ABSTRACT

This project developed a solution for *water sustainability* in a large metropolitan city in the United States. This work involved designing a wastewater collection system, decentralized wastewater treatment facility, groundwater recharge system. We also used advanced hydrologic modeling techniques to ascertain the effects on an unconfined aquifer. Regions highly dependent on local groundwater resources pump water from a local aquifer, employ it for household and other use, then sends wastewater downstream to a central facility for treatment. After treating the wastewater, it is transported to a nearby body of water. In our study area, the local aquifer depletion rate is higher than the replenishment rate, naturally reducing internal aquifer pressure, lowering the water table, and causing land subsidence. The site is also near the ocean, and lower internal pressure will put the aquifer at risk of briny water incursion, which will make the water unusable for drinking. A lower water table can make the surface soil dryer and more hydrophobic and, therefore, less able to absorb rainfall to recharge the aquifer naturally. Subsidence is causing infrastructure damage that is expensive to rebuild and repair. Our system design seeks to mitigate these unsustainable impacts by collecting and treating the wastewater locally and then reinjecting the treated water back into the local unconfined aquifer. Reinjection conserves both the water and the expense incurred in the treatment and transportation process. In addition, a network of these decentralized, modular facilities would add water supply resiliency to the entire region by keeping the water local. The design reduces demands on the current centralized treatment facility system and potential environmental impacts of offshore wastewater disposal.

The specific tasks involved in this project include (1) site selection, (2) designing a decentralized facility that requires minimal space, (3) developing a collection system to treat all the wastewater generated from 13,000-14,000 residents in the five nearby cities, (4) designing the injection well, (5) performing hydrologic modeling of the injection well scenarios (3D model), (6) considering environmental impacts, (7) and performing cost analysis. We used several datasets to derive the model configuration including geological maps, well observations, borehole soil measurements, and hourly meteorological data. We used ParFlow, an open-source, object-oriented, physically-based, three-dimensional (3D), parallel hydrologic model to simulate the surface and subsurface hydrologic processes for 12 years. All pre-and post-processing (input datasets and model simulations) involved ArcMap (geographic information systems) and MATLAB. Given the population in the area, the decentralized facility will treat waste from 13,000 residents, which amounts to 800,000 gallons per day.

We simulated three injection well scenarios and compared them to a no injection scenario (business-as-usual). Scenario 1 involved one well injecting 800,000 gallons per day (GPD) at 21.3 m depth. Scenario 2 involved two wells injecting 400,000 GPD each at 21.3 m depth. Scenario 3 involved injecting 400,000 GPD each at 27.4 m depth. All scenarios caused the water table level to rise; this trend improves as we continue to inject water into the subsurface. The differences were minimal between the scenarios; therefore, to minimize costs, we selected Scenario 1 since one injection well case significantly reduces the infrastructure and pumping costs. We followed the California Environmental Quality Act (CEQA) guidelines and assessed the aesthetics, noise, and air quality issues of the project. Cost analysis determined the project would cost $28.95 million US Dollars but would contribute to the overall goal of local water sustainability and would save the centralized treatment facility $1.4 million per year.

Professional Engineers from municipal water, structural, and geotechnical engineering disciplines assisted in the project design. Our Faculty advisor specialized in Hydrology and Water Resources and sponsored the project through a grant awarded from a state agency and provided ParFlow tutorials and publications. Other faculty members in Environmental, Structural, and Geotechnical engineering also assisted. The PE's and the Faculty advisor met with students in person to set expectations, present advice and solutions to students' questions twice a week. There was outside consultation and interaction with a Professional Geologist (P.G.), hydrologist, and other multidisciplinary consultants and visits to local water treatment facilities.