ENGR 4692.01

Professor: Dr. Casale

**Bacteria Busters**

Water Quality and Kitchen Design
Post-Trip Documentation

**Engineering Service-Learning at Montana de Luz (Honduras)**

*Spring Semester 2014*

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Date: 04/17/2014
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1. Introduction of Team Members

1.1 Budget/Materials Coordinator
David Ellison is a freshman in Chemical Engineering at the Ohio State University. As the budget/materials coordinator, David researched any needed materials for the completion of the budget, as well as searched and compare prices for any needed items.
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1.2 Communications Director
Michelle Hurtubise is a sophomore in Biomedical Engineering at the Ohio State University. As the communications director, Michelle communicated with the team, set up times and locations for team meetings, and emailed the team representative from MdL with any questions or notes from the project’s progression.
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1.3 Project Supervisor
Tori Wilson is a junior in Chemical Engineering at the Ohio State University. As the project supervisor, Tori oversaw and communicated project progress and deadlines with team members, set practical and realistic goals for project progress.
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1.4 Documentation/Secretarial Manager
Marissa Schroeder is a sophomore in Chemical Engineering at the Ohio state University. As the documentation/secretarial manager, Marissa maintained all written recordings of meeting designs and project development.
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2. Background Information

2.1 Background
Over the past few years, service teams from The Ohio State University have traveled to Montana de Luz to help the facility purify their water. The staff has been buying purified drinking water and this method is a costly means of obtaining drinking water. Tests for coliform, arsenic, and other bacteria have come back positive even after several attempts to fix this problem. Last year, a sediment filter was installed and the chlorine system was evaluated. Water sample tests showed that levels of chlorine were significantly lower than the necessary amount.
2.3 Problem Statement

According to the staff from Montana de Luz, the sediment filter continuously clogs and the chlorination system is not effective. It is also the desire of Montana de Luz to construct an outdoor kitchen to aid their cooking capabilities. Electricity at Montana de Luz is not reliable and it is necessary for the orphanage to maintain the ability to cook through extended power outages. It is for this purpose that the outdoor kitchen will be designed. In the computer lab there is one functioning computer.

3. Schedule

3.1. Original Plan

*Monday 03/10/2014*

7:30 am
- Meet with Jorge to evaluate the chlorination system and location of the system components
  - I.E. cistern, water tanks, filters, clean sediment filter
8:30 am
- Talk to kitchen women
  - When is the best time to remove filters, timeframe that they do not have water
9:00 am
- Take bacteria tests and check chlorine levels (kitchen sink, well, cistern, and tanks)
  - Measure well depth and water depth
10:00 am
- Assess sitting tanks and cistern
  - If tanks need to be cleaned, the plans for the rest of the day will be scrapped and the remainder of the day will be spent cleaning the tanks
11:30 am
- Assess what we did so far and what will be done the rest of the day
12:00 pm - 1:00 pm
  - LUNCH
After lunch
- Make signs
- Fill bins with water
- Take filters out
4:00 pm
- Begin shocking system:
  1. Add chlorine to the well
  2. Add chlorine to the tanks and cistern
  3. Wait half an hour
  4. Circulate water throughout system
  5. Once chlorine is smelt begin water lockdown
Tuesday 03/11/2014
5:30 am
- Check tank water level status
7:00 am
- Two guys will clean the tanks
8:00 am
- Prepare and research for shocking
- Talk to Kristen about having water system guys come out and give an estimate and talk about chlorination system
12:00-1:00 pm
- Lunch
1:00-2:00 pm
- Prepare bathrooms for the children and Staff
3:00 pm
- Have Jorge take out the arsenic filter
4:00 pm
- Shock the system
8:00 pm Met with Dr. Casale and Carlos

Wednesday 03/12/2014
- Arsenic test
- Schedule kitchen meeting
- Computers
- Sediment testing
- Bill of materials
- Box around filter
- Shadow chlorine contractors

Thursday 03/13/2014
- Bacteria Tests
- Work on fixing computers
- Take Kitchen measurements for design
- Keep checking filter

Friday 03/14/2014
- Continue to check on filter
- Work on computers
- Watch chlorination system installation

3.2. Actual Schedule
Monday 03/11/2014

7:45 am
- Met with Jorge, Alanso, Paul, Laura, Kristen, and Jackie to discuss the shocking process and project overview

8:45 am
- Unload and organize materials

9:10 am
- Water test in kitchen with arsenic filter

9:42 am
- Jorge took us to the well
- Took coliform and E. coli test
- Realized that we should put the chlorine in the distribution pump because it is not possible to put it into the well

10:32 am
- Went up the top of water tank tower
- Took bacteria test
- Evaluate if tanks are clean or not
  - Found out that they needed to be cleaned

10:45 am
- Iron test in the water tank: 1.0ppm

11:20 am
- Verified that the tanks will be cleaned and Jorge will hire two guys to clean them

11:30 am
- Tori and David went to clean the current sediment filter
  - The current filter is being cleaned so that the new filter is not ruined when the system is shocked

12:00 pm
- Lunch

1:00 pm
- David and Tori finished cleaning and installing the old sediment filter
- Marissa and Michelle filled up the pila to make sure there is enough water to last during the shock

1:30 pm
- Made signs to put up around the complex to notify the kids and staff about the water usage protocol

