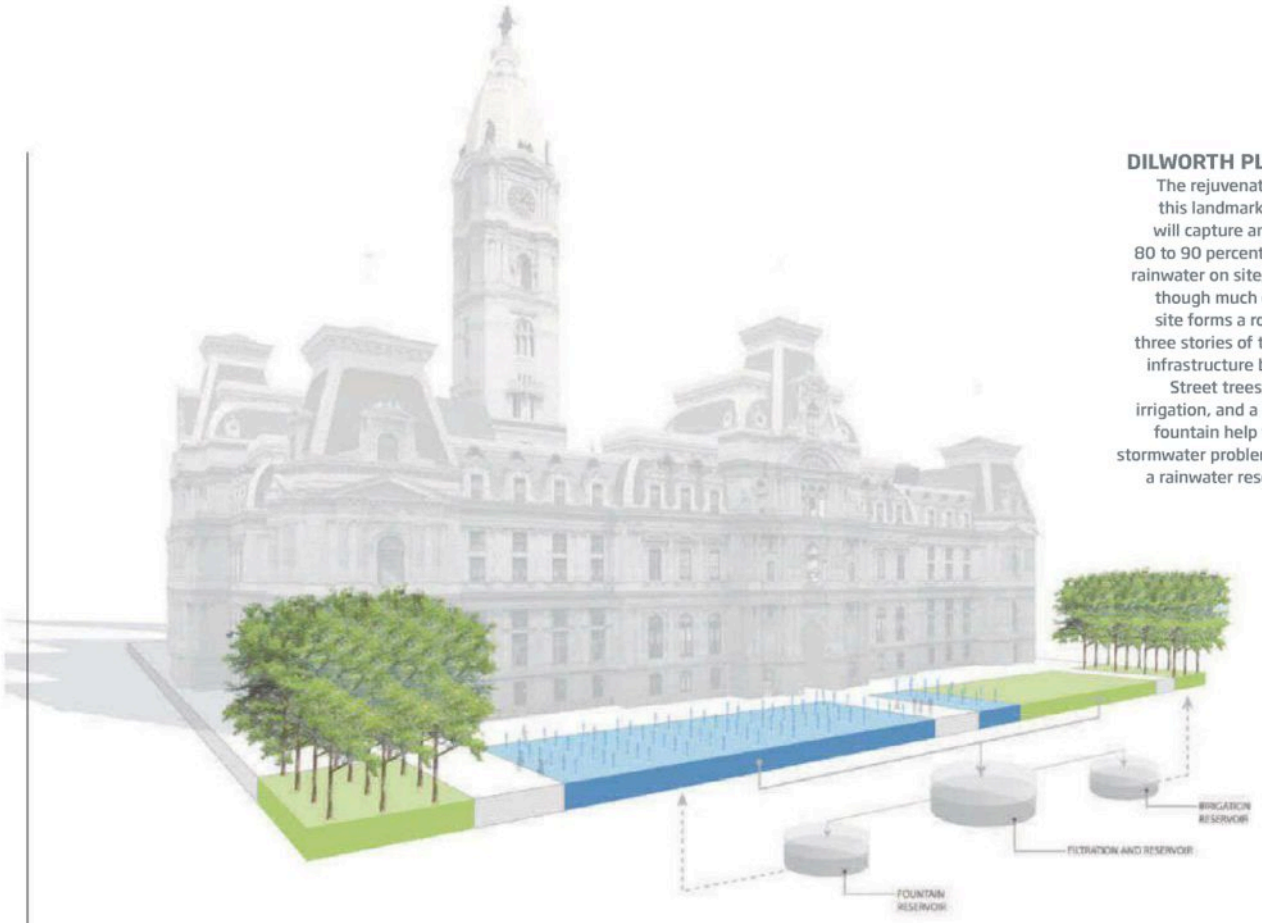
KEEP

IT CLEAN

TO PROTECT ITS WATERSHED, PHILADELPHIA ROLLS OUT GREEN INFRASTRUCTURE ON A CITY-WIDE SCALE.

