Clean Water Supply System for Quebrada Pinzón

Bocos Del Toro, Panama

Introduction

Quian Designs (QD) is a group of four Civil and Environmental Engineering undergraduate students from Michigan Technological University's 2015 International Senior Design Program. QD traveled to the remote Ngöbe community of Quebrada Pinzón in the province of Bocas Del Toro, Panama in August 2015 in order to assess the existing water supply and distribution systems within the community.

Figure 1: Map of Bocas del Toro, with the location of Quebrada Pinzón

Community Overview

Census Information (2013)

- 37 houses with 220 residents
- 36% illiterate
- Monthly income average: 144 Balboas (144 USD)
- 6th grade education on average

Historical & Cultural Dynamics

- Biocomunidad Project site
- Family units valued over organized committees
- Main source of income: Cacao & Banana farming
- Second Peace Corps volunteer: Briana Arnold

Objective

This project focused on providing access to basic water infrastructure and potable water to the 'Las Delicias' section of the community. The main tasks were to:

- Evaluate the feasibility and reliability of a ram pump (Alternative 1) and a rainwater harvesting system (Alternative 2)
- Recommend a final design based on technical and social constraints including cost, constructability, and responsibility within the community

Methods

Surveying: A land survey was performed between the three structures in 'Las Delicias' of concern in order to determine the placement of a tank and pipe networks. This was performed using a tape, Laser rangefinder and Garmin GPS.

River: A survey of the river was performed in order to determine the velocity and slope of the river. This information was then used to calculate the available energy and flow rate of the river (Figure 2).

Water testing: Quality of the river water and rainwater was tested using 3M Petrifilms (Figure 3).

Figure 2: River Site

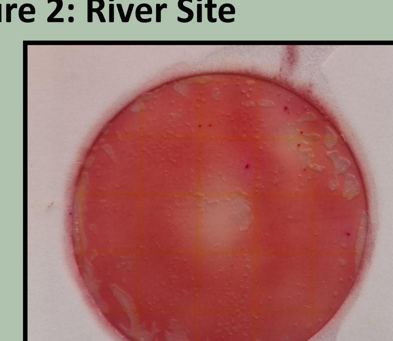

Figure 3: 3M Petrifilm

Data Analysis

Surveying: An elevation profile between the three structures in 'Las Delicias' was generated using the collected data (Figure 4).

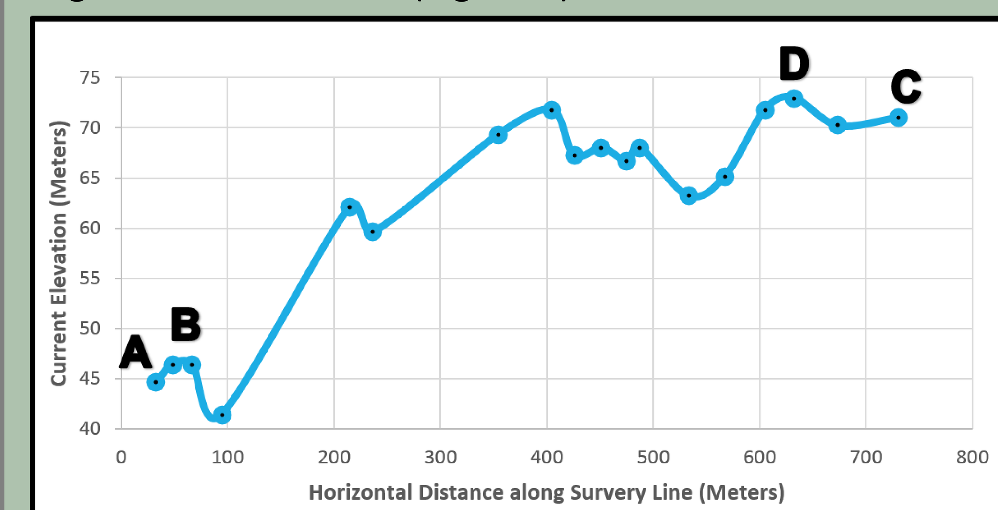

Figure 4: Elevation Profile of Las Delicias. (A) Structure A, (B) Structure B, (C) Structure C, (D) Proposed Tank Location

Month	Reliability (%)	Normal Demand (gallons)	Dry Day Demand (gallons)
January	100	120	110
February	100	110	70
March	100	110	70
April	100	110	50
May	100	130	100
June	100	150	80
July	100	150	130
August	100	150	80
September	100	80	40
October	100	80	60
November	100	80	60
December	100	180	110

Table 1: Storage Analysis & Adjusted Demand for 100% Reliability

Storage and Reliability Analysis: Monthly rainfall data from 2000–2012, along with demand, was used to produce Table 1 which shows the reduced water demand needed to ensure 100% reliability of the rainwater harvesting system for Structure B.

