Michigan Technological University
Department of Civil & Environmental Engineering

Quebrada Arena Community Water Distribution System
Cerro Piedra, Panama

International Senior Design
FALL 2013

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Trip Background

Cerro Piedra, located in the Ngöbe-Buglé Comarca of western Panama (Figure 1), is home to the Quebrada Arena community. During August of 2013, Yucca Engineering travelled to the community to perform an assessment and feasibility study. The goal was to assess the current water situation and gather data on the community's needs and wants concerning a water supply system. Upon return to the United States, Yucca Engineering began designing a water distribution system in order to supply the Quebrada Arena community with safe and reliable drinking water.

Figure 1: Ngöbe-Buglé Comarca of Western Panama. Cerro Piedra is denoted by the star.

Community Background

The Quebrada Arena Community lies within the Ngobe Bugle region and is surrounded by large mountains which isolate several nearby communities. For nearly 200 years, the community has resided in the Ngobe-Bugle region and today is comprised of nearly 300

- 30 Households
- Approximately 240 members
- 50% under age of 15
- Subsistence Farming
- Primary Education
- 3-4 Month Dry Season
- 7-8 Month Wet Season
- Commonly eat; rice, beans, yucca, chicken
- Clothing is mostly homemade
- Walking is primary form of transportation

Current Water Situation

- Location of Source
  - Women of children hike long distances to get water for bathing, laundry, and consumption (Figure 2).
- Water Quality
  - Untreated agricultural runoff and bacteria contamination are leading to health issues in children and elders.
- Fluxes in annual water availability
  - During the wet season, several springs provide water to community members.
  - During the dry season, only one spring provides water but at a very minimal rate.

Figure 2: Layout of community households and chosen source with retains flow year round.

Data Analysis

Survey of proposed pipeline route (Figure 3) was conducted via the use of an Abney level and GPS. Using this data, elevation profiles were constructed to determine the feasibility of a water distribution system.

Figure 3: Survey route of proposed pipeline.

Microbial assessment was performed at the chosen source to identify the presence of bacterial contamination. Based on results obtained from 3M Petrifilm counts (Figure 4), Bacterial contamination was identified, indicating the need for treatment.

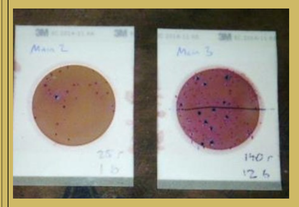

Figure 4: 3M Petrifilm counts taken at the source.

Flow measurement was conducted using the volume-time method at the chosen source (Figure 5). This was performed to determine the ability of the source to provide water to the community throughout the year.

Wet season = 60 GPM

Dry Season = 1 GPM

Figure 5: Yucca Engineering performing flow analysis.

Design

Based on conclusions made from the data analysis, a water distribution system was determined to be the most appropriate improvement for the Quebrada Arena Community and will provide easily accessible, disinfected water to all community members (Figure 6).

Pipeline: The largest and most costly component of the system is the polyvinyl chloride pipe (PVC). Each service line leading to a tap stand will be ½". Implementation of higher rated pipe such as SCH 40 PVC would not hinder the system if chosen but was avoided due to high costs.

- SDR 26
  - Low Cost
  - High Pressure Rating
- 3.6 miles
  - Over 900m elev. change
- In accordance to Figure 6
  - 0.5" is Green
  - 1.0" is Blue
  - 2.0" is Red

Pressure Release Tanks: Due to the 300 meter drop in elevation between the source and the lowest house, large pressures throughout the system may cause harm to pipes and faucets. To alleviate the high pressures encountered in the pipeline, six pressure break tanks are recommended.

Storage Tank: To allow time for disinfection and storage during the night, a 9 m^3 storage tank will be constructed after the spring box.

- Concrete Block walls
- Stores 8m^3 Water
- 1 m^3 air
- Res. Time of 2.8 hrs.

Spring Box: To provide the initial capture of the system's water, a standard spring box will be constructed:

- Provides Protection and Initial Capture of Water
- Constructed of Concrete Walls
- Offers primary treatment through gravel and sand filter
- Excess Water will return to original path of travel

Gully Crossings: Due to the extreme changes in elevation surrounding the community, gully crossings will need to be constructed (Figure 7).

- 2 Suspension Bridges
  - Easy Constructability
  - Low Cost
- 1/8" Steel Cable
- 1 m^3 concrete anchors at each end
- 2" Casing Pipe to protect main pipeline from
  - UV Deterioration
  - Animal and Human Travel

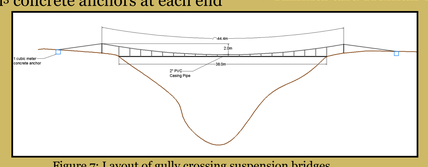

Figure 7: Layout of gully crossing suspension bridges.

In-Line Chlorinator:

- Constructed of 4" PVC Tee (Figure 8).
- 3" Capsule inserts into Tee
- Capsule contains calcium hypochlorite tablets

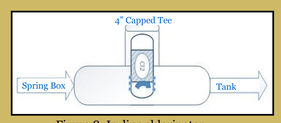

Figure 8: In-line chlorinator.

Tap Stands: There will be 32 tap stands constructed within the system, one at each household. These will consist of 1/2" PVC pipe with a metal faucet at the end. The pipe will rise up through a concrete column reinforced with rebar and will have a concrete splash pad to limit erosion.

Figure 6: Proposed water distribution system with labelled components.

Cost Estimate

The total cost for construction of the aqueduct system was estimated at $13,000. This cost accounts for all members of the design, as well as transportation of materials (Table 1).

Table 1: Cost estimate of the proposed system broken into components.

Spring Box (1)	$950
Storage Tank (1)	$1,230
Tap Stand (32)	$1,465
Pressure Break Tanks (6)	$740
Bridge Structures (2)	$655
Pipeline (3.6 miles)	$5,070
Air Release Valves (5)	$30
Transportation of Material	$1,000
Total Cost (+10% Contingency Cover)	**$12,254**

Construction

The construction schedule for the design has been estimated at 6 months and assumes a crew of 5 laborers and 1 Peace Corp Volunteer. With dry seasons lasting only 4 months per year, construction will need to be divided into two dry seasons to avoid wet season work.

Acknowledgements : Christopher Kingsley, PCV : Jacob Midkiff, PCV : Zoe Miller, Graduate Student Trip Mentor

Yucca Engineering

International Senior Design 2013
Jack Ammerman, Environmental Engineering
Victoria Leveille, Environmental Engineering
Jennifer Robinson, Chemical Engineering
Nathan Zgnilec, Civil Engineering