BY KATHARINE LOGAN · PHOTOGRAPHY BY DARREN BRAUN



DILWORTH PLAZA
The rejuvenation of this landmark plaza will capture and use 80 to 90 percent of its rainwater on site, even though much of the site forms a roof for three stories of transit infrastructure below. Street trees, lawn irrigation, and a public fountain help turn a stormwater problem into a rainwater resource.

Beneath the city

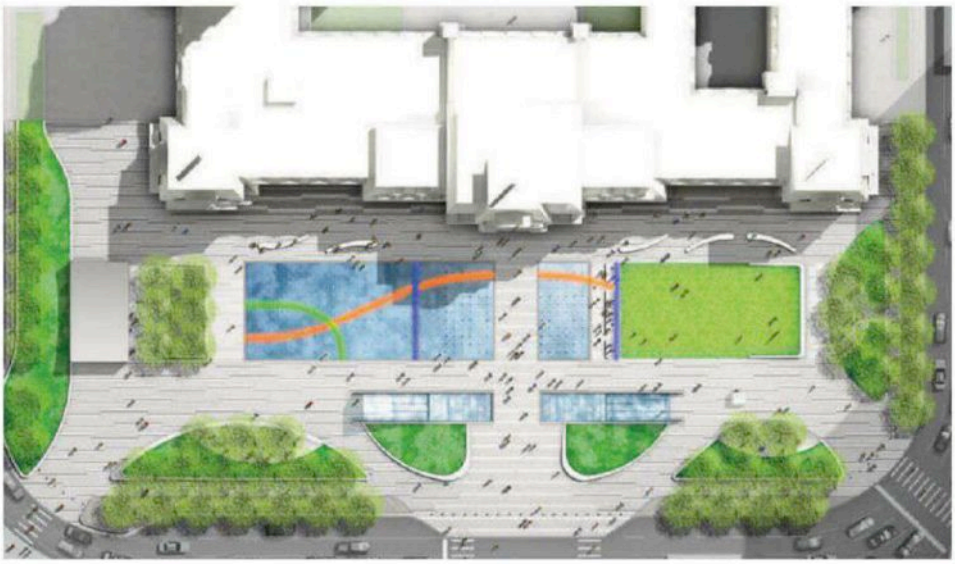
of Philadelphia runs one of the oldest combined sewer systems in the country, serving about 60 percent of the area of the city and about three-quarters of its population. On a good day, the system carries its contents to a treatment facility, where the wastewater is cleaned up and sent on its way.

But after moderate to heavy rainfalls, the volume of runoff and sewage exceeds the system's capacity. When that happens, 164 combined sewer discharge points around the city release a rain-sewage mixture—an estimated 13 billion gallons per year—directly into the rivers and creeks of Philadelphia's watershed.

Philadelphia isn't the only city with this problem. According to the EPA, combined sewer overflows (CSOs) are a major water-pollution concern for nearly 800 cities across the U.S. In 1994, the EPA issued the CSO Control Policy, a national framework to control CSOs through a permitting program and to require municipalities to develop a long-term plan ultimately to provide for full compliance with the Clean Water Act.

To upgrade Philadelphia's system using conventional infrastructure would cost in the range of $10 billion, according to the Philadelphia Water Department's estimates. At the 2010 Charting New Waters event in Washington, D.C., Philadelphia Mayor Michael A. Nutter bluntly concluded, "There is no way in the world we could ever pay for something like that."

Instead, Philadelphia has developed a plan to prevent overflows by reducing the volume of rainwater entering the sewage system in the first place. The "first inch" is a big idea in rainwater management: across most of North America, it's rare that more than an inch of rain falls in any single storm or shower. In fact, the first inch accounts for 80 to 90 percent of all rainfall. Under its Green City, Clean Waters program, launched officially in 2011, Philadelphia has committed to a 25-year program of



The plaza will feature an interactive fountain that uses thin columns of mist to trace the paths of trains as they run through the transit station below. In winter, a public skating rink continues to turn water into a public amenity.

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retrofitting nearly 10,000 acres (a third of its combined sewer system area) with green infrastructure that will keep that first inch out of the sewers.

"Philadelphia really is leading the way in using green infrastructure as its main approach to managing sewage overflows," says Larry Levine, senior attorney with the National Resources Defense Council's (NRDC) Water Program. In the NRDC's 2011 assessment of green-infrastructure initiatives in 14 leading North American cities, Philadelphia alone achieved all six of the NRDC's "Emerald City" criteria, which outline steps that should be taken to maximize investment in green infrastructure.

