Saint Paul scores big with smart regional rainwater harvesting system

Landmark clean water infrastructure at the Allianz Field soccer stadium in Saint Paul, Minnesota, United States (US), and neighboring buildings captures, stores, treats, and reuses every drop of rainwater for beneficial use. **Craig Fairbaugh** of Contech Engineered Solutions explains how the system works.

Rainwater harvesting is often the holy grail of meeting low impact development (LID) stormwater permit requirements. Not only are runoff and pollutants retained onsite and kept out of downstream receiving waters, but stored runoff is also put to beneficial use such as irrigation or non-potable water supply. So why isn't rainwater harvesting used more frequently to meet LID permitting requirements?

In the US, challenges to rainwater harvesting arise when site owners and developers shy away from the capital investment, or the developer and the long-term owner are two different entities and the long-term savings of reuse will not be shared by the party that doled out the capital investment. Other barriers to reuse success can be lack of demand, low cost of municipal water, water-tightness of the storage system, or complex reuse calculations. Accounting for future water demand is typically a modeling estimation, and in reality the reuse water available from actual storms versus water demand could differ significantly from the intended design. However, there is an example of ingenuity and funding mechanisms in a regional rainwater harvesting system – the largest of its kind – in Saint Paul, Minnesota, US, at the Major League Soccer stadium Allianz Field.

At the Allianz Field soccer stadium site, the City of Saint Paul, with support from Capitol Region Watershed District (CRWD), developed landmark clean water infrastructure, which will recycle thousands of cubic meters (m^3) of rainwater every year. Within the 14-hectare (ha) Midway Development District, every drop of rain and snow melt from the roof of Allianz Field and neighboring future district buildings will be captured and directed to a 2,555-m^3 storage tank. From here, the water is processed through a smart hub that analyzes and treats the stormwater. This smart hub can even read weather forecasts to predict rainfall and adjust water levels accordingly. After being treated in the smart hub, the water is distributed throughout the district for irrigating trees and grass across the site. Irrigated boulevard trees are planted in engineered soil trenches to capture and clean polluted runoff from roadways and sidewalks before discharging to the Mississippi River. Connecting new developments with the landmark water system will also provide these businesses with a source of filtered water for uses such as laundry, irrigation, or restroom flushing.

These future developments essentially have stormwater permit compliance built into the property, with the ability to connect to the Allianz field reuse system, and take advantage of a stormwater system that capitalizes on using rain as a resource. Providing built-in stormwater compliance lowers cost for developing, produces water supply savings, while also ensuring the highest level of stormwater treatment possible: 100-percent pollution reduction from the design storm event by capturing, treating, and reusing stormwater runoff.

