LIGHTING THE FUTURE CITY THE IMPORTANCE OF LIGHTING IN FUTURE CITIES

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Figure 1: Urban Light (2008) is a large-scale assemblage sculpture by Chris Burden - Los Angeles. The installation consists of 202 restored street lamps from the 1920s and 1930s. Most of them once lit the streets of Southern California [1]


Wilshire Bl
ONLY
ONLY

Rupert Brooke was said to be a gifted writer "on whom the gods had smiled their brightest." But he was flummoxed by the bright gods he discovered in Times Square, New York, when he went there around 1914. He had never seen anything like these beings, comporting in their sky-high pantheon as he gazed up at them: a devil unable to bend back the bristles of "vast fiery tooth-brushes"; not far was "a divine hand writing slowly . . . its igneous message of warning to the nations: 'Wear—Underwear for Youths and Men-Boys'". Nearby, "a celestial bottle, stretching from the horizon to the zenith." Close to that "a Spanish goddess, some minor deity in the Dionysian theogony, dances continually, rapt and mysterious. And near the goddess, Orion, archer no longer, releases himself from his strained posture to drive a sidereal golf-ball out of sight through the meadows of Paradise; then poses, addresses, and drives again." For all their determined activities these "coruscating divinities" including two warring youths "clad in celestial underwear," and the "Queen of the night," a winking sphinx whose "ostensible message burning in the firmament beside her, is that we should buy pepsin chewing-gum" remained a mystery. "What gods they are who fight endlessly and indecisively over New York is not for our knowledge." For Brooke, Times Square was a "*flammantia moenia mundi*"; a fiery-walled world, a notion first voiced by Lucretius regarding the border between the earth and the heavens, across which tracked the blazing sun (Brooke, 1916).

Brooke was speaking, of course, about the array of "spectaculars" or sky-signs that illuminated and animated multi-story rooftop-mounted billboards bristling from the buildings surrounding Times Square. Times Square had been famous for them for more than a decade before Brooke arrived. The first large-scale electric sign went up in Times Square in 1903 to sell whiskey, something that fit well with a nighttime entertainment district. Numerous signs followed swiftly, many of them achieving near iconic status and recalled warmly decades later. One of the largest signs advertised Wrigley's Spearmint Chewing Gum. Installed in 1915, it spanned an entire block, reached up eight stories and featured "spearmen" hunting colored fishes (Starr, 1998)

For many, the randomness of these signs seemed to recapitulate the unplanned boisterousness of American cities. Foreigners saw them as a metaphor for America's untutored energy. The animated signs' short, repeated sequences asked nothing of memory, an appropriate request for a still-young country. The journalist Mildred Adams argued that New York's lights displayed brash American commerce, "conglomerate and cock-sure, hard-edged, blatant, young enough to turn a full blaze of light into every corner," rather than the "ordered and experienced, worldly wise" Parisian manner, which spotlighted only what was tasteful about French society (Adams, 1932). There was no place on earth quite like it and, by many accounts, Times Square remains today the most popular tourist destination in the world.

Figure 2: Historic view of Times Square, 1920 - where the urban zone of illuminated commercial speech first appeared[2]

EVERY PLACE LIGHTS UP

But Times Square is no longer unique. Its combination of blinking patterns of color and light, its soaring scale summoned to sell stuff, its flaming walls of animated winks, dances and underwear; all have appeared in city after city around the world. Ximending, in Taipei; Piccadilly Circus, in London; Shibuya and Shinjuku, in Tokyo; Causeway Bay and Mong Kok, in Hong Kong; Orchard Road, in Singapore; and Nanjing Road, in Shanghai all brim with entertainment, shopping, food and street life bathed in the light of over-scaled flashing signs. Another such district, Bukit Bintang, in Kuala Lumpur, even features a shopping mall, one of the world's largest, actually named for Times Square. Las Vegas and Pudong, Shanghai, might likewise be considered city-scaled versions of Times Square, with hectares of winking spectaculars. All these places have distinct histories and diverse geometries but the experience of visiting them is surprisingly similar. The people there, the goods for sale, the languages spoken, and the smells wafting about; all are different enough to be distinguishable, but all are overlooked by the same cast of coruscating divinities of illuminated commercial speech. Electric light brought these disparate far-flung places together into a distinct urban type, forged in the canyons of Manhattan and subsequently spun off like sparks from a flame.

