocarbons because only domestic users are connected to the system. It is recommended therefore, once dried and aesthetically friendly, to be distributed and used as soil conditioner.

3.2.6 Wastewater Treatment Plant

The water treatment plant will handle the collected wastewater and will consist of the following treatment components:

- Settling Tank
- Anaerobic Baffled Reactor (ABR)
- Horizontal Gravel Filter
- Effluent pumping station plus sea outfall, and
- Sludge drying beds.

The total surface requirements for this treatment concept is approximately 500 m² including traffic space. It is preferable to lay the tanks underground, only a few manhole covers will remain visible. However, this option is out of question along the coastal road of Soufriere given the fact that both, settling and ABR tanks will be 2.5 meters in depth and the (saline) groundwater is within reach. Another option, though a difficult one, could be its placement in front of the church. This area is sufficiently elevated to avoid buoyance and, as mentioned earlier, the settling tank and the anaerobic tanks will not be visible. The Horizontal Gravel Filter and the small effluent pumping station could be placed in such a way that they do not disturb normal activity at the site. The sludge drying (40 m²) should take place elsewhere, preferably upstream of Soufriere – maybe in vicinity of the school due to sufficient available space. Maintenance work will be needed only occasionally.

Detailed capital expenditures and operation and maintenance cost are presented in Annex 6 – T1.

3.2.7 Faecal Sludge Treatment Facility

The sludge collected from the households by the evacuation vehicle must be transported to the treatment site. The components of the faecal sludge treatment facility are the following:

- Anaerobic Baffled Reactor (ABR)
- Horizontal Gravel Filter
- Sludge drying beds.

The most appropriate location for the Faecal Sludge Treatment facility would be upstream of Soufriere. With 200 m², surface requirements already account for some extension. Annex 5 – Photo 7, shows a spot that could accommodate such a facility. It is easy to reach for the FS-vehicle and distant enough to the next residential building to avoid nuisance.

On a side note: This treatment site should be used for all faecal sludge that is being collected in Soufriere. In time, and with more septic tanks being constructed to standard, the volume of collected faecal sludge will increase.

Capex and Opex for the Faecal Sludge Treatment concept are presented in Annex 6 – T2.

3.3 Investment and Recurrent Cost

3.3.1 Four Alternatives

In total four alternatives, combining drainage and treatment options are presented:

	Drainage Option	Treatment Option	
1	Conventional sewerage (D1)	Anaerobic Baffle Reactor (ABR) and Sea Outfall (T1)	D1-T1
2	Simplified sewerage (D2)	ABR and Sea Outfall (T1)	D2-T1
3	Vacuum sewerage (D3)	ABR and Sea Outfall (T1)	D3-T1
4	Improved septic tanks (D4)	Faecal sludge treatment (T2)	D4-T2

Investment costs are shown in below table. Note that for the economic analysis, the expected life time was taken into consideration. Civil works were assumed to be fully depreciated after 40 years. Electro-mechanical works have an expected life time of only 15 years.

As concerns the operation costs, they are related to the public facilities. For details of unit prices, energy cost and others, please refer to Annex-5.

Option	Process option: Collection option	Process option: Treatment option	Collection: Investment cost * (XCD)	Collection: annual operation cost (XCD/year)	Treatment: Investment cost ** (XCD)	Treatment: annual operation cost (XCD/year)
1	Conventional sewerage (D1)	Decentralized WW-Treatment (T1)	625.000	22.000	202.000	19.000
2	Condominial sewerage (D2)	Decentralized WW-Treatment (T1)	681.000	21.000	202.000	19.000
3	Vacuum sewerage (D3)	Decentralized WW-Treatment (T1)	923.000	33.000	202.000	19.000
4	Improved Septic Tanks (D4)	Sludge Treatment Facility (T2)	90.000	12.000	15.000	9.000

*) inhouse facilities included, **) land acquisition included

Above table reveals that option 4, the replacement of soak pits with improved, standardized septic tanks is the most cost efficient solution. This holds true for both, investment and operation costs.

In-house costs which are associated with the different options are an important aspect for the concerned households and will reflect primarily on their willingness to accept a given solution. These costs are not included in above table but presented in the table below.

Option	Process option: Collection option	Process option: Treatment option	Inhouse Facilities (to be carried by each household)	Investment cost (XCD/hh)	Operation cost (XCD/hh/year)
1	Conventional sewerage (D1)	Decentralized WW-Treatment (T1)	Small pumps in parts of premises, refurbishment of floors in some houses	3.000	42
2	Condominial sewerage (D2)	Decentralized WW-Treatment (T1)	Septic Tanks, Soak pits, small pumps in some premises	5.100	35
3	Vacuum sewerage (D3)	Decentralized WW-Treatment (T1)	Abolish septic tank, provision of pipe and reinstatement of floor	1.800	39
4	Improved Septic Tanks (D4)	Sludge Treatment Facility (T2)	Replacement of old septic tanks and soak pits	2.300	14

Here, the vacuum sewerage is the least expensive in terms of investment cost. When it comes to recurrent, operation and maintenance costs the picture is different. With only 14 XCD per household per year, Option 4, again, appears to be the most affordable. It is important to note that the overall costs per household are higher. Because, for the collection and treatment concept to remain financially sustainable, the households will have to contribute to the operation of the conveying system and the cost related to the wastewater and faecal sludge treatment.

3.3.2 Total Cost

Aggregating all "public" cost reveals that the sewerage-based solutions, regardless of the technology adopted, come at a significantly higher price. The pipe works and the civil structures, both referred to as civil works in below table and the equipment are more expensive. The land acquisition, which contributes only with marginal 5%, is also more expensive than the on-site-solution.

Option	Process option		Total Cost			
	Collection option	Treatment option	Civil Works XCD	Electro-Mechanical Works XCD	Land Acquisition XCD	Investment Cost * XCD
1	Conventional sewerage (D1)	Decentralized WW-Treatment (T1)	842.500	102.700	55.000	1.000.200
2	Condominial sewerage (D2)	Decentralized WW-Treatment (T1)	803.150	94.600	55.000	952.750
3	Vacuum sewerage (D3)	Decentralized WW-Treatment (T1)	779.200	292.600	55.000	1.126.800
4	Improved Septic Tanks (D4)	Sludge Treatment Facility (T2)	133.500	3.000	11.000	147.500

*) inhouse facilities not included

3.3.3 Environmental impact

In contrast to the financial aspect of the approach, the expected environmental impact suggests that the sewerage-based options are in principle a better option, only the location of the treatment facility is critical.

Option		Treatment efficiency *	Protection of Alumn Stream	Nuisance (odour, traffic, noise)	Land-use	Extension
1	D1-T1	++	++	-,-,0	--	-
2	D2-T1	++	++	-,-,0	--	-
3	D3-T1	++	++	-,-,0	--	-
4	D4-T2	+	+	--,-,0	-	++

*) ++ (very positive), -- (very negative)

The treatment efficiency of Wastewater Treatment Plant (T1) is expected to eliminate at least 90% of the BOD5 in contrast to some 60% expected in the Process T2. Some BOD5 will be released by the improved septic tanks into the subsoil. The volumes of eliminated BOD5 which no longer pollute the environment will be 3,300 kg BOD5 per year for option T1 and 2,150 kg BOD5 respectively for option T2.

3.3.4 Dynamic Prime Cost

The Dynamic Prime Cost (DPC) calculation is a method that allows the comparison of different technical alternatives by:

- Considering both, investment cost and operation/maintenance cost.
- Including the life time of civil and electro-mechanical works.
- Relating the cost to a product of the process. This could be either the aggregated volumes of treated wastewater or annually removed BOD5.

- Approximating cost covering prices for wastewater collection and treatment for tariff design.

This method is used by the German Development Bank (KfW) and is employed here to decide upon the most efficient option (in terms of cost for handled wastewater, red column in below table) and most effective one (in terms of protection of the Alumn Stream, expressed as eliminated BOD5, green column below). For details please refer also to Annex 7.

