# City parks, clean water

## Making great places using green infrastructure

THE TRUST FOR PUBLIC LAND

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The Trust for Public Land

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The Trust for Public Land creates parks and protects land for people, ensuring healthy, livable communities for generations to come.

Our Center for City Park Excellence helps make cities more successful through the renewal and creation of parks for their social, ecological, and economic benefits to residents and visitors alike.

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# Table of contents



## Case Studies



## Boxes

## Glossary: some key terms

### Bioretention

The process by which vegetation and soil naturally slow down or capture sediment, nutrients, oils, and other pollutants commonly found in stormwater runoff. Bioretention areas are sometimes called "rain gardens."

### Combined sewer system

A network of pipes that carry a combination of domestic sewage, industrial wastewater and stormwater runoff to a municipal treatment facility. In dry weather the system works well, but the huge volume from a rainstorm or snowmelt may overwhelm the capacity, and untreated commingled wastewater may get dumped directly into a waterway or ocean. The discharges are called "combined sewer overflows," and the point where the wastewater enters a waterway is a "combined sewer outfall." Most older cities still have neighborhoods with combined sewer systems and are under orders to separate them.

### Consent decree

A negotiated settlement between the Environmental Protection Agency, state regulatory agency, and municipality (or sewer district) that provides a framework for local compliance with pollution regulations under the Clean Water Act. The resulting long-term control plan charts steps to bring water quality into compliance, often over several decades.

### Permeable pavement

Engineered surfaces designed to function like standard construction materials while still allowing stormwater to pass into the ground. Materials can include asphalt, concrete, and spaced paver blocks.

### Phytoremediation

Technique for cleaning stormwater runoff and soils, relying on trees and plants to take up and hold or neutralize pollutants, especially heavy metals or nutrients.

### Rain gardens

Sunken, carefully vegetated areas with permeable soil that hold and clean runoff before it percolates into groundwater or evaporates.

### Retention and detention ponds

Two contrasting stormwater management facilities. Retention ponds have hard bottoms and retain stormwater for later reuse; they are usually wet, even in dry periods. Detention ponds have soft bottoms and detain stormwater so that it can percolate down to an aquifer; in dry periods they are dry.

### Structured soils

Artificially created mixtures that provide better drainage, more load strength, or other benefits over existing soils.

### Swales

Soft-bottomed, grassy, linear channels that direct stormwater runoff to rain gardens, holding basins, or, sometimes, the sewer system. Vegetated swales, also known as "bioswales," are more thickly planted and can partially treat flowing stormwater by removing silt and pollutants.

### Wetlands

Watery, low-lying areas that slow and hold stormwater, filter out contaminants, and soften the impact of storm surges. Also known as swamps, bogs, or marshes.

# Introduction

The effort to clean our nation's waterways has been underway, with increasing strength, for more than 50 years (see Box 1). Great progress has been made, particularly against pollution from untreated sewage and unregulated factories. Rivers no longer catch on fire, oil slicks are a rarity, and most raw discharge pipes have been eliminated. But in cities there remains work to be done, with most urban waterways still not clean, not swimmable, not safely fishable, sometimes not even pleasantly boatable.

The primary culprit is pollution from rain and snow runoff.

The problem is not the rain and snow itself. The problem is too many paved surfaces — streets, sidewalks, driveways, parking lots, roofs, patios, plazas, even playgrounds that quickly shed the rain. The solution is to hold back the water where it hits, slow it down so that the destructiveness of erosion and contaminants is controlled, and clean it before it reaches a waterway. But with two different methods of doing this — using giant holding tanks for storage or a natural, spongier approach for infiltration — the U.S. is at a critical decision point in how it will allocate billions of dollars in the coming decades. Will we spend the money on vast numbers of constructed vaults, pipes, tunnels, or chambers? Or will we steer the water away from drains and let it percolate and absorb into natural, soil-based surfaces?

The soil-based approach is often characterized as "green infrastructure," a loosely-defined term for landscape elements that utilize or mimic natural systems relating to water and energy. The phrase is generally contrasted with "gray infrastructure," which relies on a constructed system of pipes and mechanical devices to capture and convey runoff. In some documents, "green infrastructure" refers to the regional-scale preservation of large swaths of conservation lands, but in this report the term is limited to specific, small-scale management techniques to preserve and restore the natural capacity of land to slow, filter, and absorb stormwater.

To make the decision between gray and green the nation has to be realistic about the opportunities and possibilities. Do both approaches work equally well? Is one less expensive? Can they be combined? Are residents willing to put up with years of tunneling under their neighborhoods? Conversely, does the city have enough unbuilt land to capture water on the surface?

In cities, water-capturing surfaces are often somewhat scarce, located primarily in four places: in private yards, in campuses of various types, alongside public roadways — and within public parks.

Parks already play a significant role in absorbing stormwater since they comprise 2 percent, 5 percent, 10 percent or even more of every city's land area (see Box 2). Thus far, most of these lands capture only the rain and snow that falls directly on them, but the systems could theoretically do much more. While not every city park can be legitimately termed "green" (some are not even porous, such as paved playgrounds and plazas), these disparate spaces are potentially the sites of great new "water-smart parks" that treat runoff as a multiple-benefit asset.

On the other hand, urban parks have numerous other benefits to cities and their residents, some of which may not be fully compatible

BOX 1

## Green infrastructure and the Environmental Protection Agency

THE RUNOFF PROBLEM started attracting notice in the 1950s, and tentative steps at remediation began with the federal Clean Water Act of 1972. That law empowered the U.S. Environmental Protection Agency (EPA) to set and enforce water quality standards not only for factories but also for municipal sewer systems, many of which were designed to combine street runoff with household sanitary waste but to overflow into waterways in the event of larger, unmanageable storms. (Today there are still some 860 communities, primarily in the Northeast, Midwest, and Pacific Northwest, served largely by combined sewer systems.)

EPA has taken a hard line on combined sewer overflows since the early 1990s. Working with state regulators, the agency has initiated legal proceedings against non-complying communities. The resulting agreements, known as consent decrees, have resulted in long-term control plans requiring scores of cities to collectively spend more than $100 billion in the coming decades to add capacity to sewer systems and manage urban stormwater runoff. This huge mandate has city officials anxiously looking for any and every available method to comply, including the use of green infrastructure on public parklands.

With EPA formally endorsing the use of green infrastructure in 2007, cities have been formally revising their compliance plans to replace gray with green where appropriate. (In 2015 the agency even sent back a Pittsburgh control plan for not incorporating enough of the natural techniques.) Both approaches are subject to equally strict accountability measures and reporting requirements, and non-compliance can result in stiff fines.

For many cities, making double-use of some public lands for managing runoff is a cost-effective alternative to traditional gray infrastructure. Some park agencies are doing it even without the stipulations of a consent decree. "It's the right thing to do," said Nette Compton, former director of green infrastructure for the New York City Parks and Recreation Department. "Landscape architects and engineers have been inspired to develop better expertise, and every city can benefit from these innovations."

with absorbing and holding large quantities of water. Could fields become too soggy for sports and recreation? Might playgrounds lose too much space to fenced-off rain gardens? Some skeptics worry that rain gardens might deteriorate into unattractiveness. Others fear an increase in mosquitoes. Still others fret that pervious paving could buckle under heavy usage. Many of these theoretical worries never come to pass, but they can also represent emotional and political roadblocks to moving forward. The opportunities for cost-saving, win-win solutions are enormous, but there may also be a risk of unanticipated side-effects, especially when design and planning of these systems does not account for the other uses of park space.

The goal, then, is to maximize benefits while minimizing drawbacks – and to use the synergies to reduce costs.

The Trust for Public Land is already deeply involved in the intersection of parks and stormwater management, consulting with cities to reduce flooding, mapping opportunities to counter the effects of rapid urbanization that has paved formerly porous land, and showing citizens how to get involved in the political process.

The Trust for Public Land has physically built water-absorbing parks, from New York and Philadelphia to San Francisco and Los Angeles, and it is an official partner of the U.S. Environmental Protection Agency through the Green Infrastructure Collaborative, a learning alliance to share best practices among national organizations.

This study shines a light on the successes and challenges of water-smart parks, looking both at the technologies and the political issues involved in using green infrastructure to make our cities more desirable, more livable, and more successful.

## BOX 2. PUBLIC PARKLAND AS PERCENT OF CITY AREA

SELECTED CITIES

| CITY | PARKLAND (ACRES) | PERCENT PARKLAND |
|---|---|---|
| Albuquerque | 27,438 | 24% |
| San Diego | 46,168 | 22 |
| Washington, D.C. | 8,525 | 22 |
| San Francisco | 5,693 | 19 |
| Boston | 4,956 | 17 |
| St. Paul | 4,932 | 15 |
| Austin | 27,248 | 15 |
| Omaha | 10,621 | 14 |
| Los Angeles | 38,822 | 13 |
| Seattle | 6,590 | 12 |
| Chicago | 12,588 | 9 |
| Kansas City | 17,683 | 9 |
| Corpus Christi | 8,036 | 8 |
| Denver | 5,957 | 8 |
| Tampa | 4,818 | 7 |
| Atlanta | 4,990 | 6 |
| Orlando | 2,974 | 5 |
| Indianapolis | 11,464 | 5 |
| Tucson | 4,369 | 3 |
| North Las Vegas | 859 | 1 |
| **Total, 100 largest cities** | **1,829,283** | |
| **Median, 100 largest U.S. cities** | | **8%** |

Parkland includes city, county, metro, state, and federal acres within city limits.

# The problem

Because of the vast expanse of impervious streets and rooftops, every city generates much more runoff than would an equivalent area of undisturbed forest or meadow. Even grass-covered urban playing fields and backyards can be surprisingly impervious, thanks to soil compaction from the pounding of thousands of users.

Historically, of course, cities paved their roadways, sidewalks, trails, parking lots, sports courts, alleys, driveways, and other surfaces to reduce the annoyance and cost of slippery mud and blowing dust. Unfortunately, having so many hard, water-repelling surfaces (along with a vast sweep of urban rooftops) is ecologically detrimental. Among the negatives:

- most stormwater cannot reach and replenish groundwater
- runoff escapes natural cleansing by plants and soil (known as bioretention and phytoremediation)
- urban streams become prone to flash flooding from rapid runoff, resulting in severe scouring, erosion, and reduction of biodiversity
- flooding becomes more common
- stormwater, which is generally clean enough for a variety of productive uses, gets treated as a waste product, overburdening sewage treatment plants.

In a nutshell, from the ecological perspective, the less runoff — and the slower the runoff —

FLICKR/CLINT MIDWESTWOOD

Stormwater runoff from paved surfaces can make urban streams prone to flash flooding and erosion; it also reduces biodiversity.

## BOX 3. PARKLAND DESIGNED FOR FLOODING
SELECTED CITIES

| CITY | ACRES OF PARKLAND THAT REGULARLY FLOOD |
|---|---|
| Austin | 2,913 |
| Baltimore | 23 |
| Boston | 50 |
| Cincinnati | 200 |
| Denver | 1,500 |
| Detroit | 600 |
| Fort Wayne | 900 |
| Kansas City | 142 |
| Los Angeles | 1,800 |
| Lubbock | 324 |
| Madison | 300 |
| Memphis | 400 |
| Minneapolis | 200 |
| Nashville | 1,132 |
| Orlando | 6 |
| Plano | 1,722 |
| Scottsdale | 415 |
| Virginia Beach | 300 |

the less damage there is to water bodies and the environment. Whether fully capturing stormwater or merely keeping it from racing away too quickly, cities should strive to "hold every raindrop where it falls." However, in very densely developed areas that's not always practical or affordable. Sometimes a more efficient approach is to make use of larger collection sites such as portions of parklands, or even to create new parks specifically to capture water.

Parks need water. In many cases they must make do with what normally falls directly on them, just like any other natural system. Thus, natural areas become green (and sometimes muddy) in the rainy season, dry (and sometimes brown and dusty) at other times, and they occasionally suffer the damaging effects of droughts or floods.  In some circumstances — smaller, high-profile parks with much-beloved trees and horticulture, or heavily-used sports fields — cities resort to complex irrigation and drainage systems to ward off the extremes of nature. But drainage and irrigation are expensive to install and maintain. Irrigation can also be wasteful since it commonly uses water that has been purified to a drinking standard.

To the extent that some excess water from the surrounding neighborhood can be directed into a park, or runoff generated within a park can be kept there, the result can be doubly beneficial: the city sends less water down the sewer to an expensive treatment plant or to a polluted water body, and the park receives more water for storage and use in dry periods. There are caveats, however. The water must be relatively clean. The flow must be controlled so that it doesn't cause erosion and siltation. And, of course, the system must be designed to handle occasional flooding safely.

