# Document 525
# Pre-Implementation Report

CHAPTER: Rice University
COUNTRY: Nicaragua
COMMUNITY: Sadrach Zeledon
PROJECT: Sadrach Zeledon Water Distribution System
TRIP TYPE: Implementation

PREPARED BY

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# Pre-Implementation Report Part 1 – Administrative Information

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

| Project Title | Name | Email | Phone | Chapter Name or Organization Name |
|---|---|---|---|---|
| **Project Leads** | Rachel Sterling | res5@rice.edu | (630)290-9029 | Rice Student |
| | Edgar Silva | eas5@rice.edu | (832) 272-2667 | Rice Student |
| **President** | Adrian Bizzaro | acb6@rice.edu | (908)397-8192 | Rice Student |
| **Responsible Engineer in Charge** | Hilda Espinoza | | 8855-8022 | |
| **Traveling Mentor** | Tyler Nading | Tyler.Nading@CH2M.com | (573)270-0996 | Houston Professional |
| **Faculty Advisor (if applicable)** | Pedro Alvarez | alvarez@rice.edu | (713)348-5903 | Rice University Professor |
| **Health and Safety Officer** | Travel Member* | | | |
| **Assistant HSO** | Travel Member* | | | |
| **Education Lead** | Travel Member* | | | |
| **PMEL Lead** | Travel Member* | | | |
| **In-country Community Contact** | Sonia Vasquez | yaosca2007@yahoo.es | 50588444855 | Community |
| **In-country NGO Contact** | Roberto López | | 8740-2170 | ENACAL |

**Our travel team has not yet been chosen. This will be done after implementation approval. Once chosen, their contact information will be provided.*

 

## 2.0 Travel History

| | Dates of Travel | Trip Type | Description of Trip |
|---|---|---|---|
| Lucidia Mantilla (LM) Bridge Project | **08/01/11 - 08/08/11** | Assessment | Conducted meetings with the local municipality and the community to draft MOU for Lucidia Mantilla bridge construction. Conducted surveying of river profile to enhance data provided by local engineers. |
| | **01/03/12- 01/10/12** | Assessment | Obtained further river analysis, conducted health survey in community, conducted water quality analysis, conducted meetings with the community, and signed MOU with local government. |
| | **05/04/12- 05/25/12** | Implementation | Finished anchor excavation and construction, material collection, towers and wall construction, cut cables, finished cable sag set, decking and fencing, and approach ramps. Bridge construction completed. Met with community members and discussed potential projects. Community's priorities are water distribution system, electricity, public lighting, and black water system. |
| LM Water Project | **12/13/2012 - 12/21/2012** | Assessment | Surveyed for water pipeline project, met with government and community leaders, ENACAL, signed MOU. |
| | **08/15/2013 - 08/23/2013** | Implementation | Installed pump, control system and tanks. Performed hydraulic testing on the system and searched for a new project. |
| Sadrach Zeledon Water Project | **1/4/14- 1/11/14** | Assessment | Gathered technical information from the community Sadrach Zeledón, previous projects were monitored, met with government/community/ENACAL and signed the MOU. |

## 3.0 Travel Team (Should be 8 or fewer):

| # | Name | E-mail | Phone | Chapter | Student or Professional |
|---|---|---|---|---|---|
| 1 | Rachel Sterling | res5@rice.edu | (630)290-9029 | Rice Student | Student |
| 2 | Edgar Silva | eas5@rice.edu | (832) 272-2667 | Rice Student | Student |
| 3 | Tyler Nading | Tyler.Nading@CH2M.com | (573)270-0996 | Houston Professional | Professional |
| 4 | Travel Member* | | | | |
| 5 | Travel Member* | | | | |
| 6 | Travel Member* | | | | |
| 7 | Travel Member* | | | | |

**Our travel team has not yet been chosen. This will be done after implementation approval. Once chosen, their contact information will be provided.*

## 4.0 Health and Safety

The team will follow the site-specific HASP that has been prepared for this specific trip and has been submitted as a standalone document along with this pre-trip report.

