Document 525
Pre-Implementation Report

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

Prepared By:

18 October 2015

ENGINEERS WITHOUT BORDERS USA
www.ewb-usa.org

Table of Contents

Draft Final Design Report Part 1 – Administrative Information

1.0 Contact Information *(correspondence regarding report reviews will be sent to the listed President, Project Leads, Mentors and Faculty Advisors)*

Project Title	Name	Email	Phone	Chapter Name or 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 Travel Team

Travel team is not yet finalized. The members listed below by name will be travelling on the upcoming trip. Traveling members identified strictly by role will be selected in the weeks following document submittal.

#	Name	E-mail	Phone	Chapter	Student or Professional
1					
2					
3					
4	Assistant Construction Lead				
5	PMEL Lead				
6	Education Lead				
7	Student Translator				

4.0 Health and Safety

The travel team will follow the site-specific HASP that has been prepared for this specific trip. The HASP has been submitted with this report as a stand-alone document.

5.0 Planning, Monitoring, Evaluation and Learning

5.1 The travel team has reviewed the 901B – Program Impact Monitoring Report template and has assigned travel team members to complete this report during the upcoming trip. We acknowledge that the

completed 901B is required with the eventual submittal of the 526 – Post-Implementation Trip Report. _X_Yes ___No

5.2 The team has selected monitoring indicators from the 906 - Project Monitoring Indicators charts. These will be assessed on this trip and reported on in the 526 – Post-Implementation Trip report. _X_Yes ___No

5.3 Is the signed 903 - Implementation Agreement included as an appendix to this report? _X_Yes ___No

Note: The chapter was unable to get a physical signature within the timeframe of this project. The terms of the implementation agreement have been discussed at length with community leadership, and a transcript of the call has been attached to this document with the 903. The implementation agreement will be signed prior to starting project construction and submitted with the 526 Post-Implementation Report.

.

6.0 Budget

EWB-USA TRIP BUDGET	
EWB-USA Chapter Name ::	RPI
Project Name ::	
Type of Trip ::	
Trip Type: A= Assessment; I= Implementation; M= Monitoring + Evaluation *NOTE: The fees associated with each trip type will auto-populate the EWB-USA HQ section.*	I
Lines with an asterisk are automatically calculated.	**BUDGET *(PRE-TRIP)***
DIRECT COSTS	
Travel + Logistics	
Airfare	$6,675
Food + Lodging	$500
Other Travel Expenses (ex: Rental Vehicle, Taxis/Drivers, Exit Fees/Visas, Innoculations/Medical Exams, Insurance)	$1,000
Sub-Total*	**$8,175**
Labor	
In-Country Logistical Support	$500
Local Skilled labor	$75
Sub-Total*	**$575**
EWB-USA HQ (this section is auto-calculated based on trip type)	
Program Quality Assurance/Quality Control + Infrastructure*	$4,900
Less EWB-USA HQ Subsidy*	$3,690
Owed by Chapter Sub-Total*	**$1,210**

Project Materials + Equipment (itemized, as appropriate)	
Hardware Store Purchases	$565
Wood Purchased	$250
Sub-Total*	**$815**
Misc. (details required)	
Bug Repellent Devices	$5
Phone Card	$15
Skype Credit	$10
Sub-Total*	**$30**
TOTAL DIRECT COST*	**$10,805**
IN-KIND CONTRIBUTIONS **Community In-Kind Contributions to Project Costs**	
Labor	$0
Materials	$0
Logistics	$0
Sub-Total*	**$0**
TOTAL IN-KIND CONTRIBUTIONS*	**$0**
FUNDS RAISED **Funds Raised for Project + Grants Received**	
Cash from community (EWB-USA requires a minimum 5% contribution)	**$71**
Total $ in Project Fund at EWB-USA HQ	$11,448
Total $ in Project Fund at University	$0
Total*	**$11,448**
Funds Raised for Chapter	
Total $ in Chapter General Fund at EWB-USA HQ	$5,569
Total $ in Chapter General Fund at University	$0
Total*	**$5,569**

7.0 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

8.0 Project Location

Longitude: -82.1405
Latitude: 9.2204

9.0 Number of People

Number of persons directly affected: 350
Number of persons indirectly affected: 350+

10.0 Professional Mentor Resume(s) - Please see document *405 - Mentor Qualifications* for the requirements of the Responsible Engineer in Charge (REIC) and the overall Professional Mentor Team. This can be found in the Sourcebook Downloads on the Member Pages of the website.

Draft Final Design Report Part 2 – Technical Information

1.0 Executive Summary

This document outlines the proposed implementation plan for the Development of Clean Water Source Project by the Rensselaer Polytechnic Institute Chapter in Isla Popa II, Panama, project number 8801. The implementation trip this document describes is scheduled to take place in early January of 2016. The objective of the trip is to construct a chlorine treatment system that integrates well with the community of Isla Popa II by building off of the chapter's previously implemented rainwater catchment system.

EWB-RPI plans to travel to Isla Popa II in order to implement a chlorine treatment system to address the lack of community adoption of the previously implemented biosand filters. Following the January 2015 implementation trip, community members expressed their dislike of the biosand filters, and reported that they did not adequately meet their requirements for a water treatment system. The flow rate of the system was too slow; they preferred a method of water treatment that would provide on-demand access to clean water. Therefore, the chapter is requesting approval for a second implementation trip to address the community's issues with water quality by building a chlorine treatment system integrated into the chapter's previously constructed rainwater catchment system.

The goal of this project is to provide on-demand access to treated water that is safe for immediate consumption to meet the daily water needs of the local school. This will be accomplished through a minor addition to the previously implemented rainwater catchment system installed on the community pavilion adjacent to the school. A secondary, much smaller, intermediate water storage tank will be added. This intermediate tank will be filled with water from the main rainwater storage tank manually. As water is added to the intermediate tank, the proper amount of chlorine can also be added. In this way, the intermediate storage tank will store a small supply of treated water that can be drawn from and replenished as needed. Once completed, students and staff at the local school will be able to access treated water any time, addressing the community request for a system that provides on-demand access to treated water. It is estimated that this project will affect approximately 350 community members.

The community of Isla Popa II is a rural community on the island of Isla Popa. The community has a relatively dispersed layout, but is centered around the school and dock. The population is approximately 350 people, consisting mostly of families with young children. The community is governed through democratically elected leaders responsible for various aspects of community life, such as the school, church, and community structures. A draft of the Implementation Agreement has been created for this implementation trip, and is attached to this document. The chapter has thoroughly discussed the terms of the agreement with the community through telephone and has received a verbal agreement.

The program with Isla Popa II started in the fall of 2010. It was quickly determined that the community's needs mandated a water project. The chapter completed three assessment trips before implementing the rainwater collection system in January of 2015. The first assessment trip took place in January of 2012, the second during August of 2012, and the third assessment trip took place in August of 2013. During the first implementation trip in January of 2015, 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 for community use. This is the only project that EWB-RPI is currently working on, with about twenty members actively involved.

For the current project, calculations were performed to determine the appropriate amount of chlorine to be added per gallon of water. This will ensure that the community is dosing the collected rainwater with an adequate amount of chlorine while minimizing the effect on taste. This will allow for effective treatment of water without discouraging use due to an unpleasant taste. Structural integrity analysis was again required for design of the chlorine treatment tank stand. These calculations can be found in Appendix A.

Project drawings are attached that describe the proposed design and how it will interact with the previous implementation. This includes accurate dimensions for the tank stand and necessary piping. These are also included in Appendix A.

The team plans on staying in Isla Popa II for seven days, with two extra days for travel to and from the region. The first day will be spent gathering materials on Isla Colon and transporting them via water taxi to Isla Popa. The following three days will be spent constructing the tank stand. Then, on the fifth day the team will attach the required piping to the system. The last day of planned construction will focus on community training and education. An extra day was built into the plan to accommodate any unexpected challenges. Traveling chapter members will act as technical contractors. They will provide construction oversight and assist with the construction of more technical aspects of the design. However, community members will be doing most of the physical construction, with a team of three to four assisting in construction each day.

The sustainability of this project is affirmed by its low maintenance cost, availability of replacement parts, and community-driven nature. The community has demonstrated that it has the technical and financial capacity to maintain the project, given initial proper training. The materials needed to operate and repair the proposed system can be purchased on another island in the region, Isla Colon. Once the materials are obtained, the system is easy to preserve, simply requiring cleaning four times a year. The community also has several individuals who are invested in the system and the clean water it provides who will be responsible for operations and maintenance.

This implementation will adequately meet the needs of Isla Popa II in a sustainable manner. It provides an on-demand source of clean water with low maintenance and operating costs. The community has demonstrated its technical and financial capacity to maintain the project given proper training. Most importantly, the relationship between the community and EWB-RPI has steadily improved over the years, resulting in open dialogue which allows the project to flow more smoothly and better meet the needs of the community.

2.0 Program Background

When the project was started, the community of Isla Popa II did not have reliable access to clean water. Primarily, the community relies on rainwater collection. Often, the rainwater is stored in unsanitary conditions and is not treated prior to consumption. To address these issues, the chapter traveled to Isla Popa II multiple times on a series of assessment trips and an implementation trip to provide the community with a dependable source of water and a method of water treatment. The constructed system harvested the rainfall that fell on the community pavilion and stored it in two 600 gallon tanks placed adjacent to it. Point-of-use biosand filters were constructed to treat the collected water, and community members were taught the necessary procedures for constructing and maintaining them.

The community quickly became dissatisfied with biosand filtration. They believed that the biosand filters were complicated and took too much time to treat water. They also informed us that one of the biosand filters constructed for community use had accidentally been broken. In light of this information, the chapter determined that biosand filters were not the best option for water treatment within Isla Popa II. As a result, the chapter completed an alternatives analysis of possible water treatment options for Isla Popa II. Through this analysis, the chapter concluded chlorine treatment was the best option for them. Chlorine treatment both effectively purifies water and was the option preferred by the community. The chapter is currently planning to return to Isla Popa II in January of 2016 to address the need for a water treatment method that is compatible with their needs.

Previous documents for this project include site assessment activities, implementation planning, and a post-trip implementation report. Previous site assessment activities include information on water quality from various sources within the community, while several pre-implementation documents and a post-implementation report detail the design of the implemented system. The chapter has also completed an alternatives analysis for water treatment and draft final pre-implementation report for the coming implementation trip.

3.0 Facility Design

3.1 Description of the Proposed Facilities

The proposed design adds a new water treatment method to the rainwater catchment system implemented on the chapter's previous implementation trip. A 55 gallon drum will be placed horizontally on a separate stand to be built in front of each of 600 gallon rainwater storage tanks. Water will flow from the large tank into the 55 gallon drum, which serves as an intermediate storage tank. Chlorine can then be added to the intermediate tank in appropriate amounts. Once treated, water can be accessed at any time throughout the day from the intermediate tank. This treatment method is designed to make the process of chlorination as simple as possible for community members and to allow for on-demand access of treated water.

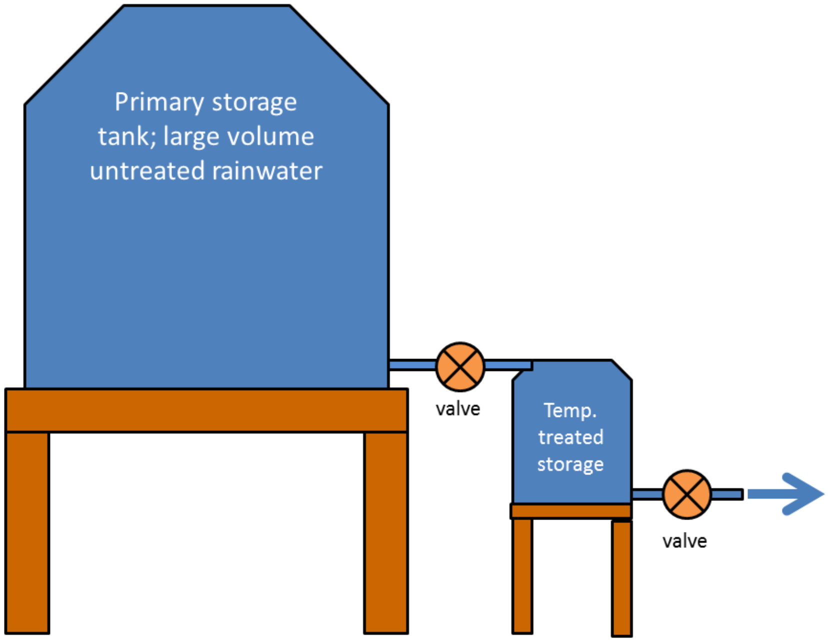


Figure 5.1.1 – Simplified graphic of proposed sytem

The system functions through the use of a valve to control the flow of water from the large rainwater storage tank to the smaller 55 gallon drum. Once filled, the appropriate amount of chlorine can be added to the now full 55 gallon drum. This task will be performed by community members trained by traveling chapter members in the proper chlorine dosing techniques. Once the water stored in the 55 gallon drum has been treated, community members can draw water from this source as needed through the use of a secondary valve. The intermediate storage tank, is necessary to control the inflow of water to allow for accurate levels of chlorination and store treated water for community access.

3.2 Description of Design and Design Calculations

The proposed system uses a 55 gallon drum as an intermediate storage tank between the outlet spigot and the 600 gallon rainwater storage tank implemented on the chapter's last trip to Isla Popa II. This modification to the previously constructed system will allow the community to have access to treated water without having to wait for the completion of a long treatment procedure. The two tanks are to be connected via PVC piping and flow between the two tanks will be controlled by a manually operated valve. The 55 gallon intermediate storage tank will be placed horizontally on its side, rather than standing vertically, in order to keep the outlet spigot as high above the ground as possible. This will allow easier community access and limit exposure of the outlet spigot to contamination by local wildlife.

The intermediate storage tank is necessary to meet the community's request for treated water that can be accessed on-demand without having to wait for a treatment process. The intermediate storage tank was chosen to be a plastic 55 gallon drum due to the wide availability, compact size, and adequate volume. The availability of 55 gallon drums for purchase at local hardware stores has been confirmed. Additionally, on previous trips to Isla Popa II, communities were observed to be using plastic 55 gallon drums for rainwater catchment, providing a strong indication that a plastic 55 gallon drum is an available commodity, making it highly likely an alternate vendor could be found should problems arise while acquiring the 55 gallon drum. Also, the relatively small diameter of a 55 gallon drum allows the access spigot to be kept as far from the ground as possible. The volume of water stored in a 55 gallon drum is also adequate to meet the daily needs of the community. When designing the previously constructed rainwater catchment system, it was estimated that the school students would be the primary users of the system. Prior calculations estimated that approximately 250 liters of water would be required to meet the daily needs of the school[1]. This equates to approximately 66 gallons of water per day. The two 55 gallon drums, one coupled to each 600 gallon rainwater tank, will be sufficient to meet the needs of the community, providing just under 110 gallons of treated water per day. This volume is sufficient to supply the school with treated water for the entire day, and a water treatment procedure is only needed once at the start of each day. Once treated at the beginning of the day, the 55 gallon drum intermediate storage tanks will provide treated water for the duration of the day.

