Stormwater Capture and Reuse System

Problem Statement

At the same time that the benefits of urban farming are being discovered, the Midwest is seeing historic levels of rainfall due to climate change. We considered the question of how the large roof space of The Plant and the rainwater that runs off of it could be used most effectively from a resource and cost standpoint. How could this water be diverted for use in The Plant's most water intensive activity, urban agriculture, and how could the farms at The Plant reduce the impact of their agricultural production on the City water system? In addition, how could we reduce the load of our rainwater runoff on the City's storm drains and sewage filtration system during a storm event?

Hypothesis

Our approach was capture stormwater from The Plant's 24,000 square foot roof, to supply water to one of our business community's most water-intensive activities, urban farming. We recognized the opportunity to repurpose a huge, immovable fiber-reinforced polymer tank in the basement of The Plant, which had been used by Peer Foods to store brine for preserving meat products. However, the tank could not be relocated without destroying it, so we needed to design a system to utilize the tank without having to move it.

A stormwater capture system utilizing the brine tank as a giant cistern could store rainwater that would otherwise wash directly into the sewer system. Instead of being treated as waste, this water would be a resource that would reduce costs and the impact of The Plant's urban farms on City potable water supplies. Given Chicago's outdated combined sewer system, we envisioned the benefits of a system that could capture and hold a large volume of water, helping prevent the overwhelm of the City's sewer system and regional water treatment plant during heavy rain events.

Backstory on the Building and its Brine Tank

The building now known as The Plant was previously a meatpacking facility owned by Peer Foods. The tank that Bubbly Dynamics identified for reuse had been used during Peer Foods' meatpacking days to hold brine used for preserving pork and beef products. In its former life, the brine tank housed 8,500 gallons of salt and water.

When Bubbly Dynamics acquired the building, we left the brine tank in place – it had great potential but was impossible to move without destroying it. The idea to use the tank for stormwater capture came early in the concept of The Plant as a means to harvest useful rainwater for irrigation. The nickname "brine tank" has stuck over time even though the system now couldn't be farther from its salty past.

Rationale

The brine tank stormwater capture and reuse system allows us to derive benefit from The Plant's 24,000 square feet of roof space. Given that each inch of rain provides approximately 0.62 gallons of rainwater per square foot of roof space, the amount of rainwater able to be harvested for a given roof may be calculated using the following formula:

Rainwater volume = area of the roof (ft2) x inches of rainfall x 0.62

The brine tank, in background, with its break tank and connections to the water distribution system.

Starting with a portion of the roof connected to the system, measuring approximately 18,000 square feet, one inch of rain would net 11,160 gallons of water. Since Chicago gets an average of 35.82 inches of yearly rainfall, the brine tank could hypothetically collect as much as 400,000 gallons of water a year. (This is only a hypothetical number, as the system is shut off outside the growing season when outdoor agricultural water usage is not needed.) Although about three-quarters of the roof area currently feeds directly into the water tank system, 100% cover is planned within the coming years.

This project highlights Bubbly Dynamics' mission of sustainable urban industrial development and closing waste loops. Using almost no power, the brine tank system reduces the facility's reliance on City tap water, lowering costs and cutting the energy that would be used for the treatment and pumping of both stormwater runoff and tap water bound for The Plant's resident urban farms.

Like many older cities, Chicago has a **combined sewer system**. In a combined system, both sewage and rainwater are collected together, and an overwhelmed combined sewer system is liable to back up into homes and businesses, flood streets, and release raw sewage into lakes, rivers, and other sources of clean drinking water. This not only harms residents and damages property, but impacts local ecosystems as well. Combined sewer systems are no longer being built, but many continue to operate due to the extreme costs of retrofitting them into modern-day systems that convey and treat sewage and stormwater outflows separately. Stormwater collection reduces the strain on these systems and local sewage treatment plants. This is not a trivial benefit considering the recent climate change-related increases in rainfall during the spring and summer months.

More recently developed areas typically have a **separate sewer system**, in which stormwater and sewage flow separately into different pipes. Although sewage overflow during heavy rainfall is not a problem experienced by separate sewer systems, there are still important benefits to be had from rainwater collection. Unlike in older combined systems, surface runoff from rain and other sources may not pass through a filtration plant but instead flow directly into waterways, along with any trash or chemicals it may have picked up. Catching and storing stormwater where it falls would help ease the amount of water and, by extension, pollution flowing into local waterways.

Implementation

Bubbly Dynamics' first step in the process was mapping out the existing roof drain system – The Plant has three sets of internal drains: roof drains, floor drains, and sewer – and developing a plan to route stormwater directly to the brine tank, which would be the main stormwater holding tank. It stands at over 14 feet with a ten-foot diameter and holds 9,000 gallons. Due to its enormous size, relocation of the brine tank was not possible. It remains in its original location, tucked away in a corner of the basement, so tall that the top reaches above the level of the first floor.

