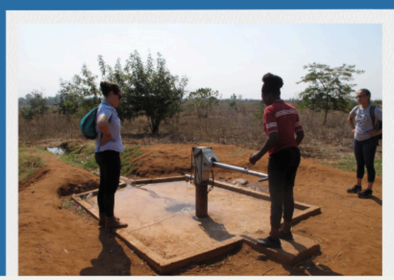


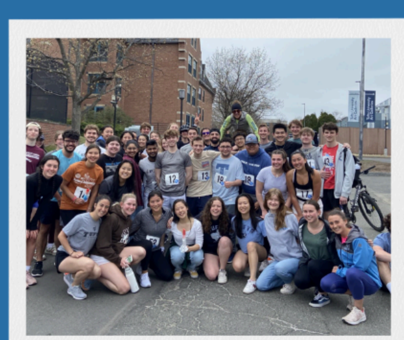


Tufts Engineers Without Borders- Malawi Chapter





Project: Solomoni Clean Water Access Project

Sponsor: Engineers Without Borders USA, Tufts University Chapter

Location: Solomoni, Malawi

Duration: Aug 2016 - Aug 2024

Project Leads: Max Harrington, Natasha Wan, Sophie Gawronski, Elsa Rohm, Sarah Dawson, Sophie Impelletiri

Executive Summary

Tufts Engineers Without Borders' mission is to provide engineering solutions to communities in need while giving students hands-on experience on real-life projects, while learning about international cultures and communities. Since 2017, Tufts University chapter of Engineers Without Borders has been working closely with the community of Solomoni, Malawi to expand access to clean water and promote hygiene for the 1,550 Chigumukire Primary and Secondary School students and teachers.

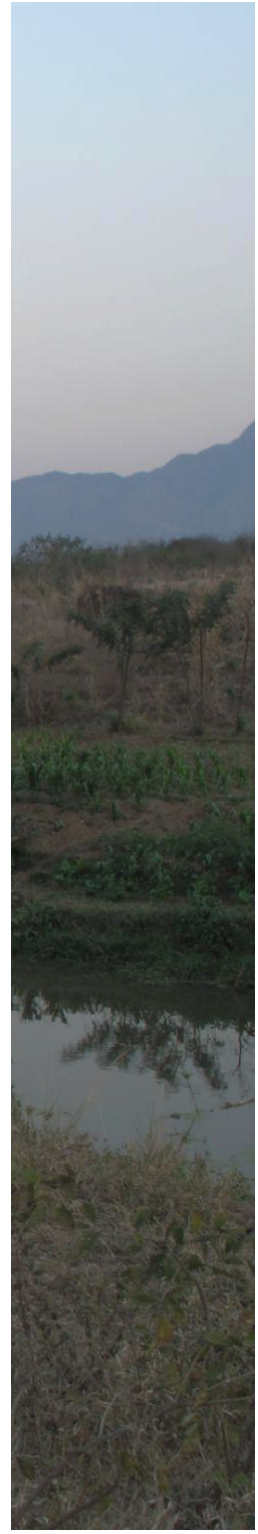
Tufts EWB designed a solar-pumped gravity-fed water distribution network that would have health, educational, and economic benefits. Previously, members of the community relied on the river for drinking water, bathing, washing, and cleaning. However, this practice was unsafe due to sanitation issues related to cholera, and it also resulted in missed school time while collecting water. After identifying this need with the school headmaster, community chiefs, students and teachers, we worked closely with our NGO partners, Joshua Orphan and Community and Freshwater Project International, to ensure the project met the needs of its stakeholders. In 2023, Tufts EWB installed 7 tap stands, 2 sinks, and 3 showers for the Solomoni community.

Throughout the process, we examined long-term risks and sustainability issues for the project and allowed our club members to engage with engineering in a practical way. During Tufts' travel to Malawi in 2023, the team worked with FPI and contractors to gain hands-on knowledge on the electrical system and piping networks. The team also conducted community interviews to understand the change in water accessibility and community health. They collected and distributed science supplies for the newly built science complex, volunteered at a monthly mobile health clinic, and much more. This year, in weekly meetings, 60+ members learned about Malawian culture while designing and building a sustainable greenhouse on Tufts Campus, with practices that reflected those from construction in Malawi.