Green infrastructure mimics the natural hydrocycle. Instead of piping water off the surface as fast as possible, green infrastructure catches rainwater. It then uses the rain to irrigate plants, allows the rain to infiltrate the soil and replenish groundwater supplies, or filters and slows the rainwater, preventing erosion and reducing the flow of pollutants into adjacent waterways.

Green infrastructure can take many forms, including green roofs, street trees, increased green space, permeable pavement, cisterns, and rain gardens. It can beautify neighborhoods, cool and clean city air, improve public health, reduce the need to heat and cool buildings, and boost local economies. "Managing water on the surface is better than wasting it and then capturing it and pumping it back to clean it," says Howard Neukrug, Philly's water commissioner.

And at $1.67 billion, Philadelphia's green infrastructure will cost the public purse a fraction of what would be needed to achieve the same goals with new piping infrastructure. What's more, managing rainwater on the surface leverages the water-management budget to create public amenities. In about 45 years, the value of these amenities is expected to exceed the city's investment in the program.

WATER CITY CENTRAL: THEN AND NOW

A prime example is currently under construction on City Hall's front doorstep. After a disappointing few decades as a sunken, inaccessible, and underused hardscape, Dilworth Plaza is being revitalized as a green civic park at street level, with integrated rainwater management and an exquisite fountain.

Adding to Philadelphia's contemporary culture of progressive rainwater management, the site carries its own rich historical references to water: in the early 1800s, it was the location of Benjamin Henry Latrobe's Centre Square Water Works, the first water distribution pump-house in America, and of Philadelphia's first fountain.

The design for the plaza's transformation accepts the site's invitation to celebrate water. "We didn't want to send up geysers of water or be wasteful," says Richard Roark, a partner at OLIN, the project's landscape architect. "We asked ourselves, 'Is there a really contemporary way to use water that, just as Latrobe used the best engineering of his day, would represent best engineering practice?'"

The resulting approach is both deliberate and delightful. Front and center of the design is an

This course was approved by the GBCI for one CE hour for LEED Credential Maintenance.

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Valid through November/December 2015.

Use the learning objectives below to focus your study:

>Describe how green infrastructure can prevent combined sewer-system overflows.

>Provide examples of components in a green-infrastructure system.

>Describe the significance of "the first inch" to on-site rainwater management.

>Propose a green-infrastructure concept for an impermeable site.

The CEU quiz for **"Keep It Clean"** is available online at **ce.construction.com** at no charge.

interactive water fountain, designed by artist Janet Echelman, which will animate the plaza with thin columns of mist tracing in real time the paths of trains running through the transit station below the plaza, illuminated in colors corresponding to each transit line. The fountain's mist also recalls the steam from Latrobe's pumping station and the trains at the Pennsylvania Railroad Station, which was located across the street. To accommodate events such as concerts and public markets, the fountain can be turned off in segments. And in winter, the thin layer of water it sends across the surface of the plaza will transform it into a skating rink.

Behind the scenes, the design team hunted high and low for opportunities to infiltrate or catch and store rainwater on the densely used site. Strategies include exploiting limited zones of infiltration; introducing permeable paving; increasing plantings, lawns, and canopy cover for water uptake and slow release; and using storage cisterns to irrigate with ultra-violet-treated rainwater. "We went from a totally impermeable plaza to one that could catch and manage the first inch of rainfall, even though much of the plaza is a roof above a subway concourse," says Roark.

GREEN ARTS AND SCIENCE

Illustrating green infrastructure as both art and science is Shoemaker Green, a new 3.75-acre public commons at the University of Pennsylvania. The green completes a continuum of open spaces that link across the school's West Philadelphia campus. As a pilot project in the Sustainable SITES Initiative (a certification system the American Society of Landscape Architects is developing in collaboration with the Lady Bird Johnson Wildflower Center at the University of Texas, Austin, and the U. S. Botanic Garden), Shoemaker Green offers a model for sustainable campus design.

