Document 523
Alternatives Analysis Report

Chapter: Rensselaer Polytechnic Institute
Country: Panama
Community: Isla Popa II (Sandubidi)
Project: Development of Clean Water Source

Prepared By

16 August 2015

ENGINEERS WITHOUT BORDERS USA
www.ewb-usa.org

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Alternatives Analysis Report Part 1 – Administrative Information

1.0 Contact Information

	Name	Email	Phone	Chapter/ Organization Name
Project Leads				
President				
Responsible Engineer in Charge				
Additional Mentor				
Additional Mentor				
Faculty Advisor (if applicable)				
Health and Safety Officer				
Assistant Health and Safety Officer				
Education Lead				
Planning, Monitoring, Evaluation and Learning (PMEL) Lead				
In-country Community Contact				
In-country NGO Contact				

2.0 Travel History

Dates of Travel	Assessment or Implementation	Description of Trip
January 2012	Assessment	Initial Assessment trip: Established contact with community; preliminary water testing
August 2012	Assessment	Secondary Assessment: Collected data on existing infrastructure, rainfall, water quality, and land
August 2013	Assessment	Tertiary Assessment: Revisited water quality data; gathered structure measurements on pavilion
January 2015	Implementation	Constructed large-scale rainwater catchment system and installed biosand filters in school kitchen for water treatment.

3.0 Project Discipline(s): Check the specific project discipline(s) addressed in this report. Check all that apply.

Water Supply
____ Source Development
__X__ Water Storage
__X__ Water Distribution
__X__ Water Treatment
____ Water Pump

Sanitation
____ Latrine
____ Gray Water System
____ Black Water System

Structures
____ Bridge
____ Building

Civil Works
____ Roads
____ Drainage
____ Dams

Energy
____ Fuel
____ Electricity

Agriculture
____ Irrigation Pump
____ Irrigation Line
____ Water Storage
____ Soil Improvement
____ Fish Farm
____ Crop Processing Equipment

Information Systems
____ Computer Service

4.0 Project Location

Isla Popa II, Bocas del Toro, Panama
Latitude: -82.11667
Longitude: 8.183333

Alternatives Analysis Report Part 2 – Technical Information

1.0 Executive Summary

The Development of Clean Water Source project, project number 8801, of the Rensselaer Polytechnic Institute Student Chapter has been ongoing since the chapter's founding in 2010. The chapter has implemented within the community of Isla Popa II, Panama and was successful in many aspects; however widespread community adoption of the implemented biosand filter water treatment system is lacking. To correct these issues and to implement an additional, smaller rainwater catchment system, a return trip is planned for January of 2016.

The goal of this project is to provide a reliable and sustainable source of potable water for the community of Isla Popa II. This has and will be achieved through the construction of rainwater catchment systems followed by a water treatment process compatible with the given community environment. In the past, the community has suffered from occasional water shortages, and this bi-faceted project aims to prevent shortages from occurring and to provide a method of treating collected water to improve public health.

The community of Isla Popa II is located on an island off the Gulf coast of Panama near the northern border. It has a population of approximately 350 people, consisting mostly of families with young children. This rural community sprawls outward from a centralized school and community dock. Leaders within the community are democratically elected, and serve terms of varying lengths in positions responsible for particular aspects of community life. Examples of community leaders include a president for the school and president for community structures. Based on discussions held in-country during previous trips, community members are aware of the terms of the implementation agreement, but more detail is needed before an implementation agreement can be formally made.