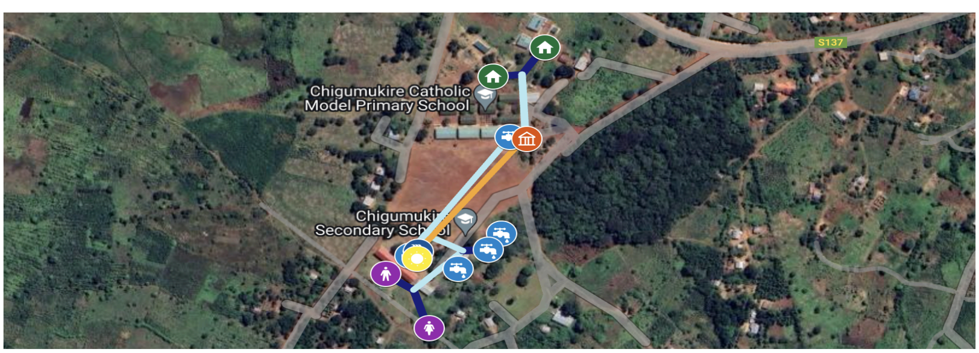
Currently, we are in the Monitoring and Evaluation phase of our project, and traveling in August 2024 to assist with repairs to the broken taps and conduct interviews with community members to ensure that the project has resulted in a notable improvement by the community and stakeholders. We intend to assess new projects in the Blantyre and Zomba region, with assistance from our NGO partners.

Project Purpose and Justification

- Background:
  - Community members struggled with access to clean water, and resorted to drinking from a river, as well as bathing, washing, and cleaning in the river.
  - Students at the day school in the village often missed class time, needing to walk long distances to collect water for themselves and their families.
- Purpose:
  - To design and implement a sustainable water distribution system that ensures reliable access to clean water for the Chigumukire school community of 1500 students, the 20 teachers, and the families of any students.
- Justification:
  - Health benefits: Reduction in waterborne diseases.
  - Educational benefits: Students will receive better education and spend more time in class.
  - Economic benefits: Time saved from water collection can be used for productive activities like education, construction, and family care.



Solomoni Water Distribution Community Map (below)



Project Objectives

- Provide a reliable water supply for the students at the day school.
- Reduce incidence of waterborne diseases by improving water quality.
- Improve education by reducing class time missed.
- Develop local capacity to maintain and manage the water distribution system.
- Install tap stands to wash hands after using toilets.

Scope

- **In-Scope:**
  - Assessment of previously existing water sources and distribution challenges.
  - Design and installation of water distribution infrastructure.
  - Community education and training programs.
  - Collaboration with local authorities and stakeholders.
- **Out-of-Scope:**
  - Direct involvement in unrelated community infrastructure projects.
  - Long-term maintenance beyond initial training + handover.

Four Phase Deliverable Plan:

1. Needs Assessment
   a. Current status evaluation
   b. Alternatives analysis
2. Project Implementation
   a. Detailed engineering plans and specifications
   b. Water pressure simulations
   c. Installation and construction of tap stands, tower, tank, solar panels
3. Monitoring and Evaluation
   a. Overall impact evaluation
   b. Educational materials and training sessions for community members.
   c. Maintenance, updates, changes
4. Closeout and Handoff
   a. Transition project management to the community members