2:00 pm
- Tested the old sediment filter

3:00 pm
- Project documentation

8:00 pm
- Meeting with Dr. Casale

Tuesday 03/11/2014
7:45 am
- Begin sediment installation
- Cut open previously installed pvc around the filter
- Observed a lot of algae in the pvc
- Tested algae in pvc
8:30 am
- Guys to clean tanks arrived
8:50 am
- Cut mesh
9:30 am
- Went to store for pvc parts
10:00 am
- Started resinstallation of new sediment system
  - Algae was in the pipes of the sediment filter. We were concerned algae could be in the rest of the system pipes. Since the valves were shut and algae growth mostly started in the filter (where there is sunlight) there wasn’t algae growth past the valves. Little pipe before the top valve was cleaned
11:30 am
- Finished installing pipes around the filter.
  - Let sealant dry over lunch and
  - Realized we were getting new chlorination system tomorrow so we no longer need to shock
    - Reviewed Budget:
      - Cleaning guys: $15.00
      - Pvc: L 187= $9.35
12:00 pm
- Lunch
- Worked on project for kids
1:20 pm
- Inserted filter
2:10 pm
- Took oxygen pipes off tanks and cleaned frogs out
  - Put pipes back on tanks 1 and 2
  - Part of the new pipe purchased today was cut and an extra coupler (3/4’ x 1’) was used to put pipe back on the third tank
    - Filter filled up very quickly
3:00 pm
- Filter cleaned
After dinner  
- Met with Carlos and Dr. Casale

Wednesday 03/12/2014  
6:30 am  
- Coliform tested positive in well and cistern  
- Cleaned sediment filter  
  - Note about sediment filter: Filter was cleaned last night at 11:00 (when we all took showers) and then again at 6:30 am (when we all took showers) and then again at 6:30 am (when all the kids took showers). So when more water is flowing, when everyone is using it, there is more sediment, which clogs the filter.

7:50 am  
- Arsenic test on kitchen sink (0 ppb)

8:30 am  
- Arsenic test in service teams kitchen sink (80 ppb)  
- Determined research needed to be done on coliform / E. coli test  
- Determined the only thing that can be done about arsenic is to use an arsenic filter

9:30 am  
- Sediment filter was clogged and cleaned

9:40 am  
- Sediment filter box designed

10:30 am  
- Worked on computers

12:00 pm  
- Lunch

1:00 pm  
- Went back to work on computers

2:00-3:00 pm  
- Went over kitchen design with Ana, Kristen, Jorge, and Alonso

3:00 pm  
- Coffee

5:15 pm  
- Sediment filter clogged and cleaned

The chlorination system guys are not coming today, they rescheduled for Friday.

Thursday 03/13/2014  
8:00 am  
- Met with Dr. Casale to discuss our plan for the day and previous days work

9:00 am  
- Found plastic boxes to cover the filters
9:30 am
- Cut pvc and cut green plastic box

11:00 am
- Cut yellow box to put over small filter
- Waited for couplers

12:00-1:00 pm
- Lunch

1:00-2:00 pm
- Watched wild fire

2:00 pm
- Fixed wire for boxes

2:05 pm
- Bacteria tests

Friday 03/14/2014
- Attempted to work on computer, but unable to due to no power
- Continued to check on sediment filter
- Aquatec professionals came and still the chlorination system
- Inspected the installed chlorination system

4. In Country Implementation

4.1 Sediment Filter

The current sediment filter at Montana de Luz (MdL) was collecting sediment very quickly and had to be checked and cleaned multiple times a day. It became a hassle for the workers and eventually MdL bypassed the filter and allowed the sediment to enter the water distribution system. The team did some research and decided to buy a new sediment filter for the complex. The new filter is a stainless steel, T style 2” Rusco Sediment Trapper Filter. An image of this filter can be found in Appendix A, Figure A1. Compared to the previous filter, the new one is an inch in diameter bigger and has stainless steel mesh compared to polyester. The stainless steel mesh allows for easier maintenance and can withstand the sediment for a longer period of time. This new filter is able to withstand a flow rate between 18 and 100 gpm. The previous filter was only able to tolerate a flow rate between 1 and 25 gpm.

Upon arrival to the orphanage, the current state of the sediment filter was analyzed and the team finalized their decision to insert a new sediment filter. Initially, the existing PVC framework was going to be used for the new filter. Since this current PVC was 1” in diameter, couplers were going to be used to connect the new filter from 1” to 2”. However, when the PVC was cut around the old filter, there was a lot of algae buildup in the pipes as shown in Figure 1 below. This accumulation was due to the bypassing of the system for almost a year.
Figure 1: Algae buildup in the framework of the old PVC. This occurred because MdL bypassed the system for almost a year.

A bacteria test was conducted on the algae and it came back positive for coliform. The entire structure was taken apart and new U-shaped framework was built with newly purchased 1” PVC. All of the PVC connections were made with PVC primer and cement.

After this new framework was built, the team installed the new, 2” sediment filter. For several days, the filter was observed and two conclusions were made. First, the filter clogged when large amounts of water were being used. This normally occurred at sunrise and sunset when the children and volunteers were showering. Secondly, if the power shut off, the filter clogged when it came back on. The filter was getting blocked very quickly at these times because large chunks of sediment (about the size of a nickel) were blocking the mesh.

To decrease the buildup of sediment around the mesh, the team thought of a way to catch the large pieces before they entered into the new filter. The old sediment filter was cleaned and the polyester mesh was removed. The mesh is used to catch the small, sand-like sediment from the water, so removing the mesh allows for this filter to catch large pieces. The old filter was then placed in front of the new filter to see if this would keep the new filter from clogging up. Thankfully it did. An image of this setup can be seen below in Figure 2.
Figure 2: Image of the two sediment filters. The small sediment filter on the left catches the large pieces of sediment before the water enters into new 2” filter.

