Water Distribution System in Cruz Chich y Chumisa, Guatemala

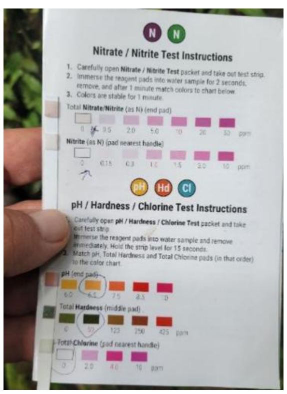
Project Overview

Cruz Chich, Guatemala in August 2025

The villages of Cruz Chich and Chumisa reside in the highlands of Guatemala, north of Joyabaj, in Quiché. At an altitude of 2,211 meters, the two neighboring towns are located with a population of 3,700. The communities primarily rely on subsistence agriculture, living in widespread poverty.

Regarding water resources, both communities historically struggle for sources of clean water. Small, private springs cannot fully support the population, necessitating daily trips to collect water in streams or rain systems. Local water sources remain untested for safety due to limited resources. According to the local health clinic, waterborne diseases and parasites are common, especially during the dry season. Disease dramatically increases infant mortality and hinders consistent school attendance.

The village of Chumisa began addressing these issues by purchasing a natural spring in 2017. Soon after, Chumisa teamed up with Cruz Chich to share the deed to the spring and apply to work with Engineers Without Borders (EWB) in 2019. After delays because of the worldwide COVID-19 pandemic, the official joint proposal was accepted by EWB-Guatemala in 2022.



Water test results with safe EPA values from the spring

Water tests of the spring were quickly performed, along with a vetting process by EWB to verify the viability of the location and available resources for the project. Next, the water treatment and distribution project was matched with a university chapter of Engineers Without Borders in the U.S. in early 2024.

In August 2024, students made their first site visit. The trip included a visit to the main elementary school in Cruz Chich to learn more about the community and the current situation involving the area's children. The EWB students recorded information about a tentative timeline for the project, the number of taps needed for all the families, the total number of volunteers needed for construction, and general requirements for successful implementation of the water treatment system.

After returning to school in late August 2024, the EWB students began the full design process for the project for the academic year. The system includes a spring box, conduction line, water tank, and distribution lines to the taps. The spring box is a watertight structure above a natural spring that collects water and protects it from contaminants. The conduction line consists of pipes from the spring box to the water tank. The tank safely stores the water from the spring, allowing chlorination and maintaining water pressure. The distribution lines carry the water to break-pressure tanks, which relieve pressure from the pipes for each household and parcel within the community.

Several stakeholders are involved in this project. First, the communities of Cruz Chich and Chumisa initiated the project and assumed responsibility for the construction and a portion of the funding. Second, the EWB students designed, planned, and supervised the successful implementation of the system. Third, this process involved a team of professional engineers and mentors, including workers from Engineers Without Borders. In the U.S., professors and industry professionals provided technical guidance and feedback to students. The EWB-Guatemala engineers assisted students with instruction about the spring, tank, and taps through surveying and sharing knowledge of the local laws and guidelines, the optimal sources of materials, regional construction methods, and the indigenous language. Lastly, Rotary International clubs provided significant funding in their worldwide efforts to provide clean water. These combined efforts resulted in a sustainable project with life-changing impact.

Collaboration of Faculty, Students, and Licensed Professional Engineers

Numerous individuals collaborated on this project, including licensed professional engineers, university faculty, and students. Two student project leads coordinated the effort. They oversaw four design teams specializing in water quality, construction, structural design, and computer-aided design (CAD). Each team of 5-10 students met weekly to develop and refine the system design.

Professional engineers actively supported each group, and a licensed Responsible Engineer in Charge (REIC) oversaw the entire project. The REIC, an environmental engineer with extensive experience in wastewater projects, shared his professional knowledge, supporting the tank and distribution system design. Another professional engineer with experience in civil engineering in Guatemala, provided leadership as he was familiar with design constraints of the region and the development process. In addition, a former professor and current transportation consultant for the United Nations provided guidance on international project planning.

Professional support enabled the students to function as a unified team in an international experience. The professional mentors offered consistent feedback and industry expertise.

The collaboration of faculty and students was directed by the long-time faculty advisor, whose extensive experience as a construction engineer and leader in both corporate and academic sectors provided essential guidance. He played a pivotal role in project networking by connecting the project leads with the REIC and other professional mentors. Beyond the technical coordination, he reinforced the importance of what was being done in Guatemala and the value of real, life-changing projects. He, along with the university's engineering education director, traveled with the students down to Guatemala on the implementation trip to supervise in the construction of the water tank and ensure the safety and logistics of the process.

