WATER DISTRIBUTION IN QUEBRADA PASTOR, BOCAS DEL TORO, PANAMA

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December 2015

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Executive Summary

AquaVenture traveled to Quebrada Pastor, a village of 800 people in the Bocas del Toro region in Panama, in August 2015. AquaVenture was tasked to analyze the largest water distribution system in Quebrada Pastor that is currently serving 30 homes, the school, a church, and a small business. The Peace Corps Volunteer in Quebrada Pastor requested an as-built survey of the system and recommendations to improve the pressure and distribution throughout the system as some houses do not receive water every day. She identified the school as the biggest priority for water as it benefits the most amount of people in Quebrada Pastor.

AquaVenture completed an as-built survey of the entire system while on site in August, 2015. Since then, they have used that data to create an EPANET model of the system that helped identify problem areas within the system. Community interviews were also conducted while on site in order to better determine the needs of the community and some of the societal and cultural constraints of the project.

AquaVenture identified three areas for improvement of the current aqueduct system; water supply and quality, system control, and lifespan of the system and have compiled their recommendations in this report. Water supply is suggested to be supplemented by rainwater catchment at the school. Overall water quality can be improved through the sealing of *toma* 2 and the installation of a first flush system for the rainwater catchment tanks. System control can be increased through the placement of an additional 13 ball valves. To increase the lifespan of the system, the degrading metal support at the first stream crossing should be replaced with a masonry block design. For each stream crossing, carrier pipes should be utilized. In order to support the line and prevent pipe separation, where it travels up the steepest incline of the entire system, the main line should be clamped to 2.5" PVC T connections mounted in concrete footings. Painting of exposed PVC would limit damaging UV rays, which would also improve the lifetime of the system.

INTRODUCTION

Community Background

Quebrada Pastor is located in the Bocas del Toro Province in the northwestern portion of Panama (Figures 1 and 2). Quebrada Pastor is home to a Ngöbe community of approximately 100 homes and over 800 people. The community boundaries have been drawn to include the homes that send their children to the primary school located in the center of the community. Another community, Quebrada Pitti, to the southwest, has its own primary school but sends their children to the secondary school in Quebrada Pastor as well. Attendance for primary and secondary school varies, and students who travel from the top of the hill cannot arrive safely when the streams are swollen after large amounts of rainfall events. Students who wish to pursue a college education after high school can travel to Almirante, but most students in the community do not. There are two churches in the community and three major denominations within the population. The Evangelical church is connected to the aqueduct, whereas the other church, the Church of Christ, is not. A small portion of the community practices a Ngöbe-specific interpretation of Christianity. Religion plays a large role in the lives of community members and affects social circles within the community.

Sources of income vary; however, many community members own fincas, which are small pieces of property used for farming. The most prominent crops grown in the community are yucca, cacao, and bananas. The Bocas Islands are a large tourist destination where many of the community members sell their goods and products such as cash crops. Additionally, Quebrada Pastor is divided by the two lane Chiriqui Grande-Changuinola highway, giving many people easy access to Almirante, 15 km down the road, to sell their goods. There is a cacao cooperative in Almirante that helps ensure people are getting fair prices for their chocolate products. Almirante also offers other forms of employment through the tourism industry or through security firms working at the port.

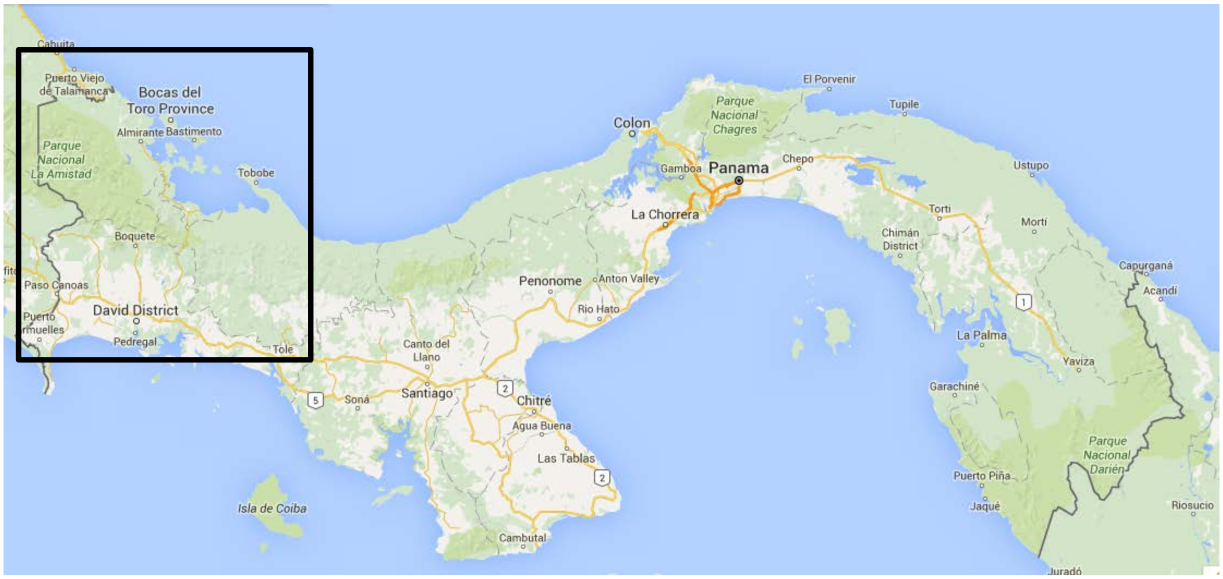

Figure 1: Map of Panama- Google

Figure 2: Bocas del Toro Region

Aqueduct Background

The government funded an aqueduct project in 2002, allowing the school to get a steady supply of water. Many of the members of the current water committee were part of the original construction, along with many parents of the school children. Having water at the school benefits the largest portion of the community because many families send their children to the school. The project was originally constructed to service 8 to 10 connections, including the school. The current system operator was involved in the original construction and was one of the original residential connections. His knowledge of the aqueduct has been beneficial in trying to maximize the number of people served and balancing the quantity of water supplied on a daily basis. A sealed, concrete spring box around the spring source and three 1,000 gallon tanks were part of the original system. A second spring source was added to the system three years ago, with a spring box built and funded solely by the community. The community refers to these spring boxes as *tomas*. The second *toma* was built to supplement the flow of water from the first, as the current system started to lack the supply needed to meet growing community demands.

The Water Committee

The water committee, or *directiva*, is the governing body of the aqueduct. AquaVenture put a top priority on understanding the water committee and how they operate, and determining the level of ownership within the system in order to design the most effective solution to the problems identified. It is known that if systems are donated to a community, they tend to lack a sense of ownership and are less likely to maintain the system and operate it efficiently.

The water committee is composed of six roles including a president, treasurer, secretary, rule enforcer, representative and operator. The president plans and schedules work days, and defines the water bill and fine amounts. The secretary is the master record keeper for the aqueduct and keeps a record of all missed payments, work day attendances, and fines. The treasurer manages money for the operation and maintenance of the system, and she collects monthly water bills and fines. The residents that are on the aqueduct pay $3 per month. If a resident's water bill goes delinquent eight days after the second missed monthly water bill, then their water supply is cut. The Peace Corps Volunteer (PCV) in Quebrada Pastor ensured AquaVenture that people do actually get their water shut off if they do not pay. The school is not required to pay a monthly water bill, as the system was originally built to supply them with water. The representative informs users of work days to clean the storage tanks, and other general overall system maintenance. There is a $5 fine for those who choose not to attend work days. The *fiscal*, which translates into public prosecutor in English, is the rule enforcer of the system. There are fines in place for those who are overusing or wasting water or those who have breaks in their system but do not report them to the operator for repair. The *fiscal* has yet to issue fines to anyone. However, during surveying, AquaVenture did observe one house with a broken line that was using a stick to stop the flow of water. The last person associated with the water committee is the operator. The operator is the maintenance man for the system and has the only paid position, receiving $20 per month to perform repairs. The operator is also in charge of opening and closing control valves to ensure that the school receives water.

After interviewing each member of the water committee, AquaVenture concluded that this is a highly functioning committee and all members seem to realize the importance of doing the jobs that their positions demand of them. These individuals were elected into the positions that they are in, and many seem to enjoy and take pride in their positions. According to the treasurer, all residents were paid up on their water bill at the time of the interview. One issue noted was the lack of participation on work days. Some people would rather pay the fine than spend the day hiking up to and cleaning out the tanks.

Problem Statement

Quebrada Pastor's thirteen year old aqueduct system is no longer as efficient or reliable as the original design and does not have the ability to meet current or future system demands. Initially servicing eight to ten connections and the school, the system now services 30 homes, the Evangelical church, a small business, and the school. Though the system is still functioning, the supply of water to all connections is variable and unreliable because the system was not designed to service the additional 20 connections that have been added. To help alleviate some of the variability in the system and ease repairs, there needs to be an increase in controls valves in order to allow for the system to be shut off at multiple points. Other problem areas were identified and the three categories of design that AquaVenture chose to focus on are as follows: water supply and quality, system control, and lifespan improvements of the system.

DATA COLLECTION AND ANALYSIS

Surveying

AquaVenture was asked to complete and as-built survey of the current aqueduct system. Ground distance and angles of inclination or declination were measured with the range finder or the abney level and tape. As requested by the PCV, the distances would be measured in metric units, for ease of use by her and the community, and for purchasing local supplies. Roughly 260 GPS data points were taken which will illustrate the path of all the water lines and services from a plan view.

The location of the line was determined by members of the community who assisted AquaVenture during surveying. They cleared brush, made paths, and helped mark where the unexposed portions of the line were. Two sticks marked at eye height (1.76 m) were used to ensure the same rod height. If the point was especially difficult to sight, a cardboard piece covered in shiny duct tape was used to help the rangefinder take a reading. One crew member then walked down the line looking for any major changes to be the next point, usually taking points every 10-15 meters. An example of surveying can be seen in Figure 3. The key points surveyed included valves, junctions, or changes in pipe diameters. The tap heights in houses, the school, and the church were all measured, and a GPS point was also taken. Sometimes spiders, trees, plants, or treacherous terrain changes affected the location of the next point, and therefore turning points were used. The raw survey from the field book can be found in Appendix B.

Figure 3: Field Surveying Techniques

Elevations were calculated from an initial GPS reading on top of the first *toma.* From the angle of inclination or declination and hypotenuse, the vertical change was calculated as

$$Vertical = Hypotenuse * sin(\theta)$$

This vertical measurement was then added to the elevation of the point before it to ensure that all elevations were from the same reference plane.

Figure 4 shows a profile view of the changes in elevation of the main water line from the spring boxes, the highest point in the system, to the lowest point in the system, slightly past the school. There are two water crossings, which are low points in the system and have been marked on the elevation profile. The first one is located before the storage tanks and the second at the lowest point in elevation in the system. The second water crossing has a steep grade on either side that contributes to a large amount of head and extra stress on the system. The weight of water in the pipes also has affect the strength and reliability of the pipes and pipe connections.

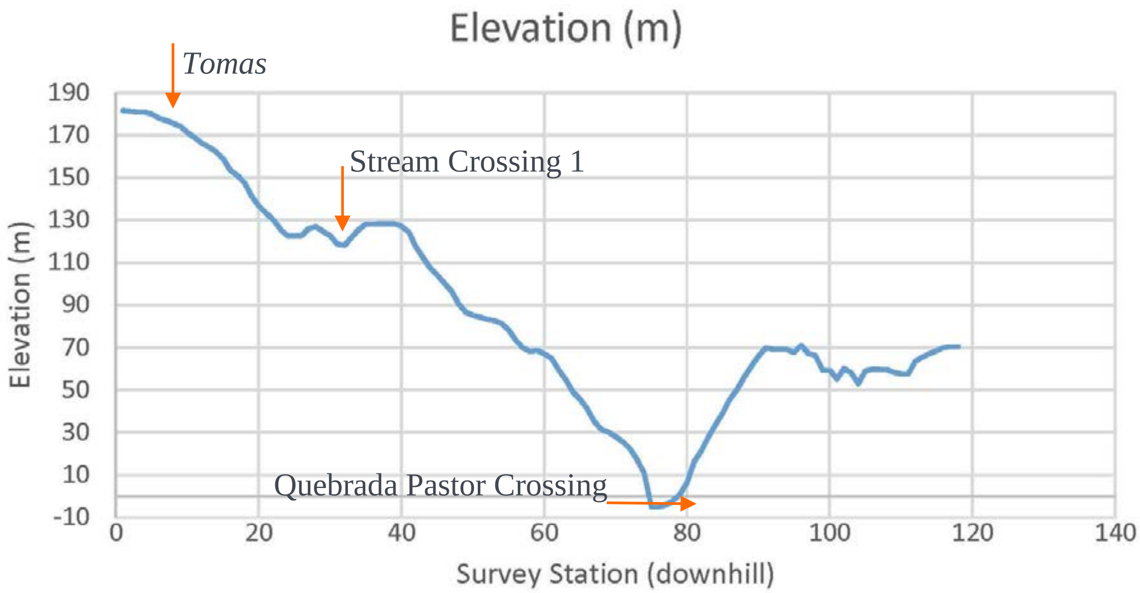

Figure 4: Elevation Profile of Main Transmission Line

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Interviews

Interviews were conducted with the assistance of the PCV to obtain information on the number of residential users per home and uses of water within each home. The survey sample includes 16 of the 30 connections served, with interviews from each branch of the system. Table 3 provides a summary of the data collected for users per household in addition to data provided by the PCV [1]. According to the data collected, the average number of users per home is approximately 5. The most common uses of water included cooking, household cleaning, laundry and bathing. Many users reported daily incidences where there was no water available from the aqueduct, with some homes going numerous days without water. Rainwater catchment for individual homes was sometimes used as a supplement, and some homes stored water in buckets from the aqueduct in case it ran dry at some point during the day. Nearby streams were sometimes used to bathe and wash clothes, in addition to aqueduct use. It was rare that users had flush toilets; many reported use of pit latrines and a few composting latrines. Two community members were able to give estimates of daily water use at 40-50 gallons per household per day.

Table 1: Residential Water Use

Residential Connection:	Users per home	Use of water storage	Rainwater catchment	Other Comments
OB	5	Y	N	
RS	5	N/A	N/A	
AC	1	Y	Y	Where PCV lives
JS	7	Y	Y	
HP	5	Y	Y	Sometimes goes weeks w/o water
MC	8	Y	Y	Don't currently have water, but pay to. Have gone months w/o service
YA	3	N	N	
IB	2	Y	N	
RA	5	Y	N	
EB	6	Y	N	
DA	12	Y	Y	
RB	2	Y	N	Estimates ~40gal/day use
WB	5	Y	Y	Estimates ~50gal/day use
MB	5	Y	Y	Use flush toilet
FL	9	Y	N	
JS	4	Y	N	
MB	2	Y	N	Water is sometimes turbid and has odor
Average Users Per Home: 5				

Other information on water use and the system itself was collected through interviews with each member of the water committee, the school principal, women who work at the school, and the system operator. Interviews with the water committee provided information on the duties of each position, conditions for water users, and ideas for improvements within the system. The operator provided 4 current locations for valves that control the aqueduct; one located at the first and second *toma*, one by the church and one by the school. The operator additionally expressed a desire for more valves in order to increase control over the system. For example, he wishes to see the installation of valves directly before and after the 1,000 gallon storage tanks, and after specified T-connections near the road and along the highway. He explained that currently he closes valves at certain times of the day. For example, he might close a valve 6pm and open it back up at 7am in order to supply enough pressure to the system. He also described trouble areas in the line in terms of lack of pressure as well as locations of pipe breaks. Overall, the system operator sees that the major issues to address including replacing pipe, covering exposed areas, and adding more valves.

The interview with the principal of the school aimed to better understand the dynamics and water demands of the school. The interview revealed that 305 students attend the school, 165 of which account for the primary classes. The students are served a snack and a lunch with ingredients provided by the government. Meals involve water use which strengthens the need for adequate water supply at the school. For example, the snack called *Crema Nutriva* comes in five pound bags that require 14 Liters of water to make. The principal stated that the school uses five bags a day, putting water use for just the snacks for primary school at 350 liters, or about 93 gallons/day. Sanitation infrastructure that requires water use includes flush toilets and handwashing stations, but not all are functioning or in use. A brief conversation with the operator for the school revealed that when there is not much water, they only open valves from 7-9am and 1-2pm to cook and flush toilets.

A new project, funded by the electric company that ran lines through the community, involves the construction of one new shower and two toilets, both of which are expected to be serviced by the aqueduct. The maintenance staff at the school gave an estimate of water use of 800-1000 gallons per day for these facilities. The principal hopes that the school can have a reliable supply of water in order to meet what she sees as top priorities of providing students with sanitation and meals. A group of women that work at the school gave a different perspective of improvements to the system in regards to exposed pipe being damaged. They suggested teaching all students, especially those who walk alongside the line on their way down to school, not to play on or break the pipes and to promote water conservation.

Interviews were important in determining some of the cultural and societal constraints of the project. The final recommendations for the project took these constraints into account and the construction schedule was based upon observations of how community members operate and work together. Getting to know the members of the community and their daily routines allowed AquaVenture to make realistic recommendations and an appropriate construction schedule for the project.

EPANET

A model of the current aqueduct in Quebrada Pastor has been created using the survey data and EPANET [5]. EPANET is a water distribution system modeling software developed by the EPA. AquaVenture used EPANET to model the gravity water distribution system for Quebrada Pastor and all its components, including reservoirs, tanks, pipes, valves and taps. All of the elevations, distances and water demands collected during the field survey were used to create the model of the entire system as seen in Figure 5. In addition, a daily water demand pattern curve was created in order to more accurately represent the demand throughout a 24 hour period, as seen in Figure 6. It should be noted that the demand pattern is an approximation of the uses throughout the day and is not based on any collected data. Upon running the model, it outputs the pressure, flow rate, head loss and demand at any point in the system. This is useful in determining where and when the stresses occur in the system. A full layout of the system in EPANET can be seen in Appendix A. From the model it was determined that *toma* 1 and 2 deliver enough water to the tanks such that the tanks never empty completely. In addition, all the water taps in the system should have adequate pressure suitable for the water demands placed on them. The model does not include factors such as unknown leaks, cracks and separated pipes. Some of the leaks and breaks were identified while conducting the field survey, but much of the pipe is buried and it is not possible to identify the condition of the pipe. These factors have the potential to affect the outcome of the model including pressure, flow rate and headloss. Therefore the model should be used as a tool for making improvements to the system, but not as an exact representation.