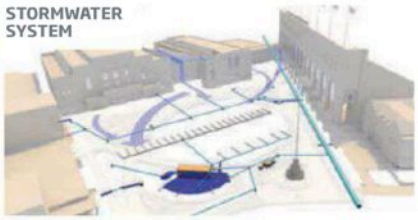
Because the green sits high above a creek buried in an enormous culvert that leads to one of the top five CSO offenders in the city, lessening the burden on that discharge point became a major goal for the project. "Minimizing the water that leaves a site is really nothing new," says Jose Almiñana, principal at Andropogon, landscape architects for the project. "But it takes a systems-thinking approach to make it happen."

The design team's first thought was to peel away some old tennis courts buried beneath the site and allow rainwater to infiltrate the ground. But when percolation tests of the site showed water pouring through at rates of 12 to 15 inches a minute, the team realized they had way too much of a good thing. "Pouring water into a void with no idea where it's going or what it will do when it gets there is not a good idea," Almiñana points out. The team decided instead to opt for the same strategy they would use for a contaminated site: cap the drainage problem by leaving the tennis courts in place and creating a new landscaped covering, treating the whole project as an enormous green roof.

The landscape architects paid close attention to the properties of the various growing media they specified for the site. For effective green infrastructure, as well as healthy plants, soils have to allow rainwater to soak through and encourage the formation of deep root systems. To complete the Green's on-site system, an irrigation cistern adjacent to a large rain garden at the lower portion of the site catches water not immediately taken up by soils and plantings and holds it for their future use.

SHOEMAKER GREEN
A new 3.75-acre public commons at the University of Pennsylvania is designed to reduce the burden on one of the worst CSO offenders in the city. A rigorous monitoring program will generate hard data on green-infrastructure performance.

STORMWATER SYSTEM



EXCAVATION

BARRETT DOHERTY (PHOTO); ANDROPOGON ASSOCIATES (DRAWING)

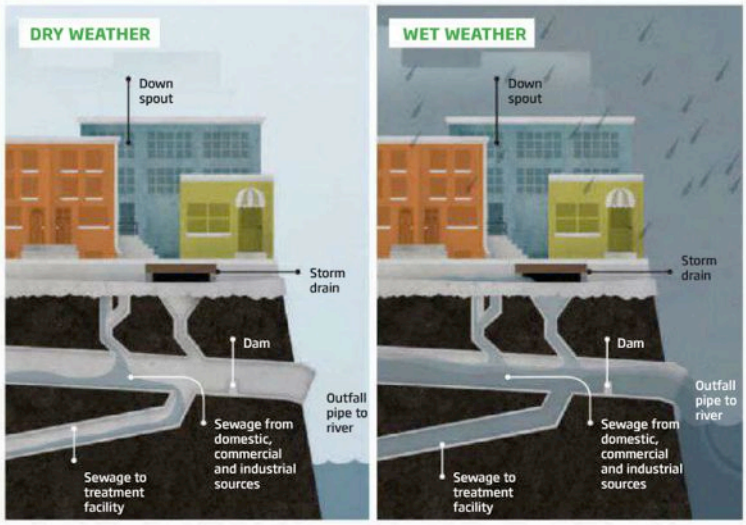
When performance criteria are assigned to a landscape like Shoemaker Green, it becomes part of an operating system. Critical to its success, Almiñana stresses, is maintenance. "You wouldn't have a sewage system without an operator," he says. "If you're not going to be able to maintain and sustain [green infrastructure], then don't use it."

One of Shoemaker Green's most significant contributions to the science of green infrastructure is its five-year monitoring program. These are early days in the understanding of performance landscapes, but quantifying how the landscape at Shoemaker Green works will provide green-infrastructure professionals with rare empirical data.

Andropogon's researchers are still processing data from this year's wet summer, but early indications are impressive. After several inches of rain fell over one 24-hour period, for example, an inspection port showed water still flowing into the cistern five days later. "That lag of time is what soil and vegetative systems create," says Almiñana. "Engineered systems have not been able to perform in this fashion."

TWO IN ONE

Combining sewage and rainwater in a single pipe works just fine—until it rains. Overflow from nearly 800 combined sewer systems across the country dump billions of gallons of contaminated water into oceans, lakes, rivers, and streams.