Option	Process option: Collection option	Process option: Treatment option	Dynamic Prime Cost **: for operation (XCD / m3 wastewater)	for investment *** (XCD / m3 wastewater)	**Total cost per m³** (XCD / m3 wastewater)	for operation (XCD / kg eliminated BOD5)	for investment *** (XCD / kg eliminated BOD5)	**Total cost per m³** (XCD / kg eliminated BOD5)
1	Conventional sewerage (D1)	Decentralized WW-Treatment (T1)	6,7	8,5	**15,2**	12,1	15,4	**27,6**
2	Condominial sewerage (D2)	Decentralized WW-Treatment (T1)	6,6	8,1	**14,6**	12,0	14,7	**26,6**
3	Vacuum sewerage (D3)	Decentralized WW-Treatment (T1)	8,5	9,7	**18,2**	15,4	17,6	**33,1**
4	Improved Septic Tanks (D4)	Sludge Treatment Facility (T2)	3,5	1,2	**4,7**	9,4	3,3	**12,8**

) dynamic prime cost at a discount rate of 5%, *) land acquisition not included in dynamic prime cost calculation

Both calculations clearly identify Option 4 as the most favourable. It is worth mentioning that, in order to achieve sustainability, at least the cost for operation have to be generated from revenues by adopting an appropriate mechanism for cost coverage. This said, the cost of 3.5 XCD per m3 of handled wastewater has to be put into relation to the average household income. International recommendations suggest that both, access to water and sanitation should not cost more than 5% (maximum) of the household income. The table below indicates that the only option that may be considered affordable in the context of Soufriere is option 4 – improved septic tanks and faecal sludge treatment.

		option 1: D1-T1	**option 2: D2-T1**	**option 3: D3-T1**	**option 4: D4-T2**
monthly water consumption:	m³/month	10,5			
annual wastewater production:	m³/year	101			
annual wastewater cost for maintenance of the inhouse facility:	XCD/HH/year	42	35	39	14
dynamic prime cost, on the:					
- operation	XCD/year	673,2	663,6	855,3	348,7
- investment	XCD/year	855,5	812,5	978,3	123,0
percentage of household income* spent on **water supply** services					
32 XCD / month	%	2,1%			
percentage of household income* spent on **wastewater** services					
- operation only	%	4,0%	3,9%	5,0%	2,0%
- operation and investment	%	8,5%	8,2%	10,2%	2,6%
Total monthly spendings on water and sanitation per household	**% of household income**	**10,6%**	**10,3%**	**12,3%**	**4,8%**

*) average household income per month = 1,500 XCD (source: questionnaire, refer also to Annex 3)

4. Conclusions

The mission to Soufriere in the week from 27th to 31st of October 2014, the meetings conducted and the completed questionnaires revealed that the situation encountered in Soufriere along the Alumn Stream is typical of countless organically developed settlements. Whether these settlements are rural or urban is eventually irrelevant because they all face consequences which are, in most instances, indicative of limited resources, absent or poor urban planning and lack of awareness among the residents.

The objective to alleviate the problems which affect the Alumn Stream and the marine environment can only be met with an integrated sanitation concept for Soufriere. This concept would advocate for an appropriate solution for handling the solid waste and for containing the wastewater quantities generated by the residents. A communication and awareness raising strategy would mobilize the community and complement the works. In this regard a 3-D model of St Mark Parish, which included the project area in Soufriere, will help develop a better understanding of the spatial arrangements.

The main outcome of the mission is a recommendation on how to proceed with the wastewater sanitation topic in the vicinity of the Alumn Stream. Improved septic tanks which comply with environmental standards are recommended to substitute the currently used soak pits. An emptying is foreseen to take place once per year. This service is expected to be provided in conjunction with the treatment of faecal sludge in a facility upstream of Soufriere.

The selected option fulfils a number of criteria:

Environmental appropriateness: The objective of protecting Alumn Stream and Soufriere Bay from untreated wastewater generated in the project area is accomplished. The treatment efficiency, in terms of BOD5 reduction is assumed to be in the magnitude of 60%. The overall treatment is much higher though because the faecal sludge is stabilized and effluent water which is released into the underground is safe to be diluted into the groundwater without harm. The degradation of coliforms and other germs depends largely on the travelling time until abstraction. Drinking water is provided in all cases through the public water distribution network.

Cost Efficiency and Affordability: Comparing different technical options has revealed that the proposed solution is much more efficient than sewer-based options of different standard. This advantage reflects positively on the affordability. Applying the “polluter-pays-principle” requires the producers of wastewater, namely the households, to bear the cost for collection and treatment. The discussion has shown (chapter 3.3.4) that the selected option fits well into the socio-economic environment encountered in the project area.

Regulation and In the case of on-site-sanitation the regulatory part might be regarded as less relevant. This is misleading however, because soak pits will not be

Operation:

replaced with improved septic tanks without an authority administering the process. This role ranges from standard setting for septic tanks and faecal sludge treatment, to monitoring the quality of on-site facilities and the on-going operation. Tariff setting is another key task of the regulatory body as well as incentivising households to invest into their environment.

Knowing that almost all households are subscribed to DOWASCO suggests that the operational responsibilities for Faecal Sludge collection and treatment should be given to them. Non-subscribers to the water supply should be registered as septic tank owners and should pay a tariff for sludge evacuation and treatment.

At this point DOWASCO has only little experience with wastewater and sludge treatment. The required expertise for the operation of T2 (FS-Treatment facility) is less critical than the expertise needed to operate a wastewater treatment plant (T1). In all cases a dedicated and professional attitude is required to sustainably protect the environment, which certainly is in the best interest of a water utility.

Scalability:

The proposed concept is considered to be best among the discussed options in terms of scalability because it may be easily expanded by installing the improved septic tanks in other households. There is no difficult sewerage needed that connects to a wastewater treatment with limited hydraulic capacity. The FS-vehicle has a reserve of more than 200% and the treatment facility can be temporarily surcharged and can be easily extended.

Scalability however is first and foremost a matter of setting the right framework conditions. In the context of Soufriere this means that regulatory arrangements (see above) and incentives in addition to a pronounced willingness to protect the environment have to be in place to carry the process forward.

ANNEXES

Annex 1: Mission Programme

Caribbean Aqua-Terrestrial Solutions

Sewage Solution Mission, Soufriere, DOMINICA

October 27-31 2014

GIZ & CARPHA:
- Clauzel, Shermaine, Environmental Health & Sustainable Development Department, CARPHA
- Defoe, Brendan, National Project Officer CATS1 for Dominica
- Hassib, Younes, GIZ Programme "Sustainable Sanitation Solutions"
- Naeher, Eva, Principal Technical Adviser CATS1

Dominica:
- Ministry of Lands, Housing, Settlements & Water Resource Management
- DOWASCO
- Environmental Health Department
- SSG Village Council

#

Monday, 27th of October 2014

Meeting with Permanent Secretary, Mr. Letang (Ministry of Lands, Housing, Settlements & Water Resource Management), Mr. Jules of Housing, Mr. Lestrade of Lands & Survey and Mr. Magnus Williams, DOWASCO in Roseau

Briefing for mission

Field visit 1:

Trip to Soufriere & Visit of households along Alumn Stream and assessment of sewage system

Joined by Mr. Austrie and Mr. Magnus Williams from DOWASCO and briefly discussed with Mr. Oscar, Chairman of SSG Village Council, Soufriere

Tuesday, 28th of October 2014

Field visit 2:

Trip to Soufriere & Visit of Soufriere, the sulphur springs and assessment of potential areas for water treatment solutions. Joined by Mr. Sylvester St. Ville and Ms. Zilma Charles from the Environmental Department, and Mr. Hypolite Austrie from DOWASCO. Later that day we met Mr. Robinson, resident officer from the Environmental Health Department.

Wednesday, 29th of October 2014

Preparation in Roseau

Trip to Soufriere, attending the Community-Meeting in Soufriere, Village Council. Participants were 3 SSG Village Council Members: Ketura St. Ville, Pamela Delsol and Benjamin Pascal. A number of villagers attended.

Thursday, 30th of October 2014

Preparation of first solutions in Roseau

Trip to Soufriere for wastewater treatment site inspection

Friday, 31st of October 2014

Meeting with Ministry LHSWRM, PS Mr. Letang, Mr. Jules from Housing, Mr. Lestrade from Land & Survey, Mr. Austrie and Mrs. Curvelle Monroe from DOWASCO as well as Mr. Ray Robinson of Environmental Health.