Parks have been capturing stormwater from the beginning, often unintentionally through vegetation and porous soils, sometimes purposefully through such large-scale projects as Frederick Law Olmsted's 1885 redesign of Boston's Muddy River to deal with festering mudflats and flooding. But the movement ebbed and flowed, mirroring the changing philosophies of water handling over the decades, and for much of the 20th century the dominant strategy was to move water downstream as quickly as possible. That anti-ecological approach is now being upended, and a new generation of stormwater capture techniques is being pioneered, with some city park agencies leading the way (see Box 3). In a 2014 survey by The Trust for Public Land, 82 percent of responding agencies reported that they have created at least one stormwater capture facility, and the collective acreage of these early efforts is already in the thousands.

# The different goals

Parks and clean water are both public goods of the highest order, and combining the two offers great opportunities for collaboration. In the simplest terms, water management requires space, and parkland is a leading resource of space in cities. Conversely, park maintenance requires money, and water utilities have a steady, predictable source of revenue through residential and business water fees.

Nevertheless, there are challenges that sometimes interfere with partnering. For one thing, stormwater has a complex range of impacts, and the techniques for dealing with those impacts are not easy to carry out, or even to explain to the public. For another, there are many different kinds of park users who have vastly different opinions about what makes a park great and what degrades it.

From the perspective of water agencies, there are four principal goals, each of which can play out in a public park:

- **REDUCING STREAM POLLUTION BY HOLDING AND SLOWING WATER.** Bioswales, rain gardens, and vegetated buffer strips in parks can detain stormwater so that a downpour doesn't wash out large quantities of sediment and pollutants. The swales also filter out chemicals, animal waste, oils, and heavy metals and improve the quality of the runoff. An underground holding tank could do the same job expensively and disruptively, but utilizing a large natural or man-made depression in a park might be a better solution if it is sensitively and attractively designed to function in both wet and dry situations. One of the nation's preeminent examples is Atlanta's Historic

PETER HARNIK

It's "infrastructure" and the field is "green," but this is not the way to deal with stormwater in a park. Metal drains constitute a hazard to sports players, they spirit away water that would otherwise nourish the lawn, and they add unnecessary runoff to a city's already overburdened sewer system.

CASE STUDY

## Historic Fourth Ward Park, Atlanta

One of the nation's most celebrated marriages of recreation and green infrastructure, Atlanta's Historic Fourth Ward Park is a $23-million triumph of engineering over flooding and landscape design over stop-gap asphalt.

The central stream of the old Fourth Ward, Clear Creek, was less known for clarity than for flooding. This was particularly true around the huge Sears warehouse (once the largest brick building in the Southeast), the basement of which was wet ever since it was constructed in 1926. After Sears vacated in 1989, the situation got worse: Atlanta bought it for an annex to City Hall, so the documents mildewing in the lower levels were public records.

At about the same time, as part of a legal settlement with the U.S. Environmental Protection Agency, Atlanta agreed to spend millions of dollars to end pollution of the Chattahoochee River, which entailed doing something about the storm sewer along Clear Creek. The initial concept was to dig a gigantic underground tunnel and channel stormwater to a processing plant before sending the cleaned residue to the river, but the cost was projected at $40 million. Some years earlier an engineer-economist named Bill Eisenhauer had come up with an alternative approach. Calculating the amount of stormwater needed to be held back, the amount of space that would be required, and the cost of assembling land in various communities, he hit upon the idea of a storage pond in a ramshackle industrial strip just upstream from the Sears warehouse. Eisenhauer had good organizing skills – he had earlier successfully led the opposition to building a sewage treatment plant in Piedmont Park – but his idea didn't gain traction until local architect Markham Smith heard about it.

"From the mayor on down," said Smith, "the city had already committed to the massive pipe, and I thought promoting an alternative would be insurmountable. But there was one glimmer of hope. Most of the underutilized land was held by major property owners who might be able to gain from improvements in the area. The neighborhood had undergone a terrible downward transition since the 1960s – it was blighted. I said to Bill, 'This needs to be not a holding pond but something much bigger – greenspace for community redevelopment with a water conservation element.' It had to work for both people and nature."

It was a breakthrough, but even that might not have been enough if it weren't for other stars aligning in 2004. For one thing, the city owned one of the parcels. For another, the area was crossed by abandoned railroad tracks – just at the moment that the new concept of a "Beltline" of light-rail transit, bike trails, parks and housing was gaining attention. Third, the Jamestown Construction Co. had purchased the Sears building for a huge redevelopment project that hinged partly on solving the flooding problem in the basement. Lastly, the real estate market was extremely hot and properties in the area were finally desirable.

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"Everyone liked the park in concept but no one wanted to take the lead," said Smith. "We were willing to lead, but we couldn't because we didn't have control over any property. We finally found a little milk storage warehouse right in the epicenter of the drainage, got an option on it, and went to The Trust for Public Land. TPL liked the concept and took an enormous risk by buying the property. It turned out to be the first purchase of the entire Atlanta BeltLine. We then started working three-way deals with the city and with developers – they would get a rezoning and part of a property for housing if they would leave TPL the rest for the park. It was done on a wing and a prayer. We were showing them a design for a park that didn't exist, that hadn't been approved by the city, and for which there was no money – and they were enthusiastic."

By 2008, 17 acres had been assembled. Phase I of the park was the 5-acre pond, set deeply into a bowl below the water table. Phase II was the 12 surrounding acres of landscaped walkways, bridges, observation points, walls, splashpad, and playground. Phase III was a skatepark and a grassy field. Starting in January, 2009, the effort was turned over to Kevin Burke, senior landscape architect for Atlanta BeltLine, Inc.

"From the water perspective, the park is actually overdesigned," said Burke. "It can handle a 500-year flood. We're in the position where the city has even allowed two additional developers to tie their runoff into the pond."

The park does not infiltrate or clean the water flowing in from the 300-acre subdrainage; it simply gets detained. With a gradual and manageable outflow over a 24-to-36-hour period after a storm, this consistent volume then travels steadily to the city's sewage treatment plant. (Ironically, since the park is built over a natural spring, it happens to generate water even without a storm; the combination of the spring plus artificial fountains and an ornamental stream keeps the pond aerated and circulating

DARCY KIEFEL

without an algae or a mosquito problem.) The pond also provides water for irrigation so that potable water is not wasted on plants.

As for clean-up after any storm that raises the level of the pond, a city parks department crew removes debris, cleans out the drainage basins, and power-washes any sediment away. However, the park definitely requires attention.

"Fourth Ward Park is very high maintenance," said Esther Stokes, chair of the maintenance committee of the Historic Fourth Ward Park Conservancy. "Part of its charm comes from the many shrub species and the many different grass species, but it's hard for the staff to deal with all those factors. The park department is underfunded, which is why the conservancy partners with them. We recently hired a company to do deep core aeration and fertilization. We also work with different companies to each adopt one of the park's seven zones."

Doug Voss, director of parks at the Atlanta Department of Parks, Recreation and Cultural Affairs, explained some of the details. "Rather than removing invasives by hand, we use pine straw as mulch — a lot of pine straw, 1,000 bales worth. We get volunteers to put it down at an event called 'Pinestrawpalooza.' It works well, but when the water gets high the bowl fills up, and straw mulch drifts everywhere. That's when we have to clear out all the drains and catch basins."

Despite the challenges, the park is well worth it.

"It's a prodigious economic engine," the Beltline's Burke concluded. "The Jamestown Company didn't decide to go ahead with its Ponce City Market project until the pond had been built and proven. Once that happened, they committed $250 million. That was followed, soon thereafter, with another $150 million of new development."

Fourth Ward Park (see Case study, page 11), which not only solved stormwater problems but also serves as a powerful engine for housing and economic development in its neighborhood.

- **PREVENTING LOCALIZED FLOODING.** Flooding is a catastrophic and expensive problem—from 2005 to 2014, U.S. flood insurance claims averaged more than $3.5 billion per year. Beyond the death and destruction, frequent flooding angers residents, riles politicians and can even cause the exodus of commercial enterprises. In the worst low-lying situations, the most cost-effective solution may be to remove structures and turn the area into parkland that periodically inundates. With less severe cases, it may be practical to direct some of the upstream stormwater into a nearby park. Doing this sensitively could even result in a park with more visual interest, greater beauty, more ecological diversity and even, as in Alewife Stormwater Wetland (see Case study, page 16), better public access. However, since water engineers and storm sewer districts don't always have a mandate for public access or beauty, such a project must be designed by outstanding landscape architects with the active involvement of the park community.

- **RECHARGING GROUNDWATER.** Allowing rain to percolate into the soil is critical since groundwater is the nation's major source for drinking and irrigation. It's particularly important in western states (where water is scarce) and in coastal communities (where overdrawn aquifers get filled by the salty ocean). Los Angeles's Tujunga Wash Greenway, for example, diverts water from a concrete channel into a meandering re-created natural streambed, allowing it to percolate into the depleted aquifer.

- **PROVIDING SEWER RATE-PAYERS WITH MORE VISIBLE AND TANGIBLE BENEFITS.** Although traditional gray infrastructure can successfully transport and treat stormwater, it is expensive and provides only the unitary benefit of pollution conveyance. In contrast, green infrastructure in parks provides multiple benefits that are visible, usable, and enjoyable to the public that is paying the bills.

Conversely, from the perspective of park agencies, there are two major goals — improving ecological function and reducing costs — that can be furthered by collaboration with stormwater utilities. These can take several forms:

- **CONTRIBUTING TO IMPROVED PARK HYDROLOGY.** In hilly cities, water racing into parks can not only flood playing fields and undermine trees, but also wash out streams and dump sediment downstream. Since every new swale and detention pond slows the runoff and reduces the burden on waterways and treatment plants, it may be cost-effective for stormwater utilities to help pay for these improvements on parkland. Moreover, these features can serve as attractive, ecological alternatives to the wasteful and dangerous practice of putting drains in the middle of grassy recreational fields.

- **SAVING MONEY ON IRRIGATION.** Just like private citizens, many park agencies have to pay for water. (Even if the bill is picked up by the government at large, it's still a cost to taxpayers.) This expense is often substantial — in San Diego it came to more than $12 million in 2013 and in Chicago $10 million (see Box 4). Even where fees are lower, the tab is rising rapidly. Beyond that, some agencies pay a stormwater or drainage fee to a sewer agency based on the size of their property holdings and the percent of their impermeable land. Therefore, the less water sent down the drain, the more water is available to feed the parks — and the more funds are freed up for programming and other needs. Even better are situations where park departments are financially rewarded for saving water. According to a 2014 Trust for Public Land survey, about 14 percent of park agencies, including those in Seattle, Minneapolis, and Cincinnati, are given a rebate for water that parks treat and manage, keeping it

### BOX 4. SELECTED PARK AGENCY WATER BILLS 2013–2014

| | |
|---|---|
| San Diego | $12,238,433 |
| Chicago | 10,000,000 |
| Detroit | 7,560,000 |
| Los Angeles | 7,078,000 |
| San Francisco | 5,200,000 |
| Tucson | 3,011,000 |
| Colorado Springs | 3,000,000 |
| Aurora | 2,900,000 |
| Denver | 2,800,000 |
| Mesa | 2,789,120 |
| Seattle | 2,659,297 |
| Austin | 1,920,302 |
| El Paso | 1,500,000 |
| Phoenix | 1,300,000 |
| Scottsdale | 1,191,746 |
| Reno | 1,030,001 |
| Nashville | 700,000 |
| Boston | 621,798 |
| St. Petersburg | 426,706 |
| Orlando | 305,000 |
| Anchorage | 147,612 |
| Madison | 130,403 |
| Boise | 82,609 |

Source: The Trust for Public Land

WATER EDUCATION FOUNDATION

The Tujunga Wash Greenway recreates a historic streambed in Los Angeles. The concrete flood channel (left, beyond the trail) remains in place to handle water from large storms.

out of the sewer system. This arrangement gives the agencies a financial incentive to creatively modify some of their parkland.

Beyond the multiple agency goals, there are also citizen issues that can make compromise challenging. Both water systems and recreation are highly complex topics that have their own languages, acronyms, and nuances, so even public conversations can be difficult — from slope analysis to children's safety, water infiltration rates to insect gestation periods, plant selection to tree removal, reconfigured soil to artificial turf. The historical separation of the recreation profession from the stormwater business means that many park and water agencies are new to the interplay of issues that might arise. Also, cities by definition are dense places; trade-offs that might be easy where the spaces are wide open can become more difficult where every acre counts and each group has an agenda.

Ultimately it is critical to define objectives. Is the goal merely to keep the park from shedding the water that directly lands on it? Or is it to do more — to bring in offsite water to help manage larger neighborhood runoff? Is the park roomy enough to give up space to a rain garden? Would other uses be curtailed or rearranged? Or would more land need to be acquired?