## 5.0 Planning, Monitoring, Evaluation and Learning

**5.1 The travel team has reviewed the 901B – Program Impact Monitoring Report template and has assigned travel team members to complete this report during the upcoming trip. We acknowledge that the completed 901B is required with the eventual submittal of the 526 – Post-Implementation Trip Report. _X_ Yes ___No**

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

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

**5.3.1 Please see Appendix A: MOU**

## 6.0 Budget

Please see Appendix B: 508 – Trip Budget Worksheet

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

**Water Supply**
____ Source Development
__x_ Water Storage
__x_ Water Distribution
____ Water Treatment
__x_ Water Pump

**Sanitation**
____ Latrine
____ Gray Water System
____ Black Water System

**Structures**
____ Bridge
____ Building

**Civil Works**
____ Roads
____ Drainage
____ Dams

**Energy**
____ Fuel
____ Electricity

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

**Information Systems**
____ Computer Service

## 8.0 Project Location

**Latitude:** 12.55 N
**Longitude:** 85.55 W

## 9.0 Number of People

**Number of persons directly affected:** 1,200 people
**Number of persons indirectly affected:** 1,700 people

## 10.0 Professional Mentor Resume

Please see Appendix C: Tyler Nading's Resume.

# Pre-Implementation Report Part 2 – Technical Information

## 1.0 Executive Summary

The Rice University chapter of EWB is constructing the Sadrach Zeledon Water Distribution System (Project ID 9212).

The purpose of this document is to receive approval to implement in January 2015. The proposed final design for this system is described in detail with full calculations (Appendix D: Calculations) and drawings (Appendix E: Drawings) for the hydraulic, structural, and electrical components of the water distribution system.

The main goal of this project is to construct a water pipeline and distribution system for the community Sadrach Zeledon. This system will include an upstream and downstream pipe network, a pump station, a pump control system, and storage tank facilities. This water distribution system will be constructed in the community of Sadrach Zeledon, located in the mountains surrounding Matagalpa, Nicaragua. The community consists of approximately 1,200 people divided into 170 households. The community is generally centralized with little spacing between each lot. The current method of receiving water for community members, is via water trucks which deliver stale and unsanitary water. The Rice University chapter aims to provide potable water to each residents lot, thus improving the health and wellbeing of the community and the residents' quality of life.

The in-country contact is the Chief Engineer Roberto Lopez of ENACAL. In the community, the main contact is Sonia Vasquez, one of the community leaders. The team has a Memorandum of Understanding (MOU), which was signed by ENACAL (the Nicaraguan national water company), the Alcaldia (the local government), the community, and the Rice team during the assessment trip in January 2014 (Appendix A: MOU).

Since the program opened in August 2011, two projects have been successfully completed- a cable suspended pedestrian bridge and a water pipeline and distribution system. Both of these projects were completed in Lucidia Mantilla. Five trips have already been made within this program- three assessment trips and two implementation trips. Following the completion of the team's last implementation trip for the Lucidia Mantilla water distribution system, the community members of Sadrach Zeledon approached the team about the construction of another water distribution system, expressing intentions to pay for metering of potable water from their homes, if such a system existed.

Several calculations and drawings have been completed in order to adequately design this water distribution system for the community. and storage facility. Beyond standard hydraulic, structural and electrical calculations, the team also put a major focus on expansion given an anticipated increase in migration into the community. The team used the UN national growth rate of Nicaragua (1.4%), and a safety factor of 5 to calculate an expected growth rate of 7%. This was used throughout the design process to ensure the system designed would serve the community for several years to come. All calculations can drawings can be found in Appendix D: Calculations and Appendix E: Drawings.

In accordance with the signed Memorandum of Understanding, ENACAL, with the help of the community, will lead the construction of the proposed water distribution system. Further, ENACAL will be responsible for transporting all materials, as well as installation of pipes in accordance with the design, water measurement systems in the homes, and the tanks in the community. The community of Sadrach Zeledon will be in charge of trenching, and providing help in the form of manual labor for the installation of the pump and pipes. Additionally, the community will be providing skilled labor for the masonry and construction needs the two facilities to be built. The role of the Rice EWB team is to provide clear designs to the aforementioned groups for all construction, as well as fund and implement all components of the pump station (control system, piping and pump). The Rice University team will also provide technical help where needed.