Since there was a lot of algae buildup around and in the old sediment filter, the team wanted to build a box to place around the two filters. The box needed to be very accessible and easy open and close. If the design was too tricky, the staff at MdL may get frustrated and not check the filters enough. Initially, a box design was drawn for Jorge to build out of wood. The design of this box can be seen as Figure A2 in Appendix A.

After discussing the design with Jorge, the team thought that there would be an easier way to cover the filters. There were a couple of unused bins in the children’s schoolroom. These bins were appropriate for the filters and were able to cover them completely. In order to fit over the PVC, squares were cut on each side of the box and a wire cord was used to attach the box around the PVC. This acted like a hook and eye for user-friendly accessibility to check the status of the filters regularly. The final product of the sediment filters is shown below in Figure 3.
In the image, the four different valves are labeled 1 through 4. In order for the water to pass through both of the filters, all of the valves must be horizontal. If something is wrong with the filters or they need to be emptied/cleaned, the valves can be moved to a vertical position. Below are the steps for cleaning the filter. A translated version can also be found in Appendix C.

Procedure:
Unhook boxes and check filter morning and night or more frequently if you would like. If the power goes out, check filter shortly after the power comes back on.
If the filter is full, take the following steps:
1. Turn the two leftmost valves (1 and 2 on Figure 3) vertical.
2. Turn the two rightmost valves (3 and 4 on Figure 3) vertical.
3. Turn the red valve on the larger (green box) filter. Unscrew the filter and remove mesh.
4. Turn the red valve on the smaller (yellow box) filter. Use that water to rinse the filter mesh of the large filter.
5. If the mesh of the large filter is still not clean, rinse it off using an outside spigot. Once the mesh is clean, push the mesh of the large filter back up into the filter head and then screw filter back into place.
6. Turn the rightmost valves (3 and 4 on Figure 3) horizontal.
7. Turn the leftmost valves (1 and 2 on Figure 3) horizontal.
8. Fill out the sediment filter inspection sheet.
9. Replace and hook the boxes.

4.2 Water Quality

A meeting was held with orphanage coordinators and maintenance to discuss water quality concerns and measures that would be taken throughout the week in order to restore drinkable water to the complex. A bacteria test and water test was completed in the kitchen sink with the arsenic filter and the following water test results were obtained:

<table>
<thead>
<tr>
<th>Test</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>0</td>
</tr>
<tr>
<td>Akalinity</td>
<td>80</td>
</tr>
<tr>
<td>Hardness</td>
<td>0</td>
</tr>
<tr>
<td>Nitrate</td>
<td>5</td>
</tr>
<tr>
<td>Nitrite</td>
<td>0</td>
</tr>
<tr>
<td>Copper</td>
<td>1.3</td>
</tr>
<tr>
<td>Iron</td>
<td>3</td>
</tr>
<tr>
<td>pH=6.5</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Mineral Test Completed at the Kitchen Sink with the arsenic filter

There was no chlorine detected in the water because the current chlorination system was not in use. The alkalinity in the water was 80 ppm or 79.9 mg/L. Alkalinity is a measure of the buffering ability of water and the recommended level is greater than 100 mg/L. A neutralizer may have to be used in order to treat the water and restore proper levels of alkalinity if this value is still low after project plans have been implemented. Hardness is the total calcium and magnesium in the water and should not be over 5 grains/gallon. Nitrate and nitrite in the water comes from fertilizer, sewage, and natural forming mineral deposits. Nitrate should be no greater than 10 ppm and nitrite should not be higher than 1.0 ppm. The results from the test are ideal. Copper results from corrosion of system components and the amount of detected in water should not exceed 1.3 ppm, this is the maximum contaminant level goal designated by the EPA. As can be seen in the table above, the amount of copper was right at 1.3 ppm and is not harmful. Iron levels in drinking water should not exceed 0.3 ppm, above this value the taste of water may be affected and the water may cause discoloration and staining in clothing. The test results showed copper levels being at 3 ppm. This is to high, however, chlorination is a treatment solution for this mineral. The ideal pH range for drinking water is between 6.5 and 8.5. This test result showed the pH was at 6.5, which is sufficient. In Appendix A figures A3, A4, and A5 show visuals of these different mineral tests being completed.

The original plan was to shock the water system. This is introducing an excessive amount of chlorine into the entire water system in order to kill bacteria that may be collecting in the well or tanks and pipes and also to maintain the system. In order to calculate the amount of chlorine that would be needed to shock the well the amount of water was planned to be determined using a small rope or string.
attached to a rock. The idea behind this was to lower the rock (attached to the string) down into the well, remove the object after the rock reached the bottom of the well, and then measure how far from the top of the string was wet. This would determine the water depth in the well. When the well site was visited, it was found that the pipe leading down into the well was too small in order to fit a rock down into. A sample was taken from the release pipe of the well in order for a bacteria test to be ran. The second option in order to shock the well was to pour the chlorine into a pipe just after the distribution pump and before the filtration system. The chlorine would flow back down the pipe and into the well. In order to do this a way to funnel the chlorine into the pipe would have to be determined. This option would have been tedious and time consuming, but possible to complete.

