526 – Post-Implementation Report

Community:	Isla Popa II (Sandubidi)
Country:	Panama
Chapter:	Rensselaer Polytechnic Institute (EWB-RPI)
Project ID(s):	8801
Submittal Date:	February 21, 2016
Dates Traveled:	January 4th - January 13th 2016
Authors:	Kyra Dauwalder, Tim Andrews, Mike Kubista, Elizabeth Kwon, Frank Sokolowski, Elisabeth Ryan, Joe Saulsbery, Matt Tice, Adam Ney, Patrick Murphy, Ariel Walter, Noa Davis, Megan Kennedy, Jonathon Blumers

Acknowledgements

The Project Leads and Mentor Team acknowledge that:

KD The chapter reviewed the accompanying 526 – Post-Implementation Report Instructions for accurate completion of this report.

KD The PMEL lead updated, the 901B – Program Impact and Monitoring Report and it is submitted as a separate document with this report.

KD The PMEL lead completed the 905 – Program Logic Framework and included it as an appendix to the 901B report.

KD The team has included the Signed 903 – Implementation Agreement as an appendix to this report.

KD The most current contact information is updated in this report and all other reports included with this submittal.

KD If there were any health and safety incidents during the trip, a completed 612 - Incident Report document is included as a separate document with this report.

We, the project team leadership confirm that the above information and tasks have been completed and that this report accurately reflects our chapter's implementation activities during the implementation trip.

Kyra Dauwalder Kyra Dauwalder 2/19/16

Project Lead Printed Name | Project Lead Signature | Date

JAMES KILDUFF J Kilduff 2/19/16

Faculty Advisor Printed Name | Faculty Advisor Signature | Date

It is the responsibility of the Responsible Engineer In Charge (REIC) to ensure that the team's Post-Assessment report meets the typical engineering standard of care. I have reviewed the subject project. I am qualified by education and experience to design and oversee construction for this type of project. In my best engineering judgement, the implementation carried out on this Implementation trip followed the design approved by the Technical Advisory Committee. The construction quality met the normal standard of care for a facility of this type.

David M. Railsback David M. Railsback 2/19/16

REIC Printed Name | REIC Signature | Date

Table of Contents

Part I –Administrative Information

Part II – Pre-Assessment Report

Appendices

Part I –Administrative Information

1.0 Contact Information

	Name	Email	Phone	Chapter/ Organization Name
Project Leads	Mike Kubista	kubism3@rpi.edu	401-632-6820	RPI
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Responsible Engineer in Charge	David Railsback	david.m.railsback@gmail.com	978-895-3220	RPI
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Assistant Health and Safety Officer	Mike Kubista	kubism3@rpi.edu	401-632-6820	RPI
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Planning, Monitoring, Evaluation and Learning (PMEL) Lead	Elizabeth Kwon	kwone2@rpi.edu	716-940-1370	RPI
In-country Community Contact	Ambrosio Bekar	none	507-6492-3211	N/A
In-country NGO Contact	None	N/A	N/A	N/A
In-country Local Government Contact	None	N/A	N/A	N/A

2.0 Budget

2.1 Project Budget

EWB-USA TRIP BUDGET			
EWB-USA Chapter Name ::	RPI		
Project Name ::	Development of Clean Water Source		
Type of Trip ::	I		
Lines with an asterisk are automatically calculated.			
	BUDGET *(PRE-TRIP)*		ACTUAL EXPENSES *(POST-TRIP)*
DIRECT COSTS			
Travel + Logistics			
Airfare	$6,675		$6,482
Food + Lodging	$500		$600
Other Travel Expenses (ex: Rental Vehicle, Taxis/Drivers, Exit Fees/Visas, Inoculations/Medical Exams, Insurance)	$1,000		$978
Sub-Total*	**$8,175**		**$8,060**
Labor			
In-Country Logistical Support	$500		$320
Local Skilled labor	$75		$30
Sub-Total*	**$575**		**$350**
EWB-USA HQ (this section is auto-calculated based on trip type)			
Program Quality Assurance/Quality Control + Infrastructure*	$4,900		$4,900
Less EWB-USA HQ Subsidy*	$3,690		$3,690
Owed by Chapter Sub-Total*	**$1,210**		**$1,210**
Project Materials + Equipment			
Hardware Store Purchases	$565		$974
Wood Purchased	$250		$187
Sub-Total*	**$815**		**$1,161**
Misc.			
Bug Repellent Devices	$5		[inc. in Food + Lodging]
Phone Card	$15		[inc. in Food + Lodging]
Skype Credit	$10		$10

pH Test Strips	-	$13
Chlorine Testing Supplies	-	$134
Fabric and cord for bacterial tests	-	$17
Mosquito Nets (x4)	-	$33
Sub-Total*	**$30**	**$207**
TOTAL DIRECT COST*	**$10,805**	**$10,988**
IN-KIND CONTRIBUTIONS		
Community In-Kind Contributions to Project Costs		
Labor	$0	$0
Materials	$0	$0
Logistics	$0	$0
Sub-Total*	**$0**	**$0**
TOTAL IN-KIND CONTRIBUTIONS*	**$0**	**$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**	

2.2 Professional Mentor Team Hours

Names of Professional Mentors	Pre-trip hours	During trip hours	Post-trip hours	Total Hours
1. **Scott Underhill**	8	0	2	10
2. **Chip Kilduff**	8	70	5	83
3. **Paul Pagnozzi**	8	70	5	83

3.0 Project Discipline(s)

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

Sanitation
_____ Latrine
_____ Gray Water System
_____ Black Water System
_____ Solid Waste Management

Structures
_____ Bridge
_____ Building
_____ Retaining Wall

Civil Works
_____ Roads
_____ Drainage
_____ Dams

Energy
_____ Fuel
_____ Electricity

Agriculture
_____ Irrigation Pump
_____ Irrigation Line
_____ Water Storage
_____ Soil Improvement
_____ Fish Farm
_____Crop Processing Equipment

4.0 Project Snapshot for Publicity

4.1 Problem Identification

At the start of this project, the community was in need of a reliable source of safe drinking water throughout the entire year.

4.2 Project Goal

Our chapter aims to provide a reliable source of safe drinking water for the community school by implementing a rainwater catchment system, which was successfully constructed in January 2015, as well as an integrated water treatment station for chlorine application on the community pavilion. During this past implementation trip, January 2016, our team installed the integrated water treatment station. Our current goal is to return for a monitoring trip next year and help the community to maintain this system.

4.3 Project Status

The overall implementation trip this January 2016 was a success. Although the previously built rainwater catchment system was leaking slightly and needed some repairs upon arrival, it was functioning and provided one hundred school children and nearby residents with water throughout the entire year. The integrated chlorine station was implemented during the trip and was functioning when the travel team left. Together, the entire system provides the community with a reliable source of treated drinking water for a large portion of the community. A manual with information to treat other community water supply sources was also provided. Our current goal is to travel in January 2017 for monitoring.

Part II – Pre-Assessment Report

1.0 Executive Summary

The Engineers Without Borders student chapter at Rensselaer Polytechnic Institute (EWB-RPI) has been working on the Development of Clean Water Source project with the community of Isla Popa II, Panama, since November 2010. The most recent trip, January 4 2016 - January 13, 2016, was the chapter's fifth time to the community and our second implementation trip. The chapter project number is 8801.

The goal of the project is to develop a sustainable, reliable, and clean source of drinking water for the 350 community residents. During this implementation trip, chapter members designed an integrated water treatment station, where chlorine can be added based on the water level, for both of the 600-gallon rainwater collection tanks that were constructed during the first implementation trip in January 2015. The entire integrated system ensures the community has access to a stable supply of treated water in the heart of the community.

The rural community of Isla Popa II is situated on an island located in the Bocas del Toro region of Panama with a population of approximately 350 people. Two prominent leaders of the community that remained highly involved on the water board are Ambrosio Bekar, the community president and our chapter's main point of contact, and Daniel Villagra, the president of the school. Community households are spread out, but the local school and dock act as the heart of the community. Most community members do not leave the island, except for several fishermen, so most families only have easy access to resources provided on Isla Popa II itself. The Implementation Agreement (Appendix A) outlines the respective responsibilities of the community and EWB-RPI. Ambrosio Bekar, the president of the community and member of the water board, signed the agreement, which recognizes that the community is responsible for all future costs necessary to operate and maintain the system.

EWB-RPI was founded in the fall of 2010. Soon after, our chapter began the project with Isla Popa II. The first assessment trip occurred January 7th to January 12th, 2012 where our chapter focused on identifying the community's main concerns and fostering a relationship with community members. The second trip, August 12th to August 21st, 2012, was an assessment trip that focused on collecting water quality data, analyzing possible implementation strategies, and reaffirming relations with the community. The third trip was our final assessment trip during August 12th to August 21st, 2013, with the purpose of assessing and taking measurement of the implementation site, the community's pavilion. Additional water quality tests were conducted and community relations continued to strengthen. The fourth trip was an implementation trip, which occurred January 5th to January 14th, 2015. During this trip, two large-scale rainwater catchment systems were constructed on the pavilion, one on each side of the pavilion roof. On each side, gutters were built to catch rainwater along the corrugated metal roof and a first flush system was constructed to discard the first 1 mm of rainfall, sufficient to remove the majority of contaminants that wash off the roof. Rainfall exceeding the 1 mm depth is stored in a 600-gallon rainwater catchment tank, supported by a tank stand. During this trip, water board members helped construct the system and learned about bacteria in their water through bacterial tests the travel team conducted. This is the only open project that EWB-RPI is currently working on, although our chapter is applying for a local project in Troy, NY this spring. Our chapter has about thirty members actively involved.

The purpose of the second implementation trip was to provide the community with a way to treat the collected rainwater for each 600-gallon tank that was previously constructed. On either tank, an integrated water treatment station was built. PVC pipe connected the 600-gallon tank to a 40-gallon chlorine drum with a valve to control flow. Each drum was supported by a wooden drum stand. In the 40-gallon drum, chlorine is poured through an application site made of PVC. The treated water is then accessible via a spigot. Members of the community were given manuals and taught how to add chlorine based on the water level, which is depicted by a water meter next to the drum. Community members were also shown the results of bacterial tests that were conducted around the community (Appendix C). This showed them the level of bacteria in different water supply sources on the island, and the importance of drinking treated water. Upon arrival, the travel team found that parts of the gutters were leaking and sagging. Also, the first flush system outlet port was clogged with dirt due to vegetation growth. The gutters were repaired and the first flush system was re-designed to run along the pavilion foundation in order to elevate the outlet port and to avoid future clogging. Water board members aided with repairs.

Both the location and height of the drum for chlorine treatment were changed from the original design to make access to the tank easier and to ensure that the top of the chlorine drum was at the same elevation as the drainage piping for the main tank. Due to this change, PVC piping from the main 600-gallon tank to the intermediate drum was routed underneath the 600-gallon tank stand (Figure 3.5.1). Another design change included an access valve that was inserted before the valve that controlled inflow to the drum (Figure 3.5.2). The drum was also reduced to 40 gallons from the proposed 55 gallons due to availability at the hardware store. This forced the team to alter the designs of the intermediate drum support cradle significantly to account for the change in size (Figure 3.5.3). In addition, the application site for chlorine on the intermediate drum was integrated with the vent (Figures 3.5.4). Finally, the first flush system was redesigned to run along the concrete support footings of the pavilion instead of the ground in order to allow the exit flow of water to be elevated off the ground (Figure 3.5.5-6). A full report of each design change is reviewed in section 3.3.

The second implementation trip was successful and the travel team left with the system fully operational. The chapter continues to call Ambrosio weekly for updates on the maintenance and functionality of the complete system. Because the community school now has reliable access to treated water year round, our chapter is ready to move to the monitoring phase.

2.0 Trip Description

In mid-January 2016, five students and two professional mentors travelled to the community of Isla Popa II for a second implementation trip. During the first implementation trip in mid-January 2015, the travel team constructed two large rainwater catchment systems on either side of the community pavilion. Two tank stands were assembled and mounted on concrete footings at the rear of the community pavilion, with one tank on each side. A gutter system built with 4 inch PVC piping was then installed along the roof of the pavilion to channel rainwater into two 600-gallon collection tanks, which were mounted on the tank stands. This gutter system incorporated a first flush system to remove first 1 mm of contaminants that washed off the roof into the collected rainwater. Over the past year, this system has been successfully provided the community with enough rainwater for the community school, with approximately 100 students.

The purpose of the second implementation trip was to provide the community with a way to treat the rainwater collected in each 600-gallon tank. In addition, upon arrival, the travel team found that parts of the previously constructed rainwater catchment system required repairs. Different parts of the gutters were leaking at the cemented joints. This was caused, in part, by the loss of several support straps, which concentrated stress at these sections, and caused sagging. With the aid of water board members, the travel team added several additional support straps, and re-applied adhesive to these sections. The travel team also noticed settlement of the first flush system, and clogging due to sediment and vegetation growth near the discharge hole. The travel team redesigned the first flush to elevate the exit so that the water could drain above the ground away from future vegetation growth.