Once built, ENACAL will own and maintain the system, while the community will be in charge of paying ENACAL for metered water and forming a committee that will manage the piping usage of the community. Rice EWB will be available for technical help for up to two years after the finalization of the project.

## 2.0 Program Background

Since its establishment in August 2011, this program has successfully completed a cable suspended pedestrian bridge, as well as a water pipeline and distribution system within the nearby community of Lucidia Mantilla. Currently, the team is working with the community of Sadrach Zeledon, where a lack of clean and reliable water is the prominent cause for concern. The team has already taken one assessment trip for this project and has prepared several designs with the final draft presented in this report.

 

# 3.0 Facility Design

## 3.1 Brief Description of the Proposed Facilities

The proposed facilities include 1) a pump station, 2) a pressurized upstream pipeline to a 3) storage facility with six 22,000L tanks, and 4) a network of downstream pipelines from the storage facility. The following is a description of each design. Calculations and drawings can be found in section 6 and 7, respectively.

Additionally the team has taken new growth rate information into account. Once this community gains access to water, it is expected that many families will move into the community. The team has estimated community growth using the national annual growth rate of Nicaragua (1.4%[1]) and multiplying by a safety factor of 5 given recent growth. This method for calculating population is applied to each component of the system and is described in full in the subsections to follow. Calculations for population growth can be found in Appendix D:  Calculations. A summary of those calculations are as follows:

| | **Comments** | **Value** |
|---|---|---|
| Current population: | Given by community | 1,200 people |
| Growth rate utilized: | $1.4\% \times 5$ | 7% |
| Max population current system can hold: | Given 8 tanks, 24 gallons/person/day | 1,937 people |

[1] https://data.un.org/CountryProfile.aspx?crName=NICARAGUA

### 3.2 Description of Design and Design Calculations:

Please see Appendix D Hydraulic, Structural and Electrical Calculations

#### 3.2.1 Pump Station Design Overview

The proposed pump station will house the following:

- A 15-hp 8 stage Gould's pump
- An Programming Logic Controller (PLC)
- Appropriate pressure sensors
- A variable frequency drive (VFD)
- An electrical box
- Relevant valves and piping for the pump
- An Air release valve
- Ball and check valves (two of each)

These design decisions were made through calculations and discussion e=with ENACAL to ensure the Rice University system would be compatible with current ENACAL designs. Calculations for pump sizing can be found in Appendix D: Calculations. Further, the team decided to go with a PLC and variable frequency drive system after determining this to be the preferred control system set up for the electricians at ENACAL. The PLC will be programmed like a timer to the pump on at the same time every night, pumping water to the storage tanks at a time when the water source is mainly unused. The PLC will turn the pump off after the storage tanks have reached a full level, as indicated by the amount of time the pump has been running or by pressure readings on the pressure indicators. The control system is further described in the electrical section (3.2.5).

The pump station will be constructed out of Concrete Masonry Unit (CMU) and mortar. The pump station will be 5.75m x 2.55m (40 CMU block perimeter) and 2.40m (12 CMU blocks) tall and reside on a 5.80m x 2.60m and 0.20m tall 3,000-psi concrete base. The pump station will also contain a 1.80m x 0.80m hinged reinforced sheet metal door on the side with a padlock for security. The entire station is enclosed, and designed to be weatherproof. The station will have a reinforced slanted sheet metal roof to prevent collection of precipitation. A 1.00m x 0.40m and 0.50m tall concrete base within the station will elevate the pump as a precaution if waterproofing is poorly implemented and precipitation collects on the floor of the facility. A concrete thrust block will support a 90-

degree turn in the discharge/outlet pipeline. A 0.50m x 0.15 m concrete skirt will be placed underground to prevent erosion from compromising the soil base of the foundation.

The team sized up the pump from an acceptable 7 stage 15-hp pump to and 8 stage pump to account for future growth in the system and ensure a new pump will not need to be purchased in the next 15 years. Additionally, the PLC and VFD are expected to last at least 15 years, given that an increase in population does not add stress to either component.