The tank stand designed to support the intermediate tank will be built from local nispero lumber, purchased directly in Isla Popa II. The tank stand will be mounted in concrete footings to improve stability and durability. Strength calculations were conducted to ensure the structural integrity of the tank stand (Appendix A). Tests were conducted by the chapter in previous years to determine the material properties of nispero wood. The stand also must straddle a four foot by four foot square concrete splash pad constructed on the previous implementation trip. As a result, the longitudinal length of the tank stand is much longer than the length of the 55 gallon drum.

Water will be piped from the 600 gallon rainwater storage tank to the intermediate tank through schedule 40 PVC piping. The outflow piping on the 600 gallon tank will have to be removed and replaced with piping that is compatible with the current design. The previous design utilized metal piping for its durability. However, due to the imprecise nature of construction in remote areas, the flexibility in length sizing of PVC piping is preferred to the durability of metal piping. Pipes will be joined using standard PVC pipe fittings and PVC cement. Silicone sealant will be used to ensure a water tight seal. As a precautionary measure, the valve controlling the outflow of the 600 gallon tank will be placed as near as possible to the 600 gallon tank while still remaining in an accessible location. Therefore, if the piping were to develop a leak, water flow could be shut off to allow the leak to be fixed. The piping flowing from the 600 gallon tank currently is initially PVC piping, but converted to metal piping after several inches. This metal piping can be removed and a PVC coupling can be used to connect the pipe exiting the 600 gallon drum with the piping leading to the 55 gallon drum.

---

[1] EWB-RPI. "525 Pre-Implementation Report". *Appendix B: Rainwater Data Simulation Sample.* 15 June 2014.

The 55 gallon drums have two access holes for piping. These holes are located on the flat face of the drum near the outer diameter. The holes are arranged 180 degrees apart. See design drawings in Appendix A for further details. The 55 gallon drums will be oriented so that they line up vertically, with the top hole serving as an inlet and the bottom hole serving as an outlet. Since there are only two holes present, a chlorine access pipe has been built into the inlet piping connecting the 55 gallon drum to the 600 gallon tank so that chlorine can be added. Chlorine can be added to the drum through this vertical pipe without further modification of the drum.

In the event that the community would like to replenish treated water reserves before the tank is completely emptied, water can still be added to the 55 gallon drum. As long as the community is able to determine how much untreated water has been added to the intermediate tank, the appropriate amount of chlorine can be added to the tank to treat the newly added water. In order to ensure accurate chlorine addition, it is necessary to know the volume of water added to the 55 gallon drum. However, the water level in the tank is not easily observable simply by looking at it. Therefore,, a water meter will be constructed into the outlet piping of the 55 gallon drum in order to display the volume of water present. The water meter consists of a clear plastic PVC tube that is connected to the outlet piping and extends vertically above the diameter of the 55 gallon drum. By placing the water meter in the outlet piping but before the outlet spigot, pressure in the 55 gallon drum will force water in the water meter up to a level that is equal to the water level in the storage drum. This tube will be demarcated by traveling chapter members on site to accurately measure the water level of the 55 gallon drum. This will be done by adding known volumes of water to the tank, allowing the water to settle, and then marking the water meter with the corresponding volume present. Alternatively, calculations can be done using the tank dimensions to determine the volume of water present based on the water level indicated.

The community will be able to access treated water in the storage tank through an outlet valve. This outlet valve is located about two feet above the ground. It is positioned in a way similar to the previous implementation, and the two feet of vertical space will be sufficient to allow community members to easily fill water receptacles.

When chlorinating drinking water, the International World Health Organization recommends that the residual chlorine level be 0.5 mg/L. In order to achieve this level, it is recommended that water be dosed with 2.5 mg of chlorine per liter of water[2]. Using this information, the chapter performed calculations to determine the amount of bleach that should be added to each gallon of water. These calculations are outlined in Appendix B.

Bleach is available to the community in the form of non-concentrated liquid bleach. The specific concentration of this bleach is unknown, but will be verified prior to travel. Dialogue with the community indicates that the bleach available is standard household bleach. Household bleach typically has a concentration of 5.25% to 8.25% sodium hypochlorite, the active ingredient in bleach, and the chapter has prepared dosing information for both of these concentrations. For 5.25%, 0.17 mL of bleach should be added per gallon of water. For 8.25%, 0.11 mL of bleach

[2] Bob Reed. "Measuring Chlorine Levels in Water Supplies". *World Health Organization*. 2011.

should be added per gallon of water. Several graduated cylinders will be purchased for the community water board to accurately measure the volume of bleach to be added.

The presence of certain solutes and organic matter in water can cause residual chlorine levels to fluctuate. To ensure proper levels of chlorine are being maintained, dpd (diethyl paraphenylene diamine) indicator tests will be conducted. The dpd tests, similar to pH test strips, change color with different concentrations of free chlorine. When first using the system, the chlorine residual will be tested with these strips to ensure proper levels of free chlorine are present, and that the amount of chlorine added to the intermediate tank results in the recommended residual of 0.5 mg/L. This will ensure that chlorine levels are not too low, leading to ineffective treatment, or too high, leading to an unpleasant taste. Should the previously calculated chlorine levels be outside the recommended limits, the dosing plan will be adjusted accordingly on-site and any manuals left with the community will be updated. Additionally, community members will periodically use these test strips to ensure proper chlorine levels are being maintained.

When dosing with chlorine, the World Health Organization WHO recommends that the turbidity of the water should be less than 5 NTU, and the pH level of the water should be between 6.8 and 7.2[2]. The first flush system present on the rainwater catchment system will separate the majority of particulate contaminates, and turbidity is not expected to be an issue. Tests conducted in August 2012 show that the pH level of direct rainfall in the community is 5. Various tanks within the community had pH levels ranging from 5 to 7. The Safe Drinking Water Foundation states that below a pH of 4.5, chlorine can react to form dangerous compounds which are harmful to human health[3]. Adding bleach, a highly alkaline solution, should increase the pH to within acceptable levels. Due to the relatively pure nature of the available water, which is collected from rain, this is not expected to be a problem. However, the chapter will conduct pH tests on litmus paper to ensure that the pH of collected rainwater is not approaching unsafe levels.

3.3 Drawings

See Appendix B: Proposed System Design Drawings

3.4 Names and Qualifications of Designers

Name	Student or Professional	Qualifications	Work Done

[2] Bob Reed. "Measuring Chlorine Levels in Water Supplies". *World Health Organization*. 2011.
[3] "What is Chlorination?" *Safe Drinking Water Foundation.*

3.5 Draft Final Design Report Review Comments

Below is a copy of the comments received during the review of the 524 Draft Final Design Report. Chapter responses in call are included to provide a full picture of the review discussion. How the chapter addressed comments in this document are covered in parts of the table labeled "Chapter Response in 525" and can be below each comment.

Review Comments

No.	EWB-USA PE Comment	Chapter Response (In-Call)
C1	Well-written report - very thorough documentation of a simple design. Thank you for the extra effort. The report was very polished and professional. Your team of mentors is highly qualified to review your technical calculations, which look complete to me. I will focus on sustainability and community issues in my comments today.	Ok. We have had issues with the TAC in the past, so we wanted to make sure everything was clearly documented.
C2	**Chlorine Dosing and Mixing** 1. Dosing when the 55 gallon drum is partially full may be more complex than you want all the community members to attempt. You should limit this task to certain individuals. 2. Individuals should be responsible (on a schedule) to dose the chlorine daily. This should not be left to the last person who gathers water from the drum when it empties. This is like the community coffee pot at our office. Nobody wants to make	Someone would dose the chlorine in the morning and that would suffice for the day. Ideally, there would be one individual responsible for dosing. One individual will not want that responsibility and they will probably try other people to use it. The idea would be to train as many people as possible on the process, so that it can be used. We will talk with [redacted], and ask him to introduce us to the kitchen staff. We can dose the water with chlorine then. We were planning on having one person to fill

	coffee, so they either wait for someone else to make it if the pot is empty or they buy coffee from the shop across the street. “Community” shared responsibilities sometimes get overlooked. Individuals can be held accountable if they do not follow through. 3. Will there be a lock on the valve between the main tank and the intermediate tank? To prevent people from bypassing treatment. 4. Is there a way of mixing the chlorine in the drums? 5. How will the chlorine dosing work? Is there a mixing tank or a connected receptacle for the chlorine? Or is it going to be manually do with funnels and buckets? This may be messy and cumbersome. The easier you can make it, the more likely the community members will be able to does the drums effectively.	it in the morning, regardless of the current state of the tank. We were going to have the valve between the tanks open. There is not spigot at the larger tank. The water must go through the 55 gallon drum. Based on the geometry of the tank, there is no way to easily mix. They will dilute the chlorine before adding it. They will mix in a funnel and bucket. *Katrina: You may consider adding a small mixing box or tank that would help automate that process.*

Chapter response in 525:
1 & 2. The chapter has updated the project ownership section of this report to identify members of the community responsible for filling the intermediate storage tanks at the start of each day.
3. The chapter has decided not implement a lock on the valve between the main tank and the intermediate tank to prevent people from bypassing treatment. Forcing the community to adopt water treatment in this way is not sustainable, and it increases the risk of community members not being able to access stored water when they need it. The chapter will instead focus on education and training to encourage community members to make the decision to treat water.
4. As 55 gallons drums laid on the side, stirring of the intermediate storage tanks is a difficult task due to the geometry of the tanks. The chapter recognizes that it is important that bleach is properly mixed with untreated water in order to successfully treat it, so the operations section of this document was updated to include a procedure that would ensure the bleach is well mixed once added to the intermediate storage tank.
5. The chapter has updated the operations section and attached a manual to thoroughly explain the chlorine dosing procedure. The chapter considered the suggestion of adding a small mixing box or tank in between the large rainwater storage tank and intermediate storage tank to help automate the process of chlorine dosing. However, the chapter decided that this would result in a less durable system with only marginal benefits to convenience. The mixing box would make it easier to dose with chlorine. However, it would add significant complexity to the piping system.

<table>
<tr><td colspan="3">Adding more components to the piping system between the two tanks increases the likelihood that a leak would develop, risking the loss of collected water and putting the treatment system out of commission until it is repaired. Additionally, the only benefit gained by adding this mixing tank is the elimination of pouring a bleach and water mix back into a secondary inlet pipe. Therefore the chapter has concluded that the added convenience of a built-in mixing tank does not outweigh the added complexity and reduced durability to the piping system.</td></tr>
<tr><td>C3</td><td>Community Buy In & Communication
Great that the water committee has been heavily involved in the design of this system! Describe how you have communicated with them about this project scope and details. Have they seen the design?</td><td>They have not looked through this particular design through [redacted]. As part of the preparation of the trip, we sent someone from EWB Panama to the community. That person talked with the community about chlorine treatment. In the past, the community has said that they do not like the taste of this community.

Katrina: It is important to talk with the community about this design before the final design. This is especially important for the aspects of operation that they will be responsible for on a daily basis.</td></tr>
<tr><td colspan="3">Chapter response in 525:
The chapter has since communicated with [redacted] at length over the phone of design specifics and terms of the implementation agreement. [redacted] has in turn discussed the design and terms of the Implementation Agreement with members of the Water Board. Following this discussion, the chapter has updated the design and terms of the implementation agreement to reflect community input. At this point, the community is fully knowledgeable about the design of the proposed system, its operation, and the terms of the Implementation Agreement.</td></tr>
<tr><td>C4</td><td>Education
Taste test - demonstrate different concentrations. You could make it a community event that exposes a larger audience to the issue of chlorine and water quality and treatment.</td><td>Ok. That sounds like a good idea.</td></tr>
<tr><td colspan="3">Chapter response in 525:
The chapter has updated the education section of this report to include a plan for conducting chlorine taste tests among members of the water board and other community members involved in the construction and operation of this system.</td></tr>
<tr><td>C5</td><td>Operation and Maintenance
Please provide an O&M Manual, and training materials with your 525 submittal. This should be a big focus of this trip considering the project failure and</td><td>Ok.</td></tr>
</table>

<table>
<tr><td></td><td>the small scope of this implementation.</td><td></td></tr>
<tr><td colspan="3">Chapter response in 525:
The chapter has attached manuals for the operation and maintenance of the proposed system to this document.</td></tr>
<tr><td>C6</td><td>It's great that your team has identified who is responsible for O&M and who is responsible for technical assistance.</td><td>Ok.</td></tr>
<tr><td colspan="3">Chapter response in 525:
Not applicable.</td></tr>
<tr><td>C7</td><td>In the PMEL lead role description, it mentions that they would be responsible small repairs. Repairs are the responsibility of the community; it is important that your team does not blur that line. Empower the community to make any repairs themselves (unless issues are due to design errors).</td><td>Ok.</td></tr>
<tr><td colspan="3">Chapter response in 525:
The role description for the PMEL has since been updated. The PMEL lead responsibilities now include inspecting systems for needed repairs, then bringing identified repairs needed to the attention of appropriate community leaders and working with them to ensure they understood the source of the damage and how to repair and prevent it in the future.</td></tr>
<tr><td>C8</td><td>Automated System
Did you look at tablet chlorination or other options that would be more automated? Considering the failure of the bio-sand filters, is there an option that may be more automated for the community?</td><td>We have, but the scope was too big for such a small system. This is something that is simple and they can buy at the store.</td></tr>
<tr><td colspan="3">Chapter response in 525:
See in-call chapter response. The scale of the project is too small for a more automated system.</td></tr>
<tr><td>C9</td><td>Assessment Activities
Why no site assessment? What about the other issues that the community has that we discussed at 523? Since you have a small scope project, you may consider adding site assessment activities.</td><td>That section confused me. We were not planning to do more projects with this community. We will do assessment activities to make sure that we did meet the need.

We plan to close out the project after this implementation.

Katrina: Looking back at past projects is Monitoring & Evaluation. Looking forward to new projects is Assessment. You will probably</td></tr>
</table>

<table>
<tr><td></td><td></td><td>just want to include Monitoring & Evaluation in this case.</td></tr>
<tr><td colspan="3">Chapter response in 525:
See in-call chapter response. Chapter plans to close out the project after this implementation.</td></tr>
<tr><td>C10</td><td>Drawings
Thorough drawings and calcs - please add labels to the drawings. Add construction notes to drawings.

Also, a site layout would also be useful to show where this system is located in the community and provide an overview of the site.</td><td>Ok.</td></tr>
<tr><td colspan="3">Chapter response in 525:
The chapter has updated the design drawings to include more notes and labels. A site layout has also been attached.</td></tr>
<tr><td>C11</td><td>Have you discussed the implementation agreement with the community?</td><td>No yet. We have told them that they will be there in January and that the agreement will have similar terms as the partnership agreement.