A 40-gallon water treatment drum was integrated with each 600-gallon collection tank. PVC pipes were connected between the 600-gallon tank to a 40-gallon drum. A valve controls flow between the tank and the drum. Chlorine can be added to the 40-gallon drum based on the water level, which is depicted via a water meter. Chlorine tests were conducted to show that the treated water was free of bacteria. Two community members were taught how to add chlorine and successfully treated their water correctly by the end of the trip.

Additionally, travel team members conducted bacterial tests on other sources of water supply in the community and surveyed different community members about their water supply Results showed *E.coli*, coliform, and fecal matter present in many of these water supply sources, with the community well showing the highest amount of bacteria (Appendix C). Furthermore, the team emphasized to water board members that their community was in charge of the entire system and was responsible for its maintenance.

3.0 Project Summary

3.1 Project Description

During EWB-RPI's second implementation trip, five members and two professional mentors traveled to Isla Popa II for seven days. In January 2015, the team constructed a water treatment system for each 600-gallon rainwater-harvesting systems that were constructed on either side of the community's pavilion, approximately 50 yards from the community school. The purpose of the second implementation trip was to provide the community with a station on both 600-gallon tanks to treat the collected rainwater. The team also assessed and repaired the rainwater catchment system constructed during the first implementation. Additional straps were placed to hold up gutters and the first flush system was redesigned to avoid sediment backup.

3.2 Summary

On this implementation, a 40-gallon drum was placed horizontally on a wooden drum stand mounted on concrete footings and positioned behind the 600-gallon tank and stand adjacent to the community pavilion. Piping was then assembled to connect the tank and the drum (Figure 3.5.1). A concrete splash pad was poured in front of the 40-gallon drum where water is accessed. The first flush system was repositioned such that the main first flush volume runs along the concrete footings of the pavilion (Figure 3.5.5)

The drum stand was constructed from 2 x 4 inch beams and supported on 3 x 3 inch legs. The stands were constructed using nispero, a dense tropical hardwood that is grown and harvested locally and is used in many construction projects within the community. The wood was cut by community members to the specified (true) dimensions using a chain saw.

The stand was built so that the access point of the water was approximately two feet off the ground. Relative to the main tank, the midpoint of the height of the horizontal drum was at the same altitude as the bottom of the main tank. This allows the drum to be filled completely as long as the main tank has more than a foot of water in it (Figure 3.5.1). In the event the water level in the main tank is below this point, the drum can still be partially filled and dosed with an appropriately scaled amount of chlorine.

The drum stand consisted of two main parts: the drum cradle with the long axis and the supporting structure. The drum cradle refers to the beams used to support the 40-gallon drum and surrounding corrugated aluminum. The supporting structure carries the drum cradle and includes the legs of the stand (Figure 3.5.3).

The 40-gallon drum was mounted in the drum cradle with the long axis horizontal. In this position, it was supported by two longitudinal beams, which were angled at 45 degrees so that the 4 inch wide surface was contacting the body of the barrel. These two beams were positioned about 6 inches apart and prevented the drum from rolling in addition to bearing the load of the drum. The plane made by the face of the supporting beam is approximately tangent to the surface of the drum at the point of contact. In this way, when the drum flexes under loading, the load will be distributed over a large surface area, reducing stresses on the drum (Figure 3.5.3).

The drum cradle is essentially a box of wood to support the drum, and corrugated aluminum was nailed to the outside of the box to protect the drum. The only face not covered by corrugated aluminum was the bottom. When performing maintenance on the drums, the sheet metal can easily be removed and then nailed back into place.

The supporting structure is constructed of wood beams that is connected to the drum cradle and the legs of the stand. The support structure rests on top of the leg columns, directly bearing the load of the stand. Additional support was added using angled struts connecting the longitudinal support beams to the leg column. The drum cradle rests on top of the supporting structure, and the load of the drum is transferred to the legs. The supporting structure also supports parts of the piping used to transfer water between the tank, drum, and access piping (Figure 3.5.3).

Connections between beams and legs were made with 3.5 inch long nails. Due to the density and hardness of the wood, the nail holes were partially pre-drilled. This helped to prevent the wood from splitting, which was a frequent problem. Whenever possible, wood glue was used in addition to nails to strengthen the connection. The angled struts that connect the drum cradle to the legs were also secured with 8 inch galvanized mending plates to connect the strut to the leg. Large headed nails were used to secure the corrugated aluminum to the drum cradle.

The tank stand was placed on concrete footings 6 inches deep with a 9 inch by 9 inch surface area. Concrete anchors were placed in the footings before they had set. The legs were trimmed as needed once the tank stand was positioned over the footings to make the stand level. Each leg of the stand was then connected to the metal strapping of the concrete anchors using galvanized steel screws once the concrete had set.

In order to access the water in the drum and transfer the water from the main tank to the drum, 3 / 4 inch schedule 40 PVC piping was used (Figure 3.5.1). The exit from the main tank was converted from a 1 / 2 inch PVC pipe to the 3 / 4 inch pipe, and a shutoff valve was connected to allow all flow out of the main tank to be stopped, a useful feature if repairs need to be made. A T-fitting was then connected to the piping. One part of the T-fitting traveled to the chlorine drum, while the other, supported by a plank of wood attached to the main tank stand (Figure 3.5.2), provided an access point controlled by a second valve, allowing water to be drawn directly from the main tank. On the path to the drum, the piping passed under the main tank stand and was secured to the bottom of the stand with galvanized brackets. After passing under the stand, a valve was connected which controlled the flow of water into the drum from the main tank (Figure 3.5.1). Opening this valve would fill the drum with water from the main tank. The piping was then connected to a bulkhead fitting attached to the outer circumference of the drum about midway between the two end faces of the drum and at the midpoint of the height of the horizontal drum.

To access the water stored in the drum, a bulkhead fitting was attached to the bottom of the horizontal drum, midway between the two end faces. This bulkhead fitting was then connected to 3 / 4 inch schedule 40 PVC piping, which lead to the front face of the drum, facing away from the pavilion. Here a T-fitting was connected to the pipe. One part of the T-fitting led to a valve that controls water flow out of the drum and the access spigot. The other part of the T-fitting led to a capped end of the PVC pipe which was adapted to a small length of flexible clear tubing which was used as the water meter (piezometer) to indicate the level of water in the drum. This access piping was supported by brackets attached to the drum stand (Figure 3.5.7).

A bulkhead fitting was also placed on the top of the horizontal drum, midway between the two faces of the drum. Piping was attached to this bulkhead fitting and directed towards the front of the drum stand furthest from the pavilion. The piping was then connected to a three-way elbow. The part of the elbow oriented vertically was left open. This serves as the disinfection inlet where bleach can be added to the main tank. This inlet is capped with a screw-in plug to prevent outside contamination. The other part of the three-way elbow continued to another opening at a higher altitude which was covered with a mesh screen. This opening served to vent the drum, allowing air to escape when the drum is filling, while the screen keeps out unwanted debris (Figure 3.5.4).

The first flush system was raised from its original position on the ground to the pavilion footings, to avoid clogging and to facilitate drainage. Constructed from 4 inch schedule 40 PVC, the vertical portion of the first flush system that connects to the gutters was cut to remove the bottom water-storing piping. A 45 degree T-fitting was then put in place and the main storage volume of the first flush system was connected to this fitting, running parallel to the ground and resting on the pavilion footings (Figure 3.5.5). The end of the 45 degree T-fitting that continued vertically towards the ground was connected to a length of pipe that ended in a capped elbow fitting. This elbow fitting was supported on a concrete block (Figure 3.5.6). A 1/16" drainage hole was made at the bottom of the vertical piping (Figure 3.5.5).

To vent the horizontal storage pipe of the first flush system, a metal threaded-to-barbed adapter was screwed into a hole drilled into the end cap of the horizontal first flush piping. Polyurethane tubing was then connected to the barbed adapter and run vertically upwards along a supporting column of the pavilion so that the tube ended at an altitude higher than the point where the gutters connect to the first flush system. This tube vented the horizontal first flush piping, allowing it fill completely and the long vertical polyurethane tube prevented water stored in the first flush from draining out of the vent hole (Figure 3.5.5).

A square splash pad 4 inches deep and 27 inches wide was placed in front of the stand where the water from the drum is accessed. This pad facilitates filling containers with water and reduces erosion from spills.

3.3 Difference Between Planned and Actual Implementation

Location of Intermediate Water Treatment Drum:

The intermediate 40-gallon drum for disinfection treatment, via chlorine, was relocated from its original position in front of the main rainwater storage tank to behind the main rainwater storage tank. This allowed for location of the water access point for the intermediate storage drum to be perpendicular to the pavilion and higher off the ground. The ground surrounding the pavilion slopes downwards from the front of the pavilion to the back. Because of this slope, positioning the intermediate drum in the back allowed the intermediate drum to be positioned higher off of the ground while maintaining full functionality. Were the intermediate drum to be positioned in front of the main tank as originally planned, the spigot would have had to be very close to the ground. This was undesirable because it makes accessing the water difficult and increases the risk of contamination from local domesticated animals.

Alternatively, the drum could have been placed higher relative to the main tank, but this would have prevented the main tank from draining completely. This would mean that the community would not be able to access all of the water stored in the main tank. This would limit their water supply capacity.

To avoid having to limit the available water capacity or place the access spigot in an inconvenient, unsanitary location, the decision was made to move the intermediate stand to the rear of the main storage tank. This would avoid both problems without impacting the functionality of the system. The only change of consequence is that the location of the access spigot changed to perpendicular to the pavilion, rather than parallel to it.

Size of the Intermediate Drum:

Each intermediate drum installed had a volume of 40 gallons. This is smaller than the planned design, which utilized 55-gallon drums. 55-gallon drums were unavailable, so 40-gallon drums were used as a comparable substitute. Maderas Richard's, a hardware store in country where all of the supplies used on this trip were purchased, was contacted prior to the trip and confirmed 55-gallon drums were in stock. However, when the chapter arrived in January this was not the case. Since the desired tank size was unavailable, a substitution was made with the available similarly sized tanks: two 40-gallon drums.

Height of Intermediate Drum Relative to Main Rainwater Storage Tank:

The intermediate drum was positioned at a height relative to the main tank such that the midpoint of the horizontal intermediate drum is at the same altitude as the drainage piping for the main tank. In the proposed design, the top of the intermediate drum was at the same altitude as the drainage piping for the main tank.

This change was made to accommodate for the change in drum size and following adjustments to the water transfer piping while balancing the need to be able to completely fill the intermediate drum for chlorine dosing with the need to have the drum access spigot located as far away from the ground as possible. The priority was to have the access spigot located at an acceptable height from the ground to facilitate filling containers from the intermediate drum and to keep it away from potential environmental hazards, such as domesticated animals. The acceptable height that was decided put the midpoint of the height of the horizontal drum at the same level as the drainage spigot for the main tank. This means that when the drum is completely empty, the maximum level possible volume in the intermediate drum is only half full. However, the main tank is rarely expected to reach such a low level. Members of the community stated that the tanks were never completely emptied, even during a month long period without rain. Also, with the water meter attached to the side of the intermediate drum, the community will be able to properly dose the bleach so that the system will maintain its functionality even when the intermediate tank cannot be completely filled.

Pipe Connection Locations on Intermediate Drum:

The flow of water into and out of the intermediate drum takes place at three access points (Figure 3.5.1-2). Bulkhead fittings were attached to the barrel at three points around its circumference at approximately the midpoint of the barrel between the end faces. The inflow point to the barrel was repositioned to connect to the side of the barrel adjacent to the main rainwater storage tank. The outflow point from the barrel was moved to the bottom of the barrel. Originally, the inflow from the main tank and the intermediate drum outflow were located on the face of the barrel. The location of the vent was unchanged (Figure 3.5.4).

These changes were made because of the change in barrel geometry. The 40-gallon drum, unlike the 55-gallon drum, did not have end faces that would have allowed for full use of the volume of the tank had the inlet and outlet piping been connected to the drum face as originally planned. The drum narrowed significantly at each end, so all connection points were moved to the outside circumference of the drum. This would allow nearly full drainage of the intermediate drum, something that would not have been possible had the original plans been followed. Also, this reduced the amount of piping that needed to be used to connect the main and intermediate drums.

Chlorine Addition Point Relocated:

The point of chlorine addition was positioned as a part of the vent for the intermediate drum. Originally, the point of chlorine addition was on the inflow piping connecting the main and intermediate drums. This change was made to accommodate the change in pipe connection locations on the intermediate drums. Moving the chlorine addition point to the vent piping meant that the chlorine was still added at the highest point possible on the intermediate drum, ensuring that all of the added chlorine would find its way into the intermediate drum and that proper mixing would occur as the drum was filled (Figure 3.5.4). When the recommended amount of chlorine was added to the intermediate drum, the residual chlorine level was tested and found to be within the targeted range, indicating that the relocation of the chlorine addition point still enabled all the chlorine to make its way to the intermediate drum.

