Rural Potable Water Supply Development in Mtera Secondary School Iringa Region, Tanzania

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2.0 Project Profile

2.1 Project Location

Region:	Iringa, Tanzania
District:	Iringa Rural Region
Place:	Mtera Secondary School
Climate:	Less than an inch rain for half the year Temperatures reaching 90^{o}F Humid

2.2 Beneficiaries Information

Number of Beneficiaries:	Students: 457 Staff: 31 Family of Staff: 30

2.3 Project Duration

In-kind Labor from School:	2 months (to dig and re-bury trenches)
Kilolo Star Well Drillers:	2 weeks (to install pump, piping, and tank)

2.4 Project Budget

$15,839

3.0 Executive Summary

Mtera Secondary School, located at 7° 8'11.54"S, 35°56'4.26"E, is 5.85 km west of the Mtera Hydroelectric Dam, south of the Mtera Reservoir and south west of the Mtera Village. The reservoir separates the village from the school, with the nearest crossing between the school and the village located at the dam. See Figure 1 for an overview of the area.

Figure 1: Google Earth view of the Mtera Secondary School, reservoir, and Dam.

The secondary school at Mtera was originally built as an army base in the 1980s for soldiers involved in constructing the dam and reservoir located near the school. At the time of the base's creation, a water system was installed that delivered water directly from the reservoir to a cistern and filter system elevated above the base. Water from the reservoir fed into a cistern at the highest elevation, which fed into a gravel and sand filter at lower elevation. The filter then dumped water into a final cistern at lower elevation. This did not purify water, a sand filter system is not the same as purification system. The elevation of the cisterns provided the head needed to pressurize the water system and provide water at various locations within the base. The original intake piping from the reservoir was 3 inch galvanized steel (GS) pipe. When the army base was turned into a school in the early 2000's, a well was drilled in close proximity to the school in 2007 and substituted as its main water source. This was done by connecting 1.5 inch PVC pipe from the well into the main intake line on the GS pipe system. Piping from the reservoir to the school was then removed. See Figure 2 for a detailed map of the current water system.

After many years of use, the school water system is in poor condition. Much of the pipe, GS and HDPE, is exposed to the surface and has been damaged in multiple areas and now leaks. See Figures 3 and 4.