Team Organization

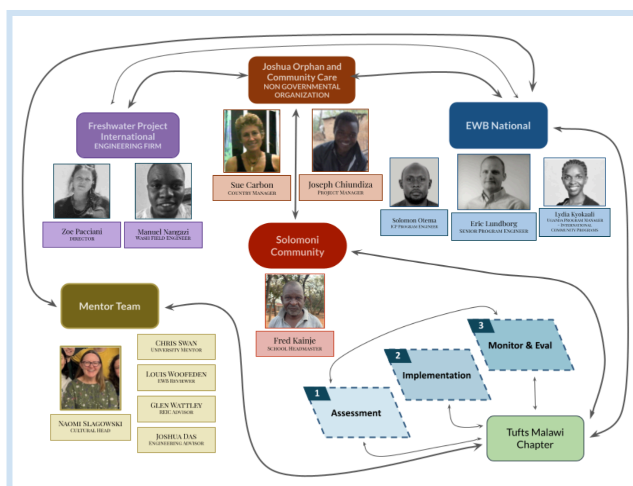
- Project Lead (2): Manage weekly student meetings, coordinate and communicate with NGOs, plan travel, manage finances and final decision making for installation.
- President (2): Coordinate outside funding from local organizations, oversee administrative duties and meetings with educational advisors.
- Treasurer: Manage financial sources, coordinate payment processes
- Technical Leads: Lead a subset of the project (Pipes, Pumps, Solar panels, etc.)
- Engineers: Execute engineering tasks, documentation, and research within subsects of the project.

Budget and Resources

- **Project Completion Budget: ~$40,000**
- **Funding Sources:** Student Organization funding, Crowdfunding campaigns, 6k Charity Run, Bake Sale
- **Resources:**
  - EWB Tufts University members (Project Leads and Engineers)
  - Local Malawian contractors and labor
  - Solomoni community volunteers
  - FPI Field Engineers
  - JOCC Cultural Field guides

Partners and Stakeholders

- **Primary Stakeholders:**
  - Students and Teachers at Chigumukire Day School
  - Community members
  - Tufts University EWB members
- **Secondary Stakeholders:**
  - Partner NGOs: Joshua Orphan and Community Care
  - Engineering firm: Freshwater Project International
  - Crowdfunding donors, Tufts Community Union and Financial Department
  - Academic and Cultural advisors: Chris Swan, Naomi Slagowski
  - EWB-National advisors: Glenn Wattley, Eric Lundborg



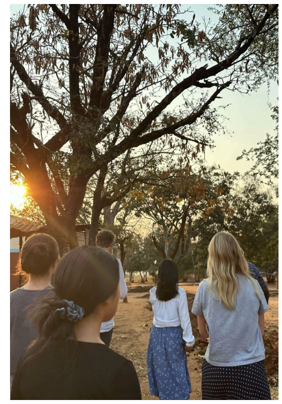
Clean Water Access Success Criteria

- Supply 1500 students with fresh water access on demand at 7 tap stands
- Install 2 sinks in the school laboratory, a shower in the women's bathroom, and sinks and showers for 2 staff houses
- Stay below budget of ~$40,000, avoiding overspending of School of Engineering funds
- Noted improvement by community and stakeholders while in the Monitoring phase.

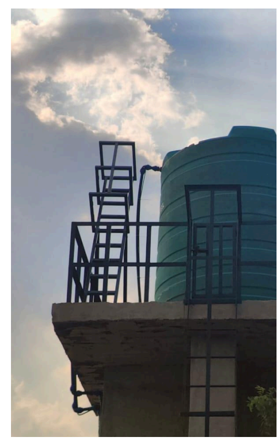
Current and Future

- Greenhouse
  - Spring 2023
    - There was a lot of interest in the club, and not enough work for people to do post implementation. Instead of working on the Clean Water Access project directly, students have designed and built a greenhouse on the Tufts University campus. With this project, we learned how to timeline an engineering project from start to finish, mobilize tech groups to create something they can see, build, and take ownership for an engineering project.
  - Fall 2023
    - Our chapter members have learned skills such as CAD, strength simulations, laser cutting, 3D printing, community surveying, project management, and more through Project Greenhouse that can be applied directly to our international Malawi Project.
  - Spring 2024 - Onwards
    - With similar engineering aspects, such as a solar panel and a water tank, and educational interactives, students are also able to learn more about our international project. This last May, we shared our hard work to the public and hosted a grand opening, inviting the Medford/Somerville community to engage with the Malawian Culture, sustainability efforts, and community collaboration.
- Monitor & Evaluation Phase: Solomoni Project
  - Fall 2023
    - Following our trip in August of 2023, we wanted to bring back the knowledge that we gained and present it in a

community gathering event. Our travel team and Malawi committee led workshops and collaborative challenges through an event "Malawi the Journey". This brought together members of the club and the greater Tufts community through sharing Malawian food, racing to tie Chitenjis, throwing sentence making dice to learn to speak Chichewa, learning about Malawi culture through a presentation on different tribes, making a "Rube Goldberg" to learn about water filtration and WASH, and more. Our cultural advisor, Naomi, spoke on her experience as a Peace Corps Volunteer, and we shared a video highlighting the entire trip, the borehole, and the entire project!