When we confirmed the feasibility of the effort, we prepared the tank to be repurposed. During its use for meat processing, it contained 8,000 gallons of salt that now had to be removed. The waste salt was mixed with rock salt and used for melting snow.

We then rerouted the internal roof drains to deposit water directly into the brine tank. Tests on the collected water showed that it was suitable for irrigation purposes, allowing us to move ahead with our plan to run plumbing outdoors to the farms in the yard.

For this project, we acquired two additional salvaged tanks. These smaller tanks, which were previously used for apple cider vinegar and for process water for boilers, sit outside in the yard, and bring the volume of the system to a total capacity of approximately 15,000 gallons. The stainless steel piping as well as the control system used for this project were salvaged from past uses in the building. All materials for this project were from recycled sources except for the plastic PEX tubing which connects the tanks to the outdoor spigots used by the farms.

Repurposed equipment from industrial neighbors

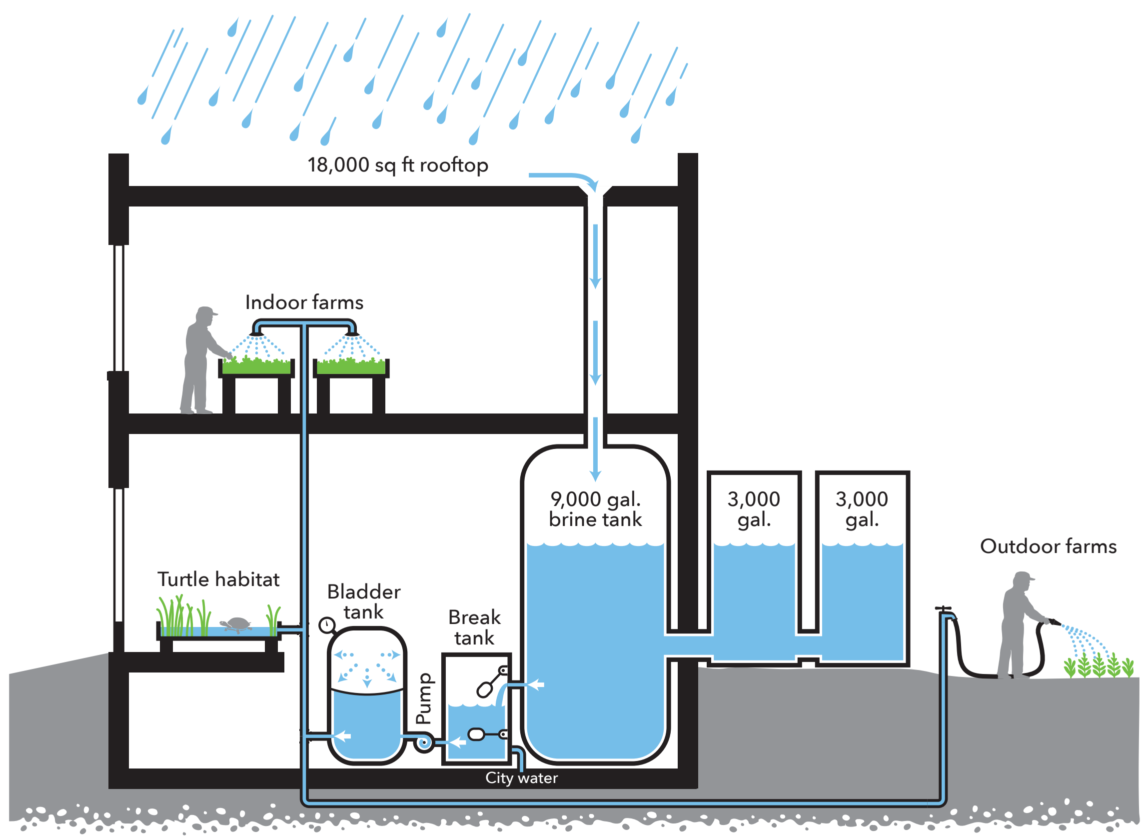
Industrial neighbors can have really interesting hand-me-downs! The tank previously used to hold apple cider vinegar (marked simply "CIDER") was a surplus tank provided by Fleischmann's Vinegar Company, located nearby at 48th St. and Oakley Ave.

Businesses at The Plant also use Rheaply, a marketplace that facilitates repurposing equipment and materials with other companies and institutions on a broad scale – think Craig's List for universities and research institutions.

