Partnerships, perseverance, and progress: Overcoming the challenge of the COVID-19 pandemic to rehabilitate wells in Malawi

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Project Description

Addressing community water needs in Malawi

The "Warm Heart of Africa" is a small, landlocked country in southeastern Africa that is known for–more than its beautiful landscape or rich history–the friendliness of its people. Malawians pride themselves on their reputation for being welcoming and generous and the country certainly lives up to its nickname. However, Malawi faces a problem. The combination of a naturally dry climate and a lack of economic resources means that over 4 million Malawians–about a quarter of the population–lack access to clean drinking water.

In 2014, Malawian non-governmental organization (NGO) Villages in Partnership (VIP) reached out to our student organization and asked us to assist in drilling borehole wells in four of VIP's partner communities in the Sakata region. From 2013 to 2019, the student team successfully implemented a drilling program, completing a total of four borehole wells in the communities of Mphero and Chilimani. Over these six years, annual travel to Malawi allowed our organization to build a base of experienced travelers and establish strong relationships with our in-country partners. In 2019, students traveled to Malawi to meet with community leaders, hold town halls, and survey households in the communities of Liti and Nkagula in order to determine potential locations for new wells to be drilled in 2020. After the assessment trip in 2019, students planned to return to Malawi in August of 2020 to drill one borehole well in each community.

Unfortunately, just six months before this trip, the COVID-19 pandemic began and, as the summer of 2021 approached with international travel still impossible, the students were determined to pursue something entirely new for our organization: a "remote implementation" project to meet the need for increased access to clean water in Liti and Nkagula, which had only grown more pronounced through the pandemic. This project represented an entirely new endeavor for our organization and allowed for an immense amount of growth and opportunities for learning among the team.

Borehole Well in Malawi

Students in Malawi in 2017

Project outline

In order to facilitate our remote project, the students hired a consultant to inspect wells and report their condition. We and our technical mentors planned to use that information to make decisions about which wells most needed rehabilitation and direct the driller to complete appropriate work on the wells. We also relied on VIP to liaise with the community, sharing updates and relaying community concerns to the student team.

In the inspection phase, water quality testing, pumping tests, and camera surveys were performed on each well to establish benchmarks for the well condition. For the wells that were chosen for rehabilitation, an air blowing exercise was performed to flush the wells of debris and measure their maximum output rate. Any missing, worn, or broken parts were replaced in order to restore the wells to proper function and lengthen their lifespan and, as required, more extensive rehabilitation was performed.

The second objective of the student team's remote project was to provide detailed borehole well maintenance training to community members. VIP ran two maintenance training sessions primarily focused on dismantling, inspecting, and replacing the pump head. Additionally, a local mechanic was trained for more intense repairs, such as those to the well seal or casing.

Collaboration of Faculty, Students, and Professional Engineers

About our collaboration

Our organization is a student-run, faculty-advised group with multiple local and international projects, including this project in Malawi. The Malawi team was led by three project managers who worked with student general body members, faculty advisors, hydrogeologist mentors, and our program engineer.

Table 1. Team structure and communication and responsibility breakdown

Party	Responsibilities	Communication
Project Managers	- Communicate with in-country partners - Research and make project decisions - Manage budget	- Shared Google Drive - Daily communication via group chat - As-needed additional internal meetings
General Body	- Assist project managers as needed	- Weekly general body meetings
Faculty Advisors	- Handle financial transactions - Communicate with College of Engineering - Provide guidance to project managers	- Weekly executive board meetings
Professional Hydrogeologist Mentors	- Provide insight after decades of field experience in borehole drilling - Sign off on construction plans	- Semi-monthly meetings - More frequent meetings during remote implementation
Program Engineer	- Long-term project oversight - Ensure all work meets proper standards	- Annual meetings - Review and approval of project reports and safety plans

Collaboration was critical for determining a safe and feasible path forward

As travel in summer 2021 became less and less feasible, we considered alternatives to support our community partners without travel. Three alternatives–borehole mapping, remote water testing, and remote well drilling–were considered and, after taking input from all parties in the project, a fourth option, remote well rehabilitation, emerged as most favorable.

In determining the direction of our project, the student team worked closely with our professional mentors to assess the feasibility of each option. Given the geological profile of Sakata, it is necessary to have a hydrogeologist present during drilling to analyze soil samples and ensure that the well depth is sufficient. Therefore, remote drilling was not possible and rehabilitation was suggested instead. Because this remote implementation was a new area for our organization, we had an additional meeting with our program engineer to set a go/no-go date, weigh the impact of remote implementation on the community, and discuss COVID-19 concerns.

Technical project support in collaboration with professional mentors

The students worked with our professional mentors in outlining the scope of work, as the mentors had previously traveled to the communities and were knowledgeable about the current well conditions and VIP's capabilities. Our mentors recommended the use of pump tests and outlined specific water testing metrics. Additionally, after a well was inspected, the mentors advised on which parts needed to be repaired as well as the specifications for replacement parts.

