

Editor's note: this is the second in a series of articles addressing key aspects of the National Academy of Engineering's and the National Science Foundation's list of *The Grand Challenges of Engineering in the 21st Century*. Looking at the challenge of creating better urban infrastructure, the author focuses on the strengthening infrastructure supporting stormwater management, an increasing challenge in our region.

YESTERDAY'S INFRASTRUCTURE = TODAY'S CHALLENGES!

By Donald Carpenter

 In August 11, 2014, the Detroit Metropolitan area received between 3 and 6 inches of rain in a matter of hours. The region's overwhelmed infrastructure experienced widespread flooding and estimates from Oakland, Wayne and Macomb counties indicated flood damage exceeded \$1 billion. The damage was great enough that President Barack Obama signed a disaster declaration for the region.

Media outlets referred to the event as a “500-year flood” or a “once in a lifetime” storm. Yet, only two years later on September 29, 2016, areas of Detroit experienced the same type of flooding when approximately 4 inches of rain fell causing flooding downtown and on the lower east side. Similar to the 2014 flood event, news outlets reported the “sewer system failed” but in reality, it was never designed to capture storm events of this size.

Climatologists are reporting that more frequent intense storms are becoming the “new normal” in Michigan (and elsewhere in the

world) due to increased climate variability. It is this uncertain future that the engineering, architecture, and planning professions have to manage.

Traditionally, Michigan communities have managed stormwater through “gray infrastructure” such as storm drains, concrete pipes, detention basins, and—in the case of combined sewer areas—wastewater treatment plants. A combined sewer is one where stormwater and sanitary water share the same pipe and are legacies of aging Midwestern cities. While flooding events make headlines, rainfall as small as ½ inch can cause a combined sewer overflow (CSO) event in Detroit. A CSO event is a situation where a large amount of untreated sewage mixed with stormwater is discharged directly into adjacent water bodies. Even in communities with separate sewers, there are significant water quality issues associated with stormwater runoff including excess sediment, nutrients, pathogens and heavy metals that harm our nation's waterways.



The Challenge: Infrastructure Conditions

According to the American Society of Civil Engineering Infrastructure Report Card, Michigan's overall infrastructure grade is a D+ with over \$2 billion required to fix waste water infrastructure alone. The report card does not specifically evaluate separate stormwater infrastructure, in part because until recently little was known about the exact conditions of stormwater infrastructure in the state of Michigan.

Over the past three years, many communities have had

their stormwater infrastructure inspected as part of stormwater, asset management and wastewater (SAW) grants awarded by the state and undertaken by consulting companies such as OHM Advisors of Livonia, Michigan. OHM Advisors Senior Project Manager Greg Kacvinsky reports that in some communities they inspected, the pipes are 80 to 100 years old and well past the average life expectancy of 50 years. Even some of the younger assets are in poor shape and need to be repaired or replaced.

“The reality is that the systems are aging, and need to be repaired or replaced,” says Kacvinsky, adding that in many cases the funding gap between what a community spends on infrastructure operations and maintenance (O&M), and what is required to maintain the system, is a widening gap of up to millions of dollars per year for single communities.

Kacvinsky reports that “funding is needed to address both critical repairs and routine maintenance to prevent further degradation of the system. This funding will be a perpetual need, because other issues will arise as the system continues to age.”

A key reason for the gap is a lack of dedicated funding for stormwater improvements. Michigan House Bill 4100, sponsored by Representative Mike McCready of Bloomfield Hills, is legislation that would provide a clear path for communities to establish stormwater utilities in Michigan, provided that they evaluate their assets and establish a cost-effective budget to meet their defined needs. A stormwater utility fee would set aside the dedicated funding that is required to address aging infrastructures.

One champion of the bill is Oakland County Water Resources

Commissioner Jim Nash who organized a committee to assist in writing the bill language.

“We are working with stakeholders from across Michigan to develop legislation enabling local communities to set up stormwater utilities to fund needed projects, charge property owners for the stormwater they actually produce, and allow charges to be reduced when mitigation is installed,” he explains.

Green Infrastructure to the Rescue

One solution for alleviating the burden on overtaxed stormwater infrastructure is to implement green

our waterways and limiting future flooding.

