Engineering Project Spotlight

(Grades 9-12, Suggested time: 45 minutes)

Objectives

- To learn how geography and engineering are connected to each other by exploring a real-life example of a freshwater resource-management project.
- Analyze a location-based water-related problem using various parameters.
- Examine the solution to the problem by learning about a specific project implemented by CH2M HILL, a global engineering company based in Colorado (www.ch2m.com).

Materials

- Engineering projects list included in this activity
- Marker and whiteboard/chalk and chalkboard

Instructions

- Choose one to three (plan to spend apx. 15-20 minutes on each one) of the 15 projects from the engineering projects list that you know and understand the best.

- Give the students a short description of the problem at that particular location. Write the headings "Geographic and Environmental Factors" and "Human Factors" on the board and list appropriate issues under each heading as you mention them. (Geographic and environmental factors include climate, water availability, type of water source, etc. Human factors include political and regulatory issues, cost, etc.)

- Ask students to brainstorm other factors that might be important to the community to add to your lists.

- Now ask students to brainstorm solutions to the issue (cleaning wastewater or providing potable water) and then finish by telling them what the engineering company CH2M HILL actually did in this circumstance.

*Extension: Have upper-level students (grades 11-12), work in pairs or small teams on one each of the 15 examples to do some background research and lead their own class discussions.

CH2M HILL Engineering Project Examples

North America

1. Project Name: Pine Creek Wastewater Treatment Plant

Client Name: City of Calgary (Alberta, Canada)
Project Type: Bioremediation, filtration, and ultraviolet disinfection
Description: In order to increase the capacity to treat all the wastewater the people of Calgary were producing, the city turned to the Bow River as a new outlet on which to build an additional wastewater treatment plant. However, Bow River is a world-class sport-fishing river, so the effluent from the plant had to meet stringent requirements before being discharged into the river. The water-treatment plant was built to meet the city's "Triple Bottom Line" policy for sustainability. The innovative design for the water-treatment plant includes wind power, which provides 50 percent of the energy to the plant; a green roof; use of locally available construction materials; minimization of construction waste; and use of recycled building materials and energy-saving heating/cooling systems. Portions of the treated effluent will be reused within the plant and to irrigate the nearby city tree nursery and Blue Devil Golf Course. This will help the city to achieve its long-term water efficiency goal of reducing the use of potable water for non-potable needs.

Talking Points:

- What do "Triple Bottom Line" and "sustainability" mean? What is the importance of locally available materials, minimization of waste, use of recycled materials, energy-saving systems, reduction of the use of potable water for non-potable needs, etc?
- Why are freshwater uses for recreation important? Why does it matter if people form personal connections to water?
- This is a LEED Gold facility; discuss LEED if you have sufficient familiarity.

2. Project Name: Wetlands Project

Client Name: Major U.S. Manufacturer (Chesterfield County, Virginia, USA)
Project Type: Wetland restoration
Description: In this project, industrial wastewater with high nitrogen and phosphorus (nutrients that can result in algal blooms, which adversely affect aquatic life and pollute surface water sources) is treated using wetlands, which naturally filter water. Since 90 percent of the natural wetlands in the area have been destroyed, a 15-hectare man-made wetland, bigger than 18 soccer fields, was developed using more than 150,000 plants of 15 different species and is now home to more than 85 varieties of animals that come and go with the seasons, including birds, foxes, turtles, deer, and more.

Talking Points:

- What are the ecological functions/services of wetlands?
- What is the difference between man-made and natural wetlands?
- Discuss the chemistry of industrial waste and runoff (especially the effects of nitrogen, phosphorous, and algal blooms).

3. Project Name: Prairie Waters Project

Client Name: City of Aurora (Colorado, USA)
Project Type: Riverbank filtration system and ultraviolet disinfection
Description: Severe drought conditions prompted the city of Aurora to look for additional ways to supplement its water supply that would protect residents and businesses during droughts and meet future needs without seriously impacting the environment. The city officials, residents, environmental experts, professors, and others compared different ideas before deciding to use water from the South Platte River, which would be filtered and treated before entering the reservoir because the river has very different water-quality characteristics than Aurora's mountain melt water supply. CH2M HILL then designed a purification system that combines natural and advanced purification to meet this challenge. First, water is purified through riverbank filtration as it is pulled through sand and gravel found along the banks of the South Platte River. The water then percolates in a protected aquifer recharge-and-recovery area, which reduces the demand for more energy-intensive filtration. Following treatment, water is piped 35 miles through 60-inch-diameter steel pipes to a new 50-million-gallon-per-day treatment facility that uses ultraviolet disinfection methods. (To see a diagram of this facility go to http://www.prairiewaters.org/images/ncampus.jpg.)