Direct Access to Main Rainwater Storage Tank:

In the piping connecting the main tank to the intermediate drum, an access valve off of a T-connection was added before the valve that controlled inflow to the intermediate storage drum. This valve allows direct access of water stored in the main tank, enabling users to bypass the intermediate drum if desired (Figure 3.5.1-2). This feature was added to the system because the team realized that the community depended heavily on the water collected in the two main rainwater storage tanks. In the event that something caused the intermediate treatment drum and treatment system to become inoperable, this should not prevent the community from being able to access the water stored in the main tanks. This access point was added as a precaution to make sure the community would always have access to the large volumes of water stored in the main tanks in the event the additions constructed on this trip fail.

First Flush Repositioned:

The first flush piping was relocated to the edge of the floor of the pavilion and now rests on the concrete support footings of the pavilion (Figure 3.5.5). Previously, the first flush piping ran along the ground. In the original configuration, the first flush system drained through a small hole in the first flush piping. This small hole was positioned at the bottom of the pipe circumference, directly in contact with the ground. The ground surrounding the hole was covered with gravel to prevent clogging of the hole with mud. The gravel was not able to protect the hole from being clogged with mud, as the mud simply flowed back through the gravel. This clogged the first flush drainage hole frequently. Since the hole was located on the bottom of the pipe adjacent to the ground, the first flush was often clogged. Given the location of the drainage hole, clearing the mud from the hole was a difficult task.

To prevent the hole from becoming clogged so frequently and to make it easier to clean if the hole becomes clogged, the first flush piping was removed from the ground and placed on the footings of the pavilion and the drainage hole was made on the bottom of the vertical first flush piping. The new drainage location allowed nearly all of the first flush system to drain, but a small volume of water will always remain in the bottom of the first flush unless the cap at the bottom of vertical piping is removed (Figure 3.5.6). This was a necessary trade off, since it made the first flush system much less likely to clog and simplified the maintenance process.

Structure of Intermediate Drum Stand:

The part of the intermediate drum stand that supported the 40-gallon barrel was changed significantly from the proposed drawings due to the change in size of the intermediate drum used. The drum is now supported on two beams that run along the length of the horizontal drum positioned at 45 degree angles, cupping the drum between them. These beams are then supported by the rest of the drum stand structure, which was left mostly unchanged (Figure 3.5.3).

Water Meter Material Changed:

Rather than using clear solid polycarbonate tubing, small-diameter flexible clear polyurethane tubing was used for the water meter. This tubing was connected to the 3 / 4 inch PVC by capping an end of the piping, drilling a hole, and screwing a copper barbed adapter into the hole. The polyurethane tubing was then connected to the barbed end of the adapter. To secure the tubing to the side of the corrugated aluminum that surrounded the intermediate drum, pipe fittings were attached to the tubing and then nailed into the aluminum. This change was made because of concerns about using the polycarbonate piping under continued intense sun exposure. The polyurethane tubing was used instead since it is easier to replace if sun exposure degrades the strength of the water meter (Figure 3.5.7).

3.4 Post Trip Follow-Up/Update

The team has called Ambrosio Bekar weekly since the second implementation trip. He reports that the gutters are no longer leaking. The revised first flush system is also working properly. The land side drum that is accessible through a cap is not leaking like the ocean side drum, which was leaking during the trip and sealed by the travel team with adhesive. Overall, he says the whole system is working perfectly. Ambrosio says he takes care of adding chlorine to the drums, although he does not use the water there much himself. Currently, he and Daniel, the school president, are still the only two that know how to operate the system. Our chapter will continue to encourage them to teach other community members. Although Ambrosio is not using the treated water himself, he reports that people who live close by use it regularly for drinking and washing. Despite past complaints from the community about the taste of chlorine, Ambrosio says the treated water from the drum does not taste any differently. Our chapter believes the bad taste was due to the over chlorination.

3.5 As-Built Drawings

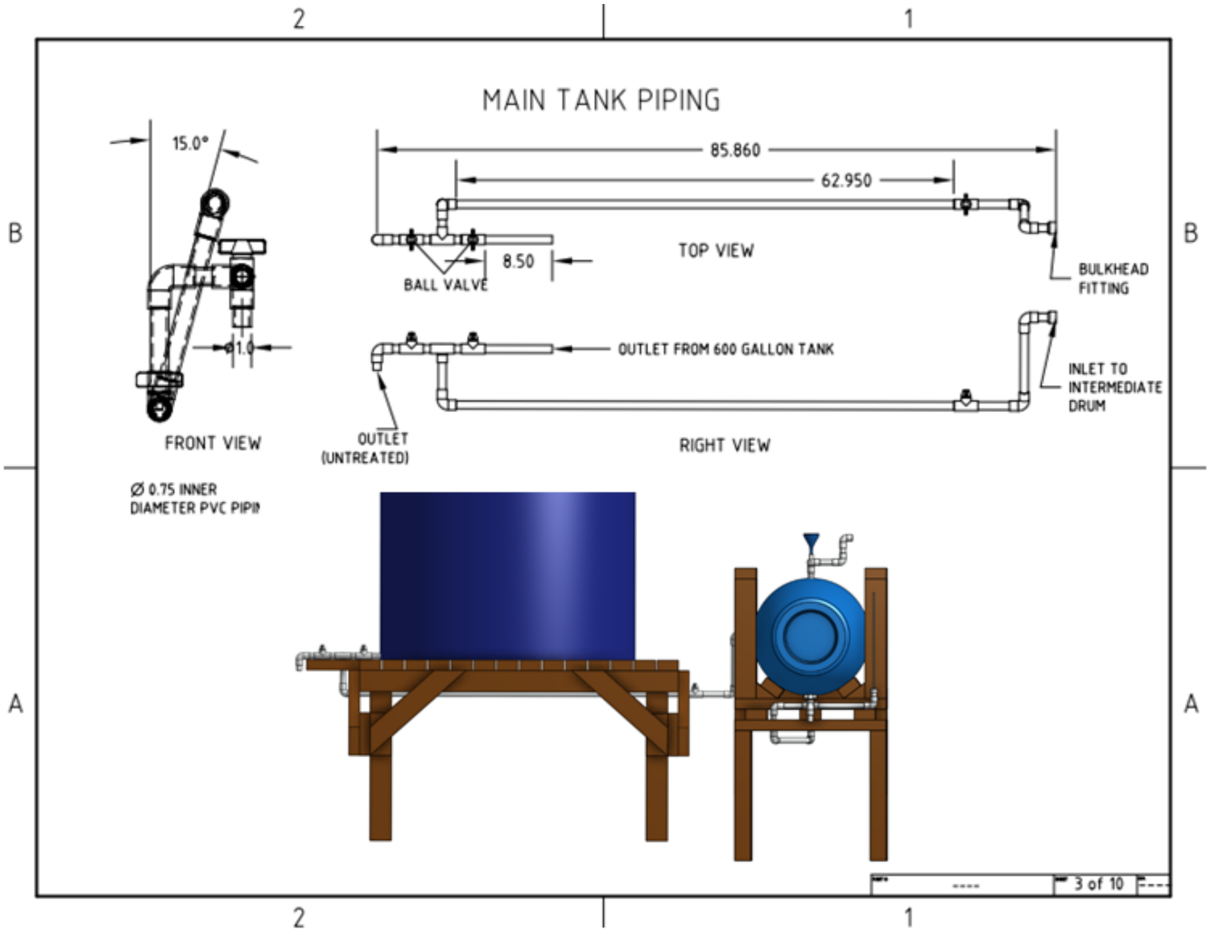

Figure 3.5.1 – As-built drawing of the PVC piping from the main 600-gallon tank to the intermediate drum. The piping runs underneath the 600-gallon tank stand. Also note the CAD rendering on the bottom; the midpoint the horizontal drum height is at the same altitude as the bottom of the main tank.

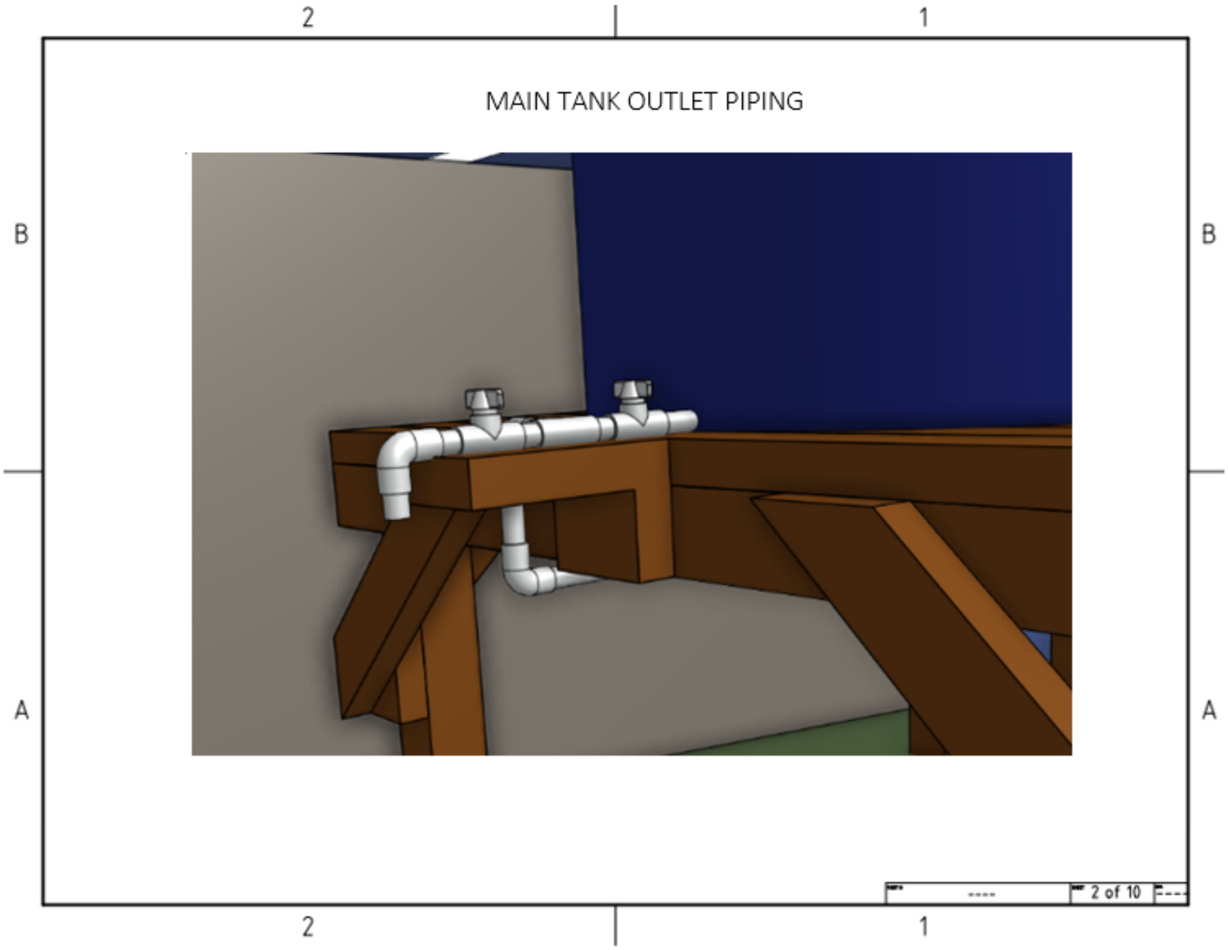

Figure 3.5.2 - As-built rendering of the outlet PVC connections from the 600-gallon tank. The PVC running underneath connects to the 40-gallon drum. A valve at the end of this connection controls flow into the drum. The valve closest to the tank allows for water flow to be shut off for any necessary repairs. The valve farther from the tank allows users to direct access to the stored water in the 600-gallon tank, bypassing the intermediate 40-gallon drum if for any reason it becomes damaged.