### 3.2.2 Upstream Pipeline Design Overview

The team has decided to use a 3 inch diameter pipe while pumping 5.5 hours per day at a flow rate of 85-90 gpm. To determine desired flow rate, pipe diameter and total dynamic head for the future, the team estimated the future population of the community using a 5 year growth model. Five years was chosen for upstream due to the understanding that beyond five years growth is somewhat unpredictable given the capacity limits of the community itself. The growth rate used took an acceptable intermediate value between the average growth over the past two years and the average growth rate of Nicaraguan cities. The current population of our community is roughly 1200 people and we estimate the number to be 1680 in 5 years. The growth rate the team used was 7%, using the average Nicaraguan growth rate of 1.4 % times a safety factor of five. Currently averaging 24 gallons of water per person per day and pumping time interval of 5.5 hours throughout the night, gives a desired flow rate of 88.1 gpm. Therefore, the team maintains the flow rate of the pump at 85 - 90 gpm.

The team decided to use a 3-inch diameter pipe because this guarantees the pipe will operate under a safe and low noise condition resulting from the velocity of flow that is approximately 3.906ft/s. This gives a corresponding total dynamic head of 386 ft. As population grows, minor changes would need to be made. The pump's optimal flow rate is 90 gpm, and with a population of 1680, a pump run time of only 5.5 hours would not sufficiently reach capacity. Because of this, as population increases, the pumping time would need to be increased, from 5.5 hours to 7.5 hours throughout the course of five years. It should be note that the pump is capable of pumping for a maximum 9.5 hours given the suction pressure available and the minimum suction pressure the pump can run at. Thus, although the team used a 5 year model, the system will be able to withstand a much larger capacity. While the decision is up to the community and ENACAL after the 2 year agreement, the team is making this recommendation due to its sustainability and proximity to maximal pump efficiency.

### 3.2.3 Storage Facility Design Overview

The water storage facility will house five 22,000 L high-density polyethylene (HDPE) tanks designed for drinking water applications, manufactured by Rotoplas. Each tank will be anchored to a 3,000 psi reinforced concrete foundation of dimensions and design specified by the American Concrete Institute (ACI), and the five tanks will be interconnected in parallel with flexible tubes provided by Rotoplas to allow for flow between tanks and adequate drainage of the entire reservoir. All piping will only be exposed within the facility's walls. Water will be fed into the tanks via the pressurized upstream pipe from the pump station, and water will drain from the tanks in a gravity-fed downstream pipe into the downstream network.

The entire facility will be enclosed: three sides will be constructed of Concrete Masonry Unit (CMU) blocks and mortar, and the fourth side will be constructed of sheet metal service door large enough to move the tanks in and out of the structure when necessary. The sheet metal wall will be reinforced with a steel frame. This door will also be elevated 6" off the ground in order to allow ample drainage. This door will be secured with a lock. The structure will not have a roof. The facility will be 9.1m x 17.25m (22 CMUs x 42 CMUs) and the CMU walls will be 2.4m (12 CMUs) tall. This height corresponds to two thirds of the height of the tanks. CMU walls will be appropriately reinforced with both vertical and horizontal bond beams every 1.2 meters, except where a gap is indicated. This will enclose a total of 8 storage tank concrete foundations. The facility will initially house 6 storage tanks and the other 2 pads will allow the facility to be expanded for the future population expansion..

Given the communities expected growth rate, the team designed the storage facility for future increase in capacity needs. Five tanks will support the current population of 1200, serving up to 1211 people. However, working with a growth rate of 1.4% and a safety factor of 5 (~7%), an additional tank will need to be added within two months. Therefore, our recommendation is to include six tanks in the original construction.

Six tanks will support 1453 people and will support the population for 2.8 years. The storage facility has additional concrete pads for a total of eight tanks in the case that more water storage is needed. After 2.8 years, another tank will need to be added for a total of seven tanks, which will provide water for 1695 people. After 5.1 years, an eight tank will need to be added, which will provide water for 1937 people. Our eight-tank system will accommodate community expansion for 7.1 years.

Additional tanks will be purchased by ENACAL and the community who have both committed to all funding required by community expansion. It should also be noted that the land acquired for this project is capable of expansion of the storage facility, if that is in fact needed in the future.