A bacteria test was conducted on the water tank tower. Due to the sediment filter being bypassed, which is right before the sitting tanks, sediment was visible inside the tanks and it was determined that the tanks needed to be cleaned. The tanks were cleaned so that the sediment currently in the tanks would not contaminate the water after the new filter was installed. This could occur because the sitting tanks are after the sediment filter in the water system. An iron test was also conducted on top of the water tower. Also, there are oxygen piped leading to the tanks. However, it was discovered that there were an abundant amount of frogs in these pipes. There was a tree planted close to the water tank tower and branches overhung these pipes so it was easy for tree frogs to get inside them. This was a problem because their waste could be causing bacteria in the water. These pipes were removed, the frogs were cleaned out, and the pipes were replaced. In order to prevent the frogs from entry in the future a zip tie was used to secure a piece of metal wiring around the top end of the pipe. This allowed oxygen to flow in, but inhibited pests. Refer to Figure A6 in Appendix A

The team decided to keep the old filter installed until after shocking so that the new filter would not be harmed by the high concentration of chlorine in the water. The current filter was cleaned because algae had grown inside it. All filters around the complex had to be removed before shocking because high levels of chlorine could damage them and cause corrosion. Where these filters are located was discussed with Jorge. The water was turned off so that the water currently in the sitting tanks and cistern could be used up before the high concentrated chlorine water was added. Equation D1 in Appendix D was used to determine the total amount of chlorine that would be neede to shock the entire system, which included the well, the 3 sitting tanks, and the cistern.

It became apparent that a chlorination system was desperately needed and the funds were available to purchase one. The team made the decision that the greatest improvement in the water quality of the orphanage would come from an effective chlorination system so the decision was made to purchase one. Professionals were hired to complete this process. Part of the chlorination system installation process was shocking. Due to the fact that part of the payment for the system would be going towards shocking the team no longer had to implement this part of the project plan.

When the new filter was installed algae was visible in the piping also. A mineral test was conducted on the substance inside the pipes. The results are shown in the table below.

<table>
<thead>
<tr>
<th>Test: PVC around filter</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>0</td>
</tr>
<tr>
<td>Akalinity</td>
<td>0</td>
</tr>
<tr>
<td>Hardness</td>
<td>0</td>
</tr>
<tr>
<td>Nitrate</td>
<td>0</td>
</tr>
</tbody>
</table>
Since algae growth started in the filter (where sunlight was available) and the valves were shut, there wasn’t algae past the shut valves. New pvc piping was purchased and the piping around the new filter was replaced to ensure that a problem would not occur due to this growth.

The results from the bacteria tests are as follows:

<table>
<thead>
<tr>
<th>Location</th>
<th>Date</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic Filter</td>
<td>3/10/2014</td>
<td>Negative</td>
</tr>
<tr>
<td>Well</td>
<td>3/10/2014</td>
<td>Positive</td>
</tr>
<tr>
<td>Sitting Tanks</td>
<td>3/10/2014</td>
<td>Negative</td>
</tr>
<tr>
<td>Cistern</td>
<td>3/10/2014</td>
<td>Positive</td>
</tr>
<tr>
<td>Filter PVC</td>
<td>3/11/2014</td>
<td>Positive</td>
</tr>
<tr>
<td>Sitting Tanks</td>
<td>3/12/2014</td>
<td>Positive</td>
</tr>
<tr>
<td>Cistern</td>
<td>3/12/2014</td>
<td>Positive</td>
</tr>
<tr>
<td>Arsenic Filter</td>
<td>3/12/2014</td>
<td>Positive</td>
</tr>
</tbody>
</table>

As can be seen in the table above, the bacteria test completed on the first day at the kitchen sink where the arsenic filter is located came back negative, which is ideal. In Appendix A, Figure A7 shows a negative bacteria test while Figure A8 is a visual of a positive test result. No bacteria should be present in drinking water. The result of the bacteria test on the well was positive. This was most likely due to the fact that the sample of water from the well was taken from the distribution pipe, which is free to the surrounding environment and contaminants could have easily developed in that pipe. The bacteria test on the tanks came back negative, which most likely meant the frogs were not in the tanks and were not a source of bacteria. The cistern was also positive for bacteria. Due to this the, it was also drained and manually cleaned. The bacteria test from the substance from the filter pipes came back positive, which was expected considering the system had been bypassed for a year and any material present in those pipes had been stagnant, there was no flowing water passing through. The second set of bacteria test completed were all positive, the well was not included in this round because bacteria came from the sample pipe and there was a forest fire near the well location. The most obvious reason for this was that the tanks and cistern had been cleaned out the day before so the freed and loosened bacteria was working it’s way out of the system. It was difficult to conduct any more tests before the departure date because the chlorination system was being installed and the shocking completed. Currently, the water is being tested by water quality professionals and results are pending.

An arsenic test was ran on the kitchen sink with the arsenic filter to ensure that it was properly working and being maintained and also in another location (the volunteer kitchen) in order to compare the test results. In Appendix A, Figure A9 shows the test being completed while Figure A10 shows the result from the test being measured.. The results are in the table below:
### Table 4: Arsenic Test

<table>
<thead>
<tr>
<th>Arsenic (ppb)</th>
<th>Date</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3/12/2014</td>
<td>Kitchen sink with filter</td>
</tr>
<tr>
<td>80</td>
<td>3/12/2014</td>
<td>Dining hall kitchen</td>
</tr>
</tbody>
</table>

As can be seen, there was no arsenic present in the location of the filter so it is properly working. However, there was arsenic present in the volunteer dining hall kitchen. This was predicted, but the only way to control arsenic in drinking water is to purchase an arsenic specific filter. These are costly and would be a project that would have to be completed over time.