Forming in the autumn of 2010, the chapter quickly adopted a water project on Isla Popa. The first trip taken by the chapter was an initial assessment trip from January 7th to the 12th, 2012. This trip focused on identifying the community's main problems with water quality and supply while building a relationship with community members. A second assessment trip took place from August 12th to the 21st, 2012. The aim of this trip was to collect water quality data and identify potential implementation strategies. The final assessment trip was made from August 12th to the 21st, 2013. The primary purpose of this trip was to assess the construction site in order to make a detailed design of the planned rainwater catchment system. Additional water quality tests were conducted, and relationships with the community were strengthened with the planning phase completed, the chapter's first implementation trip took place from January 5th to the 14th of 2015. On this trip, the chapter built a rainwater catchment system on a communal structure near the school and installed biosand filters in the school kitchen to treat the collected water. While some issues have arisen since the chapter's return home, the system is able to successfully harvest large volumes of rainwater. This is the only project that EWB-RPI is currently working on, with about twenty members actively involved.

The alternative designs under consideration are meant to address the lack of community adoption of the biosand filter as a treatment method. Many issues have caused this incompatibility, chief among which are design complexity, difficulty of use, and lack of durability. The chapter is analyzing other options to determine if there is a better method to stand-alone biosand filters. Under consideration are system-integrated biosand filters, ceramic filters, ultraviolet (UV) disinfection, chlorine treatment, and promoting boiling as treatment. Biosand filters work by using sand to filter out contaminants and are capable of removing microorganisms and particulates from contaminated water. Another alternative, ceramic filters, function similarly to biosand filters, using clay instead of sand to achieve filtration. UV systems were also considered, which are able to disinfect pathogens from water through exposure to ultraviolet light. Chlorine treatment is another possibility, and works via chemical disinfection of water to disinfect any microorganisms that may pose a threat to human health. The last method considered was a pointed education plan focusing on the boiling water for treatment.

In order to identify the most viable method of water treatment given the context of Isla Popa II, a selection matrix was employed for discrete comparison of the alternative in critical areas necessary for a successful project. The four main design categories included treatment effectiveness, feasibility, cost, and sustainability. Effectiveness deals with how successful each filtration method is at removing potentially unhealthy contaminants. Feasibility measures the difficulty in construction and maintenance of each alternative. Cost considers any expenses that are necessary for the construction, operation, and maintenance of the system. Finally, sustainability analyzes the probability that the alternative will continue to function within the community once the chapter has closed the project. Each of these categories contained several specific subcategories where alternatives were directly compared. The chapter's executive board rated each alternative with their best engineering judgement. The two highest rated alternatives from this matrix, chlorine treatment and biosand filters, were then presented to community leadership for a final decision. Along with having a first-hand, working knowledge of the alternatives, community leaders were provided detailed information by the chapter about the two possible water purification methods, ensuring an informed decision was made. Chlorine was chosen by the community as the alternative that would best meet their needs. This treatment method will also be accompanied by a comprehensive education plan that will encourage widespread water treatment and ensure proper operation of the implemented system.

Chlorine was chosen primarily because of community input, but this alternative has many other advantages. Chlorine is readily available within the community, and can be purchased at the nearest city on an adjacent island that community members visit frequently. As a treatment method, it is also effective in this environment. Rainwater gathered within the community is relatively clear of particulate matter due to the use of first-flush systems; and remaining unflushed microorganisms can be readily eliminated with the use of chlorine. Chlorine treatment is the preferred alternative to treat collected rainwater in Isla Popa II due to its effectiveness, availability, and community acceptance.

2.0 Program Background

The community of Isla Popa II does not have reliable access to clean water. The main source of water in the community is rainwater catchment. Prior to EWB-RPI's implementation trip in January 2015, water supply was sufficient during the rainy season. However, the collected water remains unsafe to drink due to contaminants washed in with the rain, as well as infrequent tank cleaning and exposure to the environment. While some homes had their own closed catchment systems, families without them had to rely on shallow hand-dug wells or open barrels which collected rainwater. The hand-dug wells were of especially poor water quality, as they lacked the necessary depth to draw from a clean water source. These wells are essentially large puddles.