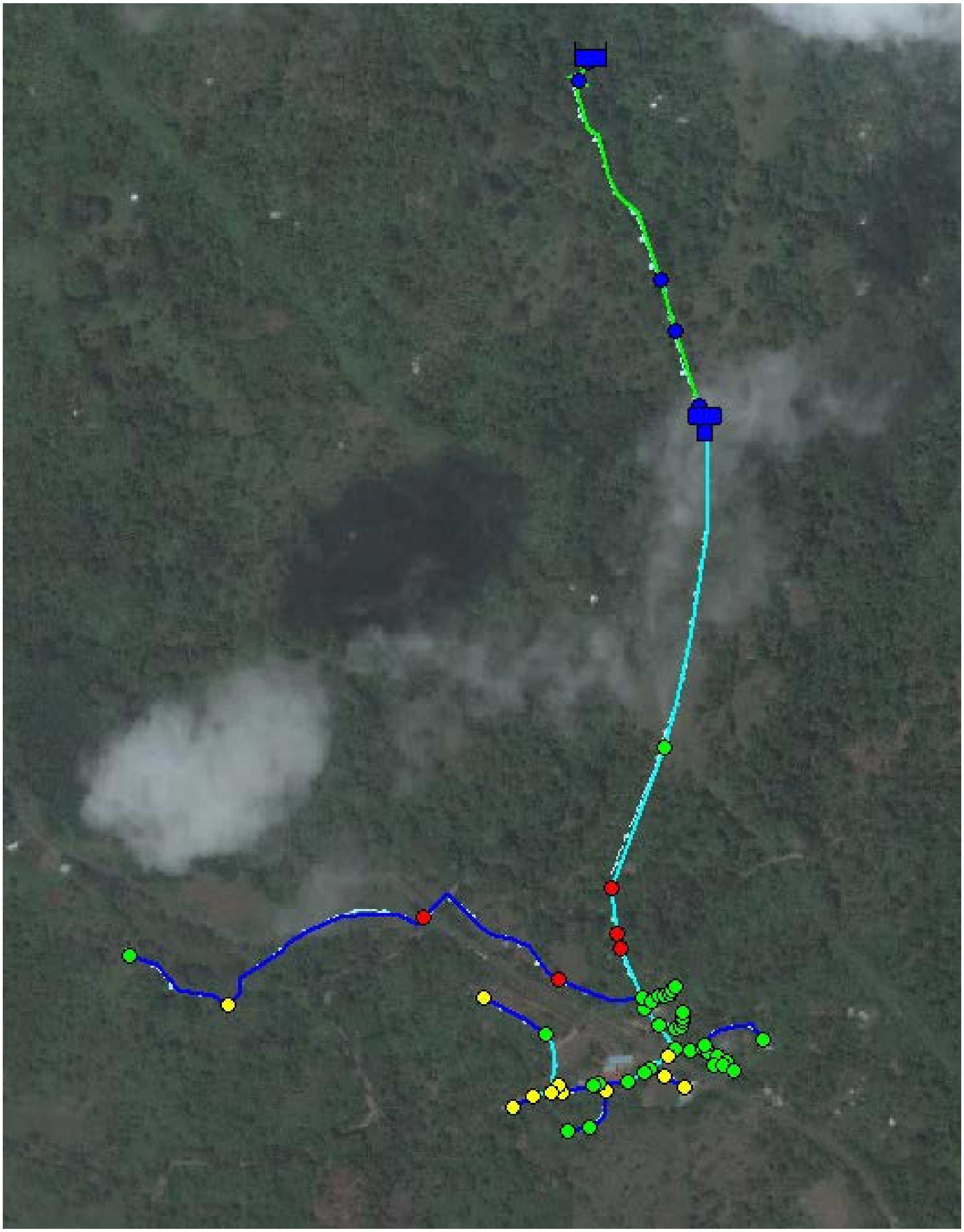

Figure 5: EPANET Model of Quebrada Pastor Aqueduct

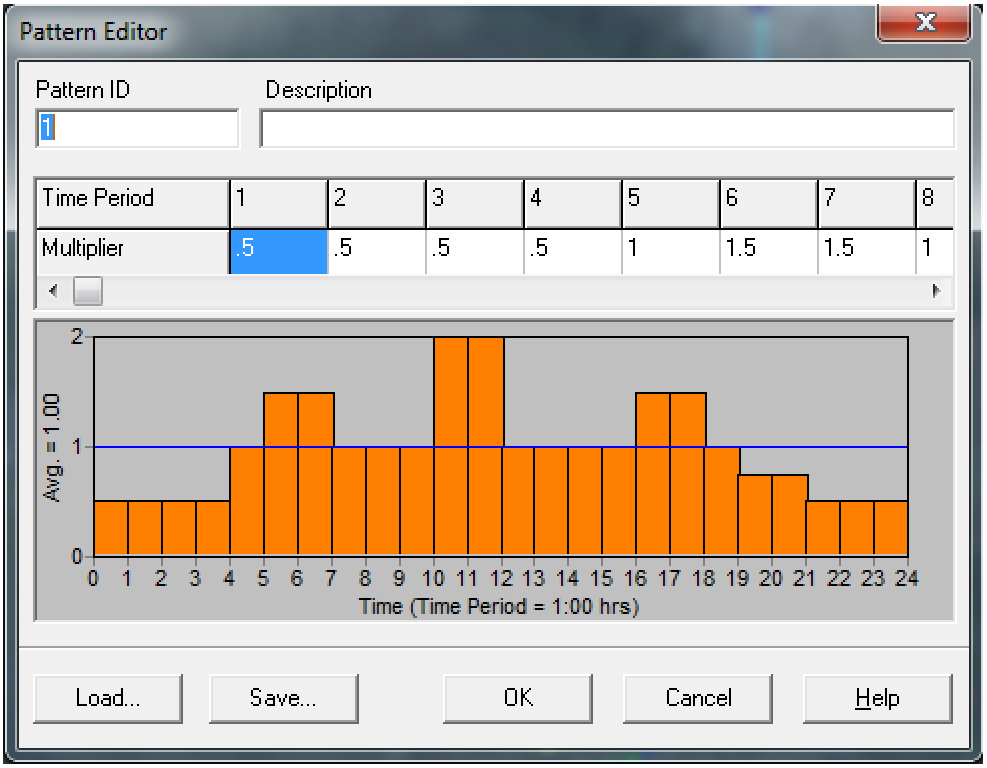

Figure 6: EPANET Daily Demand Pattern

Final Designs

Water Supply and Quality

Toma 2

It is recommended that Quebrada Pastor make improvements to the second springbox, or *toma*, in order to increase the water quality and flow of the system. The current *toma* is an oversized reservoir lacking proper protection. AquaVenture lacks images of the second *toma*, but confirmation from PCV affirms that it is just an unsealed reservoir dug into the hillside with a bedrock floor. Considering both social and economic concerns, AquaVenture does not feel the community would benefit from completely rebuilding the spring box and recommends proper sealing and a maintenance program. Proper sealing of the *toma* involves constructing a low profile spring box anchored into the ground surface, which is primarily clay like soil. Figures 7 and 8 provide side and top view drawings of this low profile design. Additional drawings which include dimensions can be found in Appendix C. The downstream concrete wall, outlet pipe, and clean out pipe are already in place, so construction will include removing the lid of the existing *toma* structure, filling the area downstream of the spring with large rocks and gravel, and sealing the area with a concrete cap for protection. Though an overflow pipe is recommended, it will not be included as the concrete wall is already in place. A maintenance lid must be constructed to allow for cleaning of the concrete walls. This lid will need to be flush with the concrete to prevent any intrusion from insects. A low-profile design, as displayed in Figure 7, presents no risk of back pressure as there is no reservoir to fill up, and nothing can leak in. Sealing off the *toma* will decrease sediment build up, increasing water quality as well as the amount of flow into the aqueduct.

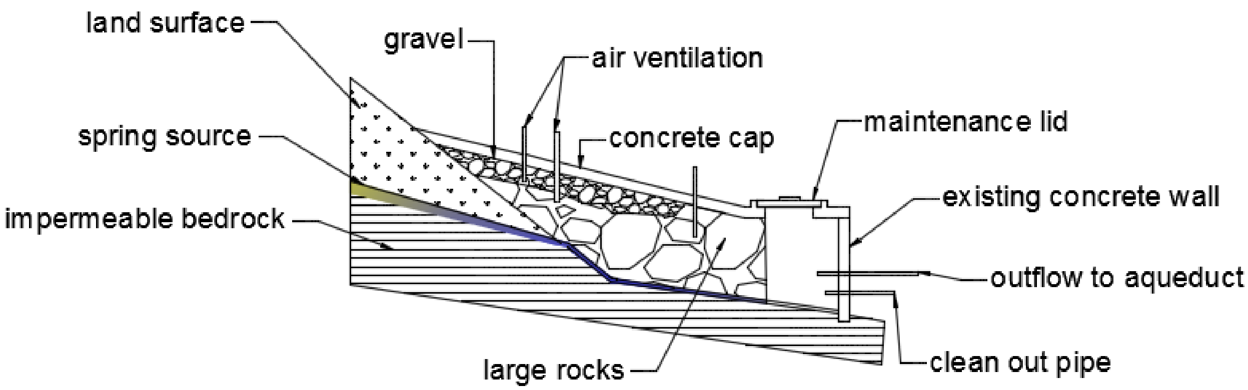

Figure 7: Low Profile Toma Cross Section

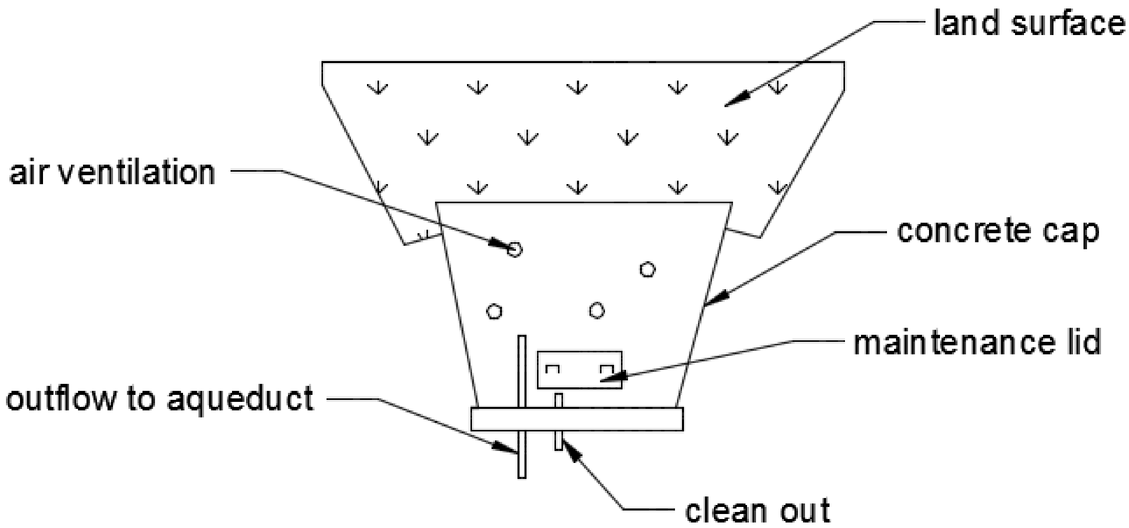

Figure 8: Low Profile Concrete Cap Plan View

Rainwater

AquaVenture recommends the use of rainwater catchment at Quebrada Pastor's community school in order to increase their water supply and reduce demand on the community system. Two 1,500 gallons tanks were previously donated to the community for use at the school, but are currently not in use due to abuse by outside users. The tanks were meant to serve only users at the school, and therefore they were decommissioned until a fence can be installed to prevent misuse of the water by outside users. It is recommended that once the school can fund construction of this fence, the tank be put to use to supply water for cooking and drinking. AquaVenture believes that providing a data analysis on the reliability and water supply rain catchment can provide to the school will motivate the community to get the tanks back in service. Using rainwater as a separate supplemental source will provide users at the school with a more reliable supply, as well as decrease reliance on the aqueduct system, allowing for more supply to other connections throughout the system.

Results found in Tables 2-3 display the percent demand met for each month using the monthly average and minimum rainfall for the 46 years of data. The percent demand based on this this approach ranges from 25-82% for average rainfall and 5-25% for minimum rainfall in each month [3]. The same approach was applied to the entire raw data set, providing a percent demand met for each month over 46 years, which can be seen in Appendix G. This analysis resulted in an average percent demand met of 50% [7].

Table 2: Potential Supply using Average Monthly Rainfall Data

Month	Rainfall (mm)	Supply (gallons)	Demand (gal/month)	% Demand Met
Jan	241.4	17,272	30000	58
Feb	147.7	10,573	30000	35
Mar	148.4	10,618	30000	35
Apr	193.6	13,858	30000	46
May	224.8	16,089	30000	54
Jun	204.9	14,663	30000	49
Jul	290.2	20,765	30000	69
Aug	205.4	14,696	30000	49
Sep	106.7	7,634	30000	25
Oct	137.9	9,869	30000	33
Nov	267.3	19,127	30000	64
Dec	344.5	24,657	30000	82
Average Monthly Demand Met: 50%				

Table 3: Potential Supply Using Minimum Monthly Averages of Rainfall Data

Month	Rainfall (mm)	Supply (gallons)	Demand (gal/month)	% Demand Met
Jan	56.1	4014.8	30000	13
Feb	21.6	1545.8	30000	5
Mar	27.7	1982.3	30000	7
Apr	41.4	2962.8	30000	10
May	46	3292.0	30000	11
Jun	65	4651.7	30000	16
Jul	89.4	6397.8	30000	21
Aug	33.5	2397.4	30000	8
Sep	22.1	1581.6	30000	5
Oct	57.1	4086.3	30000	14
Nov	57.2	4093.5	30000	14
Dec	104.6	7485.6	30000	25
Average Monthly Demand Met: 12%				

Both approaches display that rainwater is a viable supplement to meeting the water demands of the school. It is recommended that the school rely first on rainwater and then on the aqueduct, as this will allow for more supply in the aqueduct to reach other connections. Another way to increase water supply would be to add a second gutter to the roof in order to increase the catchment area. The area of the school roof is roughly 602 square meters, but because only one side is guttered, only half of that catchment area can collect rain. Guttering the other side of the roof will increase the catchment area and subsequently the rainwater supply to the tanks. The average percent demand met by rainwater catchment would increase 50% to 87% with the addition of a second gutter to the system. (See Appendix H)

Other design recommendations aim to improve water quality by adding screens and a first flush system to the current rainwater catchment system. It is recommended that screens be added over gutters in order to capture larger debris, such as twigs and leaves. A first flush system will flush away the first few gallons of water that collect on the roof between rains. This water tends to be highly contaminated, especially after extended dry periods. A rule of thumb is that at least ten gallons of water be flushed for every 1000 square feet of collection area [2]. One recommendation involves installing a second vertical pipe to divert runoff before it reaches the storage tank. The volume of this pipe should correspond to the suggested volume of water to be flushed given the catchment area of the roof. After the volume of the second pipe is filled, the remaining water can flow to the storage tank. The water from the second pipe can be manually emptied and used for non-potable needs [2]. A second recommendation involves investing in a pre-made first-flush water diverter, which uses the same technique, but includes a ball that rises to seal the chamber as well as a slow release valve to allow for the chamber to empty itself after rain and reset automatically.

AquaVenture recommends that the community invest in an in-line first flush system such as the First Flush Water Diverter found through the company RainHarvest Systems LLC and shown in Figure 9 [4]. The diverters are supplied in kit form and include everything needed to complete installation. The user just needs to add the length of PVC pipe required to form the diverter chamber. This product costs roughly $30 and requires minimal maintenance.

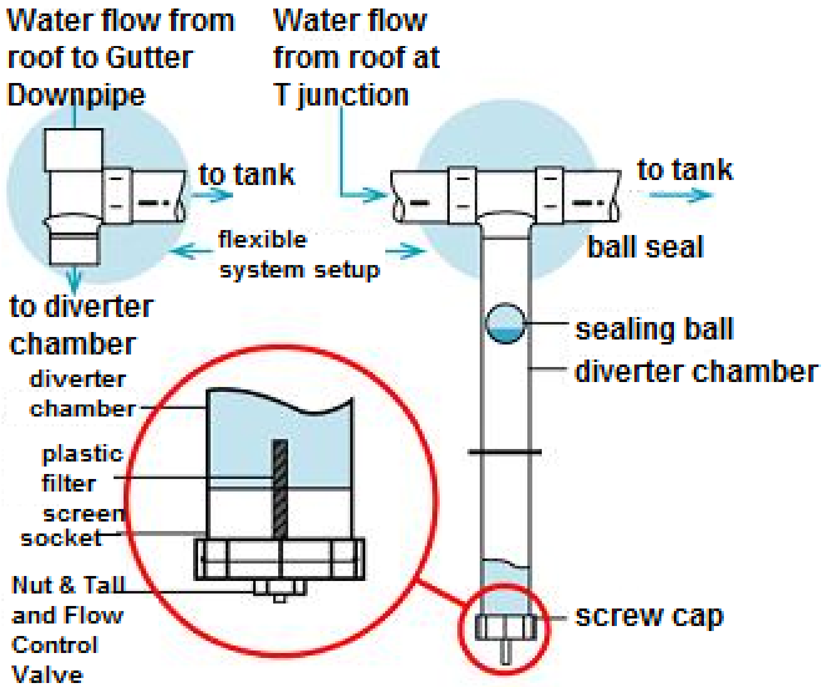

Figure 9: First Flush System (RainHarvest Systems LLC)

System Control

Increasing the number of valves in the system will greatly increase the control of the flow. The valve type chosen will be a ball valve which will allow for the line to flow freely while open, but completely restrict flow while closed. During the interview with the operator of the line, he asked for more control and suggested valves be installed before the storage tanks, after the storage tanks, and at the T-connection in the culvert before the school. The arrows on Figures 10 and 11 show the proposed placement of the thirteen valves throughout the system. The circles are nodes that represent points of interest such as taps, low elevation points and high elevation points which were taken into account when proposing locations of the valves. A list of the recommended valve locations is displayed as follows:

- *Toma* 2 outflow
- At stream crossing 1
- Before storage tanks
- After storage tanks
- On service line 1 next to the church
- On service line 2 next to the church
- On service line 3 next to the church
- At service line 4 at the T-connection just upstream of the culvert
- At the school
- On service line 5
- On service line 6
- On service line 7
- On service line 8

Adding these valves will make shutting off the water supply easier for repairs and outages. It will no longer require hiking up the hill towards the *tomas* to find the nearest control valve. Instead, a nearby control valve can be closed without disrupting the flow of water throughout the entire system.