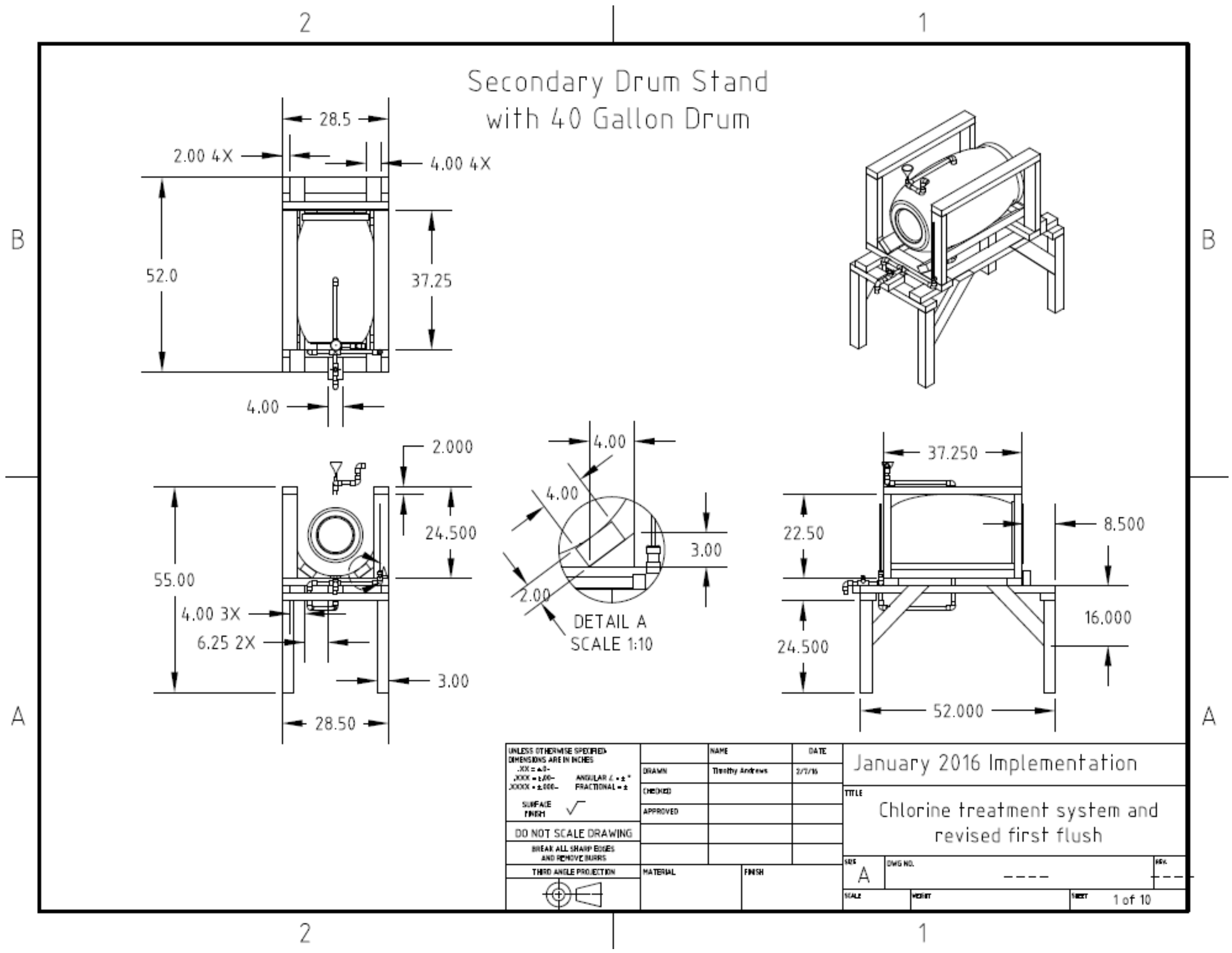

Figure 3.5.3 - As-built drawing of the drum stand for the intermediate 40-gallon drum.

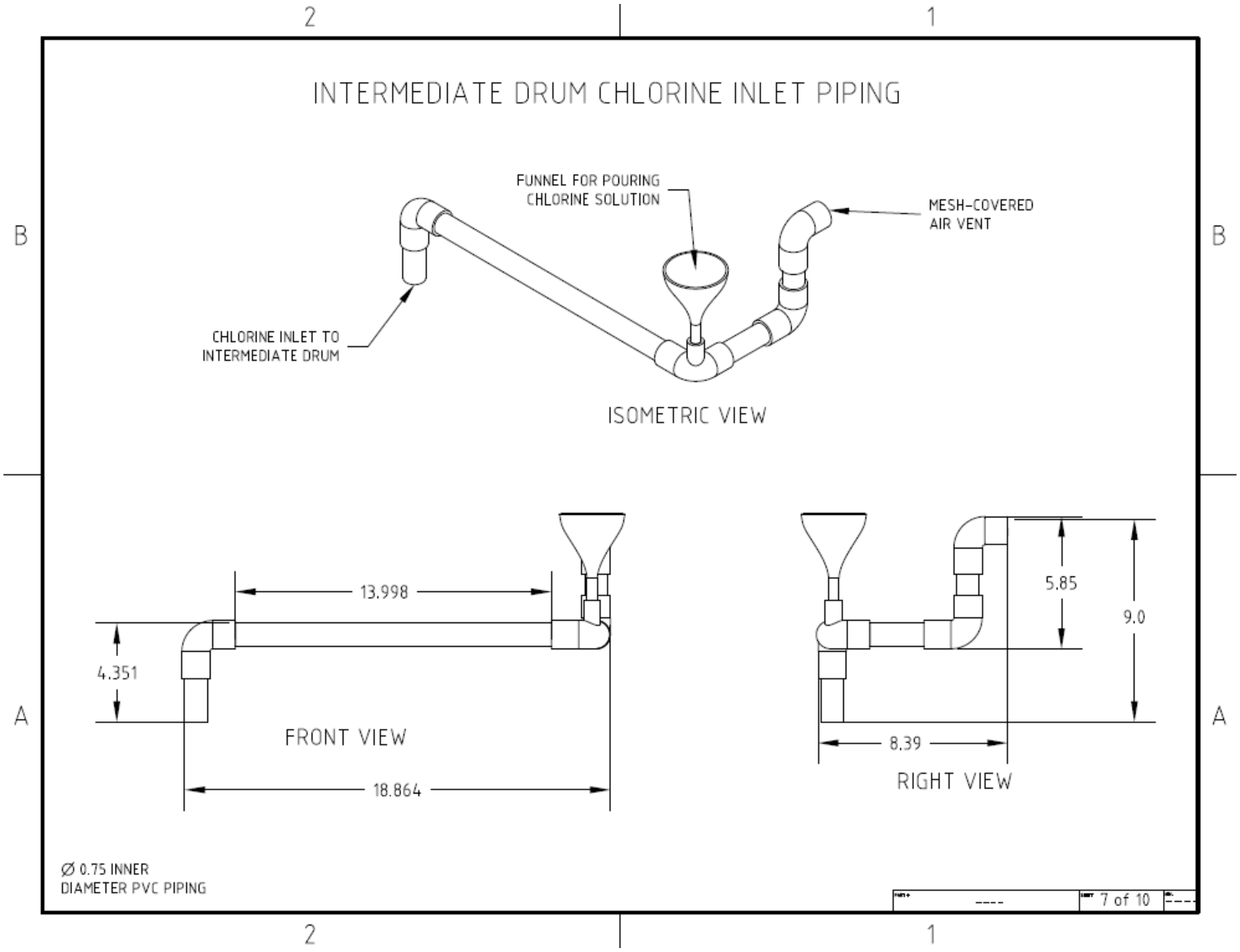

Figure 3.5.4 - As-built drawing of the PVC air vent and chlorine application site for the intermediate drum.

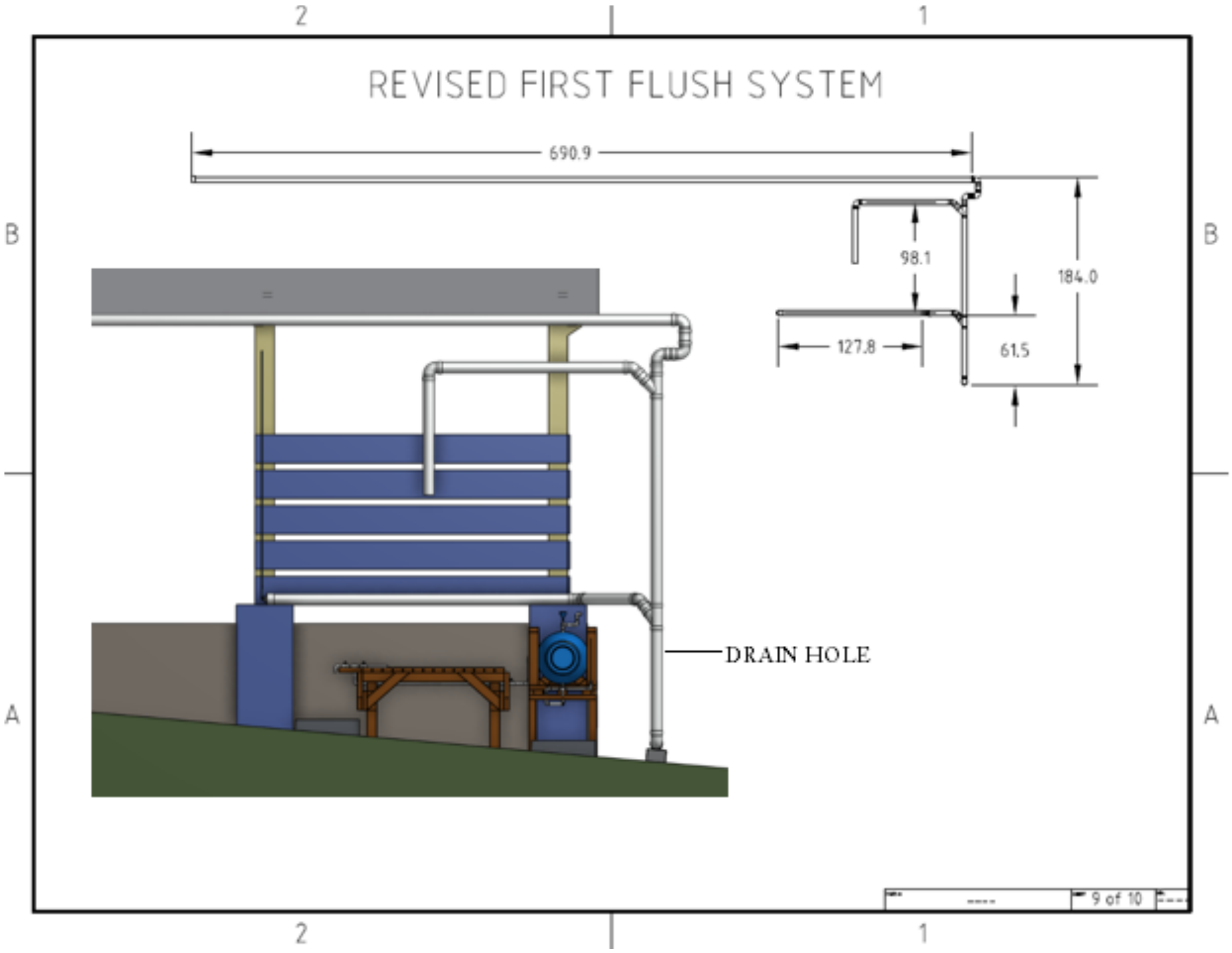

Figure 3.5.5 - As-built rendering of modified first flush system. The original exit to the right of the drum stand is capped. Water flow continues through the elevated PVC along the pavilion concrete support footings and where water now exits at the end.