Talking Points:

- What is drought? What are its causes and consequences?
- Collaboration with all the different *stakeholders* is crucial in large projects like this.

4. Project Name: Blue Plains Advanced Wastewater Treatment Plant

Client Name: District of Columbia Water and Sewage Authority (DC Water), (Washington, D.C., USA)
Project Type: Various wastewater treatment processes; particularly enhanced nitrogen removal facilities
Description: To protect the waters of the Chesapeake Bay and Potomac River, DC Water is taking steps to achieve extremely low nitrogen and other nutrient levels—some of the lowest levels ever achieved—in its wastewater effluent. For decades, DC Water has been participating in the clean-up of the Potomac River and Chesapeake Bay by improving the performance and treatment capabilities of the Blue Plains treatment plant. The facility has successfully achieved nitrogen removal since 1999 and has surpassed the regional goal of removing 40 percent of the total nitrogen in the effluent from the plant. The Blue Plains treatment plant is on an extremely constrained site, with water on one side and major highways on the others. DC Water has used virtually every inch of space on that site, so the design team had to be very creative—not only in finding ways to add the facilities onto the site, but also in determining where and how to stage construction. (Take a virtual tour of the Blue Plains Advanced Water Treatment Plant at http://www.dcwasa.com/about/model_flash.cfm.)

Talking Points:

- Discuss agricultural runoff and what a watershed is.
- With older kids, talk about how pollution can cause chemical/genetic mutations in animals.
- What are the impacts of algal blooms (such as the implications for food chain and oxygen systems)?
- What is the importance of creativity/urban planning?

South America

5. Project Name: Los Palis Water Supply Project

Client Name: Los Palis community via the Engineers Without Borders-USA Atlanta Professional Chapter (Los Palis, Haiti)
Project Type: A solar pump, storage tank, disinfection system, and new pipes
Description: During the dry season, residents have to walk two miles each way to the nearest river for water. Since the existing water infrastructure in Los Palis, a village of about 3,000 people, was old, inadequate, and contaminated, it was decided by the Engineers Without Borders team and the villagers to upgrade the system by installing a new solar-powered pump and disinfection system in the local schoolyard, as well as repairing the older pipes and storage cistern. Additionally**,** the community has agreed to a community water tax for future maintenance of the system and the local parish has agreed to match the amount raised by that tax by 100 percent.

Talking Points:

- What is Engineers Without Borders?
- What are alternative energy sources? What is a renewable energy?
- Discuss the various challenges and factors of ensuring water availability for impoverished communities and communities with little energy infrastructure.

6. Project Name: La Garrucha Water System

Client Name: La Garrucha community via the Engineers Without Borders-USA Marquette University and Wisconsin Professional Partners Chapters (La Garrucha, Guatemala)
Project Type: Construction of a six-kilometer gravity-fed potable water system with slow sand filtration
Description: La Garrucha, a mostly Maya community, lacked clean drinking water for its 1,500 residents. The community obtained water from a local stream that is contaminated, so university students, a CH2M HILL engineer, and the village leaders decided that the best option would be to build a long pipeline (dug by hand) to a stream the villagers had saved up to buy the rights to a long time ago, and install a slow-sand filtration system that they could use and teach other villages how to use. It was also decided that clean drinking water supplied at each household was important because that could free up the time and energy, spent usually by women and children, dedicated to carrying water and gathering wood to boil the water. Other goals of the project were to increase attendance at the community school by 25 percent—from 150 to 200 children within one year—and decrease deforestation, which was caused by villagers needing wood to burn in order to boil the contaminated water. The village leaders were concerned especially with this problem since the loss of forested area is contributing to erosion of topsoil and contamination of the area's streams.

Talking Points:

- What are irrigation systems and why are they a complicated issue?
- Discuss the value in having a low-tech solution to a serious problem.
- What are indirect problems caused by the lack of clean water, such as children not going to school, and deforestation?

7. Project Name: Sustaining an Endangered Culture

Client Name: Naso community via the Engineers Without Borders-USA Austin Chapter (Sieykin, Panama)
Project Type: A potable water system with a spring box, storage tank, and associated piping, as well as a non-potable system upgrade
Description: The Naso people (only about 3,300 remaining) are among the smallest and most impoverished indigenous groups in Panama. They live primarily across the northwest region of Panama and retain the last monarchy governance system in the Americas with a ruling king supported by a written constitution and a counsel of representatives elected by each community. Economic, environmental, and political pressures have encouraged integration into mainstream Panamanian culture, putting the unique Naso traditions and culture in danger of being lost forever. Sieykin, one of the 11 Naso communities, is the site of the Engineer's Without Borders – Austin Chapter's Panama Project, which seeks to support Naso self-sufficiency through the improvement of their local infrastructure. Because the community already has a source of non-potable water the students and mentors of EWB-AUS built a separate potable-water-distribution system, so that the community (especially the school and health clinic) will have a source of clean water. EWB-AUS also plans to continue the education program on hygiene for the community.