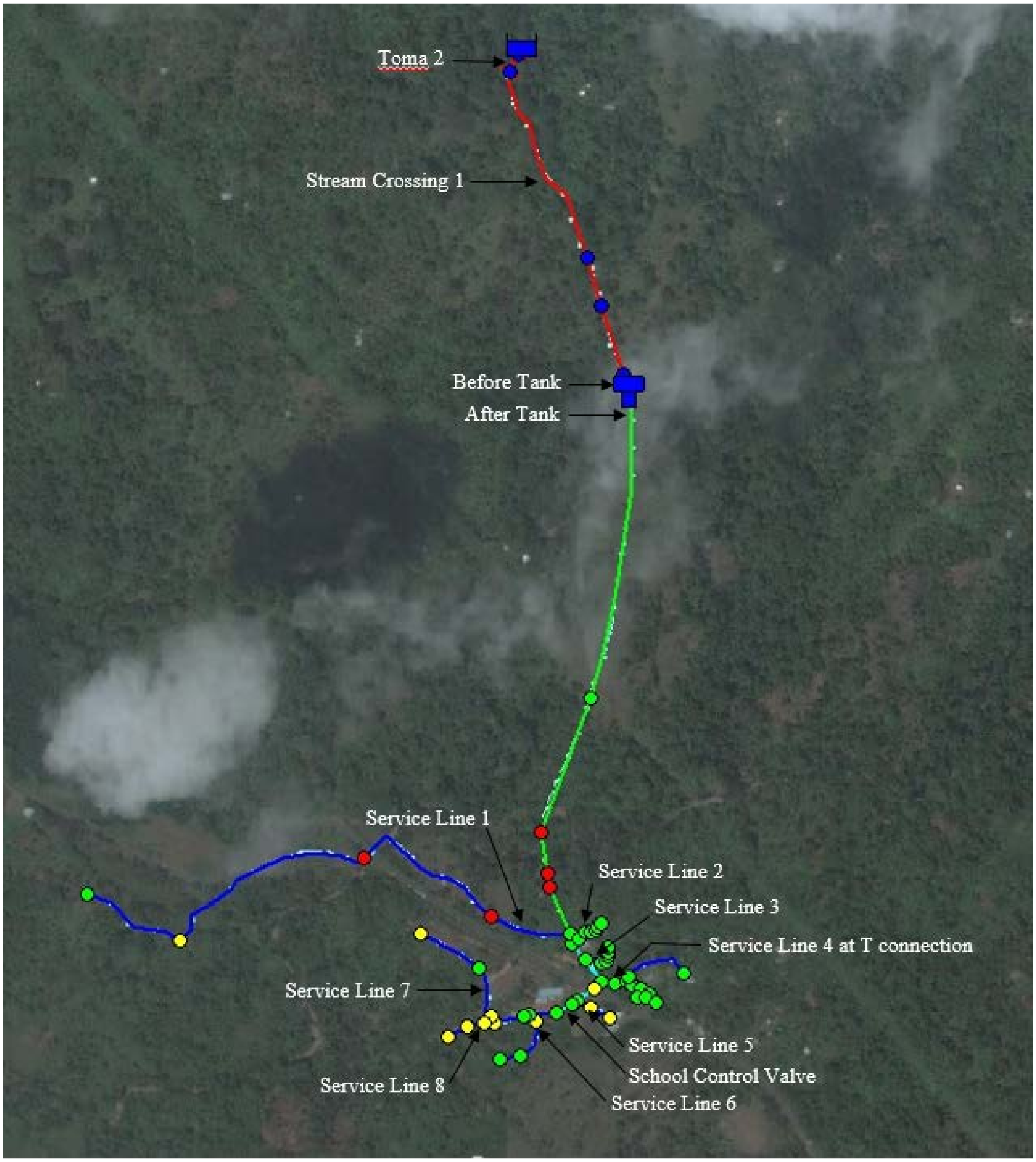

Figure 10: Proposed Valve Locations

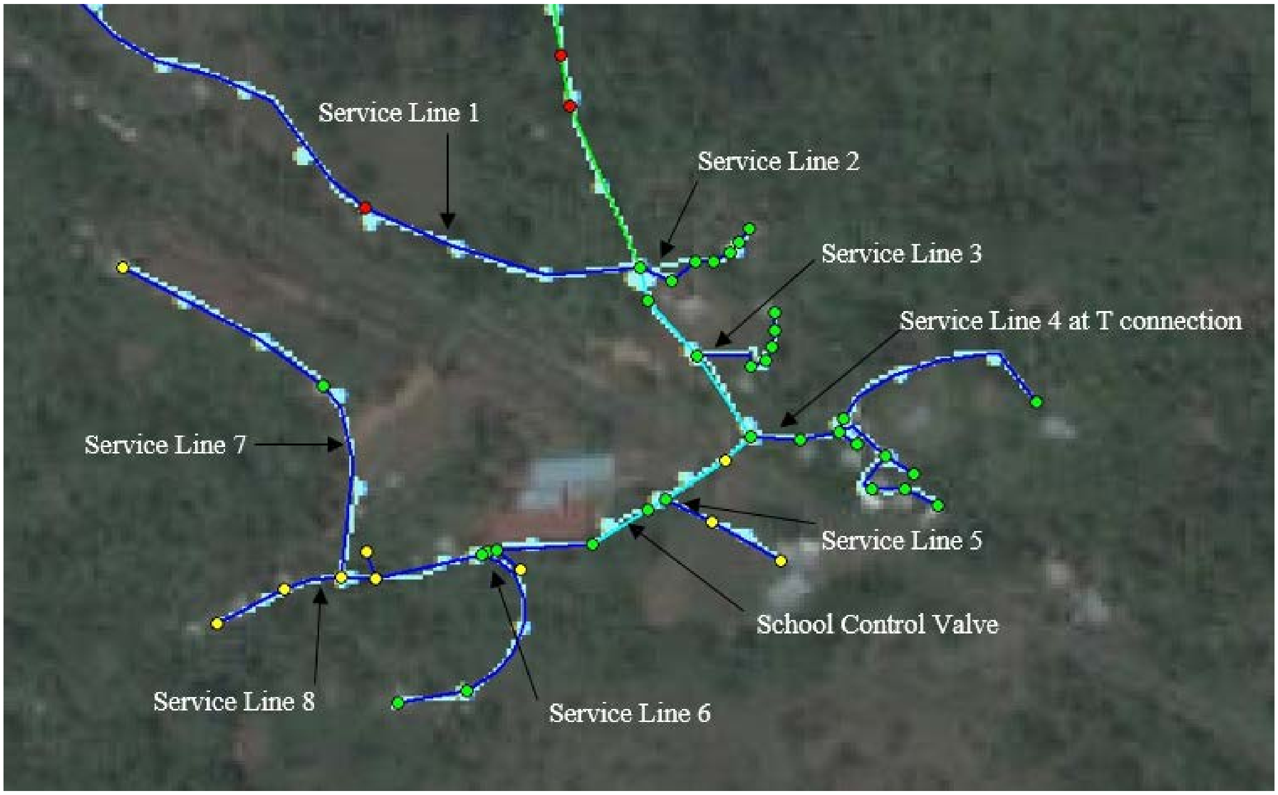

Figure 11: Proposed Residential Valve Locations

Lifespan improvements

Stream Crossing Support

Due to the degradation of the metal support column, as seen in Figure 12, on the uphill (north) side of the first stream crossing, a concrete masonry unit (CMU) has been designed to replace it.

Figure 12: Degraded Metal Support

The CMU will be 11 blocks tall (88") and two blocks (12") wide which is similar to the original height of the metal support that stands at 2.2 m (87") tall. A 4" pipe sleeve will run through top block to allow the mainline of the aqueduct to pass through the CMU, and the metal cable will be supported over the column using the bottom half of a bent piece of 1" metal pipe, as seen in Figures 13 and 14.

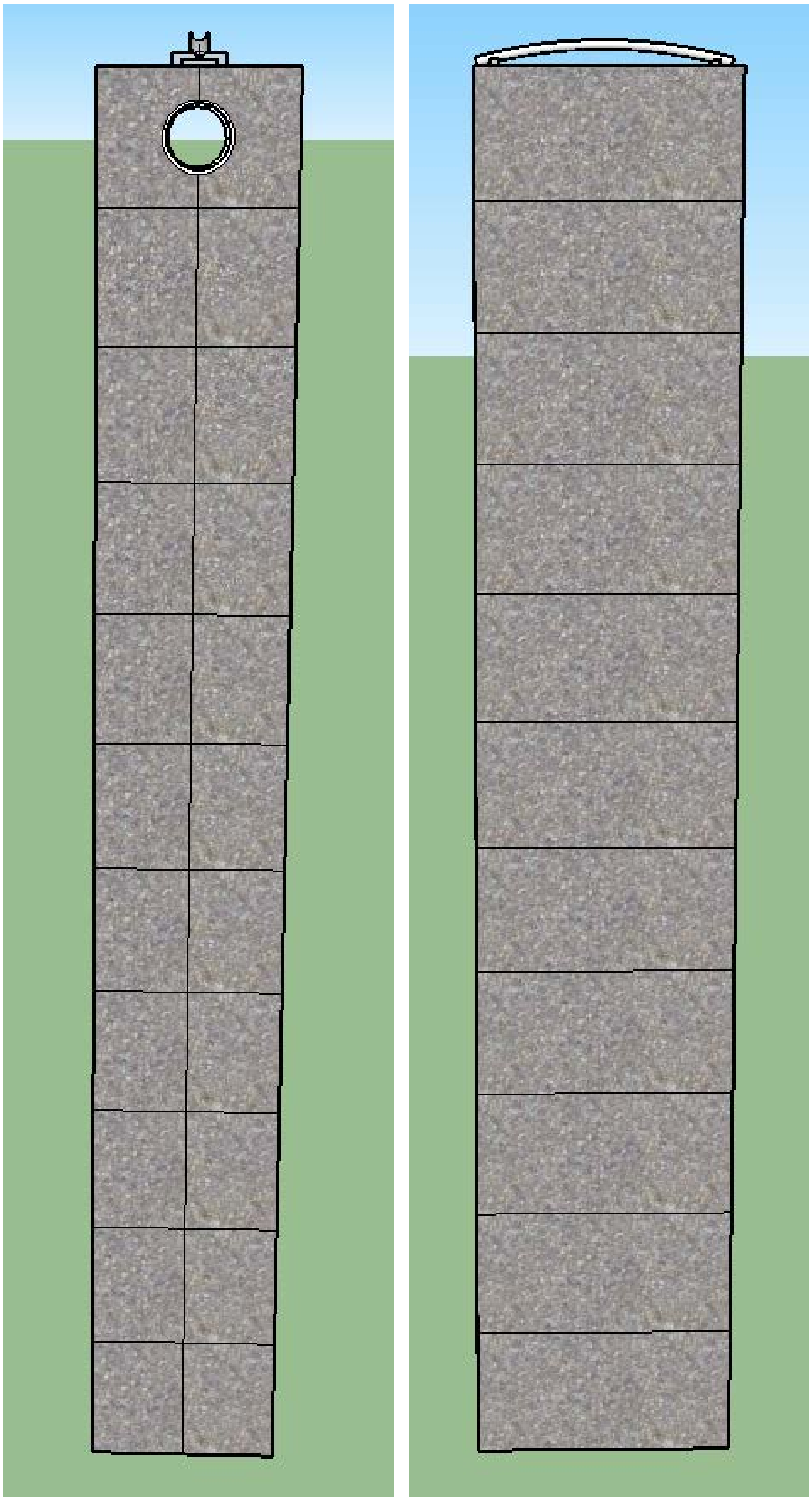

Figure 13: Front and Side View of Replacement CMU Column

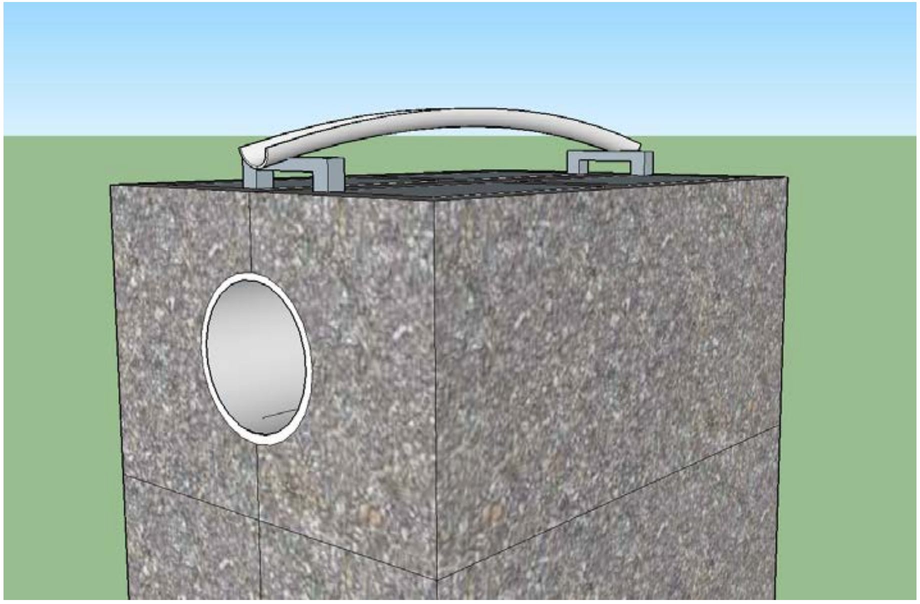

Figure 14: 4" Pipe Sleeve and Metal Pipe Saddle

There will be #5 rebar running vertically through each of the four square cut outs in the masonry blocks. Between each block, ⅜" stirrups will wrap around the vertically running rebar, as seen in Figure 14. The column will be placed on a concrete footing 12" into the ground, 16" wide, and 30" long. With this design, the allowable axial force that the column can support would be 6,800 lbs, which exceeds the weight of 100 feet of pipe, the water in the pipes, and the metal cable and support clips that carry the pipe across the stream [3]. Detailed drawings complete with dimensional characteristics can be seen in Appendix E.

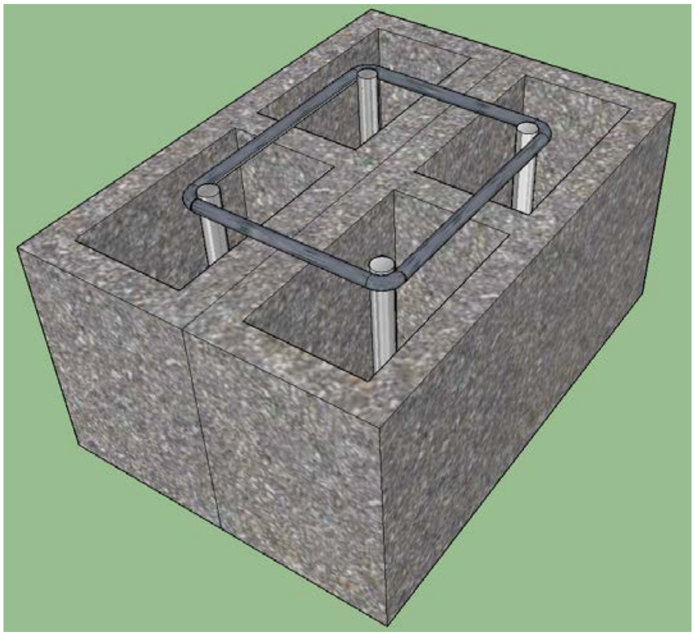

Figure 15: 6” Concrete block with rebar and stirrups

RECOMMENDATIONS AND CONCLUSIONS

Recommendations

The water distribution system in Quebrada Pastor can experience pressures of up to 132m (188 psi). This is where the aqueduct crosses the Pastor River before going up the hill 660 feet at a 30 degree incline to the Evangelical Lutheran Church. This uphill section has had many issues with the pipe separating, and it is composed of many short sections of PVC pipe spliced together. However, Pressure break tanks are currently not seen as a possible solution given the terrain of the land. Pressure break tanks allow the inflow water to bounce off a wall of the tank before continuing through the system. This allows the flow to slow down, as well as lower the pressure to protect the pipes. A pressure break tank right before the Quebrada Pastor crossing would decrease the pressure too much, preventing the water from making it up the 200m, 30 degree incline.

AquaVenture recommends that this section of pipe is replaced using the longest lengths of PVC pipe available and capable of being transported. By using longer sections of PVC pipe, there will be fewer connections that will be susceptible to separation. Using quality

PVC cement, ensuring clean connections during installation, and allowing significant time for the cement to dry before pressurizing the line will also decrease the chances of the pipe separating.

Additionally, to support the pipe as it travels up this incline, four equally spaced concrete footings 18” deep should be anchored into the side of the hill. Mounted in these footings will be 2” PVC T connections with the top half of the horizontal section cut off. This will create a cradle for the main line to sit in, as seen in Figure 16. The main line can then be attached to these T’s using metal pipe clamps which will support the weight of the line as it travels up hill.

Figure 16: Uphill Pipe Supports

The other three metal stream crossing support columns along the line appear to be in good conditions. It will be suggested to Quebrada Pastor that if the supports begin to show signs of degradation, they are to be replaced with a CMU following the design presented in this report. The crossings should also have a painted 2.5-inch PVC carrier pipe that will protect the main line from the UV rays and stress from the metal support clips.

Maintenance Schedule

The following maintenance schedule will provide the water committee with the means to sustain the *toma* [5].

Table 4: Potential Maintenance Plan

Monthly or more frequently	Clean around the site (i.e. rake leaves, clean drainage canal, clean brush from access trail)
Every 2 months or when water is turbid	Open maintenance lid to clean reservoir walls and floor, wash with bleach. Clear debris from gravel layers entrances.
Unexpected maintenance	Replace broken pipes, repair cracks and leaks.

The school does have a maintenance staff who could help maintain the rainwater catchment system and the maintenance schedule in Table 5 will be presented to those individuals. The catchment tanks should have regular cleaning to prevent bacteria growth and by continuously maintaining the rainwater catchment system, the school would help protect their students' health. A fully functioning rainwater catchment system would also mean less dependency on the aqueduct which would decrease the demand on the system allowing other users to receive a more steady supply of water.

Table 5: Potential Maintenance Plan for Rainwater Catchment

Monthly or more frequently	Clean out gutter system (i.e. remove large debris such as leaves and twigs), clean off gutter screens
Every 2 months or when water is turbid	Open tanks, clean tank walls, wash with bleach.
Unexpected maintenance	Replace broken pipes, repair cracks and leaks.

It is also recommended that the PCV and the water committee host several training sessions to help bridge the nontechnical issues with this system. The water committee did note a lack of participation on work days, therefore the importance of monthly upkeep and how it can lead to better water quality should be discussed. Several people during interviews said that people need to be taught proper usage and care of the line. Many people step on the line when they walk by it and children bounce and play on the line which leads to breaks and leaks. Other topics can include cleaning the tanks and *toma* for increased sanitation, as well as notifying the operator and water committee of any breaks or leaks that are encountered. Water conservation techniques should also be covered allowing for less water to be wasted. AquaVenture would also like to stress the time needed for PVC glue to dry before pressurizing the system which would also reduce breaks in the system. Education is an important aspect to sustainable design, allowing for the people of Quebrada Pastor to collectively work together to maintain the aqueduct system that benefits a large portion of the population.

Moving Forward

Cost Estimate

Using quotes from previous projects in Quebrada Pastor, AquaVenture produced a cost estimate for the project and can be seen in Table 6. All labor will be donated by members of the community therefore there is not a labor component of the cost. A complete breakdown of elements, quantities, and unit prices can be seen in Appendix F. Potentially sources of funding for these improvements could come from families who send their children to the school, asking the current users of the aqueduct to donate, fundraising activities in the community or soliciting the government for funds.

Table 6: Cost Estimate

Improvement	Cost
Water Supply and Quality	
Toma 2	$71
Rainwater Catchment System	$193
System Control	
Ball Valves	$346
Sustainability and Lifespan	
Pipe Crossings	$649
Total:	$1,300

Construction Schedule

The construction schedule includes all the improvements to the line that have been designed: installing the valves, improvements to *toma* 2, concrete support, painting pipes, and installing new pipes and anchors after the Quebrada Pastor crossing. The project will be completed by volunteers in the community. Given the three man crew working five hour days, all the improvements will take 59 days. Since the majority of the work is a mile walk one way, significant amount of the effort and time involves carrying the concrete materials to the various sites. Appendix G shows the Work Breakdown Structure, detailing all the work encompassed in the construction of the improvements. It also includes a Gantt Chart showing the relationships between some of the activities. The number of days to complete construction for each improvement area is summarized in Table 7.

Table 7: Construction Schedule

Improvement	Duration (Days)
Water Supply and Quality	**18**
Toma 2	16
Rainwater Catchment System	2
System Control	**11**
Installing Ball Valves	11
Lifespan Improvements	**30**
Stream Crossing 1	13
Quebrada Pastor Crossing	6
Quebrada Pastor Ascent	11

Conclusions

AquaVenture has provided the community of Quebrada Pastor with recommendations to improve the water supply, quality, system control, and lifespan of their existing water distribution system. Utilizing a rainwater catchment system at the school would improve the water supply at the school and lessen the stress of demands across the entire system. This rainwater system would include a first flush portion to increase the quality of the rainwater. Improving the second *toma* to a properly sealed low profile *toma* would increase the overall water quality. System control can be increased through the placement of an additional 13 ball valves in locations where it would facilitate maintenance. Increasing the lifespan of the system will include replacing the degrading metal support at the first stream crossing with a CMU that is similar in size as the original support. Carrier pipes should be utilized at each of the stream crossings to protect the line from the environment and UV rays. Painting the pipe would also limit damaging UV rays in areas where the line cannot be buried. Lastly, in order to prevent further pipe separation as the main line travels up its steepest ascent, the 2" T connections supports presented in this report should be used. The cost estimate for these improvements to the system is $1,300 and it should take 59 days to construct giving there is a three man crew working five hour days.