- Spring - Summer 2024
  - We are traveling to Malawi to monitor and evaluate our current project and work towards project close out and hand over. During our time in Malawi, we will assist with water quality testing, conduct community interviews, spend time with the community, and make sure the project will last for years to come without our involvement. Furthermore, it was assessed that there was breakage in the plastic taps, gate valves and stop corks in the system because of insufficient education on the new technology. Over twisting and lesser quality materials led to a lot of breakage. In this trip, better quality and metal replacement will be installed. However, this will be paired with painted informational murals at each tap stand to teach students, teachers and their families the proper usage of the taps.



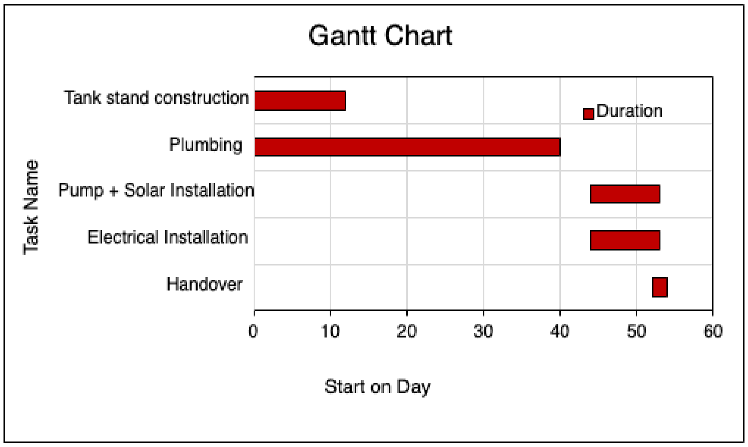
- Assessment Phase: Makwelani/Zomba Project
  - Summer 2024 - Onwards
    - The secondary goal of Summer 2024 travel is to assess for our new project and meet new stakeholders that we will work with in upcoming years. We will spend time in a new community where we will conduct interviews for their needs in sanitization, water quality, and/or health, and use this to come up with engineering solutions. We will also collect technical information we'll need to work on this project beginning fall 2024.

Thank you for your time in looking into supporting the Tufts Malawi Chapter!
Look below for more of our technical work and project photos!
Hope you enjoyed our project as much as we did in creating it!

With Love,
Project Leads Max Harrington, Natasha Wan, and Sophie Gawronski,
with our team of Committee Members and Executive Board:
Julia Zelevinsky, Sam Hecht, Ian Ross, Melanie Sun, Katie Casey, Naomi Arnold, Addy Carson, David Gillingham, Dylan Rolon, Geri Tabbachino, Natalie Long, Dani Price, Matias Corona, Charlotte Lokere, Annie Segal, Paul Wang, Anaise Ineza, Olga Dernova, Nadia Anderson, Ella Canas, Alec Levin, Bergan Kane, Kana Suzuki, Maddy Molloy, Olympe Jean

Attachments

- **Appendix A:** Detailed project schedule.



Task #	Task Name	Start Date	End Date
1	Tank stand construction	7/3/2023	7/14/2023
2	Plumbing	7/3/2023	8/11/2023
3	Pump + Solar Installation	8/16/2023	8/24/2023
4	Electrical Installation	8/16/2023	8/24/2023
5	Handover	8/24/2023	8/25/2023

- **Appendix B:** Budget breakdown.