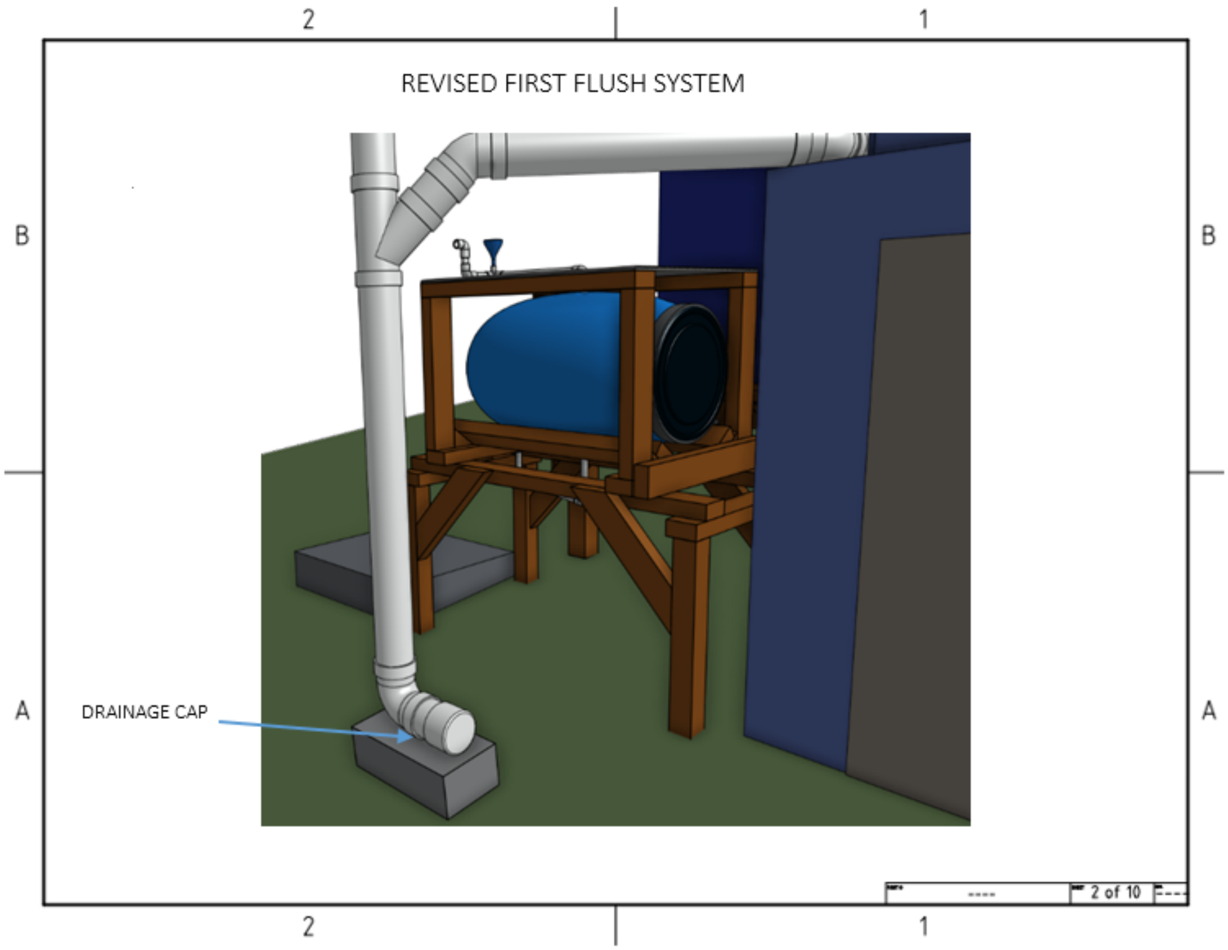

Figure 3.5.6 - As-built image of modified first flush system and added drainage cap to the original water exit location.

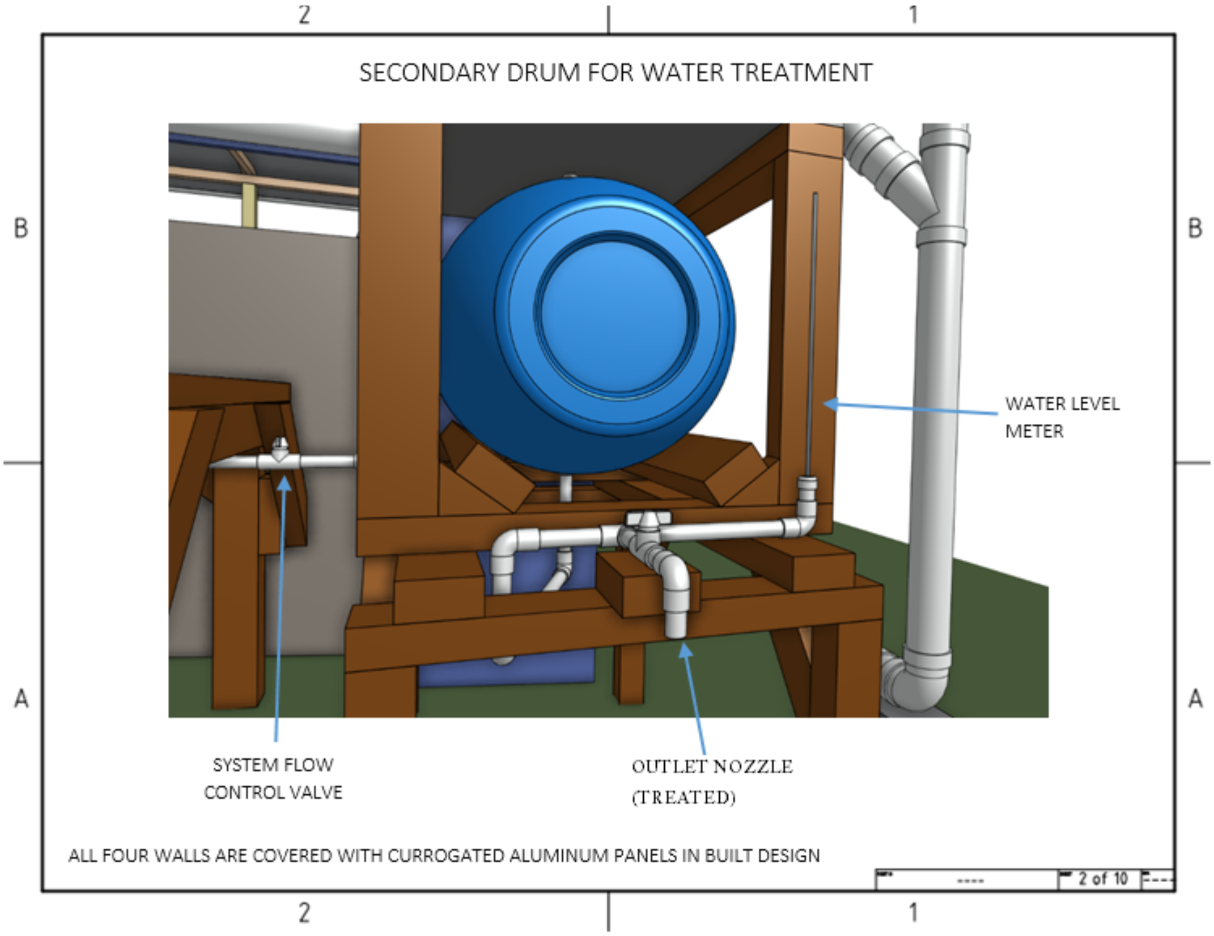

Figure 3.5.7 - As-built rendering of the 40-gallon drum piping. The system control valve controls water flow from the main 600-gallon tank. The outlet nozzle is where the treated water exits. The water meter indicates the water level within the 40-gallon drum.

3.6 Operation and Maintenance

While in the community, the travel team trained members of the water board in operation and maintenance procedures and provided reference manuals to ensure the community could maintain the system. The procedures shown to community members are outlined in detail in the 525 Pre-Implementation Report.

First Flush System:

Once the construction of the repaired first flush system was complete, the members of the water board were instructed to actively check every few days if leaves had blocked the exit and clogged the steady drainage of water. They also were told to uncap the bottom of the system at the old drainage location as often as remembered to avoid water building up. (Figure 3.5.6)

Gutters and Pipes:

Members of the water board were instructed to inspect the rain gutters monthly for any significant leaks or blockage. The metal straps used to secure the gutters to the roof should also be inspected by the water board monthly for any signs of corrosion which could lead to failure. Members of the water board aided in the repair of the gutters during the trip. Other community members are familiar with the use of adhesive materials to repair leaks in rain gutters, as there are many similar systems across the community, and were provided with extra straps for replacement. They are also familiar with the signs associated with a serious blockage in the gutters, as well as the procedures for removing the blockage.

Rainwater Catchment Tanks:

Members of the water board were instructed to clean and disinfect the rainwater storage tanks four times per year, or as necessary if the tank becomes contaminated. Community members were told to always be mindful of the quality of the water being drawn from these tanks, and to check for any signs that the tank is contaminated. Signs the tank may be contaminated include visible contaminants in the water. Community members were instructed to use their best judgment when considering whether a tank requires cleaning. A brush was provided to aid with cleaning.

Chlorination Drums:

After the construction of the 40-gallon chlorination drums, members of the community were instructed in its operation, using the manuals provided as a guide. Following training from EWB-RPI, the community members Ambrosio Bekar and Daniel Viallgra were able to perform the water treatment procedures.

For maintenance, water board members were educated in the importance of ventilation and instructed to make sure that the vent was never blocked. A method to check if the system is blocked is that clear tubing goes up the side of the system to vent air. Water will rise up to the level where the water enters the tank. If the water level does not drop, this is an indication of blockage in the vent line.

In addition, members of the water board were provided with chlorine test strips, trained how to use them, and were provided with manuals for instruction in order to test the water to see if they applied the correct amount of chlorine.

The community was also instructed to drain one of the chlorination tanks by opening the screw cap on the side of the tank to avoid bacterial growth at the very bottom and to clean the tank with a brush provided by the travel team. Unfortunately, only the ocean-side chlorination drum has this option since the land-side drum was leaking at this screw cap and needed to be sealed to avoid leakage.

In addition to training members of the water board in the proper maintenance and operation procedures of the system, manuals in Spanish outlining these procedures were provided to the community. These manuals contain simplified and specific instructions regarding proper operation and maintenance procedures and were included with our 525 report. The manuals were left with members of the water board and are intended to be used as reference materials for community members. Also, nearly all materials used in the construction of this system were purchased locally. In the event of a broken part within the system, community members will be able to obtain a replacement part as well as use the manual for assistance.

The chapter's main contact within the community, Ambrosio Bekar, has agreed to be responsible for overseeing the maintenance of the constructed system. This includes the rainwater catchment system on the community pavilion constructed on this implementation trip. To fund any necessary maintenance, money is primarily collected through small donations from members throughout the community. The community has been successful in the past collecting money for this project. As established before construction, the community will be responsible for regular maintenance costs associated with this system, and the water board confirmed this responsibility.

Ambrosio Bekar and Daniel Villagra, the president of the local school, were taught how to operate the system and proved that they can successfully treat the collected rainwater correctly. They are both responsible for teaching other community members how to operate the system.

3.7 Sustainability

A major factor that affects the sustainability of this system is the availability of supplies and knowledge of the tools that are required to maintain and operate the system. Because Isla Popa II is an isolated island community, supplies need to be found locally whilst still being affordable. Our chapter has designed the system based upon availability of materials found either on Isla Popa II (eg. wood, corrugated aluminum) or on Isla Colon (eg. chlorine, adhesives, screws, tanks), a nearby island about forty-minutes away that community members visit about twice a month. Our chapter also provided tools they do not have for their own use: a brush for cleaning, two funnels for chlorine application, a box of syringes for testing and dispensing chlorine, as well as chlorine test strips. Members of the water board were trained in using all these tools, however this knowledge needs to be reinforced and disseminated to other community members in order for successful future operation and maintenance. The travel team also provided manuals that outline operation and maintenance procedures. The regular maintenance and repairs that we suggested to the community were previously outlined in Section 3.6: Operation and Maintenance.

When the travel team arrived, repairs were required. While water board members helped us, it was evident that they have the knowledge to repair the leaks and sagging gutters. However, the fact that these repairs had not been addressed when the travel team arrived is concerning. Our team worked with the water board and stressed the significance of keeping up with repairs. When they left, they seemed more inclined to continue maintaining the system more diligently. In order for this system to remain sustainable, the community needs to stay committed.

Financial sustainability in the community will also determine the lifetime of the system. The maintenance and operation fees will be maintained through monetary contributions from households in the community. The money will be collected by the president of the community. Since the system is on the community pavilion, a public space, the water will mostly be used by the children of the nearby school. Therefore, contribution for the fees will be primarily provided by families with school children.

The travel team also focused on educating the water board more about the bacteria in their water. Multiple bacterial tests were conducted on both the water from our system and from other water supply locations on the island. Large signs of coliform, *E.coli*, and fecal matter were detected in some of the samples (Appendix D). Chlorine strips tests were also conducted on the water after water board members were taught to use the system. The tests showed them that they had successfully treated their own water. It is up to the water board to teach other community members how to operate and maintain the system.

For further sustainability, the community was provided with a manual that shows bleach dosages for various amounts of water (Appendix E). The document focused on outlining treatment for the 40-gallon drum, but our chapter hopes that individual community members will dose their own 5-gallon rainwater collection buckets. These buckets are commonly used on the island for household water supply, and the treatment procedure consists of putting 1.5 mL of bleach into the bucket. This type of chlorine treatment performed at the household may be more viable for some members who live farther from the community pavilion. To verify the accuracy of these buckets, the community was left with a few hundred chlorine test strips. Our chapter is currently attempting to locate a local source of chlorine test strips. In the meantime, our chapter plans to supplement the community's supply by bringing more chlorine test strips on the monitoring trip.

In the case the 40-gallon system becomes unusable or fails, a T connection at the outlet of the 600-gallon tank will allow the community to bypass the 40-gallon drum and utilize the 600-gallon tank.

4.0 Photo Documentation

Figure 4.1 - This picture shows the concrete-filled supports for the chlorination tank stand on the land-side of the community pavilion.

Figure 4.2 - The concrete supports for the ocean-side tank stand are located behind the main 600-gallon rainwater catchment tank.

Figure 4.3 - The new elevated first-flush system, designed to prevent clogging of the exit hole.