Electric lighting brought other sorts of uniformities, too. Early in the 20th century, cities could experiment with a wide range of light sources, including two kinds of mercury-vapor lamp, Nernst lamps, Moore tube lamps and a number of types of arc lamps, not to mention gas lamps, which stayed competitive with electric for the first two decades of the 20th century. The commercialization of tungsten filament incandescent bulbs, with their many advantages, narrowed the options considerably. In addition, cities competed to outshine each other even in the dark days of global depression, with street lighting a visible sign of urban health and a token of progress. More than a few boasted of being "the best lighted city in America" or, like Denver, fancied themselves a "City of Lights."

An entire "white way movement" sprang up in the early 20th century, referring to Times Square and the brightly lit blocks of Broadway that led up to it. Manufacturers specialized in "white way" lighting systems that usually consisted of clusters of incandescent tungsten-filament bulbs encased in translucent globes and hung in clusters from decorative lamp standards. In a short time, there were several hundred "white way" installations in the United States and Europe. An advertisement for modernity, they became foundational to civic identity, with New York often serving as the barometer. In Los Angeles, for example, city boosters argued that the wattage on their Broadway was greater than New York's if the calculation were made on a *per capita* basis (Isenstadt, 2014).

At about the same time, the automobile led to a further homogenization of urban lighting. Lighting engineers began to think more about maintaining uniform visual conditions for drivers moving 40 km/hr rather than pedestrians walking 5 km/hr. This led to brighter lights and less variation, as well as more light directed to the surface of streets rather than to sidewalks. The factors of lighting design - including brightness, color, orientation, distribution, pole intervals and lamp mounting heights - were recalibrated to meet the needs of moving vehicles. Then, as cars followed roads out into the countryside, towns and suburbs were lit in similar fashion. Drivers' needs for higher levels of lighting and constant visual conditions prevailed over other concerns such as local architectural character, or the visual comfort of those whose homes stood along major arteries. To a large degree, lighting engineers focused on the question of how to move the largest volume of traffic through any given road system at night.

As such thinking spread, a global luminous order blanketed otherwise dissimilar cities. As the historian John Jakle described it: "In the nighttime city, functionality hinged on one dimension,"automobility". Street lighting soon brought a profound sameness to nighttime seeing" (Isenstadt, 2014). For quite a long time, similar transportation oriented concerns underpinned the planning of urban lighting through much of the world.

Figure 3: "Open Air," an interactive aerial architecture of light, Philadelphia, Pennsylvania. Photo by James Ewing[3]

LIGHTING TECHNOLOGY TODAY

Today, everything has changed. On the technological side, fields such as electrical engineering, software design, materials science and photometry, to name just a few, have been making enormous advances in lighting technologies. Light-emitting diodes (LEDs) have been around since the 1960s but only in the past two decades have they been used broadly for lighting applications. They are small and efficient, which means that most of the energy they use is converted to light, rather than heat, as with conventional incandescent bulbs. Consequently, they are now being used more and more for street lights and for building interiors and exteriors. In fact, there is now a global push to ban incandescent bulbs altogether. The United States, the European Union, Japan, China, India, Russia and Brazil have all set up deadlines to replace incandescent lights and, in some cases, even halogen lamps, with LEDs. And the changeover is only just starting to accelerate as global markets are penetrated more and more by LEDs. As efficiencies increase and costs per element continue to decrease, LEDs are expected to come into even wider use. Their tiny size also lends them great versatility. LEDs can now also be found embedded in furniture and bathroom and kitchen faucets, woven into clothing and attached to jewelry, to name just a few recent applications.