CASE STUDY

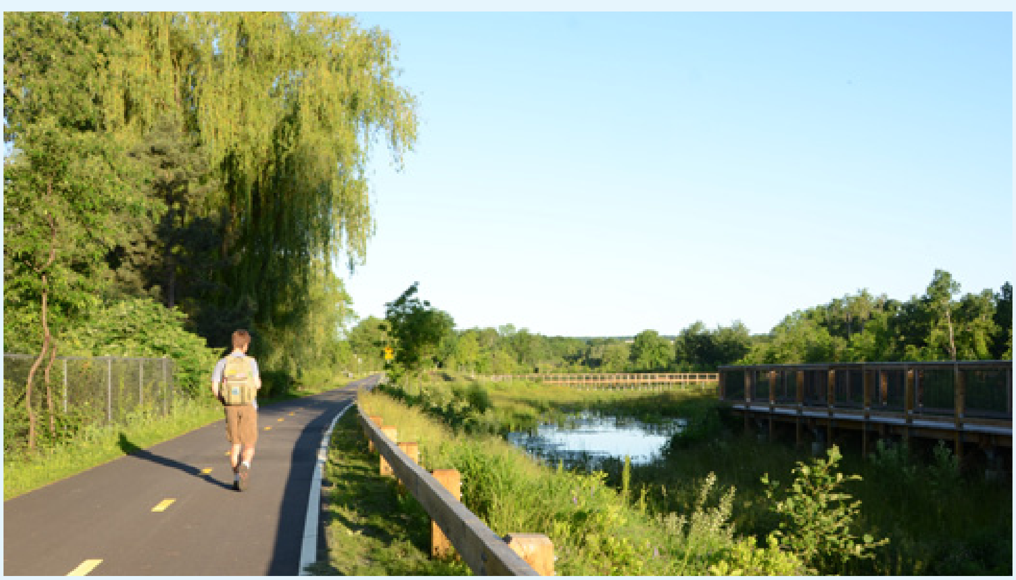
## Alewife Stormwater Wetland, Cambridge, Mass.

Before the development of today's Massachusetts communities of Cambridge, Arlington, Medford, and Somerville, the area was a low-lying, spongy wetland. Over the years its ecology was severely disrupted by dredging, mining, and dumping, and most of the land – which once protected the water quality and modulated the flow of Little River, Alewife Brook, and the Mystic River – has since been developed for housing and industry. However, back in the 1890s the Commonwealth of Massachusetts had the foresight to preserve 130 natural acres, now managed as the Alewife Reservation by the Department of Conservation and Recreation (DCR).

Unfortunately, with DCR's severe underfunding, by the 1990s the Alewife Reservation was derelict land, overgrown with invasive plants, lightly visited by wildlife, home to some sturdy indigents, and shunned by most everyone else. But when the city and the state came under court order to end the pollution of Boston Harbor through the separation of sanitary and storm sewers, the reservation presented itself as an outstanding potential solution.

"Until we started talking about stormwater capture, hardly anyone even knew there was a stream down there," said Catherine Woodbury, a project manager with the Cambridge Department of Public Works.

Historically, the Alewife basin posed a huge stormwater problem for residents and the state. In the 1980s, that one basin had an average of 63 sewer overflows per year that dumped about 53 million gallons of raw sewage into the brook. Roadway flooding and sewer backups occurred regularly, even with storms as relatively small as two-year events. Larger storms caused such bad flooding that the city's nearby drinking water reservoir itself was compromised. But utilizing a green infrastructure approach was not the state's initial impulse.



CHESTER ENGINEERS

"The Massachusetts Water Resources Authority (MWRA) came to us asking to put a giant underground concrete cistern in the Alewife Reservation," said Dan Driscoll, director of recreational facilities planning and design for DCR. "We didn't like that idea at all. We said, 'Is there some way we can make this stormwater work with the environment rather than against it?' They said, 'Can you handle 3 million gallons at one shot?' We said, 'Let's find out.' We hired a bioengineering firm to do the analysis and undertake public outreach."

DCR had an additional agenda in mind. Long cognizant of the reservation's shortcomings as an urban park, the department in 2003 had produced an ambitious master plan calling for a bikeway, a lengthy boardwalk, a bridge, the removal of polluted soils and invasive plants, and replanting with appropriate plants, at a price tag of about $3 million — money it didn't have. As mitigation for using Alewife as a stormwater wetland, DCR asked the sewer authority to pay for those upgrades. When the bioengineering numbers came back looking good, the MWRA agreed to the extra expenses. But just then, thanks to the public discussion, some fierce opposition arose.

"They thought it was an inappropriate use of parkland," Driscoll said. "They appealed under the wetland protection act. It was a group of only about 10 people, and they lost in every court, but it held things up for four-and-a-half years."

"Defending against the opponents in court cost the city of Cambridge $4.5 million," said William Pisano, a principal with MWH Global, which engineered the wetland. "Beyond that, I calculated that during those years of delay there was enough sewer overflow to cover the entire city of Cambridge to a depth of seven inches."

The opponents finally ran out of money, but the tricky engineering itself was also time-consuming. The designers not only wanted millions of gallons of stormwater to enter the wetland, but they needed the water to slow down and drop its suspended sediment. They also had to provide an escape route in the case of too much water. And they had to provide a "reverse" mechanism during times of drought so that water from the wetland could keep at least a trickle in the brook to maintain fish habitat.

The park agency got one more benefit from the multi-agency arrangement: the city of Cambridge agreed to operate and maintain the area by sweeping streets and cleaning sediment from filters. "We worked out a really great operations and maintenance process," said DCR's Driscoll. "This level of maintenance is definitely something we would not have been able to afford on our own."

"It's been a great partnership," said Cambridge's Woodbury, "DCR provided 3.4 acres of bottom land, the city and the Metropolitan Water Resources Authority shared in the $17 million cost of construction and utility relocation, and Cambridge got much less flooding and a cleaner river."

"Best of all are the people coming from all over to use the park," concluded MWH's Pisano. "They showed up from the very first day, and they tell us how much they love it. Going out there on the trail now is like walking through a Monet painting."

# The different solutions and how they work

There is no simple formula for green infrastructure in parks. For one thing, geography alone dictates that there are dozens of different kinds of urban parks, from narrow streamside greenways to large flat forestlands, from stepped brick plazas to lush community gardens, from windswept hilltop viewpoints to massive sports complexes. For another, each park has its own history and culture, resulting in different political responses to ideas for designs to manage stormwater.

In grossest terms, when it comes to water-smart parks, there are three principal issues to be considered:

- **PHYSICAL RELATIONSHIP.** Is the physical relationship of the park to the surrounding community such that a redesign could reduce neighborhood flooding or the pollution of downstream waterways?
- **AVAILABLE SPACE.** Does the park have any available space for water flow and storage?
- **ABSORPTION.** Is the composition of the existing soils, water table and underlying rock such that the park can absorb a significant amount of water in the necessary amount of time?

There are two overarching methods of slowing water: holding it for conventional treatment, or using natural processes to percolate it through the soil.

A 2014 survey by The Trust for Public Land revealed that 48 major cities have constructed or modified more than 5,000 acres of parkland in one way or another to control stormwater (see Box 5).

Detaining stormwater for conventional treatment is only "half green" — it's a method that helps prevent sewer overflows and flooding, but it still treats runoff as waste by keeping it out of the soil, sending it through traditional physical and chemical treatment processes, and eventually discharging it into a waterway. The "fully green" way of handling stormwater approaches it as a resource, using soil, plants, and microbes, diverting it from the sewer system, and returning it directly to the ground.

The broad set of strategies ranges from using highly engineered, human-made systems to simply guiding water flow and enhancing natural processes. While not without costs, green infrastructure is relatively inexpensive (see Box 6). Mostly, cities use a mix of techniques, complementing lower-cost green infrastructure with more expensive and more familiar gray infrastructure. A large rain garden installation, for instance, will usually have an overflow drain connecting to the traditional storm sewer system in the event of a deluge.

## Creating new parks

When it comes to green infrastructure, the easiest parks to work with are new ones — facilities that don't yet exist and can be specifically designed with stormwater management in mind. Depending on available financial resources, the land is regraded to the optimal slope and shape, a proper sub-base is installed, engineered soil is added to increase absorption, and plant materials are selected specifically to manage stormwater.

The best of these new projects find inspiration from the original geography and natural history of the site. Railroad Park, 19 acres of former tracks in Birmingham, Alabama, is

## BOX 5. STORMWATER CAPTURE – ACRES AND METHODS USED

PRIMARY MUNICIPAL PARK AGENCIES, SELECTED CITIES, 2014

| CITY | PARK ACRES DESIGNED OR REDESIGNED | RAIN GARDENS AND SWALES | RESTORED STREAMS | CONSTRUCTED WETLANDS | GREEN ROOFS | PERMEABLE PAVING | RETENTION | DETENTION BASINS | STORMWATER REUSE |
|---|---|---|---|---|---|---|---|---|---|
| Anchorage | N.A. | x | | | | x | x | x | |
| Arlington, TX | 200 | x | x | x | | x | | | x |
| Arlington, VA | 10 | | | | | x | x | | |
| Aurora | 133 | x | | | | | | | |
| Austin | N.A. | x | | | | | | x | x |
| Bakersfield | 14 | | x | x | | x | | | |
| Baltimore | 100 | | | | | | | | |
| Baton Rouge | 16 | x | | | | x | | x | |
| Boise | 65 | x | | x | | | | | |
| Boston | 10 | x | | | | | | | |
| Chesapeake | 20 | | | | | | x | | |
| Chicago | 572 | x | | x | x | x | | x | x |
| Cincinnati | 84 | x | | x | | | | x | |
| Colorado Springs | 5 | | | x | | | | | |
| Denver | N.A. | x | | x | | | x | x | |
| Detroit | 10 | x | | | | x | | | |
| Durham | 200 | | x | x | | | | | |
| El Paso | 24 | | | | | | | x | |
| Fort Wayne | N.A. | x | | | | | x | | |
| Gilbert | 140 | | | | | | | x | |
| Kansas City | 1 | x | | | | | | | |
| Lexington | 10 | x | | | | | x | | |
| Los Angeles | N.A. | x | | | x | x | x | | |
| Louisville | 200 | x | | | | | x | x | |
| Lubbock | 125 | | | | | | x | | |
| Madison | 400 | x | | | | | x | | |
| Mesa | 730 | | | | | | | | |
| Miami | N.A. | x | | | | x | x | x | |
| Milwaukee | 12 | x | | x | x | x | | x | x |
| Minneapolis | 50 | x | | | | | x | | |
| Nashville | N.A. | x | | | | x | x | | |
| New Orleans | 48 | x | | | | | x | x | |
| New York | 120 | x | x | x | | x | x | x | |
| Norfolk | 3 | | | x | | | | | |
| Orlando | 100 | x | | | | | x | x | |
| Plano | 50 | x | x | | | | | | |
| Raleigh | N.A. | x | | | | x | x | x | |
| Reno | 1 | x | | | | x | | | x |
| Sacramento | 17 | | | | | | x | | |
| San Diego | 1 | x | | | | x | | | |
| San Francisco | 25 | x | | | x | x | x | | |
| San Jose | N.A. | x | | | | x | x | | x |
| Scottsdale | 415 | x | | | | | x | | x |
| Seattle | 887 | x | | | x | x | x | x | |
| St. Louis | N.A. | x | | | | | x | x | |
| St. Petersburg | 200 | x | | | | | x | x | |
| Tucson | 23 | | | | | | | x | |
| Virginia Beach | 100 | | | | | | | x | |

N.A. - not available

| BOX 6. STORMWATER CONTROL MEASURES<br>INSTALLATION AND MAINTENANCE COSTS PER ACRE (2012) | | | | |
|---|---|---|---|---|
| | **CAPITAL COST** | **ANNUAL OPERATIONS AND MAINTENANCE COST** | **ANNUAL MATERIALS COST** | **ANNUAL PERSONNEL TIME** |
| Vegetated swale | $14,650 | $ 923 | $100 | 10 hrs |
| Retention basin | 16,471 | 3,169 | 110 | 28 |
| Detention basin | 16,471 | 2,489 | 110 | 24 |
| Bioretention area | 25,576 | 1,999 | 110 | 21 |
| Porous asphalt | 26,588 | 1,781 | – | 6 |

Source: University of New Hampshire Stormwater Center.

located in a one-time marsh that drained all of the present-day downtown (see Case study, page 21). Not surprisingly, local flooding had plagued the subsequent industrial landscape. When it was finally converted into a park, the designers prioritized stormwater management, creating a stream system to circulate runoff through wetlands and a one-acre lake that doubles as a detention basin. With about five acres of green infrastructure, the park filters 100 percent of the site's runoff; after a storm, the water is released to a traditional wastewater management facility. The park has greatly reduced flooding, and it stimulated a multi-million-dollar construction boom in a formerly decrepit, park-poor neighborhood.

Similarly, the new Tujunga Wash Greenway partially recreates a historic streambed in the North Hollywood section of Los Angeles. Sixty years after the original wash was obliterated by a concrete flood control channel (allowing developers to build in much of the old flood-plain), a new, adjoining artificial stream has been created with water diverted from the channel.