		LABOUR AND CONTRACTS			-
DESCRIPTION	UNIT	QUANTITY	AMOUNT	TOTAL (MwK)	TOTAL (USD)
Electrician	Lumpsum	1		0	-
Tank Tower Construction	Lumpsum	1	15,000,000.00	15,000,000.00	14,619.88
Plumber	Lumpsum	1	1,000,000.00	1,000,000.00	974.66
Masoner	Lumpsum	1	900,000.00	900,000.00	877.19
Casual Labour	Lumpsum	1	600,000.00	600,000.00	584.8
Trip for Bricks	Lumpsum	1	100,000.00	100,000.00	97.47
Trip Sand	Lumpsum	1	100,000.00	100,000.00	97.47
Trip for Quarry	Lumpsum	1	100,000.00	100,000.00	97.47

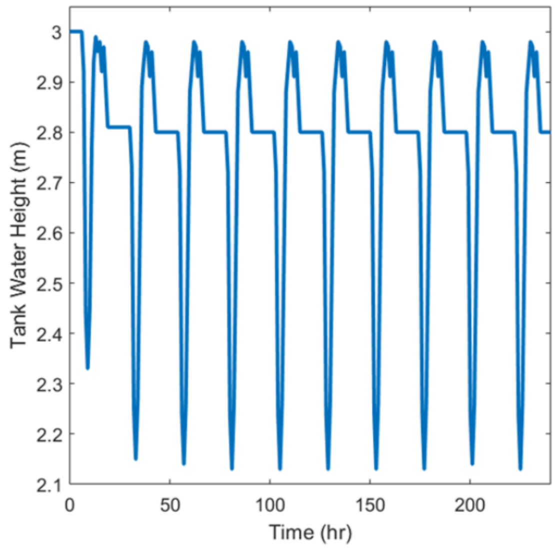
ITEM	TOTAL (MwK)	TOTAL (USD)	DESCRIPTION
Well Pump	4,388,200.00	$4,277.00	Includes borehole piping, security cables, control and wiring electronics, cement, cables
Tank	1,848,800.00	$1,801.95	Tank and Tank adapter fittings
Pipe Layout	2,254,900.00	$2,197.76	40mm piping, 20mm piping, adapters for each
Taps	1,780,000.00	$1,735.27	20mm piping, 11 tap stands, shower head, adapters
Tower	15,000,000.00	$14,619.00	Construction, delivery of cement, cement laying, rebar bending
Masoner	900,000.00	$877.19	For constructing tower
Plumber	1,000,000.00	$974.66	For ensuring correctly functioning piping system
Extraneous	900,400.00	$878.09	Trips by community members to obtain sand / rocks
SUB TOTAL	28,072,300.00	$27,360.92	
CONTINGENCY	2,807,230.00	$2,736.09	
GRAND TOTAL	**30,879,530.00**	**$30,097.01**	

PROVISIONAL MAINTENANCE BUDGET

DESCRIPTION	UNIT	QTY	AMOUNT (MK)	TOTAL (MK)	$	COMMENTS
Bib Taps ½" (Plastic Types)	Each	20	5 000.00	100 000.00		5 AS SPARES
Gate Valves ½"	Each	15	20 550.00	308 250.00		6 AS SPARES
Gate valve 1 ¼"	Each	2	60 000.00	120 000.00		
Stop Cork ½"	Each	20	40 200.00	804 000.00		5 AS SPARES
Under Wall Stop Corks	Each	2	48 350.00	96 700.00		
Elbows ½"	Each	50	1 000.00	50 000.00		
Cement	50 Kg	6	25 000.00	150 000.00		
Labor plumber	Lumpsum	1	300 000.00	300 000.00		
Labor Masonry	Lumpsum	1	200 000.00	200 000.00		
Miscellaneous (TPT etc)			300 000.00	300 000.00		
				2 329 935.00	1 365.26	

Attachment H - Overall Installation Q…

- **Appendix C:** Technical drawings and specifications.



Tank water height for 10 days using Simulation 1.

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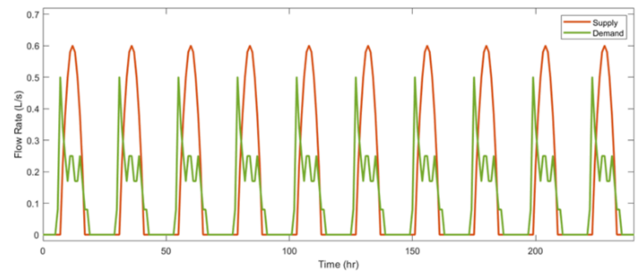


Flow rate trajectories for water supply and demand for 10 days using Simulation 1.