We will explain over the phone with the community and make any changes and finalize it before they arrive on site.</td></tr>
<tr><td colspan="3">Chapter response in 525:
The chapter spoken at length over the phone with Ambrosio Bekar, president of the community, about the terms of Implementation Agreement. He has discussed the terms with other members of the Water Board, suggested changes to the terms, and accepted the Implementation Agreement.</td></tr>
<tr><td>C12</td><td>Thank you for the insightful mentor assessments.</td><td>Thanks.</td></tr>
<tr><td colspan="3">Chapter response in 525:
Not applicable. However, the EWB-RPI mentors appreciate the feedback.</td></tr>
</table>

4.0 Project Ownership

The team has designed a simple chlorination system to be added to the rainwater catchment system that was constructed in January 2015. The constructed chlorination system will be built adjacent to the existing rainwater collection tank stands, and will have a footprint much smaller than that of the rainwater collection tank stands. The additional infrastructure built for retrofitting the existing catchment system with a chlorination system will be constructed on the same plot of land in the community that was used for the January 2015 implementation. This centralized community land is publically owned. As the purpose of the entire system, including catchment and chlorination treatment, is to serve the needs of the community's school children, the school president, [redacted], will have partial ownership of the project. Additionally, construction lead and president of public structures [redacted] will have partial ownership of the constructed systems as well. Water Board members designated on the first Assessment trip by EWB-RPI will also be key co-owners of the project.

[redacted] and [redacted], acting as primary owners of the project, will be charged with maintaining the system. Maintenance includes, but is not limited to, quarter-yearly rainwater catchment tank cleaning with chlorine and the replacement of any broken system components. [redacted], a community elder and Water Board member, has been identified as an appropriate aid for technical maintenance tasks that must be done to the system. [redacted] has accumulated years of experience replacing plumbing fixtures in the community and expressed great interest in the technical aspects of the team's January 2015 rainwater catchment system construction.

The system will be operated by a team of community members trained in the proper chlorine dosing procedures. To ensure an adequate volume of treated water is available throughout the day, the intermediate tanks will be filled and treated at the start of each day. This task is slightly more complicated than filling and treating an empty water tank, so it will be performed only by [redacted], president of the school. At the request of [redacted], the chapter may train other members of the community in the proper procedures as well. [redacted] and [redacted] will also be trained in the proper procedures for filling and treating water in the intermediate storage tanks, as a back-up for [redacted]. Once trained, the chapter will give these members of the community certificates to certify that they are capable of performing all aspects of chlorine dosing operations.

It may be possible for the intermediate storage tanks to run dry during the day, since all the water is used up. Were this to happen, staff at the school would not want to spend time looking for a trained member of the community to access water, they would want the capacity to refill the tanks themselves to meet their need for water as soon as possible. As such, certain school staff will be trained in the proper procedures for refilling an empty intermediate tank. This procedure will be fairly simple, since only one volume of bleach will need to be added to each tank. Travel team members will work with members of the Water Board to identify and train school staff that may need to perform this operation. Additionally, a manual highlighting the specific procedure to be followed in this scenario will be left attached to the system explaining the refill procedure.

In this way, [redacted] will be responsible for topping off the tanks at the start of each day. In the event that the tanks run empty, school staff will trained in the proper refill procedure. This will ensure treated water is available at all times of the day, and that the system is being operated only by trained individuals.

5.0 Construction Plan

The chapter plans to construct the proposed implementation over the course of six days. However, chapter members will remain in the community for seven days to accommodate any unforeseen challenges. The largest logistical challenge the team will face is acquiring all required supplies on the first day in Panama. If certain supplies are overlooked, a team member may be forced to return to Isla Colon during the additional "contingency day" to acquire the missing component.

Phase Number	Tasks	Est. Days to Complete
Phase I	- Acquire materials at hardware store - Transport materials to Isla Popa II	1
Phase 2	- 55 gallon drum stand construction	3
Phase 3	- Assemble piping	1
Phase 4	- Training and testing	1

Phase 1
This phase consists of acquiring the required construction materials prescribed by the implementation plan and transporting them to Isla Popa II. Materials will be purchased on Isla Colon, where members will be arriving from Panama City. The team will spend the morning and early afternoon on this commercialized island, ensuring that all the necessary materials have been acquired. Materials will then be transported to Isla Popa II via water taxis which are available for hire around Isla Colon. By reserving three water taxis in advance, the chapter will be able to transport themselves and the necessary materials to Isla Popa II.

Phase 2
In this phase, chapter members will work closely with three laborers from the community to collaboratively construct the stand that will support the 55 gallon drum intermediate tank. This will be a hands-on construction task. Footings for the foundation will need to be dug, the stand assembled, and concrete poured into the footings to securely mount the stand. Key project leaders in the community are familiar with this process, as it is very similar to the construction completed on the previous implementation trip. Additionally, operation of the existing rain catchment system will be evaluated in this stage to determine if the first flush system is operating properly. Traveling chapter members will be trained prior to travel in the proper use of hand tools and simple powered tools that will be used during construction. Additionally, the chapter will practice using PVC cement and silicon sealant to ensure an adequate seal is made on the actual project prior to travelling. Community residents who participated in construction during the last implementation trip will be recruited to assist in construction. These laborers are familiar with woodworking, concrete mixing, and other basic construction tasks. Combined with their knowledge of the local environment and experience building locally, they are incredibly valuable assets to the construction team.

Phase 3
During phase 3, chapter members will work with community members to assemble the piping that connects the 600 gallon rainwater storage tank to the intermediate 55 gallon drums. This

work is more technical, and while the workload is smaller, it needs to be done carefully in order to avoid jeopardizing the integrity of the system, as a failure in the piping could cause hundreds of gallons of water to go to waste. Fewer community laborers will be needed for this construction task, but key stakeholders in the community should assist in construction to understand the purpose of each component and proper assembly techniques.

Phase 4

By this phase, all construction should be completed. Chapter members will shift focus and will engage in training community members in the proper operation, cleaning, and testing of the constructed system.

Primarily, the chapter will serve as a technical contractor for the community. Chapter members are expected to serve in a managerial role, ensuring construction is proceeding as planned and that community members are well trained in the use of the system. As they learn best-practice in tank stand construction, community members will provide most of the direct labor. Community members are capable handymen and can handle almost any construction task, such as assembling wooden structures or mixing and pouring concrete. A labor force of approximately three to four workers a day during heavy construction days during Phase 2 will be necessary to allow construction to flow smoothly.

During the trip, each travelling member will have a specific role to ensure efficient use of time and that each objective is completed. These roles are outlined below.

Construction Lead (Student)

This role will be filled by a student who is very familiar with the proposed design. This position will be filled by the project lead. Responsibilities of this role include managing efficient use of community labor to complete the construction of the proposed system and ensuring construction accuracy to proposed designs. The construction lead will ensure that the design is built properly and is built to last.

Assistant Construction Lead (Student)

The primary responsibility of this role is to assist the construction manager throughout the construction process. The construction site will likely have many activities going on at once, and an assistant construction lead should take charge as a technical advisor for these activities when the construction manager is busy with other tasks.

Assistant Construction Lead (Mentor)

The mentor in this role should advise the construction manager throughout the construction process. With more experience comes better foresight; this mentor should be constantly observing all the activities going on at the construction site to ensure decisions are not made that may seem like an appropriate solution at the time, but could result in a failure of the system. This mentor will also be able to provide technical advice should unexpected problems arise during construction.

PMEL Lead (Student)
The role of the PMEL lead is to measure the impact of the project on the local community. The PMEL lead will conduct interviews with families in the community about current water usage and treatment practices to establish an updated baseline of health in the community. This baseline will be critical in benchmarking the impact of the clean-water system the team has implemented. Efforts to strengthen community involvement with the Water Board will be made. Additionally, the PMEL lead is responsible for conducting monitoring tasks related to the previous implementation. This includes inspecting previously implemented systems, documenting the state of the systems. In the event that necessary repairs are identified, the PMEL lead will bring these repairs to the attention of the appropriate community leadership. They will then work with the appropriate community members, teaching them how to repair the observed damage and how to prevent the damage from occurring again.

Community Education Lead (Student)
The education lead is responsible for ensuring that the community is aware of water quality issues. The education lead will serve in a missionary role, teaching community members of the importance of water quality. They will also be responsible for teaching community members how to properly use the newly implemented system and properly dose chlorine for water disinfection.

Quality Assurance Lead (Mentor)
The mentor in this role is responsible for general oversight of the project. The mentor should attempt to identify project sustainability issues and work to resolve these issues prior to trip completion in order to ensure a successful implementation. In addition to construction, this team member should also advise the PMEL and Education leads on issues regarding community relations.

Student Translator (Student)
The student in this role will facilitate communication between the team and community members. While many students traveling will have a limited grasp of Spanish, the common language in Panama, the student translator will be fluent in Spanish. This will ensure that critical design aspects, operation procedures, and other important information are properly communicated to the community. Although the translator can provide conditional support on the construction site, their main function is to work closely with the PMEL and Community Education Leads, as these functions are less tangible and require a more in-depth understanding of the language.

6.0 Materials List And Cost Estimate

6.1 Hardware Store Purchases

The majority of construction supplies can be purchased at Madera's Richard, a hardware store on Isla Colon. Previously called Sertebocas, this hardware store is where the chapter purchased supplies for the last implementation trip. The store can also be contacted directly by the chapter via phone, allowing for confirmation of material availability. The chapter has contacted this vendor to ensure the availability of materials critical to the design that need to be purchased in Panama, such as the 55 gallon drums.

Construction Materials List			
Item Name	Price	Qty.	Extended Price
55 gallon plastic drum	$ 69.99	2	$ 139.98
3/4 in. x 10 ft. PVC schedule 40	$ 2.93	2	$ 5.86
3/4 in. x 5 ft. Clear PVC Sch. 40	$ 10.56	2	$ 21.12
3/4 in. PVC Sch. 40 Elbow	$ 0.48	6	$ 2.88
3/4 in. PVC Sch. 40 Tee	$ 0.48	2	$ 0.96
3/4 in. PVC Sch. 40 3-way elbow	$ 14.82	2	$ 29.64
3/4 in. PVC Coupling	$ 0.35	4	$ 0.70
3/4 in. PVC Bulkhead fitting	$ 3.60	4	$ 14.40
3/4 in. PVC Threaded Adapter	$ 0.66	4	$ 2.64
3/4 in. PVC ball valve	$ 1.95	8	$ 7.80
2.8 oz. silicone sealant	$ 3.95	2	$ 3.95
3 in. stainless steel screws	$ 0.10	100	$ 10.00
3.5 in. Galvanized nails (per pound)	$ 1.28	1	$ 1.28
12 cubic ft. Concrete	$ 45.00	1	$ 45.00
PVC purple primer	$ 5.96	2	$ 5.96
PVC Cement	$ 4.94	2	$ 4.94
1/4 in. steel mesh 2 ft. x 5 ft.	$ 8.70	1	$ 8.70
1 gallon of wood impregnating oil	$ 36.50	1	$ 36.50
		TOTAL	$365.66
		Add approximately $75 buffer	$440.66

Operations and Maintenance Supplies			
Item	Price	Qty	Extended Price
DPD Free Chlorine Reagent Power Pillows, 10 mL, pk/100	$20.65	1	$20.65
pH Paper, 0 - 14 pH Range, 100/pk	$24.95	1	$24.95
Scrubber Brush	$17.94	1	$17.94
6-ft Long Pipe Brush Heavy Duty	$30.40	1	$30.40
Wide mouth Water Jug	$4.58	2	$9.16
10 mL Liquid Plastic Graduated Cylinder	$4.37	6	$8.74
		Total	$124.54

Pipe Cuttings Length and Quantity		
Type of Pipe	Length (in.)	Qty.
3/4 in. PVC Schedule 40:	2.50	2
	4.50	2
	4.75	2
	7.00	6
	8.75	2
	10.75	2
	17.50	2
Total Length	55.75	
3/4 in. Clear PVC Sch. 40	23.00	2

6.2 Wood Count

Wood is ordered directly from a supplier on the island of Isla Popa, and is cut to specifications. Therefore, an order of 2x4's will have cross sectional dimensions of 2 inches by 4 inches, unlike the United States standard of 1.5 inches by 3.5 inches. The vendor has been informed of the chapter's intent to purchase wood and the order will be placed when travel approval has been granted. The chapter is purchasing wood from the same vendor as the last trip, and the chapter was satisfied with the quality of the wood purchased and the quality of the cuts.

Quantity	**Cross Section (inches)**	**Length (inches)**
8	3 x 3	29
8	2 x 4	58
8	2 x 4	28
8	2 x 4	16
8	2 x 4	16
6	2 x 4	6
4	2 x 4	8
2	2 x 4	60

7.0 Operation and Maintenance

7.1 Operations

The proposed system is operated by filling the intermediate tank with water, adding the appropriate amount of chlorine, and then drawing water from the intermediate tank. Flow of water through the system is controlled with two valves. One of these valves controls inflow to the 55 gallon drum from the 600 gallon rainwater storage tanks and the other controls outflow from the 55 gallon drum. The outflow valve will be operated by residents who wish to access water from the system. When the intermediate tank needs to be refilled, the inflow valve will be opened until the tank has reached the desired capacity. Prior to drawing water from the intermediate tank, chlorine will be added to the intermediate tank. The exact volume of chlorine to be added per unit of water is specified in the facility design. The chlorine is added to the 55 gallon drum through a secondary inlet valve on the piping connecting the 600 gallon tanks to the 55 gallon tank. This chlorine inlet valve will be capped when not in use to prevent contamination of the intermediate water tank.

Prior to filling the intermediate water tank, the current water level needs to be recorded. Chlorine only needs to be added to treat the newly added water. For example, if the tank was one quarter full of treated water and then completely refilled with untreated rainwater, only three quarters of the total tank volume is untreated water, so the user would only add three quarters of the chlorine necessary to treat a full tank of water. The system will include a water meter which clearly tells the user the current water levels in the tank. The water meter will be labeled in both the ascending and descending directions. For example, if a 55 gallon drum is ten gallons short of full, the water meter will read both 45 gallons and 10 gallons. This will ensure that the user is easily able to identify how much water needs to be treated.

The following procedure for adding bleach to the intermediate tank is recommend to ensure all the bleach poured into the inlet valve makes its way to the tank, and that the bleach is well mixed within the 55 gallon drum. Before adding bleach or untreated water to the intermediate storage tank, about a gallon of water should be drawn from the system and stored in a sealable container, such as a large water bottle, which will serve as a mixing container. Then, the appropriate volume of bleach should be added to the mixing container. The mixing container should then be vigorously shaken to thoroughly mix the bleach with the added water. This bleach solution should now be poured into the chlorine inlet valve. At this point, the tank can now be filled with untreated water from the 600 gallon tank. The turbulence generated within the tank from the incoming water will agitate the tank contents and thoroughly mix the bleach. This process will ensure all the chlorine added is washed into the main storage tank and the bleach is thoroughly mixed in the 55 gallon drum. After bleach is added, water should not be drawn from the tank for another thirty minutes. It is estimated that this process will take five minutes to complete for each tank, resulting in a daily operational time of ten minutes, plus a thirty minute waiting period.