EWB-Guatemala Engineer teaches a student to level a surface with water.

After completion of the designs, a professional engineer licensed in Guatemala reviewed the plan set for the project to ensure that the project met local laws and standards. Due to the lack of extension of U.S. licensure, the Guatemalan professional engineer's collaboration proved to be crucial, allowing the project to move forward.

Project implementation in Guatemala demonstrated the importance of collaboration between the distinct groups. The help of the professional mentors, the REIC, and EWB-Guatemala licensed engineers all had played a vital role in securing a successful student project. Their consistent engagement in weekly meetings, communication, and leadership both in the U.S. and Guatemala pushed students to perform at a higher level.

Throughout the project, students gained valuable lessons not taught in the classroom, learning from experienced industry professionals. The international scope of the work exposed the young engineers to the striking differences in engineering and construction processes between Guatemala and the U.S. Students strengthened their ability to communicate across multiple teams over large geographic areas — a skill that cannot be taught easily in the classroom. The professional engineers and faculty displayed their mentorship as role models while sharing talents and abilities that foster humanitarianism. Working for the public good is an admirable trait that can and should continue beyond the students' time in college.

Protection of the Health, Safety, and/or Welfare of the Public

The Cruz Chich y Chumisa water treatment and distribution project significantly improves health and safety for the people of the two Guatemalan villages. For the first time, both communities will be connected to potable water taps in individual houses and in important public areas. Specifically, 350+ households will have access to the life-changing benefits of clean water that will improve quality of life. Children now have more opportunities to obtain a full-time education while all residents can live in cleaner homes, experience fewer diseases, and live longer. The communities can rapidly expand infrastructure through roads, better clinics, and stronger houses.

Students and community members stand in front of EWB-Guatemala mural.

To sustain these improvements, Engineers Without Borders-Guatemala will provide training to members of the villages to maximize the benefits of better hygiene and health (i.e., proper hand-washing and safe food handling). Additionally, a local water committee has been appointed to educate the public and manage the water treatment system. They are trained to maintain the system and identify issues over the expected 20-year lifespan of the project.

In this broad context, students gained awareness about the impact of their engineering decisions. For example, the water and construction teams made a key decision about the method for water chlorination, which could include using chlorine bleach, gas, or tablets. Students evaluated safety, effectiveness, and cost, ultimately choosing chlorine tablets. Also, students needed to follow population constraints of the two villages to appropriately size components of the water tank. Calculations were performed to estimate the growth rate of the communities from current year to 20 years out to appropriately plan for an increase in water demand. This improved cost estimation and sustainability for the project. Throughout these two examples, students understood the importance of educated decision-making to ensure the optimal wellbeing for all stakeholders in an engineering project.

Throughout the project, students took charge of the design process. The four teams for water, construction, structural, and CAD, along with the two project leads, independently made decisions on the implementation plan. Progress took time and effort, with consistent trial and error in performing the tank calculations and developing CAD files and the pipe distribution map. Students raised money to help fund the project through a student-coordinated silent auction, communicated with local and international stakeholders, and coordinated travel to Guatemala for construction.

Student discussions with Guatemalan Engineers about tank location.

By spearheading project development, students gained both a sense of accountability and ownership. Such capabilities extend to their internships, future careers, and school projects. The students can face the world with natural leadership and approach engineering challenges with a problem-solving mindset to continue making a difference across the globe. Every place in the world faces financial, political, and physical constraints, and every project needs responsible, ethical engineers to communicate with every unique stakeholder effectively. Through this project, students experienced firsthand how they can make meaningful changes to the health of communities worldwide through clean water projects and countless other human-centered projects.

Multidiscipline and Allied Profession Participation

The Cruz Chich and Chumisa water distribution project reflected the combined effort of many different areas of engineering. The design process invited all types of engineering students at the university – civil, environmental, mechanical, electrical, biomedical, and computer - to step in and use their unique talents and abilities to make a difference outside the classroom.

From the student perspective, the four teams working on the project welcomed more specialized interests for diverse groups of students. The hydraulics team included environmental and water resources engineers who applied knowledge of pressures, demands, and forces to properly size the system. The CAD team, in charge of designing the tank on plan sets, required the mechanical engineers' experience with Fusion360. The structural team relied on civil and structural engineers to calculate shear, water weight, and self-weight to determine needed dimensions of the tank walls, roof, and foundation along with rebar spacing and thickness. Lastly, the construction team engaged students from a range of engineering specialties that included computer engineers to implement crucial digital management materials such as schedules, inventory lists, and cost estimates relevant to any real-world project.