In order to ensure Isla Popa II has a clean and reliable water supply, our team constructed a large-scale rainwater catchment system on a centrally located community structure. It is estimated that the tanks will only be empty for a few days each year. In order to minimize contaminants, a first flush system was installed to redirect the initial rainfall and the debris it washes off the roof before it enters the tanks. Since rainwater is not safe to drink without treatment, biosand filters were also constructed for community use. Through continued communication with the community, they have expressed that they do not like biosand filters as a treatment. They find the filters difficult to use and understand. Thus, our chapter must determine a more simple, yet effective way for community members to treat collected rainwater.

3.0 Project Description

The main goal of EWB-RPI's project in Isla Popa II is to provide a reliable source of clean water. By implementing the rainwater catchment system, we have successfully met the water supply needs of the community. Since the community has expressed their dissatisfaction in the use of the biosand filters, our new goal is to find the most effective way to purify their water supply. The community members feel that the filters are complicated and slow, so the new method must be convenient, less time consuming, and equally as effective. This will ensure that the community will be able to effectively treat collected rainwater for years to come.

4.0 Description of Alternatives

4.1 - Chlorine treatment

One of the alternative solutions for water treatment under consideration is the use of chlorine to disinfect the water held in the storage tank. Chlorination is a commonly used method for disinfecting drinking water. When combined with particle filtration, chlorination effectively eliminates many disease-causing microorganisms and pathogenic bacteria, including those found in the water supplies on Isla Popa[1].

[1] http://www.water-research.net/index.php/water-treatment/tools/chlorination-of-water

While eliminating harmful microorganisms, chlorination is not the easiest or safest method for disinfecting drinking water in Isla Popa II. Water treatment using chlorine requires regular maintenance. In order to ensure the safest quality of drinking water, the free-chlorine concentration in the water must be regularly measured using special testing materials. These materials may be difficult to obtain in this community. Additionally, the proper amount of chlorine must be added and mixed to keep the free chlorine concentration at the proper level, which is between 0.3-0.5 mg/l[1]. If the drinking water is under chlorinated, then there will not be enough chlorine to disinfect bacteria and microorganisms. If too much chlorine is added, then a foul taste and odor is noticeable, and those who drink it might experience stomach discomfort.[2] In order to insure that the chlorine levels are at the correct level, the water must be frequently tested and chlorine frequently added. This treatment method runs a serious risk in that improper use could result in lower water quality in the case of adding too much chlorine.

The supply of chlorine was previously thought to be through the Panamanian government, which provided subsidies for its purchase. However, the president of community structures, Ambrosio Bekar, has informed us that community members must buy their own chlorine for personal use, and he is responsible for purchasing the chlorine needed to maintain community water storage tanks. Chlorine is purchased by community members in Isla Colon, a city on an adjacent island that community members frequently visit. Available at a relatively low price, supply of chlorine to the community should not become an issue. However, chlorine treatment requires the continuous purchase of supplies in order to be successful.

Implementing a sustainable chlorination treatment plan would require widespread education within the community, especially among the members of the water board. While this is still feasible, past experiences working with the leaders of the community have shown that they don't like to treat their water with chlorine. The community members complain that water treated with chlorine has an unpleasant taste, so they prefer to drink untreated water. This means that they might not be willing to follow through with the treatment plan after our team leaves. Therefore, we worry that a chlorination treatment plan may not be a sustainable solution for the particular needs and preferences of this particular community. To mitigate this problem, community members will be trained in proper dosage amounts to ensure proper treatment while minimizing the impact on taste.

4.2 - Biosand Filter

Biosand or slow sand filtration is an attractive method for water purification in developing nations and is heavily utilized worldwide. Many organizations and companies have standardized the construction of these filters to promote their use on a global scale. Biosand filters and slow sand filters both operatively remove bacteria from influent water by slowly percolating the water through very fine-grained sand. These filters are also excellent at reducing water turbidity. Using adhesion to the sand grains (slow sand filter), lack of oxygen in the depths of the filter, and presence of natural predatory bacteria cycles (biosand filter), bacterial removal can reach an

[2] http://water.epa.gov/drink/contaminants/basicinformation/disinfectants.cfm

efficacy of up to 98.5% in these filters.[3] The Centre for Affordable Water and Sanitation Technology (CAWST) v.10 standard Biosand filter can also remove up to 99% of waterborne viruses.