How it works

Drains from the roof capture and divert rainwater to one of the three tanks on site: the 9,000 gallon brine tank or one of the two smaller tanks in the yard. The water level is at the same height in all three tanks, with the largest tank extending from the basement to the first floor and the two smaller ones at ground level. This causes somewhat of a reduction in the capacity of the brine tank to 8,500 gallons. All three tanks are connected to each other through **equalizing lines**, causing them to act as one giant tank.

The brine tank is attached to a **break tank** that has two **float valves** inside, one higher than the other. If the water level in the break tank begins to drop, the ball of the float valve drops. This causes more water to flow in from the three tanks. If the tanks are empty, the water will drop to the level of the second, lower, float valve. Once this happens, municipal water is allowed to flow into the system through the break tank. In this way, the use of rainwater is prioritized, but the tanks never run out of water even in periods of little rainfall.



The break tank is also attached to two **three-phase pumps**, which are in turn connected to a **well tank**. Inside the well tank, the water flows into a bladder that is surrounded by pressurized air and which monitors internal tank pressure. From the well tank, the water flows underground through **PEX tubing** to three underground freeze-proof **yard hydrants,** and then to two outdoor spigots where the water is used by the outdoor farms in the yard of The Plant. Whenever the spigot is turned on, water flows out of the well tank, dropping the pressure in the tank. When a drop in pressure is detected, the three-phase pumps turn on to bring more water out of the break tank into the well tank and on to the yard. Once the spigot is turned off, the pumps will refill the well tank back to its proper pressure before turning off again.

Installation Costs

The setup of the project was highly cost-effective. By using 95% salvaged industrial materials, we were able to create the three-tank system with a new materials cost of only about $200. The entire process from start to finish took about 120 hours to complete. About twenty of those hours were specific to our site constraints, which required excavating a trench in the yard to lay the underground piping to the farms about 150 feet away from the building, for which a backhoe was needed. The system is simple, cost-effective, and durable. We believe it could successfully be modified, expanded, or downsized to suit a variety of urban activities and buildings.

Project Benefits

Successful implementation of a stormwater capture and reuse system creates many benefits and efficiencies.

Water Efficiencies

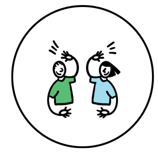
Stormwater, which would typically flow into the sewer after washing over the roofs of buildings and other impermeable surfaces, is a free and plentiful resource for those with the capabilities to collect it. The use of stormwater for watering crops reduces reliance on drinking water supplies. This approach may be successfully applied on a small scale for residences by diverting downspouts to rain barrels.

Energy Efficiencies

The capture and reuse of stormwater removes the energy cost associated with treating and pumping potable water. Stormwater remains on site for reuse where it falls, without need for processing at a water purification plant.

Materials + Resource Efficiencies

Almost all of the materials for our project were salvaged, and repurposed tanks can be an option for other applications. By choosing salvaged materials, we were able to divert a large amount of "waste" from the landfill and prevent the needless use and transport of new materials. Not only did this keep costs down, it also reduced our footprint in terms of energy and resource use.



Land Use Efficiencies and Social Benefits

Capturing stormwater reduces the amount of runoff flowing over land and into waterways. Reducing stormwater flows means fewer flooded streets and basements, and less chance that untreated sewage ends up in the basements of homes and businesses. This also reduces soil erosion, as a reduced volume of stormwater may more slowly soak back into the ground.

Furthermore, regardless of whether a municipality has a combined or separate sewer system, stormwater capture and reuse helps protect water resources and local ecosystems. With combined sewer systems, stormwater collection relieves pressure on sewage treatment plants and helps avoid release of raw sewage and untreated water. For separate systems, stormwater catchment may reduce the amount of trash and pollution entering local waterways when it rains.

Cost Benefits

A stormwater capture and reuse system benefits not only the users of the reclaimed water, but also the surrounding neighborhood and City as a whole. Rainwater is a free source of water for farming and other activities while its collection saves the City and taxpayers money by reducing the strain on the sewer system and treatment plants. For a low upfront cost, a durable yet simple system could be utilized for basic outdoor water needs for homes or businesses, such as to irrigate a garden or landscaping.

Additional Resources

Ajia, Z. (2017, May 29). *Rainwater harvesting for sustainable agriculture*. Permaculture Research Institute. https://www.permaculturenews.org/2017/05/29/rainwater-harvesting-sustainable-agriculture/

Angima, S. (2014, December). *Harvesting rainwater for use in the garden*. Oregon State University Extension. https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9101.pdf

Laborde, L. (2020, October 14). *Safe uses of agricultural water*. Penn State Extension. https://extension.psu.edu/safe-uses-of-agricultural-water