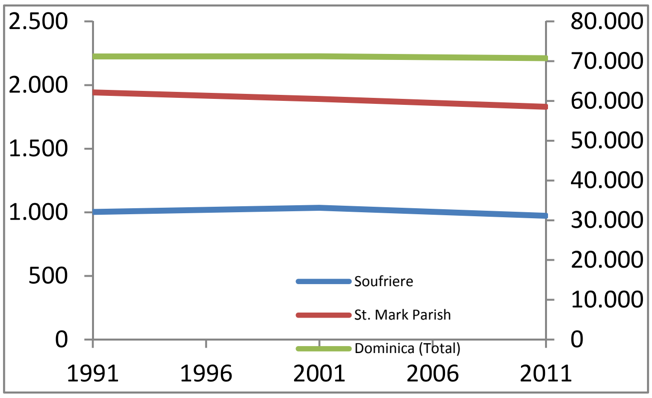
Presentation of Results and Recommendation for Preferred Solution, Discussion of Next Steps

Debriefing with GIZ and CARPHA

ANNEX 2: Population Development in Soufriere, Dominica

source: **2011 Population and Housing Census**
PRELIMINARY RESULTS
CENTRAL STATISTICAL OFFICE
MINISTRY OF FINANCE
KENNEDY AVENUE
ROSEAU, 1.9.2011

	Sensus year		
	1991	**2001**	**2011**
Soufriere	1.003	1.036	973
St. Mark Parish	1.943	1.891	1.829
Dominica (Total)	**71.183**	**71.242**	**70.739**



	1991			**2001**			**2011**		
	Male	Female	**Total**	Male	Female	**Total**	Male	Female	**Total**
Soufriere	496	507	1.003	505	531	1.036	479	494	973
Gallion	69	69	138	72	62	134	88	59	147
Scotts Head	400	402	802	342	379	721	341	368	709
St. Mark Parish	965	978	1.943	919	972	1.891	908	921	1.829

Annex 3: Questionnaire for Household Survey in Soufriere

Household Survey on sanitary facilities - Soufriere, Dominica

The specific objectives of this household survey are:

1. the collection of quantitative data for the assessment of sanitary facilities;
2. the willingness of residents to connect to a sanitary system: and
3. the ability of residents to pay for improved sanitation services.

In addition, given that water supply and sanitation concepts are closely linked, water aspects will be addressed as part of this survey.

Because the level of available information is not yet known, a set of general questions will be required beforehand. (On this note: the 2011 census may provide some insight into water and sanitation service levels too).

Instructions for use:

- Conduct the survey with households which contribute to the pollution of the Alumn stream (?)
  According to the "2011 POPULATION AND HOUSING CENSUS" the number of persons per household is 2,7. With a given number of 973 inhabitants in 2011, the number of households is 364. Only household which are adjacent to the "stream" and which are likely to have no proper means to dispose their waste water are subjected in this survey.
- It is important to use a map and indicate the location of the households included in the questionnaire.
- DOWASCO should be involved in the process of completing the questionnaires.

1. General description of household:

Number of questionnaire:	Located in map:		
Name of respondent			
Address			
Telephone *			
Permanent family members (nr.)			
Employed members of household	1	2	3
F – Full time P – Part time Y – Year round S – Seasonal /Sporadic	F P Y S	F P Y S	F P Y S
Profession/type of employment			
Average monthly household income (XCD)			
Children under 16 years old (nr.)			
Residence (pls tick)	house	apartment	
Owned / rented	owned	rented	
Type	domestic	non-domestic	
Linked to DOWASCO network?	Yes: Subscription Nr. ……………………………………………………….. No – for what reasons?		

Annex 3: Questionnaire for Household Survey in Soufriere

2. Water consumption

2.1. Water source (circle one mostly used for the purpose of)

Purpose	Food/ Drinking	Wash dishes	Shower / bath	Toilet	Wash	Irrigation or livestock
Water source in the house (network)	1	1	1	1	1	1
Water source in the yard (network)	2	2	2	2	2	2
Public tap (pipe outside of the yard)	3	3	3	3	3	3
Public well	4	4	4	4	4	4
Private well	5	5	5	5	5	5
Lake, river, spring	6	6	6	6	6	6
Rainwater	7	7	7	7	7	7
Other *(specify)*	8	8	8	8	8	8

2.2. Water source availability:

Water supplied 24h / 7days / 12 month a year?	yes	no
Frequency of interruption:		
i. Daily	yes	no
ii. Several times a week	yes	no
iii. Several times a month	yes	no
iv. Several times a year	yes	no
v. Never	yes	no
Sufficient water available during the dry season ? For which purposes ?	yes	no
i. Drinking	yes	no
ii. Cooking	yes	no
iii. Hygiene	yes	no
iv. Laundry	yes	no
v. Irrigation	yes	no

Annex 3: Questionnaire for Household Survey in Soufriere

2.3. Financial information on water supply (both connected and non connected users):

Do you have a water meter?	yes	no
How much is your water consumption per month?	Gallons : Price XCD:	
Do you pay for water supply regularly?	yes	no
How much you pay on average monthly basis?	XCD :	
Are you willing to pay more for improved water services?	yes	no

3. Sewage access and utilization of waste water

3.1. Sources of waste water

How many water sinks do you have in the:	House:	Yard:
How many toilets do you have in the:	House:	Yard:
Do you have a bathtub/shower?	yes	no
Do you have a washing machine?	yes	no
Any other water consuming devices? (pls specify)		

3.2. Where do you discharge your waste water ?

Point of discharge / Type of wastewater	sewerage	Septic tank	latrine	drainage to the stream	drainage to the road
Sink (grey water)	1	1	1	1	1
Toilet (black water)	2	2	2	2	2
Shower / Bathtub (grey water)	3	3	3	3	3
Storm water (rain water)	4	4	4	4	4
Other *(specify:)*	5	5	5	5	5

3.3. Environmental situation :

Is your waste water discharge environmentally friendly ?	yes	no	
What is the major environmental problem ? (pls tick <u>two</u> from list)	Bad odour	Dirty stream	Dirty sea
	Bad for Tourism	Bad for health	Visual impact
Are you willing to contribute to an improved environment ?	yes	no	

Annex 3: Questionnaire for Household Survey in Soufriere

3.4. Financial information on waste water discharge :

What is your approximate monthly cost for waste water discharge ?	XCD :	
If you use a septic tank / latrine – how many times do you empty it per year? OR When was it last emptied?		
What is the approximate distance from the toilet/latrine to the road?	Length unit:	
Are you planning to replace the latrine with septic tanks in near future?	yes	no
Would you prefer to be connected to sewerage?	yes	no
Would you be willing to pay for sewage services? If Yes, what would be the limit in XCD?	yes	no

Climate change scenario

How often were you affected by flooding in the last 2 years? Description of damage:	Not at all
	1-2 times
	More than twice
Did you perceive periods of interruption longer than 5 hours to the regular water supply such as during a drought or after a hurricane has destroyed infrastructure in the last 2 years?	Not at all
	1-2 times
	More than twice
During times of interruption – what is your alternative source of water for domestic use and sanitation?	Alumn Stream
	Other (specify)
Did your need in water supply change over the last 5 years?	Increased
	Same
	Decreased

Additional data (descriptive):

Size of house		
Type of construction	wooden, stone, etc.	
Utilization	Residential	Business
Outside space available for potential infrastructure		
Accessibility from road for works, maintenance of septic tanks, etc.		

Annex 4: Tabular summary of household questionnaire

1.	Total number of questionnaires filled		**45**					
			total	average	total respondents			
	Total persons		94	3,4	28			
	Employment pattern		Full	Part-time	Year round	Seasonal		
			9	12	0	1		
			total	average	total respondents			
	Average monthly household income (XCD)	XCD:	22.700	1.513	15			
	Children under 16 years old (nr.)		19					
	Residence (pls tick) house/appartment		house	appartment				
			31					
	Owned / rented		owned	rented				
			33	1				
	Type - domestic/non-domestic		domestic	non-domestic				
			27	2				
	Subscription Nr. with DOWASCO ?		yes	no				
			29	2				
2.1	Purpose		Food/ Drinking	Wash dishes	Shower / bath	WC	Wash	Irrigation or livestock drinking
	Water source in the house (network)		28	17	19	16	2	1
	Water source in the yard (network)		2	11	3	1	10	
	Public tap (pipe outside of the yard)		2	2	6	2	3	1
	Public well						1	
	Private well		1					
	Lake, river, spring							
	Rainwater					2	3	4
	Other (specify							
			yes	no				
2.2	Water supplied 24h / 7days / 12 month a year?		22	1				
	Frequency of interruption:			3				
	Daily		3	23				
	Several times a week		1	25				
	Several times a month		1	25				
	Several times a year		6	24				
	Never		3	16				
	Sufficient water available during the hot season ?		19	1				
	Drinking		28	1				
	Cooking		26	1				
	Hygiene		24	1				
	Laundry		19	1				
	Irrigation		12	1				
2.3	Do you have a water meter?		19	5				
	How much is your water consumption per month?	Gallons :	248,5	28	9			
			yes	no				
	Do you pay for water supply regularly?		15	4				
			total	average	total respondents			
	How much you pay on average monthly basis?	XCD :	511,1	32	16			
			yes	no				
	Are you willing to pay more for improved services?			5				
			total	average	total respondents			