The simplicity and affordability of these filters has led to an increase in their employment worldwide. Simply requiring a filter housing unit (concrete casting or large bucket), fine sand, coarse gravel, basic PVC fittings, and plastic to act as an influent water diffuser, these filtration units can be produced economically with locally-sourced materials. For this reason, Rotary International clean water efforts have selected this filtration method for standard use.[4] Employment of a biosand filter sanitation strategy is technically feasible in the community on Isla Popa II because our chapter has experience prototyping 5-gal bucket based filters in the USA and building multiple filters in-country during the January 2015 implementation trip. Sourcing materials for these filters was also demonstrated on this implementation trip. Hardware stores on the adjacent island of Isla Colon, visited frequently by community members, all the necessary materials can be purchased. Sand filters also offer the added benefit of low maintenance requirements, often critical for product longevity in developing nations. CAWST's "swirl and dump" cleaning method for sand filters must only be performed about once a month, requires only minutes, and does not involve filter disassembly.

While sand filtration has been utilized by our chapter in the past, this filtration strategy has come with some important learning experiences in filtration shortcomings. Of primary concern, the community members on Isla Popa II struggle to understand the abilities and necessity of the filter. With a target filtration time of ~15 min/gallon, the community has grown impatient with the process of filtering water using our filters. Such a slow filtration rate is inherent in all sand filters and is required to allow sufficient bacteria removal. To encourage use of the biosand filters, more time will spent educating the community on the importance of water treatment, and then demonstrating the effectiveness of biosand filters. This will hopefully persuade the community to embrace the biosand filter when in the past they have rejected it. Assembly time of these filters in-country was also shown to be greatly underestimated in planning the January 2015 Implementation. Due to limited resources for rinsing and preparing the sand for the filter, this process was lengthy, taking several days. Aside from long assembly time, the durability of the buckets used to house the filtration sand was also shown to be poor; this has led to early onset of filter failure in the community. Use of more durable materials, more efficient planning, and better community education is necessary for the biosand filter to take hold in the community of Isla Popa II.

Two possible implementation strategies are available for biosand filter use. The first strategy was already attempted by the chapter and involves creating individual biosand filters to be placed at the point of use, referred to as point of use biosand filters. These filters are small and are placed in individual homes of families for them to use as water treatment. Water can be poured into the filters, and then accessed from the same location after treatment. Advantages to this strategy include that involves a uniform design that is effective and can be placed almost

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[3] http://www.cawst.org/resources/biosand-filter

[4] http://rotaryeclubone.org/makeups/articles/biosandfiltershelp/

anywhere. The disadvantages are a slow processing capacity and limited access by community members.

The second implementation strategy developed is an integrated biosand filter. This system will involve connecting a water tank directly to a biosand filter which will then store a small amount of treated water to be accessed at a later time in an intermediate tank. As treated water is used up, the biosand filter slowly replenishes the treated water supply, allowing clean water to be accessed whenever it is desired without having to wait. The disadvantage to this design is that it is much more complicated, and therefore much more likely to fail in some way, and that it will be much more difficult to construct.

4.3 - Ceramic Filters

Another option considered for water filtration was the use of ceramic filters. This technology has been in use in developing countries like Cambodia and Nicaragua, where clay is an abundant resource. Ceramic filters are made of porous clay, which water passes through while contaminant particles are left behind. Ceramic filters are capable of removing most bacteria and protozoa.[5] A benefit of ceramic filters is that they are easy to use, with simple cleaning and maintenance, meaning little training is required.[6]

While ceramic filters are fairly effective, there are a few downsides to this method. One downside is that they cannot filter out viruses. Additionally, ceramic filters have a relatively low flow rate of 1-3 liters per hour for non-turbid water, and must be cleaned often to keep up the flow rate. Another potential issue is the variability of effectiveness based on quality of production[6].