EPANET Demand Patterns: The demand pattern of the system was modeled on a 24-hour cycle. Two demand patterns were created to replicate the daily demand fluctuations of the system.

- Peaks are modeled to occur at these times because the people in Quebrada Pinzón generally take two showers a day: one in the afternoon, the other at night.
- Water use was assumed to begin at 6 a.m. and end at 10 p.m.
- Times were based on QD's onsite experiences and Peace Corps Volunteer's observations

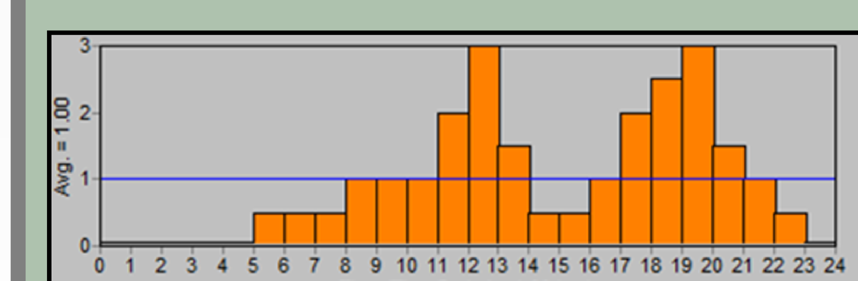

Figure 5: Building B and C water demand, weekday

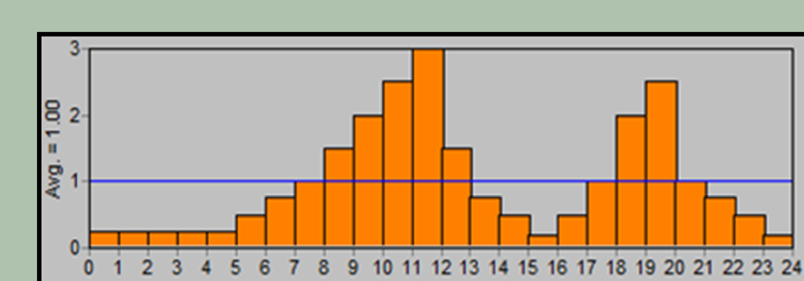

Figure 6: Building A, B, and C demand, weekend

Alternative 1: Ram Pump Network

Hydraulic Ram Pump: A hydraulic ram pump utilizes the falling head differential & velocity of an elevated water source to pressurize a system and overcome significantly larger head value.

System Highlights:

- 500 gallon storage tank located at the highest point of the ridgeline
- Two alternating check valves operating at over 100 cycles/minute
- 10% of input water volume is outputted
- No external power necessary as energy is induced by gravity and flow rate

System was not chosen because of (1) High construction cost, (2) Failure of pump will cease all water supply to storage tank and community, and (3) High maintenance requirement

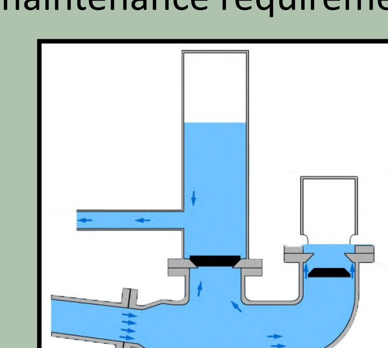

Figure 7: Section View of Ram Pump Schematic

Alternative 2: Rainwater Harvesting (Final Design)

This alternative comprises individual rainwater harvesting systems for each structure.

System Components: All system components and a potential design for a two story house are show in Figures 8 through 11.

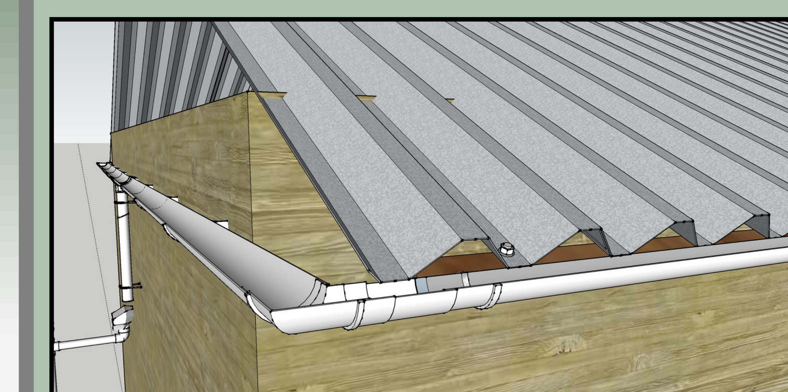

Figure 8: Collection system using PVC gutters

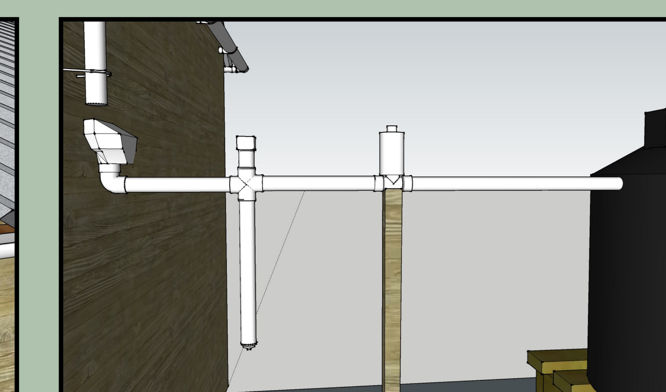

Figure 9: Self-cleaning filter, first flush system, in-line chlorinator & storage tank