The team's professional mentors also served as the point of contact for our contractor and led communication when negotiating the price and determining driller capabilities. Decisions regarding pricing and contractor choice were made in consultation with the project managers, with the professional mentors reviewing contractor proposals to ensure proper engineering and safety standards were being met. Finally, our professional mentors held the necessary hydrogeological licenses and certifications to oversee the work done during implementation.

Collaboration on project logistics

The team's faculty advisors supported the logistical and financial aspects of the project by submitting invoices, written by the students, for approval through the University. The process for paying overseas contractors is long and involves complex University procedures and financial systems, which the faculty advisors helped students navigate.

Project impact on the health, safety, and welfare of the public

Well inspection activities

During remote project work, the contractor inspected 14 borehole wells to evaluate any damage and identify concerns that may impact functionality. Water quality testing was performed on all wells to measure pH, temperature, total dissolved solids, total carbonate, bicarbonate, chloride, sulfate, nitrate, and fluoride. Additionally, a camera survey was conducted to check for subsurface issues and inspect the inside of the wells, along with a pump test to determine well output and recharge.

The camera surveys provided valuable information about well depth, diameter, and presence of precipitates. Many of the wells had actual depths well below their reported depths, which is significant because shallow wells run dry more quickly and are more prone to contamination. Additionally, camera surveys showed significant precipitation and debris in many wells. The presence of debris in the well interior comes from worn parts, indicating the necessity for frequent maintenance.

Camera survey

Pumping test

Inspecting well casing

Well rehabilitation work

Based on the inspections, necessary repairs were made to 12 of the 14 borehole wells. Of the 14 wells inspected, two had become completely nonfunctional. One well was blocked with a tree branch lodged 29.5 m into the well. The origin of the tree branch and how it became stuck in the well remain a mystery to our organization; it was removed and the well restored to functionality. A second well had a broken pump, rendering it nonfunctional. That well pump was replaced.

Furthermore, minor repairs were made on 10 additional wells. From the camera surveys, it was learned that one well had rubber debris in the bottom from worn out centralisers, a component which prevents the borehole well casing from contacting the walls. To prevent this kind of contamination in the future, centralisers were replaced in all wells. Cup seals were also replaced on each well, as a good seal prevents bacterial contamination of the well water. Minor parts, including 48 bush bearings, 35 double-end sockets, and 14 O-rings, were replaced on all wells. A total of three pump heads were replaced along with three pump head covers. After the conclusion of the team's planned work, VIP hired another contractor to further protect the wells through reconstruction of the civil works of 8 of the rehabilitated wells.

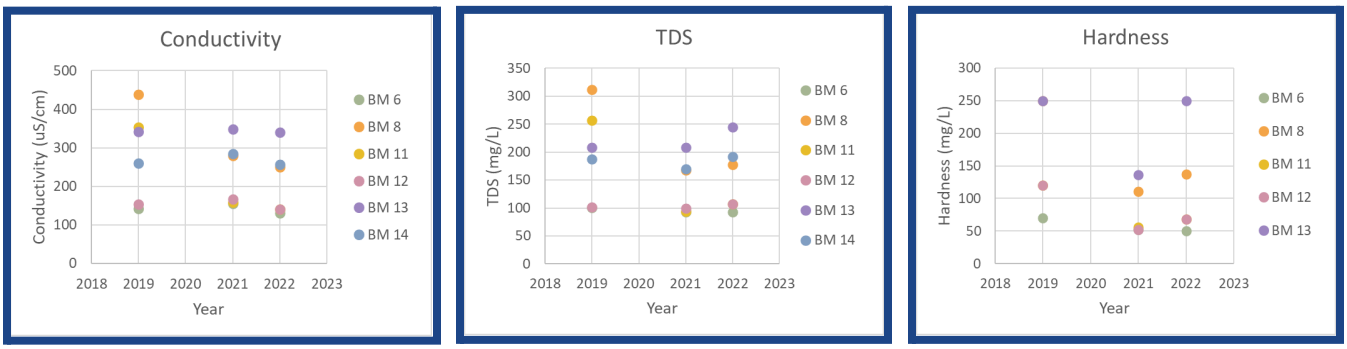
Ensuring well longevity through community maintenance trainings

As evidenced by the extensive repairs needed, frequent and proper maintenance of the borehole wells is necessary in order for the wells to remain functional and free of contaminants. VIP arranged two borehole maintenance trainings which were open to all community members and particularly advertised to the water committee members, groups elected by the communities to manage each borehole. These trainings covered weekly and monthly well inspections, common issues and potential solutions, and replacement of common parts. The community training focused mainly on repairs and maintenance of the

pump head, while a local mechanic was trained to perform more complicated work on the well seal and casing. In total, 145 people representing all fourteen borehole well committees attended these training sessions.

Evaluating project success

One year after the completion of this rehabilitation and following a decrease in the COVID-19 risk level, a student travel team returned to Malawi in the summer of 2022. Three metrics, hardness, conductivity, and total dissolved solids (TDS), were tracked across from 2019 through 2022 for 6 boreholes. Between 2019 and 2021, all three measurements decreased, indicating that the rehabilitation improved these metrics of water quality. Furthermore, between 2021 and 2022, the metrics remained relatively stable, an encouraging sign that well maintenance improved following the community trainings.