The estimated operational costs for this project only include the cost of chlorine used to treat collected rainwater. It is estimated that the community will draw approximately 66 gallons of water per day from the rainwater storage tanks. Following the recommended dosing plan, this equates to approximately twelve milliliters of bleach per day required to treat collected rainwater. Over the course of 30 days, the community will need 360 milliliters of bleach. Annually, this is just over one gallon of bleach. While bleach prices can vary widely, in the United States, bleach is available for as little as three dollars for 121 fluid ounces at grocery stores. However, assuming bleach costs ten dollars per gallon in the Bocas del Toro region of Panama, this is still well within the financial capabilities of Isla Popa II. The cost of bleach will be verified prior to travelling to ensure the community is able to meet daily operating expenses.

7.2 Maintenance

To promote the longevity of the proposed system, some routine maintenance is required. The two main aspects of maintenance include cleaning the 55 gallon drums and inspecting the piping for leaks.

It is expected that minor damage may occur to the piping of the system. In order to repair a leak in the piping, silicon sealant or other adhesive materials can be used. In order to properly seal the leak, most pipe repair systems require the piping to be dry. Flow through the pipe should be shut off prior to attempting repairs if possible to assure a high quality patch. In the event that a component of the piping is broken beyond the capabilities of silicon sealant and adhesive materials, a replacement part can be purchased at the local hardware store. The chapter is planning on purchasing additional materials that may be useful for maintenance when buying construction supplies. This includes additional parts, sealant, and pipe adhesive, giving community a temporary supply of materials that may be needed to make repairs.

The intermediate storage tanks should be thoroughly cleaned and disinfected four times per year, or if a tank has obviously become contaminated. Sources of obvious contamination include noticeable reduction in water quality, such as increased turbidity. Following the guidelines outlined by the World Health Organization, the tank should be cleaned using the following procedure[4]:

1. The cleaner should wash their hands and put on appropriate protective gear, including a facemask and gloves.
2. Empty the tank until it is at ¼ of its full volume.
3. Use a brush and two liters of concentrated chlorine solution to scrub the interior surfaces of the tank.
4. Allow the concentrated chlorine solution to remain standing in the tank for 24 hours.
5. Empty the tank onto the gravel surrounding the first flush system to limit damage to the environment.
6. Rinse the tank thoroughly prior to continuing use. If possible, check the chlorine residual of the first volume of water added to the tank to ensure chlorine levels are within recommended limits.

The system is expected to require little maintenance. It is estimated that routine maintenance on the system should amount to only 10 hours of labor per year. The expected cost of this routine maintenance is estimated to be 65 dollars per year, primarily spent on sealant for leaks, replacement parts, and bleach for tank cleaning.

[4] WHO (World Health Organization). (1997). *Guidelines for Drinking-Water Quality (Second Edition)*

8.0 Sustainability

8.1 Background

The main target of the team's sustainability initiatives are regular maintenance and preservation of the water catchment and chlorine treatment systems. Working with the community for several years, the team is confident the water board is capable of navigating various issues the system may face over time.

With a chlorination system, a steady supply of chlorine is required. Chlorine is readily available at another island in the region, Isla Colon. Community members travel to Isla Colon about twice a month. With proper planning, enough bleach can be bought during these regular trips to meet their demand for many weeks. As a result, community members are able to obtain supplies necessary for proper system operation without serious deviation from their current daily routines.

Structural maintenance of the constructed infrastructure is another key area for sustainable initiatives .The wood used to construct the tank stands is local nispero wood. Moving forward, the same type of locally-harvested wood will be used as the primary lumber for any required structural repairs. Since the wood is both affordable for the community and has been used by the team in the primary water tank stand construction, it would be the best option for structural maintenance. Furthermore, this local wood species is naturally resistant to rotting which prolongs its service life.

Another primary system sustainability initiative is the prescribed cleaning of the tank system. Since initial construction, the tank system has been emptied and disinfected with chlorine by quarter-yearly according to reports from the community. Tank cleaning was accomplished using a scrubbing brush and a high concentration bleach and water solution. While cleaning, any defects found in the piping and structure can be repaired or fixed. All maintenance tasks have been successfully delegated to [redacted] and [redacted], with [redacted] assisting in technical repairs. In order to ensure smooth operations, those currently responsible will need to be trained operate the new chlorination system.

To promote healthy communication between the team and the community members and to ensure system longevity, the team plans to expand the community water board during the January 2016 Implementation trip. There are currently no women on the water board; women community-wide have taken less of an interest in the project than men and children. Maintaining a dialogue supporting the involvement of a larger portion of the community, especially women, would help ensure long-term longevity of the filtration/chlorination system.

With the implementation of a new chlorine treatment system, routine system maintenance must be expanded to include the valve that controls water flow into the chlorination tank. This component may wear and break with continued use by young children. With proper training from the team, members of the water board will be able to replace a potentially faulty or worn valve. A replacement valve could be obtained from the nearby Isla Colon.

8.2 Organizational Capacity of The Community

On the island, a water board has been established which is made up of three key members: [redacted], [redacted] and [redacted]. In total there are about four to five members. The current number of members is transitory due to the long duration of the project. During the trip in January 2016, the team will expand the water board to include a variety of members, especially more women. The board is in charge of fundraising on behalf of the project and maintaining the current structures. In the future, designated board members will be in charge of dosing the tanks with chlorine, maintaining all tanks, and general operations. Meeting times are closely tied to the church, which meets every Thursday night. Fundraising also occurs at church; the board raised money for implementations in January 2015 at church bingo events. The committee has been heavily involved in the design process, providing feedback after the previous implementation trip and commenting on proposed designs. After the trip in January 2015, the community expressed dislike towards the biosand filters. They felt the biosand filters were slow, not durable, and unable to produce clean water when they wanted it. Additionally, the community was confused as to how the biosand filter was able to treat water. As chlorine treatment is more commonplace in the community and the community members have more of an interest in this method of water disinfection, the team is eager to demonstrate proper chlorine usage to community members. During the previous implementation trip, the community was also heavily involved in building the tank stand and the biosand filters, demonstrating their interest in the project.

8.3 Financial Capacity of The Community

Chlorine is available at a low cost to the community in the form of liquid bleach that can be purchased on Isla Colon. Besides the chlorine, the valve connecting the collection tank and treatment tank, as well as maintenance of the tanks themselves, is able to be sustained by individuals in the community who regularly commute to Isla Colon and are available to acquire parts as the need arises. Wood is readily available on Isla Popa II and can be supplied by the community members.

In order to ensure the costs associated with system maintenance and repair are available when needed, mandatory community collections are in place in conjunction with Church functions. Money gathered in these collections is used towards maintaining and operating the rainwater catchment and treatment system. These collections are specifically targeted towards the parents of the community's children, as the school children are the primary benefactors of this system. Since the majority of community members congregate at church, it is the ideal location and time for collection of funds.

8.4 Technical Capacity of The Community

Chlorine treatment has been chosen as the preferred treatment method since the community already has experience with it. It does not require much technical knowledge or experience to operate or to build. The major concern in operation is dosing with the correct quantity of chlorine. This will be explained in a manual which will be laid out in simple directions and displayed with the tank to ensure proper operation.

The members of the community have ample experience in construction, which they demonstrated to the team during the January 2015 implementation process. Multiple copies of the plans for the tank stands will remain at the community with the water board so that any repairs can be easily performed by its members. Cleaning of the tank is a simple task as well, which can easily be performed by a member of the water board. Again, detailed instructions for tank cleaning procedures will be laid out in a manual left with the community. Since the community also has experience with chlorine treatment, they will be performing a familiar process that needs little instruction. Guidelines will be provided to them that explain the ratio of chlorine solution to water volume, and other specific operation points.

8.5 Education

One of the underlying problems in the community is a lack of understanding of the importance of clean water. In order to show the community the importance of treating collected rainwater, traveling members of the chapter will conduct rapid bacterial tests on water sources throughout the community. These bacterial tests will be compared to a control test of treated water to show community members that the water they are drinking is not as clean as it appears. The goal of these bacterial tests is to show community members that chlorine treatment is necessary in order to improve their water quality, hopefully leading to more community members adopting chlorine treatment.

Ensuring community members understand the proper operation of the proposed system is another important education objective. In order for chlorine treatment to be effective, the proper amount of chlorine needs to be added to the system. Adding too little chlorine makes the treatment ineffective. Adding too much gives the water a strong taste that most people find unpleasant, discouraging chlorine use. It is important the community doses their water supply properly to ensure chlorine treatment is effective and accepted within the community. In order to achieve this objective, charts dictating the amount of chlorine to be added to the tank based on the water added will be attached to the system in a conspicuous location. The operator will then be able to reference this chart when dosing the intermediate tank with chlorine to ensure the proper amount is added.

In the past, the community has expressed their dislike of the taste of chlorine in treated water. To overcome the community’s aversion to the taste of chlorine, the travel team will conduct chlorine taste tests. These tests will be conducted with members of the water board and as many members of the community as possible. The goal of these tests is to show community members what water treated with appropriate levels of bleach tastes like compared to water that is slightly over and under the recommended chlorine levels. Samples of water will be prepared for community members to taste test. Prior to tasting each sample, the community members will be informed of what concentration of chlorine they are drinking: whether it is above the recommended limit, below that limit, or just right. The chapter will not add levels of bleach to these samples that will be harmful for consumption. According to the EPA, it is safe to add double the recommended amount of bleach to untreated water[5]. The chapter will only be adding one and one half times the recommended volume of bleach to the taste sample to ensure no harm in consumption.

To ensure the operational lifespan of the system, water board members will be educated in the proper maintenance of the system. This will be achieved through participation in the construction of the system and through training once the system is complete. The water board will also be given a manual that describes routine maintenance procedures, such as tank cleaning, and how to go about repairing aspects of the system that may break, such as piping connections.

Another major effort that must be undertaken is the expansion of the water board. At times in the past the water board has been ineffective. Some members often stop participating or move away without finding a replacement. Whether a result of this or through direct action, responsibility for the system has fallen to those that are most invested in the system, including Ambrosio, Daniel, and Ramon. The small size of the water board limits their capabilities and influence in the community as a group dedicated to improving water quality and supply.

Another issue with the water board is a lack of comprehensive involvement of the whole community. Currently, the water board is primarily male due to a tendency among the community to separate by gender. A goal of this implementation trip is to improve the stability of the water board by recruiting women to improve the board's gender diversity. This will be a priority during the trip, as a more stable, comprehensive water board will make the project more sustainable.

9.0 Site Assessment Activities

No site assessment activities are planned for this trip.

10.0 Professional Mentor Assessment

10.1 Professional Mentor Name and Role

10.1.1 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.

In cooperation with the community, the chapter has developed a feasible plan to dose chlorine to the collected rainwater. Chlorine disinfection is a logical next step for the community. System operation is straightforward, and the chapter has put substantial emphasis on education and

[5] EPA. *Emergency Disinfection of Drinking Water*. 24 June 205.

knowledge transfer. The likelihood of successfully implementing a long-term system seems high.

10.1.2 Professional Mentor Affirmation

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

10.2 Professional Mentor Name and Role

Professional Mentor

10.2.1 Professional Mentor Assessment

I have thoroughly reviewed all of the foregoing plans contained within this 525 document. I believe the proposed plans represent a feasible method of improving the safety and quality of the community's current water supply system. I do not find any major flaws in design, nor errors in calculation that would prevent implementation of the system as proposed. Implementation of this plan should achieve the objective of providing a system of clean drinking water on demand that can be readily maintained by the community. I am particularly satisfied with the emphasis on education and outreach to the greater community to engender support and understanding about the importance of sanitary drinking water. I have also reviewed all of the appendices as well as the 600 HASP document and find all of these plans and protocols to be sound.

10.2.2 Professional Mentor Affirmation

I [redacted], have been involved throughout the design phase of this project as a professional mentor. I am satisfied with the progress made and the path by which the project goals are to be met.

10.3 Professional Mentor Name and Role

Professional Mentor

10.3.1 Professional Mentor Assessment

I have thoroughly reviewed all of the foregoing plans contained within this 525 document. I believe the proposed work will significantly improve the safety and quality of the Sandubidi community's water supply.

I do not find any major flaws in design, and I have carefully supervised the calculations (in particular chlorine dosing) of the system as proposed.

Implementation of this plan should achieve a system of clean drinking water, on demand, that can be readily operated and maintained by the community.

I am particularly pleased with the education and outreach program, which is essential to the long term success of the project.

I have also reviewed the appendices as well as the 600 HASP document and find all of these plans and protocols to be sound.

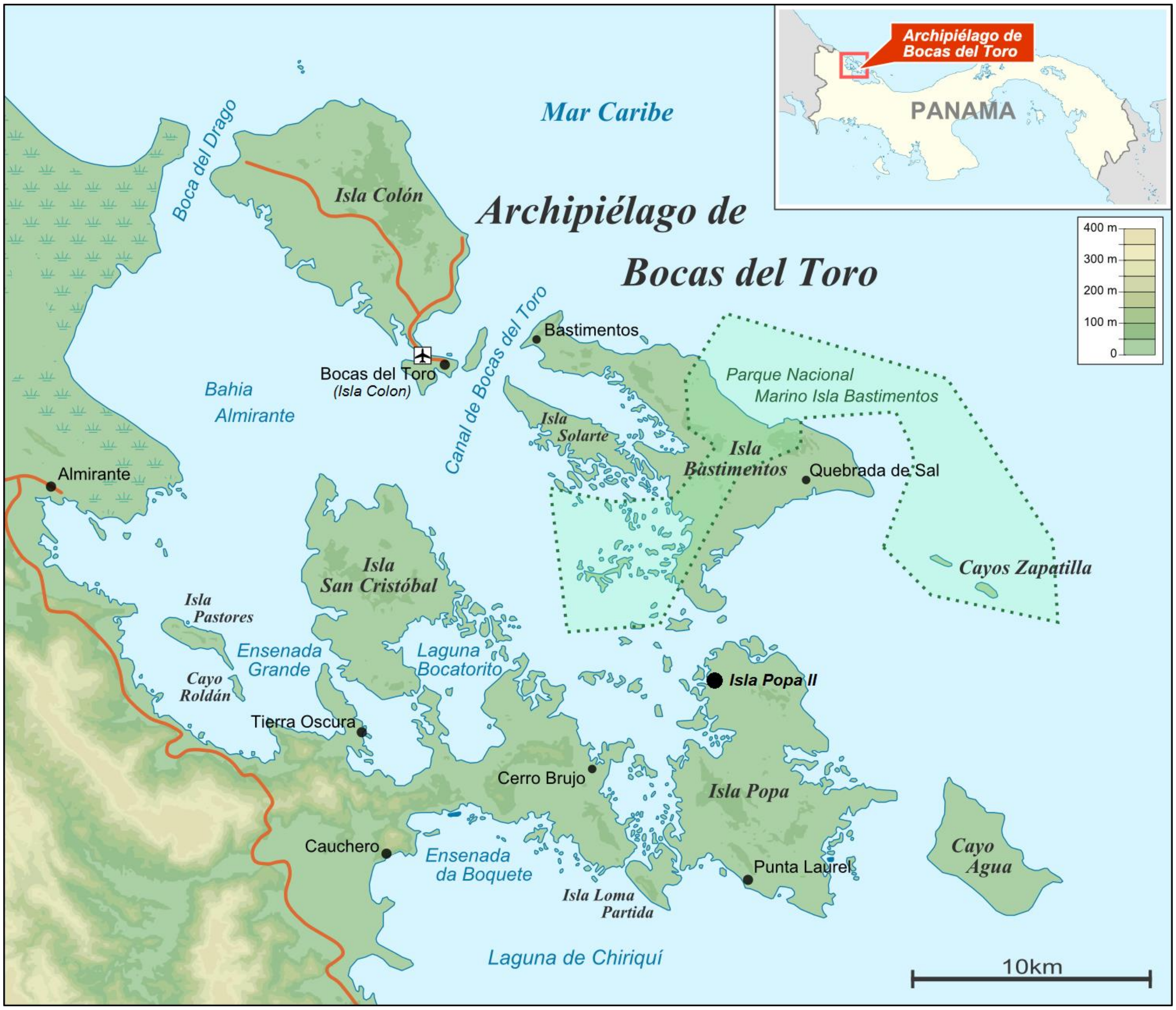
10.3.2 Professional Mentor Affirmation

I, [redacted], have been involved throughout the design phase of this project as a professional mentor. I am satisfied with the progress made and that the scope of work will meet project goals.