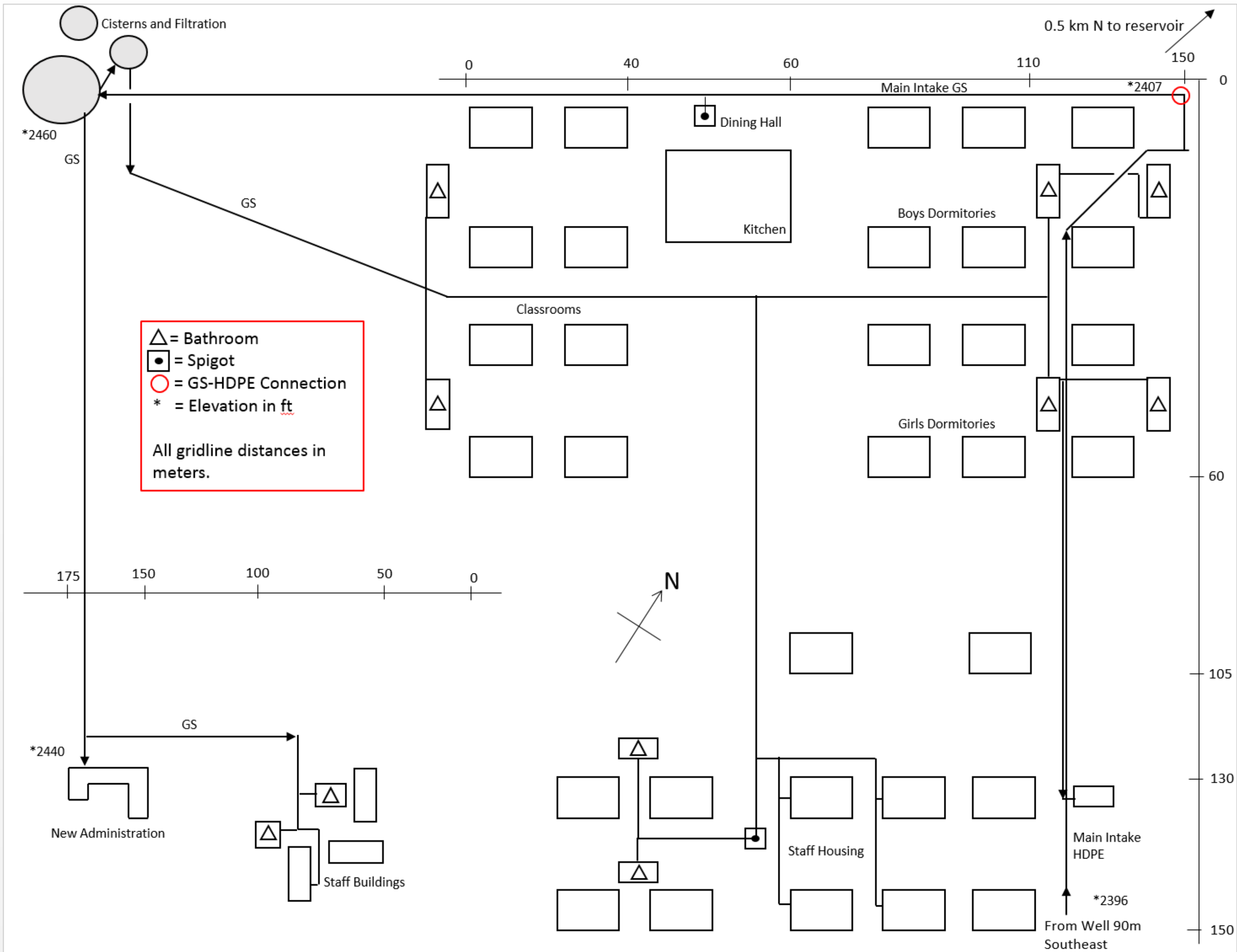

Figure 2: Map of Mtera Secondary School showing current water system.

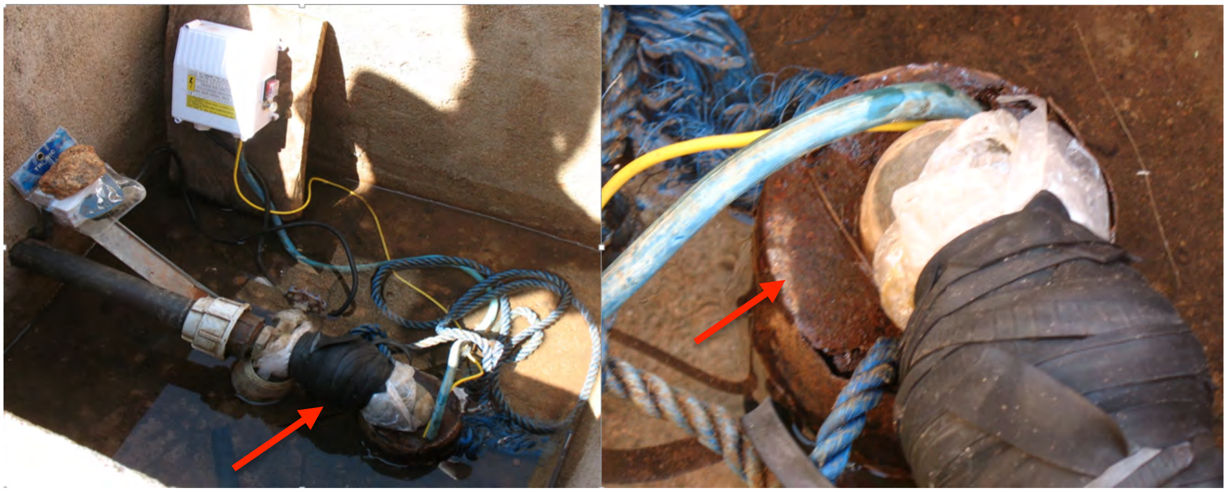

Figure 3: Access to pump in well. Notice the rubber tubing around the leaking pipe on the left and the corrosion on the metal cap on the right.

Figure 4: Disrepair at various points in the current pipe system. Bottom left: HDPE system intake pipe; bottom right: GS system intake pipe; middle left: GS system intake pipe; middle right: GS system pipe near staff buildings; top left: HDPE pipe originally use.

A screen test for total coliform presence was conducted on the well water[1]. The water for this test was taken from the dining hall spigot off the system intake line (Figure 6). The water from the well tested clean and showed no growth of coliform bacteria after 24 hours of incubation (see left image of Figure 7, page 9). The clean well water is pumped to the cisterns above the school. Since the water is already clean when entering the first tank, the gravel and sand filter was removed so that both cisterns could be used for water storage.

Figure 5: The well cover. The well was locked to keep the area clean and secure.

Figure 6: Water test of well water. Dining hall spigot off the main line from the pump.