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APPENDIX

Appendix A: EPANET Model

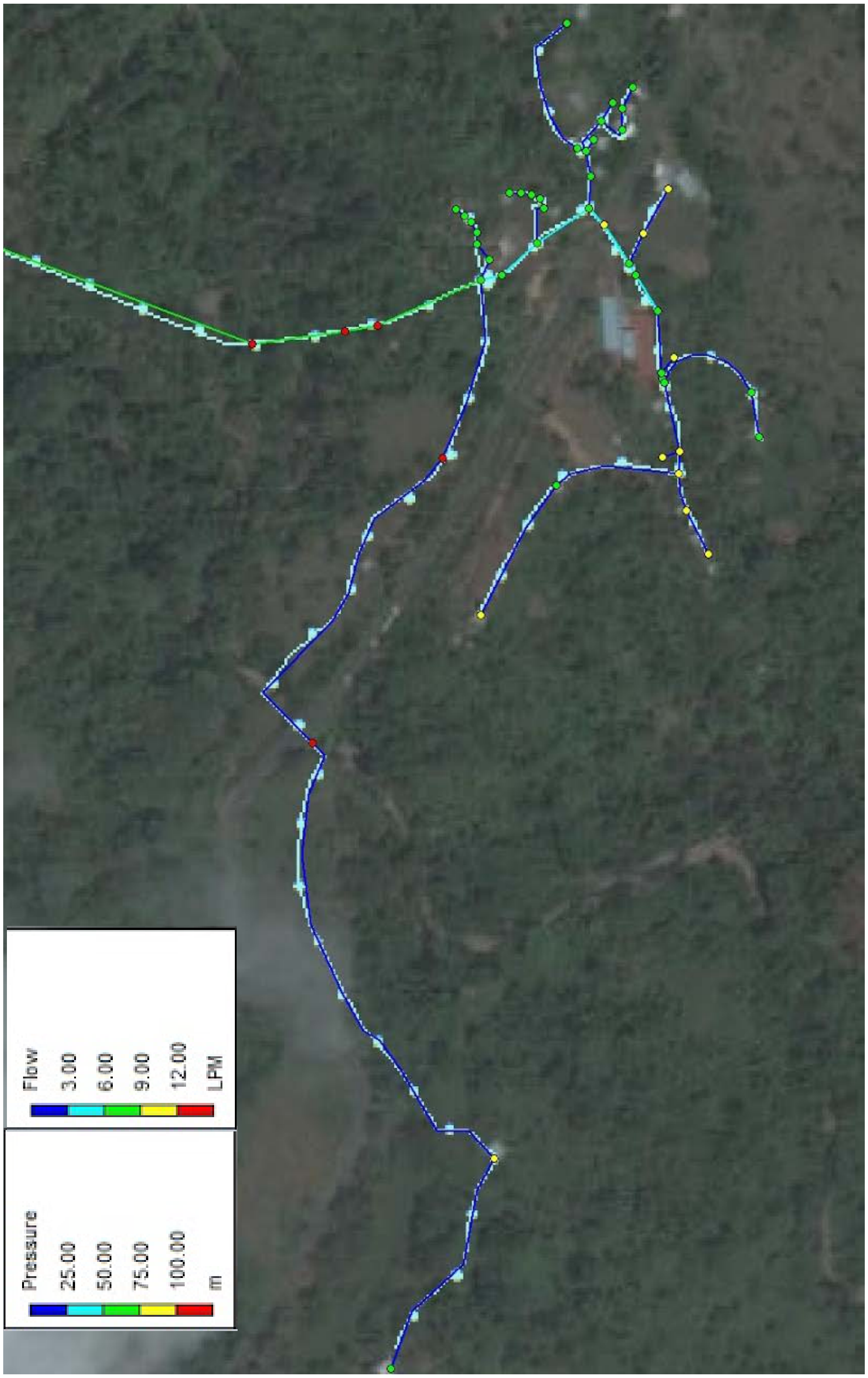


Figure 1: Residential Section of Aqueduct

Table 1: EPANET Outputs at t= 6hrs

Network Table - Nodes at 6:00 Hrs									
	Elevation	Demand	Head	Pressure		Elevation	Demand	Head	Pressure
Node ID	m	LPM	m	m	Node ID	m	LPM	m	m
Junc 3	178	0	129.4	-48.6	Junc 28	70.66	0.19	128.74	58.08
Junc 4	122.66	0	129.24	6.58	Junc 48	57.47	0	128.88	71.41
Junc 5	118.5	0	129.18	10.68	Junc 30	63.09	0.19	128.77	65.68
Junc 6	128.23	0	129.12	0.89	Junc 31	67.14	0	128.72	61.58
Junc 7	54.85	0	128.98	74.13	Junc 32	67.02	0.19	128.72	61.7
Junc 8	10.83	0	128.95	118.12	Junc 33	65.93	0.19	128.71	62.78
Junc 9	-4.96	0	128.94	133.9	Junc 34	74.31	0.19	128.7	54.39
Junc 10	0.74	0	128.93	128.19	Junc 35	70.51	0.19	128.68	58.17
Junc 22	69.22	0	128.9	59.68	Junc 36	71.77	0.19	128.68	56.91
Junc 29	59.41	0	128.88	69.47	Junc 37	69.05	0.19	128.66	59.61
Junc 40	52.91	0	128.88	75.97	Junc 38	70.02	0.19	128.66	58.64
Junc 41	60.16	0	128.88	68.72	Junc 39	69.37	0.19	128.65	59.28
Junc 44	59.79	0	128.88	69.09	Junc 42	49.67	0	128.88	79.21
Junc 45	59.61	3.9	128.88	69.27	Junc 43	53.56	0.19	128.87	75.31
Junc 11	65.83	0	128.9	63.07	Junc 47	50.5	0.19	128.88	78.38
Junc 12	24.25	0.19	128.9	104.65	Junc 46	58.18	0	128.88	70.7
Junc 13	16.54	0	128.9	112.36	Junc 49	57.47	0	128.88	71.41
Junc 14	38.17	0.19	128.9	90.73	Junc 50	55.52	0.19	128.85	73.33
Junc 15	58.1	0.19	128.88	70.78	Junc 51	54.38	0.19	128.84	74.46
Junc 16	71.79	0.19	128.77	56.98	Junc 52	48.58	0	128.88	80.3
Junc 17	68.72	0.19	128.71	59.99	Junc 53	51.23	0.19	128.88	77.65
Junc 18	67.81	0.19	128.69	60.88	Junc 54	51.28	0	128.86	77.58
Junc 19	67.54	0.19	128.69	61.15	Junc 55	56.47	0.19	128.82	72.35
Junc 20	67.54	0.19	128.68	61.14	Junc 56	40.44	0.19	128.8	88.36
Junc 21	67.35	0.19	128.68	61.33	Junc 57	46.09	0.19	128.85	82.76
Junc 23	67.57	0	128.89	61.32	Junc 58	40.34	0.19	128.84	88.5
Junc 24	70.79	0.19	128.82	58.03	Junc 2	181.67	0	182	0.33
Junc 25	71.65	0.19	128.76	57.11	Resvr 1	182	-16.2	182	0
Junc 26	70.39	0.19	128.75	58.36	Tank 100	127	6.06	129.12	2.12
Junc 27	70.66	0.19	128.75	58.09					

*1 meter head = 1.42 PSI

APPENDIX B: RAW SURVEY DATA

Point	Hypotenuse (m)	Angle (degrees)	Angle (radians)	Vertical (m)	Elevation (m)	Notes
1					181.6	First Point and base elevation
2	2.96	-6.5	-0.113446	-0.3351	181.26	At first Toma
3	4.86	-6	-0.10472	-0.508	180.76	
4	3.4	-12.2	-0.21293	-0.7185	180.04	
6	7.4	6	0.10472	0.7735	180.81	Toma 2
5	13.01	-9	-0.15708	-2.0352	178.00	Connection of Toma 1 and 2
7	8.1	-8	-0.139626	-1.1273	176.88	
8	12	-6.4	-0.111701	-1.3376	175.54	Using range finder
9	14	-6	-0.10472	-1.4634	174.07	
10	19	-8.8	-0.153589	-2.9067	171.17	To residential connection
11	20	-7	-0.122173	-2.4374	168.73	
12	22	-6.8	-0.118682	-2.6049	166.13	
13	21.5	-4.4	-0.076794	-1.6495	164.48	
14	15.5	-8.8	-0.153589	-2.3713	162.11	
15	19.5	-9.4	-0.164061	-3.1849	158.92	
16	20	-16	-0.279253	-5.5127	153.41	
17	13.5	-10.5	-0.18326	-2.4602	150.95	
18	14	-14.8	-0.258309	-3.5762	147.37	
19	15	-24	-0.418879	-6.101	141.27	
20	19.5	-14	-0.244346	-4.7175	136.55	
21	18	-10.8	-0.188496	-3.3729	133.18	
22	14	-12.4	-0.216421	-3.0063	130.17	
23	27	-9.6	-0.167552	-4.5028	125.67	chugging sound in the line

22	14	-12.4	-0.216421	-3.0063	130.17	
23	27	-9.6	-0.167552	-4.5028	125.67	chugging sound in the line
24	27	-6.4	-0.111701	-3.0097	122.66	at barbed wire fence 1
25	6.65	0	0	0	122.66	Water Crossing Approach At the Valve
27				0	122.66	Start of the approach triangle
26	14.5	-4.5	-0.07854	-0.0054	122.66	At the water suspension
28	31	3.2	0.055851	3.4065	126.07	Other Side of the creek
29	13.5	3.2	0.055851	0.7536	126.82	
30	16.8	-7.6	-0.132645	-2.2219	124.60	
31	18.8	-6.2	-0.10821	-2.0304	122.57	
32	29.2	-8	-0.139626	-4.0639	118.50	
33	8.96	-2.5	-0.043633	-0.3908	118.11	
34	23.6	9.2	0.16057	3.7732	121.89	
35	16	13	0.226893	3.5992	125.49	
36	21.5	7	0.122173	2.6202	128.11	
37	19	0.2	0.003491	0.0663	128.17	
38	7.47	1	0.017453	0.1304	128.30	
39	5.68	0	0	0	128.30	
40	21.5	-0.2	-0.003491	-0.075	128.23	At the tanks at fence
41	23.5	-3.6	-0.062832	-1.4756	126.75	TP around tanks
42	19	0.8	0.013963	0.2653	127.02	Downhill of tanks at fence
43	19	-8.1	-0.141372	-2.6771	124.34	
44	59	-6.8	-0.118682	-6.9858	117.36	
45	36.5	-7.9	-0.137881	-5.0167	112.34	
46	24	-11.6	-0.202458	-4.8259	107.51	
47	20.5	-9.6	-0.167552	-3.4188	104.09	
48	28	-8	-0.139626	-3.8968	100.20	winding in line
49	48	-4.4	-0.076794	-3.6825	96.51	

50	55.5	-6.2	-0.10821	-5.994	90.52	On the fence line into the side pasture, not a main fence crossing
51	44.5	-5	-0.087266	-3.8784	86.64	was a buried line
52	18	-5	-0.087266	-1.5688	85.07	
53	22	-2.1	-0.036652	-0.8062	84.27	
54	25.5	-2.4	-0.041888	-1.0678	83.20	
55	11	-2.8	-0.048869	-0.5373	82.66	
56	17	-4.8	-0.083776	-1.4225	81.24	
57	17.5	-9.8	-0.171042	-2.9787	78.26	
58	24.5	-11.2	-0.195477	-4.7587	73.50	
59	19	-11.6	-0.202458	-3.8205	69.68	under power lines
60	26	-3.2	-0.055851	-1.4514	68.23	
61	22.5	1	0.017453	0.3927	68.62	not exposed
62	29.5	-3.4	-0.059341	-1.7495	66.87	
63	19	-5.6	-0.097738	-1.8541	65.02	at barbed wire fence 2
64	35	-9.1	-0.158825	-5.5355	59.48	
65	15	-18	-0.314159	-4.6353	54.85	about to fall off cliff at trees edge
66	13	-26.4	-0.460767	-5.7803	49.07	
67	10	-19.3	-0.336849	-3.3051	45.76	bends to go around tree
68	11	-24.6	-0.429351	-4.5791	41.18	
69	15.5	-23.4	-0.408407	-6.1558	35.03	
70	14.5	-14.8	-0.258309	-3.704	31.32	
71	11	-6.2	-0.10821	-1.188	30.14	
72	16	-7.4	-0.129154	-2.0607	28.08	
73	18	-8.2	-0.143117	-2.5673	25.51	
74	13	-14.4	-0.251327	-3.233	22.28	
75	16	-18.5	-0.322886	-5.0769	17.20	
76	17	-22	-0.383972	-6.3683	10.83	top of the drop off

77	27	-35.8	-0.624828	-15.794	-4.96	Steep Drop off to the valve
78	3.72	0	0	0	-4.96	
79	5.58	8	0.139626	0.7766	-4.19	
79.5	4.07		0	1.9	-2.29	
80	29	4.2	0.073304	3.0309	0.74	Across Creek
81	12.5	26.4	0.460767	5.5579	6.30	
82	20	29.4	0.513127	9.8181	16.12	
83	11.5	27.2	0.47473	5.2566	21.38	
84	12.5	31.2	0.544543	6.4753	27.85	lots of mud
85	13.5	26	0.453786	5.918	33.77	
86	15	21.4	0.3735	5.4732	39.24	
87	15.5	24.4	0.42586	6.4031	45.65	
88	10.5	25.6	0.446804	4.5369	50.18	
89	13	26.8	0.467748	5.8614	56.04	
90	11.5	26	0.453786	5.0413	61.09	
91	13	21.4	0.3735	4.7434	65.83	
92	10	22.8	0.397935	3.8752	69.70	to reach the Evangelical Church
93	17.5	-1.6	-0.027925	-0.4886	69.22	Valve next to Church
94			0	0	69.22	where kids stepped on line
95	16.5	1.2	0.020944	0.3455	70.05	Service Line 2: To the Church & homes shot from 92
96	19.5	2.83	0.049393	0.9628	70.18	Service Line 2: To the Church & homes shot from 93
97	20	4.8	0.083776	1.6736	71.79	SL2 Church showers
98	27.5	-6.4	-0.111701	-3.0654	68.72	SL2 houses
99	10.5	-5	-0.087266	-0.9151	67.81	SL2 houses
100	6.2	-2.5	-0.043633	-0.2704	67.54	SL2 houses
101	6.45	0	0	0	67.54	SL2 houses

102	5.38	-2	-0.034907	-0.1878	67.35	SL2 houses
103	22	-0.2	-0.003491	-0.0768	69.14	same as 94, ML
104	18	-5	-0.087266	-1.5688	67.57	ML down to school
105	12	7.9	0.137881	1.6493	70.79	SL3 houses
106	14	0.8	0.013963	0.1955	70.98	TP
107	7.7	5	0.087266	0.6711	71.65	SL3 houses
108	16.5	-4.4	-0.076794	-1.2659	70.39	SL3 houses
109	7.67	2	0.034907	0.2677	70.66	SL3 houses
110	3.67	0	0	0	70.66	SL3 houses
111	15	-1.6	-0.027925	-0.4188	67.15	on ML from 104
112	17.5	-2.8	-0.048869	-0.8549	66.30	
113	25	-16	-0.279253	-6.8909	59.41	Almost to T
114	1.3	0	0	0	59.41	At the T
115	15	-16.8	-0.293215	-4.3355	55.07	to culvert under road
116	12.5	24	0.418879	5.0842	60.15	Turning Point on Road
117	32	-3.6	-0.062832	-2.0093	58.14	Turning Point on Road
118	11	-28.4	-0.495674	-5.2319	52.91	exits culvert under road
119	19.5	18	0.314159	6.0258	58.94	up to school
120	7.8	9	0.15708	1.2202	60.16	SL5 branches to go to store
121	15	-1.4	-0.024435	-0.3665	59.79	school control valve
122	13	-0.8	-0.013963	-0.1815	59.61	
123	5.05	0	0	0	59.61	tap at school
124	19.5	-4.2	-0.073304	-1.4281	58.18	
125	29	-1.4	-0.024435	-0.7085	57.47	leak
126	11.5	0	0	0	57.47	ML behind school
127	5.24	25	0.436332	2.2145	61.62	trying to get SL4 from 114
128	15	7.4	0.129154	1.9319	63.55	tp
129	12	-2.2	-0.038397	-0.4607	63.09	SL4 FA's house

130	6.6	18	0.314159	2.0395	65.59	SL4 from 128
131	3.55	0	0	0	65.59	
132	5.97	15	0.261799	1.5451	67.14	
133	15	-4.6	-0.080285	-1.203	65.93	SL4 EA's shower
134	5.84	-1.1	-0.019199	-0.1121	67.02	SL4 from 132 PCV's house
135	10	3.8	0.066323	0.6627	67.80	SL4 from 132
136	5.65	6.5	0.113446	0.6396	68.44	curve in line
137	13	6.4	0.111701	1.4491	69.89	.5 " pipe
138	17	7.5	0.1309	2.2189	72.11	SL4 to MC
139	10	7.5	0.1309	1.3053	73.41	SL4 to MC
140	5.28	2.6	0.045379	0.2395	73.65	SL4 to MC
141	7.06	0	0	0	73.65	SL4 to MC
142	7.9	-1	-0.017453	-0.1379	73.51	SL4 to MC
143	17	-2.2	-0.038397	-0.6526	72.86	SL4 to MC
144	10	5.1	0.089012	0.8889	73.75	SL4 to MC
145	8.03	4	0.069813	0.5601	74.31	SL4 to MC
146	14	14.4	0.251327	3.4817	70.51	SL4 shot from 134
147	2.62	0	0	0	70.51	from 146 with tape pluma
148	7.85	-10	-0.174533	-1.3631	69.14	SL4
149	7.46	-5	-0.087266	-0.6502	68.49	SL4
150	2.05	-5	-0.087266	-0.1787	68.31	SL4
151	1.59	0	0	0	68.31	SL4 HP house
152	7.09	6	0.10472	0.7411	69.05	SL4 HP house from 150
153	3.14	-14	-0.244346	-0.7596	69.75	SL4 from 147
154	14	3.2	0.055851	0.7815	70.53	
155	10.5	6.8	0.118682	1.2432	71.77	SL4 JS
156	7.63	5	0.087266	0.665	71.19	SL4 from 154
157	2.89	-24	-0.418879	-1.1755	70.02	SL4 HeP