3.1	How many water sinks do you have in the:	house:	37	161%	23		
		yard:	5	83%	6		
	How many toilets do you have in the:	house:	24	109%	22		
		yard:			1		
			yes	no			
	Do you have a bathtub/shower?		20	5			
	Do you have a washing machine?		14	8			
	Any other water consuming devices? (pls specify)			1			
3.2	Type of wastewater		sewerage	Septic tank	latrine	drainage to the stream	drainage to the road
	Sink (grey water)			5		23	5
	Toilet (black water)			16		12	1
	Shower / Bathtub (grey water)			5	1	20	3
	Storm water (rain water)					8	5
	Other (specify:					3	
	Toilet (solid waste)					4	
			yes	no			
3.3	is your waste water discharge environmentally friendly ?		15	13			
	What is the major environmental problem ?		Bad odour	Dirty stream	Dirty sea		
			19	24	14		
			Bad for Tourism	Bad for health	Visual impact		
			11	16	16		
			yes	no			
	Are you willing to contribute to an improved environment ?		24	1			
3.4	What is your approximate monthly cost for waste water discharge ?	XCD :	0				
			total	average	total respondents		
	If you use a septic tank / latrine - how many times do you empty it per year?		3	1	3		
	What is the approximate distance from the toilet/latrine to the road?	feet	870	51,2	17		
			yes	no			
	Are you planning to replace the latrine with septic tanks in near future?		8				
	Would you prefer to be connected to sewerage?		12	7			
	Would you be willing to pay for sewage services?		14	5			
			total	average	total respondents		
	if yes, what would be the limit in XCD?	XCD:	60	30	2		
			Not at all	1-2 times	more than twice		
3.5	how often are you affected by flooding in the past 2 years?		15	6	4		
	Did you perceive periods of interruption longer than 5 hrs ...		14	5	3		
			Alumns stream	Other			
	During times of interruption, what is the source		10	11			
			increased	same	decreased		
	Did you need in water supply change in the last 5 yrs?		6	12			
			total	average	total respondents		
3.6	size of house	sqf	2200	733	3		
			wood	stone			
	Type of construction		9	19			
			residential	business			
	Utilization		24				
			yes	no			
	outside space available for infrastructure		13	2			
	accessibility from road for works, maintenance of septic tank etc.		14	1			

Annex 5: Photo Documentation

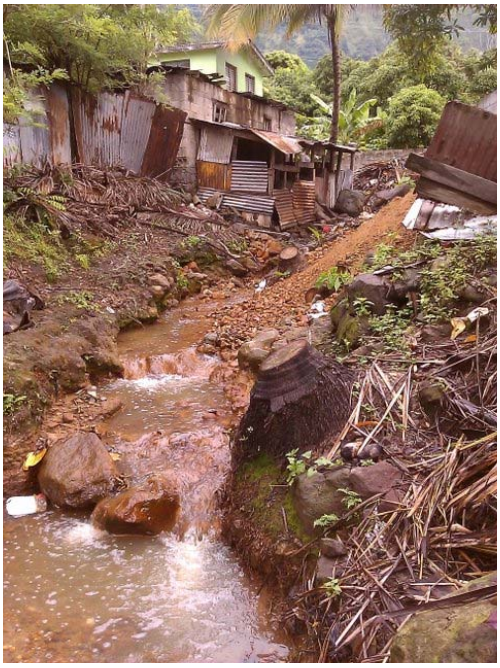


Photo 1: Upstream view of Alumn Stream showing pigsty on the left side

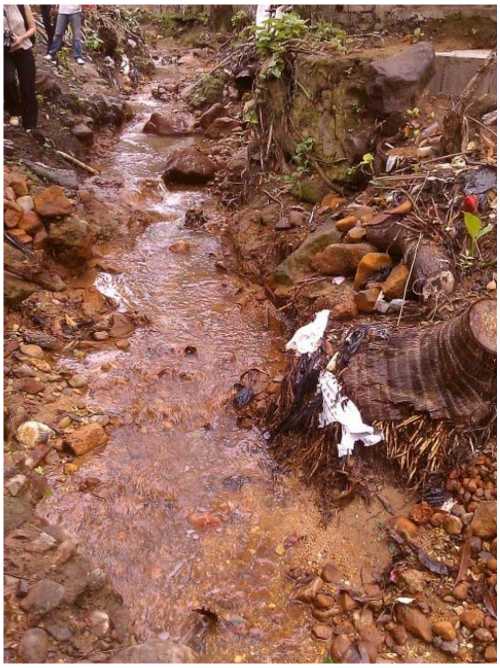


Photo 2: Downstream view of Alumn Stream

Photo 3: Alumn Stream bed after clean-up

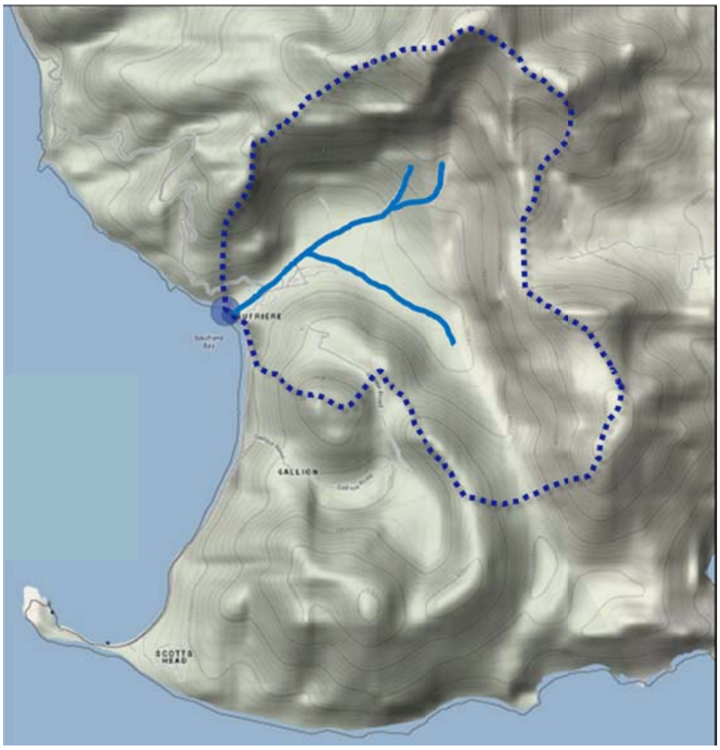
Photo 4: Open wastewater drain not feeding into Alumn Stream

Photo 5: Pigsty next to Alumn Stream

Photo 6: Stagnant wastewater at the shore

#
# #

Annex 5: Photo Documentation



Map 1: Cachtment area of Alumn Stream with a total surface of approximately 4 km²

Map 2: Project area along Alumn Stream with some 50 dwellings

Photo 7: Tilted areal view showing the project area and the proposed alternative locations for the treatment facilities T1 and T2

Annex 5: Calculation of cost - CAPEX and OPEX

Assumptions:

Conversion rates:

EUR	3,6	XCD
USD	2,6	XCD

Energy price:

XCD/kWh	0,713	XCD/kWh

Life time:

Civil:	40	years
Electromechanical:	15	years

Land Price:

Village center, by the sea:	110	XCD/m2
Village, upstream (50%)	55	XCD/m3

Labour cost:

Unskilled worker	60	XCD/day
Skilled worker	80	XCD/day
Foreman	120	XCD/day
Engineer	200	XCD/day

Repair & rehabilitation cost:

civil works:	0,5	%
electro-mech. (if not stated otherwise)	1,5	%

D1 : Cost for Gravity Sewerage

Connected Households: 45

Construction Cost:

		units	unit price	sub-total	XCD
Material:	Pump sump	2	10.800	21.600	
	Pumps (1+1) - submersible type	2	7.200	14.400	
	Cabinet	1	3.600	3.600	
	Total-Equipment:				39.600
	Piping:				
	Fittings per Households (T-piece, PE 90)	45	180	8.100	
	Collector 1 (300, PE, soft soil, 30 m manholes)	475	814	386.460	
	Collector 2 (200, PE, soft soil, 30 m manholes)	252	738	185.976	
	Collector 3 (200, PE, soft soil, 30 m manholes)	51	738	37.638	
	Pressure Pipe (150, PE, soft soil)	30	234	7.020	
	Total-piping:				625.000
Inhouse piping: (private cost for one single household, not included in Gross-Total)					
	Length per Households (PE 90, average 21 feet)	6,51	108	703	
	Reinstatement of floor (substructure, tiles, paint)	6,51	126	820	
	Pumping (3 meter head, Q = 0,5 m³/day) - only half the houses	1	900	900	
	Interface (Toilet + superstructure) (only part of the houses)	1	540	540	
	Total-inhouse:				3.000