[1] The most basic test for bacterial contamination of a water supply is the test for total coliform bacteria. Total coliform counts give a general indication of the sanitary condition of a water supply. Total coliforms include bacteria that are found in the soil, in water that has been influenced by surface water, and in human or animal waste. http://www.health.ny.gov/environmental/water/drinking/coliform_bacteria.htm

The cisterns are open-topped containers with concrete foundations and cinderblock walls. Attempts have been made to cover the tops of these cisterns with a roof, mesh, and chicken wire, but all of these protection methods are in disrepair (See Figure 8). As a result, the water in the cisterns is exposed to the air, and animals and insects are able to get access to the water. There have also been occurrences of animals falling into the cisterns and drowning. A screen test for total coliform presence showed the water stored in the cisterns to be contaminated. The school has fortunately been using the dining hall spigot from the main intake pipe for drinking. When it is able to be used, the water from the cistern is used primarily for washing and cleaning.

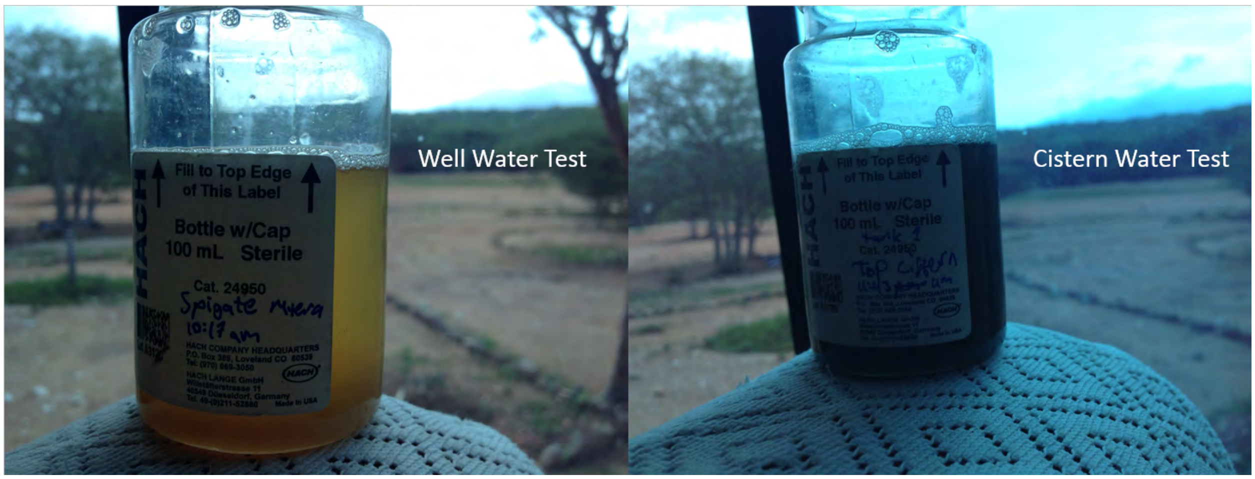

Figure 7: Coliform water test after 24 hours of incubation. Yellow and translucent indicates clean water while very dark water indicates coliform bacterial presence.

Figure 8: Cisterns at the top of the hill. Left: largest cistern; middle: largest cistern; right: lower cistern.

At the time the University of Minnesota students visited Mtera, only the new administrative building was receiving water consistently from the cisterns (see administrative unit in lower left corner of Figure 2). Of the piping after the cisterns, about 80% of the water system was shut off at the cistern because of water leakage from the GS pipes running to the school buildings. In addition to the contaminated water and broken pipes, the foundations of the cisterns leak and the concrete is not sealed from bacterial and plant growth.

The school is also on its third pump since drilling the well in 2007. The first pump was a 2 hp pump made in the U.S. The second pump was a 1 hp pump, also made in the U.S. The third pump, put in about 2 months ago, is a 0.5 hp pump from China and is quite undersized for the current system. Only information regarding the most recent pump is known, see **Appendix D**. It takes 10 days to fill the cisterns above the school using this pump. When the spigot near the dining hall, which takes water from the main line, is turned on, the water flowing into the cisterns completely stops. It is assumed that the school went with a 0.5 hp pump due to lack of funding. It is clear this pump will not last very long due to the prolonged periods of continuous operation. In addition, the 220-volt wire that powers the pump is exposed to the air. This type of wire is usually buried in the ground after installation. Much of the insulation on this wire has been damaged by exposure to the sun. Patching jobs and splicing jobs that have been one to repair the wire are exposed on the ground and pose a major safety risk to the students and faculty. See Figure 9.

Figure 9: Exposed wire splice. Located on the east side of the school grounds.

3.1 Program Objectives

- To provide access to and storage for clean drinking water to Mtera Secondary School by the end of this project.
- Collaborate with SPP to provide hygiene and sanitation training for students and staff.
- To implement a sustainable water system that is engineered correctly and owned, maintained, and repaired by the school.

3.2 Program Deliverables

- Meet with staff of Mtera Secondary to gain full support of the implementation plan and make clear their expectations and obligations.
- Replace current pump with a 3 hp pump.
- Replace cistern with 10,000L SIMTANK.
- Phase 1: Lay PVC pipe to new administrative building, dining hall, and kitchen and provide needed spigots (3 total).
- Phase 2: Lay PVC pipe to dormitory bathrooms, staff buildings, and staff houses and provide needed spigots (6 total).