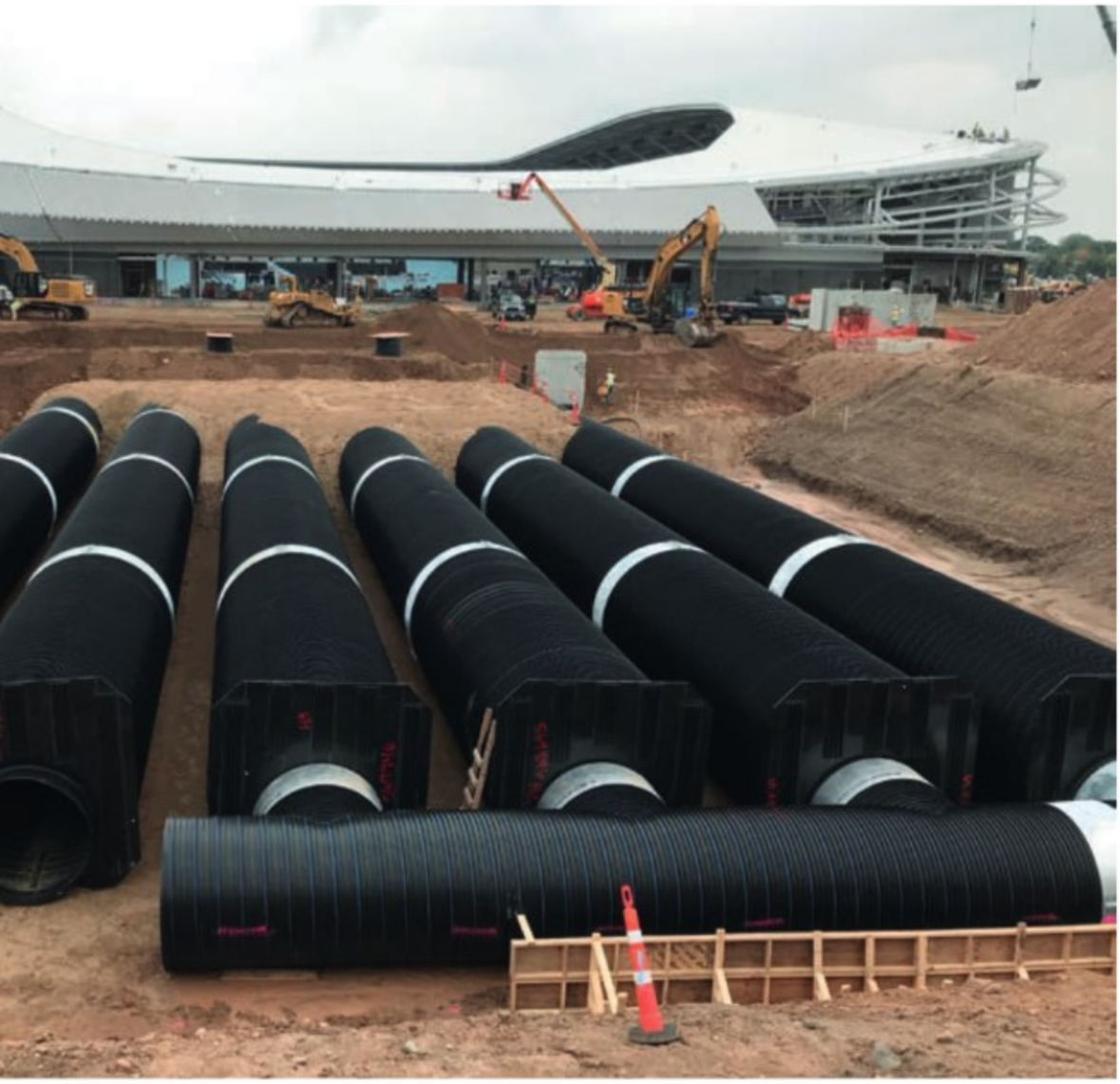
Project partnerships

The ambitious Allianz Field stormwater project is just as much a story about a unique stormwater reuse system, as it is a story about a shared vision and partnership between the City of Saint Paul and CRWD. Saint Paul is permitted to discharge to US waters through the National Pollution Discharge Elimination System permit framework. However, the state of Minnesota also uses watershed districts like CRWD to ensure that water quality protection does not stop at the city limits, and to account for water quality benefits in a holistic, watershed-level approach.

Additionally, Saint Paul is a capital city located on the banks of the Mississippi river, and it is the mission of the CRWD to protect and improve the water quality of the Mississippi river, to which the Allianz field site ultimately discharges. The city established an aspiration to use rain as a resource as part of their stormwater management initiative in 2013, and with funding from the US Department of Housing and Urban Development, outlined the concept of "shared, stacked-function green infrastructure (SSGI)." This approach shares the benefits of stormwater management across multiple property owners. It provides multiple benefits though stacked functions of recreation, open space, and habitat amenities, and it is green because it provides a sustainable, LID-based approach to mimicking predevelopment hydrology and preventing stormwater and associated pollutants from entering downstream receiving waters. In 2016, the city partnered with CRWD to evaluate SSGI at the Midway super block development, which included the proposed soccer stadium. The result of SSGI analysis was a public-private partnership to construct a comprehensive stormwater management facility that will service the entire 14-ha super block redevelopment area. The landmark feature of the project was to include the rainwater harvest and use system, while it also used other tools in the stormwater best management practices (BMP) tool kit such as tree trenches, raingardens, media filtration, and pretreatment systems.

Project requirements versus goals

CRWD regulations require that for new developments over 0.4 ha, the first 28 millimeters (mm) of runoff volume on impervious surfaces must be retained onsite through the mechanisms of infiltration, evapotranspiration, or harvest-and-use. The proposed



PROVIDING BUILT-IN STORMWATER COMPLIANCE LOWERS DEVELOPING COSTS, PRODUCES WATER SAVINGS, AND ENSURES THE HIGHEST LEVEL OF STORMWATER TREATMENT POSSIBLE.

stadium site featured an existing, decommissioned bus parking and maintenance area with soils containing pollutants that could be mobilized by stormwater runoff, so infiltration was limited to small portions of the site. Evapotranspiration was maximized throughout the site through the incorporation of landscape area where possible, but was insufficient to manage the stormwater quality design volume. This left stakeholders with rainwater harvesting as the only way to implement a LID approach, retain a majority of the 28-mm storm event runoff volume onsite, and as such retain 100 percent of stormwater pollutants, which are washed off during this event.

The city previously pioneered a shared rainwater harvest-and-use system for irrigation and indoor reuse at CHS Field, home of the minor league baseball team the Saint Paul Saints. However, the proposed Allianz field site was much larger and faced the typical aforementioned rainwater harvesting challenges. Continuing with the concept of treating stormwater runoff as a resource, the city and CRWD collaborated on an SSGI analysis for the new stadium site and aimed high: what if the RWH system collected runoff for use in the entire 14-ha super block development? Is a regional rainwater harvesting system even possible from a funding and regulatory perspective?