#### 4.3 Chlorination System

On Monday, the group presented the plan for the week to the staff of Montana de Luz. During this meeting, the staff informed the team that the current chlorination system was one that was meant for a pool. Because of this information, the purchase of a new chlorination system was prioritized. An estimate had been previously made for 900 dollars for the purchase and installation of the system through Aquatec. Jorge contacted the company and on Friday, members from Aquatec came to Montana de Luz and installed the chlorination system.

This new chlorination system will be sustainable for Montana de Luz. The system uses powder Calcium Hypochlorite dissolved in a large barrel full of water, as shown in Appendix A, Figure A11. This chlorine dissolves much more efficiently in water than the previously used trichlor. Chlorine is distributed to the water every time that the lift pump turns on. When the lift pump is off, there is no chlorine entering the system. The system has a feed rate that is able to be adjusted to allow for adequate levels of chlorine in the water. The stroke rate was originally set to 180 in order to get the chlorine levels in the water up, as there had not been chlorine in the water supply for many months. Since departure Aquatec has returned and checked to chlorination levels in the water; they are where they should be. The current stroke rate is not known due to communication confusion with MdL. An image of the new chlorination system can be seen below in Figure 4.
There is minimal maintenance required for Montana de Luz to upkeep this system. It will be important to make sure that the chlorine in the barrel does not completely deplete, as this may allow the bacteria to return to the water system and make the water undrinkable.

4.4 Kitchen

When the kitchen design project was initially proposed, it was perceived that the location and timeline of completing the kitchen were to be determined. The team received an initial design created by Jorge which can be seen in Figure A12. From this design the desired components within the kitchen were obtained. It was understood that the kitchen’s functionality would have to be independent of electricity to provide Montaña de Luz with cooking capabilities when the power goes down as well as adding an additional complex to prepare food during periods where an abnormal amount of food was needed in a short amount of time. The initial design that the team took to Montaña de Luz was based off of the initial design received from Jorge, which can be seen in Figure A13. It was noticed that in Jorge’s design, the front and back walls were two different lengths. The team determined that the abnormal shape of the kitchen was an inefficient use of space and decided to even the lengths of the two walls. The team also researched materials and utilities to input in the kitchen. It was determined that an Onil stove would be the best stove option for the design due to its efficient wood burning design. A photo of the Onil stove can be seen in Figure A14. The team also actively looked into ways to let heat out of the kitchen to prevent the interior of the kitchen from getting too hot from the combined heat of the stoves and climate. The diagrams detailing the thoughts on ventilation for the kitchen are displayed in Figure A15 and A16.

Once in Honduras, the team met with the staff on Wednesday to discuss the original design. It was then realized that the staff already had a location selected for the kitchen. This location can be seen in Figure A17. As seen in the selection of the location, the design needed to
be adjusted to account for the fact that a location had already been determined and the wall lengths were not equal. During the discussion, the team and the staff agreed that the adjacent wall between the selected location and the old cooking space would be removed to allow for a larger overall space. After the removal of this wall, any components of the old interior space that no longer worked would be removed. The metal frame overlaid with mesh wiring that already existed for the walls of the old space would be continued to complete the siding of the final kitchen in order to keep the kitchen cool. Windows were to be taken out of the design due to the intended siding aforementioned. It would be necessary to have the plumbing to run along the length of the back wall and along the left wall (where the kitchens used to be killed) in order to provide water access to where the chicken cleaning station would be created. The proposal of using Onil Stoves was received with great enthusiasm by the staff and it was discussed that the design was similar to the stove used at the house for the older boys. The cabinetry to go into the kitchen was determined to be under-counter only and should be made out of concrete due to past experience of wood cabinetry rotting. The old door would remain for the entrance of the new kitchen design. The team mentioned the possibility of adding an icebox to the design in order to keep food cold. This idea was accepted by the staff and put into the new design.

Upon returning from Honduras, the team revisited the meeting notes with the staff at Montaña de Luz and the original design. The new design for the kitchen can be seen in Figure 5 below.

![Figure 5: Final Kitchen Design](image)

The design incorporated an open floor plan and spread the necessary components of the kitchen along the wall of the larger space.
4.5 Computers

The computers were inspected on Wednesday. There was one functioning computer; however there was no internet on it. It was noticed that there were many cords missing and others were unplugged. There were many computers that were the same model, but looked very different on the inside when comparing wiring. It was concluded that inexperienced personnel had previously tried to work the computers and caused more harm than good. Memory cards were left with MdL that should help fix some of the problems in the computers. We recommended that Montana de Luz has people experienced with computers come in and look at them.

4.6 Educational Component

An educational experiment was performed with the kids to help them create their own lava lamps using oil, water, food coloring, and Alka-Seltzer tablets. An empty water bottle was filled with one quarter water and three quarters olive oil. The water was premixed with different food colorings, which the kids got to choose from. Alka-Seltzer tablets was broken into pieces and a piece will then be added to the bottle. The lid was quickly placed back on the bottle. The kids flipped the bottle upside down and back upright to see how the process works. The team explained the chemistry behind the experiment including properties including density and solubility rules.