The successful implementation of this solution also depends on the correct quality of clay available to the community in order to construct the filters. On previous assessment trips, the quality of the clay available on the island was not assessed. However, pottery does not appear to be practiced within the community. This would require an intensive training program to teach community members the proper method to construct ceramic filters. Without regular practice, community members are likely to lose the ability to make these filters over time, making the sustainability of ceramic filters questionable.

This method of filtration has many of the same drawbacks as a biosand filter. It is slow to treat water, is complicated to build, and difficult to understand how it functions. This is also a novel idea for the community, making them less likely to approve of this design. Due to the similarities in advantages and disadvantages between biosand filters and ceramic filters, our chapter believes biosand filters are a more viable solution as a water treatment method than ceramic filters, since ceramic filters have a high risk of not being sustainable in the community.

[5] http://www.cdc.gov/safewater/pdf/ceramic_2011-final.pdf
[6] http://www.who.int/household_water/resources/Roberts.pdf

4.4 - Ultraviolet Disinfection

While effective at disinfecting pathogenic bacteria and other harmful organisms from collected water, this method of water treatment is highly unsustainable given the environment of this project. The community is located on an island, where the only source of electricity comes from generators owned by some individuals within the community. In order to keep operating costs at a reasonable level, solar power would need to be used to generate the electricity needed to run the filters. The community had received solar panels in the past from another non-governmental organization, but they have since fallen into disrepair, most likely due to a lack of knowledge on the proper maintenance and operation of the system. The complexity of this project brings with it an element of unsustainability, which would most likely result in system failure after a few years. As a result, this is not a strong candidate as a method of water treatment in the community of Isla Popa II.

4.5 - Boiling

Boiling is an effective way to remove pathogenic organisms from water that will be consumed. According to the CDC boiling water is 100% effective at removing all pathogens in drinking water.[7] The primary advantage of this strategy is that the community also already has access to the materials needed to implement this strategy. Families are able to boil water for cooking rice, which is a staple of their diet. It is reasonable to assume that families are also able to boil water for drinking. Boiling also does not alter the taste of water, a concern of community members in the past. The sanitation strategies for storage tanks do not require any special equipment, just some extra labor at very infrequent intervals. Overall, this would be an effective, low-cost plan to improve water quality throughout the community.

There are also several cons to implementing this plan. Boiling water takes a long time, and requires a continuous supply of other resources in order to sufficiently heat the water. In addition, only small amounts of water can be processed at a time, as large scale boiling in excess of five gallons would involve a large amount of energy that is unavailable to community residents. Based on the communities impatience in waiting for biosand filters to treat water, it is unlikely residents will have the time to wait for boiling. Long treatment times combined with high levels of energy consumption and a small processing capacity make this alternative fairly unattractive.

[7] http://www.cdc.gov/healthywater/drinking/travel/backcountry_water_treatment.html

5.0 Analysis of Alternatives

In the following table, information regarding each alternative was synthesized into a brief list highlighting the main advantages and disadvantages of each strategy. For a more thorough description of the advantages and disadvantages of each alternative, refer to the previous section, Description of Alternatives.