Organic LEDs (OLEDs) are still somewhat new but even more promising. Whereas LEDs are point light sources made from inorganic materials, OLEDs are fabricated as surfaces comprised of layers of organic materials, which makes them more environmentally friendly and easier to recycle. Currently, they are used in digital displays and some interior applications due to their relatively high cost, but larger-scale applications are on the horizon as manufacturing capacity grows. They can be very thin and very light and offer high contrast; they can also be readily laid onto flexible substrates to create radiant sheets or even worked into luminous three-dimensional objects. It is possible even to print LEDs and OLEDs now using off-the-shelf technology, suggesting that soon anyone will be able to make their own light sources. The certain prospect is that any and every surface in a city has the potential to glow.

Lighting controls have likewise advanced greatly with the development of sensors that can detect ambient conditions such as room occupancy levels, fog, highly reflective snow or other factors that affect lighting. Sensors can be embedded in roads to detect traffic density and then initiate dimming cycles to raise or lower street lights. The latest iteration of California's building code goes so far as to require occupancy sensors that can adjust lighting and other building systems in new construction for a range of building types. Manufacturers are already touting sensors in their new lamp designs as standard features. Further, many such products are being combined in interoperable lighting systems, variations of which travel under the names of "smart lighting," "connected lighting," "intelligent lighting" and "adaptive lighting." In these systems, sensors independently communicate with each other or with computers in centralized building or urban control centers, which manage a range of "networked field devices," including sensor-enhanced lamps. Controls can also be made interactive so that passersby might use their cellphones to brighten street lights, much as one might switch on the light in a room. One example of the use of such controls could be seen at Open Air, a light show that took place several years ago along the Benjamin Franklin Parkway in Philadelphia. There, powerful projectors were manipulated by viewers' cellphones to create swaying and intersecting shafts of light. The long horizontal boulevard, a legacy of City Beautiful planning, was thereby reimagined as long diagonal beams sweeping across the night sky.

MODERN MUNICIPAL USES OF LIGHTING

Municipal governments are already using such controls to great advantage. One of the first roadways to deploy dynamic lighting was the M65, in Lancashire, England. Along that route, lighting levels might automatically drop by as much as 50 percent, depending on traffic density (Collins, 2002). A major impetus for government adoption of new light sources and sophisticated controls is the potential for drastic reductions in energy use and, thus, operational costs. Lighting often takes up large portions of municipal energy budgets and the savings can be significant. New York City swapped incandescent traffic signals for LEDs and saw a drop in related energy costs of a reported 81 percent. Hundreds of cities have by now installed LED lighting. The average savings in energy costs was 59 percent, as noted in a study of more than 100 European cities ("LED Projects", 2012). More imperative even than municipal budgets, diminished use of energy directly lowers greenhouse gases emitted in the production of electricity.

Seeing the opportunity for continued adoption, businesses, too, now specialize in lighting management, a new urban service geared to coordinate the convergence of sensors, computer controls, networked communications and lamp types, not to mention other elements of building and urban systems. The overall outcome of these developments is the smart city, a conurbation threaded through with digital infrastructure that is responsive to specific conditions, seeks sustainable infrastructure and that facilitates the making of humane urban systems.

In terms of our understanding of vision, great strides have been made in the field of photometry, which considers light in relation to visual perception, and in the physiology of vision. In engaging the eye, consideration has to be given to a number of factors, not just objective measures of radiant energy, including the position of the source in the field of view, total volume of light striking the retina, length of exposure to the source, and degree of contrast with a background, as well as the brightness of the light source. Vision, in short, is deeply subjective. Satisfactory seeing can be as much a matter of a person's frame of mind as it is a question of wattage.

Today, however, lighting engineers can manipulate light at the level of the photon, and, equally important, they can measure physiological responses just as finely. In the study of the M65 roadway mentioned above, engineers also tested "ocular stress" in drivers, finding that electrical activity in the orbicularis - the large muscle surrounding the eye - ranged nearly 25 percent in response to changing levels of lighting. These new investigative tools are arriving just in time because the conditions for vision are changing so profoundly. Until recently, most studies of vision have presumed photopic, or well-lit conditions, which is ideal for color perception and visual resolution, taking advantage of the cone cells in our eyes. In contrast, scotopic vision, which occurs under low levels of light, was infrequently analyzed. Today, however, the urban night is a mixture not only of low and relatively high lighting levels, it is also punctuated by variously colored lights from different sources in different sizes and with different degrees of animation. In response, scientists in various disciplines are starting to study vision under such mesopic, or mixed luminous conditions.