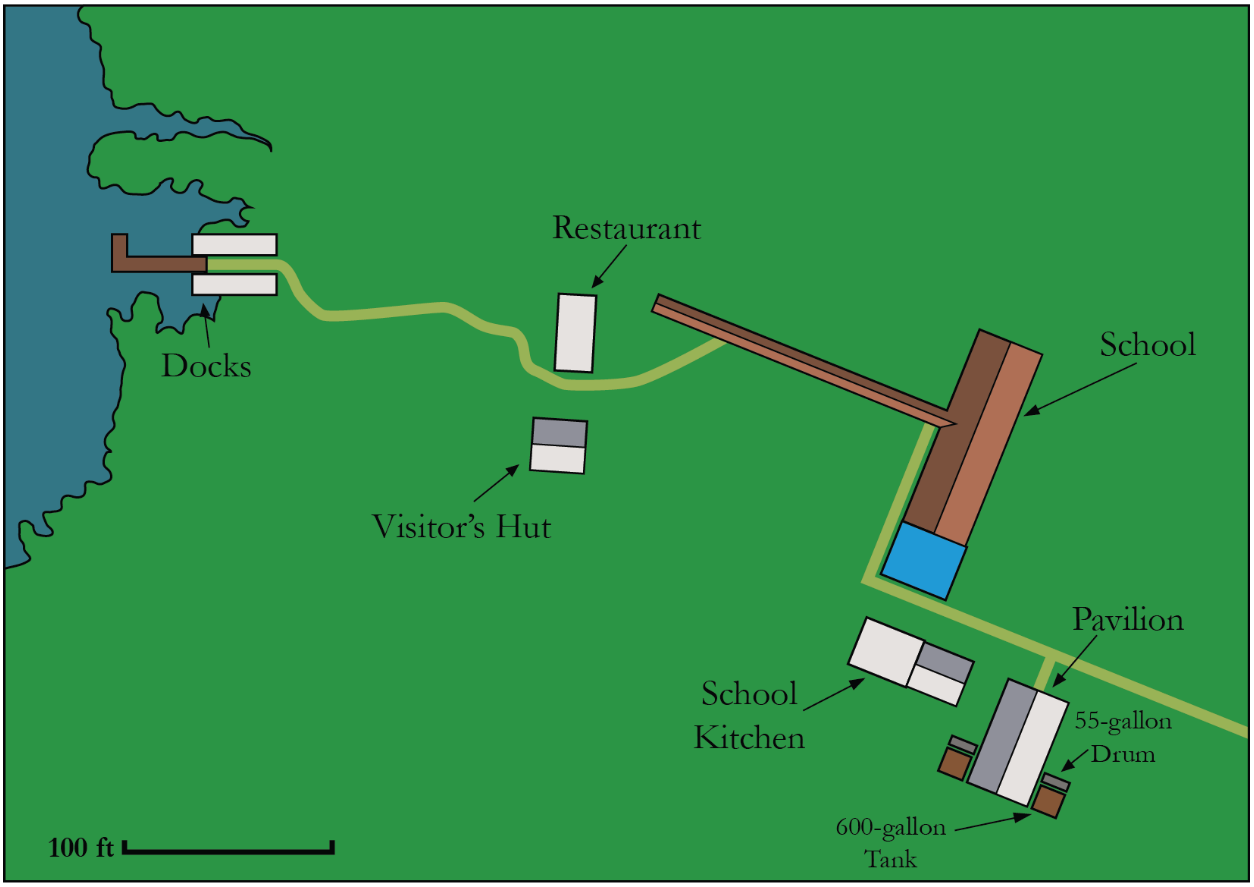
APPENDICES

Appendix A: Site Map and Photos

A.1 Region Map



A.2 Site Map


Restaurant
School
Docks
Visitor's Hut
Pavilion
School
Kitchen
55-gallon
Drum
600-gallon
Tank
100 ft

A.3 Site Photos

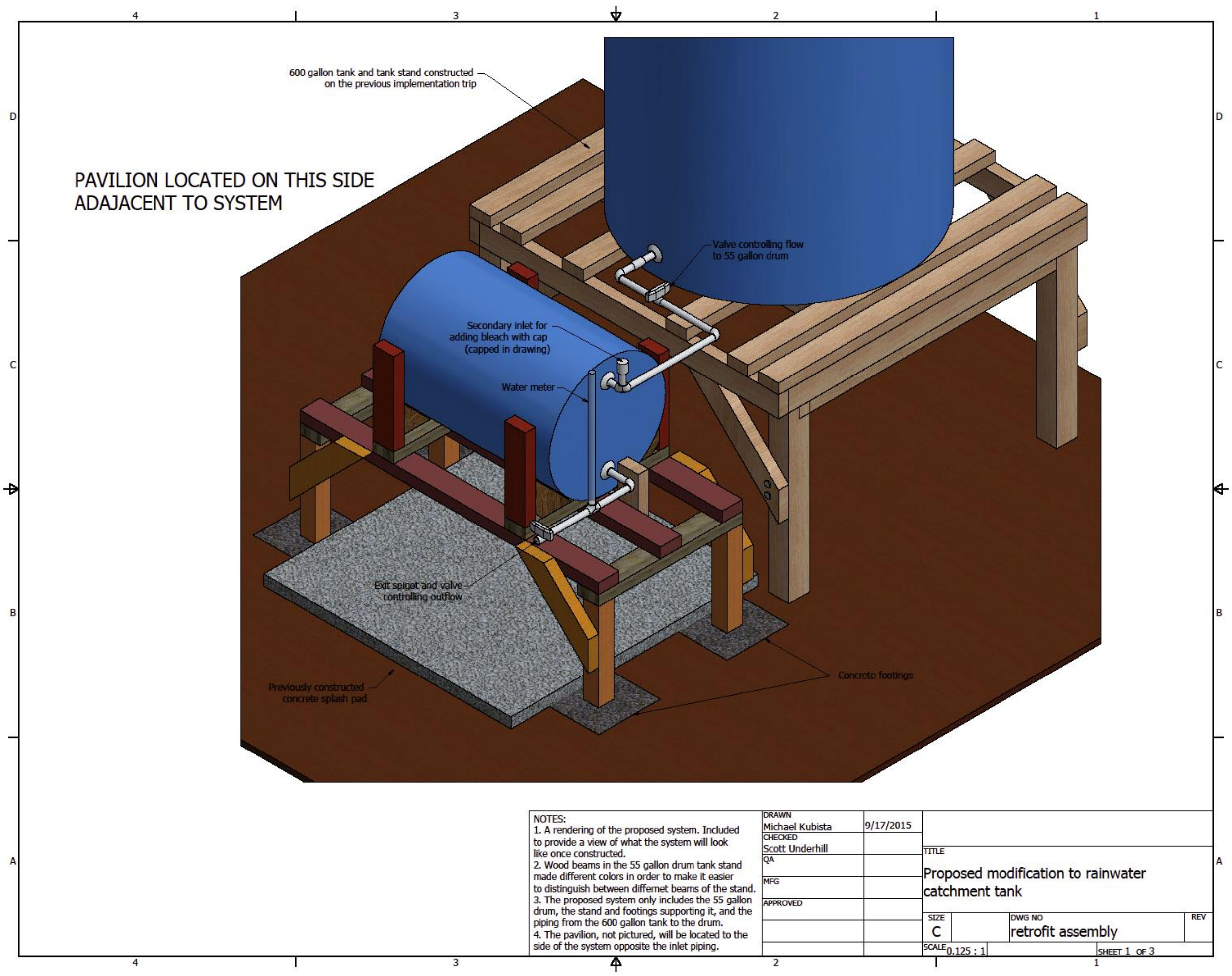
A side view of the previously implemented system. The proposed system will be installed in front of this tank stand (to the right of the stand pictured). The pavilion is in the background.

The proposed system will be located in front of the tank stand pictured; specifically, directly above the concrete splash pad.

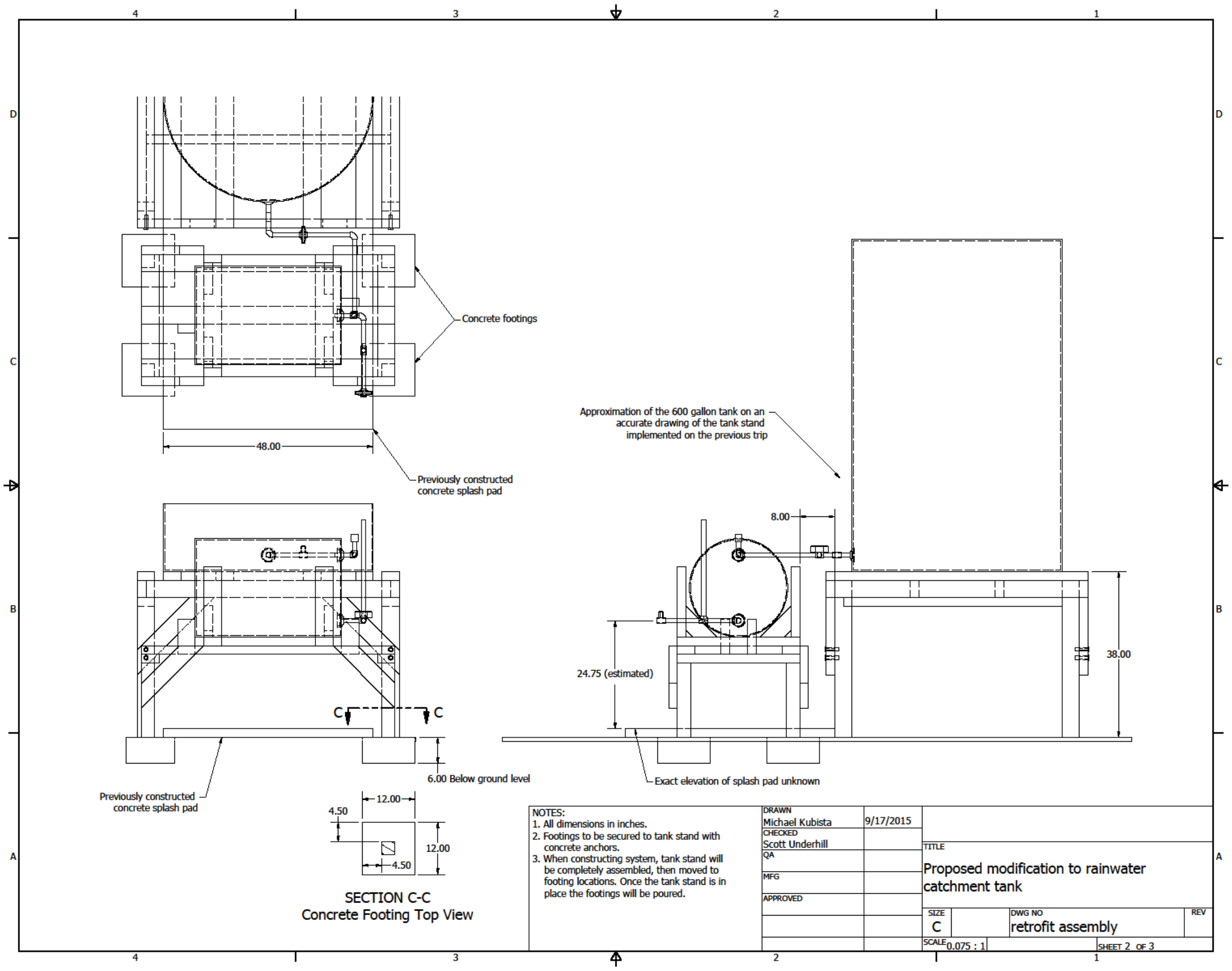
APPENDIX B: Proposed System Design Drawings

Note: Appendix B attached as separate document to facilitate reviewing.

