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Community Developed Water Supply a Case Study of a Sustainable Model in Hampstead, St. Mary, Jamaica

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Engagement in Practice: Community Developed Water Supply, Case Study of a Sustainable Model in Hampstead, St. Mary, Jamaica

Abstract

Engineers must have the knowledge and competencies to develop solutions to 'out of the box' situations. Can instructors adopt the Conceiving, Designing, Implementing, and Operating (CDIO) curricular framework for engineering education and consider incorporating development opportunities in a community to allow students to forge meaningful design solutions? Insufficient resources restrict people's access to potable water in St. Mary, Jamaica. An established water authority with the requisite technology and engineering expertise can assist with conventional practices for developing water supply systems, including operating and maintaining the system; this would enable the system to reach remote communities, even in hazardous areas, with a viable source to operate, rehabilitate, and maintain a potable water distribution network.

This paper will examine a case study of a sustainable model water supply system and community water organization (CWO) in St. Mary, Jamaica. The case study proposes a methodology for training students to solve real-life problems through collaboration with key stakeholders. The curriculum of engineering programs, through the CDIO framework, fosters humanitarian engineering by exposing students to interactions with the community. Incorporating social development within the engineering curriculum can innovate the development of potable water distribution systems using simplified engineering and construction techniques. The success of the community-developed water supply system project, through the ingenuity of engineers, community support, and grant resources, presents a model that the analysis will show as an outcome, a solution that will benefit the community and align with a course of study for tertiary education.

Background

Water is essential for life, and the United Nations recognizes its access as a human right [1]. Marginalized groups are disadvantaged by not having access to the precious commodity. An established water authority with the requisite technology and expertise can assist conventional practices for developing water supply, which will include the operation and maintenance of the system. Worldwide, the aim is to achieve Sustainable Development Goals (SDGs) Goal 6: to ensure the availability and sustainable management of water and sanitation for all by 2030 [2]. Achievement of SDG 6 within the next five years must be inventive to ensure the human right to access potable water and overcome the challenge of insufficient resources.

Many communities have a viable water source but are deficient in managing a safe and continuous supply. These communities fall between the gaps where the cost/benefit ratio or the project feasibility does not allow implementing systems that an established water authority would manage, which is apparent, especially when a community is remote or in a hazardous area. Community development using simplified engineering design and construction techniques is an innovative way to develop critical potable water distribution systems. Community involvement in development encourages collective problem-solving and empowerment. This

paper will discuss how the community can apply simplified engineering design and construction techniques to make operating and maintaining a potable water distribution system possible. It will examine a case study of a sustainable model water supply system in St. Mary, Jamaica.
Community-engaged learning is beneficial and can potentially facilitate civil engineering students' participation in civic engagement to provide solutions in a real-life learning context by applying theoretical knowledge. Incorporating social development within the engineering curriculum will also prepare students to become socially aware engineers who contribute positively to society. Goggins and Hajdukiewicz [3] posit that through community-engaged learning, students can identify, formulate, and solve engineering problems; use the relevant methods of established engineering practice through research and develop an appreciation for non-technical societal constraints as well as improve their ability to communicate effectively with the engineering community and broader society. Engineers must equip themselves to handle the multi-dimensional issues they will face.

To train engineering students adequately, professors from world-class institutes, with the input of academics, industry, engineers, and students, designed the Conceiving, Designing, Implementing, and Operating (CDIO) curriculum framework for engineering education, focusing on engineering fundamentals [4]. This open architecture model curriculum is available to all university engineering programs and can accommodate course-specific requirements. The CDIO framework uses practice to complement static structural knowledge and techniques in design thinking for future generations. Educators can integrate the CDIO framework into the engineering curriculum by embedding it across various stages of the educational process. First, in the Conceiving phase, students can be introduced to real-world problems and taught how to define project goals, identify needs, and explore feasibility through research and brainstorming. In the Design phase, design thinking with an emphasis on solutions while considering cost constraints, sustainability, and technical requirements is the focus. In the Implementing phase, theoretical knowledge is applied through building and testing designs and using hands-on projects to solidify concepts. Lastly, in the Operating phase, a reflection on the project's performance is needed to understand the importance of maintenance and accept criticism from the real world to foster continuous improvement. By embedding these phases in project-based learning, group work, and interdisciplinary projects, educators can promote a comprehensive, experiential learning environment where students prepare for modern engineering challenges' complex, iterative nature.