3.3 Impact Goals

- Improvement in the health of the beneficiaries.
- Increased student attendance.
- Reduction in time spent fetching water.

3.4 Implementation Plan

A meeting should be held with the staff of Mtera secondary school to get their input, suggestions, and support of the proposed design. Based on calculations made in the EES program, a 3 hp pump will be needed to deliver a volumetric flow rate of 3 L/s. New electrical wires will be run to the pump and buried underground to prevent excess wear. All existing piping, both HDPE and GS, will be removed from service due to its excessive wear, and be replaced with new HDPE pipe. Based on EES calculations, the discharge pressure of the pump will be 107.5 psi and the highest pressure after the SIMTANK will be 30 psi. Class E HDPE pipe will be used from the pump to the SIMTANK and Class B HDPE pipe will be used after the SIMTANK. Based on the system pressures and the burst pressure of HDPE Class E being 137 psi and HDPE Class B being 55 psi, HDPE will be sufficient for the piping system and will not require GS. The new HDPE piping system will also be installed and buried underground to prolong the life of the pipe and eliminate punctures and cracks due to foreign materials in the environment. Figure 10 shows a new, suggested route for laying the HDPE pipe to the SIMTANK, which will also need to be verified with the school staff; note that Phase 1 construction is indicated by 'green' lines and Phase 2 by 'orange' lines.

The current cisterns will be decommissioned, due to the inability to provide and store clean water. The cisterns will be replaced with a 10,000L SIMTANK stored on a cement slab located next to the largest cistern at the highest elevation. It is estimated that a person should drink 3 liters of fluid per day[2]. With a maximum student population of 600 at the school and the staff and family of staff population of 61, the total drinking water load for the school would be 1983 L. To account for clean water that may be required for other necessities throughout the day, it is estimated that each person at the school would use 5 liters of water per day. This would require the total clean drinking water load of the school to be 3305 L/day. *If the pump were to stop working*, a 10,000L SIMTANK will supply the school with enough drinking water to last 3 days. The water supply will only last 3 days if it is exclusively used for drinking water. *If the pump is not working*, it is expected water for bathing, laundry, etc. will come from the reservoir. Furthermore, the Tanzanian government standard is all holding tanks must hold at least 60% of the daily usage of water. A 10,000L SIMTANK surpasses this standard, even up to an estimation of 20 L/day per person for a population of 661 people.

Piping will be laid from the SIMTANK to the new administrative building, the dining hall spigot, and directly to the kitchen in Phase 1. In Phase 2, piping will be laid for spigots near each of the girls and boys dormitory bathrooms and in the vicinity of the staff buildings and houses. These locations, shown on Figure 10, will need to be verified with the staff of the secondary school. A second 10,000L SIMTANK will also be installed in Phase 2 to provide more water storage capacity. When this new SIMTANK is installed, the level control will be moved from the first SIMTANK to the new one, and the first SIMTANK will be piped directly to the new SIMTANK. Additionally, hygiene and sanitation training will be conducted by SPP to ensure the clean water is not contaminated when obtaining water in buckets from spigots.