158	12	8.6	0.150098	1.7944	71.81	SL4 to Heidy Organic Chocolates
159	4.38	0	0	-2.44	69.37	SL4 to Heidy tap
160			0	0.8	58.10	SL1 MS House Elevations Backed up
161	13.5	1	0.017453	0.2356	57.30	SL1, angles changed to pos to get elev
162	7.96	5.5	0.095993	0.7629	57.07	TP SL1, angles changed to pos to get elev
163	14.5	1.6	0.027925	0.4049	56.30	SL1, angles changed to pos to get elev
164	10.5	8	0.139626	1.4613	55.90	SL1, angles changed to pos to get elev
165	15.5	9.4	0.164061	2.5316	54.44	SL1, angles changed to pos to get elev
166	16.5	12	0.20944	3.4305	51.90	SL1, angles changed to pos to get elev
167	19	9.2	0.16057	3.0377	48.47	SL1, angles changed to pos to get elev
168	21	6.6	0.115192	2.4137	45.44	SL1, angles changed to pos to get elev
169	7.77	6.51	0.113621	0.8809	43.02	SL1, angles changed to pos to get elev
170	14	10	0.174533	2.4311	42.14	TP insects, SL1, angles changed to pos to get elev
171	12.5	-3.4	-0.059341	-0.7413	39.71	SL1, angles changed to neg to get elev
172	22.5	3.2	0.055851	1.256	40.45	SL1, angles changed to pos to get elev
173	15	7	0.122173	1.828	39.20	SL1, angles changed to pos to get elev
174	10.5	-4.4	-0.076794	-0.8055	37.37	SL1, angles changed to neg to get elev
175	5.04	0	0	0	38.17	SL1, JS Pluma
176	11	-0.8	-0.013963	-0.1536	38.17	SL1 from 174
177	9.06	7	0.122173	1.1041	38.33	SL1, angles changed to pos to get elev
178	16	29.2	0.509636	7.8058	37.22	SL1, angles changed to pos to get elev
179	7.48	8.5	0.148353	1.1056	29.42	SL1, Off line due to jungle
180	27.5	-3	-0.05236	-1.4392	28.31	SL1, angles changed to neg to get elev, Offline
181	21.5	2	0.034907	0.7503	29.75	SL1, angles changed to pos to get elev, Offline
182	10	16	0.279253	2.7564	29.00	SL1, angles changed to pos to get elev, Offline
183	12	-0.8	-0.013963	-0.1675	26.24	SL1, angles changed to neg to get elev, Offline
184	61	-8.1	-0.141372	-8.595	26.41	SL1, angles changed to neg to get elev, Offline

185	61.5	5.3	0.092502	5.6808	35.01	SL1, angles changed to pos to get elev. Offline
186	19.5	9	0.15708	3.0505	29.33	SL1, angles changed to pos to get elev on the line
187	17.5	9.2	0.16057	2.7979	26.28	SL1, angles changed to pos to get elev
188	22	0	0	0	23.48	SL1
189	29	0.7	0.012217	0.3543	23.48	SL1, angles changed to pos to get elev
190	26	2.6	0.045379	1.1794	23.12	SL1, angles changed to pos to get elev
191	23.5	13.3	0.232129	5.4062	21.94	SL1, angles changed to pos to get elev
192	46.5	11.4	0.198968	9.1911	16.54	SL1, angles changed to pos to get elev, shot to pipe in culvert
193	33.5	-4	-0.069813	-2.3368	7.35	SL1, angles changed to neg to get elev, Offline, From 190
194	40.5	-3.9	-0.068068	-2.7546	9.68	SL1, angles changed to neg to get elev, on top of middle of culvert
195	38	-5.6	-0.097738	-3.7082	12.44	SL1, angles changed to neg to get elev.crossing of culvert
196	70.5	-6.6	-0.115192	-8.1031	16.15	SL1, angles changed to neg to get elev. Offline
197	32	6.2	0.10821	3.456	24.25	SL1, FL's house
198	10.5	1	0.017453	0.1833	20.79	SL1, angles changed to pos to get elev
199	18.5	7	0.122173	2.2546	20.61	SL1, angles changed to pos to get elev
200	34.5	-10.8	-0.188496	-6.4647	18.36	SL1, angles changed to neg to get elev
201	33.5	-12.6	-0.219911	-7.3078	24.82	SL1, angles changed to neg to get elev
202	27.5	-13.5	-0.235619	-6.4197	32.13	SL1, angles changed to neg to get elev
203	29.5	-5.9	-0.102974	-3.0324	38.55	SL1, angles changed to neg to get elev
204	22.5	-6.8	-0.118682	-2.6641	41.58	TP SL1, angles changed to neg to get elev
205	15.5	-7.6	-0.132645	-2.05	44.24	SL1, angles changed to neg to get elev
206	20	-33.8	-0.589921	-11.126	46.29	SL1, angles changed to neg to get elev
207	17	-7	-0.122173	-2.0718	57.42	SL1, angles changed to neg to get elev
208	25.5	-12	-0.20944	-5.3017	59.49	SL1, angles changed to neg to get elev

209	25.5	-10.4	-0.181514	-4.6032	64.79	SL1, angles changed to neg to get elev. up by evangelical church
210	13	0.8	0.013963	0.1815	69.40	SL1, angles changed to neg to get elev. tied to point 93
211	15.5	-8.4	-0.146608	-2.2643	55.21	SL8, tied to 126
212	15.5	-11.2	-0.195477	-3.0106	52.20	SL8
213	7.03	-11	-0.191986	-1.3414	50.86	SL8
214	11.5	-13.9	-0.242601	-2.7626	48.10	SL8
215	8	3.5	0.061087	0.4884	48.58	SL8, breaking off to EB
216	7.74	20	0.349066	2.6472	51.23	SL8, EB shower tap
217	13.5	0.2	0.003491	0.0471	51.28	SL8, to SB/DA
218	10.5	-4.9	-0.085521	-0.8969	50.38	TP, SL8
219	12.5	-7.2	-0.125664	-1.5667	48.81	SL8, RB shower connection
220	10	-15.8	-0.275762	-2.7228	46.09	SL8, RB shower
221	15	-9.6	-0.167552	-2.5015	43.59	SL8
222	18	-10.4	-0.181514	-3.2493	40.34	SL8, WB's
223	5.56	7	0.122173	0.6776	51.96	SL8, tied to 217
224	31.5	11.4	0.198968	6.2262	58.18	SL8, offline due to jungle holes
225	25.5	1.8	0.031416	0.801	58.98	SL8, offline due to jungle holes
226	15	4	0.069813	1.0463	60.03	SL8, offline due to jungle holes
227	18	-11.4	-0.198968	-3.5578	56.47	SL8, online SA house
228	5.9	0	0	0	56.47	SL8
229	14	-6.8	-0.118682	-1.6577	54.81	SL8
230	13.5	-5.6	-0.097738	-1.3174	53.50	SL8
231	12	-7.1	-0.123918	-1.4832	52.01	SL8
232	16	-9.1	-0.158825	-2.5305	49.48	SL8
233	18	-13.3	-0.232129	-4.1409	45.34	SL8
234	10.5	-11	-0.191986	-2.0035	43.34	SL8

235	16	-6.8	-0.118682	-1.8945	41.44	SL8
236	11.5	-3.6	-0.062832	-0.7221	40.72	SL8, DA's House
237	16	-1	-0.017453	-0.2792	40.44	SL8, DA's Shower
238	3.48	0	0	0	57.47	SL7, tied to 126
239	9.39	-12	-0.20944	-1.9523	55.52	SL7
240	4.87	-13.5	-0.235619	-1.1369	54.38	SL7 DB Tap
241	17.5	-6	-0.10472	-1.8292	52.56	TP
242	29.5	-4	-0.069813	-2.0578	50.50	SL6 RA shower
243	14.5	1.8	0.031416	0.4555	60.25	SL5, tied to 121
244	5.9	-7	-0.122173	-0.719	59.53	SL5
245	18.5	-32.2	-0.561996	-9.8582	49.67	SL5, lowest point of pipe crossing stream
246	38.5	0.4	0.006981	0.2688	49.94	TP SL5, on the road at culvert
247	48	2.8	0.048869	2.3448	52.28	TP SL5, on the road
248	22	3.6	0.062832	1.3814	53.67	TP SL5, playground
249	19.5	-0.3	-0.005236	-0.1021	53.56	SL5, IB Tap
250	3.48	6	0.10472	0.3638	50.86	SL7, tied to 242
251	11.5	-25.6	-0.446804	-4.969	45.89	TP SL7, offline
252	21.5	-25.2	-0.439823	-9.1543	36.74	TP SL7, stream crossing, offline
253	15	7.2	0.125664	1.88	38.62	TP SL7, offline
254	23	0.6	0.010472	0.2409	38.86	SL7, on line
255	12	16.4	0.286234	3.3881	42.25	SL7, on line
256	17.5	10.4	0.181514	3.1591	45.41	TP SL7
257	15.5	-4.6	-0.080285	-1.2431	44.16	SL7, MB Tap
258	12.5	-4.4	-0.076794	-0.959	43.20	TP SL7
259	15	-6.2	-0.10821	-1.62	41.58	SL7
260	7.62	-16	-0.279253	-2.1004	39.48	SL7 AA shower

Appendix C: Toma 2 Detail Drawings

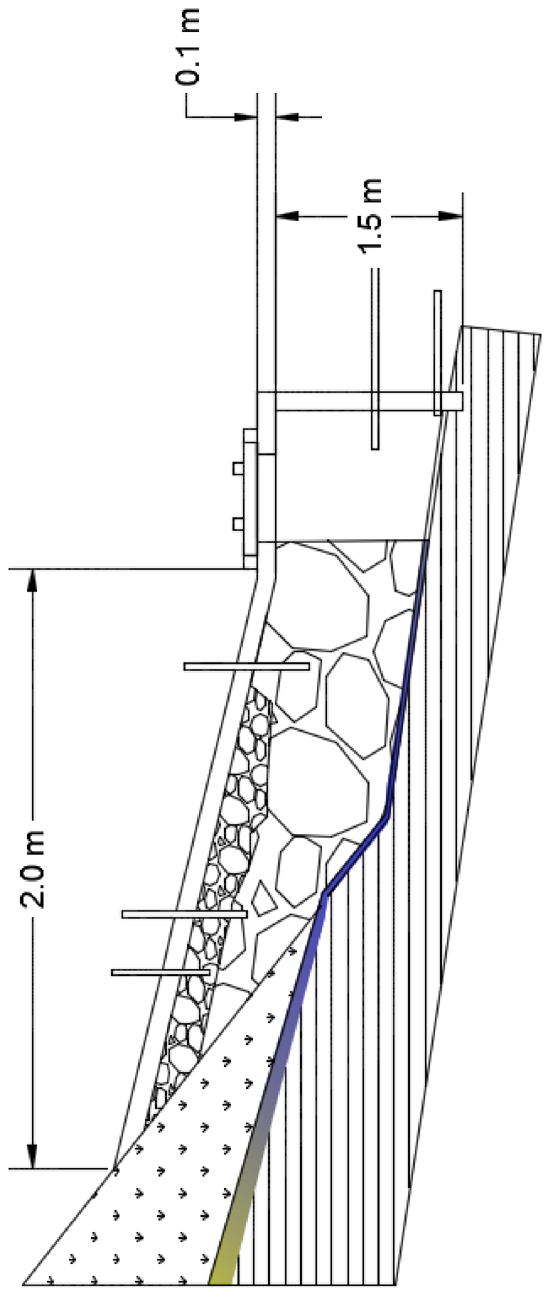


Figure 1: Cross Section of Low Profile Toma Dimensions

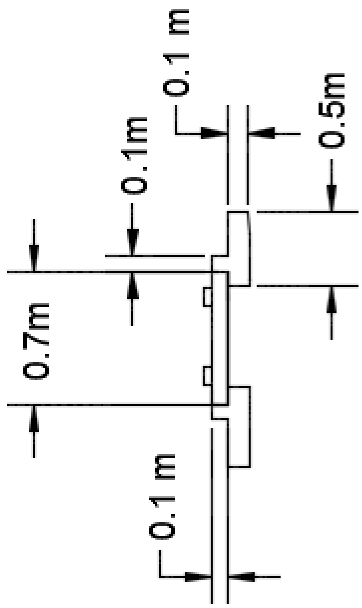


Figure 2: Maintenance Lid Dimensions

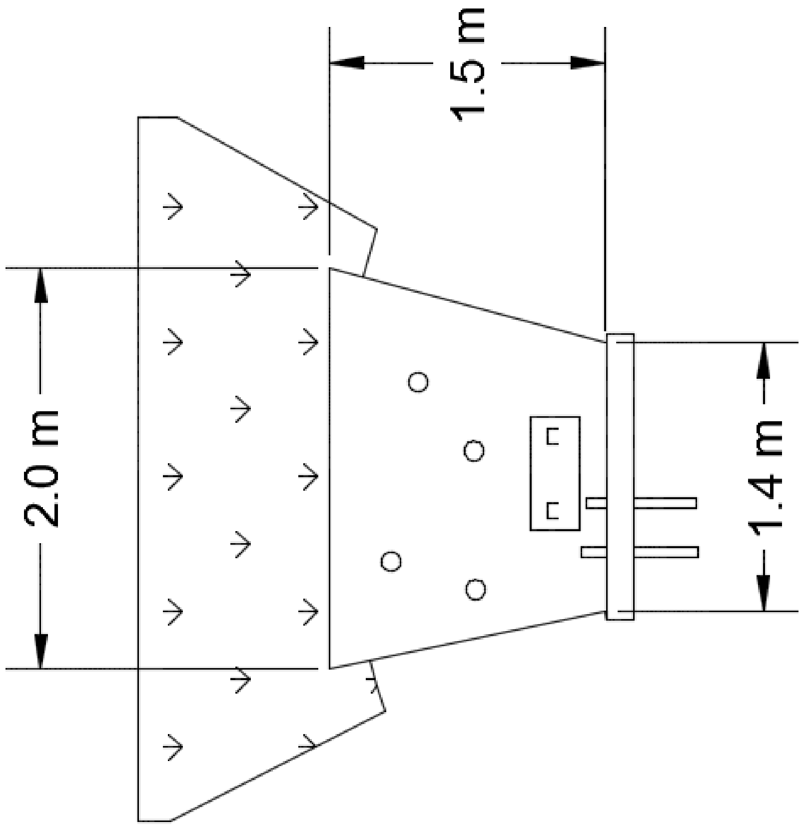


Figure 3: Top View of Low Profile Toma Dimensions

APPENDIX D: SAMPLE CALCULATIONS FOR CONCRETE STRUCTURE

Allowable Axial Force Calculation comes from the "*Field Guide to Environmental Engineering for Development Workers*". Allowable axial force was calculated as buckling will be the most likely reason the column will fail.

The column is 11 blocks, or 88" tall
Effective height is double or 176"
The masonry column will be two 6" blocks wide
The effective width of column is 8.25"
4 pieces of vertically running 5/8" rebar will be used, each with a cross-sectional area of $0.31in^2$

Allowable Axial Force =

$$\big[[0.25 * (masonary\ strenth) * (Effective\ masonry\ area)] + [0.65 * (Steel\ strength) * (Steel\ area)]\big] * \left(\frac{20 * effective\ width}{effective\ height}\right)^2$$

$$= \left(\left(0.25 * \left(250\frac{lb}{in^2}\right) * (8.25in * 8.25in)\right) + (0.65 * \left(36000\frac{lb}{in^2}\right) * (4 * 0.31\ in^2)\right) * \left(\frac{20 * 8.25in}{176in}\right)^2 = 6804\ lbs$$