Figure 4.4 - A front view of the ocean-side chlorination tank stand with drum before the protective zinc was placed. Wooden supports, metal braces, and strapping were used to stabilize the drum.

Figure 4.5 - The additional ball valve and connection to the 40-gallon drum are attached to the 600-gallon tank spigot.

Figure 4.6 - The connection PVC pipe went under the 600-gallon tank, feeding into the 40-gallon drum from the bottom.

Figure 4.7 - The completed water treatment station with corrugated aluminum metal sheets surround the 40-gallon drum for protection, as requested by the community.

5.0 Lesson Learned

More Open Communication

Communication is vital to the project success. Although this was something that was discussed for the previous implementation, we ran into issues with how the system was designed, located, and how they met the communities needs.

The system as it stands currently is able to provide enough treated water for the community, which is a successful accomplishment for the project. What we unfortunately didn't know going into the project, is that the community wanted a pipe that brought water to the kitchen. Doing this would have required a large amount of construction that we did not have the funds for or the design for. Although we met their water needs, it ended up being difficult for the community to utilize the water all the time due to the sheer weight of the water.

Something that may have helped the design is allowing the community to really express what they want, and having the community design the system, instead of us going in there and looking at what would be most convenient for our limited resources. At the time of the decision for design, the pavilion seemed as if it would give the most water, it had a structurally stable roof, and we decided that members would have to walk because a piping system would be large and complicated. This backfired, as not as many members used the water as we anticipated.

Purchasing Building Materials

When the team arrived in the community, it was apparent that design changes would have to be made, and that these changes could not be done using the materials already purchased. As a result, a return trip to the hardware store needed to be made to purchase the additional supplies. Two other return trips were also made, as even more design changes arose.

The lesson learned here is that plans change almost as soon as implementation begins, and it is impossible to know in advance what changes will be made. Therefore, chapters should be sure to allocate both time and resources for a secondary supply run after their initial purchase, especially if the worksite is located far away from the source of materials. In our case, the nearest hardware store was an hour away by boat, and scheduling a boat ride to the hardware store was a challenge.

Degradation in a Harsh Environment

Upon arrival, it was clear that the environment had a greater impact on the system than anticipated. The straps holding up the gutters had fallen off due to corrosion on the metal screws and clamps. The travel team made sure to purchase galvanized screws when adding more straps. If possible, it is best to avoid corrosive metal and use non corrosive metals (e.g., galvanized, stainless steel) or PVC when applicable.

Scout locations thoroughly for logistical support

The hardware store where we purchased our materials was difficult to work with and despite calling in orders ahead of time, some items, like a 55-gallon drum, were not available, causing the travel team to work with a 40-gallon drum instead. During our assessment trips, it would have been helpful if our team spent a more significant amount of time scouting out different resources for logistical support.

Bringing Multiple Sets of Tools

Bringing multiple sets of tools would have saved a lot of time. Only having one of each tool can cause limitations if there are multiple people who could be using the same the tools doing different tasks. An example of this is that 1 drill meant only 1 tank stand could be worked on at once. Two drills would have allowed two teams to start doing 2 tank stands or different parts of the project. This expense compared to the total cost of the project is very small.

6.0 Project Phase

Project Type	Implementation Continues	Monitoring & Evaluation
Water Storage	No	Yes
Water Distribution	No	Yes
Water Treatment	No	Yes

7.0 EWB-USA Project Monitoring

7.1 Post Trip Follow-Up/Update

Project ID	Project Type	Project Discipline(s) (list all in one cell)	Date of Completion (mm/dd/yy)	Functionality (check one range per project)			Periodic Maintenance (yes or no)	Demonstration of Community Capacity (yes or no)
				0-50 %	51-75 %	76-100 %		
8801	Water Supply	Water Storage, Distribution, and Treatment						

7.2 EWB-USA Project Functionality Indicators

Project ID	Project Type	Project Functionality Indicator	Monitoring Result
8801	Water Supply	Quality of the water at water point	Petrifilm bacteria testing was performed at the water collection points before and after the implementation of the chlorination system. Most water tests from the untreated water from the main tank showed the existence of colonies of non-E. coli coliform bacteria. Some samples showed colonies of E.coli bacteria. While most of the test samples of the untreated water had a relatively low risk of causing disease, the presence of E. coli in some of the samples was sufficient to conclude that treatment was necessary. After implementing the chlorination system, the bacteria tests indicated that the chlorine-treated water contained no colonies of E. coli or non- E. coli coliform. The complete results of the bacteria testing can be found in Appendix D.
		Number of days per month that the system is not operational	According to Ambrosio, the main tanks have never been dry. The tanks usually remain relatively full. During last year's dry season in which a few weeks passed without much rain, the tanks became fairly low, but never went dry. During this dry period, several other commonly used sources for drinking water throughout the community ran dry, so more families relied on the tank at the pavilion.
		Quantity of water available to each household during dry and wet seasons	During the school year, the tanks provide a plentiful supply of water for the 100+ school children and teachers. Water is collected for school use multiple times a day. Several families (5-10) regularly collect water from the pavilion as well. The tanks have never run dry. Most families in the community collect their drinking water from personal rainwater harvesting tanks or natural springs.

7.3 Periodic Maintenance Indicators

Project ID	Project Type	Periodic Maintenance Indicator	Monitoring Result
8801	Water Supply	Existence of broken components	The team observed several broken components in the previously installed system on the pavilion, primarily due to the effects of corrosion. Three of the six gutter-support straps on the side of the pavilion closest to the ocean had broken off. This caused the middle portion of the gutter to detach from the roof. Several sizable leaks existed at the overlap of the gutters, causing puddling on the ground beneath. The first flush drainage pipe had become overgrown with brush, preventing it from draining properly. As a result, the first flush system was non-functional.
		Level of cleanliness of gutters	Primarily due to the non-functionality of the first flush system, a significant layer of sediment had accumulated in the horizontal pipes leading to both of the main tanks.
		Observed evidence of routine maintenance on the system done accurately without EWB-USA	The community leaders told the team that they had cleaned the main tanks twice during the past year. Since the tanks were full, it was difficult to determine the level of cleanliness of the inside of the tank. One of the community members modified the exit nozzle on the left tank by tying a rag around the opening as a way to better direct the flow.

7.4 Periodic Maintenance Indicators

Project ID	Project Type	Community Capacity Indicator	Monitoring Results
8801	Water Supply	Observed method of community members handling and transporting water	The children of the community are primarily responsible for collecting the drinking water for their families. Throughout the week, the children were observed collecting water in the morning and afternoon. Most often, several children would go to collect water from the tanks at the same time, helping each other to fill their various buckets and storage containers.
		Observed method of community members storage of water	The community members stored their water in a variety of different sized bottles and containers. These bottles were portable to facilitate easy carrying from the tank to their home.
		Observed evidence of maintenance on the system done accurately without EWB-USA	The community covered the nozzle of one of the spigots on the main tank with a cloth to control the flow. After installing the chlorine treatment system, the team observed Ambrosio correctly treating the water in the secondary drum on his own after instruction. Ambrosio also constructed a Y-shaped device using a tree branch as a way to support the sagging gutter so that it could be repaired.

8.0 Next Phase of the Program

EWB-RPI plans to return to Isla Popa II in January 2017 to monitor the state of the rainwater catchment and chlorine treatment system. Based on the observations made on the second implementation trip, it appears that the school and the majority of the surrounding families now have plentiful access to clean and safe drinking water as supplied by the system installed by EWB-RPI. If the monitoring trip confirms that the goals of this project have been met, the team plans to close out the project.

Appendices

A.1 Appendix A – Signed Final 903 – Implementation Agreement

Acuerdo de Implementación – EWB-RPI y Isla Popa II (Sandubidi)

Los proyectos del EWB-USA son más exitosos cuando existe una asociación entre las entidades mencionadas a continuación. Cada socio tiene habilidades específicas y conocimientos, que en su conjunto, contribuyen a un proyecto más sostenible a largo plazo.

- **Comunidad** – Junta de agua en la comunidad
  - Administrado por Ambrosio Bekar, Presidente de la comunidad
- **Capítulo de EWB-USA:** Capitulo de estudiantes de Rensselaer Polytechnic Institute

Este contrato es entre el capítulo de Rensselaer Polytechnic Institute de Engineers Without Borders, USA e Isla Popa II para el propósito de establecer guías para el Desarrollo de una fuente de agua limpia en Isla Popa II, Panamá. Las condiciones específicas mencionadas a continuación deben ser incluidas en el Acuerdo de Implementación de EWB-USA. Roles adicionales y responsabilidades identificadas por cualquier socio para el acuerdo podrá ser añadido a la discreción de todos entidades del acuerdo. Este documento tiene que ser firmado por todos para que se pueda comenzar la construcción del proyecto de Desarrollo de fuente de agua limpia en Isla Popa II, Panamá. Los roles y responsabilidades aprobadas en el Acuerdo del proyecto previo se mantiene en efecto en adición a los compromisos descrito a continuación.

<u>**Etapa de Pre-Construcción**</u>

Responsabilidades de Isla Popa II: Ambrosio Bekar

- Proveer 5 % del costo de la construcción capital en efectivo o contribuciones antes de comenzar la construcción. El costo estimado es $71.
- Proveer confirmación escrita que la tierra necesaria para la implementación del Proyecto es propiedad propia de la comunidad antes de comenzar la construcción. Alternativamente, en lugar de posesión, la comunidad debe tener confirmación escrita el derecho del uso permanente de la propiedad.
- Proveer confirmación escrita que tiene derecho legal para usar la reserve de agua que se está desarrollando en este proyecto.
- Contratar 3 trabajadores para 8 horas al día por 3 días para a obra. Estos serán compensados $5 por día completado.
  - El labor será coordinado por Ambrosio Bekar
- Proveer la siguiente lista de equipo y herramientas:
  - Equipo de herramientas y cantidades de cada uno
    - escalera
    - estadía para el capítulo RPI de EWB
    - palas
  - Proveer los siguientes materiales para construcción:

Madera
2x4: 29 tablas, 5 pies (60 pulgadas) largo
3x3: 10 tablas, 2.5 pies (30 pulgadas) largo

Responsabilidades Capitulo Rensselaer Polytechnic Institute de EWB-USA:

- Proveer 95% del costo para la construcción en efectivo antes de empezar el proyecto.
- Proveer representantes cualificados del equipo de diseño durante la construcción para observación y supervisión.
- Comunicar los requisitos de la preparación del lugar para el proyecto antes del comienzo de la construcción. Esto será informado a la comunidad y el socio local 2 meses anteriores a la construcción, o antes depende de las necesidades del Proyecto.
- Proveer la siguiente lista de herramientas requeridas para la construcción:

Destorinilladores, surtido	martillo	Cortador de caja
Taladro electrico con baterias	Sierra para madera	Sierra para pvc
Trozos del taladro	pinzas	Sierra para ojo de cerradura
driving bits	Cortador de tubo	utility knife
Cintas de medir	guantes	probeta
Cargador para bateria	Gafas de proteccion	dropper
tin snips	vice grips	escoplo
nivelador	grapa de maderas	Papel de lija

- Proveer las siguientes materiales para la construcción:

Nombre del material	**Nombre del material**
Barril plastico de 55 galones	3.5 in. clavos galvanizados (por libra)
3/4 in. x 10 ft. PVC grado 40	12 pies cubico de concreto
3/4 in. x 5 ft. Clear PVC Sch. 40	PVC primer violeta
3/4 in. PVC Sch. 40 codo	PVC Cemento
3/4 in. PVC Sch. 40 T	1/4 in. malla acero 2 ft. x 5 ft.
3/4 in. PVC Sch. 40 codo (3 salidas)	1 galon de aceite para madera
3/4 in. PVC union	DPD Almohadas de polvo de reactivo cloro, 10 mL, pk/100
3/4 in. PVC Bulkhead fitting	pH papel, 0 - 14 pH rango, 100/pk
3/4 in. PVC union con rosca	cepillo de limpiar
3/4 in. PVC valvula de bola	6-ft cepillo para tubos largos Heavy Duty
2.8 oz. sellador de silicon	Envase de agua con boca ancha
3 in. Acero inoxidable tornillo	Lamina de metal

Etapa de pos construcción y mantenimiento

Responsabilidades de Isla Popa II: Ambrosio Bekar

- Pagar 100% de los costos para operar y mantener el Proyecto, Desarrollo de agua limpia en Isla Popa II, Panamá. Este costo es estimado ser $65 por año.
- Dinero será recogido por la comunidad para operaciones y arreglos cada mes a través de eventos para recaudar fondos como noches de bingo u otras maneras cada mes. La cantidad recogida según el plan mencionado será $5 por mes.
- El comité responsable de identificar las necesidades adecuadas para el mantenimiento es La junta de agua.
- Este comité será apuntado por el presidente de la comunidad
- El comité servirá en esta posición por dos años
- La junta de agua también será responsable de llevar a cabo el mantenimiento
- Este comité será apuntado por el presidente de la comunidad.
- El comité servirá en esta posición por dos años

Responsabilidades del Capítulo Rensselaer Polytechnic Institute de EWB-USA:

- Desarrollar una operación detallada y un manual de mantenimiento para la comunidad (incluyendo fotos y lenguaje local, como apropiado). El manual tendrá incluido un horario de mantenimiento y costos esperados.
- Proveer supervisión y evaluación del Proyecto, Desarrollo de agua limpia en Isla Popa II, Panamá, para un periodo no menos que un ano pos construcción y mientras que el programa este activo.
- Hacer los arreglos para el proyecto que son resultado por errores en el diseño hasta que estén arreglado.