CONTEMPORARY LIGHTING DESIGN

Perhaps the most impressive change has come about on the design side. For years, corporate interests have been behind most lighting research and design. In the early 20th century General Electric was the majority stakeholder in the National Electric Lamp Association (NELA, originally the National Electric Lamp Company), a trade organization, until an American federal court found it guilty of colluding to fix prices and forced it to divest. Nonetheless, NELA persisted, launching various lighting education programs based on its research, much of it valuable, but aimed ultimately at bolstering the electrical industry's growth. At the same time, many of the most innovative lighting designers worked in theater, only occasionally venturing on to design architectural lighting, as was the case with Abe Feder, Howard Brandston and Basset Jones. Even within the theater, lighting designers did not receive their due until the early 1960s, when the profession was recognized as such and allowed to join the United Scenic Artists Union.

In the last two decades the field has moved well beyond these strictures with the founding or refashioning of a number of professional and governmental organizations such as the International Association of Lighting Designers, the American Lighting Association, the National Lighting Bureau, the Illuminating Engineering Society, to name just a few. While corporations still conduct useful studies, a number of independent groups have become leaders in lighting research, such as the Lighting Research Center at the Rensselaer Polytechnic Institute and the Intelligent Lighting Institute at the Technische Universiteit Eindhoven. In addition, there have been special initiatives such as the Lumina Project and the World Bank's Lighting Africa project, both dedicated to finding sustainable, off-grid lighting solutions for areas without an electrical infrastructure in place.

In many ways, lighting design is in the midst of an unprecedented flowering, driven in part by the wide range of new sources and computerized controls and, most influentially, a heightened awareness on the part of the public and city officials regarding the importance of urban lighting. The International Dark Sky Association, for instance, has successfully campaigned to educate people about the dangers of light pollution with numerous community events across more than 50 local chapters around the world. Making urban lighting more efficient and more sustainable is a primary goal of their efforts. Leading design firms, such as Light Collective, Light Cibles, Agence Concepto, Speirs + Major, ACT Lighting Design, Atelier Ten, Philips Lighting, Arup Lighting, to mention only some, now see cities as canvases for luminous inventions that are effective, evocative and environmentally sound.

The net result is a substantial widening of the scope of our understanding of what lighting can do in the city. Traditional functions of lighting remain, of course. Security, the most enduring role of urban light, is still paramount. Wayfinding and orientation, that is, knowing where you are in the city and where you need to go, are likewise long-standing aims of urban lighting. Cities have been requiring lighting on commercial frontages or in public squares for hundreds of years, for example. These functions continue to be crucial but they are understood differently now.