APPENDIX E: CONCRETE STRUCTURE DETAIL DRAWINGS

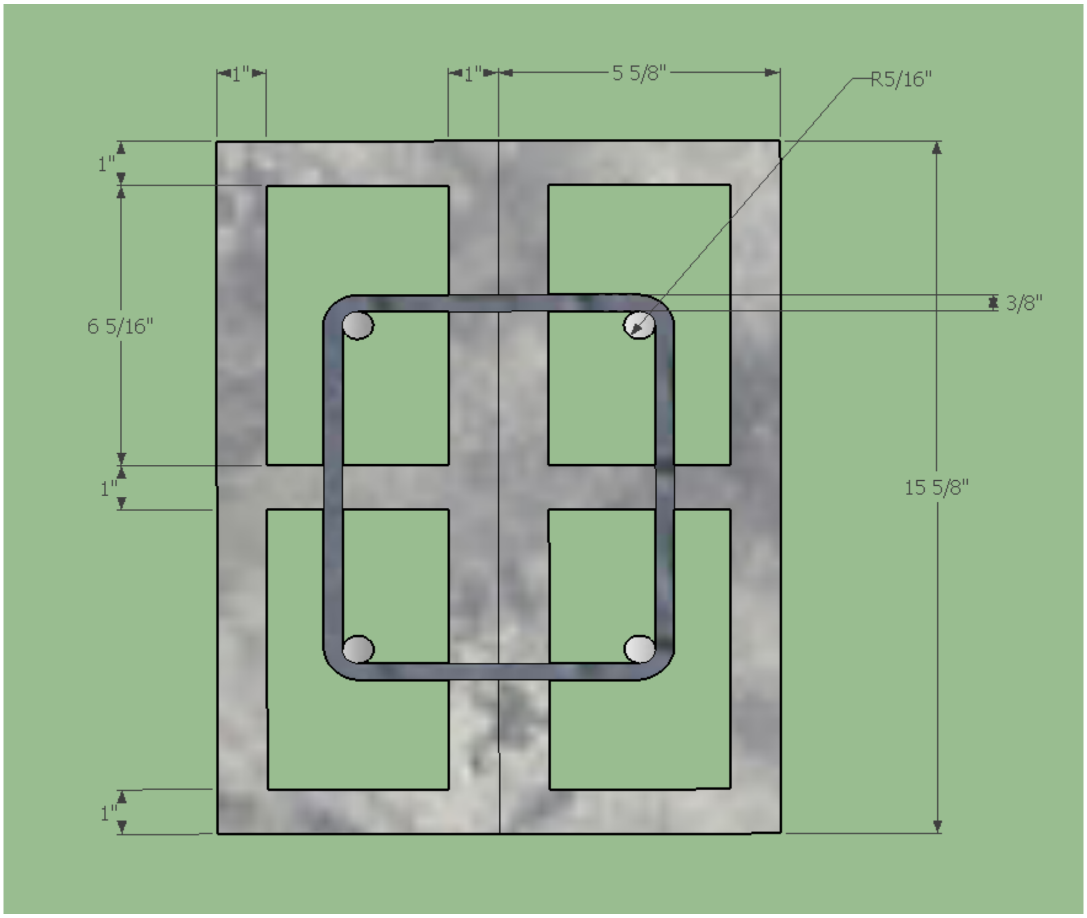


Figure 1: 6” CMU Dimensions

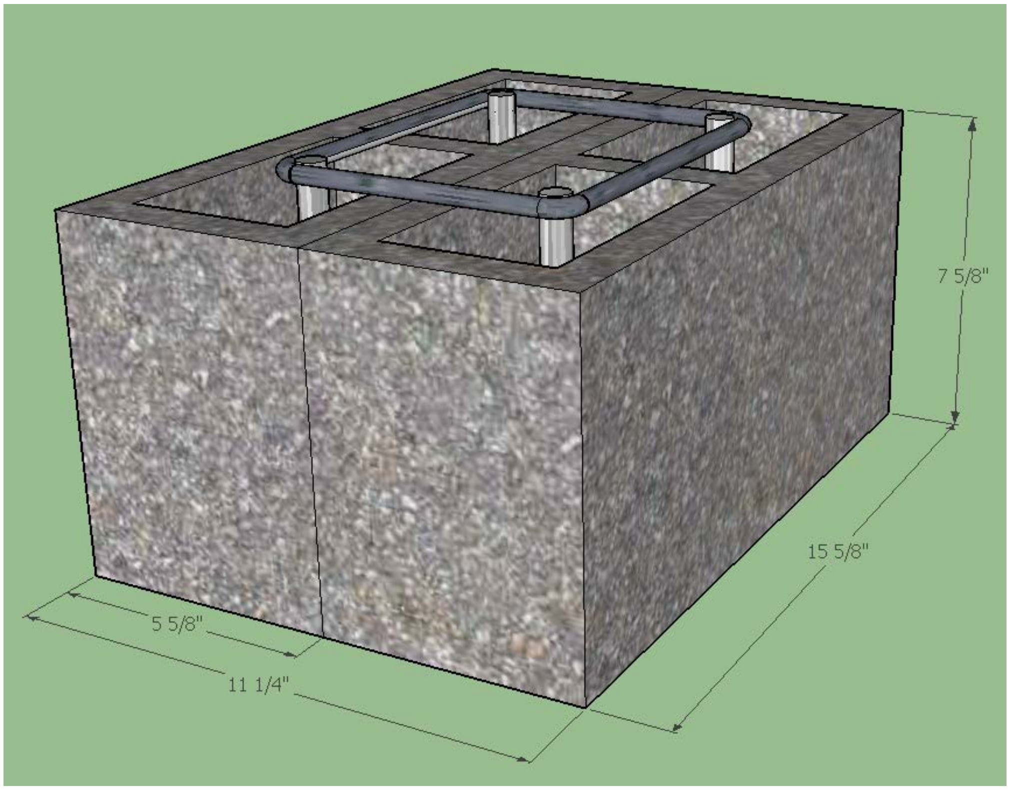


Figure 2: 6" CMU Dimensions

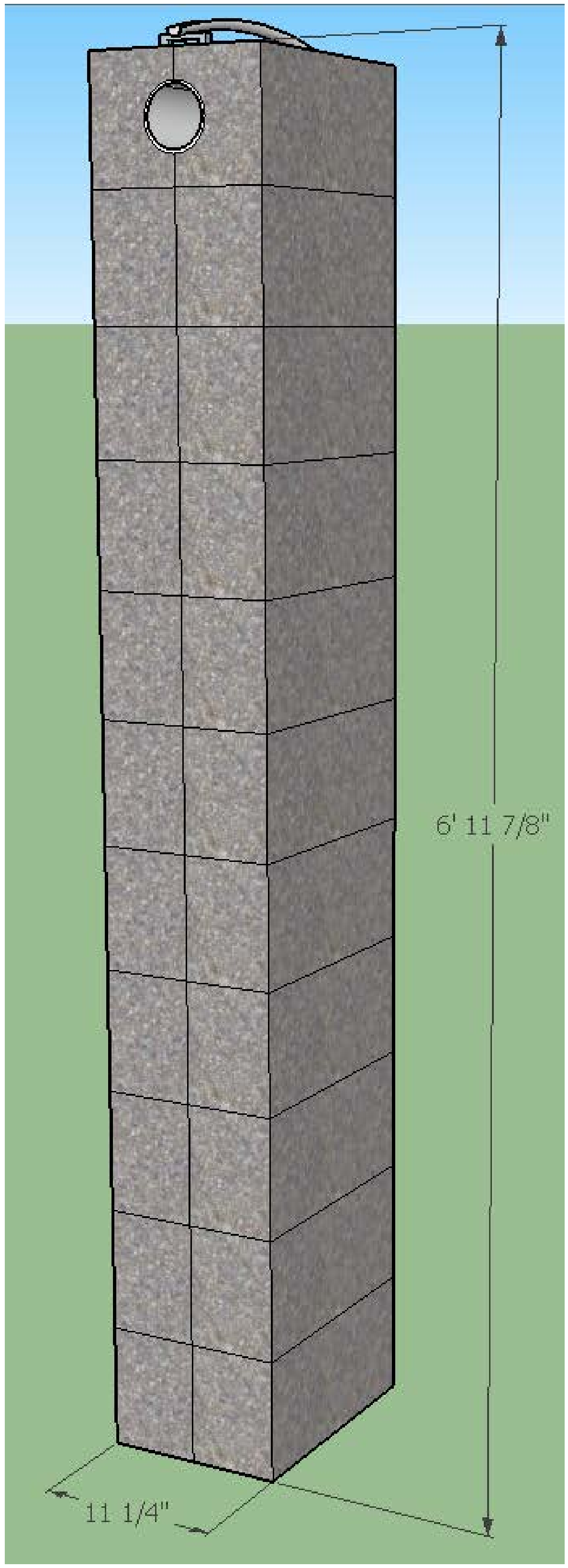


Figure 3: Entire Column Dimensions

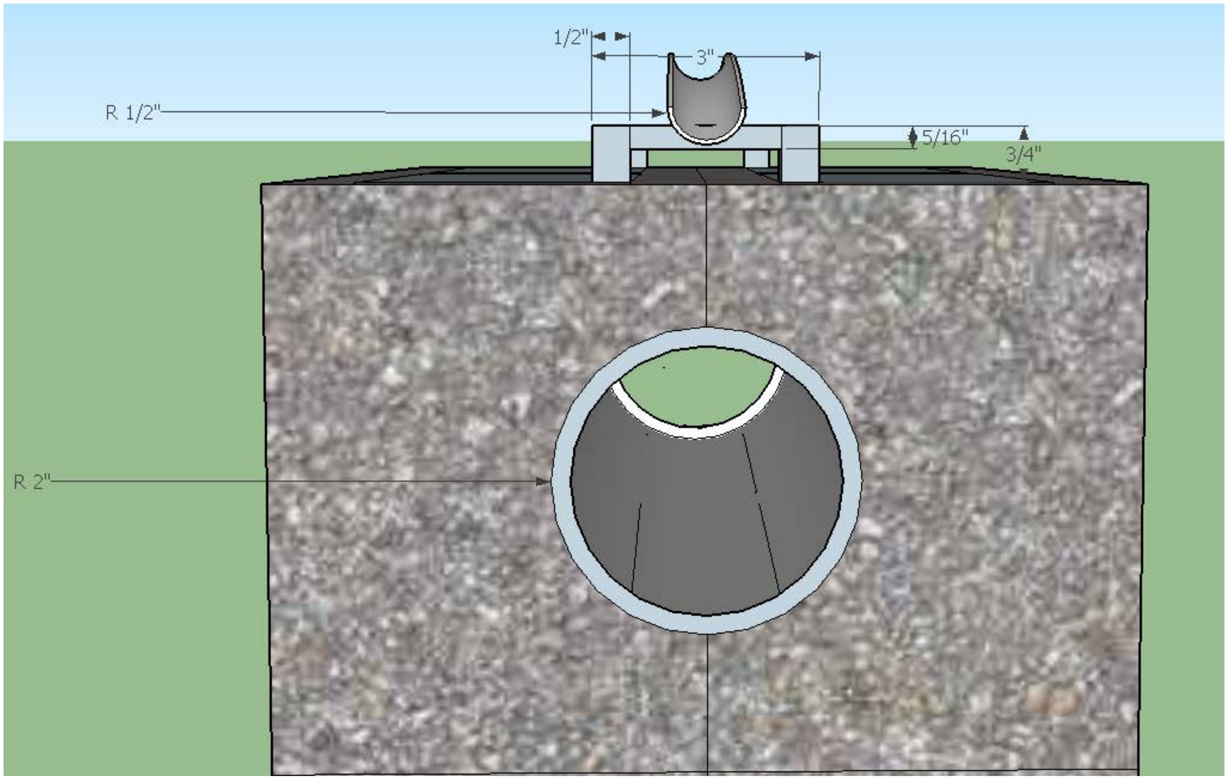


Figure 4: Top Structure Dimensions

APPENDIX F: COST ESTIMATE

Category	Element	Quantity	Units	Unit Price	Material Cost	Comments
Water supply						
Raincatchment	3" PVC	8	20 ft pipe	$10.95	$87.60	Slice to form gutter
Low Profile Springbox	Concrete	2	100 lb bag	$10.50	$21.00	Concrete cap
	Waterproofing SIKA	1	Bucket	$10.50	$10.50	Concrete cap
	Gravel	3	Small Sack 1"	$1.00	$3.00	Fill for spring box
	2" PVC	1	10 ft pipe	$4.50	$4.50	Air ventilation
	plywood forms	1	4x8x1/2" Plywood	$25.50	$25.50	Maintence lid
Water Quality						
Raincatchment	first-flush device	1	EACH	$29.95	$29.95	
	additional 2" PVC	7	20ft pipe	$9.50	$66.50	
	chicken wire	1	2x5ft roll	$8.77	$8.77	Debris screen for gutter
Sustainability/lifetime						
Stream Crossing 1	masonary block	22	EACH (6")	$0.68	$14.96	
	Grout	4	4.4 lb packet	$13.19	$52.76	
	5/8" rebar	1	30 ft	$10.95	$10.95	
	2" Schedule 40 PVC	5	20 ft pipe	$9.50	$47.50	
	2.5" PVC	5	20 ft pipe	$12.00	$60.00	Carrier pipe
	3/8" rebar	1	30'	$3.85	$3.85	Bend on site form stirrups
Stream Crossing 2	2.5" PVC	10	10 ft pipe	$12.00	$120.00	Carrier pipe
Quebrada Ascent	2" Schedule 40 PVC	22	20 ft pipe	$9.50	$209.00	
	Concrete	4	100 lb bag	$10.50	$42.00	Anchors
	Tee 2" PVC	4	EACH	$1.50	$6.00	Cut half
	Adjustable hose clamp	8	EACH	$0.50	$4.00	Clamp pipe to tee
	additional PVC	1	20ft	$9.50	$9.50	Supports
Miscellaneous						
	2" steeel ball valve	5	EACH	$48.53	$242.65	
	1/2" steel ball valve	8	EACH	$12.95	$103.60	
	cement spreader	2	EACH	$3.00	$6.00	
	PVC glue	10	bottle (large)	$5.75	$57.50	
	Paint (latex based)	1	Gallon	$7.95	$7.95	Latex based
	220-grit sandpaper	5	EACH	$0.60	$3.00	For PVC before paiting
Total					**$1,258.54**	

Appendix G: Construction Schedule

Construction Work Breakdown Structure

Ball Valves

1. Main Line Shut Down
    a. Notify everyone that the line will not be in service for the next day
    b. Shut off the line at Toma 1
    c. Leave shut for 6 hours after After Tanks Valve is installed
2. Toma 2 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
3. Steam Crossing 1 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
4. Before Tanks Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
5. After Tanks Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
6. Open up line
    a. Leave line open for 24 hours to allow everyone to use and save water
7. Main Line Shut Down

a. Notify everyone that the line will not be in service for the next day
b. Shut off the line After Tanks
c. Leave shut for 6 hours after Service Line 4 Valve is installed

8. Service Line 1 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
9. Service Line 2 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
10. Service Line 3 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
11. Service Line 4 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
12. School Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
13. Open up line
    a. Leave line open for 24 hours to allow everyone to fill up jugs

14. Main Line Shut Down
    a. Notify everyone that the line will not be in service for the next day
    b. Shut off the line at Service Line 4
    c. Leave shut for 6 hours after Service Line 8 Valve is installed
15. Service Line 5 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
16. Service Line 6 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
17. Service Line 7 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
18. Service Line 8 Valve Replacement
    a. Cut main line
    b. Apply glue to both ends of the valve
    c. Connect the valve to the pipes
    d. Allow to dry for 12 hours before pressurizing the line
19. Open up line
    a. Valve replacement and installation should be complete

Stream Crossing 1

20. Carry tools
    a. Bring up ladder, bucket, and shovel
21. Set up shelter
    a. Canopy for protecting materials and mixing concrete

22. Carry Supplies
    a. 4 Grout Bags
    b. 8 40” #5 rebar bars
    c. 28 6” CMU blocks
23. Stack Blocks
    a. Dig hole in ground
    b. Mix grout
    c. Install first block
    d. Install rebar
    e. Pour grout
24. Cure
    a. Allow four days to cure fully
25. Paint carrier pipe
    a. Paint the carrier pipe to make it resistant
26. Carry pipe up
    a. Take new pipe and carrier pipe to stream crossing
27. Feed through carrier pipe
    a. Feed the water pipe through painted carrier pipe
    b. Connect water pipe to main line
    c. Feed through the block support
    d. Allow to dry for 12 hours before pressurizing the line
28. Hang pipe
    a. String pipe supports on wire
    b. String wire through block support
    c. Feed carrier pipe through pipe supports
    d. Connect main line to pipe through block
    e. Allow to dry for 12 hours before pressurizing the line
    f. Tighten wire in block

Toma 2

29. Carry Tools
    a. Bucket
    b. Shovel
30. Dig to spring
    a. Remove top of toma
    b. Dig until the water runs clear
    c. Clear debris from around the Toma
31. Carry Supplies
    a. 50 Cement Bags
    b. 6 60” #5 rebar bars
32. Concrete
    a. Mix concrete
    b. Pour into forms
33. Cure for 4 days
34. Protect the spring
    a. Place rock and gravel behind the storage area
    b. Pour concrete over rocks to protect
35. Cure for 4 days

Quebrada Pastor Ascent

36. Carry Supplies
    a. 7 Cement Bags
    b. 4 PVC supports and clamps
    c. Bucket
    d. Shovel
37. Install supports
    a. Dig hole
    b. Mix cement
    c. Pour cement in hole
    d. Add support

38. Lay pipe
    a. Using higher grade pipe
    b. Using higher strength PVC glue
    c. Allow to dry for 12 hours before pressurizing the line

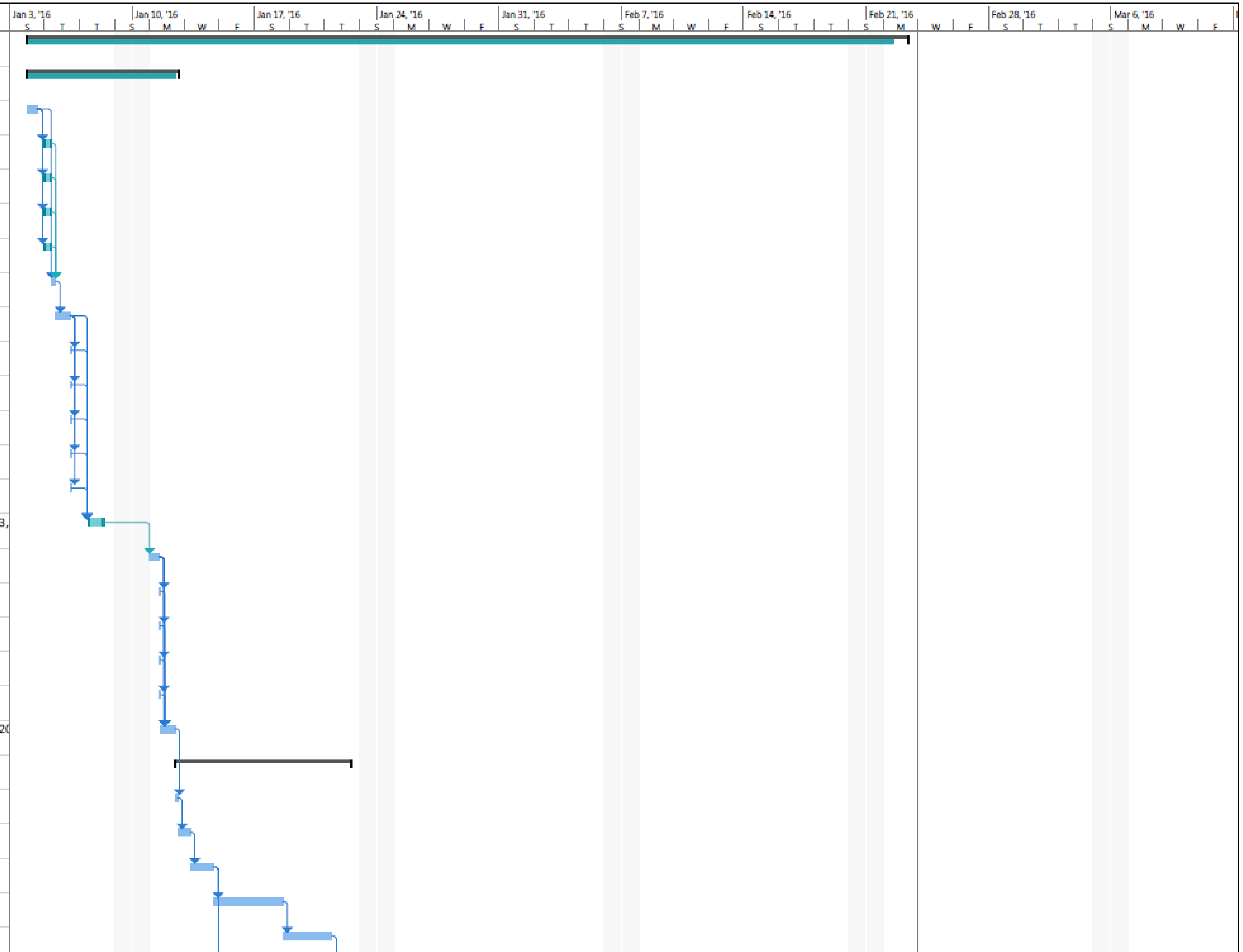
Quebrada Pastor Crossing

39. Paint carrier pipe
    a. Paint the carrier pipe to make it resistant
40. Carry pipe up
    a. Take new pipe and carrier pipe to stream crossing
41. Hang pipe
    a. Feed carrier pipe through pipe supports

Rainwater Catchment

42. Screen gutters
    a. Cover gutters with chicken wire to protect from contamination
43. Install first flush
    a. Cut the pipe
    b. Install system
    c. Allow to dry for 12 hours before allowing catchment