5. Post-Trip Results

Since departure, several emails and a phone conversation on April 3rd has taken place to follow up with the project. The team found out that the filter has only had to be cleaned twice.This is because the chlorination system has been installed. The chlorine is reacting with the sediment and breaking it down so the large pieces that were collecting in the filter are no longer an issue. Two bacteria test have been conducted in the last month. The results of the first one were recorded on March 27th and they were positive. This was due to all contaminants still working their way through and out of the system. The results of the second test were negative and that was recorded on April 2nd. The chlorination system installation team by the name of Aquatec was at Montana de Luz on the 27th and the chlorination system was evaluated. It was recorded that the system was operating at maximum capacity. The rate on the chlorination system currently has not been determined. When this issue was mentioned in a recent email the following response was received, “they had it at a higher level than the setting level to clean out the system Laura needs to ask Jorge that question”. Sanar, a professional water quality team took a sample of the water on March 31st and the results are pending. The last time the well was cleaned is being checked on and this is a job that is being recommended for future teams. This needs to be completed in order to control sediment buildup and microorganisms that can collect in the well over time.
6. Cost Analysis

The team was given a budget of one thousand dollars for their project. Initially, MdL wanted the students to buy and install a new rain collection system. This put the team over budget. However, MdL notified the team a week before departure and said that they no longer wanted this new system. MdL was going to get new roofs soon and they did not want any money spent on this. Because of this change, the team spent their budget on two major projects. The Sediment Filter project used $231.74 out of the allotted budget and the Chlorination System project used $503.74 out of the allotted budget as you can see in Figure 6 below.

![Overall Trip Costs](image)

**Figure 6:** Pie chart illustrating the total costs for the sediment filter and the chlorination system

In Appendix A, Figures A18, A19, and A20 show a breakdown of the costs for each of the two different projects (Sediment and Chlorination) and final budget costs. In final, the team used $735.48 out of the one thousand dollar budget. Appendix B, Table 2B is a table of all of our expenses for the entire trip.

8. Sustainability

The chlorine system turns on automatically every time the lift pump comes on. You can adjust the stroke rate of the chlorinator to the desired concentration level. This system is easy to maintain because its simple with few parts and few operating directions.
A filter with a stainless steel mesh was purchased, which will last longer and be more durable against sediment buildup. Boxes were placed over both filters in order to block them from sunlight and prevent algae growth. There are valves in the filter piping system. These are easily adjusted in case something would go wrong with the filters and they would need to be bypassed.

The kitchen design was for a space that uses no electricity in order to function. It is structurally sound to withstand weather and climate. Incorporated components will be practical and functional for the kitchen. This design is eco friendly. It also utilizes screen for the upper part of the walls to ensure ventilation. Onil stoves will be purchased that require minimal maintenance. This stove also uses efficient burning technology to take smoke and carbon monoxide from the home. A galvanized steel chimney is used to vent the system and wood consumption is reduced by 70%.

7. Future Works

In the interest of guiding the direction of future project groups and maintenance that the staff can perform between project groups, there were several areas in need of service at Montaña de Luz that were identified over the course of our trip. When monitoring the sediment filtration system that was constructed, it was observed that large chunks of sediment were being kicked up sporadically from the well. This was occurring because the well has never been cleaned or maintained. The easiest solution to this problem would be using the service provided by Aquatec (the company that installed the chlorination system) that would clean out the well. An estimate for the cost of this service was to be provided by Aquatec in the near future but not available at this time. By cleaning and maintaining the well, the strain on the filtration system will be significantly lessened and lengthen the life of the filtration system.

The kitchen design we proposed for MdL has no timetable for the actual construction. It would be of great assistance to MdL to have a construction project team that would aid in funding and expediting the construction process. A week-long trip would be hard pressed to finish the entire construction of the kitchen, but segmenting the construction process and spearheading one phase of the project would be a tremendous help for MdL to successfully accomplish this long term project.

In the examination of the water system, it was observed that the PVC piping that provided oxygen to aid in the flow of the water tanks was open and unprotected. As a result, a small community of tree frogs inhabited these pipes and had access to the water tanks. The tubing was removed and any tree frogs that were in the tubes were humanely encouraged to find a new home. When the piping was replaced metal grating was attached to prevent any tree frogs from entering the tube. After a couple days it was noticed that not all of the tree frogs were removed from the system as there were a few (drastically less than the original number) who insisted on living in the tubing. It will be necessary to continue to monitor the frog population that live in the tubing/tanks to ensure that they are not breeding and/or entering the system at
another point. If this problem continues to persist a project group should devise a frog extermination strategy to eliminate the problem of the frog population in the water system.

General maintenance of the water system needs to be upheld by the staff at MdL and when there are project teams on site, they can assist with this maintenance. The tanks should be inspected monthly for sediment buildup and cleaned every six months if there is significant buildup within the tanks. If coliform is unaffected by the normal dosage of chlorine provided by the new chlorine system the entire water system should be shocked in two stages using liquid chlorine. Each stage should occur over a twelve hour period. If the bacteria problem persists, a project team needs to perform an investigative study to identify at what point the bacteria is entering the water system and proactive ways to combat this problem at the bacteria’s entry point.

It was initially planned to make improvements upon the water collection system that was constructed by the project team the year before our trip. This plan was eventually scratched to focus on the water system but the need to refurbish the water collection system remains. This project would probably need to start from scratch because the main components of the water collection system were disassembled and/or not in ideal condition for use. The gutter system will also be torn down in the near future when the roofing is replaced.

In the small amount of time that our team had available to examine the computers it was identified that there were several missing components in the computers but the exact parts and problems were not identified. A future project team should have computers as a main priority rather than a side task to properly identify the necessary components needed, obtaining, and installing the components.