#### 3.2.4 Downstream Network Design Overview

The downstream network consists of 2” diameter pipe (SDR 26). The network starts as one pipeline out of the south end of the storage facility, and proceeds to divide into 12 pipelines (Appendix D: Calculations). Nine isolation valves allow for maintenance and stability of the system. Additionally, T’s will be installed throughout the downstream network for ENACAL to connect the system to individual homes.

Given the communities expected growth rate, the team designed the downstream network for long-term expansion. This is done by strategically placing valves throughout the downstream network to allow for construction without interfering with the rest of the water distribution system. Expanding any of the pipelines would require trenching and laying pipe were new habitation occurs. This will be the responsibility of ENACAL and the community to determine because direction of growth cannot be predicted. Additionally, the MOU for this project limits the responsibility of the Rice University team to only the pump station.

#### 3.2.5 Electrical Design Overview

The electrical design is based on the existing power found in the community of Sadrach Zeledon, Our design requires a 1 phase, 240 V, and 74 amp power supply. The team will be using a programmable logic controller (PLC) by Siemens to control the pump. Additionally, an variable frequency drive (VFD) has been selected in order to transform from single phase to three phase for the three phase pump. This system will be enclosed in a NEMA-2 enclosure in order to protect the system from any water, or weather damage. A circuit breaker will be connected to the device in order to protect the system. The line coming from the grid will have a conduit to protect it from any damage resulting in electrical surges. All electrical installation will be conducted by ENACAL and overseen by the Rice University team.

There will be 2 inputs to the PLC, both of which will be pressure sensors. One will be located at the suction end of the pump and the other at the discharge. The suction pressure sensor turns off the pump if there is not sufficient amount of pressure to avoid cavitation. The discharge pressure sensor turns off the pump if the pressure indicates the tanks are full. There will be two timers that will be in charge of operating the pump. The first is a timer delay. The delay is needed because of a large pressure surge created when the pump first turns on. This pressure surge exceeds the allowable pressure for the discharge sensor. To avoid the pump shutting off and on and potential system damage, a delay will be installed to override all pressure readings for the first 5 minutes that the pump is on. After the 5 minute start time, the pressure sensors will resume priority in controlling the pump.  Our second timer will serve as an indicator of allowable pumping times. The pump will function during the night (11pm – 5:30 am), when the water supply to the station is at an optimal level. Nonetheless, the pressure sensors will override the timer after the initial start time to avoid the tanks over-filling during the night. All electrical installation will be conducted by ENACAL and overseen by Rice EWB.

As the community grows and more storage tanks are added, the PLC can be programmed to run for longer hours in order to fulfill the increasing demand for water. Given the current population, the system is set to run from 11 pm to 5:30 am, for a total of 5.5 hours. Looking into the future, given the available water pressure in the pipeline being tapped into, the maximum amount of time the pump can run is 9.5 hours. This, combined with the minimum pump capacity of 85GPM allows the system to serve 1938 people with the pumping time as the limiting factor. There are no other components of the electrical system that will lose functionality due to population increase. Given a safety factor of 5 and a population growth rate of 1.4% (~7%), this will last at least 15 years.

### 3.3 Drawings:

Please see Appendix E: Drawings, for all Hydraulic, Structural and Electrical drawings.

### 3.4 Names and Qualifications of Designers:

| Name | Student or Professional | Qualifications | Work Done |
|---|---|---|---|
| Tyler Nading | Professional | Civil engineer for CH2MHill | Supervised and checked all drawings and calculations |
| Kyle Shepherd | Student | Junior level student in Civil Engineering, AutoCAD training, Intern at Finfrock | Structural Calculations AutoCAD Structural Drawings |
| Ryan McKnight | Student | Senior level student in mechanical engineering, AutoCAD training, Intern at Nelson Architectural Engineers | Upstream pipeline calculations and review of drawings |
| Kathleen Francis | Student | Sohpomore level student in bioengineering, AutoCAD training | Downstream pipeline AutoCAD drawings |
| Lindsey Witte | Student | *Senior level student in chemical engineering, AutoCAD training* | Downstream pipeline AutoCAD drawings |
| Run Jiang | Student | Sophomore level student in electrical engineering, AutoCAD training | Downstream pipeline AutoCAD drawings |
| Lucas Bizzaro | Student | Sophomore level in Biomedical Engineering, AutoCAD and Spanish Training | Downstream pipeline AutoCAD drawings and calculations |
| George Zhu | Student | Sophomore level in mechanical engineering. Pump | Pump Selection, Find distributor in Nicaragua, Pump |