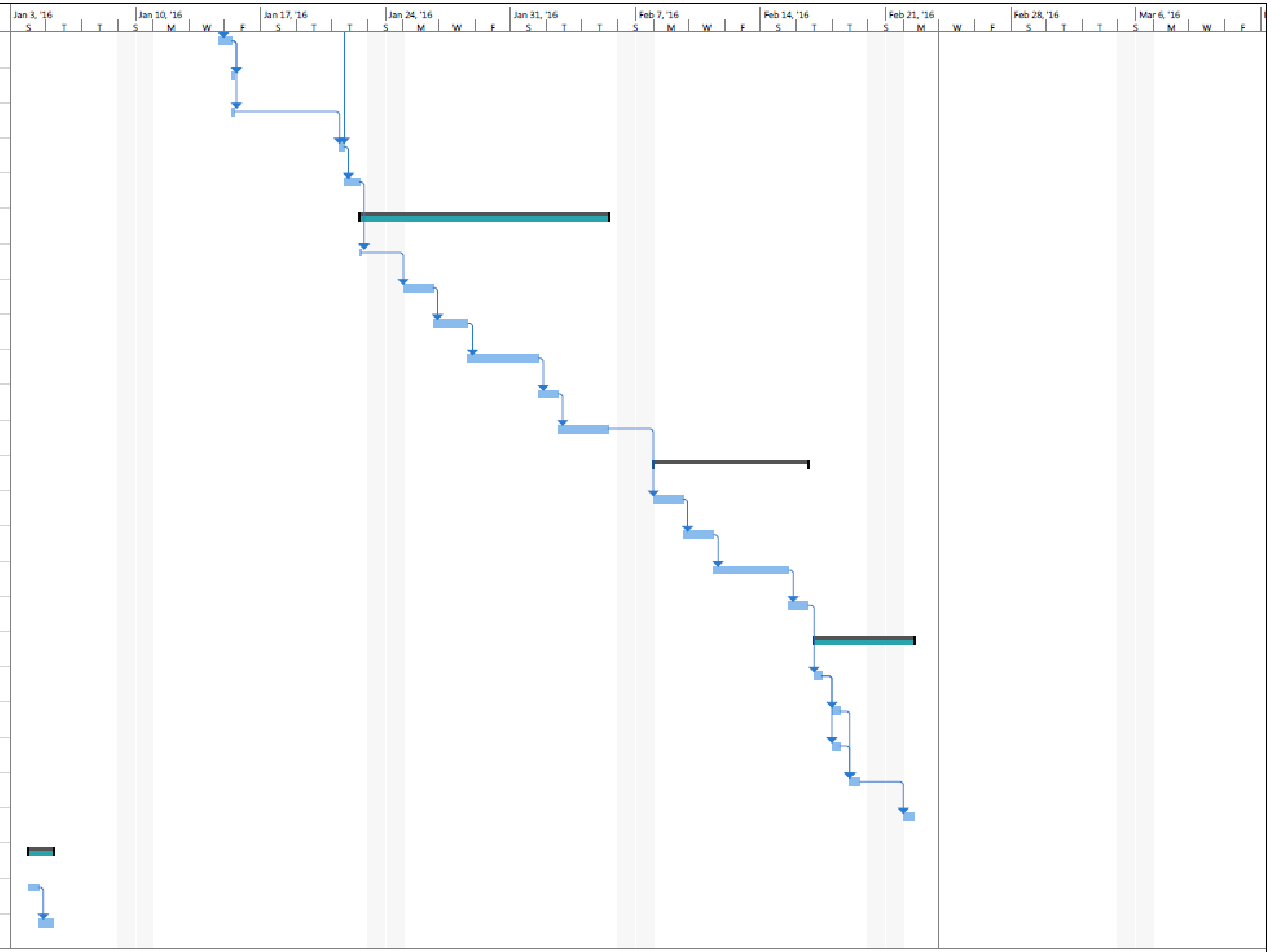
ID	Task Name	Duration	Start	Finish	Predecessors
1	**Construction Time**	**58 days**	**Mon 1/4/16**	**Tue 2/23/16**	
2	**Ball Valve Installation**	**11 days**	**Mon 1/4/16**	**Tue 1/12/16**	
3	Main line shutdown	1 day	Mon 1/4/16	Mon 1/4/16	
4	Toma 2	0.25 days	Tue 1/5/16	Tue 1/5/16	3
5	Stream Crossing 1	0.25 days	Tue 1/5/16	Tue 1/5/16	3
6	Before Tanks	0.25 days	Tue 1/5/16	Tue 1/5/16	3
7	After Tanks	0.25 days	Tue 1/5/16	Tue 1/5/16	3
8	Open line	1 day	Tue 1/5/16	Tue 1/5/16	3,4,5,6,7
9	Main line shutdown	1 day	Tue 1/5/16	Wed 1/6/16	8
10	Service Line 1	0.2 days	Wed 1/6/16	Wed 1/6/16	9
11	Service Line 2	0.2 days	Wed 1/6/16	Wed 1/6/16	9
12	Service Line 3	0.2 days	Wed 1/6/16	Wed 1/6/16	9
13	Service Line 4	0.2 days	Wed 1/6/16	Wed 1/6/16	9
14	School	0.2 days	Wed 1/6/16	Wed 1/6/16	9
15	Open line	1 day	Thu 1/7/16	Fri 1/8/16	9,10,11,12,13,
16	Main line shutdown	1 day	Mon 1/11/16	Mon 1/11/16	15
17	Service Line 5	0.25 days	Mon 1/11/16	Mon 1/11/16	16
18	Service Line 6	0.25 days	Mon 1/11/16	Mon 1/11/16	16
19	Service Line 7	0.25 days	Mon 1/11/16	Mon 1/11/16	16
20	Service Line 8	0.25 days	Mon 1/11/16	Mon 1/11/16	16
21	Open line	1 day	Mon 1/11/16	Tue 1/12/16	16,17,18,19,2
22	**Stream Crossing 1**	**13 days**	**Tue 1/12/16**	**Fri 1/22/16**	
23	Carry Tools	0.5 days	Tue 1/12/16	Tue 1/12/16	21
24	Set up Shelter	0.5 days	Tue 1/12/16	Wed 1/13/16	23
25	Carry Supplies	3 days	Wed 1/13/16	Thu 1/14/16	24
26	Stack Blocks	3 days	Thu 1/14/16	Mon 1/18/16	25
27	Cure	4 days	Mon 1/18/16	Thu 1/21/16	26



Project: Quebrada Pastor Construction Schedule

Task, Split, Milestone, Summary, Project Summary, Inactive Task, Inactive Milestone, Inactive Summary, Manual Task, Duration-only, Manual Summary Rollup, Manual Summary, Start-only, Finish-only, External Tasks, External Milestone, Deadline, Progress, Manual Progress

ID	Task Name	Duration	Start	Finish	Predecessors
28	Paint carrier pipe	0.5 days	Thu 1/14/16	Fri 1/15/16	25
29	Carry carrier pipe	0.5 days	Fri 1/15/16	Fri 1/15/16	28
30	Carry new pipe up	0.5 days	Fri 1/15/16	Fri 1/15/16	28
31	Feed pipe through	1 day	Thu 1/21/16	Thu 1/21/16	30,27
32	Hang pipe	1 day	Thu 1/21/16	Fri 1/22/16	31
33	**Toma 2 Renovations**	**16 days**	**Fri 1/22/16**	**Fri 2/5/16**	
34	Carry Tools	0.5 days	Fri 1/22/16	Fri 1/22/16	32
35	Dig to spring	3 days	Mon 1/25/16	Tue 1/26/16	34
36	Carry Supplies	3 days	Tue 1/26/16	Thu 1/28/16	35
37	Place Rocks	3 days	Thu 1/28/16	Mon 2/1/16	36
38	Pour Concrete Cover	2 days	Mon 2/1/16	Tue 2/2/16	37
39	Cure	4 days	Tue 2/2/16	Fri 2/5/16	38
40	**Quebrada Pastor Ascent**	**11 days**	**Mon 2/8/16**	**Tue 2/16/16**	
41	Carry Supplies	3 days	Mon 2/8/16	Tue 2/9/16	39
42	Install Supports	2 days	Tue 2/9/16	Thu 2/11/16	41
43	Cure	4 days	Thu 2/11/16	Mon 2/15/16	42
44	Lay Pipe	2 days	Mon 2/15/16	Tue 2/16/16	43
45	**Quebrada Pastor Crossing**	**6 days**	**Wed 2/17/16**	**Mon 2/22/16**	
46	Paint carrier pipe	0.5 days	Wed 2/17/16	Wed 2/17/16	44
47	Carry carrier pipe	0.5 days	Thu 2/18/16	Thu 2/18/16	46
48	Carry new pipe up	0.5 days	Thu 2/18/16	Thu 2/18/16	46
49	Feed pipe through	1 day	Fri 2/19/16	Fri 2/19/16	47,48
50	Hang pipe	1 day	Mon 2/22/16	Mon 2/22/16	49
51	**Rainwater Catchment**	**2 days**	**Mon 1/4/16**	**Tue 1/5/16**	
52	Screen Gutters	1 day	Mon 1/4/16	Mon 1/4/16	
53	First flush system	1 day	Mon 1/4/16	Tue 1/5/16	52



Project: Quebrada Pastor Construction Schedule

Task	Project Summary	Manual Task	Start-only
Split	Inactive Task	Duration-only	Finish-only
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks
Summary	Inactive Summary	Manual Summary	External Milestone
Deadline	Progress	Manual Progress	

APPENDIX H: RAINWATER DATA

Table 1. Potential Supply Using Average Rainfall with Additional Gutter

Month	Rainfall (mm)	Supply (gallons)	Demand (gal/month)	% Demand Met
Jan	241.4	34544	30000	100
Feb	147.7	21147	30000	70
Mar	148.4	21237	30000	71
Apr	193.6	27715	30000	92
May	224.8	32178	30000	100
Jun	204.9	29325	30000	98
Jul	290.2	41530	30000	100
Aug	205.4	29392	30000	98
Sep	106.7	15267	30000	51
Oct	137.9	19737	30000	66
Nov	267.3	38254	30000	100
Dec	344.5	49314	30000	100
Average Monthly % Demand met				87

Table 2. Potential Supply Using Minimum Rainfall with Additional Gutter

Month	Rainfall (mm)	Supply (gallons)	Demand (gal/month)	% Demand Met
Jan	56.1	8030	30000	27
Feb	21.6	3092	30000	10
Mar	27.7	3965	30000	13
Apr	41.4	5926	30000	20
May	46	6584	30000	22
Jun	65	9303	30000	31
Jul	89.4	12796	30000	43
Aug	33.5	4795	30000	16
Sep	22.1	3163	30000	11
Oct	57.1	8173	30000	27
Nov	57.2	8187	30000	27
Dec	104.6	14971	30000	50
Average Monthly % Demand Met				25

Table 3. Percent Demand Analysis 46 years

46 Year Rainfall Data Analysis						
Water Demand of the School			113.562	m^3/month		
Catchment Area, A			301	m^2		
Runoff Coefficient, C			0.9	for galvanized iron		
Available Storage in Tanks			11.3562	m^3		
Year	Month	Percipitation (mm)	Supply	Vt	Vt correct	% Demand
1926	Jan	664.2	179.9	66.4	11	100
	Feb	149.9	40.6	-6.6	0	36
	Mar	188.7	51.1	-62.4	0	45
	Apr	227.6	61.7	-51.9	0	54
	May	348.0	94.3	-19.3	0	83
	Jun	200.7	54.4	-59.2	0	48
	Jul	325.4	88.2	-25.4	0	78
	Aug	181.3	49.1	-64.4	0	43
	Sep	165.4	44.8	-68.8	0	39
	Oct	57.1	15.5	-98.1	0	14
	Nov	261.6	70.9	-42.7	0	62
	Dec	355.6	96.3	-17.2	0	85
1927	Jan	761.2	206.2	92.6	0	100
	Feb	249.9	67.7	-45.9	0	60
	Mar	176.0	47.7	-65.9	0	42
	Apr	237.7	64.4	-49.2	0	57
	May	180.6	48.9	-64.6	0	43
	Jun	372.4	100.9	-12.7	0	89
	Jul	138.9	37.6	-75.9	0	33
	Aug	205.0	55.5	-58.0	0	49
	Sep	115.8	31.4	-82.2	0	28
	Oct	177.0	47.9	-65.6	0	42
	Nov	244.3	66.2	-47.4	0	58
	Dec	487.2	132.0	18.4	0	100
1928	Jan	234.9	63.6	-49.9	0	56
	Feb	257.8	69.8	-43.7	0	61
	Mar	86.4	23.4	-90.2	0	21
	Apr	216.2	58.6	-55.0	0	52
	May	150.9	40.9	-72.7	0	36
	Jun	267.7	72.5	-41.0	0	64
	Jul	322.8	87.4	-26.1	0	77
	Aug	176.0	47.7	-65.9	0	42
	Sep	68.8	18.6	-94.9	0	16
	Oct	151.9	41.1	-72.4	0	36
	Nov	434.6	117.7	4.2	4	100
	Dec	256.5	69.5	-39.9	0	61
1929	Jan	234.9	63.6	-49.9	0	56

	Feb	257.8	69.8	-43.7	0	61
	Mar	86.4	23.4	-90.2	0	21
	Apr	216.2	58.6	-55.0	0	52
	May	150.9	40.9	-72.7	0	36
	Jun	267.7	72.5	-41.0	0	64
	Jul	322.8	87.4	-26.1	0	77
	Aug	176.0	47.7	-65.9	0	42
	Sep	68.8	18.6	-94.9	0	16
	Oct	151.9	41.1	-72.4	0	36
	Nov	434.6	117.7	4.2	4	100
	Dec	256.5	69.5	-39.9	0	61
1930	Jan	56.1	15.2	-98.4	0	13
	Feb	99.3	26.9	-86.7	0	24
	Mar	139.4	37.8	-75.8	0	33
	Apr	253.5	68.7	-44.9	0	60
	May	292.4	79.2	-34.4	0	70
	Jun	161.0	43.6	-69.9	0	38
	Jul	439.7	119.1	5.6	6	100
	Aug	247.1	66.9	-41.1	0	59
	Sep	136.4	37.0	-76.6	0	33
	Oct	156.0	42.3	-71.3	0	37
	Nov	265.2	71.8	-41.7	0	63
	Dec	242.6	65.7	-47.8	0	58
1931	Jan	82.3	22.3	-91.3	0	20
	Feb	41.1	11.1	-102.4	0	10
	Mar	65.5	17.7	-95.8	0	16
	Apr	161.8	43.8	-69.7	0	39
	May	212.1	57.5	-56.1	0	51
	Jun	209.0	56.6	-56.9	0	50
	Jul	500.6	135.6	22.1	11	100
	Aug	467.9	126.8	35.2	0	100
	Sep	223.5	60.5	-17.8	0	53
	Oct	76.2	20.6	-92.9	0	18
	Nov	141.7	38.4	-75.2	0	34
	Dec	181.9	49.3	-64.3	0	43
1932	Jan	267.7	72.5	-41.0	0	64
	Feb	37.6	10.2	-103.4	0	9
	Mar	173.2	46.9	-66.6	0	41
	Apr	318.5	86.3	-27.3	0	76
	May	102.6	27.8	-85.8	0	24
	Jun	154.2	41.8	-71.8	0	37
	Jul	209.0	56.6	-56.9	0	50
	Aug	110.2	29.9	-83.7	0	26
	Sep	75.9	20.6	-93.0	0	18

	Oct	91.2	24.7	-88.9	0	22
	Nov	141.7	38.4	-75.2	0	34
	Dec	181.9	49.3	-64.3	0	43
1933	Jan	196.6	53.3	-60.3	0	47
	Feb	142.2	38.5	-75.0	0	34
	Mar	95.8	26.0	-87.6	0	23
	Apr	41.4	11.2	-102.3	0	10
	May	193.3	52.4	-61.2	0	46
	Jun	68.1	18.4	-95.1	0	16
	Jul	174.2	47.2	-66.4	0	42
	Aug	33.5	9.1	-104.5	0	8
	Sep	84.8	23.0	-90.6	0	20
	Oct	100.6	27.3	-86.3	0	24
	Nov	132.6	35.9	-77.6	0	32
	Dec	296.7	80.4	-33.2	0	71
1934	Jan	85.9	23.3	-90.3	0	20
	Feb	43.7	11.8	-101.7	0	10
	Mar	86.6	23.5	-90.1	0	21
	Apr	104.6	28.3	-85.2	0	25
	May	61.7	16.7	-96.8	0	15
	Jun	183.9	49.8	-63.7	0	44
	Jul	306.1	82.9	-30.6	0	73
	Aug	272.5	73.8	-39.7	0	65
	Sep	124.5	33.7	-79.8	0	30
	Oct	116.3	31.5	-82.1	0	28
	Nov	320.0	86.7	-26.9	0	76
	Dec	355.6	96.3	-17.2	0	85
1935	Jan	454.7	123.2	9.6	0	100
	Feb	124.7	33.8	-79.8	0	30
	Mar	201.7	54.6	-58.9	0	48
	Apr	158.0	42.8	-70.8	0	38
	May	46.0	12.5	-101.1	0	11
	Jun	233.9	63.4	-50.2	0	56
	Jul	328.4	89.0	-24.6	0	78
	Aug	105.4	28.6	-85.0	0	25
	Sep	94.0	25.5	-88.1	0	22
	Oct	144.5	39.1	-74.4	0	34
	Nov	389.9	105.6	-7.9	0	93
	Dec	673.6	182.5	68.9	0	100
1936	Jan	73.2	19.8	-93.7	0	17
	Feb	85.1	23.1	-90.5	0	20
	Mar	30.2	8.2	-105.4	0	7
	Apr	239.0	64.7	-48.8	0	57
	May	138.7	37.6	-76.0	0	33

	Jun	65.0	17.6	-96.0	0	16
	Jul	89.4	24.2	-89.3	0	21
	Aug	168.4	45.6	-67.9	0	40
	Sep	22.1	6.0	-107.6	0	5
	Oct	77.7	21.0	-92.5	0	19
	Nov	210.6	57.1	-56.5	0	50
	Dec	104.6	28.3	-85.2	0	25
1937	Jan	259.8	70.4	-43.2	0	62
	Feb	92.2	25.0	-88.6	0	22
	Mar	79.8	21.6	-91.9	0	19
	Apr	95.8	26.0	-87.6	0	23
	May	133.3	36.1	-77.5	0	32
	Jun	212.1	57.5	-56.1	0	51
	Jul	293.9	79.6	-33.9	0	70
	Aug	256.5	69.5	-44.1	0	61
	Sep	81.3	22.0	-91.5	0	19
	Oct	95.0	25.7	-87.8	0	23
	Nov	102.1	27.7	-85.9	0	24
	Dec	359.4	97.4	-16.2	0	86
1938	Jan	326.4	88.4	-25.1	0	78
	Feb	201.2	54.5	-59.1	0	48
	Mar	151.1	40.9	-72.6	0	36
	Apr	308.6	83.6	-30.0	0	74
	May	487.4	132.0	18.5	0	100
	Jun	162.1	43.9	-69.6	0	39
	Jul	311.9	84.5	-29.1	0	74
	Aug	151.4	41.0	-72.5	0	36
	Sep	153.2	41.5	-72.1	0	37
	Oct	97.3	26.4	-87.2	0	23
	Nov	202.2	54.8	-58.8	0	48
	Dec	450.6	122.1	8.5	0	100
1939	Jan	90.2	24.4	-80.6	0	22
	Feb	88.9	24.1	-89.5	0	21
	Mar	126.2	34.2	-79.4	0	30
	Apr	138.4	37.5	-76.1	0	33
	May	212.1	57.5	-56.1	0	51
	Jun	182.4	49.4	-64.2	0	44
	Jul	577.1	156.3	42.8	0	100
	Aug	247.4	67.0	-46.5	0	59
	Sep	168.4	45.6	-67.9	0	40
	Oct	117.9	31.9	-81.6	0	28
	Nov	490.0	132.7	19.2	11	100
	Dec	325.9	88.3	-6.1	0	78
1940	Jan	171.4	46.4	-67.1	0	41

	Feb	257.8	69.8	-43.7	0	61
	Mar	97.3	26.4	-87.2	0	23
	Apr	72.6	19.7	-93.9	0	17
	May	175.8	47.6	-65.9	0	42
	Jun	155.2	42.0	-71.5	0	37
	Jul	364.5	98.7	-14.8	0	87
	Aug	248.4	67.3	-46.3	0	59
	Sep	129.8	35.2	-78.4	0	31
	Oct	177.5	48.1	-65.5	0	42
	Nov	209.5	56.8	-56.8	0	50
	Dec	181.1	49.1	-64.5	0	43
1941	Jan	97.3	26.4	-87.2	0	23
	Feb	145.5	39.4	-74.1	0	35
	Mar	169.2	45.8	-67.7	0	40
	Apr	134.9	36.5	-77.0	0	32
	May	142.0	38.5	-75.1	0	34
	Jun	175.0	47.4	-66.2	0	42
	Jul	221.7	60.1	-53.5	0	53
	Aug	284.5	77.1	-36.5	0	68
	Sep	118.4	32.1	-81.5	0	28
	Oct	201.7	54.6	-58.9	0	48
	Nov	122.7	33.2	-80.3	0	29
	Dec	178.8	48.4	-65.1	0	43
1942	Jan	224.3	60.8	-52.8	0	54
	Feb	53.8	14.6	-99.0	0	13
	Mar	417.8	113.2	-0.4	0	100
	Apr	191.8	52.0	-61.6	0	46
	May	191.5	51.9	-61.7	0	46
	Jun	154.9	42.0	-71.6	0	37
	Jul	112.3	30.4	-83.1	0	27
	Aug	76.7	20.8	-92.8	0	18
	Sep	64.8	17.6	-96.0	0	15
	Oct	124.2	33.6	-79.9	0	30
	Nov	57.2	15.5	-98.1	0	14
	Dec	120.9	32.8	-80.8	0	29
1943	Jan	393.2	106.5	-7.0	0	94
	Feb	140.2	38.0	-75.6	0	33
	Mar	70.6	19.1	-94.4	0	17
	Apr	61.5	16.7	-96.9	0	15
	May	226.6	61.4	-52.2	0	54
	Jun	227.1	61.5	-52.0	0	54
	Jul	300.5	81.4	-32.2	0	72
	Aug	70.6	19.1	-94.4	0	17
	Sep	37.1	10.1	-103.5	0	9