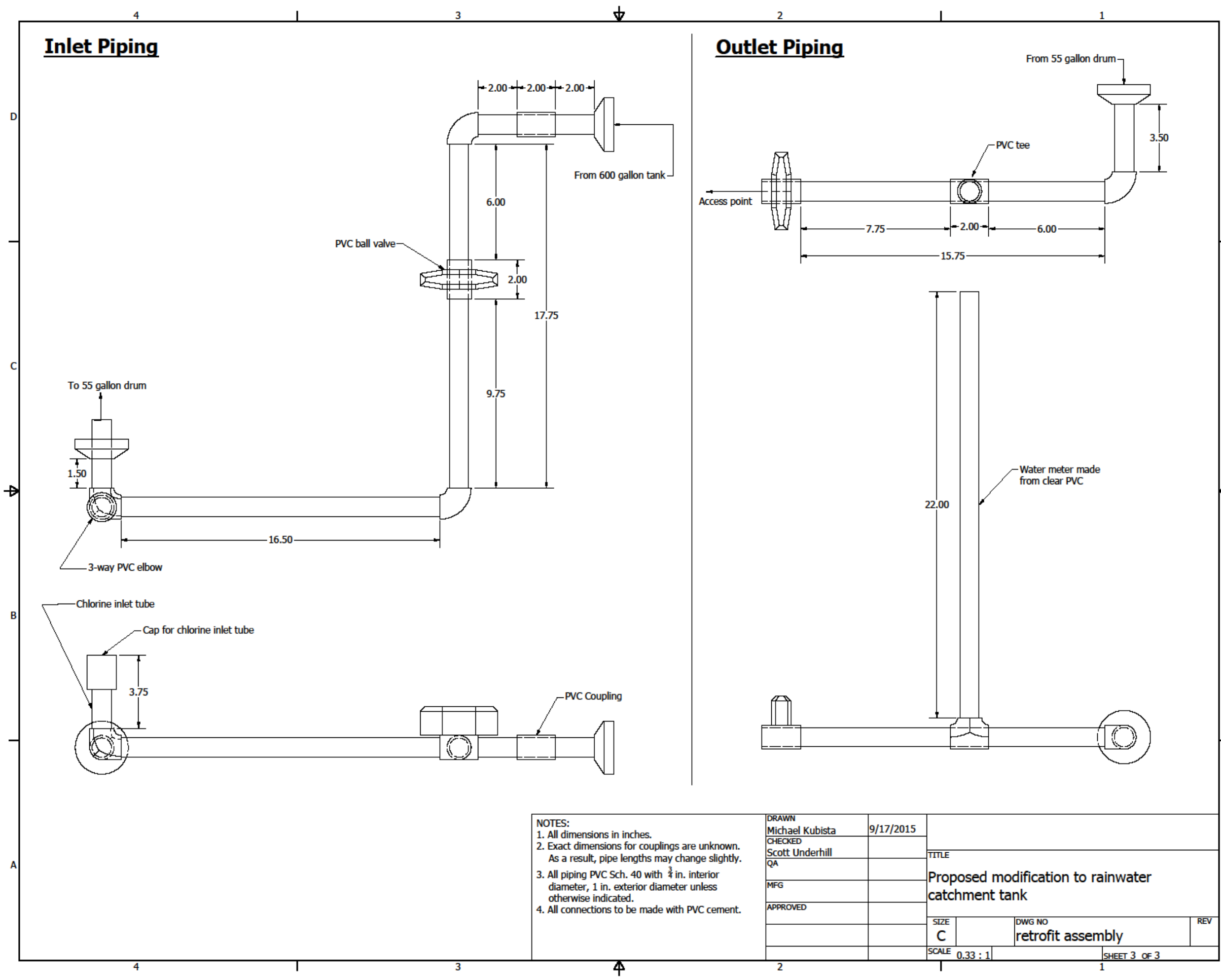
B.1 Proposed system design rendering



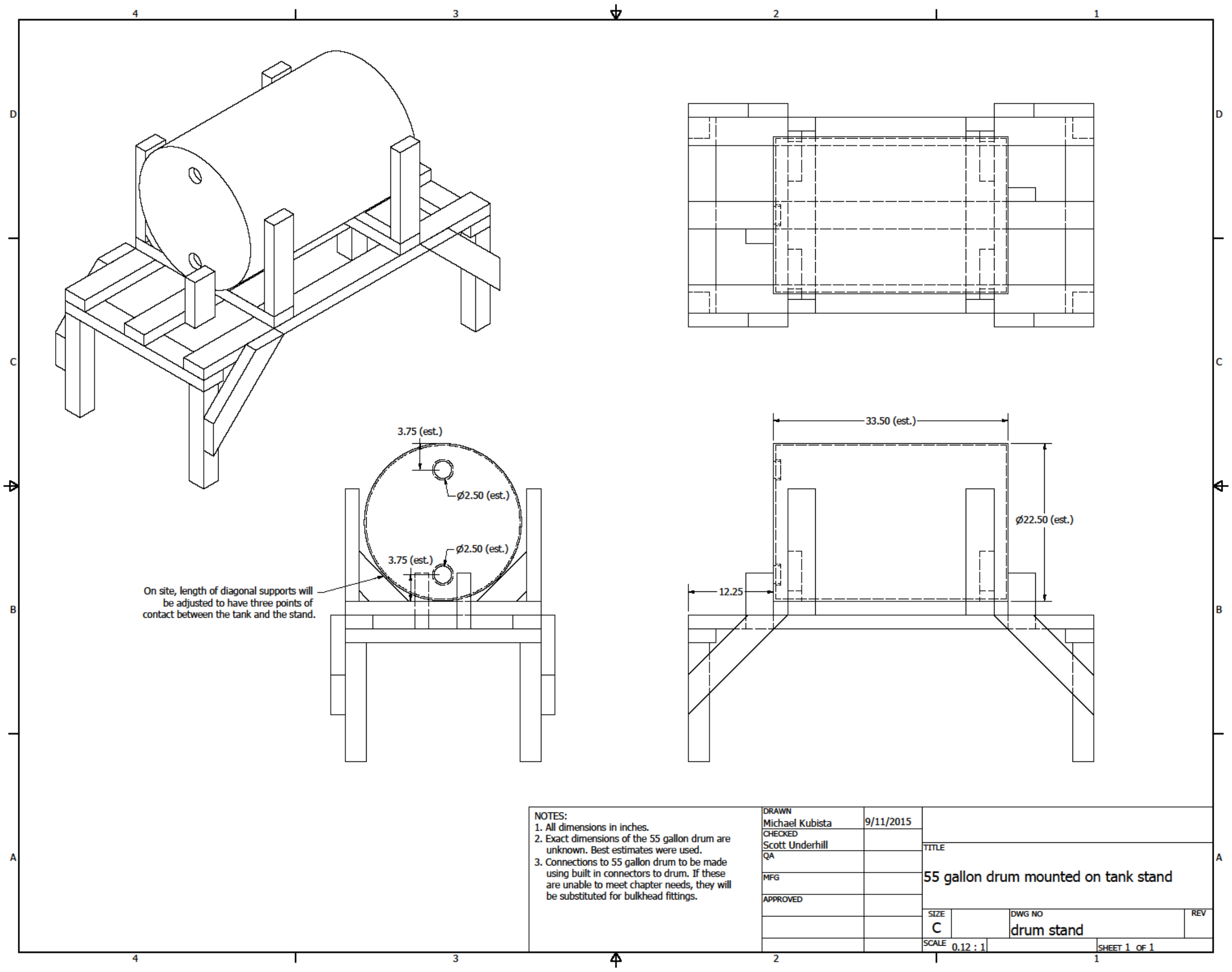
B.2 Proposed system design



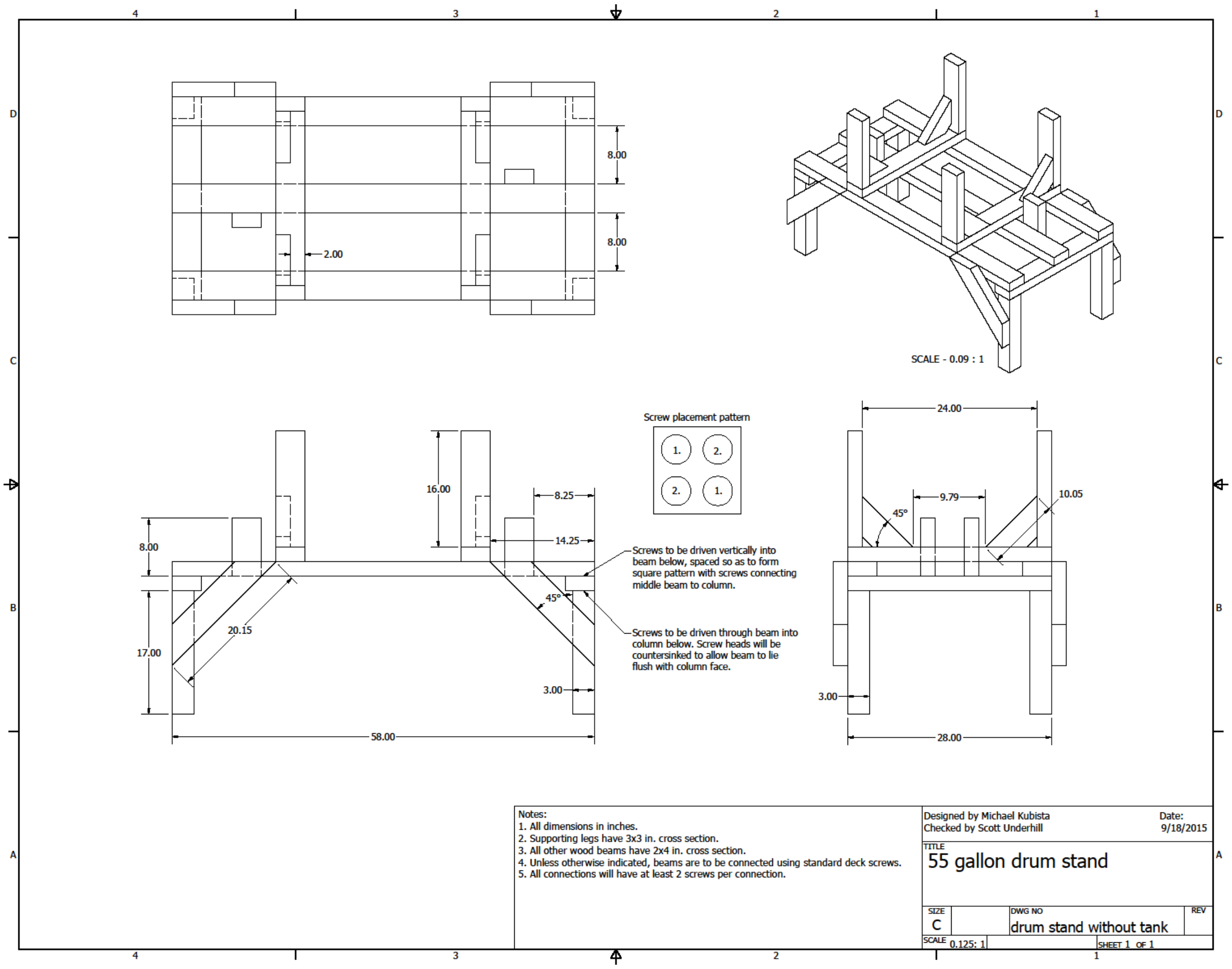
B.3 Proposed piping assembly



B.4 Proposed 55 gallon drum stand assembly



B.5 Proposed 55 gallon drum stand dimensions



APPENDIX C: Strength Calculations

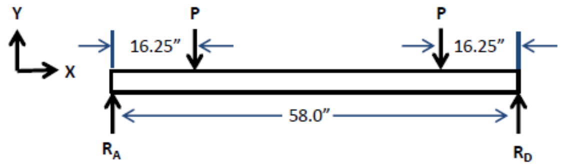
C.1: Material Properties of Wood

Property	Condition	Number of samples tested	Metric (Mpa)
Tensile Modulus	dry	2	11856.34
	wet	1	11894.09
Ultimate Tensile Stress	dry	2	43.04
	wet	1	2.61
Flexural Modulus	dry	1	3.10
	wet	1	1.30
Ultimate Flexure Stress	dry	1	4.17
	wet	1	6.17
Compressive Modulus	dry	1	4082.28
	wet	1	1555.22

C.2 Stuctural Integrity Calculations

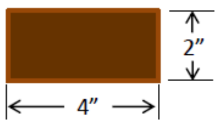
Stress of Supporting Decking

Free body diagram of longitudinal beam



$\sigma_M = bending\ stress$
$M = maximum\ bending\ moment$
$c = distance\ from\ neutral\ axis$
$I = second\ moment\ of\ inertia$
$P_{total} = total\ load$

Beam cross section



$$\sigma_M = \frac{Mc}{I} \qquad I = \frac{1}{12}bh^3$$

Total load is 55 gallons of water, supported by two transverse beams. The two transverse beams are supported by three longitudinal beams. See design drawings for further detail.

$$P_{total} = 460\ lbs\ of\ water$$

$$P = \frac{P_{total} \cdot 1.3\ (factor\ of\ safety)}{(3\ long.beams) \cdot (2\ trans.beams)}$$

$$P \cong 100\ lbs$$

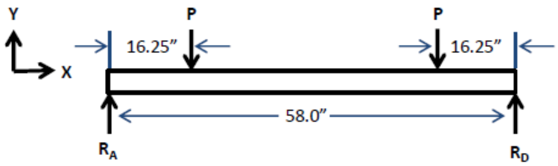
$$M = 1625\ lb \cdot in \qquad \sigma_M = \frac{12Mc}{bh^3} \qquad \boxed{\sigma_M = 609.4\ psi} \qquad \sigma_{ultimate} \approx 3121\ psi$$

$$c = 1\ in$$

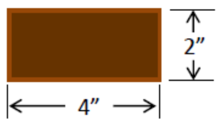
The ultimate stress for Nispero wood is estimated to be 3121 psi. Prior test results show the ultimate tensile strength of Nispero wood to be 6242 psi when dry and 378.5 psi when saturated with water. This exponential drop in strength is most likely a result of error, as only one sample was tested while saturated.

Deflection of Supporting Decking

Free body diagram of longitudinal beam



Beam cross section



The maximum deflection of the longitudinal supporting decking is calculated using singularity functions and the equation of the elastic curve.

Panamanian building code for light wood framing structures:

$$Maximum\ allowable\ deflection = \frac{L}{240}$$

$$E = 1.7 \times 10^6\ psi$$

$$L = 58\ in$$

$$I = \frac{1}{12} bh^3$$

$$Equation\ of\ the\ elastic\ curve:\ \frac{d^2y}{dx^2} = \frac{M(x)}{EI}$$

$$From\ free\ body\ diagram, the\ following\ moment\ singularity\ function\ is\ derived:$$

$$M(x) = (100lbs)x\ - (100lbs) < x - 16.25" >^1\ - (100lbs) < x - 41.75" >^1$$

By solving the above differential equation for deflection in terms of displacement [$y(x)$], the maximum deflection of the beam can be calculated.

$$Max.\ displacement\ occurs\ at\ midpoint\ of\ beam: x = 29\ in$$

$$\boxed{y(29\ in.) = 0.135\ in}$$

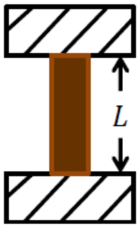
$$y_{allowable} = 0.242\ in$$

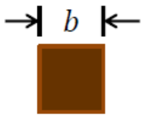
Maximum deflection of the decking is less than the maximum allowable deflection.

Column Buckling

Euler Buckling Formula: $P = \frac{\pi^2 EI}{(L_e)^2}$

$P = load\ on\ column$
$E = elastic\ modulus$
$I = second\ moment\ of\ inertia$
$L_e = effective\ length$
$L = length\ of\ column$
$b = side\ length\ of\ square\ column\ cross\ section$





$assume\ ends\ of\ column\ are\ fixed,\ therefore:\ L_e = 0.5\,L$

Total load: $55\ gal.water \cong 460\ lbs\ (assuming\ denisty\ of\ 8.36\ lbs\ per\ gallon)$

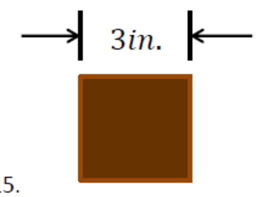
$4500\ in^3 of\ structural\ wood \cong 222\ lbs\ (assuming\ density\ of\ 84.5^{*} lbs/ft^3)$ (1)

*Density of Black Ironwood lumber used as approximation, density of Nispero lumber unknown.

$I = \frac{b^4}{12}$ $\quad b = \left(\frac{3PL^2}{\pi^2 E}\right)^{1/4}$

$E = 1.7 \times 10^6\ psi$
$L = 17\ in$
$P = \frac{(222\ lbs + 460\ lbs) \cdot 1.3\ (factor\ of\ safety)}{4\ (number\ of\ legs)}$
$P = 221.75\ lbs$

$\boxed{b = 0.0115\ in}$



The proposed design calls for supporting columns with a 3in. x 3in. cross section. This is significantly larger than the minimum allowable dimension of 0.0115 in. calculated above.