The city's Water Resource Coordinator Wes Saunders-Pearce was critical to championing the aspirational vision for the system by communicating a line of sight for viable financial strategies and galvanizing the public agencies and private partners into action. Concurrent with the design of the stadium site, the city was participating in Living Cities' City Accelerator 18-month Infrastructure Finance cohort. Saunders-Pearce then led a cross-departmental team in a focused effort to develop a replicable funding and financing model for regional or district stormwater infrastructure that addresses construction, operation and maintenance, and replacement costs. With a long-term financing pathway created for this unique system, three design options were then pitched to the stakeholders by the engineering consultant Loucks engineering and ultimately the large-scale, regional system was selected as the final design.

Water drop graphic shows the stadium roof, cistern and treatment skid. Graphic by Saint Paul/CRWD

Design

The reuse system was designed to capture runoff from the roof of the stadium, and convey the captured water to an underground storage cistern. Material for the cistern was originally selected to be a concrete system, however due to concern of water-tightness at the concrete section joints, other cistern materials were entertained. The final material selected for the cistern was DuroMaxx Steel Reinforced Polyethelyne (SRPE) pipe with a welded coupler system at pipe joints. SRPE is a commonly used material for rainwater harvesting cisterns in the US due to its unique properties possessing the strength of steel, the durability of plastic, and a welded watertight joint system. The 3.05-m diameter SRPE cistern complied with the city of St. Paul's allowable leakage rate and also was able to be configured in a highly customized layout, which worked around existing utility conflicts, and facilitated access to the entire system for maintenance purposes.

Pollutants on urban rooftops typically only build up due to atmospheric deposition and are usually present in runoff at low concentrations. As such, no filtration was required on the inlet to the cistern. However, the state agency (MPCA) does require pretreatment of the facility to capture gross pollutants such as coarse total suspended solids (TSS), hydrocarbons, and trash. Two continuous deflective separation (CDS) hydrodynamic separators were selected for pretreatment of reuse runoff, and were designed to

Environmental engineer Craig Fairbaugh, who designed the cistern and all Contech systems, is in front of the Allianz Stadium great lawn in St. Paul, Minnesota, with covers of two pretreatment systems before a sporting event. According to Fairbaugh, he was the loudest person cheering when the sprinklers were turned on during halftime. Photo by Contech

capture 50 percent of all TSS generated from the rooftops, as well as retain 100 percent of neutrally buoyant trash, floatables, and debris larger than 5 micrometers (µm). Additionally, the SRPE manifolds directly downstream from the CDS systems featured a pretreatment wet pool constructed out of custom weirs, effectively creating a pretreatment treatment train to settle out and capture finer sediments and pollutants.

After coarser solids and particulate pollutants are removed through pretreatment practices, runoff is stored in the SRPE tanks. Stormwater is then pumped to a treatment system, which provides real-time monitoring of flows and water quality as the rainwater is sent through filters and ultraviolet (UV) light for treatment. The level of treatment is intended to satisfy Minnesota state plumbing code water quality standards allowing for indoor use of harvested rainwater. When irrigation is not active, pumps have the capacity to recirculate rainwater through the system where it can be disinfected with ozone to prevent stagnation in the large tank. Additionally, the pumps can be signaled by a continuous monitoring and adaptive control (CMAC) system. This system monitors local weather and optimizes the volume of harvested water to ensure that adequate storage is provided for anticipated storm events. Not only is the Allianz field system the largest of its kind in the US, the CMAC optimization also made the system the smartest of its kind.

In addition to the landmark reuse system, the site features tree trenches with mature trees to treat runoff from the new streets and sidewalks, and a media filtration system to treat runoff and pollutants generated by the large parking lots. 120 of the 192 mature trees on site are located in tree trenches, which utilize a gravel and soil mixture to filter and store stormwater and snow melt generated by sidewalks and pedestrian open spaces. Together, the tree trenches capture and filter an average of 3,400 m^3 of stormwater runoff annually. Additionally, the trees are irrigated by the reuse system during dry weather.

A proprietary media filtration system was designed to remove the heaviest pollutant loading from the site, including TSS, metals, oils, and hydrocarbons generated from cars in the parking lot. The proprietary system is a passive, siphon-actuated media filtration system with zeolite, perlite, and granular activated carbon (ZPG) media cartridges and a self-cleaning mechanism, which regenerates media sorptive capacity and function. The filtration system was designed to remove 80 percent of TSS from the parking lot on an annual basis, with the ancillary benefits of also removing total phosphorus and heavy metals.

Allianz inspiration for other cities

Allianz Field opened on April 19, 2019, with the rainwater harvesting system and all stormwater management features installed and fully operational. Also in the spring of 2019, the city formally adopted its green infrastructure district financial framework into ordinance – ensuring long-term funding, maintenance, and operation of the system could be achieved. This unique approach ensures that the Midway Development District will be environmentally and economically sustainable for the neighborhood and city of St. Paul for years to come.

Author's Note

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