| | | | |
|---|---|---|---|
| | | Team Lead. Fluent in AutoCAD. | station design, Pump station AutoCAD |
| James McCreary | Student | Sophomore level in Chemical Engineering | Pump Selection, Pump Station Calculations |
| Anqi Sun | Student | Sophomore level in mechanical engineering. AutoCAD drawing | Upstream Pipeline, calculation and AutoCAD drawings |
| Megan Kehoe | Student | Sophomore level student in bioengineering, AutoCAD training | Storage facility design and AutoCAD |
| Michael Donatti | Student | Junior level student in Mechanical Engineering | Hydraulics Team Leader, Downstream P&P |
| Edgar Silva | Student | Junior Mechanical Engineer, Travel Team Member | Coordination of CAD drawings and electrical calculations |
| Nikhil Shamapant | Student | Sophomore Bioengineer, Travel Team Member | Participant in CAD drawings and calculation |
| Aida Castillo | Student | Sophomore Material Science Engineer | Participant in calculation |
| Samuel Soyebo | Student | Sophomore Electrical & Computer Engineer | Participant in CAD drawings |

### 2.1 524 - Draft Final Design Report Comments

The Rice University team has thoroughly addressed all the comments that were provided to the chapter during the review of the 524 – Draft Final Design Report.

Please see Appendix F: Peter Waugh's Comments.

The team did decide not to proceed with adding hydraulic grade lines to any downstream lines. Based on what the team has previously seen in the last water project for the community of Lucida Mantilla, where water was able to reach all the homes by gravity, a hydraulic gradient line was considered but deemed unnecessary for the downstream network of the team's current project. A hydraulic gradient profile for the downstream network would require the team to consider all the cases for which water is being used by each of the pipelines, which could become am unnecessarily complex task for our current design.

Nonetheless, a hydraulic grade line can be found for the upstream pipeline.

## 3.0 Project Ownership

Upon completion of implementation, the Rice University team will proceed with proper transfer of knowledge to ENACAL and the community water committee, both of which will resume co-responsibility for the operation and maintenance of this project.

More specifically, the community water committee will be responsible for organizing funding for major purchases, coordinating expansion with ENACAL and reporting any maintenance needs.

ENACAL will be responsible for providing professional technicians to perform regular maintenance on the system, as well as responding to maintenance requests by the community water committee. They will also be responsible for designing any system expansion in future years.

All land, facilities and components to the project are owned by ENACAL who will hold a key to these facilities. They are the national water company and serve as a public function in this region. Additionally, the Rice University team will also have an additional set of keys.

The system has been designed to run automatically, thus there is no need for an operator. The only operation costs to be incurred are that of the electricity draw from the pump. This cost is folded into the meter price of water for each resident.

 

## 4.0 Construction Plan

The majority of construction is to be completed by ENACAL and the community. This includes all trenching, pipe laying, facility construction and installation of tanks. The community will be providing skilled masonry labor and an additional 20 people for each day of construction. ENACAL will be providing professionals to lay the pipeline and will oversee construction while the Rice team is not in country. Additionally, they will transport materials as needed.

The Rice University team is solely responsible for installation of the pump and relevant piping in and out of the pump, as well as overseeing proper installation of the programmable logic controller (PLC) and variable frequency drive (VFD). This will be completed during the proposed January 2015 Implementation trip.

To ensure progress before the team travels, the Rice University team will be receiving weekly construction updates via call and pictures sent. Additionally there is a hard deadline of November 22nd for all upstream pipes and main downstream pipes to be laid, 90% of facilities constructed and for a plan to be put in place for installing tanks. These deadlines have been communicated to the community and ENACAL. If they are not met, the Rice University team cannot, with confidence, purchase tickets for implementing in January and will postpone travel until necessary construction is complete.