JOB No. FPI	SHEET NO.	DATE: Nov 2022	FRESH WATER PROJECT INTERNATIONAL STANDARD WATER TANK DESIGN
PROJECT NAME.	DSN.BY EN		
TITLE: Tank Stand	CHKD. BY EN		
SECTION	APPROVED. BY GS		

REFERENCE	CALCULATIONS	OUTPUT
	<u>TOP SLAB</u>	
	1. LOADING	
	a. Characteristic Dead Load	
	Slab self weight (200 mm thk)	
	= 0.2m x 24 KN/m3	
	G_k= 4.8 KN/m2	G_k= 4.8 KN/M2
	b. Characteristic Imposed Load	
	(i) Imposed load due to full tank (10m3)	
	weight of water; 1m3 = 1000 kgs	
	10m3 of water = 10000kgs	
	10000 x 9.81 kgs = 98.1 KN	
	98.1 KN / (3.45 x 3.45) = 8.24 KN/M2	
	(ii) Imposed load due to access for cleaning and maintenance = 0.6 KN/m2	
	Total Qk = 8.24 + 0.6 = 8.84 KN/M2	Q_k= 8.84 KN/M2
	c. Ultimate Design Load	
	Ultimate design load, n = 1.4 G_k + 1.6 Q_k	
	n = (1.4 x 4.8) + (1.6 x 8.84) = 20.86 KN/M2	n = 20.86 KN/m2

	2.MOMENTS	
BS 8110-01	Slab subjected to punching due to column below	
Clause	Design ultimate pressure,p = 20.86 KN/M2	
3.11.2.2	Mx = (pLyL12)/2 = (20.86 x 3.45 x 1.425x 1.425)/2 =73KNM	
3.11.3.1		
	3. REINFORCEMENT	
BS 8110-01	Fcu= 25 N/mm2, Fy=450N/mm2, d=174 mm, b=3450mm	
Clause	k= M/(bd2fcu)	
3.4.4.4	= (73 x 106)/ (3450 x 174^2x25) = 0.028	
	Z)	
	Z= 0.966d	
	therefore use Z = 0.95d =165.3 mm	Z = 165.3mm
	As = 73 x106/(0.95 x 450 x 165.3) = 1033 mm2	
	Asmin = 0.13x200x3450/100 = 897 mm2	
	Therefore use 12T12 (1357 mm2) at top and bottom in both directions	12T12(1357 mm2) in both directions T12@ 250 c/c
	4. COLUMN FACE SHEAR	
	Column perimeter, u= 600x4 = 2400 mm	
	face shear = N/(ud) = (20.9x3.45x3.45)/ (2400x200)	
	= 0.52 < 4 N/mm2	face shear OK!
	5. TRANSVERSE SHEAR	
BS 8110-01	Shear calculated at 1d; 1d = 174mm	
Table 3.8	L1 = 1425 mm	
	Shear force = 3.45 x (1.425 - 0.74) x 20.9	
	= 90.2 KN	
	Shear force v = 90.2x 102/(174x3450)	
	= 0.15N/mm2 <Vc = 0.44 N/mm2	Transverse Shear OK!
	5. PUNCH SHEAR	
BS 8110-01	Punch shear calculated at 1.5d = 174 x 1.5 = 261 mm	
Clause	Punch shear perimeter = (8x261) + (600x4) = 4488 mm	
3.11.3.4	Punch force = [(3.45x3.45) - (1.122 x 1.122)] x 20.9 = 222.5 KN	Punch Shear
3.7.7	Punch shear = 222.5 x 103/(4488x1.74) = 0.28 N/mm2< Vc	OK!

Attachment T - EPANET Results

Attachment B - EPANET Tank Water Heights, Demand, and Supply Trajectories

Attachment D - Tower and Tank.pdf

- **Appendix D:** Calculations

2.4.1. Total Demand Calculations

The total demand for the combined primary and secondary schools is 9,230 L/day, as shown below. According to a member of the community, there are 1,200 community members, 150 of which are students. In the school, there are 1,550 total students (1264 primary students and 286 secondary students) and 14 teachers who are not community members. We used the conversions of 20 L/day for community members and teachers and 5 L/day for non-community member students. These water usage statistics were obtained by school headmaster Fred Kainje.