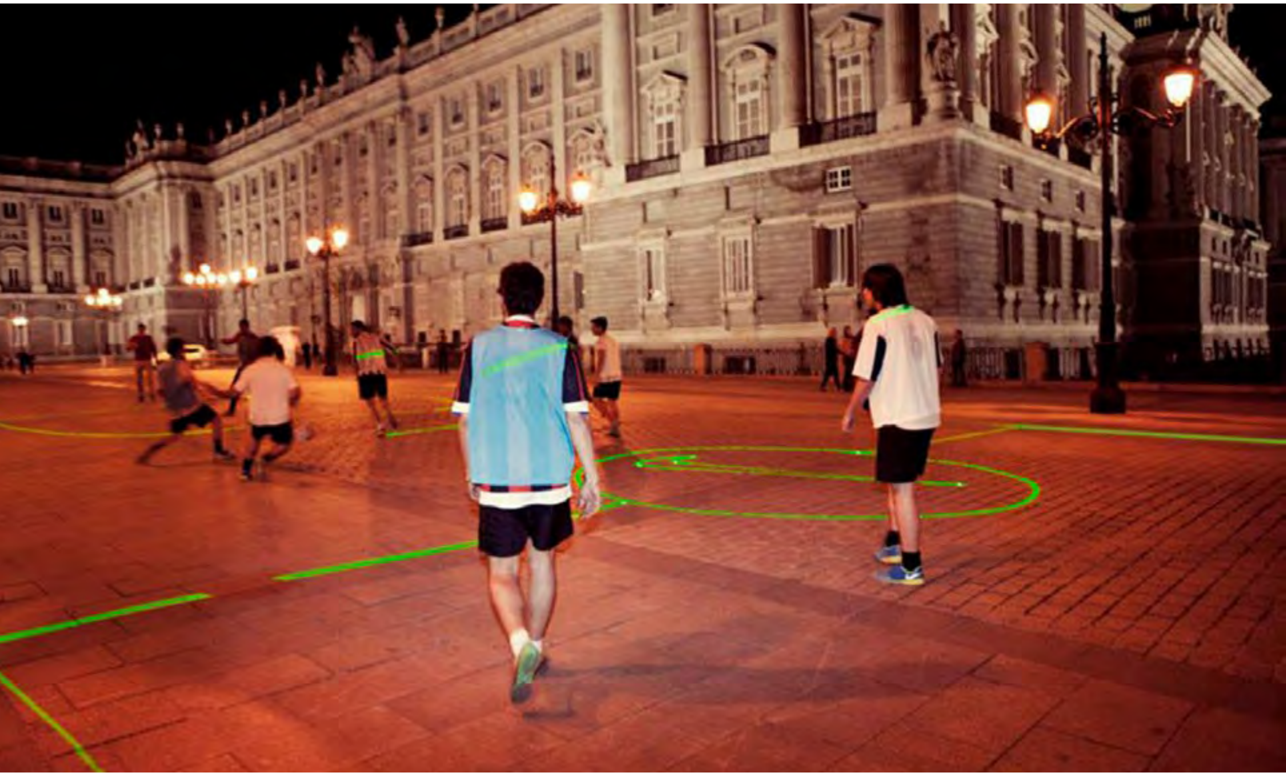
Feeling secure in the city entails much more than moving through an envelope of bright light. A good deal of research has shown that a sense of security is a psychological state that rests on a number of factors not found in crime statistics. Brightness alone can create stark shadows and lead to slower visual apprehension or lead to afterimages that can momentarily impair vision. The possibility of a pedestrian controlling nearby lamps through her cellphone can also contribute greatly to a feeling of security as well as provide an actual deterrent to crime. (Painter, 1999; Welsh, 2009; Grohe, 2011) Likewise, orientation today means more than providing illuminated directional signs. With urban transit systems needing to integrate a range of vehicles, including bicycles, trams, light rail, automobiles, buses and so on, not to mention pedestrians, lighting can help differentiate modes, facilitate transfers and, at the same time, visually unify the entire system. The lighting for Canada Rail in Vancouver, for example, designed by Total Lighting Solutions, encompasses a system comprised of sixteen differently configured stations with clarity, crisp lines and graphic character.

Figure 4: Canada Line Station at the Vancouver International Airport, ca. 2010. Total Lighting Solutions, Inc. Photo by: Charlie McLarthy[4]

FUTURE DIRECTIONS FOR URBAN LIGHTING

Beyond rethinking these traditional functions of light, designers are proposing whole new possibilities. Lighting as an element of urban redevelopment is one potential direction. In 2006, for example, the Dutch firm Daglicht en Vorm won a competition sponsored by the city of Rotterdam to help redevelop Katendrecht, a run-down district near the harbor. On one street, the Atjehstraat, the firm created “Broken Light,” a remarkable scheme that casts ample light on the street for cars, pillars of light between windows on buildings and a staccato, mottled pattern of light on the sidewalk. Residents followed the unusual design’s planning and installation and took part in the festivities once the lights were switched on (Metz 2012). Building community awareness was likewise a goal in a very different project at Canal Park, in southeast Washington, DC. There, an area of abandoned houses and vacant lots was redeveloped as a diverse and affordable area redubbed Capital Waterfront. A weed-strewn lot at the center was transformed into a park, with the public invited to work with designers and planners. Atelier Ten, the lighting designers, placed a luminous cube at the center, on which local artists project their work and movies are screened at night. The park’s attractions draw visitors at night, making this formerly perilous area an urban oasis (Loeffler, 2015).