Please see Appendix G: Construction Plan for gantt chart of construction plan.

## 5.0 Materials List and Cost Estimate

Our project total cost is $76,284.08. This includes all materials and travel, as well as a 15% margin for error to be conservative.

Please see Appendix H: Material List and Cost Estimate for cost break down.

## 6.0 Operation and Maintenance

Upon completion of this project operation and maintenance will be assumed by ENACAL and the community water committee.

The system has been designed to run automatically. Therefore there is no operation plan needed. Operation costs, namely electrical costs due to power draw from pump motor, is folded into the cost of metered water. Thus, this cost is taken on by community members. It should be noted that the price of water will be the same as it is currently and is heavily subsidized by both ENACAL and Alcaldia. Since the price is water is no different than the price they already pay for truck water, the Rice University team is not concerned with the communities ability to pay for the operation of the system or to obtain newly provided water.

Regular maintenance of the system will be conducted by ENACAL, as well as responding to maintenance requests made by the community water committee. The committee is formed to maintain water distribution system by collecting funding and organizing efforts for system expansion and communicating maintenance needs to ENACAL. The following are potential replacement needs of the system:

- Replacing the pump
- Replacing ruptured pipes
- Expanding the systems downstream pipeline network

The pump can be purchased from the original vendor Bomohsa. Bomohsa is located at “Kilometro 3 carretera sur, semáforos el Guanacaste, 10 vrs. Este, contiguo a Gasolinera Uno, Managua, Nicaragua”. The main contact is George Jude Faraj Musleh. The Rice University team will ensure communication is started between George Jude Faraj Musleh and the lead ENACAL engineer for this project, Hilda Espinoza. A new pump will cost around $7,000. For the first two years, this purchase will fall on the Rice University team. However, following monitoring and close out this purchase will fall on the community and ENACAL to purchase. Given the communities ability to collect over $10,000 for the current project, the Rice University team is confident in both the community and ENACAL’s ability to raise these funds.

For ruptured piping the purchase will fall on ENACAL, who will also install the new pipeline. Two and three inch pipe can be found at any local hardware store within Matagalpa. For system expansion, new pipeline will be purchased by the community. The pipeline will be laid by a professional from ENACAL.

The team has created several operation and maintenance manuals for the system. These can be found in Appendix I: O&M Manuals. Attached are copies in English, however the team has also developed Spanish equivalents to deliver to the community water committee. During the planned implementation trip a large portion will be devoted to teaching community members and ENACAL engineers of the system, ensuring a proper transfer of knowledge.

## 7.0 Sustainability

### 7.1 Background:

The major sustainability issue for this project is the rapid growth rate of the community. When traveling in January 2014, the team talked with community leaders who described the community’s large influx of families due to the recent installation of electricity. There is an extensive amount of land still available, leading the team to believe there will be any even greater increase in families once water is available. This poses a problem for sustainability because an increase in capacity needs requires additional storage tanks, larger facilities, longer run time for the pump and in the far off future a larger pump.

### 7.2 Organizational Capacity of the Community:

The community has established a water committee out of their own initiative that is responsible for overseeing the construction, operation, and maintenance of our project. This community holds meetings on a weekly basis that are scheduled by the committee head, Sonia Maria Hernandez. The committee has been in charge of making sure that the all the labor necessary for the construction of the system will be carried out by the community members and providing updates to our chapter in the form of pictures on a weekly basis.

### 7.3 Financial Capacity of the Community:

The Water Committee of Sadrach Zeledon has set up a bank account, with the help of ENACAL, where funds will be collected from all community members.

The facilities are designed to be automatic and therefore should have a minimal and negligible service cost overall. When considering the expansion of the community we determined the number of people our current system can hold. With the addition of two tanks in a future implementation phase to be carried out by the community and ENACAL the system will be able to serve 1926 people. With the current population growth rate in Nicaragua of 1.4% and a safety factor of 5 this system will be able to serve the community for at least 7 years. It should also be noted that given a static growth, the system itself is structurally capable of serving the community for over 15 years.