Our final recommendation is only under the circumstance that the current sediment filter fails in the future. If it is identified that the filtration system does not perform to the level that it is thought to perform and the lack of performance is not maintenance or wear related, the next step would be identifying and installing a system that would work better than the one currently in use. The one system that we would recommend looking into replacing the current sediment filter in the case that a new solution is necessary would be a reverse osmosis system.

8. Acknowledgements

A debt of gratitude goes out to Dr. Casale and Carlos Montoya for devoting their time outside of class and guiding the team toward a successful completion of the project. Also thanks goes to Sally Lindeboom for helping the team order all online project materials. The team would like to thank Leslie Callahan and the Office of International Affairs for scheduling flights, arranging living conditions, and ensuring that each member completed the proper paperwork. The project could not have been completed without the primary communicators at the orphanage, which were Laura and Paul Manship. They answered many pre-trip questions and clarified any uncertainty which helped greatly in project planning. Kristen was also great assistance in
answering pre-trip questions and concerns. Learning about country culture and information about Montana de Luz before departure was thanks to Erica Shell Castro, she came to talk to the class and helped the class organize materials before leaving. The trip coordinator, Ruth, guided trip members through the country and area each day and helped to keep everyone on schedule. The Bacteria Busters would also like to thank the donors who made purchasing a chlorination system for the orphanage possible. A special thanks goes to Jorge for answering on site questions and physically helping to complete the project. Lastly, acknowledgments go to Montana de Luz and the staff and children for providing a clean living area for the week, delicious food, and memories that will never be forgotten.

9. Works Cited


10. Appendices
Appendix A
Figures
Figure A1: New, stainless steel, T-style 2” Rusco Sediment Trapper Filter

Figure A2: Original box design
Figure A3: Chlorine, alkalinity, pH, and hardness test completed on the substance in the pvc around the filter.

Figure A4: Copper test completed on the substance in the pvc around the filter.
Figure A5: Copper test completed on the substance in the pvc around the filter.

Figure A6: Zip tie used to fasten metal screen to the top of the oxygen pipes to prevent tree frogs from getting into them.
**Figure A7**: Picture showing a bacteria test that came back positive for coliform.

**Figure A8**: Picture showing a bacteria test that came back negative for coliform.
Figure A9: This Figure shows an arsenic test being completed.

Figure A10: This Figure shows the result from the arsenic test being measured.
Figure A11: Current chlorine being used in the new chlorination system: Calcium Hyochlorite
Figure A12: Jorge’s Initial Design
Figure A13: Bacteria Buster’s Initial kitchen design

Figure A14: Proposed Onil Stove
Figure A15: Open Roof Ventilation Design
(Note on picture reads: “open ceiling design naturally allows heat to escape” “edges of roof extend past wall edge to prevent rain from entering opening”)

Figure A16: Stove Chimney Attachment to Siding and Roof
(Note on picture reads: “chimney of stove removes smoke from kitchen and transports smoke above roof to prevent smoke from reentering“)
Figure A17: Intended Location of Kitchen Construction

Figure A18: Pie chart illustrating the total costs for all the components of the sediment filter project
Figure A19: Pie chart illustrating the total costs for all the components of the chlorination system project

Figure A20: Pie chart illustrating the total costs for the entire trip and the leftover budget
Appendix B
Tables
<table>
<thead>
<tr>
<th>Contaminant</th>
<th>*mcl, mg/l</th>
<th>Source</th>
<th>Health Affects</th>
<th>Treatment</th>
</tr>
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<tbody>
<tr>
<td>Alkalinity</td>
<td>&gt;100 mg/l recommended but &lt;500 mg/l</td>
<td>Naturally occurring</td>
<td>impart &quot;alkali&quot; taste and cause drying of skin</td>
<td>Neutralizer in case of low alkalinity</td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td>Added to water for disinfectant</td>
<td>Possible carcinogenic</td>
<td>Carbon Filter</td>
</tr>
<tr>
<td>Copper</td>
<td>1.3 (action level)</td>
<td>Formation occurs during corrosion of interior household and building pipes</td>
<td>Stomach and intestinal distress, Wilsoni's Disease</td>
<td>Ion exchange (water softener), chlorination/filtration, distillation</td>
</tr>
<tr>
<td>Hardness</td>
<td>Over 5 grains per gallon-Hard</td>
<td>Sum of calcium and magnesium, naturally occurring</td>
<td>Aesthetic problems in home</td>
<td>Water softener</td>
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<tr>
<td>Nitrate</td>
<td>1</td>
<td>Fertilization, sewage, natural forming mineral deposits, feed lot runoff</td>
<td>Methemoglobinemia (Blue Baby Syndrome)</td>
<td>Ion exchange or distillation</td>
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<tr>
<td>Nitrite</td>
<td>10</td>
<td></td>
<td>Methemoglobinemia (Blue Baby Syndrome)</td>
<td>Ion exchange or distillation</td>
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<tr>
<td>Iron</td>
<td>0.3</td>
<td>Naturally occurring, igneous and sandstone rocks, corrosion of plumbing material</td>
<td>Taste, staining, scaling, discoloration of water</td>
<td>Ion exchange (water softener), chlorination/filtration, distillation</td>
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**Table 2B:** Breakdown of the entire budget from the trip