LEVERAGING PRIVATE INVESTMENT

On-site rainwater management may be a clear choice for public and institutional owners. However, of the 10,000 greened acres projected under the Green City, Clean Waters program, Philadelphia needs an estimated 4,000 acres from the private sector. To achieve that, the city must convince private-property owners that investing in green infrastructure is in their best interest.

"The first thing you need to do is to value the rainwater," says Neukrug. "That's the whole basis of the system. We know what an acre of runoff is worth to us." From there, the Philadelphia Water Department (PWD) has developed a program of regulations and incentives to tie rainwater-management costs to property owners' decisions about how much runoff a site generates.

In 2006, the city enacted legislation to require all new developments and redevelopment projects with more than 15,000 square feet of earth disturbance to manage their first inch of rainfall on-site. This must be done by infiltration wherever technically feasible. Where site conditions require alternative compliance methods, some or all of the first inch must route to an approved rainwater management device such as planter boxes, green roofs, cisterns, or bioretention beds with underdrains, with further restrictions on the rate at which any portion of the first inch may be released into the sewer system. Regulations also govern the release of run-off from larger (one-year, 24-hour) storms. Redevelopment projects can qualify for exemption from these channel-protection and flood-control standards by reducing their impervious area (if directly connected) by at least 20 percent.

The permitting process for new construction requires developers to submit rainwater management plans early in the process, as utilities must. And before a new development receives a building permit, an Operations and Maintenance Agreement describing its rainwater-management commitments is registered against the land deeds of the project, to be kept through subsequent owners, in perpetuity.

This year, Philadelphia completed phasing in a stormwater utility fee for nonresidential properties. No longer buried in a general utility charge based on the property's water meter, the stormwater fee now constitutes a separate line item based on the area of the site's impervious cover, and it applies to properties, such as parking lots, which may not even have a water meter. Property owners who reduce the impervious area of their site qualify for a credit of up to 100 percent of this fee, and, to support property owners wanting to retrofit with green infrastructure, the PWD provides site inspections, design recommendations, and low-interest loans.

Projects disconnecting more than 95 percent of their impervious area from the sewer system can apply for a fast-track review. And projects with a green roof that meets minimum-area criteria are eligible for

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a tax credit of up to 25 percent of the installation cost (up to a $100,000 credit).

Ten years ago, there was only one green roof in Philadelphia. In its 2013 annual report, the PWD reports that it approved tax credits for 18 green roofs this year alone and for a total of 86 since the start of the program. Green roofs are an especially attractive option for buildings that occupy most of their lot, according to Charlie Miller, president of Roofmeadow, an engineering and landscape architecture firm specializing in green roofs.

Neukrug recalls Miller's first visit to City Hall to convince PWD engineers that green roofs could help with their infrastructure problems. "My guys were all sitting there with their arms crossed," Neukrug says, "but they were listening by the end." Since then, Philadelphia's green roof incentives have spawned a local industry with expertise the city can export to municipalities nationwide.

According to Miller, the industry is now bifurcating into making two types of green roofs. On the one hand, there's the compliance green roof, with shallow growing medium and a limited range of plants, which enables a property to meet the criteria for PWD incentives and credits. And on the other hand, there's the green roof with deeper medium, taller and more varied plantings, and visual consequences that can benefit the city at large and demonstrate, says Miller, "how powerful these spaces can be."

As examples of the latter, Miller points to the Kensington High School for the Creative and Performing Arts, which uses different green roof designs to take advantage of microclimates around the building, and the Children's Hospital of Philadelphia New Ambulatory Care Center, now under construction, which will feature two major rooftop landscapes, including a 14,000-square-foot roof garden with paths, lawns, "healing gardens," and water features. At South Philadelphia High School, a master plan now seeking construction funding will create a half-acre rooftop farm, engaging kids in an agricultural world they might otherwise never encounter.

GREENING THE NEIGHBORHOOD GRID

Large lots may be green infrastructure's easiest and most cost-effective sites, but there aren't enough of them to achieve Philadelphia's goal of 10,000 greened acres. Even if every large lot in the city managed its rainwater on-site, green infrastructure would still have to be inserted into the neighborhood street grid, with its multiple owners and small parcels tightly packed with existing infrastructure. "That's the challenge," says OLIN's Roark. "That's what everybody needs to be thinking about."