Table 5.1: Pros and cons summary analysis

Chlorine	
Pros: ● Already used within the community, although on a limited scale ● No additional construction required ● Low operating cost ● Effective at disinfecting pathogens if used properly	Cons: ● Community has previously expressed dislike over the change in taste ● Does not remove particulate contaminants ● Requires regular operation and monitoring that community may not be capable or willing to perform
Ultraviolet Disinfection	
Pros: ● Rapidly treats water ● Effective at disinfecting pathogens and viruses ● If system designed properly, will not require much community operation or maintenance	Cons: ● Does not remove particulate contaminants ● Potentially complex, requiring fairly advanced electronics ● Requires external power source
Ceramic filter	
Pros: ● Effective at removing pathogens ● Effective at removing particulate contaminants ● Low complexity	Cons: ● Unfamiliar idea to community ● Difficult to build and maintain; community is new to ceramics ● Slow processing speed
Stand-alone Biosand or slow sand filter	
Pros: ● Effective at removing pathogens ● Effective at removing particulate contaminants ● Low maintenance	Cons: ● Complex construction process ● Confusing for community to understand ● Slow treatment rates

<table>
<tr><td colspan="2">Integrated Biosand or slow sand filter</td></tr>
<tr><td>Pros:
Effective at removing pathogens
Effective at removing particulate contaminants
Low maintenance</td><td>Cons:
Complex construction process
Potentially complex operation
Community opposed to biosand filtration</td></tr>
<tr><td colspan="2">Boiling</td></tr>
<tr><td>Pros:
No construction required
Community familiar with process
Effective at removing pathogens
Little maintenance</td><td>Cons:
Slow processing capacity
Labor intensive process
High energy usage</td></tr>
</table>

Using the information that has been gathered about each of these alternatives, the following decision matrix was formulated by the chapter. Each alternative was evaluated in critical areas relating to effectiveness, feasibility, cost, and sustainability and given a rating compared to its competitors. This rating comes from the best engineering judgement of the chapter based on information about the alternatives and the community environment in which they will be used.

Table 5.2 - Alternatives Selection Matrix

A '+' indicates better than average, '0' indicates average, and '-' indicates less than average

Criteria	**Definition**	**Standalone Biosand**	**Integrated Biosand**	**Active Chlorine**	**UV Filter**	**Ceramic Filter**	**Boiling**
EFFECTIVENESS							
Processing Capacity	*How much water can be treated; volume over time*	-	0	+	+	-	-
Treatment Effectiveness	*Effectiveness at removing pathogens/particulates*	+	+	0	+	0	0
Durability	*How long the system is expected to last*	-	+	+	+	-	+
Reliability	*Does filter consistently function as intended*	0	+	0	+	0	+
FEASIBILITY							
Material Availability	*Can necessary materials be sourced locally*	0	0	0	-	-	+
Assembly Time	*Expected construction time of system*	-	-	0	-	-	0
Student Experience	*Level of familiarity with current EWB students*	+	+	0	-	-	0
Technical Complexity	*Difficulty to assemble and understand functionality*	0	0	+	-	-	0
COST							
Material Costs	*Expected cost of materials, including transportation*	+	+	+	0	-	+
Maintenance Costs	*Expected cost of routine maintenance*	+	+	+	0	0	+
Operational Costs	*Expected cost to operate system as designed*	+	+	0	+	+	-
SUSTAINABILITY							
Required Community Training	*How much training is required to familiarize residents with operation and maintenance procedures*	-	0	0	0	-	0
Environmental Impact	*Effect of system on environmental health (i.e. any pollution generated, destruction of nature)*	+	+	0	0	-	+
Ease of Maintenance	*How much regular maintenance is required to keep system operational*	0	0	0	0	0	+
Community Driven x 3	*Which system is preferred by the community*	0	0	+	+	-	0
TOTALS		2	7	8	4	-11	5

Based on this selection matrix, chlorine is the most suitable water treatment method for the community of Isla Popa II.

6.0 Description of the Preferred Alternative

The alternative chosen to treat collected rainwater in the community of Isla Popa II is chlorine treatment. An effective method of treatment, chlorination effectively eliminates many disease-causing microorganisms and pathogenic bacteria, including those found in the water supplies on Isla Popa. The three main merits of this choice are in its simplicity, logistics, and community acceptance.