(1) Meier, Eric. *Top Ten Heaviest Woods.* The Wood Database. 2015. Retrieved 13 Sept. 2015.

Appendix D: Chlorine Dosing Calculations

1) Objective

Calculate the amount of chlorine required from household bleach required to provide a residual chlorine level of 0.5 mg/L

2) References

The World Health Organization recommends the residual chlorine should be around 0.5mg/l. The organization states that adding 2.5 mg/l of free chlorine will give this residual chlorine level[6]. The following calculations and materials properties are referenced from "OxyChem Sodium Hypochlorite Handbook" by OxyChem[6].

3) Formulas

Start – Normal household bleach has sodium hypochlorite concentrations typically ranging from 5.25% or 8.25%. Sodium hypochlorite is the active ingredient of bleach.
Goal – Determine the appropriate volume of bleach to add to a 55 gallon tank to treat the water to make it safe for drinking.

Contents of Household Bleach:

- Household bleach's main ingredient is sodium hypochlorite (5.25% or 8.25% by weight), which is molar equivalent to free chlorine, as both free chlorine and sodium hypochlorite have the same oxidizing power[7]. Therefore, every mole of NaOCl present is equal to one mole of Cl_2.
- 0.4 to 4.0 grams per liter of NaOH is added for stability[6].

a. Starting with a weight concentration of 5.25 g NaOCl per 100 g of household bleach.
b. Levels of sodium hypochlorite are molar equivalent to the levels of free chlorine (Cl_2) in a solution. The molar mass ratio between NaOCl and free chlorine (Cl_2) is 1.05, calculated by dividing the molar mass of sodium hypochlorite by the molar mass of free chlorine.
c. The weight concentration of free chlorine can be calculated by dividing the weight concentration of sodium hypochlorite by the molar mass ratio. This gives a weight concentration of free chlorine (Cl_2) of 5.00 g per 100 g of household bleach.
d. The mass of equivalent free chlorine per liter of household bleach can then be determined by multiplying the weight concentration of free chlorine with the density of household bleach. For a 5.25% concentration bleach, the specific gravity is approximately 1.082[6]. This results in 53.8 g of free chlorine per liter of household bleach.
e. Convert this to mg/L by multiplying by 1000mg/g and get 53,800 mg/L

---

[6] Bob Reed. "Measuring Chlorine Levels in Water Supplies". *World Health Organization*. 2011.
[7] "Sodium Hypochlorite Handbook". *Occidental Chemical Corporation.* December 2014.

f. Starting with a 55 gallon tank, convert to liters with the value of 3.7684 L/G.
g. Multiply this number by 2.5 mg/L to obtain the desired amount of chlorine for the tank, which is 520.5 mg.
h. Divide this by the concentration of free chlorine in a liter of household bleach, to get the appropriate volume of bleach.
i. Multiply by 1000 to convert to ml.

4) Calculations

a. Start with a weight concentration of 5.25 g NaOCl per 100 g of bleach.
b. Levels of sodium hypochlorite are molar equivalent to the levels of free chlorine (Cl_2) in a solution. Calculate the molar mass ratio.

$$molar\ mass\ ratio = \frac{molar\ mass\ NaOCl}{molar\ mass\ Cl_2} = \frac{74.5\ g/mol}{71.0\ g/mol} = 1.05\ \frac{g\ NaOCl}{g\ Cl_2}$$

c. Calculate the weight concentration of free chlorine from the weight concentration of NaOCl using the molar mass ratio.

$$\frac{5.25\ wt\%\ NaOCl}{1.05\ \left(\frac{g\ NaOCl}{g\ Cl_2}\right)} = 5.00\ wt\%\ Cl_2$$

d. Determine the mass of free chlorine per liter of bleach. For 5.25% concentration bleach, the specific gravity is approximately 1.082. Density of water is 8.34 lb/gal.

$$density\ of\ bleach \cong density\ of\ water = \frac{453.6\ \ g/lb * 8.34\ lb/gallon}{3.7854\ L/gal * 100\%} = 10g/L$$

$$available\ Cl_2\ =\ 5.00\ wt\%\ Cl_2 * (10g/L * 1.082) = 54.1\ g/L$$

e. Convert this number to mg/L.

$$\frac{54.1g}{1L} * \frac{1{,}000mg}{1g} = \frac{54{,}100\ mg}{1L}$$

f. Using the volume of a 55 gallon tank, convert this number to L with value of 3.7684 L/Gal.

$$55G * \frac{3.7684L}{1Gal} = 208.2\ L$$

g. Obtain desired amount of chlorine for 208.2 L using recommended value of 2.5mg/L.

$$208.2L * \frac{2.5mg}{L} = 520.5mg$$

h. Divide the above by the concentration of chlorine in a liter of bleach to obtain the desired amount of L of bleach.

$$\frac{520.5mg}{\left(\frac{54{,}100\ mg}{1L}\right)} = 520.5mg * \frac{1L}{54{,}100mg} = 0.00962L$$

i. Convert this to milliliters.

$$0.00962L * \frac{1000ml}{1L} = 9.62ml$$

5) Results

For a 55 Gallon tank, 9.67ml of household bleach with a 5.25% Sodium Hypochlorite solution should be added to the 55 gallons of stored water to achieve a residual free chlorine level of 0.5g/L. The charts below outline the recommended dosage procedures for adding bleach to water for successful treatment.

Recommended Addition of 5.25% Bleach (mL) to Water (Gallons)											
Gallons	ml		Gallons	ml		Gallons	ml		Gallons	ml
1	0.18		16	2.81		31	5.45		46	8.09
2	0.35		17	2.99		32	5.63		47	8.26
3	0.53		18	3.16		33	5.80		48	8.44
4	0.70		19	3.34		34	5.98		49	8.62
5	0.88		20	3.52		35	6.15		50	8.79
6	1.05		21	3.69		36	6.33		51	8.97
7	1.23		22	3.87		37	6.51		52	9.14
8	1.41		23	4.04		38	6.68		53	9.32
9	1.58		24	4.22		39	6.86		54	9.49
10	1.76		25	4.40		40	7.03		55	9.67
11	1.93		26	4.57		41	7.21			
12	2.11		27	4.75		42	7.38			
13	2.29		28	4.92		43	7.56			
14	2.46		29	5.10		44	7.74			
15	2.64		30	5.27		45	7.91			

Recommended Addition of 5.25% Bleach (mL) to Water (Liters)							
Liters	ml		Liters	ml		Liters	ml
5	0.23		80	3.72		155	7.20
10	0.46		85	3.95		160	7.43
15	0.70		90	4.18		165	7.67
20	0.93		95	4.41		170	7.90
25	1.16		100	4.65		175	8.13
30	1.39		105	4.88		180	8.36
35	1.63		110	5.11		185	8.60
40	1.86		115	5.34		190	8.83
45	2.09		120	5.58		195	9.06
50	2.32		125	5.81		200	9.29
55	2.56		130	6.04		205	9.53
60	2.79		135	6.27		208.1	9.67
65	3.02		140	6.51			
70	3.25		145	6.74			
75	3.49		150	6.97			

The above calculations can be repeated for 8.25% concentration sodium hypochlorite bleach, another common variety of bleach. Bleach with this concentration has a specific gravity of approximately 1.12[8]. Following the same procedure, the below charts highlight the recommended dosage amounts for 8.25% bleach.

[8] "Sodium Hypochlorite Handbook". *Occidental Chemical Corporation.* December 2014.

Recommended Addition of 8.25% Bleach (mL) to Water (Gallons)										
Gallons	ml		Gallons	ml		Gallons	ml		Gallons	ml
1	0.11		16	1.72		31	3.33		46	4.95
2	0.22		17	1.83		32	3.44		47	5.05
3	0.32		18	1.94		33	3.55		48	5.16
4	0.43		19	2.04		34	3.66		49	5.27
5	0.54		20	2.15		35	3.76		50	5.38
6	0.65		21	2.26		36	3.87		51	5.48
7	0.75		22	2.37		37	3.98		52	5.59
8	0.86		23	2.47		38	4.09		53	5.70
9	0.97		24	2.58		39	4.19		54	5.81
10	1.08		25	2.69		40	4.30		55	5.91
11	1.18		26	2.80		41	4.41			
12	1.29		27	2.90		42	4.52			
13	1.40		28	3.01		43	4.62			
14	1.51		29	3.12		44	4.73			
15	1.61		30	3.23		45	4.84			

Recommended Addition of 8.25% Bleach (mL) to Water (Gallons)							
Liters	ml		Liters	ml		Liters	ml
5	0.14		80	2.27		155	4.40
10	0.28		85	2.41		160	4.54
15	0.43		90	2.56		165	4.69
20	0.57		95	2.70		170	4.83
25	0.71		100	2.84		175	4.97
30	0.85		105	2.98		180	5.11
35	0.99		110	3.12		185	5.25
40	1.14		115	3.27		190	5.40
45	1.28		120	3.41		195	5.54
50	1.42		125	3.55		200	5.68
55	1.56		130	3.69		205	5.82
60	1.70		135	3.83		208.1	5.91
65	1.85		140	3.98			
70	1.99		145	4.12			
75	2.13		150	4.26			

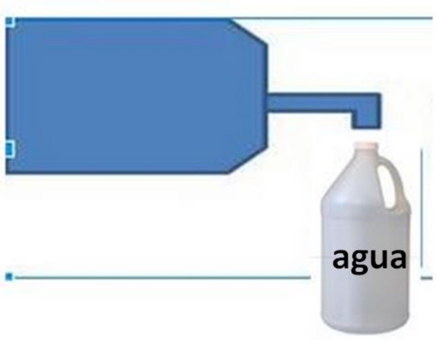
APPENDIX E: Operations and Maintenance Manuals

E.1 Operations Manual

Chlorinating Your Water on an Empty Tank

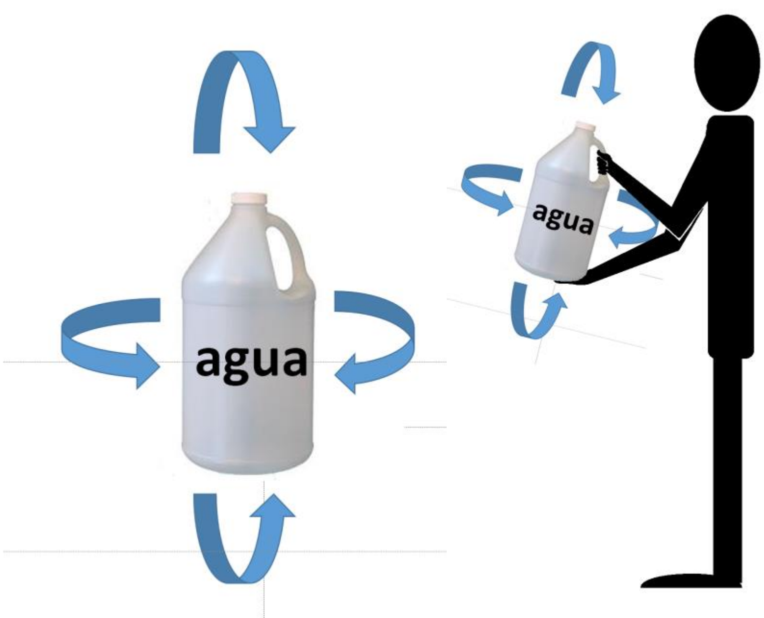
1. ***Fill a graduated cylinder up to 9 ml***

2. ***Fill mixing container halfway with water from the 55-gallon tank***



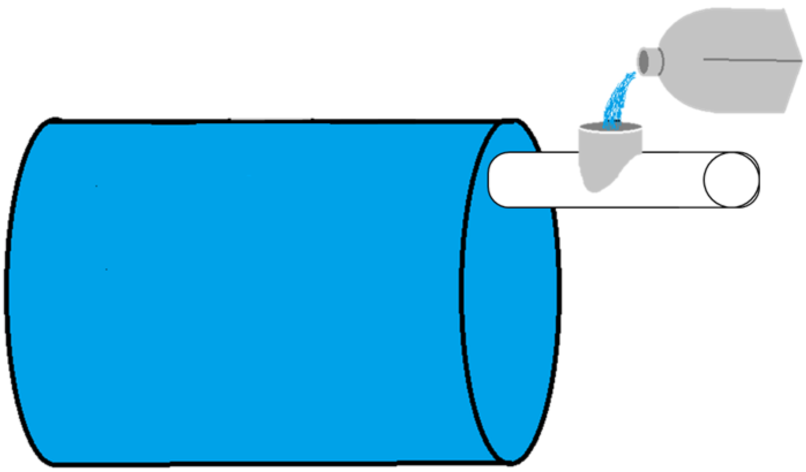
3. Add chlorine from the graduated cylinder to the mixing container

4. Stir or mix the container for about one minute



60 seconds

7. Pour the container back into the 55-gallon drum through the valve



8. <u>Wait 30 minutes</u> after adding the container before drawing water from the 55-gallon drum

Chlorinating your water when the tank is partially empty

1. Record the current volume of water in the tank.
2. Calculate the volume of water to be added by subtracting the present volume of water from the total volume of the tank, 55 gallons.
3. From the table below, determine how many milliliters of bleach need to be added to treat the volume of added water using the graduated cylinder.
4. Fill mixing container halfway with water from the 55-gallon tank.
5. Add chlorine from the graduated cylinder to the mixing container.
6. Stir or mix the container for about one minute.
7. Pour the container back into the 55-gallon drum through the valve.
8. Wait 30 minutes after adding the container before drawing water from the 55-gallon drum.

Recommended Addition of 5.25% Bleach (mL) to Water (Gallons)										
Gallons	ml		Gallons	ml		Gallons	ml		Gallons	ml
1	0.18		16	2.81		31	5.45		46	8.09
2	0.35		17	2.99		32	5.63		47	8.26
3	0.53		18	3.16		33	5.80		48	8.44
4	0.70		19	3.34		34	5.98		49	8.62
5	0.88		20	3.52		35	6.15		50	8.79
6	1.05		21	3.69		36	6.33		51	8.97
7	1.23		22	3.87		37	6.51		52	9.14
8	1.41		23	4.04		38	6.68		53	9.32
9	1.58		24	4.22		39	6.86		54	9.49
10	1.76		25	4.40		40	7.03		55	9.67
11	1.93		26	4.57		41	7.21			
12	2.11		27	4.75		42	7.38			
13	2.29		28	4.92		43	7.56			
14	2.46		29	5.10		44	7.74			
15	2.64		30	5.27		45	7.91			

E.2 Maintenance Manual

Maintenance

To promote the longevity of your system, some routine maintenance is required. The two main aspects of maintenance include cleaning the 55 gallon drums and inspecting the piping for leaks.

It is expected that minor damage may occur to the piping of the system. In order to repair a leak in the piping, silicon sealant or other adhesive materials can be used. In order to properly seal the leak, most pipe repair systems require the piping to be dry. Flow through the pipe should be shut off prior to attempting repairs if possible to assure a high quality patch. In the event that a component of the piping is broken beyond the capabilities of silicon sealant and adhesive materials, a replacement part can be purchased at the local hardware store.