Yet another possibility for bringing together groups of people is the use of projected light. In the late-19th century, stage lighting pioneer Adolphe Appia foresaw the possibility of throwing light across space to create forms and textures and advance a dramatic narrative. Today, lasers - optically amplified projected light - have moved well past the light shows where most people first encountered them. They are stronger now, and more portable; coupled with computer controls, they are also capable of intricate detail. Several years ago, sportswear manufacturer Nike, for instance, developed #MiPista, a virtual pop-up soccer pitch projected from a van on to streets and squares in Spain. The demonstration project, now over, had a van on call all night in Madrid; it could arrive and set up within minutes after receiving a request. Nike’s commercial motivation notwithstanding - the firm developed a special shoe for the laser lines - the idea holds promise for any number of impromp-



tu urban events.

Such possibilities have greatly expanded the range of questions we can now ask regarding urban lighting. Light is ubiquitous but it has somehow remained invisible in sociological research, notes Don Slater, a professor at the London School of Economics. He, along with his colleagues, co-founded "Configuring Light. Staging the Social," a research program dedicated to looking at light as a formative, material element of human environments that bears on the satisfaction of social needs (www.configurinlight.org). In one study, the team conducted research in Derby, UK, in regard to a new lighting master plan. The purpose of the lighting plan was to consider a number of issues, including ways that lighting can help revitalize urban districts, accommodate special-interest groups such as the elderly and balance current uses with anticipated and even unforeseen future uses. Significantly, they also addressed questions of financing infrastructure projects, an especially meaningful matter given the finite resources of most municipalities. The city served "multiple socialties," each with unique and sometimes

Figure 5: #MiPista, a virtual pop-up soccer/football field created by a van, mobile crane and crew, Madrid, 2013. Photo from: nike-footballspain[5]

even competing lighting accommodations. As they succinctly noted, "lighting ... involves political decisions" (Entwistle, 2015).

Although new lighting technologies have enabled such forward-looking efforts, they are likewise being called upon to look back on our shared urban heritage. Many cities have embraced preservation efforts as a means of sharpening their unique cultural assets and, in many cases, mobilizing them to increase tourism as a source both of local pride and new revenue. Cities such as Bilbao, Spain, for example, recognized the opportunity to reinvent itself as a culturally rich destination following the decline of its traditional industries. The question many such cities face is how to balance the old with the new, how to honor the past without being sac-

Figure 6: Lighting differentiated according to surface, architectural character and function create a meaningful ribbon of light along the Donaukanal as it cuts through Vienna. podpod design for the City of Vienna. Photo © MA 33/ Gerhard Dully[6]

charine or replicating a set from Disney World. Many cities now ask precisely these questions of their lighting, too: "How does "new" light reveal the historic city?" as Susanne Seitinger, a manager with Philips Lighting, phrased it. She was discussing efforts to revitalize the Donaukanal, in Vienna. There, the lighting design firm podpod called for a "light ribbon" drawn across the heart of the city that would unify both banks of the canal and at the same time distinguish special spots along it. Pedestrian strips were bathed in a warm white light to enhance facial recognition and eye contact, while vehicular routes were doused in the pinkish-yellow light of high-pressure sodium lamps and building facades were differentially lighted to accord with their architectural or historic character. The result was a cultural hierarchy rendered in light, in some ways making the city more legible by night than by day. New technologies and thoughtful design combined in Vienna to flatter the city's historic complexion (Seitinger, 2015).