Total Construction Cost:		XCD	664.600
	per Household:	XCD/household	17.769

Operation & Maintenance:

		units	unit price	sub-total	XCD
Labor:	Labor (hours/year) (regular cleansing, and pump maintenance)	30	80	2.400	2.160
	Total:				2.160
Power:	average running hrs per day	4			
	pump energy performance: kW	5,5			
	pump energy consumption: kWh/day	22			
	other energy consumption: kWh/day	5			
	Total energy consumption: kWh/day	27			
	Electrical energy price: XCD/kWh	0,71		7.000	
	Energy cost per year				7.000
Station replacement (not included, see below):					
	pumps	2	7.200	14400	960
	cabinet	1	3.600	3600	240
	other	1	1.800	1800	120
	life-time	years	15		
	Total replacement cost per year:				1.320
Repair & rehabilitation:					
	civil works: percentage of asset value	1,50%	9.700		
	electromechanical works: % of value (calibrated to producers info)	8,00%	1.400		
	Total replacement cost per year:				11.100
Wastewater lifting in some houses: (private cost for one single household, not included in Gross-Total)					
	Disposal in nearby treatment facility (100litre/cap/day):	100			
	(average 4 cap/household) (m3/year)	146			
	average head to the gravity sewer (m)	3			

energy demand (kW)	21,9		
Electrical energy price: XCD/kWh	0,713	16	
Energy cost per year			42

Total Operation & Maintenance Cost:	XCD/year	22.132
per Household:	XCD/year/household	492

D2 : Cost for Small Bore Sewer (condominial sewer)

Connected Households: 45

Construction Cost:

		units	unit price	sub-total	XCD
Material:	Pump sump	2	10.800	21.600	
	Pumps (1+1) - submersible type	2	7.200	14.400	
	Cabinet	1	3.600	3.600	
	Septage collection system consisting of small truck with suction facility and 0,5m³ volume	1	27.000	27.000	
	Total-Equipment:				66.600
	Piping:				
	Length per Households (T-piece, PE 90)	1	180	8.100	
	Collector 1 (200, PE, soft soil, 30 m manholes)	470	570	267.900	
	Collector 2 (150, PE, soft soil, 30 m manholes)	250	480	120.000	
	Collector 3 (150, PE, soft soil, 30 m manholes)	50	480	24.000	
	Pressure Pipe (150, PE, soft soil)	30	230	6.900	
	Septage collection system consisting of small truck with suction facility and 500 litre volume	1	27.000	27.000	
	Total-material cost:				453.900
Inhouse septic tank and piping: (private cost for one single household, not included in Gross-Total)					
	Septic Tanks + Soak pits:				
	rehabilitation (assumed 50% of households)	1	540	540	540
	replacement (assumed 50% of households)	1	1.800	1.800	1.800
	Length per Households (PE 90, average 21 feet)	6,51	108	703	703
	Reinstatement of floor (substructure, tiles, paint)	6,51	126	820	820
	Pumping (3 meter head, Q = 0,5 m³/day) - only half the houses	1	720	720	720
	Interface (Toilet + superstructure) (only part of the houses)	1	540	540	540
	Total-inhouse:				5.100
Total Construction Cost:		XCD			681.150
	per Household:	XCD/household			15.137

Operation & Maintenance:

Labor:	Labor (hours/year) (regular pipe cleansing, and pump maintenance)	50	80	4.000	3.600
	Total:				3.600
Power:	average running hrs per day	4			
	pump energy performance: kW	5,5			
	pump energy consumption: kWh/day	22			
	other energy consumption: kWh/day	5			
	Total energy consumption: kWh/day	27			
	Electrical energy price: XCD/kWh	0,71		7.000	
	Energy cost per year				7.000
Station replacement: (not included, see below)					
	pumps (1+1)	2	7.200	14.400	960
	cabinet	1	3.600	3.600	240
	other	1	1.800	1.800	120
	life-time	years	15		
	Total replacement cost per year:				1.320
Repair & rehabilitation:					
	civil works: percentage of asset value	1,50%	7.500		

electromechanical works: % of value (calibrated to producers info)	8,00%	1.400		
Total replacement cost per year:				8.900

Sludge removal: (private cost for one single household, not included in Gross-Total)				
Septic tank emptying:				
Disposal in nearby treatment facility (100litre/cap/year):	100			
(average 4 cap/household) (m3/year)	0,400	36	14	14
Wastewater lifting in some houses:				
Disposal in nearby treatment facility (100litre/cap/day):	100			
(average 4 cap/household) (m3/year)	146			
average head to the condominium sewer (m)	3			
energy demand (kW)	21,9			
Elektrical energy price: US cents/kWh		0,713	16	
Energy cost per year				21
Total:				35

Total Operation & Maintenance Cost:	XCD/year	21.084
per Household:	XCD/year/household	469

D3 : Cost for Vacuum Sewerage: FLOVAC

Connected Households: 45

Construction Cost:

		units	unit price	sub-total	XCD
Material:	Valvepit	17			
	Pumps	2			
	Vaccum station	1			
	Control unit	1			
	Total-Equipment (based on quotation, 09/2014):			414.000	<u>414.000</u>
	Piping:				
	Length per Households (PE 90) (add-on for particular fixation)	270	290	78.300	
	Collector (PE150)-both sides of Alumn Stream (particular fixation required, additional 50%)	1000	350	350.000	
	Total-piping:				<u>428.300</u>
Inhouse plumbing: (private cost <u>for one</u> single household, not included in Gross-Total)					
	Length per Households (PE 90)	5	190	950	
	Reinstatement of floor	5	70	350	
	Interface (Toilet + superstructure) (<u>only</u> part of the houses)	1	540	540	
	Total-inhouse:				<u>1.800</u>
Wastewater pumping by vacuum:					
	(provision of electrical line, distribution of cost among users needs to be clarified !)				
Total Construction Cost:		XCD			923.300
	per Household:	XCD/household			20.518

Operation & Maintenance:

		units	unit price	sub-total	XCD
Labor:	Labor (hours/year)	50	120	6.000	
	Transport (times/year)	25	40	1.000	
	Total:				<u>7.000</u>
Power:	average running hrs per day	4			
	pump energy performance: kW	5,5			
	pump energy consumption: kWh/day	22			
	other energy consumption: kWh/day	5			
	Total energy consumption: kWh/day	27			
	Electrical energy price: XCD/kWh	0,71		7.000	
	Energy cost per year				<u>7.000</u>
Station replacement: (not included, see below)					
	pumps	2	35.600		4.752
	cabinet	1	28.100		1.872
	other	1	17.600		1.176
	life-time	years	15		
	Total replacement cost per year:				<u>7.800</u>
Repair & rehabilitation:					
	civil works: percentage of asset value	1,50%	8.900		
	electromechanical works: % of value (calibrated to producers info)	3,30%	8.200		
	Total replacement cost per year:				<u>17.100</u>

Wastewater pumping by vacuum: (priv.cost <u>for a</u> single household, not included in Gross-Total)

	(distribution of cost among users needs to be clarified !)				
	Disposal in nearby treatment facility (100litre/cap/day):	100			
	(average 4 cap/household) (m3/year)	146			
	average head to the gravity sewer (m)	2,5			
	energy demand (kW)	18,25			
	Electrical energy price: US cents/kWh		0,713	13	
	Energy cost per year				13
Valve replacement:					
	vacuum valves	1	108	22	
	controller	1	108	22	
	other	1	180	36	
	life-time	years	5		
	Total replacement cost per year per household:				26
					39

Total Operation & Maintenance Cost:		XCD/year	32.874
	per Household:	XCD/year/household	731

D4 : Cost for improved On-site Sanitation

		units	unit price	sub-total	XCD
Connected Households:		45			
Construction Cost:					
Material:	Septage collection system consisting of small truck with suction facility and 0,5m³ volume	1	27.000	27.000	
	Total-material cost:				27.000
Inhouse septic tank and piping: (private cost for one single household, not included in Gross-Total)					
	Septic Tanks + Soak pits:				
	replacement (100% of households)	1	1.800	1.800	
	Interface (Toilet + superstructure) (only part of the houses)	1	540	540	
	Total-inhouse:				2.300
Total Construction Cost:		XCD			90.000
	per Household (average):	XCD/household			3.400
Operation & Maintenance:					
Labor:	Labor (hours/year) (regular pipe cleansing, and pump maintenance)	80	72	5.760	
	Total:				5.760
Maintenance & Operation:					
	vaccum truck maintenance (% of value per year)	5%	1.350		
	operation (fuel, grease, etc.)	1	3.600		
	Total M&O:				4.950
Repair & rehabilitation:					
	civil works: percentage of asset value	1,50%	400		
	electromechanical works: % of value	2,50%	0		
	Total replacement cost per year:				400
Sludge removal: (private cost for one single household, not included in Gross-Total)					
	Septic tank emptying:				
	Disposal in nearby treatment facility (100litre/cap/year):	100			
	(average 4 cap/household) (m3/year)	0,400	36	14	14
Total Operation & Maintenance Cost:		XCD/year			11.758
	per Household:	XCD/year/household			261