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[2] www.mayoclinic.org

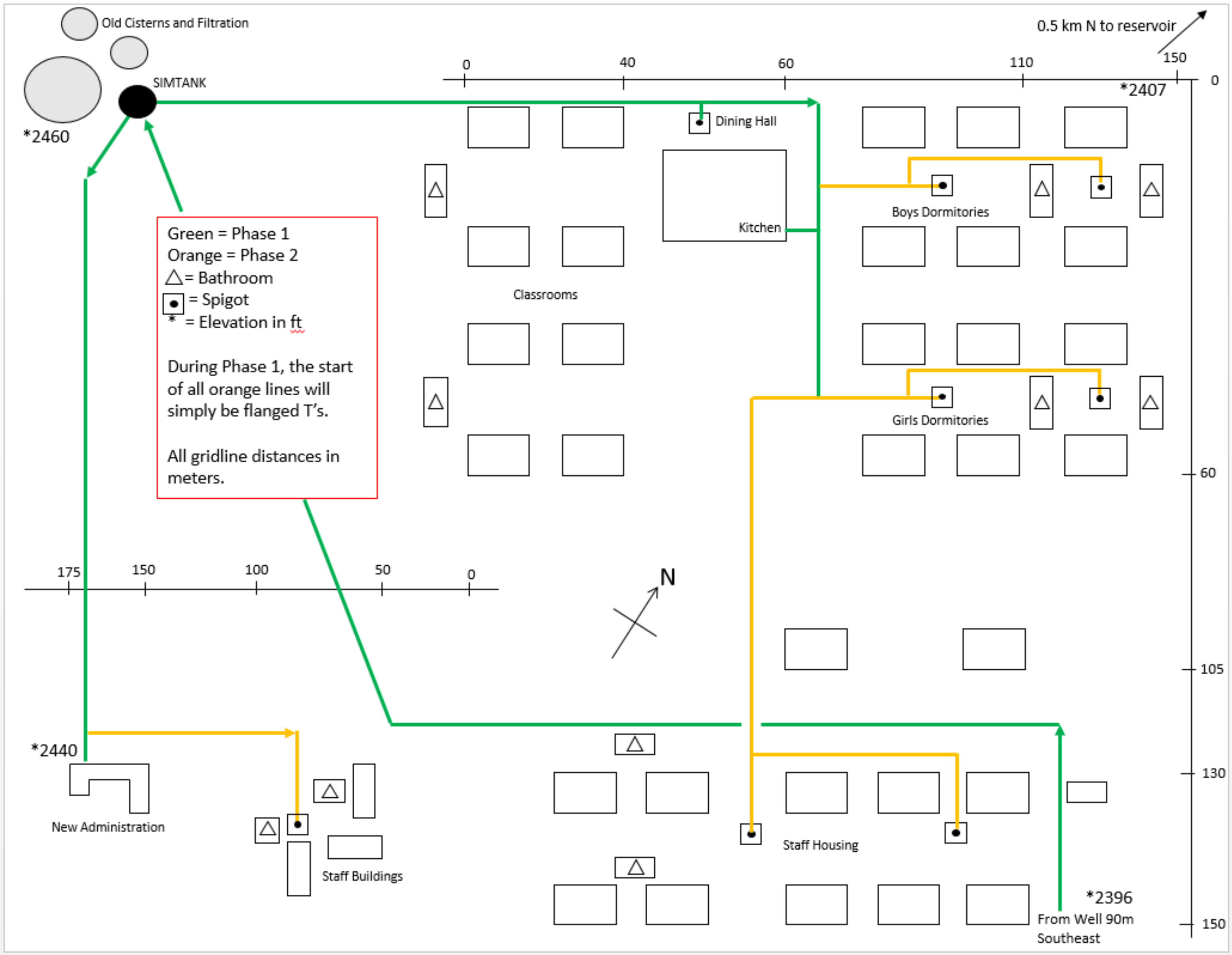

Figure 1: Map of Mtera Secondary School with proposed water system outlined

3.5 Project Sites

Because new piping will be laid, the staff of the secondary school should be consulted as to whether a new path from the pump to the SIMTANK would be more suitable than the current path. Removing the old piping and replacing it with new piping makes sense, even though the run is a bit longer. The 10,000L SIMTANK will be put near the largest cistern to supply the necessary head to deliver water to the school grounds. The project is divided into 2 phases in order to minimize cost and supply water to where it is essential in Phase 1. Phase 2 supplies water to desired locations.

Water will be supplied to the new administrative building, the dining hall spigot, and the kitchen in Phase 1 to align with the school's current system. The dining hall spigot will no longer draw from the main intake line to the SIMTANK, but instead from the discharge line of the SIMTANK. Water to the kitchen is included in Phase 1 to eliminate the current unsanitary mode of transferring water from the dining hall spigot to the kitchen through an above ground, detached, open ended HDPE pipe. This will help ensure safe preparation of food for the students. Until Phase 2 of the project is complete, students and staff will continue to gather all water they may need (bathing, drinking, laundry, etc.) from the dining hall spigot.

4.0 Project Construction Process

The trenches for the piping system will be hand dug by the secondary school staff and students, to show their dedication in installing and maintaining the new system. Kilolo Star will disconnect the current piping system and reconnect the new piping. Flanged T's will be connected at locations that will allow easy implementation of Phase 2, where more piping will be connected in the future. Valves will be used after all pipe branching in the system to allow the branch to be shut off if damage were to occur downstream. This will prevent losing any head in the SIMTANK due to leaks in pipes. The 10,000L SIMTANK will include a water level control that will indicate when the pump should start and stop. The Mtera School maintenance staff will remove and replace the current pump with the new 3 hp pump. Kilolo Star will disconnect the old electrical wiring and connect the new wiring to the new pump. With the help of a fund set aside regularly to go toward the maintenance of this system, this new pump and water system can be easily maintained by a water committee.

4.1 Project Sustainability

To ensure the long-term sustainability and success of this water project, it is critical to involve the faculty and students of the Mtera Secondary School during the entire process, to ensure that they are taking ownership of the project and will continue to maintain the system in the future. For this project, the school will contribute to the project by providing in-kind labor to dig the trenches that the new piping and electrical wire will lie in. The school will also provide meals and housing for Kilolo Star during the construction phase of the project.