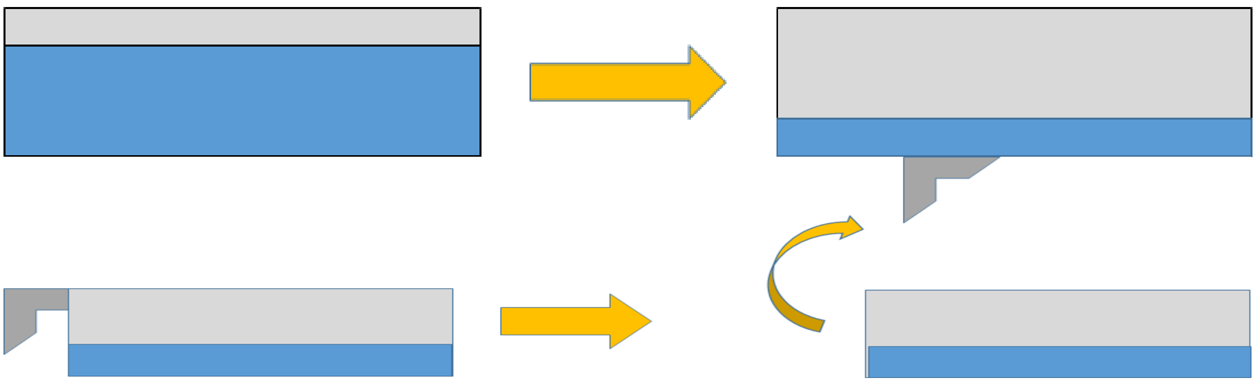
The intermediate storage tanks should be thoroughly cleaned and disinfected four times per year, or if a tank has obviously become contaminated. Sources of obvious contamination include noticeable reduction in water quality, such as increased turbidity. Following the guidelines outlined by the World Health Organization, the tank should be cleaned using the following procedure:

The system is expected to require little maintenance. It is estimated that routine maintenance on the system should amount to only ten hours of labor per year. The expected cost of this routine maintenance is estimated to be sixty-five dollars per year, primarily spent on sealant for leaks, replacement parts, and bleach for tank cleaning.

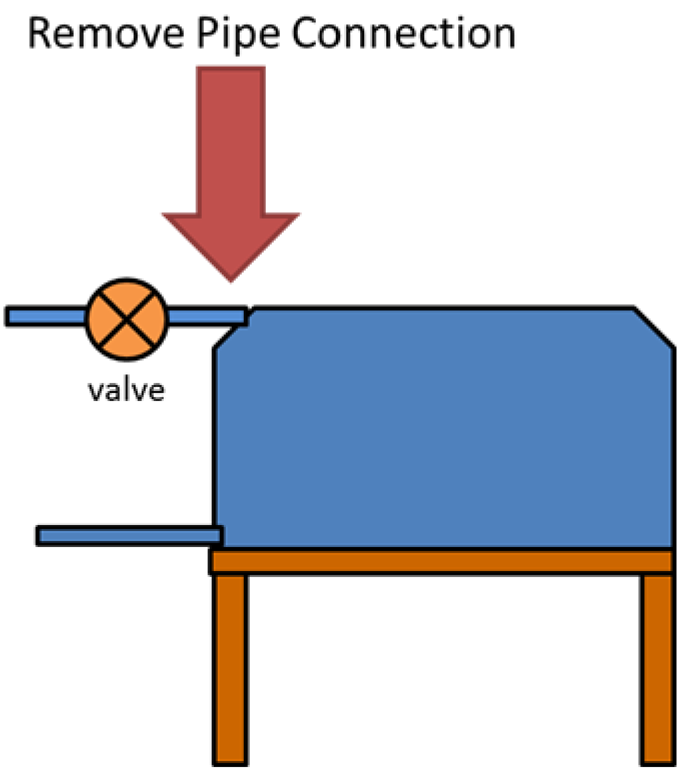
Steps to Clean the Drums

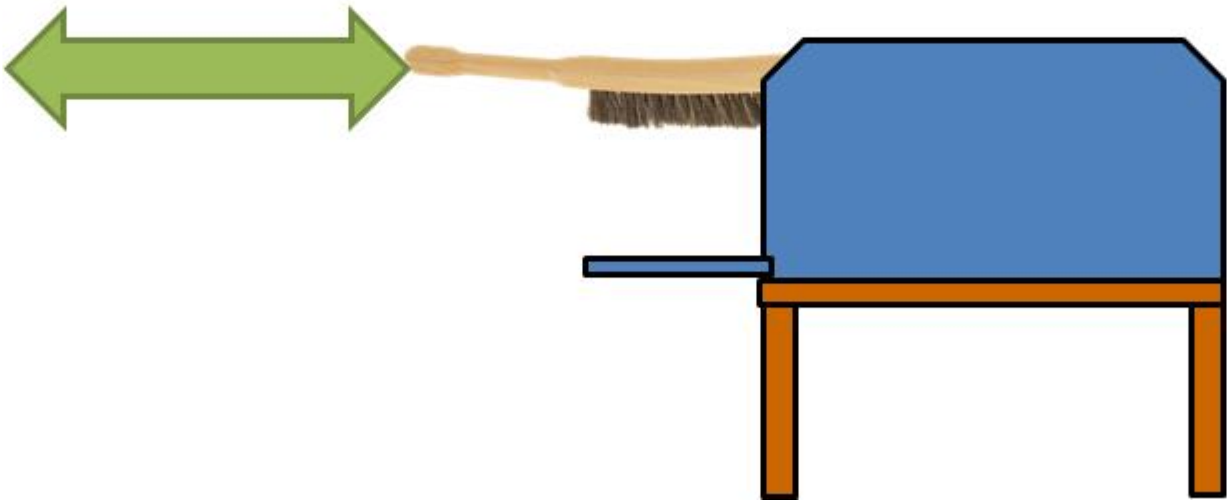
1. **The cleaner should wash their hands and put on appropriate protective gear, including a facemask and gloves.**

2. Empty the tank until it is at ¼ of its full volume. For the 55-gallon tank remove the intake pipe.



3. Use a brush and 2 liters of concentrated chlorine solution to scrub the interior surfaces of the tank. For the 55-gallon tank, scrub and pour the chlorine through the intake hole.





4. Allow the concentrated chlorine solution to remain standing in the tank for 24 hours.

5. Empty the tank onto the gravel surrounding the first flush system to limit damage to the environment.

6. Rinse the tank thoroughly prior to continuing use. If possible, check the chlorine residual of the first volume of water added to the tank to ensure chlorine levels are within recommended limits.

7. For the 55- gallon tank reinsert the intake pipe.

Using DPD strips to determine free chlorine levels

Free chlorine levels of treated water stored in the 55 gallon drum should be tested every month, or whenever the taste of stored water undergoes a noticeable change.

1. Using a cup-size sample, immerse strip in water for 2 seconds.

2. Remove the strip with the pad face up. DO NOT SHAKE OFF EXCESS WATER.

3. With pad still facing up, read immediately by comparing color of pad to color indicators on container. Residual chlorine levels should be at or near 0.5 g/L, or 0.5 ppm

4. Discard strip after use.

Appendix F: 903 Implementation Agreement

EWB-USA projects are most successful when there is a three-way partnership between each of the entities listed below. Each partner has specific skills and expertise, which together, contribute to a more sustainable project over the long-term.

- **Community** - Community Water Board
  - Headed by [redacted], President of the Community
- **EWB-USA Chapter:** Rensselaer Polytechnic Institute Student Chapter

This contract is between Rensselaer Polytechnic Institute chapter of Engineers Without Borders, USA, and Isla Popa II for the purpose of setting guidelines for Development of Clean Water Source in Isla Popa II, Panama. **The specific conditions listed below must be included in the standard EWB-USA Implementation Agreement.** Additional roles and responsibilities identified by any party to the agreement may be added at the discretion of all parties to the agreement. This document must be signed by all parties in order to begin construction of Development of Clean Water Source in Isla Popa II, Panama. The roles and responsibilities agreed to in the previously-signed Project Agreement remain in effect in addition to the commitments outlined below.

<u>PRE-CONSTRUCTION PHASE</u>

Isla Popa II responsibilities:

- Provide 5 % of the capital construction cost in cash before construction begins. This cost is estimated to be $71.
- Provide written confirmation that the land required for the project implementation is owned by the community before construction begins. Alternatively, in lieu of ownership, the community can provide written confirmation that it has a permanent easement to use the property.
- Provide written confirmation that it has the legal right to use the water supply that is being developed in this project ***(all water supply projects only – other project types omit this bullet).***
- Commit 3 paid workers for 8 hours per day for 3 days to the construction site. Workers will be compensated $5 per day.
- Provide the name of the community representative responsible for organizing the in-kind labor
  - Provide the following list of equipment and tools for construction:
  - List equipment and tools and quantities of each
    - Ladder
    - Food and residence for RPI chapter of EWB
  - Provide the following materials for construction:

Lumber

Quantity	Cross Section (inches)	Length (inches)
8	3 x 3	29
8	2 x 4	58
8	2 x 4	28
8	2 x 4	16
8	2 x 4	16
6	2 x 4	6
4	2 x 4	8
2	2 x 4	60

Rensselaer Polytechnic Institute chapter of EWB-USA responsibilities:

- Provide 95 % of the capital construction cost in cash before construction begins.
- Provide qualified representatives of the design team during construction for observation or oversight.
- Communicate the requirements of site preparation prior to the chapter arriving for construction. This will be communicated to the community and the local partner two months prior to construction, or earlier as determined by the project needs.
- Provide the following list of equipment and tools required for construction:

Item name	Qty
tin snips	1
drill with appropriate bits	2
reciprocating saw	1
clamps	4
hand saw	2
vice grips	2
pliers	2
screwdriver	4
hammer	1
chisel	1

- Provide the following materials for construction:

Item Name
55 gallon plastic drum
3/4 in. x 10 ft. PVC schedule 40
3/4 in. x 5 ft. Clear PVC Sch. 40
3/4 in. PVC Sch. 40 Elbow
3/4 in. PVC Sch. 40 Tee
3/4 in. PVC Sch. 40 3-way elbow
3/4 in. PVC Coupling
3/4 in. PVC Bulkhead fitting
3/4 in. PVC Threaded Adapter
3/4 in. PVC ball valve
2.8 oz. silicone sealant
3 in. stainless steel screws
10 mL Liquid Plastic Graduated Cylinder

Item Name
3.5 in. Galvanized nails (per pound)
12 cubic ft. Concrete
PVC purple primer
PVC Cement
1/4 in. steel mesh 2 ft. x 5 ft.
1 gallon of wood impregnating oil
DPD Free Chlorine Reagent Power Pillows, 10 mL, pk/100
pH Paper, 0 - 14 pH Range, 100/pk
Scrubber Brush
6-ft Long Pipe Brush Heavy Duty
Wide mouth Water Jug

POST-CONSTRUCTION/OPERATIONS AND MAINTENANCE PHASE

Isla Popa II responsibilities:

- Pay for 100% of the costs to operate and maintain the project, Development of Clean Water Source in Isla Popa II, Panama. This cost is estimated to be $65 per year, local currency.
- Monetary resources will be collected from the community for operations and repairs monthly and through fundraising events such as bingo nights or through monthly collections. The amount collected per the schedule above will be: $5/month
- The position/committee responsible for identifying maintenance needs is: The Water Board
- This position/committee will be appointed by the president of the community:
- This position/committee will serve in this role for 2 years.
- The position/committee responsible for performing maintenance is: The Water Board
- This position/committee will be appointed by the president of the community.
- This position/committee will serve in this role for 2 years.

Rensselaer Polytechnic Institute chapter of EWB-USA responsibilities:

- Develop a detailed operation and maintenance manual for the community (including applicable photos and local language, as appropriate). The manual will include a maintenance schedule and anticipated costs.

- Provide monitoring and evaluation of the project, Development of Clean Water Source in Sandubidi, Panama, for a period of not less than one year post-construction and as long as the program is active.
- Perform repairs to the project that are the result of errors in the design until they are corrected.

In addition to the responsibilities listed above, indicate the responsible party for each of the following:

- Coordination of transportation for travel team members of Rensselaer Polytechnic Institute chapter of EWB-USA will be provided by EWB-Panama.
- Coordination of translation services for travel team members of Rensselaer Polytechnic Institute chapter of EWB-USA will be provided by the student translator and Paul Pagnozzi
- Scheduling of community-provided labor will be provided by Ambrosio Bekar. This includes 3 community workers for 8 hours per day at the construction site.
- Procurement of construction materials before Rensselaer Polytechnic Institute chapter of EWB-USA arrives for construction will be provided by Maderas Richards.
- Transportation of materials will be funded by EWB-USA.

On behalf of, and acting with the authority of the residents of Isla Popa II and Rensselaer Polytechnic Institute chapter of EWB-USA, the under-signed agree to abide by the above conditions.

[redacted]	[redacted]
Project Lead EWB-RPI	President of Isla Popa II
________________________	________________________

Transcript of Discussion of Implementation Agreement

14 October 2015: ~7pm EST

Community members present for call:

- [redacted] – President of the Community

No.	EWB-RPI Statement	Community Response
C1	Have you spoken to the other members of the Water Board about the proposed system?	Yes, and they are interested in this project.
C2	Do you remember the general design of the system? It will be a modification of the previous system and uses bleach to treat collected water. A smaller tank, a 55 gallon drum, will be placed on a stand in front of the larger tank and connected to the larger tank with a pipe This drum will be used for storing a temporary supply of water that will be treated with chlorine at the start of each day so you can have access to clean water throughout the day. This system will also boost your existing water storage capacity by 110 gallons.	Yes.
C3	The terms of this implementation will be similar to the last one, but we have to go through the terms with you.	Ok.
C4	When we build this, we need another contribution from the community of 5% of project costs. This will amount to about $71, is that okay? Other than this contribution, the chapter will pay for the rest of construction costs.	Yes. We have already begun to start fundraising.
C5	We will need three workers to work for three days when we are building this project. We will be able to pay five dollars per day, same as last trip. Is that okay?	Yes, I will talk to people and see who is interested.
C6	We also need a ladder for some of work; does the community have a ladder we could use? We also need a place to stay for seven people for seven days. Can you make the arrangements?	Yes, we have a ladder and I will talk to [the person in the community who arranges our stay].
C7	We need wood for constructing the stands. Other than these supplies, we will bring all the other construction tools we need with us when we travel.	Okay. Tell me the size of the wood you need and I will get it. **Chapter response:** We will give you the wood order on the next call.

C8	About maintenance, we will bring manuals about how to maintain the system, but it is up to you and other members of the Water Board to maintain the system. Is that okay?	Yes.
C9	Also, after this project is over, we will need to come back in about a year to check on the system and make sure everything is working.	Okay.
C10	Do you have any questions for us?	Will Paul be coming back? **Chapter response:** Yes, Paul will be returning as well as another student who can help with translating.
C11	Anything else?	Can you call this Friday at 7pm for the wood order? **Chapter response:** We will.