The simplicity of this treatment method makes it appealing both to our chapter and the community. Chlorine treatment is a straight forward process. To treat water, simply add chlorine to it. Community members are able to more easily understand how this treatment method is used to improve water quality. Since it is easier to understand, the community as a whole is more comfortable with this treatment method, and therefore likely to continue its use. Additionally, the simple operating procedure encourages continued use as it will not take a large amount of time away from community members. Training in the proper procedures of chlorine treatment is also simple, and will encourage many members of the community to become familiar with the technique, helping sustain the use of chlorine treatment.

Chlorine treatment also does not pose any logistical problems within the community. Chlorine is already used on a limited scale within the community, and is purchased at a nearby location frequently visited by community members, ensuring that the community will always have a supply of chlorine.

The most important reason for choosing this design is community acceptance. On the chapter's previous implementation trip, point of use bio-sand filters were constructed and placed in the school's kitchen. However, our community contact, the community president Ambrosio Bekar, has informed us that the filters have not been adopted by the community at large due to a difficulty in understanding how the filter works. It is likely that community uses these filters rarely, if at all. When speaking with Ambrosio, we proposed what our chapter believed were the two best options: chlorine treatment or biosand filters, both combined with an education plan emphasizing the importance of water treatment and the proper use of each treatment system. It was the opinion of our chapter that biosand filters would be the best treatment solution for this community. However, after meeting with a representative traveling on behalf of our chapter who explained the proposed biosand filter design, Ambrosio definitively stated that chlorine treatment was the best option. Choosing a treatment plan that the community will actually use on a regular basis is the most important consideration in this selection process, and as a result our chapter plans to develop a chlorine treatment plan to be used to treat collected rainwater.

In order to make chlorine treatment successful in this community, a thorough plan needs to be constructed regarding dosing and testing for residual chlorine levels. The first issue of this plan that needs to be addressed is how chlorine will be added to collected rainwater. This could be done through direct dosing by community members or through an automated dosing mechanism.

Another aspect of the plan that needs to be considered is where the chlorine will be added. Chlorine could be added directly to main storage tanks to provide treated water on demand. Conversely, chlorine could be added to small amounts of water that have already been drawn from the main rainwater storage tank. A third option would involve the construction of an intermediate tank thank would serve as a reservoir for treated water, allowing on demand access to treated water without the risk of spoiling the whole water supply by adding too much chlorine.

Furthermore, a method for ensuring proper chlorine levels are maintained is crucial. Residual chlorine could result in chlorine levels that are too high, potentially harming community residents or resulting in a strong taste that discourages chlorine use.

To encourage the use of chlorine treatment throughout the community, our chapter will take time expressing the importance of treating collected rainwater to community members. A large impediment to community adoption of a treatment plan is the residents' understanding of the need for a treatment plan. On past implementation trips, residents have expressed that they understand that clean water is important. However, they are not aware collected rainwater may be contaminated, and as a result are not eager to improve their water quality. From the community's perspective, they have lived off this water for many years, proving to them that it must be acceptable drinking water, when it is most likely contaminated.

In order to convince community members to follow water treatment strategies, water taken from various sources will be tested for the presence of bacteria. Rapid bacterial tests will be conducted on water taken from various sources within the community. These tests will involve showing the community the difference in bacterial presence between water treated with chlorine and water left untreated. The numerous health benefits to drinking clean water will then be explained to community members. The comparison tests should convince the community members of the effectiveness of chlorine treatment, while explaining the personal health benefits associated with drinking water that has been purified will encourage water treatment.

Chlorination is the preferred method of water treatment in the community of Isla Popa II. It is simple, logistically viable, and community driven. Coupled with an education focusing on the importance of water treatment, chlorination will be a sustainable and effective method of water treatment.

7.0 Professional Mentor Assessment

7.1.1 Professional Mentor Name and Role

Professional Mentor.