A water committee will be formed to see the project through from start to finish. After the project has been completed, the water committee will meet regularly to assess the current water situation and needs. The water committee will also be responsible for ensuring the proper operation of the water system and will carry out any necessary repairs or maintenance. In addition, all faculty members and students will be required to complete sanitation and hygiene training upon the completion of the project, which will be provided by SPP.

The proposed water system has been designed to be as maintenance free and sustainable as possible. However, it is inevitable that eventually the system will be in need of maintenance and/or repair. To ensure that the water committee has the necessary tools required to repair the system when needed, the school will be required to create a bank account, separate from the school operating account, with funds that are set aside on a monthly basis to maintain the water system. It is recommend the school contribute 25,000 TSH per month to this maintenance account. This is enough to replace the $800 pump at the end of its lifetime and allow room for maintenance of the water system on a continuous basis. In addition, it is recommended that this separate account require a signature from both the head master and a person from the water committee in order to withdraw any funds for maintenance or repairs. Furthermore, the new water system will cost $838/year to run, whereas the school's current system costs $927/year to run. The combination of these suggestions and the comparable operational cost of the system allows for a sustainable water supply system for the secondary school.

5.0 Conclusion

The existing system at Mtera that was inherited from the Tanzanian Army is in poor shape. There is no storage for clean water and the clean water they have is often contaminated through poor sanitation of the transport methods that the students and faculty use. It is important that a new water system be implemented at the school, as fixing the old system is not economically viable. The phases outlined in the report will make it easy to split up the work and cost of the system so that it does not need to be done all at once if there is a shortage of money. It is crucial to get support from the school and to get them invested in the project, whether monetarily or through labor. There are dedicated staff already in place who could fill this need. Any control that St. Paul Partners could have in sustainability of the system would help keep the water system in working order and ensure that the school has clean water long term. It is of the utmost importance that this system not be allowed to fall apart after installation as no ground will be gained in improving the quality of life of future generations. Hundreds of children from 12-18 years old would benefit greatly from the completion of this project.

Figure 11: The Mtera Secondary children assembled to greet us.

6.0 Detailed Project Budget

S/N	Descriptions	Unit Cost $	Unit	Quantity	Total Cost $
1	3 HP Submersible Pump	$800	each	1	$800
2	10,000 L SimTank	$500	each	1	$500
3	Submersible Pump Wire	$7.20	m	250	$1,800
4	Cat5 Wire for Level Control	$0.50	m	450	$225
5	Liquid Level Switch	$250	each	1	$250
6	uPVC 50mm Class E	$3.29	m	40	$132
7	HDPE 90mm Class E Pipe	$6.73	m	450	$3,029
8	HDPE 63mm Class B Pipe	$2.75	m	300	$825
9	HDPE 40mm Class B Pipe	$1.21	m	150	$182
10	Spigots	$50	each	3	$150
11	63mm Valve	$100	each	1	$100
12	40mm Valve	$40	each	1	$40
13	32mm Valve	$25	each	2	$50
14	Add 15% of pipe for pipe fittings				$605
15	Add 20% of pipe for freight				$807
16	Labor to install pipe	$1.00	m	900	$900
17	SPP oversight and training	$500	day	2	$1,000
18	10% Contingency				$1,139
Phase 1 Subtotal					$12,533
1	10,000 L SimTank	$500	each	1	$500
2	HDPE 40mm Class B Pipe	$1.21	m	150	$182
3	HDPE 32mm Class B Pipe	$0.84	m	300	$252
4	Spigots	$50	each	7	$350
5	40mm Valve	$40	each	3	$120
6	Add 15% of pipe for pipe fittings				$65
7	Add 20% of pipe for freight				$87
8	Labor to install pipe	$1.00	m	450	$450
9	SPP oversight and training	$500	day	2	$1,000
10	10% Contingency				$301
Phase 2 Subtotal					$3,306
Total Project Cost					$15,839

7.0 Appendices

Appendix A - Cost Calculations from Well to Tank

Inputs	
Tank Capacity (L)	10000
Pipe Length PVC (m)	40
Pipe Length HDPE (m)	410
Pipe Class	E
Population	600
Liters/Day*Person	100
Liters/Day	60000
$/kWh	$0.15
Pump Service Life (hrs)	10000
Pipe Burst Pressure (psi)	132
Peak Demand	2.08