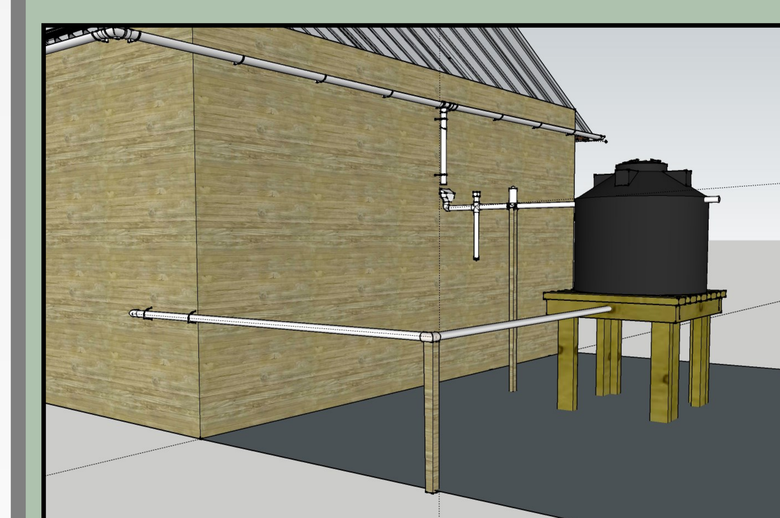

Figure 10: Complete Design View

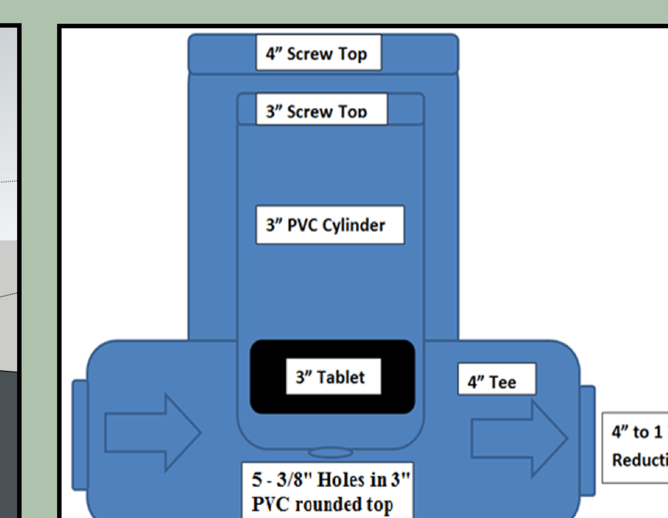

Figure 11: In-Line Chlorinator

Cost Estimate

A full list of materials and costs for the proposed system are displayed in Table 2. Costs were determined from local sources and US manufacturers of the self-cleaning filter and first flush system. Shipping from the US will be done in bulk for multiple systems.

Construction Schedule

Material shipment & system construction is expected to take 24 days. This time can be reduced down to 14 days if weather and construction delays do not occur or increased labor efforts.

Table 2: Cost Estimate for Structure B

Component	Cost ($)
300 gallon plastic tank	300
Metal Protection Band	18
PVC Gutters	54
Self-Cleaning Filter	30
First Flush System	30
In Line Chlorinator	25
Calcium Hypochlorite Tablets	40
Labor ($/day)	42
Shipping from US	40
Total Cost	**≈$600**

Recommendation

After collecting data and analyzing the needs and desires of the community, the rainwater harvesting alternative was determined to be more feasible, reliable, cost effective and an easily maintainable system. Individual ownership of these systems allow for high scalability and future implementation in other structures of the community. Most importantly, this system will provide clean water which is fit for drinking and cooking as compared to the ram pump system which will provide non-potable water.

Quian Designs

Team Members: Nicholas Wienold, Roshni Sachar, Surbhi Thakur, Jeremy Mack

Advisors: David Watkins, PhD, PE; and Michael Drewyor, PE, PS

Acknowledgements: Dr. Brian Barkdoll, Briana Arnold (PCV), and the Community of Quebrada Pinzón

Michigan Tech

Fall 2015

International Senior Design Project

Department of Civil and Environmental Engineering