T1 : Cost for DEWATS - Wastewater Treatment

Served Households: 45

Construction Cost:

		units	unit price	sub-total	XCD
Material:	Civil Works:				
	Settling Tank:	1	7.600	7.600	
	Anaerobic Baffling Tank:	1	27.100	27.100	
	Horizontal Gravel Filter:	1	20.300	20.300	
	Outlet pipe and pump:	1	40.000	40.000	
	Sludge bed:	1	7.500	7.500	
	Total Civil:				102.500
	Electromechanical Works:				
	Settling Tank:	1	2.300	2.300	
	Anaerobic Baffling Tank:	1	13.500	13.500	
	Horizontal Gravel Filter:	1	6.100	6.100	
	Outlet pipe and pump:	1	20.000	20.000	
	Sludge bed:	1	2.300	2.300	
	Total Electro-mechanical:				44.200
	Land Acquisition:	500	110	55.000	55.000

Total Construction Cost:		XCD	201.700
	per Household:	XCD/household	4.482

Operation & Maintenance:

Labor:	Labor (days/year) (qualified foreman)	30	120	3.600	12.960
	Total:				12.960
Power:	average running hrs per day	16			
	pump energy performance: kW	0,5			
	pump energy consumption: kWh/day	8			
	other energy consumption: kWh/day	5			
	Total energy consumption: kWh/day	13			
	Electrical energy price: XCD/kWh	0,71		3.400	
	Energy cost per year				3.400
Station repair & rehabilitation:					
	civil works: percentage of asset value	1,50%	1.500		
	electromechanical works: % of value	2,50%	1.100		
	Total replacement cost per year:				2.600

Total Operation & Maintenance Cost:		XCD/year	18.960
	per Household:	XCD/year/household	421

T2 : Cost for Faecal Sludge (FS) Treatment

Served Households:		45			
Construction Cost:					
		units	**unit price**	**sub-total**	**XCD**
Material:	Civil Works:				
	Anaerobic Baffling Tank:	1	200	200	
	Horizontal Gravel Filter:	1	500	500	
	Sludge bed:	1	500	500	
	Total Civil:				1.200
	Electromechanical Works:				
	Anaerobic Baffling Tank:	1	1.000	1.000	
	Horizontal Gravel Filter:	1	1.000	1.000	
	Sludge bed:	1	1.000	1.000	
	Total Electro-mechanical:				3.000
	Land Acquisition:	200	55	11.000	11.000
Total Construction Cost:		XCD			15.200
	per Household:	XCD/household			338

Operation & Maintenance:					
Labor:	Labor (days/year) (skilled worker)	30	80	2.400	8.640
	Total:				8.640
Power:	average running hrs per day	4			
	energy demand: kW	1			
	Total energy consumption: kWh/day	1			
	Electrical energy price: XCD/kWh	0,71		300	
	Energy cost per year				300
Station repair & rehabilitation:					
	civil works: percentage of asset value	1,50%	0		
	electromechanical works: % of value	2,50%	100		
	Total replacement cost per year:				100
Total Operation & Maintenance Cost:		XCD/year			9.040
	per Household:	XCD/year/household			201

Annex 7: Dynamic Prime Cost calculation (DPC)

DPC calculation for option: W - D1 - T1

INVESTMENT COSTS (all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			93.000
Electro-Mechanical Works		40.500	
Sub-Total 1		40.500	93.000
2. Wastewater collection			
Civil Works			647.000
Electro-Mechanical Works		18.000	
Sub-Total 2		18.000	647.000
3. Treatment Facility			
Civil Works (land acquisition not included)			102.500
Electro-Mechanical Works		44.200	
Sub-Total 3		44.200	102.500
Total Civil Engineering Costs			**842.500**
Total Electro-Mechanical Costs		**102.700**	
SUMMARY OF INVESTMENT COSTS			**945.200**

OPERATION COSTS (all prices in XCD)

			2015	2025	2035
1.1 Labor:	XCD/a	1,25	15.120	18.900	23.625
1.2 Power:	XCD/a	1,25	10.400	13.000	16.250
1.3 Repair & rehabilitation:	XCD/a	1,10	13.700	15.070	16.577
SUMMARY OF OPERATION COSTS		**XDA/year**	**39.220**	**46.970**	**56.452**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Wastewater Quantity m3/year
2014	0	0	0	
2015	945.200	39.220	984.420	5.913
2016	0	39.852	39.852	5.972
2017	0	40.484	40.484	6.032
2018	0	41.116	41.116	6.092
2019	0	41.749	41.749	6.153
2020	0	42.381	42.381	6.215
2021	0	43.013	43.013	6.277
2022	0	43.645	43.645	6.340
2023	0	44.277	44.277	6.403
2024	0	44.909	44.909	6.467
2025	0	46.970	46.970	6.532
2026	0	47.602	47.602	6.597
2027	102.700	48.234	150.934	6.663
2028	0	48.866	48.866	6.730
2029	0	49.499	49.499	6.797
2030	0	50.131	50.131	6.865
2031	0	50.763	50.763	6.933
2032	0	51.395	51.395	7.003
2033	0	52.027	52.027	7.073
2034	0	52.659	52.659	7.144
2035	(612.957)	56.452	(556.505)	7.215
Toatl Costs	434.943	975.244	1.410.187	137.413

Dynamic Prime Cost

Rate of return	1%	3%	**5%**	7%	9%
Dynamic Prime Cost: Investment (XCD/m³)	4,3	6,4	8,5	10,5	12,4
Dynamic Prime Cost: Operation (XCD/m³)	7,0	6,8	6,7	6,5	6,4
Dynamic Prime Cost: Total (XCD/m³)	11,3	13,2	**15,2**	17,0	18,8

DPC calculation for option: W - D2 - T1

INVESTMENT COSTS

(all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			198.150
Electro-Mechanical Works		32.400	
Sub-Total 1		32.400	198.150
2. Wastewater collection			
Civil Works			502.500
Electro-Mechanical Works		18.000	
Sub-Total 2		18.000	502.500
3. Treatment Facility			
Civil Works (land acquisition not included)			102.500
Electro-Mechanical Works		44.200	
Sub-Total 3		44.200	102.500
Total Civil Engineering Costs			**803.150**
Total Electro-Mechanical Costs		**94.600**	
SUMMARY OF INVESTMENT COSTS			**897.750**

OPERATION COSTS

(all prices in XCD)

				2015	2025	2035
1.1	Labor:	XCD/a	1,25	16.560	20.700	25.875
1.2	Power:	XCD/a	1,25	10.400	13.000	16.250
1.3	Repair & rehabilitation:	XCD/a	1,10	11.500	12.650	13.915
SUMMARY OF OPERATION COSTS			**XDA/year**	**38.460**	**46.350**	**56.040**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Wastewater Quantity m3/year
2014	0	0	0	
2015	897.750	38.460	936.210	5.913
2016	0	39.106	39.106	5.972
2017	0	39.752	39.752	6.032
2018	0	40.398	40.398	6.092
2019	0	41.044	41.044	6.153
2020	0	41.690	41.690	6.215
2021	0	42.336	42.336	6.277
2022	0	42.982	42.982	6.340
2023	0	43.628	43.628	6.403
2024	0	44.274	44.274	6.467
2025	0	46.350	46.350	6.532
2026	0	46.996	46.996	6.597
2027	94.600	47.642	142.242	6.663
2028	0	48.288	48.288	6.730
2029	0	48.934	48.934	6.797
2030	0	49.580	49.580	6.865
2031	0	50.226	50.226	6.933
2032	0	50.872	50.872	7.003
2033	0	51.518	51.518	7.073
2034	0	52.164	52.164	7.144
2035	(578.162)	56.040	(522.122)	7.215
Toatl Costs	414.188	962.280	1.376.468	137.413

Dynamic Prime Cost

Rate of return	1%	3%	**5%**	7%	9%
Dynamic Prime Cost: Investment (XCD/m³)	4,0	6,1	8,1	10,0	11,8
Dynamic Prime Cost: Operation (XCD/m³)	6,9	6,7	6,6	6,4	6,3
Dynamic Prime Cost: Total (XCD/m³)	11,0	12,8	**14,6**	16,4	18,1