Green infrastructure typically is designed to capture smaller storm events (one to two inches of rain). However, 1.67 inches of rainfall represents 98 percent of all storm events in southeast Michigan. Capturing and treating 98 percent of all rainfall events using green infrastructure will significantly reduce the number of CSO events in the city and drastically improve water quality. In non-CSO areas, green infrastructure can also alleviate the burden on the current gray infrastructure system that are being taxed by the more frequent storm events.



infrastructure in addition to or instead of gray infrastructure. Green infrastructure uses vegetation, healthy soils, and natural processes to manage stormwater and create healthier urban environments by mimicking the natural hydrologic cycle. On the local scale, green infrastructure practices include rain gardens, permeable pavements, vegetated roofs, infiltration planters, trees and tree boxes, and rainwater harvesting systems. Many of these practices promote infiltration and infiltration based design techniques are critical for protecting and restoring

Green infrastructure projects can also help communities improve safety and quality of life, conserve vital ecosystem functions, and mitigate the effects of heavy rainfall and flooding. In fact, various groups, including the U.S. Environmental Protection Agency and the Water Environment Federation, have suggested that green infrastructure projects convey environmental, social, and economic benefits, a trio of factors known as the “triple bottom line.” However, there are many barriers to the wide-scale adoption of green infrastructure

projects including a lack of dedicated funding, an understanding of design and implementation techniques, O&M concerns, and qualified contractors. Many of these barriers can be addressed through a broad based educational effort such as that being implemented at Lawrence Technological University.

Education is key

Lawrence Tech has been taking a leadership role in green infrastructure



implementation for over 10 years through the Great Lakes Stormwater Management Institute. The Institute has advanced the science of green infrastructure through research while also undertaking professional and community based education. Lawrence Tech's campus is home to a stormwater management education trail that was implemented in 2011 with funding from the Erb Family Foundation. The trail has seven stops with permanent signage and features rain gardens, bioswales, cisterns, porous pavement, native grow zones, and a vegetated roof. The trail is accom-

panied by short videos that can be access through QR codes on the sign or through the Institute website (www.ltu.edu/water).

In addition, Lawrence Tech is collaborating with various partners including the Great Lakes Commission, Environmental Consulting and Technology, Inc., the University of Michigan, Michigan Sea Grant, and other regional champions to identify strategies for removing the aforementioned barriers to green infrastructure implementation. At the heart of the projects is the need to be "smarter" with how water is managed and accelerating the transfer of innovative stormwater management technologies.

"We have not built out the management systems to more thoughtfully and carefully manage the movement of water through human systems (from nature, to use and back to nature) and we have even less intelligence on the movements of water across our landscape in urban and rural environments," says Jon Allan, Director of the Office of the Great Lakes, Michigan Department of Environmental Quality. "We not only need green solutions that create opportunities for infiltration but we need smart sensor systems and a suite of underlying information management logic models that enable storage, mediate flow, retain water, allow for more natural hydrology in our wetlands and rivers, assess risk, track water quality, and provide a better human experience and engender human well-being along with ecological value and economic capacity."

LTU also recently hosted MSU Extension's Water School: Essential Resources for Local Officials program. The objective of this two-day pilot program was to provide local decision makers and appointed and elected officials with critical, relevant information needed to understand Michigan's water resources, including the fundamentals of water science,

in order to support sound water management decisions and increase awareness of current and future local and state water issues.

Another key partnership is with Pure Oakland Water (POW). POW supports educational programs in the area of water conservation, water resource preservation, and related environmental and sustainable practices. POW, the Oakland County Water Resources Commissioner Office, and Lawrence Technological University partner to organize the annual Regional Stormwater Summit, the fifth taking place in October 2017. Attendance has grown each year to nearly 250 attendees and the summit serves as a means to transfer knowledge between regional partners and share best practices. Each year also features a speaker from another region as a keynote and previous summits have highlighted the efforts of Washington D.C., New York City, Philadelphia, and Milwaukee leadership. The 2017 keynote will focus on the work happening in Ontario.

Says Nash, "The Stormwater Summit has become an important venue to learn about the issues surrounding stormwater pollution, including policy changes, funding possibilities and the green infrastructure solutions installed locally, state wide and nationally."

Working together with innovative minds across the country, we can meet these challenges.



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Drummond Carpenter, PLLC. As founding Director of the Great Lakes Stormwater Management Institute at Lawrence Tech, he conducts research on innovative stormwater BMPs and advises communities on how to implement green infrastructure. He also serves as a Governor for Cranbrook Institute of Science and a Director for the non-profit organization Pure Oakland Water.