Talking Points:

- Discuss the importance of hygiene and why we shouldn't take sanitation for granted. Talk about disease transmission, the connection between the community's water quality and health problems, and the importance of hand-washing.
- Why is it important to work closely with cultural groups to achieve appropriate solutions?

Africa

8. Project Name: Orkeeswa Secondary School

Client Name: Indigenous Education Foundation of Tanzania (IEFT) via the Engineers Without Borders-USA Portland Professional Chapter (Lashaine Village, Monduli District, Arusha Region, Tanzania)
Project Type: Rainwater harvesting system
Description: Due to the absence of permanent surface water or groundwater aquifers, the people of Lashaine depend on seasonal watering holes (large depressions where water collects during the rainy season) as the village's only water resource; these are shared by humans, livestock, and wildlife. The watering holes often dry up during the dry season, leaving the villagers with contaminated water stored in tanks or having to ship water from neighboring villages. To combat this problem, the EWB-Portland team worked with local contractors and villagers to create a rainwater harvesting system and solar energy system at Orkeeswa Secondary School. The water system includes two 60,000-liter tanks that collect rainwater from the school roof and a bio-sand filter to provide safe and reliable water. (See: http://www.ewbportland.org/files/Rainwater%20Harvesting%20Design%20Drawings.jpg)

Talking Points:

- Discuss the seasonality of water.
- Discuss the need to share resources with animals, both wild and domestic.
- Discuss the importance of planning for maintenance needs in engineering.

Europe

9. Project Name: London Tideway Tunnels

Client Name: Thames Water (London, England, U.K.)
Project Type: Tunnels/combined sewer overflow (CSO)
Description: This program will modernize London's 150-year-old Victorian sewer system. The lack of capacity is currently causing weekly sewage discharges to the tidal area of the Thames River, the total amount of sewage discharged is enough to fill London's O2 Millennium Dome nearly 15 times. The construction of a new 32-kilometer tunnel under the city and a 10-kilometer tunnel under the River Lee will carry storm water and sanitary overflows to expanded and upgraded wastewater-treatment plants. The tunnel diameters will be wider than three of London's buses placed side-by-side. The Lee Tunnel, the deepest tunnel in London; dives down to 98 meters below ground at its lowest point. This extreme depth enables the storm sewage to flow downward to the wastewater-treatment plant while also avoiding other tunnels, pipelines, and cables that exist under London, particularly the Olympic Park cable tunnels.

Talking Points:

- Discuss where storm water/water runoff goes and the impacts of pollution.
- What are the impacts of a growing population on a finite area of space?
- Explore the geology of the Lee Tunnel.

Asia

10. Project Name: Sharjah Desalination Plants

Client Name: Sharjah Electricity & Water Authority (Sharjah, United Arab Emirates)
Project Type: Desalination
Description: The environments and source waters of three plant sites differ dramatically, each presenting unique design and engineering challenges. The Layyah Seawater Reverse Osmosis desalination plant lies on the Arabian Gulf, which has salinity levels among the highest in the world for seawater bodies. The Khor Fakkan and Kalba plants are located on the opposite side of the Oman Peninsula on the east coast of the UAE, facing the Arabian Sea. The engineering challenges have been addressed with an array of advanced desalination technologies. The Layyah and Khor Fakkan sites use filters for treatment of the raw seawater prior to reaching the high-pressure desalination system. Both plants use modern desalination technologies and energy recovery devices to minimize energy usage. The Layyah site incorporates an additional filtration system to better protect against accidental oil spills and seasonal algal blooms. Instead of conventional filters, the Kalba desalination plant will use ultrafiltration membranes that are specifically designed for seawater reverse osmosis plants. All three plants incorporate the highest efficiency energy-recovery devices available.

Talking Points:

- What is desalination and what are its benefits and challenges?