Although water flow studies by the Los Angeles Bureau of Sanitation determined that the channel couldn't be removed, the Mountains Recreation and Conservation Authority took advantage of the sandy, well-drained land parallel to the concrete spillway to build a new streambed and, in effect, a new 15-acre, 1.2-mile-long park. The recreated stream infiltrates 325,000 gallons of water into the depleted aquifer, enough groundwater to serve more than 3,000 homes.

"Land in riparian corridors often drains well, because the sands and gravels deposited by creeks and rivers are still present," explained the authority's Brian Baldauf. "That often translates into great infiltration opportunities parallel to flood channels or on the back side of a levee wall." The local community, which has a deficit of parkland, was particularly enthused about gaining a trail along the new stream.

In nearby Santa Monica, a former asphalt oceanfront parking lot is now Beach Green, serving double-duty as peak-period car storage and off-peak playing area. Its engineered soil includes not only sand but also plastic mesh, which increase load-bearing capacity sufficiently to support vehicles without compromising porosity. This formulation, which costs $180,000 per acre, anchors grass while still infiltrating about 560,000 gallons of runoff a year from 1.7 acres of adjoining asphalt. (See Box 8.)

Parks can be a great way for developers to reduce their stormwater management requirements when creating a new neighborhood. Loveland Sports Park in Loveland, Colorado, was a former farm regraded for sports fields, seven large bioswales, and 1.5 acres of wetland. The new facility now protects the Big Thompson River from the storm runoff of 136 acres of adjoining park and neighborhood.

CASE STUDY

## Railroad Park, Birmingham

Many cities align development along a river, lakeshore, or ocean, but for landlocked Birmingham, the focal point has long been the city's railroads. Even though the railyards have shrunk and industrial areas have opened up for redevelopment, trains still regularly rumble through downtown.

By the early 2000s, several studies had suggested converting Railroad Reservation, one of the old industrial sites downtown, into a park. The slowly rebounding central core needed a high-visibility project for future development; a park could reconnect the bifurcated city by linking the historic downtown with the booming University of Alabama Birmingham campus and hospital south of the tracks. The concept finally gained traction in 2002 when Planning Director Bill Gilchrest arranged for the Urban Land Institute to come down for a study. A positive review, plus the advocacy of Friends of the Railroad Reservation District, pushed the city to update its City Center Master Plan with a focus on the new park. As a bonus, it appeared the park could be designed to reduce the flooding that had plagued the former marsh since the early 1900s.

Public and private funding was in place to start the 19-acre project, which includes five acres of green infrastructure, so development began quickly. Today the park collects and filters all the precipitation that lands on the site and also provides emergency flood protection for the immediate watershed. A wetland pond on one end of the site spills into interconnected lakes that double as a detention basin. From there the system cascades westward through a meandering stream; ultimately, the water is pumped back up to the original pond to keep the system from stagnating. Along the lakeside boardwalk, an 80-foot-long rain curtain circulates water; dramatically backlit at night, it is one of the park's most popular features.

CONTINUED NEXT PAGE

TOM LEADER STUDIO

RAILROAD PARK CONTINUED

Original plans called for extending the park to adjoin the 11 active train tracks alongside the site, but the railroad was reluctant so the city settled on a 90-foot setback, forcing changes to the plans. Creative design still makes trainspotting possible, though: excavated soil was mounded into knolls, creating an elevated path with views over the railyard.

But the park was not without controversy. The planned two-and-half-year project took twice as long (and required several groundbreakings) because of political infighting, fundraising challenges, and the land use disputes. But when it finally opened in 2010, it quickly proved its worth: the park became an iconic Birmingham cultural site, attracting over 500,000 visitors annually.

Since the opening, downtown has seen great growth, with some $185 million in development around the park, including a hotel, a renovated vaudeville theater, and several condominium developments. Moreover, Regions Field, an 8,500-seat baseball stadium has even brought the minor-league Birmingham Barons back from the suburbs.

Design and construction, which cost $23 million, was paid for by a mixture of private and public sources, including the Community Foundation of Greater Birmingham, the Railroad Park Foundation, Alabama Power, Regions Bank, the City of Birmingham, Jefferson County, and even the EPA's Congestion Mitigation and Air Quality program.

According to Railroad Park Foundation Director Camille Spratling, the park's green infrastructure has been one of its greatest assets. "People love to see species of birds that had disappeared from downtown but are now living in the wetlands," she explained. "When the lake was built, it was the first time we saw the Birmingham skyline reflected in water, and that was a real point of pride. The park has been a great equalizer, bringing suburban and urban Birmingham together."

There is seemingly no end of opportunity to convert rain from a problem to a resource. The city of Santa Monica even turned a portion of its municipal airport into stormwater-treating parkland. Now, runoff from the airport, which had routinely flooded adjacent streets and polluted Santa Monica Bay, flows into Airport Park. There, it meets 8.5 permeable acres of synthetic soccer fields and a dog park, plus porous parking lots surrounded by infiltration swales (see Box 7). (Artificial turf, even though made of a carpet-like substance from woven green polymer, is nevertheless pervious since the material is punched through with thousands of water holes.)

Since these were all new parks, the interventions did not stir up much concern or public opposition. Developing a fresh park has the advantage that the space has no present human users, no recreation history, and no entrenched lobbying blocs to complain. It can be designed to maximize water management features while also selecting park features with synergistic land uses, such as trails and boardwalks. Of course, on the negative side, the land may be expensive, structures may need to be demolished, and pollution may need to be cleaned up. All these positive and negative factors came into play at one of the nation's most celebrated stormwater mitigation facilities, Atlanta's

Historic Fourth Ward Park (see Case study, page 11), where massive excavation created a beautiful space that also allows for the temporary storage of 4 million gallons of water.

In contrast, making changes to venerable, beloved landscapes can be more complicated.

## Renovating existing parks

Modifying a current park to handle stormwater has an advantage and a disadvantage. On the upside, the land is available at no cost. On the downside, the park's existing features and uses may be sacrosanct to current users who then resist any design or management changes.

While retrofitting a current park is more difficult and expensive than working unfettered in a treeless new space, it is also well known that many larger parks have unprogrammed sections that are under- or even unused. Some compromises may be required, but water features — even those that might fluctuate in depth and spread — can be great spaces if they are sensitively designed, properly maintained, and appropriately programmed.

Among existing parks, perhaps the easiest to tackle are those that already suffer problems like washouts and severe erosion. Chances are that there is a strong legal or financial justification to take remedial steps since stormwater from the park is negatively affecting downstream resources.

If trees need to be removed, contours modified, stream banks regraded, walls built or eliminated, fields forested, or any other changes made, there may be an outcry by affected groups. The process, therefore, requires a strong administrative hand, a good public information process, and top-notch scientific analysis and explication.

A typical passive stormwater management system can be found at Grass Lawn Park in Redmond, Washington, with its permeable paving, rain garden, green roof, and amended soils. These modifications keep rainwater within the park for a longer period of time. Doing more than that — filtering and absorbing water from beyond the park's boundary — generally requires more space or more complex systems, as at Echo Park in Los Angeles.

Echo Park Lake collects stormwater from a large surrounding uphill neighborhood — a swath of about 770 acres. The 125-year-old facility, which began as a reservoir of drinking water from the Los Angeles River but is now a discharging pond to that same waterway, was renovated in 2014 to handle more runoff and improve water quality through sediment traps, constructed floating wetlands, and better circulation. The upgrade improved the look and smell of the park and also allowed more boating. However, the lake can only manage rainfall from smaller storms; in a major deluge it can hold only about 25 percent of the neighborhood's water, with the rest shunted straight to the river.

In Milford, Connecticut, Eisenhower Park along the Wepewaug River was vastly improved when Connecticut Light & Power Corp. agreed to invest $800,000 as mitigation for installing a new overhead transmission line. The company paid to convert an unattractive and unusable abandoned gravel pit in the park into an ecologically active artificial wetland. The wetland served as such successful water storage that the old river levee could be partially punctured, reconnecting the Wepewaug to its historic floodplain.

Kent, Washington, did something similar, though with more artistic flair, at Mill Creek Canyon Earthworks Park. In the early 1980s, faced with the need to protect its downtown from flooding by Mill Creek, the city rejected the idea of building a traditional engineered dam and opted for a park that could do the same thing. The 2.5-acre, sculptural earthwork park contains enough detention basins and berms (now renovated to accommodate a 10,000-year storm), yet grassy lawns and hillocks provide an attraction to residents and visitors alike during the majority of times without flooding.

Another impressive success is on display at West Park in Ann Arbor, Michigan. Located in a residential neighborhood near downtown, the 23-acre facility was long popular but it had become outdated and, after Allen Creek was forced into a culvert below, the park had a chronic flooding problem. When neighbors pushed for an upgrade, city officials saw an opportunity to fix drainage and also improve water quality. They began a planning process in 2008.

The community's strongest desire — to daylight Allen Creek by raising it up out of its pipe — proved infeasible, but it was possible to redesign the park and convert its old streamside topography into a series of linear bioswales which capture and infiltrate stormwater. In fact, curb cuts were added around the park's uphill edge so that it could do more: runoff from some uphill roadways now trickles into the swales. (Allen Creek's drainage comprises 783 acres, 44 percent of which is impervious surface. In a major storm, that much water would overwhelm the park, which is why the stream was not daylighted, but having the park accept a portion of the runoff helps improve the water's quality.)

West Park's swales are designed to infiltrate within 48 hours to prevent a standing-water

BOX 7

## Pervious pavement

A WIDELY SUGGESTED SOLUTION for managing runoff is by using pervious (or permeable) pavement. In theory, replacing all the asphalt and concrete in the United States with pervious forms would make a huge dent in the runoff problem. The reality, however, is more complex.

First, not every location benefits from porosity; an impervious asphalt trail through a field is not worth replacing, since the water flowing off its edges goes into the ground just a few feet from where it would drip through if it were porous. Perviousness makes a difference only if it keeps water from running into a gutter or a pipe.

The second issue is cost. Pervious pavement is about 20 percent more expensive than its conventional counterparts, but even more significant is the cost of its management. Fine sediment in runoff inexorably clogs the pavement's pores and the spaces between paving blocks, gradually rendering it less effective, so permeable materials require sediment removal once or twice a year with sweepers or special vacuuming devices. (This also means that in snowy areas crews cannot use sand on porous surfaces; they must remove the snow mechanically. As for road salt, it works on pervious asphalt but damages pervious concrete.) Moreover, since some structural integrity is sacrificed to enhance infiltration, permeable asphalt and concrete must be laid very carefully if they are to support an equivalent amount of weight. "We don't have a single park path where we don't drive maintenance vehicles," explains Seattle's Andy Sheffer, "and some of our porous paving hasn't held up to the weight of those trucks."

That said, well-designed, -swept and -maintained permeable pavement can last for upwards of 30 years and can make a big difference in reducing runoff. Moreover, with greater public use, its cost should decline due to competitiveness.

CITY OF KENT

Kent, Washington, elegantly solved its downtown flooding problem by building the sculptural Mill Creek Canyon Earthworks Park, which can accommodate even a 10,000-year flood.

breeding ground for insects. The park also has eight hydrodynamic separators (also known as swirl concentrators), one for each small tributary that flows from the neighborhood. These non-motorized structures are designed to separate out floating trash, debris, oil, and sediment. (The separators, while effective, are not appropriate for every park situation since they require regular cleaning and must be coupled with other systems to improve overall water quality.)

Even dense cities can add green infrastructure, as is proved in San Francisco's one-acre Boeddeker Park. Located in the troubled Tenderloin neighborhood, the park had become stripped down to a cold and unwelcoming wasteland that one organization called "an empty cage watched from outside by drug dealers."

With change desperately needed, the San Francisco Recreation and Park Department teamed up with The Trust for Public Land on a $9.3-million renovation, using both public and private funding. Beginning with engagement meetings in 2007, the community developed a plan to improve safety, bring back recreational amenities – and add green infrastructure.

Today the new park features bioswales, permeable paving, and raised garden beds to absorb stormwater. A basketball court, outdoor fitness equipment, playground, and perimeter walking path keep the space active, especially now that they are paired with an energy-efficient clubhouse that hosts programming (a key crime deterrent). Catering to community interests, Boeddeker Park even features a tai chi patio. And tucked underneath the basketball court, an underground cistern captures 30,000 gallons of water runoff for irrigation.

Another project with dual goals of reducing flooding and improving recreation was Cromwell Park, in Shoreline, Washington (see Case study, page 26). Positioned downhill from an area of new development, the 9-acre park had become degraded by runoff from new streets, driveways, and rooftops on its periphery. In response to public complaints about erosion, flooding, and muddy conditions, the city undertook a major renovation that included new grading as well as a wetland. Even though the wetland reduced the amount of available dry ground, the city installed trails and boardwalks, making it attractive for walkers and runners. And improvements elsewhere in the park made the remaining recreational spaces more usable than they had been.