Additionally, it should be noted that although there is room for growth in the community now, the team does not expect this high growth to maintain for many more years because the community's available resources cannot support such growth. This has been taken into consideration during the team's design process and has been expressed both to the community and the water company of Nicaragua. The main operational cost associated with the facilities will be the cost of electricity that will come at a subsidized cost as dictated by the municipal government. This cost is folded into the cost of water and will thus be paid for by the community members. The price of water will not change from what the community currently pays, as it is subsidized by ENACAL and the municipal government, thus there is no concern of an inability to pay.

Regarding the control system, ENACAL will cover the ongoing operations and maintenance costs. This will include repairing individual components of the system. The manufacturer guarantees the control system used for the project for at least one year. During this time the Rice EWB team will also be available to assist the community and ENACAL with design advice in the case that there is a problem. Two year after final implementation, Rice EWB will not be responsible for maintaining the water system. ENACAL and community should be prepared to cover the costs of replacing or maintaining the control system.

Please see the Operation and Maintenance section for further discussion of the of the sustainability plan for maintenance repairs and associated purchases.

### 7.4 Technical Capacity of the Community:

While the community itself has no knowledge of control systems or pumps, ENACAL is in close partnership with the community for the ongoing operation and maintenance of our water system. ENACAL has agreed to provide service to the system at no cost, which includes any inspection or service needed by the system.

### 7.5 Education:

The team is implementing a design that is almost entirely automatic. Due to this automated design the team will not need to educate the community on daily usage of the system. Rather the team will focus education efforts on identifying possible maintenance concerns early on and getting proper assistance to fix problems in the system. For the engineers at ENACAL assigned to this project, little education of the system is needed as they have had several years of experience working with similar systems and are the ones who will be installing it. We will make sure that they fully understand our system before installation, and during our travel, our team and professional mentor will provide some education to them. The notable difference in this design from local Nicaraguan systems is the use of pressure switches instead of float valves to indicate when the tanks are full. Nonetheless, the rest of the system, including the PLC the team plans to implement, are all components that ENACAL is familiar with and use in their own systems.

## 8.0 Site Assessment Activities

Given the nature of this trip the team does not plan to carry out any specific assessment activities. Activities that might fall under this category and will be carried out include health surveying, to ensuring success of the implemented water distribution system in regards to improving community health. Additionally, upon arrival, the team will assess the state of the project as it stands and will ensure pipes laid, structures built and tanks installed were done so correctly. Beyond this, the team will focus only on implementing the components of the pump station (pump, controls and associated piping), as well as appropriate transfer of knowledge for the community and ENACAL.

# 9.0 Professional Mentor Assessment

## 1.1 Professional Mentor Name and Role

The professional mentor is Tyler Nading, professional engineer with CH2M HILL who specializes in water treatment process, hydraulics, and controls. Tyler has provided oversight throughout the project and participated in the assessment trip. Tyler is the responsible engineer in charge of both the design and the implementation. He also served as the mentor for last year's pump project in Lucidia Mantilla.

## 1.2 Professional Mentor Assessment

The project team has gained excellent knowledge and experience through the Lucidia Mantilla project and is leveraging this on the current project for Saldrach Zeledon. The Lucidia Mantilla project was a success, but the project team had to work through many obstacles throughout the project, including sourcing the equipment in country, purchasing materials in the community, working with ENACAL, designing a control system that ENACAL is comfortable with, and securing power for the pump station. This year's project was designed with solutions to these problems in mind which has led to a much smoother design.

This EWB team has over 25 students that actively participate in the project and have set up the team to have technical leads, facility leads, management leads, and project engineers, much like our company does for our projects. It is efficient, engaging, and empowering and is a model of success for EWB student chapters. The project leads have been able to distribute the work as well as facilitate learning across the group.

Based on the knowledge gained from last year's trip, the design progress made this year, and the improved communication with the in-country team members, this team is ready to lead a successful implementation trip. I look forward to another successful implementation by this Rice EWB team.

## 1.3 Professional Mentor Affirmation

I acknowledge involvement in this project and I accept responsibility for the course this project is taking.