En adición a las responsabilidades detalladas anteriormente, indique el comité responsable para lo siguiente:

- Coordinación para la transportación de los miembros del equipo de viaje de Rensselaer Polytechnic Institute de EWB-USA será provisto por EWB-Panama.
- Coordinación de los servicios de traducción para los miembros del equipo de viaje de Rensselaer Polytechnic Institute of EWB-USA será provisto por Mariana Cintron y Paul Pagnozzi
- Planificación de la labor por la comunidad será determinado por Ambrosio Bekar. Esto incluye 3 trabajadores de la comunidad por 8 horas al día en el lugar de construcción.
- Adquirir de los materiales para la construcción antes que el capítulo de Rensselaer Polytechnic Institute de EWB-USA llegue serán provistos por Maderas Richards.
- La transportación de materiales será fundado por EWB-USA.

En nombre de, y actuando con la autoridad de los residentes de Isla Popa II y el capítulo de Rensselaer Polytechnic Institute de EWB-USA, el acuerdo de firma para seguir las condiciones mencionadas.

EWB-RPI Representante	**Representante de la comunidad**
Nombre	**Nombre**
Michael Kubista	Ambrosio Bekar
Posición	**Posición**
Project Lead	Precidentes Junta Local
Firma	**Firma**
	Ambrosio Bekar
Fecha	**Fecha**
7 Jan 2016	7-1-2016

A.2 English Translation of 903 Implementation Agreement

Implementation Agreement – EWB-RPI and Isla Popa II (Sandubidi)

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 Ambrosio Bekar, 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 b
elow.

PRE-CONSTRUCTION PHASE

Isla Popa II responsibilities:

- Provide 5 % of the capital construction cost in cash or through in-kind contributions 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.
- Commit 3 paid workers for 8 hours per day for 3 days to the construction site. Workers will be compensated $5 per full work day.
    - Labor will be coordinated by Ambrosio Bekar
- Provide the following list of equipment and tools for construction:
    - List equipment and tools and quantities of each
        - Ladder
        - Residence for RPI chapter of EWB
        - Shovels
    - Provide the following materials for construction:

Lumber
2x4: 29 boards, 5 feet (60 inches) long
3x3: 10 boards, 2.5 feet (30 inches) long

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:

screwdrivers, assorted	hammer	box cutter
electric drill w/ batteries	wood saw	pvc saw
drill bits	pliers	keyhole saw
driving bits	pipe cutter	utility knife
measuring tapes	work gloves	graduated cylinder
battery chargers	safety goggles	dropper
tin snips	vice grips	chisel
level	wood clamps	sandpaper

- Provide the following materials for construction:

Item Name	Item Name
55 gallon plastic drum	3.5 in. Galvanized nails (per pound)
3/4 in. x 10 ft. PVC schedule 40	12 cubic ft. Concrete
3/4 in. x 5 ft. Clear PVC Sch. 40	PVC purple primer
3/4 in. PVC Sch. 40 Elbow	PVC Cement
3/4 in. PVC Sch. 40 Tee	1/4 in. steel mesh 2 ft. x 5 ft.
3/4 in. PVC Sch. 40 3-way elbow	1 gallon of wood impregnating oil
3/4 in. PVC Coupling	DPD Free Chlorine Reagent Power Pillows, 10 mL, pk/100
3/4 in. PVC Bulkhead fitting	pH Paper, 0 - 14 pH Range, 100/pk
3/4 in. PVC Threaded Adapter	Scrubber Brush
3/4 in. PVC ball valve	6-ft Long Pipe Brush Heavy Duty
2.8 oz. silicone sealant	Wide mouth Water Jug
3 in. stainless steel screws	Sheet metal

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.
- 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 Mariana Cintron 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.

Appendix B – 612 – Incident Reports

B.1 James Kilduff

EWB-USA strongly encourages the submittal of Incident Reports in an effort to improve safety measures and learn from past incidents. The Incident Report is to be completed for any health, safety, or security incident(s) that occur during an approved EWB-USA project trip. An incident report should be submitted if any of the items listed below occurs. The Incident Report should be filled out by the Health and Safety Officer(s) or Project Lead(s) and submitted to EWB-USA with the appropriate post-trip report.

Chapter Information			
Chapter Name: EWB-RPI		**Country, Community:** Panama, Isla Popa II (Sandubidi)	
Health and Safety Officers: Timothy Andrews, Mike Kubista		**Project Lead(s):** Kyra Dauwalder	
Person(s) Involved in Incident (Circle "S" for Student, "P" for Professional, "FA" for Faculty Advisor, "HCN" for Host Country National)			
Name: James Kilduff	FACULTY ADVISOR	Name:	S P FA HCN

Incident Type
Date of Incident: 1/6/2016

Incident Type:

- □ Construction Injury
- XX Non-construction Related Injury
- □ Theft / Robbery / Assault
- □ Fatality
- □ Natural Disaster
- □ Fire / Flood / Property Damage
- □ Transportation Incident
- □ Illness
- □ National Event / Political Event
- □ Evacuation / Extraction from Country
- □ Incarceration / Person in Custody / Unable to Leave Country
- □ Other (please explain) ______________________________

Transportation Incident Detail	
Type of transportation vehicle(s) involved: □ Truck □ Car □ Van □ Bus □ Boat □ Aircraft □ Other (Please Specify) ______________________	
Was an EWB-USA travel team member driving the vehicle? □ Yes □ No Did the EWB-USA travel team hire a local driver? □ Yes □ No Name/Company of Operator:	
Incident Notifications	
Was International SOS contacted? □ Yes XX No	Was a U.S. Embassy or consulate contacted? □ Yes XX No
Were Emergency Contacts notified? □ Yes XX No	Was anyone evacuated/sent home early? □ Yes XX No
Was Seven Corners Insurance or the University/College's Insurance contacted? □ Yes XX No	Were the local police notified? □ Yes XX No Was a police report filed? □ Yes XX No
Was EWB-USA Headquarters notified? □ Yes XX No	
Incident Description Summary	

Date of Incident: 1/6/16
Place of Occurrence: Sleeping quarters, Isla Popa II, Panama
Incident Description: While sleeping, James Kilduff was awoken from sleep being stung on the left buttock by a scorpion subsequently identified as Centruroides limbatus (Bark Scorpion, see below). The sting site was inspected by travelling medical personnel. The immediate area was red and warm but otherwise intact; no stinger apparatus was identified. The sting site was treated by application of a paste made of powdered meat tenderizer and water (to deactivate enzymes in scorpion venom) and a clean dressing was applied. He was monitored for the next several hours for local symptoms such as pain or inflammation at the injury site and for any systemic symptoms of venom reaction or anaphylaxis (dizziness, shortness of breath, wheezing, stridor, palpitations or hypotension). He displayed none of these and after a brief period of time the pain at the sting site ceased with no further problems. No further medical intervention was deemed necessary.

B.2 Mariana Cintron

EWB-USA strongly encourages the submittal of Incident Reports in an effort to improve safety measures and learn from past incidents. The Incident Report is to be completed for any health, safety, or security incident(s) that occur during an approved EWB-USA project trip. An incident report should be submitted if any of the items listed below occurs. The Incident Report should be filled out by the Health and Safety Officer(s) or Project Lead(s) and submitted to EWB-USA with the appropriate post-trip report.

Chapter Information	
Chapter Name: EWB-RPI	**Country, Community:** Panama, Isla Popa II (Sandubidi)
Health and Safety Officers: Mike Kubista, Tim Andrews	**Project Lead(s):** Kyra Dauwalder

Person(s) Involved in Incident (Circle "S" for Student, "P" for Professional, "FA" for Faculty Advisor, "HCN" for Host Country National)

Name: Mariana Cintron	STUDENT	Name:	S P FA HCN

Incident Type

Date of Incident:
1/9/2016

Incident Type:

- □ Construction Injury
- XX Non-construction Related Injury
- □ Theft / Robbery / Assault
- □ Fatality
- □ Natural Disaster
- □ Fire / Flood / Property Damage
- □ Transportation Incident
- □ Illness
- □ National Event / Political Event
- □ Evacuation / Extraction from Country
- □ Incarceration / Person in Custody / Unable to Leave Country
- □ Other (please explain) ____________________

Transportation Incident Detail	
Type of transportation vehicle(s) involved: □ Truck □ Car □ Van □ Bus □ Boat □ Aircraft □ Other (Please Specify) ________________________	
Was an EWB-USA travel team member driving the vehicle? □ Yes □ No Did the EWB-USA travel team hire a local driver? □ Yes □ No Name/Company of Operator:	
Incident Notifications	
Was International SOS contacted? □ Yes XX No	Was a U.S. Embassy or consulate contacted? □ Yes XX No
Were Emergency Contacts notified? □ Yes XX No	Was anyone evacuated/sent home early? □ Yes XX No
Was Seven Corners Insurance or the University/College's Insurance contacted? □ Yes XX No	Were the local police notified? □ Yes XX No Was a police report filed? □ Yes XX No
Was EWB-USA Headquarters notified? □ Yes XX No	
Incident Description Summary	

Date of Incident: 1/9/16

Place of Occurrence: Sleeping quarters, Isla Popa II, Panama

Incident Description: While making up her bed, Mariana Cintron was stung on the left index finger by a scorpion previously identified as Centruroides limbatus (Bark Scorpion, see below). The sting site was inspected by travelling medical personnel. The immediate area was red and warm but otherwise intact; no stinger apparatus was identified. The sting site was treated by application of a paste made of powdered meat tenderizer and water (to deactivate enzymes in scorpion venom) and a clean dressing was applied. She was monitored for the next several hours for local symptoms such as pain or inflammation at the injury site and for any systemic symptoms of venom reaction or anaphylaxis (dizziness, shortness of breath, wheezing, stridor, palpitations or hypotension). She displayed none of these and after a brief period of time the pain at the sting site ceased with no further problems. No further medical intervention was deemed necessary.

Appendix C: Bacterial Testing Results

Risk level	E. coli/sample	Colilert fluorescence	Petrifilm # blue & gas
Low	< 1/10ml	negative	0
Moderate	1-10/10ml	positive	0
High	1-10/ml	positive	1 - 10
Very High	>10/ml	positive	>10

Table C.1 - Definition of risk levels

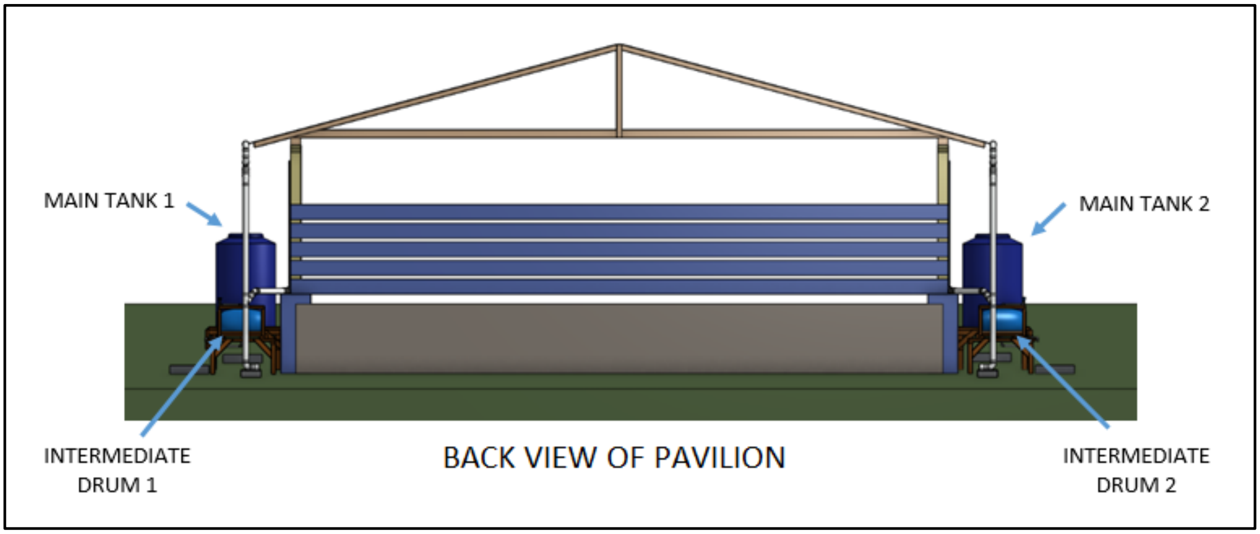

Figure C.1 - CAD drawing of testing locations on the pavilion

Test #	Date - time	Location	Water source	# red & gas on Petrifilm (non-*E.coli* coliform colonies)	# blue & gas on Petrifilm (*E. coli* colonies)	Risk of disease
1	1/5 - 4:47 PM	Pavilion	Main Tank 1 from Spigot	1	0	Low
2	1/5 - 4:54 PM	Pavilion	Main Tank 1 from Spigot	3	0	Low
3	1/5 - 4:40 PM	Pavilion	Main Tank 2 from Spigot	2	0	Low
4	1/5 - 4:40 PM	Pavilion	Main Tank 2 from Spigot	9	0	Low
5	1/5 - 5:00 PM	Pavilion	Main Tank 2 from Spigot w/cloth	0	0	Low