In addition to engineers, the student organization benefited from cross-disciplinary skills. For example, the project fundraising, especially the silent auction, necessitated event planning and marketing skills to effectively spread the word about work being done, paving the way for future support. Additionally, from the College of Business Administration, the publicity chairs gathered students through social media and posters across campus. In summary, students become more well-rounded as individuals and engineers through exposure to a diverse range of skills fostered through a project like ours.

Project leads meet with the mayor of Cruz Chich to mark the community's commitment to the project.

Along with the multifaceted work of students, the project involved the enormous effort of professionals from diverse backgrounds in Guatemala. A professional Guatemalan surveyor mapped the area's topography and confirmed the student-proposed pipeline design with provided feedback. Local officials, such as the mayor in both Cruz Chich and Chumisa, approved the student-made plan set, pledged a portion of the funding for the project, allotted land for the tank and spring boxes, and collected volunteers for construction. Local contractors from Engineers Without Borders-Guatemala graciously headed the breaking of ground, oversaw the construction process, and shared their expertise with students and workers alike on the jobsite. Without the integral work of everyone on the project, the water treatment and distribution system would not have been such a success.

Knowledge and Skills Gained

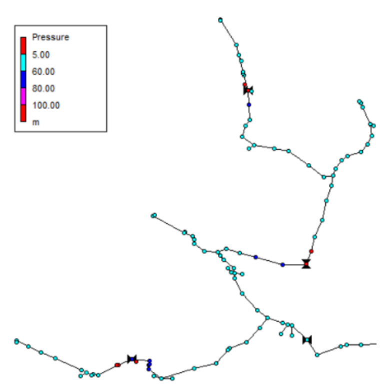
Every student involved in the Cruz Chich and Chumisa potable water distribution project grew immensely as engineers. Each step in the process taught students both technical and non-technical skills. The four teams – construction, water resources, structural design, and CAD - specialized in different technical skills.

Construction Team

Students on the construction team focused on the management and planning aspects of the project. The team members learned how to set a construction schedule and what parts can overlap to optimize efficiency over the length of the project. Assigning different teams to simultaneous tasks taught students to see the big picture and importance of using lessons from past projects to maximize efficiency. After gathering the designs of the water resources and structural groups, the construction team quantified the list of materials needed for construction. The team used pressure and volume constraints from the water resources team, along with the needed rebar lengths and spacing, to create a comprehensive list of materials including concrete, pipes of varying diameter, valves, rebar steel, etc. Using Guatemalan prices, the students calculated a cost estimate. This procedure required students to write understandable materials lists with extensive documentation in Excel, comprehensively appraise the project, and anticipate possible changes to minimize construction waste — all of which are essential skills in all professional engineering projects.

Water Resources Team

The water resources team learned the skills of water sampling, testing, and analyzing results. Once the results from the water sample were collected by the traveling students, the students confirmed that the testing process was conducted properly without contamination. With EPA recommendations for safe drinking water at hand, members of the team compared the results with the control of purified water to find the current state of the water and what needed to be done to properly treat the liquid. Through careful analysis of the situation and constraints of the system's location, the students decided that chlorine was the best solution for sanitation and that tablets were the best form to use.



Section of distribution line's map with calculated pressures at pipe junctions and break-pressure tanks in EPANET

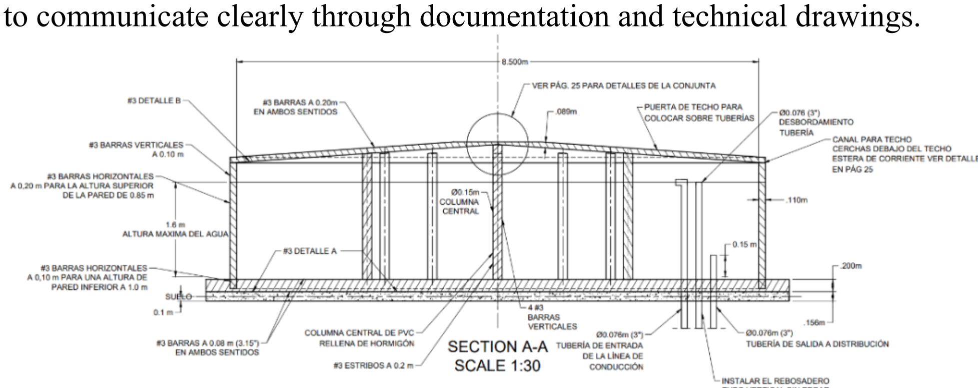
In addition to treating the water, the water resources team learned how to design a pipe system for distributing the water to homes in Cruz Chich and Chumisa. With EPANET, a software application developed by the U.S. Environmental Protection Agency to model water distribution systems, students input survey data and the spring's flow rate to analyze the pressures throughout the conduction and distribution pipelines. The team learned about break pressure tanks, along with different sized valves, to maintain correct water pressures throughout the system. The students strategically placed these tanks and pipes to ensure serviceable pressures in each house with the gravity-fed system. The group's engineers also specified appropriate locations for air-release valves and cleanout valves to safeguard the project for its planned 20-year lifespan. The team's work reflected the importance of learning how to follow government regulations, ensure public health and safety, and prioritize long-term system performance.