Parameters							Material Prices					Electrical Prices		Operational Cost		
Pipe Size	HP	Flow Rate (L/s)	Hours/Day	Time to Fill (min)	Max Pressure (psi)	Burst Prssure HDPE	HDPE Price ($/m)	PVC Price ($/m)	Pipe Price	Pump Price	Startup $	kWh/day	$/year	Pump Life (years)	Cost/Life	Cost/Year
0.09	1	1.20	13.90	139.00	90.09	136.96	$6.73	$10.52	$2,890.90	$600.00	$3,490.90	10.36	$566.98	1.97	$1,717.50	$871.40
0.075	1	1.19	13.96	139.59	90.51	136.96	$7.02	$7.40	$3,009.80	$600.00	$3,609.80	10.40	$569.36	1.96	$1,717.50	$875.05
0.063	1	1.18	14.11	141.12	91.44	138.73	$4.98	$5.23	$2,173.40	$600.00	$2,773.40	10.51	$575.62	1.94	$1,717.50	$884.68
0.05	1	1.14	14.59	145.94	94.61	136.96	$3.16	$3.29	$1,427.20	$600.00	$2,027.20	10.87	$595.28	1.88	$1,717.50	$914.90
0.04	1	1.06	15.78	157.83	102.30	136.96	$2.05	$2.14	$972.10	$600.00	$1,572.10	11.76	$643.76	1.74	$1,717.50	$989.41
0.032	1	0.91	18.26	182.61	118.40	139.29	$1.31	$1.40	$668.70	$600.00	$1,268.70	13.60	$744.84	1.50	$1,717.50	$1,144.75
0.09	2	2.21	7.56	75.55	97.92	136.96	$6.73	$10.52	$2,890.90	$700.00	$3,590.90	11.26	$616.33	3.63	$2,935.00	$809.36
0.075	2	2.18	7.65	76.49	99.13	136.96	$7.02	$7.40	$3,009.80	$700.00	$3,709.80	11.40	$623.97	3.58	$2,935.00	$819.39
0.063	2	2.12	7.85	78.51	101.80	138.73	$4.98	$5.23	$2,173.40	$700.00	$2,873.40	11.70	$640.43	3.49	$2,935.00	$841.01
0.05	2	1.97	8.48	84.77	109.90	136.96	$3.16	$3.29	$1,427.20	$700.00	$2,127.20	12.63	$691.57	3.23	$2,935.00	$908.17
0.04	2	1.70	9.80	97.98	127.00	136.96	$2.05	$2.14	$972.10	$700.00	$1,672.10	14.60	$799.31	2.80	$2,935.00	$1,049.65
0.032	2	1.37	12.17	121.74	157.80	139.29	$1.31	$1.40	$668.70	$700.00	$1,368.70	18.14	$993.15	2.25	$2,935.00	$1,304.21
0.09	3	3.01	5.53	55.30	107.50	136.96	$6.73	$10.52	$2,890.90	$800.00	$3,690.90	12.36	$676.65	4.95	$4,152.50	$838.12
0.075	3	2.96	5.63	56.33	109.50	136.96	$7.02	$7.40	$3,009.80	$800.00	$3,809.80	12.59	$689.23	4.86	$4,152.50	$853.70
0.063	3	2.85	5.85	58.48	113.70	138.73	$4.98	$5.23	$2,173.40	$800.00	$2,973.40	13.07	$715.59	4.68	$4,152.50	$886.35
0.05	3	2.57	6.49	64.90	126.20	136.96	$3.16	$3.29	$1,427.20	$800.00	$2,227.20	14.51	$794.17	4.22	$4,152.50	$983.69
0.04	3	2.15	7.76	77.59	150.90	136.96	$2.05	$2.14	$972.10	$800.00	$1,772.10	17.34	$949.46	3.53	$4,152.50	$1,176.03
0.032	3	1.68	9.94	99.38	193.30	139.29	$1.31	$1.40	$668.70	$800.00	$1,468.70	22.21	$1,216.12	2.76	$4,152.50	$1,506.32

Current School Set-up																
0.032	0.5	0.40	24.00	416.67	98.50					$500.00		8.94	$489.47	1.14	$1,058.75	$927.47

*Note: Current school set-up only allows for 57.6 liters of water per person per day.

Appendix B - EES Code

The program EES was used to model Phase 1 design calculations. The model assumes incompressible flow and negligible temperature change in the pipe water due to friction and the surroundings. In order to run the program, a pump horsepower and pipe diameter must be chosen. To see how the volumetric flow rate to the SIMTANK varied with the possible different combinations of pump and pipe sizes in the project, a parametric table was created in EES. The diameter of the pipe to the SIMTANK from the pump ranges from 32-90 mm and the horsepower of the pump ranges from 1-3 hp. The operational cost for each possible combination was also calculated. This analysis is represented by Appendix A. The pressure at the discharge of the pump compared to the burst pressure of the pipe was taken into consideration when choosing the best model. Material and electrical prices and the expected pump life were taken into consideration when calculating the cost per year. Based on the analysis and in order to minimize cost, a 90 mm pipe with a 3 hp pump is the best solution for this project. This will have an operational cost of $838 per year. It is estimated that if the system were to cost 25% more, new plumbing could be run to all of the bathrooms and connected to the SIMTANK supply system.