DPC calculation for option: W - D3 - T1

INVESTMENT COSTS

(all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			82.800
Electro-Mechanical Works		0	
Sub-Total 1		0	82.800
2. Wastewater collection			
Civil Works			593.900
Electro-Mechanical Works		248.400	
Sub-Total 2		248.400	593.900
3. Treatment Facility			
Civil Works (land acquisition not included)			102.500
Electro-Mechanical Works		44.200	
Sub-Total 3		44.200	102.500
Total Civil Engineering Costs			**779.200**
Total Electro-Mechanical Costs		**292.600**	
SUMMARY OF INVESTMENT COSTS			**1.071.800**

OPERATION COSTS

(all prices in XCD)

			2015	2025	2035
1.1 Labor:	XCD/a	1,25	19.960	24.950	31.188
1.2 Power:	XCD/a	1,25	10.400	13.000	16.250
1.3 Repair & rehabilitation:	XCD/a	1,10	19.700	21.670	23.837
SUMMARY OF OPERATION COSTS		**XDA/year**	**50.060**	**59.620**	**71.275**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Wastewater Quantity m3/year
2014	0	0	0	
2015	1.071.800	50.060	1.121.860	5.913
2016	0	50.837	50.837	5.972
2017	0	51.614	51.614	6.032
2018	0	52.391	52.391	6.092
2019	0	53.168	53.168	6.153
2020	0	53.945	53.945	6.215
2021	0	54.722	54.722	6.277
2022	0	55.499	55.499	6.340
2023	0	56.276	56.276	6.403
2024	0	57.053	57.053	6.467
2025	0	59.620	59.620	6.532
2026	0	60.397	60.397	6.597
2027	292.600	61.174	353.774	6.663
2028	0	61.951	61.951	6.730
2029	0	62.728	62.728	6.797
2030	0	63.505	63.505	6.865
2031	0	64.282	64.282	6.933
2032	0	65.059	65.059	7.003
2033	0	65.836	65.836	7.073
2034	0	66.613	66.613	7.144
2035	(935.787)	71.275	(864.512)	7.215
Toatl Costs	428.613	1.238.002	1.666.615	137.413

Dynamic Prime Cost

Rate of return	1%	3%	**5%**	7%	9%
Dynamic Prime Cost: Investment (XCD/m³)	4,5	7,2	9,7	12,1	14,4
Dynamic Prime Cost: Operation (XCD/m³)	8,9	8,7	8,5	8,3	8,1
Dynamic Prime Cost: Total (XCD/m³)	13,4	15,9	**18,2**	20,4	22,5

DPC calculation for option: W - D4 - T2

INVESTMENT COSTS

(all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			105.300
Electro-Mechanical Works		0	
Sub-Total 1		0	105.300
2. Wastewater collection			
Civil Works			27.000
Electro-Mechanical Works		0	
Sub-Total 2		0	27.000
3. Treatment Facility			
Civil Works (land acquisition not included)			1.200
Electro-Mechanical Works		3.000	
Sub-Total 3		3.000	1.200
Total Civil Engineering Costs			**133.500**
Total Electro-Mechanical Costs		**3.000**	
SUMMARY OF INVESTMENT COSTS			**136.500**

OPERATION COSTS

(all prices in XCD)

				2015	2025	2035
1.1	Labor:	XCD/a	1,25	14.400	18.000	22.500
1.2	Power:	XCD/a	1,25	300	375	469
1.3	Repair & rehabilitation:	XCD/a	1,10	5.450	5.995	6.595
SUMMARY OF OPERATION COSTS			**XDA/year**	**20.150**	**24.370**	**29.563**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Wastewater Quantity m3/year
2014	0	0	0	
2015	136.500	20.150	156.650	5.913
2016	0	20.496	20.496	5.972
2017	0	20.842	20.842	6.032
2018	0	21.189	21.189	6.092
2019	0	21.535	21.535	6.153
2020	0	21.881	21.881	6.215
2021	0	22.227	22.227	6.277
2022	0	22.574	22.574	6.340
2023	0	22.920	22.920	6.403
2024	0	23.266	23.266	6.467
2025	0	24.370	24.370	6.532
2026	0	24.716	24.716	6.597
2027	3.000	25.062	28.062	6.663
2028	0	25.409	25.409	6.730
2029	0	25.755	25.755	6.797
2030	0	26.101	26.101	6.865
2031	0	26.447	26.447	6.933
2032	0	26.794	26.794	7.003
2033	0	27.140	27.140	7.073
2034	0	27.486	27.486	7.144
2035	(72.350)	29.563	(42.787)	7.215
Toatl Costs	67.150	505.923	573.073	137.413

Dynamic Prime Cost

Rate of return	1%	3%	**5%**	7%	9%
Dynamic Prime Cost: Investment (XCD/m³)	0,6	0,9	1,2	1,5	1,8
Dynamic Prime Cost: Operation (XCD/m³)	3,6	3,5	3,5	3,4	3,3
Dynamic Prime Cost: Total (XCD/m³)	4,3	4,5	**4,7**	4,9	5,1

DPC calculation for option: P - D1 - T1

INVESTMENT COSTS (all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			93.000
Electro-Mechanical Works		40.500	
Sub-Total 1		40.500	93.000
2. Wastewater collection			
Civil Works			647.000
Electro-Mechanical Works		18.000	
Sub-Total 2		18.000	647.000
3. Treatment Facility			
Civil Works (land acquisition not included)			102.500
Electro-Mechanical Works		44.200	
Sub-Total 3		44.200	102.500
Total Civil Engineering Costs			**842.500**
Total Electro-Mechanical Costs		**102.700**	
SUMMARY OF INVESTMENT COSTS			**945.200**

OPERATION COSTS (all prices in XCD)

			2015	2025	2035
1.1 Labor:	XCD/a	1,25	15.120	18.900	23.625
1.2 Power:	XCD/a	1,25	10.400	13.000	16.250
1.3 Repair & rehabilitation:	XCD/a	1,10	13.700	15.070	16.577
SUMMARY OF OPERATION COSTS		**XDA/year**	**39.220**	**46.970**	**56.452**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Eliminated Pollution Load kg/year
2014	0	0	0	
2015	945.200	39.220	984.420	3.252
2016	0	39.852	39.852	3.285
2017	0	40.484	40.484	3.318
2018	0	41.116	41.116	3.351
2019	0	41.749	41.749	3.384
2020	0	42.381	42.381	3.418
2021	0	43.013	43.013	3.452
2022	0	43.645	43.645	3.487
2023	0	44.277	44.277	3.522
2024	0	44.909	44.909	3.557
2025	0	46.970	46.970	3.592
2026	0	47.602	47.602	3.628
2027	102.700	48.234	150.934	3.665
2028	0	48.866	48.866	3.701
2029	0	49.499	49.499	3.738
2030	0	50.131	50.131	3.776
2031	0	50.763	50.763	3.813
2032	0	51.395	51.395	3.852
2033	0	52.027	52.027	3.890
2034	0	52.659	52.659	3.929
2035	(612.957)	56.452	(556.505)	3.968
Toatl Costs	434.943	975.244	1.410.187	75.577

Dynamic Prime Cost

Rate of return	1%	3%	**5%**	7%	9%
Dynamic Prime Cost: Investment (XCD/kg BOD5 eliminated)	7,7	11,6	15,4	19,1	22,6
Dynamic Prime Cost: Operation (XCD/kg BOD5 eliminated)	12,7	12,4	12,1	11,9	11,6
Dynamic Prime Cost: Total (XCD/kg BOD5 eliminated)	20,5	24,1	**27,6**	31,0	34,2

DPC calculation for option: P - D2 - T1

INVESTMENT COSTS

(all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			198.150
Electro-Mechanical Works		32.400	
Sub-Total 1		32.400	198.150
2. Wastewater collection			
Civil Works			502.500
Electro-Mechanical Works		18.000	
Sub-Total 2		18.000	502.500
3. Treatment Facility			
Civil Works (land acquisition not included)			102.500
Electro-Mechanical Works		44.200	
Sub-Total 3		44.200	102.500
Total Civil Engineering Costs			**803.150**
Total Electro-Mechanical Costs		**94.600**	
SUMMARY OF INVESTMENT COSTS			**897.750**

OPERATION COSTS

(all prices in XCD)

			2015	2025	2035
1.1 Labor:	XCD/a	1,25	16.560	20.700	25.875
1.2 Power:	XCD/a	1,25	10.400	13.000	16.250
1.3 Repair & rehabilitation:	XCD/a	1,10	11.500	12.650	13.915
SUMMARY OF OPERATION COSTS		**XDA/year**	**38.460**	**46.350**	**56.040**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Eliminated Pollution Loa m3/year
2014	0	0	0	
2015	897.750	38.460	936.210	3.252
2016	0	39.106	39.106	3.285
2017	0	39.752	39.752	3.318
2018	0	40.398	40.398	3.351
2019	0	41.044	41.044	3.384
2020	0	41.690	41.690	3.418
2021	0	42.336	42.336	3.452
2022	0	42.982	42.982	3.487
2023	0	43.628	43.628	3.522
2024	0	44.274	44.274	3.557
2025	0	46.350	46.350	3.592
2026	0	46.996	46.996	3.628
2027	94.600	47.642	142.242	3.665
2028	0	48.288	48.288	3.701
2029	0	48.934	48.934	3.738
2030	0	49.580	49.580	3.776
2031	0	50.226	50.226	3.813
2032	0	50.872	50.872	3.852
2033	0	51.518	51.518	3.890
2034	0	52.164	52.164	3.929
2035	(578.162)	56.040	(522.122)	3.968
Toatl Costs	414.188	962.280	1.376.468	75.577