Short Term Demand Calculations:

$$(1200 \cdot 20 \frac{L}{day} \cdot 5\%) + (14 \cdot 20 \frac{L}{day} \cdot 100\%) + (1264 \cdot 5 \frac{L}{day} \cdot 100\%) + (286 \cdot 5 \frac{L}{day} \cdot 100\%)$$
$$= 1200 \frac{L}{day} + 280 \frac{L}{day} + 6320 \frac{L}{day} + 1430 \frac{L}{day} = 9230 \frac{L}{day} \text{ demand}$$

Total demand was also calculated with consideration for long-term population growth and determined to be 23,440 L/day as shown below. Per communications with the school headmaster, the school population will never exceed 4,200 students, with a maximum capacity of 3,000 secondary school students and 1,200 primary school students. To match the student population growth, the total teachers could reach 38. A community member population growth of 40%, a predicted growth for the next 20 years, was accounted for, growing up to 1680 community members.

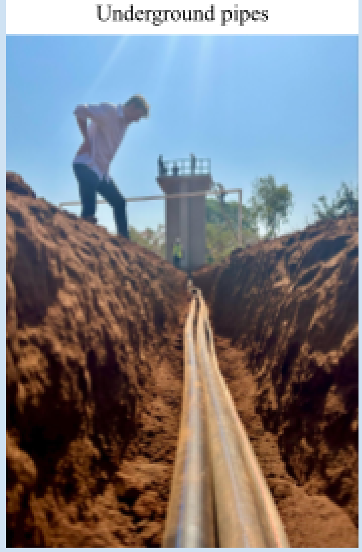
Long Term Demand Calculations (Population Growth):

$$(1680 \cdot 20 \frac{L}{day} \cdot 5\%) + (38 \cdot 20 \frac{L}{day} \cdot 100\%) + (3000 \cdot 5 \frac{L}{day} \cdot 100\%) + (1200 \cdot 5 \frac{L}{day} \cdot 100\%)$$
$$= 1680 \frac{L}{day} + 780 \frac{L}{day} + 15000 \frac{L}{day} + 6000 \frac{L}{day} = 23440 \frac{L}{day} \text{ demand}$$

- **Appendix E:** Photos of final construction

Water tank and tower

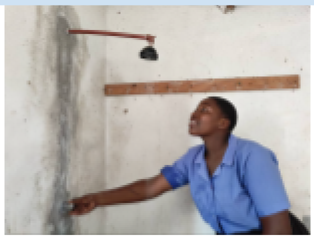
Underground pipes

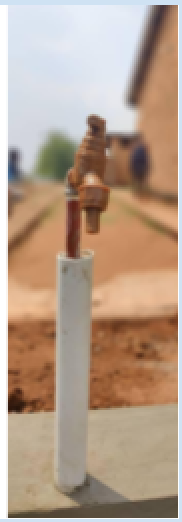


Pump Installation and Solar Panels

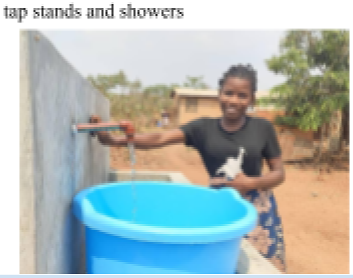
Water Tank

EWB with tap stands and sinks

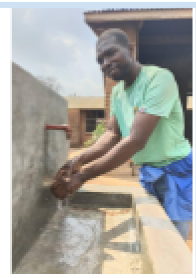




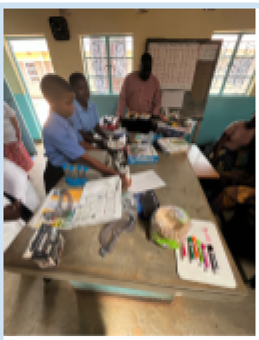
Students using tap stands and showers



2023 travel team



Chief Solomoni, Construction Worker
Headmaster Fred, and Engineer Manuel



School Students with donated science supplies