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<tr>
<th>Component</th>
<th>Location of Purchase</th>
<th>Cost</th>
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37
<table>
<thead>
<tr>
<th>Item</th>
<th>Supplier</th>
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<td>Pexsupply.com</td>
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<td>PVC primer and cement</td>
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<td>2” PVC</td>
<td>Honduras</td>
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<td>1’</td>
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<td>Chlorination System</td>
<td>Chlorine Tests</td>
<td>$9</td>
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<td>$18</td>
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<td>Bacteria tests: Coliform</td>
<td><a href="http://www.filtersfast.com/P-EZ-Coliform-Cult-Bacteria-Check-Test-Kit.asp">http://www.filtersfast.com/P-EZ-Coliform-Cult-Bacteria-Check-Test-Kit.asp</a></td>
<td>$6.99</td>
<td>20</td>
<td>$179.80</td>
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<td>Michelle check for UV light</td>
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<td>Total Budget</td>
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<tr>
<td>Leftover Budget</td>
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<td></td>
<td>$264.52</td>
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Appendix C
Maintenance
1. **English Version**

Bacteria Tests:

Test for coliform in the main kitchen sink (the sink that has the arsenic filter) with the EZ Coliform Cult-MUG test once per week.

- Fill the bottle about half an inch below the neck of the bottle with the water sample being tested
- Wait 48 hours to determine results
  - Clear yellow = negative for coliform
  - Blue-green = positive for coliform
- Example of results shown in Figures A7 and A8

If test results are positive, do not drink the water!

Figures A7 and A8: Positive (A7) and Negative (A8) Bacteria Test Results

Sediment Filter:
Unhook boxes and check filter morning and night or more frequently if you would like. If the power goes out, check filter shortly after the power comes back on.

If the filter is full, take the following steps:

1. Turn the two leftmost valves (1 and 2 on Figure C1) vertical.
2. Turn the two rightmost valves (3 and 4 on Figure C1) vertical.
3. Turn the red valve on the larger (green box) filter. Unscrew the filter and remove mesh.
4. Turn the red valve on the smaller (yellow box) filter. Use that water to rinse the filter mesh of the large filter.
5. If the mesh of the large filter is still not clean, rinse it off using an outside spigot. Once the mesh is clean, push the mesh of the large filter back up into the filter head and then screw filter back into place.
6. Turn the rightmost valves (3 and 4 on Figure C1) horizontal.
7. Turn the leftmost valves (1 and 2 on Figure C1) horizontal.
8. Fill out the sediment filter inspection sheet.
9. Replace and hook the boxes.

Tanks:
Every 6 months, check the status of the sediment in the water tanks and cistern. If there is a significant buildup of sediment at the bottom and/or around the sides of the tank, have the tanks cleaned.

2. Spanish Version

Pruebas de Bacteria:

Hacer prueba para bacterias coliformes en el lavaplatos de la cocina principal (el lavaplatos que tiene el filtro de arsénico) con la prueba EZ Coliform Cult-MUG una vez por semana.

- Llene el bote alrededor de media pulgada debajo del cuello de la botella con la muestra de agua a ser examinada.
- Espere 48 horas para determinar los resultados
  ○ Amarillo claro = negativo para bacterias de coliformes
  ○ Azul-verde = positivo para bacterias de coliformes
  ○ Ejemplos de los resultados mostrados en la Figura A7 y A8

Si los resultados son positivos, no tomar el agua!

Figura A7 and A8: Positivo (A7) y Negativo (A8) Resultados de la Prueba para Bacterias

Filtro para Sedimentos:
Remover las cajas de plástico y revisar el filtro mañana y noche o con más frecuencia si es necesario. Si la energía eléctrica se va, revisar el filtro un poco después que la energía eléctrica ha regresado.

Si el filtro está lleno siga los siguientes pasos:

1. Gire las dos válvulas ubicadas a su izquierda (1 y 2 en la Figura C1) a una posición vertical.
2. Gire las dos válvulas ubicadas a su derecha (3 y 4 en la Figura C1) a una posición vertical.
3. Gire la válvula roja en el filtro más grande (debajo de la caja verde) y desatornille el filtro y remueva la malla.
4. Gire la válvula roja en el filtro pequeño (debajo de la caja amarilla) y utilice el agua para lavar la malla del filtro grande.
5. Si la malla del filtro grande no está limpia, límpiela con un cepillo hasta que quede bien. Una vez que la malla está limpia, empújela dentro del filtro grande y atorníllela a su posición original.
6. Gire las dos válvulas ubicadas a su derecha (3 y 4 en la Figura C1) a una posición horizontal.
7. Gire las dos válvulas ubicadas a su izquierda (1 y 2 en la Figura C1) a una posición horizontal.
8. Llene el registro de inspección del filtro.
9. Vuelva a poner las cajas de protección en su lugar.

Tanques:
Cada 6 meses revisar el status de sedimento en el agua dentro de los tanques y la cisterna. Si hay una acumulación significativa de sedimento al fondo y/o en las paredes del tanque por favor limpiar los tanques.
Appendix D
Equations
0.03 gallons of chlorine per ft$^3$
Dimensional analysis: 1 ft$^3$ ~ 7.5 gallons
0.004 gallons of chlorine per gallon of water
Liquid chlorine bleach (5.25%) chlorine
Chlorine after shocking should be ~200 ppm

Well requires ~ 10.5 gallons

Three 1500 gallon tanks and 1500 cistern
- for each tank: 1500*0.004= 6 gallons per tank
in total 34.5 gallons of chlorine will be needed to shock the system

**Equation D1:** Equation used to calculate how much chlorine would be needed to shock the water system.