Efforts such as those in Vienna represent perhaps the greatest shift in lighting design thinking of recent years: how can light enhance a city's unique nocturnal identity. Picture Paris, for example, and the Eiffel Tower is there. Or Sydney, and you see the Opera House. In time, perhaps lighting might become the emblem of a city. It's already happening to some extent. The Golden Gate Bridge is a San Francisco icon by day but at night eyes shift toward the Bay Bridge, wrapped in fulgent fibers of light by artist Leo Villreal. The lucent sculpture was planned to run for two years; public affection for the work will keep the lights on permanently. Likewise, Tokyo's Skytree, at 634 meters, is not only a hard-to-miss landmark, it is also a beacon to the city's past. Each year, the tower is lighted in two styles inspired by Edo period aesthetics, recalling when the city was the seat of the Tokugawa shogunate, and timed to co-

incide with the season of cherry blossoms, a longstanding decorative and, even, philosophical motif in Japan. At night and in season, the Skytree hosts "the world's number one night cherry blossoms" and by means of this association helps to rehearse the country's initial assimilation of electricity in terms unique to Japanese society (Mizuta, 2015). Shanghai rests even more of its identity on its night lighting. Known as "the city of blazing night" since at least the 1930s, the city has in recent decades reconfigured itself as a global financial center, brandishing the slogan "Let Shanghai Light Up" since the 1990s and forging fantastic multi-colored lighting into a spectacular kind of soft power. The city has even established a Night Lighting and Construction Management Agency to oversee illumination plans, especially on the banks of the Huangpu River that separates the old city from Pudong, the new district known to a large degree by its spectacular lighting (Lin, 2015). For its part, Baltimore, an American city long in decline, is just now launching "Light City Baltimore," a large-scale light festival, modeled on those of a number

Figure 7: A new nighttime landmark: the San Francisco Bay Bridge. Leo Villareal, *The Bay Lights* (2013). Photo by Lucas Saugen[7]

Figure 8 (right): The Tokyo Skytree, the world's second tallest structure, combines height and history with its cherry blossom season lighting[8]

of other cities, intended to attract international attention and, ideally, free-spending tourists. (http://lightcity.org/about-the-festival/). Projects such as these demonstrate that, while the laws of physics that govern electricity are universal, the ways in which light is incorporated and made part of the urban fabric vary in culturally specific ways.

By means such as these, many cities are lighting up a nighttime profile that aligns only partially with their daytime geography. Kings Cross Square in London, adjacent to two major rail terminals, had long provided a disheartening entry into the metropolis, not at all in keeping with the stations' importance. A redesign has turned the situation around, especially at night.

StudioFRACTAL Lighting Design considered intersecting traffic patterns and developed an all-LED scheme that provides ambient light from a set of tall columns that also function as nighttime landmarks, smaller columns that help orient and guide pedestrians and a number of smaller sources deployed as freestanding elements or embedded in plaza furniture. All these elements combine with lighting on the station façade to create something of a variegated luminous solid that one passes through, rather than a set of surfaces one walks over or alongside. At night, a radiant kind of monumentality appears to bring the site into alignment with the essential functional role it plays in the city's life. Artec3 Studio, to take only one more example, has designed the lighting for several plazas in Spain, including Firalet Square in Olot, north of Barcelona, and Torico Square, in Teruel, Spain, north of Valencia. Both designs give to light a palpable sensibility, making the most ethereal of perceptions into a kind of living presence.

In sum, these recent, staggering developments are giving rise to a contemporary urban nightscape characterized by an amalgam of point sources, radiant surfaces, flashing words and patterns, glowing mobile screens and so on, all of which can fluctuate in color and intensity and respond to programmed sequences, changing conditions or individual whim. Until a short time ago, energy was squandered by inefficient lamps or sent into space by poorly-designed luminaires. Now, light can be placed where and when it is needed, with near-pinpoint accuracy and at relatively low cost. In the past, lighting ranged between utilitarian and decorative. Now, it can be transformative, an active element in shaping the conduct and character of urban life. Formerly, cities had come to be overspread by uniform lighting suited to automobile drivers. The Times Squares of the world were a spectacular relief to those conditions, however much they might have recalled one another. Today, cities are distinguishing themselves with patterns of light fine-tuned to their streets, the buildings that line them and the people who move along them. The synaesthetic city was once conjecture; now it is a looming reality as designers use sound and touch to activate lighting and meld the senses in new ways.