6	1/5 - 4:40 PM	Pavilion	Main Tank 2 from Spigot w/cloth	3	0	Low
7	1/5 - 5:07 PM	Pavilion	Main Tank 1 from Top Opening	7	2	High
8	1/5 - 5:03 PM	Pavilion	Main Tank 1 from Top Opening	2	0	Low
9	1/5 - 5:11 PM	Control Test	Water bottle	0	0	None
10	1/5 - 5:14 PM	Control Test	Water bottle	0	0	None
11	1/7 - 12:38 PM	Pavilion	Main Tank 1 from Spigot	1	0	Low
12	1/7 - 12:41 PM	Pavilion	Main Tank 1 from Spigot	4	0	Low
13	1/7 - 12:30 PM	Pavilion	Main Tank 2 from Spigot w/cloth	12	0	Low
14	1/7 - 12:34 PM	Pavilion	Main Tank 2 from Spigot w/cloth	10	0	Low
15	1/7 - 1:45 PM	Pavilion- Test Sample	Chlorinated 5-gallon Bucket	0	0	Low
16	1/7 - 1:48 PM	Pavilion- Test Sample	Chlorinated 5-gallon Bucket	0	0	Low
17	1/7 - 12:55 PM	Adepesco Hut	Rainwater Tank	10	2	High
18	1/7 - 12:57 PM	Adepesco Hut	Rainwater Tank	20	1	High
19	1/8 - 11:12 AM	Ambrosio's House	Unknown; overly chlorinated	0	0	--
20	1/8 - 11:14 AM	Ambrosio's House	Unknown; overly chlorinated	0	0	--
21	1/7 - 12:19 PM	Pavilion	Fresh Rainwater in Barrel	0	0	Low
22	1/7 - 12:23 PM	Pavilion	Fresh Rainwater in Barrel	0	0	Low
23	1/8 - 11:18 AM	Daniel's House	Rainwater Tank	9	0	Low
24	1/8 -	Daniel's	Rainwater Tank	10	0	Low

	11:21 AM	House				
25	1/8 - 11:26 AM	Osbaldo's House	Rainwater Tank	18	0	Low
26	1/8 - 11:28 AM	Osbaldo's House	Rainwater Tank	22	0	Low
27	1/8 - 5:07 PM	Well	Freshwater Spring	61	3	High
28	1/8 - 5:08 PM	Well	Freshwater Spring	60	5	High
29	1/11 - 11:35 AM	Pavilion	Main Tank 2 from Spigot w/cloth	4	0	Low
30	1/11 - 11:35 AM	Pavilion	Main Tank 2 from Spigot w/cloth	2	0	Low
31	1/11 - 10:08 AM	Pavilion	Intermediate Drum 1 w/10mL Cl solution	0	0	Low
32	1/11 - 10:11 AM	Pavilion	Intermediate Drum 2 w/10mL Cl solution	0	0	Low

Table C.2 - Bacterial test results

Appendix D: Chlorine Dosing Calculations

D.1 Objective

Calculate the amount of chlorine from household bleach required to provide a residual chlorine level of about 0.5 mg/L. The Appendix calculations previously assumed a chlorine concentration of 5.25% or 8.25%; these have been revised to reflect the 3.5% bleach available in Panama.

D.2 References

The World Health Organization recommends a residual chlorine of at least 0.5 mg/L. The WHO recommends a dosage of 2.5 mg/L sodium hypochlorite, the main ingredient in bleach, to yield this desired residual chlorine level, accounting for chlorine demand (1). The 3.5% bleach has a specific gravity of approximately 1.05 according to the OxyChem Sodium Hypochlorite Handbook (2). The WHO recommendation was used to design a set of experiments to confirm the dosage required to achieve an acceptable residual.

D.3 Formula

The 3.5% available chlorine with a specific gravity of 1.05 represents:

$$\frac{3.5 \text{ g available chlorine}}{100 \text{ g chlorine solution}} \times 1050 \text{ g solution/L solution} = 36{,}750 \text{ mg chlorine/L}$$

The desired dosage is 2.5 mg/L. Therefore, the 3.5% bleach must be diluted by a factor of:

$$\frac{36{,}750 \text{ mg/L}}{2.5 \text{ mg/L}} = 14{,}700$$

The 40-gallon drum has a volume (in liters) of:

$$40 \text{ gal} \times 3.785 \text{ gal/L} = 151.4 \text{ L}$$

The dilution factor of 14,700 yields a chlorine solution volume of:

$$\frac{151.4 \text{ L}}{14{,}700} = 0.0102 \text{ L} \quad \text{or} \quad 0.0102 \text{ L} \times 1000 \text{ mL/L} = 10.2 \text{ mL}$$

This dosage was the starting point for several experimental trials to validate the dose-residual relationship for the Isla Popa collected rainwater.

D.4 Testing during Implementation:

Test 1

Dosage testing was done using 5-gallon buckets; an initial test was done by dosing 1.4 ml of the 3.5% bleach solution. Results are shown in Table D.4.1 below. The measured demand was 1.28 mg/L yielding a residual of 0.55 mg/L.

Table D.4.1 - Testing Day 1 Results

Bleach (mL)	Gallons	Dosage	Total CL	Demand	Free CL	Combined
1.4	5	2.5 mg/L	1.22 mg/L	1.28 mg/L	.55 mg/L	.75 mg/L

Test 2

A second round of testing involved adding 0.5 mL of bleach to two different 5-gallon buckets every 30 minutes. The results are tabulated in Table D.4.2. Ideally, the free residual data after breakpoint chlorination would exhibit the same increment as the dosage; i.e., increasing the dosage by 1 mg/L would increase the free residual by the same amount. The data are not consistent with this expectation. However, they do confirm a free residual on the order of 1 to 2 mg/L for a dosage in the range of 2 to 3 mg/L, within WHO and EPA recommended limits.

Table D.4.2 – Testing Day 2 Results

Bleach(mL)	Dose(mg/L)	Total 1(mg/L)	Total 2(mg/L)	Free 1(mg/L)	Free 2(mg/L)
0.5	.93	0.71	.3	0.63	ND
1	1.85	1.47	+++	1.93	+++
1.5	2.84	2.43	1.53	2.39	1.27

ND: Not determined. The “+++” indicates a photometer over-range error.

Test 3

The 40-gallon chlorination drums were tested using the 2.5 mg/L dose. Results are shown in Table D.4.3. These results confirm the free residual of 1 to 2 mg/L for the 2.5 mg/L dosage, confirming that the results obtained in the 5-gallon buckets can be applied to the 40-gallon drums.

Table D.4.3 – Testing Day 3 Results

Sunday 8:30 AM	Bleach (mL)	Dose (mg/L)	Total (mg/L)	Free (mg/L)	pH
Drum 1 – Filled 18 Gallons	5.6 ml	2.5 mg/L	2.13	1.33	X
Drum 2 – Filled 18 Gallons	5.6 ml	2.5 mg/L	1.88	1.78	6.8
4.5 Gallon Bucket	1.4 ml	2.5 mg/L	1.72	X	X

Test 4

The tests were repeated on the 40-gallon drums after the system was completed. Results are shown in Table D.4.4. These results confirm a residual ranging from about 1 to 2 mg/L for an applied dosage of 2.5 mg/L (10 mL of 3.5% bleach in the 40-gallon drum).

Table D.4.4 – Testing Day 4 Results

Sunday Night	Bleach (mL)	Dose (mg/L)	Total	Free
Test 1	10	2.5	3.6	2.3
Test 2	10	2.5	2.6	2.3
Test 3	10	2.5	1.32	X
Test 4	10	2.5	1.26	1.06
Test 5	10	2.5	1.38	1.11

The pH of un-chlorinated water was about 6, slightly higher than expected for water in equilibrium with the atmosphere. Chlorinated water was around 6.8, consistent with the basic properties of sodium hypochlorite, and in an acceptable range.

D.5 Conclusion

The chlorine residual ranged from 1 to 2 mg/L when a dosage of about 2.5 mg/L was applied. The residual is above the WHO recommended residual of 0.5 mg/L, and below the maximum concentration of 4 mg/L as recommended by the EPA. The pH level of the water was acceptable to use for chlorination.

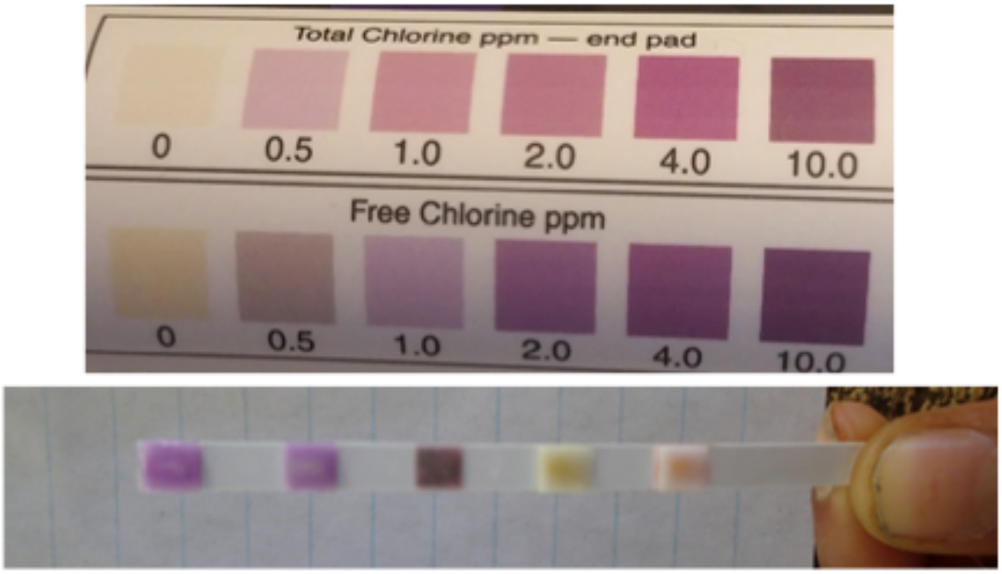

Figure D.5.1 - Example strip after a chlorinated water test. The light pink/purple on the left indicate a range around 2.0 mg/L. The left most one is total while the second left is free chlorine.

D.6 Community Provided Material

We left the community with information to help them treat the 40-gallon rainwater collection drums the travel team implementation, as well as for 5-gallon buckets, which many households have for their own use. The community can now easily dose their chlorine based on the charts and easily measureable numbers. If they do not get enough rain to fill up the entire drum, they are still able to dose partial quantities.

The travel team changed the chlorine dosage for the 5-gallon bucket to 1.5 mL from 1.35 mL. There was no significant change in the total or free chlorine between 1.35 mL and 1.5 mL. Furthermore, it is easier for community members to measure.

The following information was translated into Spanish and given to the community:

Water Chlorination with 3.5% bleach

40-Gallon Drum

Drum Mark	Volume	Bleach
¼ Quarter	10 Gallons	2.5 ml
½ Half	20 Gallons	5 ml

¾ Tree Quarters	30 Gallons	7.5 ml
1 Full	40 Gallons	10 ml

Water Testing – Do once a month and record
- Dip strip in water, shake for 30 seconds
- Compare the purple color to the color on the bottle. The levels should be between 0.5-4. Ideally they should be 1-2.
- Keep strips as dry as possible. Seal the bottle tight

Instructions for Dosing a Full Tank
- Fill up to full if possible. Then take the water from the 40-gallon drum, mix it with the 10 mL of bleach, and pour back in at the top. Wait 30 minutes for consumption

Dosage for 5 Gallon Bucket
- 1.5 mL

D.7 References

(1) Bob Reed. “Measuring Chlorine Levels in Water Supplies”. *World Health Organization*. 2011.

(2) “Sodium Hypochlorite Handbook”. *Occidental Chemical Corporation.* December 2014.