Structural Design Team

The students of the structural design team learned how to model a water tank specific to the water needs of the communities. Using the EWB-Guatemala estimations for the average quantity of water used in the region, the team members evaluated different shapes, dimensions, and materials for the tank to accomplish their task most effectively. This process involved calculations for water weight, self-weight, shear, pressure, volume, and other loads. The students considered constraints related to material availability in rural Guatemala and how these impacted their final decision to use ferrocement and concrete as well as the rebar for the walls and foundation, respectively. With final numbers regarding dimensions and materials, the structural team collaborated with the CAD team to share their calculations and with the construction team to provide numbers for cost estimation. The students of that team applied their knowledge of statics, materials science, and structural analysis to learn the professional engineering design process of modeling a water tank, following guidelines provided by the United Nations and Engineers Without Borders, and optimizing the design for the international context given.

Computer-Aided Design (CAD) Team

The CAD team learned the skills of digitally modeling the spring box and tank and making a plan set for the construction process. With the requirements and details for the spring box, the CAD team designed the dimensions and shape of the structure to properly contain the water and protect it from outside contamination. Additionally, the students added an overflow pipe to safeguard the system from extreme weather events that could damage the conduction line and a place to remove accumulated debris. After completion of the spring box, students modeled the tank with the given dimensions calculated by the structural design team. The team included places to enter the tank for maintenance, entry locations for the water conduction and distribution pipes, and escape systems for excess water to not overload the tank. The students then compiled each model into a plan set to be used at the construction site by the construction workers, contractors, and later students. These tasks developed the students' professional skills as engineers to communicate clearly through documentation and technical drawings.



Plan for the Distribution Tank developed by Structural and CAD teams.

Non-Technical Skills

As for non-technical skills acquired by all students, the project's design and implementation allowed them to see the project through from start to finish, emphasizing the value of coordination and communication with all stakeholders.

The students learned to prioritize the needs of the Guatemalan communities regarding project size, cost, and design. At the same time, the project needed to align with capabilities of the student organization and the two villages. With guidance from professional mentors, teams considered the current infrastructure, availability with materials, and local familiarity with construction methods. The students evaluated different approaches to ensure efficient project implementation with minimal material waste, given high logistical costs in the remote region. They then gained understanding about project sustainability and maintenance. Through appointing community members to a water committee and providing training for the towns, the engineers ensured the full 20-year lifespan of the system. This process reinforced the importance of considering the end user throughout the whole engineering process — an essential nontechnical practice in industry.

In addition, the students improved project management and leadership skills from their work with the other stakeholders in the project, especially the REIC and the other professional engineers. Communication on a cyclical basis with both U.S. and Guatemalan engineers was required to refine the plan set, cost estimates, and water distribution maps. Students coordinated the sharing of information to all teams involved.

Throughout the system's design and implementation, students gained a plethora of technical, such as digital 3D modeling, compiling a plan set, calculating loads, and creating construction schedules and non-technical skills like ethics, leadership, sustainability, and working in an international environment. With great mentorship and experience, these young engineers grew ethically and professionally to tackle the world's future problems.

Conclusion

The Cruz Chich and Chumisa water distribution project emphasizes the significant impact of student-led engineering with a focus on collaboration. The coordination of students, faculty, professional engineers, and other stakeholders resulted in a sustainable system that addresses a real-world problem – clean water access for two villages. This process of directly improving public health and quality of life required deep consideration of technical, political, and economic constraints. Students gained lifelong experience in technical expertise, ethical decision-making, leadership, and problem-solving abilities. Collaborative engineering can create lasting societal impact that serves the public good.