The renovation of Discovery Park in Seattle started with a minor departmental work order to repave a parking area. But when environmental engineer Andy Sheffer discovered that culverts under the park were washing out, the repair was completely re-conceived. The city tore out the culverts, brought the water back to the surface, stabilized the slope, and transformed the creek into a cascade of pools. "This began as a maintenance project but it resulted in an accessible water feature," explained Sheffer. "It's been highly acclaimed.

CASE STUDY

## Cromwell Park, Shoreline, Washington

After the Seattle suburb of Shoreline passed a parks and open space levy in 2006, the city sought renovation projects that could meet multiple city goals. One opportunity arose at 9-acre Cromwell Park, a flat field on the site of a former school in a neighborhood with frequent floods. The surrounding Meridian Park community had already been targeted for a major stormwater upgrade by the city's public works department.

"It was filled with a lot of dead grass and not much else," laughed Kirk Peterson, who oversaw the project for the parks and recreation department. The two agencies partnered on Cromwell Park's redesign, radically restoring the site's natural topography and redirecting runoff to a wetland for treatment. They built new inlets from adjacent residential streets and a nearby county building, where most of the runoff percolates into the ground. (In a deluge an overflow outlet releases excess water to the sewer system.) The 1.33-acre wetland can hold an acre-foot of water (almost 435,000 gallons), enough to eliminate the neighborhood flooding problem.

Most noticeable to residents are the recreational improvements. The renovation added a new playground, a full-size basketball court, and a new baseball field. Walking trails encircle the wetland, even crossing it on a bridge. Neighbors were adamant that the wetlands not be fenced off, Peterson noted, although the city eventually had to install safety cables by a particularly steep-sided section. One of the best investments, Peterson added, was the selection of diverse, native wetland vegetation that makes the park look good even in dry spells.

CITY OF SHORELINE

Changes in the park sacrificed some recreational space, but Peterson said the wetlands have become one of its most popular features. "In the design process, neighbors were skeptical. They were worried about mosquitoes and bad smells. But now people love the space. There is often interesting wildlife, and people are fascinated to see the basins fill up with water after a rainstorm."

Design and construction, which lasted from 2007 to 2010, cost $1.6 million, with about two-thirds coming from the park bond and one-third from the Surface Water Utility Fund. The two agencies share maintenance responsibilities, with the park costing about $60,000 a year and the stormwater features about $11,000.

People love hearing that good environmental deeds are being done, but above all, they really love watching moving water. As soon as we daylight a stream, people want to see more of the riparian corridor exposed. These projects catalyze park projects further downstream."

One of the largest, most expensive, and highest-stake stormwater projects has been constructed in a Cambridge, Massachusetts park following a court order mandating the clean-up of Boston Harbor. The proposal to convert part of the state's Alewife Reservation into green infrastructure stirred up a fierce political battle and years of lawsuits over the use of public land. Finally opened in 2013, the Alewife Stormwater Wetland is proving itself one of the nation's most successful examples of urban parkland serving as both recreation provider and pollution solution (see Case study, page 16).

## When water problems aren't evident

A park can be made more water-smart even if it doesn't have obvious stormwater problems, although it will take considerable conversation with neighbors and park users. Since there is no visible erosion or sogginess, it may be difficult to explain a construction project — much less remove trees or redesign fields. Best is to show strong scientific evidence for the redesign and then also provide a series of additional benefits — not only cleaner water but, perhaps, additional recreation, environmental education, a new playground, improved habitat, a beautiful garden of hydrophilic plants, a great sitting area, a water feature, or all of the above. Although additional benefits are more expensive, they can potentially be paid for by the stormwater department or water utility through cost savings from reduced treatment.

That's what happened at Herron Park in Philadelphia, where the promise of better recreational opportunities overrode concerns about construction impacts. The 1.1-acre inner-city playground was identified by the Philadelphia Water Department as a good site for capturing water running off a highly impervious neighborhood into the Delaware River. In return for losing the playground for a full year of redevelopment, and losing 4,500 square feet of surface area for a rain garden (which looks pretty but is fenced off from other uses), the neighborhood was rewarded with a new water playground, a walking trail, and a basketball court.

Similarly, in New York City, the Department of Education, the Department of Environmental Protection and The Trust for Public Land collaborated on a project to completely rebuild the three-quarter-acre playground of P.S. 261, an elementary school in Brooklyn (see Case study, page 28). The resulting park now captures the first inch of rainfall from any storm — about 500,000 gallons per year. The success of this project led to a full-scale program to similarly redesign 40 more schoolyards throughout New York City.

CASE STUDY

## Public School 261, Brooklyn, New York

A SCHOOLYARD IN NEW YORK is easing the burden on an overtaxed waterway while also providing additional community play space in a park-poor neighborhood.

Brooklyn's P.S. 261, whose schoolyard had been paved over decades earlier, leaving a half-acre of asphalt and a deteriorated jungle gym for recess, was one of the few locations in its neighborhood that had a bit of open space. Fortunately, the site was a priority for two different city agencies — the city's Department of Education (for playground renovation) and the Department of Environmental Protection (for water quality improvements from reduced sewer overflows) — as well as a private conservation group, The Trust for Public Land.

TPL has been working with New York City since 1996 to convert school playgrounds into after-school-hours community parks. In the early days of the partnership, the goal was merely to work with students, parents, teachers and community residents to create great play spaces with such amenities as fields, running tracks, gazebos, basketball and game courts, and even hair-braiding areas. Beginning in 2012, the mission was expanded to also include stormwater management.

P.S. 261 was the first of what became 40 schoolyard renovations carried out through the three-way partnership. Although the construction could have become a source of strife in the community, the public process and the many ancillary benefits to the neighborhood were so compelling that the reworked park was accepted enthusiastically. Permeable pavers reduce runoff from the hardtop, rain gardens and the artificial turf field absorb runoff, and the gazebo features a green roof and rain barrels to store


BEFORE RENOVATION

MARY ALICE LEE


PEDRO DIEZ

runoff for irrigation during dry spells. The field itself consists of permeable artificial turf underlain with broken stone to store stormwater and perforated pipes for drainage. All told, the half-acre park can capture about 500,000 gallons of stormwater annually.

Fortunately, even in the cramped quarters of an inner-city schoolyard, it's not either/or – play or store. "Stormwater management features always rank high on kids' priority lists. They like green spaces," explained Mary Alice Lee, New York playground program director for TPL. "It's not a tradeoff between basketball courts and rain gardens since we can squeeze both into even a small space."

Each renovated schoolyard costs about $1 million (including $650,000 for construction) and is funded primarily by the two agencies with supplemental donations raised by TPL. As with other schoolyards renovated through the initiative, P.S. 261 must be open to the general public outside of the school day from dawn to dusk and on weekends, vacations, and holidays; the school's custodian receives extra compensation from the city for taking on added responsibilities in the schoolyard.

"There are always growing pains in taking a successful program to scale," explained DEP assistant commissioner Angela Licata, "but our only challenge has been managing construction delays against our strict Consent Decree deadlines. This was such a clear win-win situation for us and the school that we'd like to see participatory design and stormwater management become standard practice in every schoolyard capital improvement in New York."

# Design considerations for success

Across the country, and across all sizes and shapes of parks, there are a few key elements to getting green infrastructure right. Some of them begin right at the beginning — in the site survey and design process.

## Getting the soil right

The mere presence of a grassy park does not guarantee water infiltration. Soil in urban parks is often highly compacted because sites have been in-filled with substandard materials packed down during construction by heavy equipment stored on the site. Athletic fields and heavily used lawns can become especially compacted; their runoff rate often resembles that of asphalt, especially during large storms. Thus, soil usually needs to be modified to perform properly (see Box 8) and sometimes it takes more than one try. Deficient soil was the culprit in a Seattle project where stormwater was lingering too long in newly installed rain gardens. Those were torn out and successfully rebuilt using a designed mix of amended and native soil that has become the city's go-to option.

Ultimately, engineering soils for a water-smart park requires balancing the project specifications, materials budget, precipitation patterns, and site limitations — including such factors as native soil porosity, fines content (measured by the percentage of clay and silt), depth to the water table and bedrock, and soil contamination. Sometimes good results can be obtained by mixing sand into existing soils; elsewhere, entirely new soils may be required. Other challenges, such as a high groundwater table or high bedrock, may prove insurmountable. Budgeting early for a technical expert, whether an in-house landscape architect or a consulting stormwater engineer, can reduce headaches and costs.

## Making room

In all considerations of urban stormwater management, space is a factor. A prime difficulty with liberating a stream from a fortified channel is that it then requires a wider footprint — but over the years that historic floodplain has usually been covered with housing, shops or industry. Mountains Recreation and Conservation Authority landscape architect Brian Baldauf has calculated that the present 50- to 100-foot-wide riparian corridor of the Los Angeles River and its tributaries (including Tujunga Wash) would need to be five to seven times wider to be naturally resilient against flooding. The problem is more severe in arid regions with their wider fluctuations between droughts and deluges, but the challenge reaches from coast to coast. In the Charlotte, North Carolina, area, which has seen rapid recent development (including a widespread increase in new pavement) and higher water levels, Mecklenburg County has an aggressive program to buy out willing sellers in the flood zone, remove built structures, and turn the land into open space (often resulting in the construction of a natural greenway to be maintained by the parks department). Austin and El Paso similarly have created broad swaths of parkland from former residential neighborhoods decimated by floods.

Angelyn Chandler, who once headed New York City's Community Parks Initiative, sees the same challenge even with rain gardens. "Rain gardens," she said, "are the cheapest and most visible demonstration of green infrastructure, but they take up a lot of space. In our small

BOX 8

## Understanding soils

Soil is the working force behind successful stormwater management. Without it, water cannot be absorbed, stored, cleansed, and infiltrated. Without healthy soil plants struggle or die.

In some cases, native soils found on a site are perfectly adequate for a water-smart park, or they might only need tilling to add to their absorptive capacity. This, of course, is most economical. But the reality in urban areas is that many soils have been so overworked or mistreated that they need to be enriched or replaced. As Seattle's Andy Sheffer noted, "If you have to tear down a building, you'll find there's almost no nutrition left in the soil underneath."

Among the options are:

- **AMENDED SOILS**, pre-existing soils that have been enhanced to meet performance goals, often by mixing in sand or compost. Amendment is the least expensive type of alteration since it doesn't require a full-fledged replacement.
- **ENGINEERED SOILS** (also called manufactured soils, designed soils, or blended soils), combinations of soil, soil components, and soil-like material that are used to replace existing dirt. To manage stormwater, engineered soils usually have higher sand content.
- **STRUCTURAL SOILS**, extreme versions of engineered soils designed specifically for strength without compaction. They are able to support plants, and they allow air and water movement even under the great weight of porous pavement and vehicles. They are particularly useful on playing fields and heavily used lawns.

community parks, we're weighing the space constraints against the cost constraints, because the more space-efficient elements, like artificial turf and permeable pavers with drains below, are more expensive."

The tradeoff between space and cost has concentrated the most elaborate underground systems in dense cities where there is insufficient open land above ground.

High-tech 3.1-acre Canal Park, surrounded by dense development in Washington, D.C., was designed to capture, pre-treat, and store in underground tanks the first inch of stormwater falling on a broad swath of surrounding buildings and streetscape. Most of the water is saved for irrigation and the park's toilets; the excess — about 500,000 gallons per year — is pre-treated and released into the sewer system on a delayed basis after a storm. Canal Park not only keeps about 1.5 million gallons of water out of the city's sewage treatment plant every year, but it also supplies 75 to 80 percent of its own irrigation water.

## Keeping green infrastructure green

Swales, rain gardens, and detention ponds are critical components for stormwater management. Long-term aesthetics may take a back seat, especially for wastewater utility staff focused primarily on regulatory compliance. Rain gardens, swales, and basins are beautiful in design renderings by landscape architects but over time some may start to look mangy.

To keep these park areas attractive, experts choose plants carefully and support good maintenance.

Tavis Dockwiller, a landscape architect with Viridian Landscape Studio, advises that short-term investments pay significant dividends later. She recommends budgeting for more intensive management in the first several years to ensure the plantings become established successfully. Says Dockwiller, "Give your designer fees for monitoring two or four times a year during the first three years to help maintenance staff with questions. These can be modest fees, but having the design professional out there makes a difference."

Adds Susannah Drake, a landscape architect at DLANDstudio, "The trick to keeping green infrastructure installations beautiful is not only maintenance; it's also smart planting design. It's important to have some woody and evergreen plants to help maintain structure upon which the perennial plantings can shine."

As far as perfecting plant choices for stormwater management, Seattle's Sheffer notes that his city is still trying. "I can't tell you how many plantings we've had to tear out and replace. It's tricky to get right. You need a total plant community, because without an overstory the understory can get burned and dry out. Green infrastructure installations are dry most of the time, especially in our Pacific Northwest summer, so plants should be suited to handle both too much and too little precipitation. If the intended plant communities don't establish early, invasive species can take over the site."