Dynamic Prime Cost

	1%	3%	5%	7%	9%
Rate of return	**1%**	**3%**	**5%**	**7%**	**9%**
Dynamic Prime Cost: Investment (XCD/kg BOD5 eliminated)	7,4	11,1	14,7	18,1	21,5
Dynamic Prime Cost: Operation (XCD/kg BOD5 eliminated)	12,6	12,3	12,0	11,7	11,4
Dynamic Prime Cost: Total (XCD/kg BOD5 eliminated)	**19,9**	**23,3**	**26,6**	**29,8**	**32,9**

DPC calculation for option: P - D3 - T1

INVESTMENT COSTS

(all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			82.800
Electro-Mechanical Works		0	
Sub-Total 1		0	82.800
2. Wastewater collection			
Civil Works			593.900
Electro-Mechanical Works		248.400	
Sub-Total 2		248.400	593.900
3. Treatment Facility			
Civil Works (land acquisition not included)			102.500
Electro-Mechanical Works		44.200	
Sub-Total 3		44.200	102.500
Total Civil Engineering Costs			**779.200**
Total Electro-Mechanical Costs		**292.600**	
SUMMARY OF INVESTMENT COSTS			**1.071.800**

OPERATION COSTS

(all prices in XCD)

				2015	2025	2035
1.1	Labor:	XCD/a	1,25	19.960	24.950	31.188
1.2	Power:	XCD/a	1,25	10.400	13.000	16.250
1.3	Repair & rehabilitation:	XCD/a	1,10	19.700	21.670	23.837
SUMMARY OF OPERATION COSTS			**XDA/year**	**50.060**	**59.620**	**71.275**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Eliminated Pollution Loa m3/year
2014	0	0	0	
2015	1.071.800	50.060	1.121.860	3.252
2016	0	50.837	50.837	3.285
2017	0	51.614	51.614	3.318
2018	0	52.391	52.391	3.351
2019	0	53.168	53.168	3.384
2020	0	53.945	53.945	3.418
2021	0	54.722	54.722	3.452
2022	0	55.499	55.499	3.487
2023	0	56.276	56.276	3.522
2024	0	57.053	57.053	3.557
2025	0	59.620	59.620	3.592
2026	0	60.397	60.397	3.628
2027	292.600	61.174	353.774	3.665
2028	0	61.951	61.951	3.701
2029	0	62.728	62.728	3.738
2030	0	63.505	63.505	3.776
2031	0	64.282	64.282	3.813
2032	0	65.059	65.059	3.852
2033	0	65.836	65.836	3.890
2034	0	66.613	66.613	3.929
2035	(935.787)	71.275	(864.512)	3.968
Toatl Costs	428.613	1.238.002	1.666.615	75.577

Dynamic Prime Cost

Rate of return	**1%**	**3%**	**5%**	**7%**	**9%**
Dynamic Prime Cost: Investment (XCD/kg BOD5 eliminated)	8,2	13,0	17,6	22,0	26,2
Dynamic Prime Cost: Operation (XCD/kg BOD5 eliminated)	16,2	15,8	15,4	15,1	14,7
Dynamic Prime Cost: Total (XCD/kg BOD5 eliminated)	**24,4**	**28,8**	**33,1**	**37,1**	**40,9**

DPC calculation for option: P - D4 - T2

INVESTMENT COSTS (all prices in XCD)

Description		Electro-mechanical XCD	Civil Works XCD
1. Inhouse-sanitation (plumbing + reinstatement)			
Civil Works			105.300
Electro-Mechanical Works		0	
Sub-Total 1		0	105.300
2. Wastewater collection			
Civil Works			27.000
Electro-Mechanical Works		0	
Sub-Total 2		0	27.000
3. Treatment Facility			
Civil Works (land acquisition not included)			1.200
Electro-Mechanical Works		3.000	
Sub-Total 3		3.000	1.200
Total Civil Engineering Costs			**133.500**
Total Electro-Mechanical Costs		**3.000**	
SUMMARY OF INVESTMENT COSTS			**136.500**

OPERATION COSTS (all prices in XCD)

			2015	2025	2035
1.1 Labor:	XCD/a	1,25	14.400	18.000	22.500
1.2 Power:	XCD/a	1,25	300	375	469
1.3 Repair & rehabilitation:	XCD/a	1,10	5.450	5.995	6.595
SUMMARY OF OPERATION COSTS		**XDA/year**	**20.150**	**24.370**	**29.563**

Dynamic Prime Costs

Year	Investment Costs XCD / year	Operation Costs XCD/year	Total Costs XCD/year	Eliminated Pollution Loa m3/year
2014	0	0	0	
2015	136.500	20.150	156.650	2.168
2016	0	20.496	20.496	2.190
2017	0	20.842	20.842	2.212
2018	0	21.189	21.189	2.234
2019	0	21.535	21.535	2.256
2020	0	21.881	21.881	2.279
2021	0	22.227	22.227	2.301
2022	0	22.574	22.574	2.324
2023	0	22.920	22.920	2.348
2024	0	23.266	23.266	2.371
2025	0	24.370	24.370	2.395
2026	0	24.716	24.716	2.419
2027	3.000	25.062	28.062	2.443
2028	0	25.409	25.409	2.468
2029	0	25.755	25.755	2.492
2030	0	26.101	26.101	2.517
2031	0	26.447	26.447	2.542
2032	0	26.794	26.794	2.568
2033	0	27.140	27.140	2.593
2034	0	27.486	27.486	2.619
2035	(72.350)	29.563	(42.787)	2.645
Toatl Costs	67.150	505.923	573.073	50.385

Dynamic Prime Cost

Rate of return	1%	3%	**5%**	7%	9%
Dynamic Prime Cost: Investment (XCD/kg BOD5 eliminated)	1,7	2,5	3,3	4,1	4,8
Dynamic Prime Cost: Operation (XCD/kg BOD5 eliminated)	9,9	9,7	9,4	9,2	9,0
Dynamic Prime Cost: Total (XCD/kg BOD5 eliminated)	11,7	12,2	**12,8**	13,3	13,8

Assessment of Small Scale Biogas Production

On pre-feasibility level the potential of biogas production in small communities, such as Soufriere, can be calculated based on the following data:

#

Base Data:		
Served Households:	45	[-]
Served Population:	180	[-]
Water consumption per user	100	[litres/d]
Wastewater generation rate	90	[%]
Volume of faecal waste from septage:	0,25	[kg/cap/day]
	91,25	[kg/cap/year]
Requirements of reactor space for faecal waste:	0,1	[m^3/kg]
	0,025	[m^3/cap/day]
Hydraulic retention time HRT:	20	[days]
	0,5	[m^3/cap]
Volume of reactor space for faecal waste:	**90**	[m^3/kg]
Biogas Production:		
Degradation of organic matter (expresses as Bio-Chemical-Oxygen Demand, BOD5)	90	[%]
BOD5 per user	55	[g/d]
COD / BOD5 ratio	1,9	[-]
daily flow of wastewater	16,2	[m3/d]
BOD5 concentration before digestion	611	[mg/l]
COD concentration before digestion	1.161	[mg/l]
Eliminated BOD5	3.252	[kg/year]
CH4 - Methane Production efficiency (primary sludge)	350	[l/kgBOD5 eliminated]
CH4 - Methane Production efficiency (septage)	300	[l/kgBOD5 eliminated]
Annual Methane Production (based on septage)	**980**	[m^3 CH4/year]
Biogas Storage:		
CH4 production per day	2,7	[days]
Gas retention time	2	[days]
Gas tank volume	6,0	[m3]
Energy production equivanlent:		
- Electrical energy	5	kW/day
- Firewood	15	kg/day
- Charcoal	4	kg/day
- Fuel (Diesel)	2	litre/day

#

With the number of population served and the expected volumed of septage collected the use of biogas in Soufriere was not considered. The generated energy is not enough for large scale use. With a more systematic of septage collection however, the biogas production may well be an interesting source of alternative energy that could be used, e.g. to dry agricultural products or similar.