	Oct	216.4	58.6	-54.9	0	52
	Nov	170.9	46.3	-67.3	0	41
	Dec	344.7	93.4	-20.2	0	82
1944	Jan	367.0	99.4	-14.1	0	88
	Feb	187.5	50.8	-62.8	0	45
	Mar	129.8	35.2	-78.4	0	31
	Apr	380.0	102.9	-10.6	0	91
	May	205.2	55.6	-58.0	0	49
	Jun	173.2	46.9	-66.6	0	41
	Jul	304.3	82.4	-31.1	0	73
	Aug	172.2	46.6	-66.9	0	41
	Sep	54.1	14.7	-98.9	0	13
	Oct	311.9	84.5	-29.1	0	74
	Nov	450.8	122.1	8.6	0	100
	Dec	881.6	238.8	133.8	0	100
1945	Jan	125.0	33.9	54.1	11	40
	Feb	166.4	45.1	-14.4	0	40
	Mar	172.7	46.8	-66.8	0	41
	Apr	119.9	32.5	-81.1	0	29
	May	102.9	27.9	-85.7	0	25
	Jun	333.8	90.4	-23.1	0	80
	Jul	199.4	54.0	-59.5	0	48
	Aug	65.5	17.7	-95.8	0	16
	Sep	119.9	32.5	-81.1	0	29
	Oct	90.2	24.4	-89.1	0	22
	Nov	222.5	60.3	-53.3	0	53
	Dec	176.0	47.7	-65.9	0	42
1946	Jan	151.9	41.1	-72.4	0	36
	Feb	105.7	28.6	-84.9	0	25
	Mar	92.2	25.0	-88.6	0	22
	Apr	150.9	40.9	-72.7	0	36
	May	252.5	68.4	-45.2	0	60
	Jun	424.4	115.0	1.4	1	100
	Jul	411.7	111.5	-0.6	0	98
	Aug	195.6	53.0	-60.6	0	47
	Sep	73.9	20.0	-93.5	0	18
	Oct	70.9	19.2	-94.4	0	17
	Nov	100.3	27.2	-86.4	0	24
	Dec	331.2	89.7	-23.8	0	79
1947	Jan	121.2	32.8	-80.7	0	29
	Feb	99.8	27.0	-86.5	0	24
	Mar	87.9	23.8	-89.8	0	21
	Apr	278.4	75.4	-38.1	0	66
	May	207.5	56.2	-57.4	0	49

	Jun	273.3	74.0	-39.5	0	65
	Jul	232.9	63.1	-50.5	0	56
	Aug	234.7	63.6	-50.0	0	56
	Sep	41.1	11.1	-102.4	0	10
	Oct	169.2	45.8	-67.7	0	40
	Nov	88.1	23.9	-89.7	0	21
	Dec	172.2	46.6	-66.9	0	41
1948	Jan	222.2	60.2	-53.4	0	53
	Feb	161.5	43.8	-69.8	0	39
	Mar	184.9	50.1	-63.5	0	44
	Apr	150.6	40.8	-72.8	0	36
	May	385.6	104.5	-9.1	0	92
	Jun	235.7	63.9	-49.7	0	56
	Jul	140.2	38.0	-75.6	0	33
	Aug	251.7	68.2	-45.4	0	60
	Sep	75.7	20.5	-93.1	0	18
	Oct	157.0	42.5	-71.0	0	37
	Nov	184.9	50.1	-63.5	0	44
	Dec	217.2	58.8	-54.7	0	52
1949	Jan	160.0	43.3	-70.2	0	38
	Feb	71.4	19.3	-94.2	0	17
	Mar	59.2	16.0	-97.5	0	14
	Apr	114.0	30.9	-82.7	0	27
	May	491.0	133.0	19.4	11	100
	Jun	153.7	41.6	-52.5	0	37
	Jul	208.3	56.4	-57.1	0	50
	Aug	198.6	53.8	-59.8	0	47
	Sep	63.5	17.2	-96.4	0	15
	Oct	127.8	34.6	-78.9	0	30
	Nov	438.9	118.9	5.3	0	100
	Dec	712.7	193.1	79.5	0	100
1950	Jan	339.1	91.9	-21.7	0	81
	Feb	162.6	44.0	-69.5	0	39
	Mar	243.3	65.9	-47.7	0	58
	Apr	79.8	21.6	-91.9	0	19
	May	410.5	111.2	-2.4	0	98
	Jun	342.1	92.7	-20.9	0	82
	Jul	583.7	158.1	44.6	0	100
	Aug	190.0	51.5	-62.1	0	45
	Sep	79.0	21.4	-92.2	0	19
	Oct	83.6	22.6	-90.9	0	20
	Nov	830.6	225.0	111.4	0	100
	Dec	358.1	97.0	-16.6	0	85
1951	Jan	156.0	42.3	-71.3	0	37

	Feb	538.5	145.9	32.3	0	100
	Mar	171.4	46.4	-67.1	0	41
	Apr	182.1	49.3	-64.2	0	43
	May	114.3	31.0	-82.6	0	27
	Jun	313.2	84.8	-28.7	0	75
	Jul	384.8	104.2	-9.3	0	92
	Aug	276.4	74.9	-38.7	0	66
	Sep	110.2	29.9	-83.7	0	26
	Oct	131.3	35.6	-78.0	0	31
	Nov	180.8	49.0	-64.6	0	43
	Dec	130.0	35.2	-78.3	0	31
1952	Jan	343.9	93.2	-20.4	0	82
	Feb	87.4	23.7	-89.9	0	21
	Mar	27.7	7.5	-106.1	0	7
	Apr	146.3	39.6	-73.9	0	35
	May	106.7	28.9	-84.7	0	25
	Jun	95.8	26.0	-87.6	0	23
	Jul	257.0	69.6	-43.9	0	61
	Aug	94.7	25.7	-87.9	0	23
	Sep	78.2	21.2	-92.4	0	19
	Oct	291.1	78.9	-34.7	0	69
	Nov	117.9	31.9	-81.6	0	28
	Dec	259.1	70.2	-43.4	0	62
1953	Jan	262.1	71.0	-42.6	0	63
	Feb	316.0	85.6	-28.0	0	75
	Mar	88.1	23.9	-89.7	0	21
	Apr	66.3	18.0	-95.6	0	16
	May	177.5	48.1	-65.5	0	42
	Jun	139.2	37.7	-75.9	0	33
	Jul	271.3	73.5	-40.1	0	65
	Aug	400.6	108.5	-5.0	0	96
	Sep	36.8	10.0	-103.6	0	9
	Oct	102.4	27.7	-85.8	0	24
	Nov	389.6	105.5	-8.0	0	93
	Dec	250.4	67.8	-45.7	0	60
1954	Jan	212.9	57.7	-55.9	0	51
	Feb	30.0	8.1	-105.4	0	7
	Mar	177.0	47.9	-65.6	0	42
	Apr	235.2	63.7	-49.8	0	56
	May	195.1	52.9	-60.7	0	47
	Jun	169.7	46.0	-67.6	0	40
	Jul	237.7	64.4	-49.2	0	57
	Aug	248.2	67.2	-46.3	0	59
	Sep	172.0	46.6	-67.0	0	41

	Oct	127.0	34.4	-79.2	0	30
	Nov	237.7	64.4	-49.2	0	57
	Dec	566.7	153.5	40.0	0	100
1955	Jan	125.7	34.1	-79.5	0	30
	Feb	142.2	38.5	-75.0	0	34
	Mar	192.0	52.0	-61.5	0	46
	Apr	131.1	35.5	-78.0	0	31
	May	275.8	74.7	-38.8	0	66
	Jun	136.9	37.1	-76.5	0	33
	Jul	264.4	71.6	-41.9	0	63
	Aug	36.1	9.8	-103.8	0	9
	Sep	80.0	21.7	-91.9	0	19
	Oct	243.8	66.0	-47.5	0	58
	Nov	204.5	55.4	-58.2	0	49
	Dec	301.5	81.7	-31.9	0	72
1956	Jan	324.4	87.9	-25.7	0	77
	Feb	132.8	36.0	-77.6	0	32
	Mar	150.4	40.7	-72.8	0	36
	Apr	141.5	38.3	-75.2	0	34
	May	271.5	73.5	-40.0	0	65
	Jun	252.5	68.4	-45.2	0	60
	Jul	463.8	125.6	12.1	11	100
	Aug	132.6	35.9	-65.6	0	32
	Sep	149.6	40.5	-73.0	0	36
	Oct	148.8	40.3	-73.3	0	35
	Nov	175.5	47.5	-66.0	0	42
	Dec	572.5	155.1	41.5	11	100
1957	Jan	240.8	65.2	-6.8	0	57
	Feb	93.2	25.2	-88.3	0	22
	Mar	51.3	13.9	-99.7	0	12
	Apr	92.3	25.0	-88.6	0	22
	May	148.3	40.2	-73.4	0	35
	Jun	169.2	45.8	-67.7	0	40
	Jul	271.5	73.5	-40.0	0	65
	Aug	590.3	159.9	46.3	0	100
	Sep	116.3	31.5	-82.1	0	28
	Oct	90.4	24.5	-89.1	0	22
	Nov	444.8	120.5	6.9	7	100
	Dec	499.6	135.3	28.7	11	100
1958	Jan	309.6	83.9	-1.0	0	74
	Feb	489.5	132.6	19.0	11	100
	Mar	208.8	56.6	-38.0	0	50
	Apr	95.5	25.9	-87.7	0	23
	May	231.4	62.7	-50.9	0	55

	Jun	208.3	56.4	-57.1	0	50
	Jul	189.5	51.3	-62.2	0	45
	Aug	366.0	99.1	-14.4	0	87
	Sep	110.5	29.9	-83.6	0	26
	Oct	108.7	29.4	-84.1	0	26
	Nov	150.4	40.7	-72.8	0	36
	Dec	172.7	46.8	-66.8	0	41
1959	Jan	87.6	23.7	-89.8	0	21
	Feb	68.1	18.4	-95.1	0	16
	Mar	143.5	38.9	-74.7	0	34
	Apr	350.0	94.8	-18.7	0	83
	May	241.0	65.3	-48.3	0	57
	Jun	321.6	87.1	-26.4	0	77
	Jul	189.5	51.3	-62.2	0	45
	Aug	194.8	52.8	-60.8	0	46
	Sep	89.4	24.2	-89.3	0	21
	Oct	64.0	17.3	-96.2	0	15
	Nov	220.0	59.6	-54.0	0	52
	Dec	202.7	54.9	-58.7	0	48
1960	Jan	216.4	58.6	-54.9	0	52
	Feb	162.8	44.1	-69.5	0	39
	Mar	165.6	44.9	-68.7	0	40
	Apr	95.0	25.7	-87.8	0	23
	May	121.2	32.8	-80.7	0	29
	Jun	204.7	55.5	-58.1	0	49
	Jul	175.8	47.6	-65.9	0	42
	Aug	199.9	54.2	-59.4	0	48
	Sep	104.1	28.2	-85.4	0	25
	Oct	80.3	21.8	-91.8	0	19
	Nov	174.0	47.1	-66.4	0	42
	Dec	313.2	84.8	-28.7	0	75
1961	Jan	125.2	33.9	-79.6	0	30
	Feb	37.1	10.1	-103.5	0	9
	Mar	205.2	55.6	-58.0	0	49
	Apr	184.1	49.9	-63.7	0	44
	May	242.6	65.7	-47.8	0	58
	Jun	303.0	82.1	-31.5	0	72
	Jul	284.0	76.9	-36.6	0	68
	Aug	227.8	61.7	-51.9	0	54
	Sep	67.8	18.4	-95.2	0	16
	Oct	138.9	37.6	-75.9	0	33
	Nov	199.4	54.0	-59.5	0	48
	Dec	220.2	59.7	-53.9	0	53
1962	Jan	198.1	53.7	-59.9	0	47

	Feb	79.8	21.6	-91.9	0	19
	Mar	86.1	23.3	-90.2	0	21
	Apr	247.9	67.2	-46.4	0	59
	May	198.6	53.8	-59.8	0	47
	Jun	197.9	53.6	-60.0	0	47
	Jul	217.9	59.0	-54.5	0	52
	Aug	108.7	29.4	-84.1	0	26
	Sep	62.7	17.0	-96.6	0	15
	Oct	90.7	24.6	-89.0	0	22
	Nov	496.8	134.6	21.0	0	100
	Dec	362.2	98.1	5.6	6	91
1963	Jan	186.7	50.6	-57.4	0	45
	Feb	115.6	31.3	-82.2	0	28
	Mar	238.5	64.6	-49.0	0	57
	Apr	409.7	111.0	-2.6	0	98
	May	152.1	41.2	-72.4	0	36
	Jun	136.9	37.1	-76.5	0	33
	Jul	136.4	37.0	-76.6	0	33
	Aug	104.4	28.3	-85.3	0	25
	Sep	90.2	24.4	-89.1	0	22
	Oct	259.8	70.4	-43.2	0	62
	Nov	134.1	36.3	-77.2	0	32
	Dec	401.1	108.7	-4.9	0	96
1964	Jan	145.5	39.4	-74.1	0	35
	Feb	21.6	5.9	-107.7	0	5
	Mar	220.5	59.7	-53.8	0	53
	Apr	144.8	39.2	-74.3	0	35
	May	289.3	78.4	-35.2	0	69
	Jun	197.9	53.6	-60.0	0	47
	Jul	163.6	44.3	-69.2	0	39
	Aug	180.8	49.0	-64.6	0	43
	Sep	170.2	46.1	-67.5	0	41
	Oct	154.7	41.9	-71.7	0	37
	Nov	123.4	33.4	-80.1	0	29
	Dec	154.9	42.0	-71.6	0	37
1965	Jan	394.7	106.9	-6.6	0	94
	Feb	227.8	61.7	-51.9	0	54
	Mar	183.9	49.8	-63.7	0	44
	Apr	59.9	16.2	-97.3	0	14
	May	252.0	68.3	-45.3	0	60
	Jun	117.1	31.7	-81.8	0	28
	Jul	531.6	144.0	30.4	0	100
	Aug	127.5	34.5	-48.6	0	30
	Sep	89.9	24.4	-89.2	0	21

	Oct	243.1	65.9	-47.7	0	58
	Nov	333.0	90.2	-23.4	0	79
	Dec	328.4	89.0	-24.6	0	78
1966	Jan	262.9	71.2	-42.3	0	63
	Feb	203.7	55.2	-58.4	0	49
	Mar	122.9	33.3	-80.3	0	29
	Apr	213.9	57.9	-55.6	0	51
	May	310.6	84.1	-29.4	0	74
	Jun	85.1	23.1	-90.5	0	20
	Jul	143.5	38.9	-74.7	0	34
	Aug	138.7	37.6	-76.0	0	33
	Sep	83.8	22.7	-90.9	0	20
	Oct	112.8	30.6	-83.0	0	27
	Nov	256.5	69.5	-44.1	0	61
	Dec	354.6	96.1	-17.5	0	85
1967	Jan	239.3	64.8	-48.7	0	57
	Feb	75.4	20.4	-93.1	0	18
	Mar	184.9	50.1	-63.5	0	44
	Apr	560.8	151.9	38.4	0	100
	May	300.5	81.4	-32.2	0	72
	Jun	177.5	48.1	-65.5	0	42
	Jul	342.6	92.8	-20.8	0	82
	Aug	329.9	89.4	-24.2	0	79
	Sep	91.7	24.8	-88.7	0	22
	Oct	112.3	30.4	-83.1	0	27
	Nov	326.1	88.3	-25.2	0	78
	Dec	304.5	82.5	-31.1	0	73
1968	Jan	180.6	48.9	-64.6	0	43
	Feb	155.4	42.1	-71.5	0	37
	Mar	275.3	74.6	-39.0	0	66
	Apr	367.5	99.6	-14.0	0	88
	May	276.1	74.8	-38.8	0	66
	Jun	138.7	37.6	-76.0	0	33
	Jul	404.4	109.6	-4.0	0	96
	Aug	204.2	55.3	-58.2	0	49
	Sep	136.7	37.0	-76.5	0	33
	Oct	156.5	42.4	-71.2	0	37
	Nov	147.8	40.0	-73.5	0	35
	Dec	297.4	80.6	-33.0	0	71
1969	Jan	56.9	15.4	-98.1	0	14
	Feb	175.3	47.5	-66.1	0	42
	Mar	113.0	30.6	-83.0	0	27
	Apr	78.0	21.1	-92.4	0	19
	May	117.6	31.9	-81.7	0	28

	Jun	138.9	37.6	-75.9	0	33
	Jul	260.9	70.7	-42.9	0	62
	Aug	136.9	37.1	-76.5	0	33
	Sep	231.9	62.8	-50.7	0	55
	Oct	90.9	24.6	-88.9	0	22
	Nov	397.5	107.7	-5.9	0	95
	Dec	259.1	70.2	-43.4	0	62
1970	Jan	484.1	131.1	17.6	0	100
	Feb	293.1	79.4	-16.6	0	70
	Mar	145.0	39.3	-74.3	0	35
	Apr	374.6	101.5	-12.1	0	89
	May	435.6	118.0	4.4	0	100
	Jun	238.3	64.6	-49.0	0	57
	Jul	100.1	27.1	-86.4	0	24
	Aug	147.3	39.9	-73.7	0	35
	Sep	98.6	26.7	-86.9	0	24
	Oct	137.7	37.3	-76.3	0	33
	Nov	492.3	133.4	19.8	0	100
	Dec	1212.6	328.5	234.7	0	289
1971	Jan	268.0	72.6	193.8	0	64
	Feb	105.9	28.7	108.9	0	25
	Mar	196.1	53.1	48.5	0	47
	Apr	150.1	40.7	-24.4	0	36
	May	190.8	51.7	-61.9	0	46
	Jun	270.0	73.1	-40.4	0	64
	Jul	538.5	145.9	32.3	0	100
	Aug	126.2	34.2	-47.1	0	30
	Sep	114.0	30.9	-82.7	0	27
	Oct	165.4	44.8	-68.8	0	39
	Nov	111.0	30.1	-83.5	0	26
	Dec	256.3	69.4	-44.1	0	61
1972	Jan	316.0	85.6	-28.0	0	75
	Feb	181.4	49.1	-64.4	0	43
	Mar	69.6	18.9	-94.7	0	17
	Apr	329.4	89.2	-24.3	0	79
	May	267.2	72.4	-41.2	0	64
	Jun	208.0	56.3	-57.2	0	50
	Jul	437.6	118.5	5.0	5	100
	Aug	399.8	108.3	-0.3	0	95
	Sep	213.1	57.7	-55.8	0	51
	Oct	180.8	49.0	-64.6	0	43
	Nov	267.2	72.4	-41.2	0	64
	Dec	493.3	133.6	20.1	11	100
			Average % Demand Met			50