Water quality metrics tracked from 2019 to 2022 across 6 borehole wells in Liti and Nkagula

An enduring issue remains the presence of coliform bacteria in many wells. Bacterial tests were not carried out as part of the rehabilitation, but samples taken in 2022 showed that nearly all wells contained some level of coliform contamination, with one well having unsafe levels. While anecdotal evidence from community leadership suggests that cases of diarrhea have decreased since the rehabilitation, the continued presence of coliform bacteria is not unexpected as many wells are in close proximity to latrines or areas where livestock are held. Therefore, improved maintenance and the use of stronger sanitary seals in future wells is very important.

To further assess the success of the remote rehabilitation project and gather data about overall water use and access in Liti and Nkagula, the 2022 travel team conducted household surveys in both communities. In the surveys, all participants from Liti and 94% of participants from Nkagula reported satisfaction with work done during the summer 2021 rehabilitation. Anecdotally, respondents also reported that the wells were easier to pump, which may be the result of the various part replacements. During these surveys, data was also collected about household members, daily water use, and sickness rates during the rainy and dry season, which will help inform the student team's drilling plans in 2023.

COVID-19 concerns

Malawi's COVID-19 rates were low compared to the United States throughout the pandemic, but precautions were taken to prevent transmission during the inspections, rehabilitation, and community trainings. Of the fourteen wells inspected, two were not rehabilitated due to community concerns that the

drilling consultant may add the COVID-19 vaccine to the water supply during rehabilitation work. In response, during the 2022 monitoring and evaluation trip, steps were taken to address COVID-19 misinformation at community meetings.

Multidisciplinary and/or allied professional participation

Collaboration between engineering disciplines

The group of student project managers leading this project was composed of mechanical, civil, and biomedical engineering majors, all of whom contributed unique skills related to their majors. For example, the project manager studying civil engineering provided insight into how the students could outline the professional relationship between ourselves, VIP, and the contractor in order to divide responsibilities as clearly as possible.

However, the scope of the project is more directly related to environmental engineering, requiring project managers to go beyond their coursework and learn about groundwater resource management, hydrogeology, and public health. The team's professional mentors have expertise directly related to borehole well drilling in sub-Saharan Africa and serve as a vital resource for students to learn about the subject.

Financial and project planning

Furthermore, students were responsible for all aspects of the project–not just those directly tied to engineering–and thus learned about many aspects of project management that engineering students may not be exposed to in their studies. Students managed the $45,000 project budget, negotiated with contractors on pricing, and orchestrated communication between the student team, VIP, the contractor, and leaders in Liti and Nkagula, with the overall project team separated by six time zones.

Knowledge or skills gained

Improving community water access through well rehabilitation

The borehole well rehabilitation performed by the student team was the first of its kind in the Sakata region, offering a new, effective model for improving community water access and quality at a lower cost than drilling new borehole wells. Following the completion of this project, VIP presented a report on our work to the Zomba District Water Department and the WASH District Team. The Zomba government has since funded their own borehole rehabilitation project and USAID, who are also active in the region, is working to do the same. Although born of necessity due to the COVID-19 pandemic, our rehabilitation project–coupled with community training–is a more sustainable and lower-cost way to improve water access in the Sakata region.

Communication is critical

The most crucial part of the remote implementation was successful communication between all parties involved. This was difficult due to geographic distance, language barriers, and cultural differences. Managing contractor activities from a half-world away also proved to be challenging; students, mentors, and faculty advisors had to engage in informal dispute resolution as a result of these challenges. In order

to achieve the project objectives, students learned to overcome these communication barriers and effectively communicate with each other, as well as with VIP, the contractor, Liti, and Nkagula, our faculty and professional mentors, and our governing national organization. In addition to helping students in their professional development, the lessons learned during the remote implementation have helped the team communicate more effectively with our partners going forward.

International engineering during a global pandemic

Additionally, the remote rehabilitation project taught students how to persevere. Due to the COVID-19 pandemic, the students decided to do something that they had never attempted and were ultimately successful in completing international engineering work that had a positive impact on community partners. The students took a significant, yet calculated, risk in embarking on a remote project, and pulled together as a team to pioneer new procedures and communication strategies to continue our mission through the pandemic.

Project-specific knowledge and skills

Finally, the remote borehole rehabilitation is only one stage of our team's work in Malawi; the knowledge and skills gained during this project will strengthen our team as we continue working in Liti and Nkagula. Students gained increased familiarity with the technical components of borehole wells and Afridev pumps along with the best practices for borehole maintenance and the prevention of contamination. This project also fostered cultural awareness and sensitivity in the student team and students learned to work with international partners, learning practical lessons such as reconciling differing expectations regarding contracts. While many intercultural lessons learned will be specifically helpful in Malawi, the skills students gained will be applicable across a range of international projects. Our organization looks forward to applying the skills and knowledge learned from this remote rehabilitation as we move forward with our partners in Malawi.

Student team, a faculty advisor, and a professional mentor with VIP staff in 2021