Engineers need to have a comprehensive understanding of all stages of the lifecycle of new techniques and technologies. Sekaran et al. [5] concur that the CDIO pedagogical topology provides lifelong learning and adaptive design thinking in engineering for students. The strategy of the CDIO curriculum framework is to create challenging experiences for which students should apply cumulative knowledge to a comprehensive project through the curriculum. Enabling adaptive competency is critical in the curriculum structure of engineering courses.

Case study of a sustainable model water supply system and CWO

The remote community of Hampstead in St. Mary, Jamaica, participated in an innovative civil engineering exercise to facilitate the implementation of critical infrastructure—water. With grant funding and the technical expertise of a social investment fund, the residents of Hampstead, alongside contractors, rehabilitated the existing water supply system for adequacy. The success of this project demonstrates the potential for replication of the sustainable water supply model in other communities, making the audience feel optimistic about the scalability of such initiatives.

The community and stakeholders benefited through community-engaged learning, community-based research, and humanitarian engineering, which yielded a successful outcome that the Community can replicate. Piped potable water was identified for the community of Hampstead. At the time of the project, the rural community in St. Mary, Jamaica, had a population of 1,650. Commercial and industrial developments include bars, restaurants, a small-scale chicken rearing and processing plant, and a garment factory, while the social infrastructures include basic and all-age schools. Over 50% of homes had water pipes, and the residents received a supply intermittently for two to three days per week. A local water catchment facility existed, but the demand outweighed the capacity. The residents had outdated meters and paid a flat rate monthly.

In partnership with the community, a social development fund organized forums to afford residents a platform to raise concerns and brainstorm solutions. Local leaders and technical experts discussed the type of water supply system suitable for the area based on community needs and environmental impacts. A community-operated water system was established, and the community group, the Hampstead Benevolent Society, maintained it. It is sustained by collecting tariffs for connection to the system and billing residents for the water supply. The project's objective was to provide an adequate water supply to the Hampstead community by exploring all options to rehabilitate the existing spring intake and pipeline and provide safe drinking water to households within the community.

The Community-Based Contracting (CBC) methodology was utilized [7]. This methodology involves community groups carrying out the manual labor while the social investment fund /grant-providing agency provides the funding and technical expertise. This method reduces costs and overheads. In this model, the community developed ownership in managing the facility and raised funds to contribute to its construction. The water demand is taken into consideration in accordance with the Jamaica Institution of Engineers/Rural Water Program guidelines standard of 129.7 liters/day and the World Health Organisation (WHO) standard of 80-85 liters per person per day.

Residents, under the stewardship of the technical experts, alongside the contractors, installed a tablet reservoir system for chlorination, laid 1.376km of 50mm distribution pipe, 4.750km of 100mm distribution pipe, and installed two sand filters. The community is supplied by a spring, entombed at the source at an approximate elevation of 290 meters above sea level, and it continuously flows to a concrete settling tank with a capacity of 5,700 liters. The Water Resource Authority [6] reported that the overflow from the system was 131,736 liters per day. The development of the source entails trapping the existing overflow to augment supply.

Design Rationale

From the primary water source, water flows through an entombment into a concrete catchment tank. The water flows through 100mm PVC and galvanized pipes to the filter/chlorination house, where the pipelines are 50mm. The water then passes through sand filtration to the tablet filter, which leads to the storage tank through 100mm pipelines. The water storage reservoir has a capacity of 112,500 liters fitted with manholes (with covers), an inlet pipe, a float valve, an overflow pipe, a washout pipe (with a 100mm gated valve), and an outlet pipe (with a 4" gated valve); all pipes leading to and from the storage tank are 4" (100mm) in diameter. The system comprises approximately 8,500 meters of PVC pipelines, consisting of 100mm, 50mm, and 25mm, laid across the Hampstead community, covering approximately four (4) square miles.