This year's Soak It Up! design competition, sponsored by the PWD and other partners, challenged design professionals to develop solutions for three different urban retrofitting conditions, one of which was the neighborhood grid. "Meeting Green," the OLIN-led team's winning entry in the neighborhood category, proposes a replicable model

HALKIN/ MASON PHOTOGRAPHY (TOP); M2 ARCHITECTURE (BOTTOM)

STROUD WATER RESEARCH CENTER

RAINWATER AND BEYOND

"Getting the water right" was the Stroud Water Research Center's primary design directive for its new 13,000-square-foot LEED Platinum education and outreach building in Avondale, Pennsylvania. The building's site is independent of municipal water, storm, and sewage systems; the project mandate extended to restoring the hydrological balance of the site as a whole.

To catch and clean runoff from roads and parking lots on the steep stream-side site, the project's integrated-design team, led by M2 Architecture, planned a series of careful interventions, including rain gardens, green roofs, and infiltration beds.

Wastewater is first reduced with the use of composting toilets and low-flow plumbing fixtures, and then treated using an innovative constructed-wetlands system. One of the first such systems in Pennsylvania, the system received a Growing Greener grant from the Commonwealth of Pennsylvania to provide ongoing performance testing.

For drinking, Stroud intends eventually to use filtered and treated rainwater. Until state and federal regulations permit this, Stroud will be testing the quality of its collected rainwater to monitor its safety.

KENSINGTON HIGH SCHOOL FOR THE CREATIVE AND PERFORMING ARTS
Rainwater collection and green roofs contribute to the school's larger intention of creating a bright, hopeful, and healthy learning environment in a distressed neighborhood.

of low-cost green-infrastructure retrofits closely tied to neighborhood improvements and social capital. (*The Infill Philadelphia: Soak It Up!* exhibition will feature this entry among others at City Hall from October 7 through December 7.)

Focusing on Queen Village, one of Philadelphia's oldest residential neighborhoods, the Meeting Green scheme is structured around centers where commercial activity, public space, and community use come together, providing the ideal setting for green-infrastructure-based improvements. These are to be connected by pedestrian-friendly avenues and finer-scaled walks and nodes that all rely on green infrastructure, a twofer repairing the ecosystem while strengthening the urban fabric.

The Meeting Green concept also proposes an "Office of Green Neighborhoods" to build the political capacity for the initiative. This would be "a kind of Quaker philosophy–based approach," says Roark. The new office would facilitate liaisons between the PWD, community leaders, and local experts to help identify the best sites, funding mechanisms, and incentives for green infrastructure retrofitting, and to foster public support for the plan.

The inclusion of this political component points to the reality that the physical mechanisms of green infrastructure are not the only, or even the primary, challenge to implementing the Green City, Clean Waters Program. Not surprisingly, the politics and administration of a massive city-wide green infrastructure retrofit pose much more of a challenge than the design and construction of it.

"If this was just a technical thing, life would be so easy," says Chris Crocket, deputy commissioner with the PWD, to whom the Office of Watersheds and the Green Cities, Clean Waters Program report. "Ninety-nine percent of my problems come from policies, procedures, and protocols, all the things it takes so that we know we can build it and prove it will do what we say it will."

And so the PWD's 2013 annual report includes not only such practical achievements as 207 greened acres constructed and a further 200 designed, two miles of streams restored, three stormwater treatment wetlands constructed, and Philadelphia's first porous street implemented. It also cites achievements in administration and facilitation, such as a Green Streets Design Manual, a 50-foot stream buffer zone secured in the Philadelphia Zoning Code, full implementation of the Parcel Based Stormwater Billing Program, an EPA-secured multimillion dollar investment for green stormwater infrastructure research, and a bevy of plans for further implementation and monitoring.

Despite all these accomplishments, Commissioner Neukrug admits the city still has a long way to go. "We're just starting," he says . "The bottom line is, we need to get people to value something they always considered free: rainwater. And that's a big change." GS

SMP ARCHITECTS (PLAN); HALKIN/MASON PHOTOGRAPHY (PHOTO)