7.1.2 Professional Mentor Assessment

This report summarizes where the chapter is in regards to improving the water treatment system within the community of Isla Popa II. Water treatment in areas where there is no dependable power and lack of education in the understanding of the importance of clean water is difficult, hence the reason why there is no one systematic way used in developing countries. At the Isla Popa II education of clean water is even more difficult as the community does not see any direct correlation between the drinking water and public health. Therefore, the water treatment system installed needs to be coupled with community education, which the chapter has nicely outlined and is prepared to implement (use of bacteria tests showing difference between treated and untreated water is an excellent visual education tool).

The use of chlorine as a primary treatment method is not without shortcomings and does not seem to be addressed in this analysis. The government provides chlorine, but in what form? How will the chlorine be administered and properly dosed to ensure there is enough to disinfect the water yet not provide foul taste. Since chlorine has been applied in the past and then discontinued, how will the program ensure this will not happen again.

Perhaps a solution will be to perform a pilot test using both chlorine on the existing rainwater collection system and install a biofilter on the newly installed rainwater collection system. The goal of any treatment system is to minimize the amount of extra work the community needs to do for water treatment. Any system design should be simple and easy to use, to the point that the community is unaware that there is any treatment whatsoever.

7.1.3 Professional Mentor Affirmation

I have read over the alternative analysis report, provided comments/changes to the report and accept responsibility for the course the water treatment project at the Isla Popa II is taking.

7.2.1 Professional Mentor Name and Role

Professional Mentor

7.2.1 Professional Mentor Assessment

Since the completion of the initial installation the group has continued to develop a plan that produces a more comprehensive and holistic solution to the water needs of the Isla Popa II community. These developments are reflected in the current document, which places a strong emphasis on community education and the movement in the use of chlorine-based disinfection practice. The resistance of the community to use of biosand filters is complex and may partially reflect on a history of other NGO sponsored projects on the island. In any event, implementation of quality source water use and chlorination represents a reasonable and realistic option for this community. The group continues to maintain and strengthen its ties to the community through frequent ongoing phone contact with Ambrosio Bekar, the community lead for this project. This relationship is critical to the success of any project as his opinion is one of the prime drivers within the community in terms of its attitudes about water use and treatment.

The current plans represent a system that can be installed and maintained by the community; additionally, this type of system could be added to the previous tanks as a retrofit to make for a uniform system. While there are still a number of details that need to be resolved these are manageable within the projected time frame and with the resources available to the group and within the community. Additionally, Mr. Bekar has become more engaged and enthusiastic about ongoing work, which, I believe speaks to increasing trust and confidence on his part with the EWB-RPI group. This confidence will be vital in the development of chlorine residual testing program which will be the key to provision of improved quality drinking water

7.2.3 Professional Mentor Affirmation

I have read and reviewed the alternative analysis; I have been active in the ongoing planning and accept responsibility for the direction of this project.

7.3.1 Professional Mentor Name and Role

Professional Mentor, Responsible Engineer In Charge

7.3.2 Professional Mentor Assessment

With this report, the chapter builds upon its previous efforts to increase the supply of safe water to the community. The chapter has refocused on treatment and disinfection, which is a critical step in developing a safe water supply.

The chapter has presented appropriate treatment alternatives to the community, and worked with the community to select chlorine as a suitable disinfection method. As noted in the report, he chapter should continue to develop its understanding of chlorine disinfection, to understand its limitations, and practices for best use. The chapter must next develop a plan to reliably dose and measure free chlorine levels.

Chlorine disinfection is a logical next step for the community, but other methods for treatment and disinfection should not be ignored for future improvement.

Education is another important step towards safe water consumption, and the chapter has followed this path determinedly. The education program focuses on the link between drinking water and public health.

7.3.3 Professional Mentor Affirmation

I, David Railsback, acknowledge that this project is being performed using good engineering judgment, and I accept responsibility for the course that the project is taking.