CHESTER ENGINEERS

Volunteers plant new vegetation during the marsh restoration at Alewife Stormwater Wetland in Cambridge, Mass. Some of these plants may need to be replaced over time.

# Staying involved

Managing water in a park requires commitment even after construction ends. The good news about maintenance is that green infrastructure is easily accessible, not somewhere deep below a utility cover. The bad news is that, compared to other park spaces, it often requires more attention because of specialized plant material and because sediment buildup can become debilitating. Infiltration basins require annual or semi-annual mowing, weeding, and removal of debris and dead plants.

Failing to anticipate the maintenance can undermine a successful design. Ann Arbor learned that lesson when pollution- and volume-controlling swales and wetlands underperformed. The runoff treatment areas were designed to utilize deep-rooted vegetation to withstand high water volumes, but understaffing at the parks department reduced upkeep and allowed shallow-rooted vegetation — less effective at slowing the water flow — to take over the site. Perhaps, with advance planning, the park department might have been able to get staffing or financial assistance from the water department or city council for better maintenance. New York City's Community Parks Initiative includes $3 million annually in supplemental maintenance funding for 67 refurbished parks. Other jurisdictions, such as El Paso and Montgomery County, Maryland, prefer that the water department maintains any park green infrastructure in perpetuity. Although this alleviates the burden on the park department, it can present other problems — Montgomery County found the two departments' maintenance standards incompatible (see page 40), while El Paso's water utility has a regulation to fence off all stormwater basins.

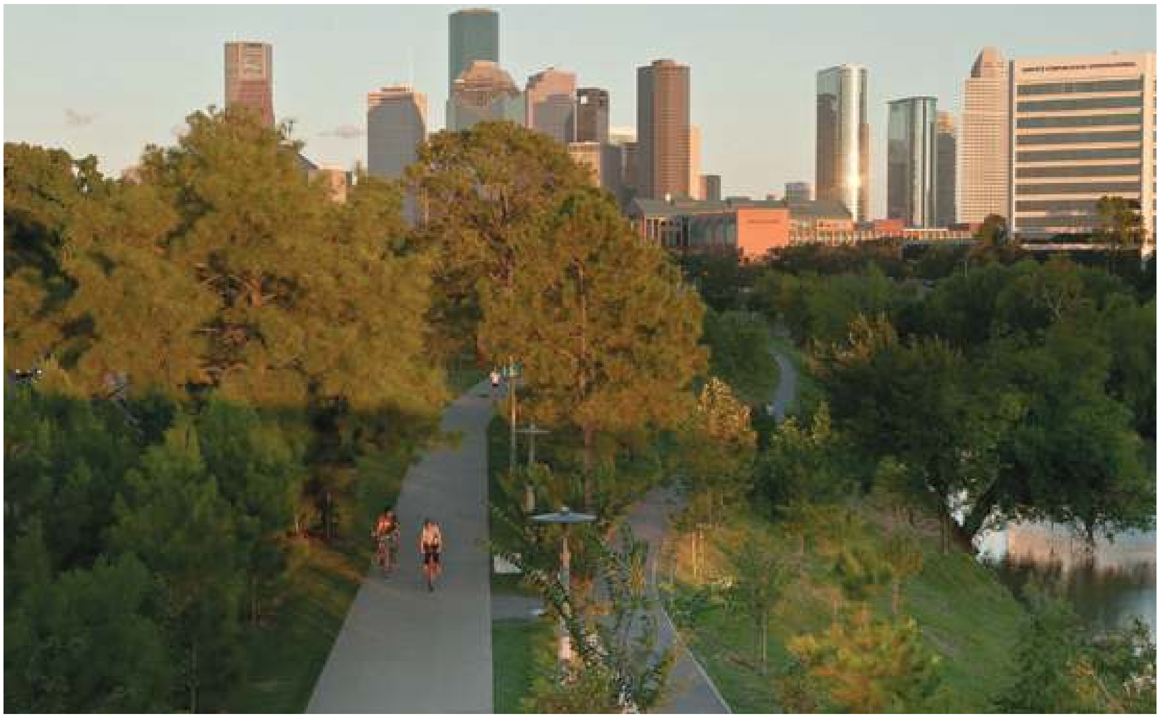
It is especially important to factor in the cost of maintenance for a park operating within a floodplain. Buffalo Bayou Park, in flat, rainy Houston, has greenway trails that are inundated regularly — about six times a year.

"We're on a coastal plain, so when water levels get to a certain height, our bayous [streams] flood for a long way," says Trent Rondot, conservation and maintenance director of bayou greenways for the Houston Parks Board. "Cleaning up the silt and debris is just par for the course."

The cleanup costs aren't insignificant. For the full 75-mile bayou greenway system, the city of Houston budgets regular maintenance and also earmarks a reserve of $914,000 to cover potential cleanup costs from a large (once-every-10-years or larger) storm event. (Any unused funds roll over to the city's capital project reserve at the end of a fiscal year.) For the busiest 2.3 miles of the waterway downtown, the Buffalo Bayou Partnership — a different organization — budgets another $100,000 annually to remove the periodic deposits on two trails.

"Whenever you're working with water, whether removing it or storing it, you need extra resources," says Houston Parks and Recreation's Rick Dewees. In the city's Hermann Park, maintaining the ecological efficacy of just an 800-foot section of swale required the Hermann Park Conservancy to hire an additional part-time worker.

While funding this kind of construction generally falls to government entities, private organizations can sometimes help with maintenance. In New York, for instance,




Houston's Buffalo Bayou Greenway features waterproof lighting fixtures and other amenities designed to survive regular flooding.

the parks department works not only with environmental education programs and "green collar" job training initiatives but also friends groups and conservancies. (For more on conservancies, see The Trust for Public Land's 2015 report, *Public Spaces/Private Money*).

But paying for more maintenance workers is by no means an unmitigated burden. The very fact of having more staff visibly out in parks is good for residents and visitors in many ways — making the park seem and feel safer, providing a mechanism to report problems and issues, helping people with wayfinding, answering questions, receiving feedback, and more.

There are sometimes countervailing factors that actually cut costs. Some sites require less maintenance than a typical garden because of less frequent watering. Also, in contrast to traditional underground gray infrastructure, the inspection burden can be lower. The University of New Hampshire's Tom Ballestro says, "It's easy to determine if it's working — just walk out there when it's raining, or after it rains, to see if the water is draining."

Maintenance can sometimes be tricky. Even Philadelphia's successful Cliveden Park provides lessons from its overlapping bureaucracies. The top two basins were built by the water department, the wetland at the bottom was designed by the Pennsylvania Horticultural Society, and the lower portion is mowed and cleaned by the parks and recreation department. ("We put up fences and signs to help them know where not to mow," said the Water Department's Jessica Brooks.) As for the community volunteers. "There was a misunderstanding about how much assistance we would need," said Nancy O'Donnell, capital projects manager for the Department of Parks and Recreation. "The local friends group, which is composed of mostly older folks, had agreed to help out, but the work isn't easy — it's a steep slope and you're constantly bending over. Plus — what's a weed and what isn't a weed? It's not always obvious."

"Your maintenance plan needs to be determined way up front," said Tammy Leigh Dement of the Pennsylvania Horticultural Society. "There is an education curve that has to be learned."

"A good designer will consider installation costs and long-term issues," says Andrew Lavallee, a landscape architect with SiteWorks. Rain gardens function best if they contain woody shrubs, but those plants are often costly to replace if the soil happens to get contaminated with road salts. Although herbaceous plants are less effective than woody ones, Lavallee notes, some designers use them anyway since they are inexpensive, they establish quickly, and they're easy to replace if damaged.

And then there is planning for winter weather, although that is a bigger issue on roadways than in parks. Sanding permeable pavement clogs the pores and necessitates sweeping or vacuuming. Excess salt can kill certain sensitive plants that aren't properly sited, not so much during the dormancy of winter but in the spring growing cycle, and salt must be diluted either naturally by rain or mechanically by irrigation. While nontoxic alternative chemicals are available, they can cost as much as five times more than salt. (On the upside, porous pavements often require much less treatment than traditional surfaces because daytime snowmelt drains through before it can refreeze into ice at night. According to the University of New Hampshire Stormwater Center, pervious pavement can succeed in the winter with as little as one-quarter the standard volume of salt.)

How long components will last with good installation and appropriate maintenance is often an unknown. But with a growing interest from landscape architects in monitoring the performance of stormwater projects, displaying information in real time by using embedded sensors, projections on the realistic lifespans of the components will become more readily available. The SITES project rating system, a landscape equivalent to the LEED green building rating system developed by American Society of Landscape Architects, U.S. Botanic Garden, and Lady Bird Johnson Wildflower Center, gives credit for monitoring the performance of an installation after construction.

## Public fears and legal liability

There's no question that standing water has its drawbacks, and hydraulic engineers walk a fine line between holding water back for too little time and for too much. Shorter retention periods and the sewage plants get overwhelmed; longer retention, and the water may allow mosquitoes to breed and algae to grow. Mosquito larvae need 72 hours to hatch, so holding ponds should be designed to drain sooner than that. To be on the safe side, New York City requires emptying in 48 hours; Cincinnati is even stricter at 24 hours. If water must be held longer, continuous mechanical circulation and aeration through fountains can help (as in the case of Atlanta's Historic Fourth Ward Park), as can the selection of vegetation that absorbs excess nutrients or supports such insect eaters as bats or fish.

Standing water may cause concern about the safety of children and other visitors. However, this issue is standard for virtually all park departments and it should not require any special rules: every park system already has rivers, streams, ponds, lakes, or ocean beaches to deal with. When a stormwater-treating wetland in Shoreline, Washington, seemed hazardous for children because of its steep sides and long drop from an adjacent walking path, the city eventually installed safety cables. New York avoids this problem by keeping its water depressions as shallow as possible in neighborhood parks, generally under six inches.

As for residues, that worry seems unwarranted.

"Although the public often has concerns that soils may become contaminated from street and right-of-way runoff," says Robert Goo, an environmental protection specialist in the Office of Water at the U.S. Environmental Protection Agency, "municipalities have not reported significant problems in terms of contaminant accumulation. In general, heavy metals and hydrocarbons that wash off impervious surfaces onto vegetated areas are filtered and trapped in the upper layers of the soil and by plants, and can be removed with normal maintenance and disposal practices."

While road salt in high concentrations can kill plantings, most other pollutants and excess nutrients are not harmful, and heavy metal concentrations grow so slowly that significant levels have not yet accumulated in even the older stormwater installations. Most state and EPA manuals recommend a minimum of two feet between the bottom of an infiltration basin and the top of the water table to allow enough space for all pollutants to be filtered.

"However," Goo added, "care should be taken to avoid discharging runoff that has high concentrations of soluble pollutants such as nutrients, pesticides, or chlorides from de-icers, due to the potential for groundwater contamination." (See Box 9.)

BOX 9

## What about brownfields?

Although it might seem counterintuitive to channel stormwater through former industrial sites (often called brownfields), these places not only offer great opportunities for new parks but can even alleviate stormwater problems. For one thing, while many sites are classified as brownfields because of the suspicion of pollution, testing may reveal the good news that no toxins are in fact present. In other cases, where a brownfield has only a relatively small, confined area of pollutants, the property can be cleaned to residential standards by removing and replacing all toxic soil.

In the most severe cases, where hazardous wastes cannot be removed and are instead capped in place with a waterproof liner, stormwater can still be managed in a limited fashion. Tree boxes and other shallow containers can be installed above the liner near the surface, where plants can absorb water and then slowly release it through evapotranspiration. Alternatively, runoff can be transported laterally, on top of the liner, to a clean part of the site or off-site.

Because of this, the U.S. Environmental Protection Agency allows the installation of green infrastructure on brownfields as long as the property is well regulated and the owner does due diligence.

"There is often a misconception that brownfields aren't appropriate for green infrastructure," explained the EPA's Robert Goo. "Actually, they can be ideal places for these approaches, and the EPA Brownfields Program has provided grants to do just that as part of community revitalization efforts. For one thing, brownfields don't always have contaminated soils. Even where they do, green infrastructure can still work if proper practices are selected to protect groundwater and prevent the mobilization of pollutants."

# Negotiating between different uses of a park

Until 2008, Grass Lawn Park in Redmond, Washington, suffered from poor drainage and flooding. In response, the city undertook a major renovation with the water agency paying for permeable pavement walking paths, a permeable basketball court, a green roof, the amendment of park soils, and the creation of a rain garden to handle runoff from a new playground and splash pad. It was a winning strategy for everyone and also gave city officials a great ribbon-cutting opportunity.

It's not common that goals easily jibe and multiple benefits are received enthusiastically by every constituent. A rain garden can be beautiful, but if it replaces a soccer field, it might raise objections unless that sports venue is replaced.

Philadelphia handles this problem with a Stormwater Plan Review Team, which brings together water department and parks department staff to evaluate green infrastructure projects for potential conflicts with park uses.