Following is the EES code, continuing on Page 18.

Unit Settings: SI C kPa kJ mass deg

$d_{12} = 0.0408$	$d_{28} = 0.0736$	$d_{45} = 0.0282$	$d_{46} = 0.0282$
$d_{83} = 0.036$	$d_{84} = 0.057$	$Pressure_{at,Pump} = 108.7$	$Pressure_{at,Top,Well} = 35.06$
$Q_{IN,SimTank} = 2.982$	$Q_{TO,Admin} = 0.9581$	$Q_{TO,Dining} = 1.675$	$Q_{TO,Kitchen} = 1.153$

```
{ Modeling Phase 1 - Mtera Proposal }
{ 02/03/14 }

{ 1. Well }
{ 2. Top of Well }
{ 3. Admin Building }
{ 4. Split in Line }
{ 5. Dining Hall }
{ 6. Kitchen }
{ 7. Right After Pump }
{ 8. Simtank}

{Constants}

rho =1000
g =9.81
nu =.000001
hp=3
w = hp*745
m = rho * v_12 * A_12
epsilon=0.2/1000

{Inputs}

{ Pipe Diameters (m) }

d_12 = 40.8/1000
d_83 = 36/1000
d_84 = 57/1000
d_45 = 28.2/1000
d_46 = 28.2/1000
d_28 = 73.6/1000

{ Pipe Lengths (m) }

L_12 = 40
L_83 = 150
L_84 = 200
L_45 = 10
L_46 = 50
L_28 = 360

{ Elevations (m) }

z_1 = (2391*0.3048)-40
z_2 = (2391*0.3048)
z_3 = 2440*0.3048
z_4 = 2415*0.3048
z_5 = 2413*0.3048
z_6 = 2409*0.3048
z_7 = (2391*0.3048)-40
z_8 = 2460*0.3048

{KV Values}

kv_12=10
kv_83=10
kv_84=10
kv_45=10
kv_46=10
kv_28=10

{Pressures}

P_1=0
P_3=0
P_5=0
P_6=0
P_8=0
Pressure_at_Pump = P_7*.000145
Pressure_at_Top_Well=P_2*.000145

{Calculations}

A_12=pi/4*d_12^2
A_83=pi/4*d_83^2
A_84=pi/4*d_84^2
A_45=pi/4*d_45^2
A_46=pi/4*d_46^2
A_28=pi/4*d_28^2

v_12=Q_12/A_12
v_83=Q_83/A_83
v_84=Q_84/A_84
v_45=Q_45/A_45
v_46=Q_46/A_46
v_28=Q_28/A_28

Re_12=4*Q_12/(pi*nu*d_12)
Re_83=4*Q_83/(pi*nu*d_83)
Re_84=4*Q_84/(pi*nu*d_84)
Re_45=4*Q_45/(pi*nu*d_45)
Re_46=4*Q_46/(pi*nu*d_46)
Re_28=4*Q_28/(pi*nu*d_28)

ed_12=epsilon/d_12
ed_83=epsilon/d_83
ed_84=epsilon/d_84
ed_45=epsilon/d_45
ed_46=epsilon/d_46
ed_28=epsilon/d_28

(P_2-P_1)/(rho*g)+z_2-z_1=((w/m)/g)-v_12^2/(2*g)*(f_12*L_12/d_12+kv_12)
(P_2-P_7)/(rho*g)+z_2-z_7=-v_12^2/(2*g)*(f_12*L_12/d_12+kv_12)
(P_8-P_2)/(rho*g)+z_8-z_2=-v_28^2/(2*g)*(f_28*L_28/d_28+kv_28)
(P_3-P_8)/(rho*g)+z_3-z_8=-v_83^2/(2*g)*(f_83*L_83/d_83+kv_83)
(P_4-P_8)/(rho*g)+z_4-z_8=-v_84^2/(2*g)*(f_84*L_84/d_84+kv_84)
(P_5-P_4)/(rho*g)+z_5-z_4=-v_45^2/(2*g)*(f_45*L_45/d_45+kv_45)
(P_6-P_4)/(rho*g)+z_6-z_4=-v_46^2/(2*g)*(f_46*L_46/d_46+kv_46)

Q_84 = Q_45 + Q_46
Q_12=Q_28

f_12=0.035
f_83=0.03
f_84=0.025
f_45=0.035
f_46=0.025
f_28=0.0275

Q_IN_SimTank=Q_28*1000
Q_TO_Admin=Q_83*1000
Q_TO_Split=Q_84*1000
Q_TO_Dining=Q_45*1000
Q_TO_Kitchen=Q_46*1000
```

Appendix C - Map of valve locations and pipe sizes for the project