Evaluation of Source

The Water Resource Authority (WRA) source hydrology investigation stated that the scope of works included a series of bi-monthly stream flow measurements at all locations [8]. These measurements characterize the flow during the dry season between January and March. Water quality samples from the sites were obtained for analysis. An analysis of samples determines the suitability of water for drinking purposes. Fifteen criteria were analyzed. The overflow from the existing system represented a potential source to augment the supply as it was not a part of the existing system. The overflow existed as the water usage rate, or outflow, was less than the inflow rate from the spring that feeds the system. The maintenance of overflow represents that inflow remains above the usage. From a water balance consumption perspective, the overflow represents the change in storage components, which could be stored if sufficient storage was present [6].

The water quality physical/chemical analysis found the quality suitable for drinking water. Although the water met the drinking water standards, several parameters showed elevated levels; these included chloride [223/mg/l], conductivity [69 mg/l], calcium [159 mg/l], and TDS [545 mg/l]. This microbiology indicates fecal coliform waste is present. Based on the quality of the water, the required treatment was disinfection in the form of chlorination. An alternative to disinfection would have been to investigate the source of coliform pollution and take action to remove it. One possible source would have been human activity near the water source [8].

The overflow measured from the Hampstead system was 131,736 liters per day. The source was improved by trapping the existing overflow. Figure 1 depicts the location of the water supply system.

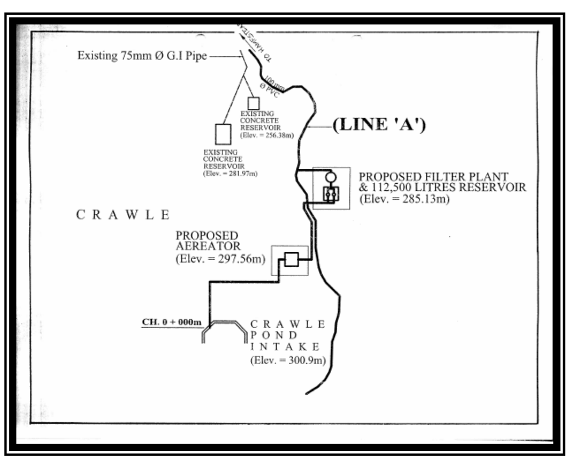

Figure 1: Location of water supply system

Targeted community members were trained and provided with equipment to ensure the community could manage and maintain the system. They were required to formulate a management structure to operate the water system.

Community Operated Water Supply (COWS)

The community embraced this form of development as an answer to their needs. It created a private enterprise that generates employment and income for community development. Under the COWS:

1. The Community and not the municipality will be responsible for the operation and maintenance of the system.
2. The system (intake, pipes, and tank) will belong to the Government or the Department of Local Government.
3. A tariff (fee) system has been developed only for this water supply system.
4. The system users pay a fee to the Community Water Organization (CWO).
5. The users/the community elect the CWO executive.
6. The Office of Utilities Regulation (OUR) licenses the CWO to operate the system.
7. The Department of Cooperatives and Friendly Societies governs the CWO executive, which is under the umbrella of the Hampstead Benevolent Society.
8. The CWO received training to operate and maintain the system efficiently.

Conclusion

The case study demonstrates that solutions to develop social infrastructure that provide sustainable development for "at-risk" communities are essential. Other risks are present. The Hampstead water system is susceptible to several risks, such as;

- Changes in the viability of the source.
- Vandalism or natural disaster.
- Lack of proper maintenance.
- Breakdown of the management structure.

Through the CDIO curriculum framework, instructors may develop a curriculum that facilitates engineering students' creativity and ingenuity in solving everyday problems, which is an innovative way of formulating solutions. The case study demonstrates a complex problem that can be broken into simple parts and made applicable to engineering training. Project-based learning and using a hands-on approach are essential ways of assessing students' ability to innovate solutions and solve real-world problems.

Communities taking charge and participating in their development is an innovative way to bring water – a critical infrastructure into their homes. Simplified design and construction techniques applied by the community make it possible to operate and maintain a potable water distribution system. The COWS model implemented in St. Mary, Jamaica, can be successfully replicated and demonstrated. Access to water is a fundamental human right that many lack. However, marginalized groups can access potable water through innovation and creativity through knowledge transfer from implementing entities in the industry, such as social investment funds that organize the community and have members play an integral role in the implementation.

If we look beyond traditional engineering practices for executing water supply systems and instead implement unconventional, authorized, sustainable methods, we are well on our way to realizing SDG 6. All while teaching students the importance of their involvement in community development and building relationships.

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