11. Project Name: Singapore Partnership

Client Name: Public Utilities Board (Singapore)
Project Type: Includes the NEWater infrastructure plan, NEWater Reuse Programme, the Changi Water Reclamation Plant, and the Deep Tunnel sewerage system
Description: Though located in a climatically wet region, the island city-state of Singapore, with more than five million people and a robust economy, has long been on the list of water-stressed nations. Singapore's leaders realize that their vast water systems can be transformed into tremendous community assets by working with a consortium of engineering firms to implement water-sensitive urban design that supports recreation, the arts, heritage, and culture. These projects not only protect water resources but also create new community spaces and a higher quality of life. For instance, at the NEWater Visitor Centre, visitors learn through multimedia presentations and hands-on interactive games how water for Singaporeans is being processed using advanced membrane and ultraviolet technologies. In addition to creating and managing a sustainable water supply, these projects are also helping Singapore secure water independence.

Talking Points:

- What is the importance of urban planning for water management (for example, managing water in a way that highlights its importance in daily living)?
- What is the importance of the visitor center to educate people about water?
- Ask how this project makes water use sustainable in direct and indirect ways.

12. Project Name: 2004 Tsunami Relief

Client Name: USAID (Sri Lanka, Maldives)
Project Type: Bridge building, harbor construction, and water supply plants including two seawater reverse osmosis facilities
Description: When a 9.3 magnitude earthquake hit the western coast of northern Sumatra in December 2004, it created the single deadliest tsunami in world history, with over 200,000 people dead or missing and over 1.5 million displaced. CH2M HILL partnered with USAID (United States Agency for International Development) to help rebuild and improve the damaged infrastructure throughout the several island nations affected by the disaster. In addition to reconstruction or rehabilitation of nine schools, installation of new water supply systems, and reconstruction and upgrades of three damaged fishing harbors, an extension of the projects included creating a health network TV system; water, sustainability, sanitation, and health workshops; and school health awareness training programs for all community members.

Talking Points:

- Use this example to talk about the interdisciplinary aspects of engineering and geography.
- Discuss other natural hazards, risk management, and recovery.

Australia

13. Project Name: Luggage Point Advanced Water Treatment Plant

Client Name: Queensland Government (South East Queensland, Australia)
Project Type/ Description: Coagulation and sedimentation, microfiltration, reverse osmosis, and ultraviolet disinfection
Description: By 2005, severe drought had caused the South East Queensland reservoir levels to drop below 20 percent of total capacity. South East Queensland is one of the most heavily urbanized regions in all of Australia and continues to experience strong population growth (it is expected to grow from 2.8 million to 4.4 million by 2026). Representing a major component of the Western Corridor Recycled Water Project, the largest project of its kind in the Southern Hemisphere, Luggage Point uses a multistep treatment process to recycle treated wastewater into potable quality water. The water reuse plant will provide a climate-independent water source for power stations, industry, and agriculture; supplement drinking water supplies in regional dams; and contribute to longer-term water management.

Talking Points:

- Discuss the relationship between increased drought and population size.
- Why is water recycling so important for this region? Where else are we implementing or can we implement those technologies?

14. Project Name: Darling Downs Power Station

Client Name: Origin Energy (South West Queensland, Australia)
Project Type: Reverse osmosis
Description: Darling Downs Power Station is located in a remote and dry area of Queensland, where water conservation is a major concern of the client, a coal-fired power plant. CH2M HILL provided a plant design that minimized water consumption and is among the quietest in the world. With a design in which the station is air-cooled, rather than water-cooled, and that uses waste heat for recycling of plant waste water the power station requires 97 percent less water than typical water-cooled coal-fired power stations.

Talking Points:

- Discuss how energy production is also water-intensive (leaving the TV on all night doesn't just waste energy).
- What are different kinds of water conservation, personal and commercial?
- Why is efficiency in engineering so important?

15. Project Name: Gippsland Water Factory

Client Name: Gippsland Water (Traralgon, Victoria, Australia)
Project Type: Bioremediation, filtration, and reverse osmosis
Description: This project incorporated social, economic, and sustainable design considerations to address the impacts of drought and climate change on Australia's water supply systems. Gippsland Water Factory is a wastewater treatment and recycling system that will improve regional waterways, increase the amount of fresh water in the local ecosystem, and significantly reduce odor emitted from the open channel section of the regional outfall sewer. It will also produce 20 percent of its required operating energy through internal energy-recovery processes. The factory will treat 35 million liters a day of municipal and industrial wastewater and produce 8 million liters of high-quality recycled water each day. Treatment of municipal and industrial wastewater occurs in two parallel systems, enabling the facility to manage saline and nutrient pollution, meeting the community's economic, environmental, and energy needs and minimizing greenhouse gas impacts.

Talking Points:

- What is bioremediation?
- How can these facilities meet community needs in indirect ways?