In the case of Cliveden Park in Philadelphia, the water department calculated that the park would be able to handle flow not only from within its own six acres but also from two city blocks uphill from the park. In theory, because of the topography, even more water could have been steered to Cliveden, but that would have transformed the park into a full-fledged detention pond, which was not something the neighborhood or the parks department wanted.

Cliveden Park had few amenities for a park its size —only a community building, a playground, a small garden, and walking paths. Thus, when the Philadelphia Water Department proposed constructing a series of stepped basins in the steeply sloping valley, with the last basin emptying into a rain garden, there was no outcry. The stormwater feature would not pre-empt any other uses. In storms the water burbles its way down the row of basins, pooling at the bottom in the garden. If the pond level reaches the height of an overflow outlet structure, it flows to the sewer. The result is a park only lightly impacted (or even improved) by extra water. In fact, as mitigation for the construction, the water department paid for an arching pedestrian bridge over the little valley, providing an attractive vista for users. Neighbors welcomed the addition, and the project was completed in less than 24 months.

"This project is in a high-impact location," explained Jessica Brooks, manager of the Green Stormwater Infrastructure program at the water department. "Our series of basins are very obvious to park users and even to passersby on the street, so we were able to highlight it to the public. The grading is so ideal that it called out to us. It can handle a significant amount of water. We had good relationships with the community partners. And we didn't have to do as much construction as we often have to — there were even already existing drainage structures at the bottom of the hill. It was a very successful project. It broke a lot of new ground for us," she concluded.

Fred Lewis, vice president of Friends of Cliveden Park, agreed. "We love it. We use it as a sort of outdoor classroom for kids, to explain the advantages of wetlands."

In contrast, eight miles away at Columbus Square, things didn't go quite as smoothly. The Philadelphia Water Department, after being invited by the park's friends organization to consider the site for a stormwater project, was surprised by a hostile reception from the rest of the community. Because of neighborhood politics, everyone needed to be heard before things could proceed. Ultimately the negotiators compromised on constructing four sunken sidewalk planters (instead of six) and small, ornamental-but-not-functional "bookend" gardens at sidewalk grade to be under the control of neighborhood gardeners. Tellingly, after the project was completed, complaints and concerns evaporated; a few years later a second Columbus Square stormwater project was installed with no community objection.

"We need to be very sensitive that we're not taking out a space that is used for picnicking, sports, or other gatherings," notes Philadelphia Water Department engineer Jessica Brooks. "This is often less obvious than you'd think. It requires us to talk to the park users to really understand what they do and what they love."

While the city has not canceled any stormwater management projects because of recreation conflicts, says Brooks, "We've definitely moved them, made the surface portions smaller, or made them completely subsurface in order to allow for other uses to be maintained."

In Santa Monica, California, the compromise occurred between water needs and sports lovers. In the city's Beach Green project, a large asphalt parking lot was converted to natural turf and opened to recreational use, with the caveat that it revert to overflow parking on the busiest beach weekends (about six days a year). Amended soils that can support both cars and recreation were used for the field, but

NEAL SHAPIRO

MARK TESSIER LANDSCAPE ARCHITECT

Beach Green, in Santa Monica, California, captures and cleans stormwater runoff under a sports field. Using specially designed amended soil, Beach Green can also support car parking on the very busiest beach weekends.

the site also relies on drought-hardy vegetation to clean runoff before it reaches Santa Monica Bay. When the space first opened, overuse quickly killed the grass, forcing the city to close and replant the field. (Artificial turf was ruled out because it cannot meet the city's water quality standard.) Today, because of aesthetics and stormwater requirements, Santa Monica has had to strictly regulate recreation hours, backing off from its original hopes of almost unlimited play time. Nevertheless, it is still an improvement over the days of the asphalt parking lot.

In contrast, compromise didn't quite work in a dense residential neighborhood in Montgomery County, Maryland. When the 2.5-acre Kemp Mill Urban Park, with its ornamental pond, came up for renovations, the county Department of Environmental Protection (DEP) asked the park agency to consider treating runoff from the adjacent street in the water basin. It would become one of many sites where the county planned to reduce neighborhood runoff to meet water quality standards.

It seemed like a win-win situation. The iconic pond was popular with the community, and the renovations would add artificial wetlands and increase water circulation to better mimic a complete ecosystem. But planners at the Maryland-National Capital Park and Planning Commission, which oversees the park, worried that the addition of oil, salt, sediment, and other street pollution would be too much for the delicate water pumps and sensitive vegetation. (After extensive study, the park commission had concluded that mechanical separators and other pre-treatment techniques were incompatible with the site.) The biggest impediment, however, was the county's requirement that all stormwater facilities in parks be maintained by DEP, rather than by the park commission.

"We knew from experience that DEP would maintain our pond as a stormwater feature, not as an ornamental pond. There was plenty of good will from each agency, but DEP had a very different maintenance plan," explained Aaron Feldman, a designer for the park commission. "We calculated that somebody would have to dredge the pond every six months to remove sediment, and we worried that the plants would have to be replaced after every winter of salty runoff. That level of maintenance just wouldn't get done, and eventually the park might fill up with algae or just be a dry pond between big rainstorms."

"In the end, we concluded that the pond couldn't be both a defining feature of the park and a runoff control tool," adds Feldman. "We were lucky that people were willing to stand up for the original intent of the park." The county is looking at other sites to meet its pollution control standards instead.

A classic case of a ragged community process over a proposed redesign to control stormwater occurred at Kalorama Park in Washington, D.C. A three-acre park in a dense neighborhood of apartment buildings and rowhouses, Kalorama Park slopes down from a major road with residences on all sides. Over time, erosion became steadily more obvious. A group of neighbors, working with a landscape architect, devised a plan to use permeable concrete to repave an old plaza at the park's highest point. The group also selected several downhill locations for both water storage swales and new overflow drains. A different group, dismayed by the planned destruction of historic resources, asked that the park's drainage pipes first be investigated for possible clogging before any new construction was done. With lack of clear direction and oversight, other activists entered the fray, including a group of parents who wanted a new playground.

In light of the controversy, the project lurched forward slowly, with neighbors increasingly fragmented over the solutions and even the problems. Swales were built and drains installed, but since neither pre-construction nor post-construction stormwater flow was


CITY OF ANN ARBOR

Renovations in Ann Arbor's West Park improved recreation facilities and added bioswales and a retention pond to help control neighborhood flooding.

measured, no one knew if they were working – which exacerbated the controversy. The construction work, done by a firm experienced only with highways, was not adequately overseen by the park department, resulting in the installation (and subsequent removal) of roadway-scaled drains on people-scaled walking paths. At the time of publication, the neighborhood and city are still not unified on a comprehensive plan to move forward.

Many factors may have led to less success at Kalorama Park than at Shoreline or Ann Arbor. As a smaller park in a denser neighborhood, Kalorama may be more of a political pressure cooker with less physical room for compromise. Perhaps issues of historical authenticity complicate the ability to compromise over innovative designs. Maybe the negative impacts of stormwater were less publicly visible, or perhaps the civic leadership was less clear in describing and justifying the proposed solutions. All these factors, and more, need to be carefully considered when a community begins the process of evaluating a park for stormwater management.

# Who pays, who benefits, and how are costs accounted?

Installing natural stormwater controls within a park is not inexpensive and it's usually not a quick process. But the relevant comparison of costs and impacts must be made against any typical park improvement process, as well as against traditional gray approaches, which are usually much more expensive and take far longer (see Box 10). How much a water-smart park costs and how long it takes to build depends on innumerable factors of geography, geology, weather, bureaucratic rules and – often – city and neighborhood politics. Nothing about urban water management is easy, but the evidence shows that the natural approach is more economical.

**BOX 10. THE COST OF UNDERGROUND STORAGE PROJECTS TO HOLD COMBINED SEWER OVERFLOWS**

| CITY | APPROXIMATE YEARS OF CONSTRUCTION | APPROXI-MATE COST (MILLIONS) |
|---|---|---|
| Chicago | 1975–2006 | $2,330 |
| Cleveland | 2011–2035 | 3,000 |
| Columbus, OH | 2010–2017 | 370 |
| Indianapolis (phase 1) | 2012–2025 | 1,900 |
| Milwaukee | 1982–2010 | 1,270 |
| Omaha | 2023–2027 | 440 |
| Portland, OR | 1998–2011 | 940 |
| St. Louis | 2016–2035 | 1,900 |
| Washington, D.C. | 2011–2025 | 2,600 |

Note: In some cases a small percentage of the cost is for green infrastructure elements.

The Trust for Public Land carried out a survey of 20 stormwater park projects in 13 states. (See Box 11.) The parks ranged in size from half an acre to more than 300 acres, with stormwater management features ranging from only a small corner of some facilities to the whole park in others. The median size of the parks is 8 acres, and the median size of the stormwater portion is 2.5 acres.

The selected projects encompass a total of 713 acres and cost $771 million to build, although most of the land and much of the spending was not related to stormwater management. For eight of the parks, we were able to get fairly accurate data on construction costs, and for five we were able to determine annual operating costs. (See Box 12.) Where financial breakdowns were available, the median cost of green infrastructure construction was about $174,000 per acre. Annual operating cost in 2014, when known, had a midpoint of about $10,800 per acre.

## Timelines

As measured by the Trust for Public Land, approval, funding, design, and construction of stormwater parks took a median of 5 years to complete, not significantly more than the time required for a traditional park. (Several especially complex projects – including Boston's Alewife Stormwater Wetland which got tied up in lawsuits and extensive political wrangling – spanned a decade or more. On the other hand, the conversion of an asphalt New York City schoolyard into a water-smart park usually takes less than two years.)

"Cutting-edge projects often take longer since designers may have to prove a concept to planners and community members," said Brian Baldauf, designer for L.A.'s Tujunga Wash Greenway, which took nine years to finish. "Our more recent projects seem to be going faster," he added, "but I expect a minimum of five years to complete a project in a flood control right-of-way while working with several different agencies."

## Funding a park with water department money

The distribution of the benefits and costs of green infrastructure can be uneven, so the question of who should pay can be complicated and controversial.

Every city seemingly handles the issue differently, and the financial landscape is not static. In some places, water and sewer utilities have no experience partnering with other agencies on projects, leaving the park department to take the first step in finding synergy between improving parkland and cleaning waterways. In other locales, such as Cleveland, the situation is reversed, with the sewer district taking the initiative (see Box 13).

Most stormwater management agencies cover the full expense of their own green infrastructure projects' design and construction. Whether they also cover the costs of temporary or permanent loss of existing parkland varies; most do not, unless there is strong pressure from the park agency or from park users and the general public. Also, most stormwater agencies, citing their fiduciary responsibility to ratepayers, are reluctant to pay for park improvements incidental to the water project. Nevertheless, some have agreed to put money in for enhancement projects. Since stormwater funding alone is rarely sufficient for an entire park project, it is usually necessary to piece together funding from multiple opportunities.

### BOX 11. SIZE OF STORMWATER PARKS AND YEARS TO COMPLETE

SELECTED PARKS

| PARK | CITY | PARK SIZE (ACRES) | STORMWATER MANAGEMENT AREA (ACRES) | YEARS TO COMPLETE |
|---|---|---|---|---|
| West Park | Ann Arbor | 23.0 | N.A. | 2 |
| Fourth Ward Park | Atlanta | 17.0 | 2.0 | 7 |
| Railroad Park | Birmingham | 19.0 | 5.0 | 9 |
| Alewife Stormwater Wetland | Cambridge, MA | 130.0 | 3.4 | 12 |
| Joe Taylor Park | Grand Rapids, MI | 2.2 | 2.2 | 7 |
| Echo Park | Los Angeles | 29.0 | 13.0 | 8 |
| Tujunga Wash Greenway | Los Angeles | 15.0 | 15.0 | 9 |
| Loveland Sports Park | Loveland, CO | 76.0 | 5.0 | 8 |
| Eisenhower Park | Milford, CT | 333.0 | 2.5 | 2 |
| Cumberland Park | Nashville | 6.5 | N.A. | 5 |
| Bushwick Inlet Park | New York | 6.8 | N.A. | 8 |
| P.S. 261 | New York | 0.5 | 0.5 | 2 |
| Cliveden Park | Philadelphia | 6.0 | 2.0 | 2 |
| Herron Park | Philadelphia | 1.1 | 1.1 | 5 |
| Grass Lawn Park | Redmond, WA | 28.5 | 2.0 | 2 |
| Boedekker Park | San Francisco | 1.0 | 1.0 | 4 |
| Airport Park | Santa Monica, CA | 4.0 | 4.0 | 2 |
| Cromwell Park | Shoreline, WA | 9.0 | 1.3 | 4 |
| Canal Park | Washington, D.C. | 3.1 | 3.1 | 2 |

N.A. - not available

## BOX 12. COST OF STORMWATER PARKS AND FACILITIES
### SELECTED PARKS

| PARK | CITY | TOTAL COST | STORMWATER PORTION COST | STORMWATER COST PER ACRE | OPERATING COST PER ACRE |
|---|---|---|---|---|---|
| Alewife Stormwater Wetland | Cambridge, MA | $140,000,000 | $9,000,000 | $2,647,059 | N.A. |
| Joe Taylor Park | Grand Rapids, MI | 680,600 | 230,000 | 104,545 | N.A. |
| Echo Park | Los Angeles | 45,000,000 | N.A. | N.A. | 41,379 |
| Tujunga Wash Greenway | Los Angeles | 7,000,000 | 7,000,000 | 466,667 | N.A. |
| Loveland Sports Park | Loveland, CO | 2,000,000 | 500,000 | 116,279 | N.A. |
| Eisenhower Park | Milford, CT | 800,000 | 800,000 | 320,000 | 16,000 |
| Cumberland Park | Nashville | 9,500,000 | N.A. | N.A. | 10,769 |
| Cliveden Park | Philadelphia | 210,000 | 210,000 | 105,000 | 5,833 |
| Grass Lawn Park | Redmond, WA | 3,330,000 | 463,300 | 231,650 | N.A. |
| Airport Park | Santa Monica, CA | 6,800,000 | 270,000 | 67,500 | N.A. |
| Cromwell Park | Shoreline, WA | 1,600,000 | N.A. | N.A. | 7,778 |
| **Median** | | **$5,400,000** | **$481,650** | **$173,965** | **$10,769** |

N.A. - not available

In many places smaller-scale construction happens frequently and with little fanfare. Philadelphia's water department routinely pays for park upgrades in conjunction with stormwater projects — from basketball courts to splash-pads to quaint pedestrian bridges. So do agencies in Austin, the Boston area, and Milwaukee (even if the water bureaus sometimes do so on their own land and avoid using the word "park" for legal reasons).

Conversely, some city water agencies financially reward park agencies for collecting stormwater and keeping it out of the sewer system. That's the procedure in Cincinnati; Minneapolis; Seattle; Mesa, Arizona; Chesapeake, Virginia; and Madison, Wisconsin (with credit programs in Anchorage and Detroit in the planning stages).

In Austin, where the water utility often uses parkland to manage stormwater, the Parks and Recreation Department has a formalized procedure to charge mitigation fees based on the level of damage to the park and the length of time that the park is impacted. Fees range from 35 percent of the park's calculated annual value if a park is temporarily inaccessible (such as for underground utility work) to 75 percent if future park development is severely precluded, to 100 percent if the park becomes fully subsumed by an installation. Calculations are based on the number of square feet involved and the going price per square foot of private property adjacent to the particular park. Funds generated are spent to improve the affected park or a nearby site, said Parks Director Sara Hensley.

"Our mitigation fees aren't popular with the other agencies," Hensley admitted, "but this policy lets us take care of residents when parks are temporarily closed." The mitigation requirement has been used to acquire more land or install needed improvements. "We wanted to install a reclaimed water irrigation system at Hancock Golf Course — where we were irrigating with precious and expensive potable water — but we couldn't afford the upfront costs to build the separate pipes," she explained. "The water utility covered the $300,000 for us in exchange for easements to construct sewer lines under parkland."

BOX 13

## When stormwater agencies take the lead

In Cleveland, it's not the park agency that's taken the initiative to use parkland but rather the stormwater utility itself. The Northeast Ohio Regional Sewer District needs to aggressively reduce sewage overflows into Lake Erie to meet the obligations of its consent decree with the U.S. Environmental Protection Agency. The District's capture rate of combined sewer overflows must improve from 82 percent to 98 percent. To accomplish this, the District is using a multiplicity of gray and green infrastructure techniques to capture, hold, store, and infiltrate stormwater. Fortunately, land is available; in a few cases, parks have also been utilized for larger ponds.

In an area on Cleveland's east side with many vacant properties and severe overflows, a public-private partnership devised an ambitious urban agriculture and green infrastructure program. The project includes new storm sewers and street catch basins, plus four bioretention ponds, the largest of which is dug out of a former playing field in Otter Park. (The park's swings, playground, and basketball court were not affected.) The field was replaced with amended soils and a thick stand of native plants; an underdrain will slowly release the stormwater to a nearby piped stream. The partnership is also building an outdoor classroom with pervious pavement, native plantings, and demonstration rain gardens to help educate tour groups and park visitors of the importance of stormwater management.

Although the city decided to remove some play space for stormwater infrastructure, that did not cause an outcry, due to the neighborhood's low population and its large tracts of open space. Cleveland is also aggressively publicizing the fact that controlling stormwater and cleaning Lake Erie will enable residents to use more of their lakefront parks more of the time. Maintenance of the green and gray infrastructure in Otter Park, as well as the outdoor classroom, will be a sewer district responsibility in perpetuity.

In Milwaukee, the situation is even more tightly led by the sewer authority. Following a catastrophic 2010 rainstorm that led to heavy flood damage in the midtown 30th Street Corridor, officials resolved to put an end to a century-old drainage problem that was threatening the city's economic viability. Using a combination of gray and green approaches, and utilizing a community involvement process led by The Trust for Public Land, the Milwaukee Metropolitan Sewerage District conceptualized a four-mile-long "Neighborway" of greenspace, trails, and detention ponds overtopping an extensive network of existing pipes and water conveyance structures. Though the word "park" will not be used (because of legal technicalities), and though the park department itself is not involved, the Neighborway will have most of the attributes of a park—benches, paths, garden plots, ornamental landscaping, limestone boulders, picnic areas, and active play areas—even as the first two constructed ponds will be able to hold more than 25 acre-feet (8.1 million gallons) of stormwater. As in Cleveland, the Milwaukee sewer district will be responsible for managing the facility in perpetuity, although it is seeking private partners to assist with the gardens and some other features.

DC WATER

Washington, D.C. has invested in green infrastructure to treat stormwater that would otherwise be stored in deep tunnels, like this one under construction. Green infrastructure enabled the city to fully eliminate one previously planned tunnel.

One of the most publicized political battles between park lovers and clean water advocates took place in New York in the early 2000s when the New York City Department of Environmental Protection announced the need to construct a massive water treatment facility under a golf driving range in Van Cortlandt Park in the Bronx. That conflict related to potable water rather than stormwater, but the issues were similar and the outcome is instructive.

Even though the plant was to be located below ground and the park was to be reconstructed afterward, the citizenry rebelled, claiming that seven years' construction effectively constituted a taking of parkland. With drinking water for millions of people at stake, the city refused to back down, and the issue went to the courts. Mayor Michael Bloomberg finally brokered a deal with state and city officials from the Bronx whereby the water agency agreed to pay $200 million for numerous park renovations and improvements throughout the borough. The citizenry acquiesced, recognizing that the park department would never be able to allocate so much money from its own severely constricted budget.

Formal agreements may be the wave of the future because it is unclear how long voluntary donations by water utilities will continue. The steep escalation in water rates has generated a backlash in some municipalities, and spending money on park amenities might run into resistance when not clearly justified and explained to the public.

In some cities the pendulum has already swung the other way, making stormwater agencies less likely sources of park funding. In Colorado — a state whose water rules are so geared to the rights of downstream users that even rain barrels are illegal — park departments are not credited for "capturing the raindrop." In fact, they can be penalized if they detain runoff for more than 24 hours. Chris Lieber, park development manager of Colorado Springs Parks, Recreation and Cultural Services, says it can get expensive. "If we build a retention pond, we have to pay for the water we keep. Even detention ponds are a problem because it's expensive to keep them clean with all the sediment in our runoff."

Colorado Springs's new parks master plan calls for more infill parks in developed areas, but it's unclear where the funding would come from. "The plan calls for parks to incentivize nearby development by handling water from surrounding properties," explained Lieber. "But as a community, we're not yet at a place for the parks department to benefit financially." Since voters have several times rejected funding for maintenance of stormwater infrastructure, the water utility is unable to financially support parks.

## Getting creative with funding opportunities

Arizona cities, in contrast, are not obligated to pass their stormwater downstream, but they do have to control it. In Gilbert, Arizona, where parks (just like residences and businesses) must keep stormwater on site, every park includes a detention or retention pond to reduce flash flooding in nearby washes. When the Arizona Department of Transportation (ADOT) recently widened Route 202 through Gilbert, the park department leveraged the water treatment requirement to acquire three new parks. ADOT sold the city parkland at a nominal price in exchange for handling the road's runoff. Today the new Cosmo, Discovery, and Zanjero parks include a dog run and sports fields that have been engineered to double as detention basins to handle runoff from a 100-year storm.

There's a similar story in Texas, where catastrophic floods in 2006 pushed El Paso to turn to parks for stormwater management. Using money from stormwater fees, the El Paso Water Utility (EPWU) worked with the parks department to create several "park-ponds" — sports fields that double as detention basins. A concrete holding basin and pumping systems are closed to the public and maintained by the utility while El Paso Parks and Recreation maintains the fields.

The largest is Saipan-Ledo Park, a low-lying tract where poorly planned residences were wiped out by a 2006 flood. The site now has three stepped terraces; the lowest is a fenced-off detention basin maintained by the water utility while the upper two hold regulation-sized sports fields which hold rising water in extreme rainstorms. EPWU built the fields; El Paso Parks and Recreation Department paid for picnic shelters and outdoor fitness equipment, and it now covers the maintenance. The fields flood once every year or two, often requiring aeration afterwards, but, says assistant park director Joel McKnight, the tradeoff is well worth it. "This city has only about half the fields we need, so a little extra maintenance in exchange for two new sports fields has been a very good deal."

In Baltimore, an unusual source of funding is the Maryland Port Administration, proving that the number of possible cooperators is limited only by people's imaginations. Because the Port of Baltimore requires a vast acreage of paved surfaces, and because the state also has a strict law protecting a 1,000-foot buffer around Chesapeake Bay, a compromise needed to be worked out. Thus, after doing everything possible to capture storm runoff on-site, the port agreed to remove hardscape elsewhere, depaving an acre for each acre it surfaces at the port. The port implemented the program in Baltimore, tearing out swaths of asphalt in nine schoolyards, trucking in good soil and providing the students with green ballfields and play areas. Next on the greening list may be venerable Patterson Park which over the years has accumulated more than an acre of unneeded asphalt that added to the runoff burden in Chesapeake Bay.

"We do a good job," said Phillip Lee, a consultant to the port. "We'll spend up to about $150,000 an acre taking out pavement and replacing it. Sometimes we put in swales, too. The rules are that the land has to be public and they have to promise that it will stay unpaved in perpetuity."

In order to reduce delays to its own construction program, the port has gone a step further and created a "bank." Now, when it completes a pervious project in advance, it puts the credits into the bank, allowing it to pave another acre of port land when needed without delay.

# Conclusion

Using city parks to proactively manage stormwater is a revolutionary step, but also a step back in time. The concept unites engineers with ecologists, recreationists with hydrologists, public health experts with developers. It reinforces what landscape architects have always known — that urban parks are carefully constructed public works that need to be exquisitely in tune with their geography, their topography, their surrounding communities, their visitors, and their climate.

Using parks as infrastructure may be a time-honored tradition, but it also requires new technologies and new practices.

In some cases it entails economic costs; in others it provides savings and the ability to share an expense between multiple agencies. Practitioners need to be realistic about what green infrastructure can accomplish, what it costs to create and maintain, and how it impacts other facets of park life. In some cases, providing water management will improve a park, or will be a barely noticed constraint on usable park space. In others, fields or trails may be soggy or covered with debris for a few extra days. In many situations, this burden will be minor and easily tolerated. Elsewhere it may be too injurious and intrusive. In all cases there should be recompensing actions, policies, and developments that result in synergies and improvements for park users.

Perhaps the most important recognition is that green infrastructure needs human attention. While true wilderness can be self-sustaining, naturalized areas in the urban environment demand maintenance, especially if they are designed to manage large volumes of water from surrounding areas. Pervious pavement needs sweeping and vacuuming, catch basins require cleaning and emptying, swales obligate weeding and replanting, high-water debris needs removal. Utilizing green infrastructure does not mean getting a free ride. In fact, like the gray infrastructure it replaces, it carries a maintenance obligation. Keeping up with that maintenance almost certainly requires more day-to-day staffing in parks and greater park budgets in the future.


CITY OF SHORELINE

Green infrastructure carries a maintenance obligation but can make parks an even greater community asset.

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## About the authors

Peter Harnik is director of The Trust for Public Land's Center for City Park Excellence and author of numerous articles and books, including *Urban Green: Innovative Parks for Resurgent Cities*. Abby Martin is research coordinator of the Center and editor of the *City Park Facts* almanac. Additional research was provided by Kyle Barnhart, Matthew Shulman, and Matthew Treat.

The Trust for Public Land
101 Montgomery St., Suite 900
San Francisco, CA 94104
415.495.4014

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