Figure 9: Pudong, Shanghai, city laser light show[9]

Figure 10: A new center at night, through light. King's Cross Square, London. Lighting Design: StudioFRACTAL.
Photography: Hufton + Crow, Will Scott Photography (2013)[10]

Figre 11: Plaza lighting with a palpable presence. Artec3 Studio, lighting design. Adjuntamente d'Olot, Girona, Spain. Photo ©Pep Sau. 2011[11]

The spatial and even behavioral implications of such changes are still unfolding but, clearly, new forms of lighting today have potential to harness otherwise dimensionless digital technologies in the formation of distinctive places that generate a sense of scale, immediacy and presence. The rhymes and reasons of these new coruscating divinities no longer elude us: they are the product of reason, design, experiment and necessity, and are pursued by countless technicians, designers, artists and civil servants. They no longer cavort mysteriously, as Brooke supposed in Times Square, they commingle now to broaden and brighten the public's dawning consciousness of the potential of lighting to rewrite the urban night. ◆

ENDNOTES

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MANAGING URBAN STORMWATER AND ITS INFLUENCE ON BUILDING A SUSTAINABLE, RESILIENT CITY PHILADELPHIA, PENNSYLVANIA

HOWARD M. NEUKRUG · LAURA BARRON

» Rainwater has a value that can be used to not only rejuvenate the environment, but also the city's economy and infrastructure. «

Philadelphia Water has been working with other city agencies, urban planning organizations, developers, private and public land owners, community groups and politicians to successfully leverage new green stormwater infrastructure (GSI) solutions into new urban thinking, planning and construction to insure a sustainable and resilient city into the 21st century and beyond. The Green City, Clean Water (GCCW) program is part of a new "One Water" management approach to integrating the traditionally "separate" business sectors of drinking water, wastewater, stormwater and water resource management. The Philadelphia model is being adopted by cities throughout the US.

Figure 1: Green roof installed on Philadelphia's Central Public Library. Source: Philadelphia Water Department

BACKGROUND

There is urgent need in the US for a new generation of infrastructure to replace the current water and sewer pipe networks which were largely designed and built between the 1880s and the 1940s. These systems are wearing out and becoming obsolete. The grand problems they solved at the turn of the 20th century (typhoid, sanitation, delivery of water, etc.) do not address new 21st century threats (emerging pathogens, toxins from Cyanobacteria, heavy metals, sewer overflows, drought, floods, and more).

The costs to rebuild these systems in the US is estimated at over 1 trillion USD[1]. It come at a time when the economy cannot afford this outlay, much less the plethora of other challenges facing 21st century urban America, such as those attributed to changes in climate, economy, security, demographics, as well as societal responses to urban issues of environmental justice and economic inequity.

To alleviate this problem, one of the most critical elements of the United States Clean Water Act of 1972 was its massive construction grant programs for expanding and improving regional wastewater treatment. By the mid-1990s, this program, along with new rules governing the discharge of industrial wastes, dramatically reduced river and stream pollution in the US. In fact, only one major pollutant source, urban stormwater runoff, remained largely unchecked.

Stormwater runoff can affect almost all aspects of a water systems, including scarcity, flooding, pollution, infrastructure capacities, erosion, wildlife habitats; and stream temperatures. To manage this runoff, utilities began constructing large underground storage systems, often employing massive tunneling projects. This approach, used by urban water engineers for millennia, manages increased demand by increasing infrastructure capacity. With little to no jurisdiction over urban planning, development controls, or land management, the urban water engineer really had no choice *but* to design to manage, regardless of how much runoff was sent to its sewer inlets. Issues of climate change and increasingly extreme weather events seemed only to further justify this approach.

Indeed, among the most significant programmatic costs to US water utilities in the past two decades have been massive tunnel construction projects designed to reduce the overflows of raw sewage and stormwater into our rivers and streams. Up until the middle of the 20th century, major portions of the nation's water waste went largely untreated and directly into rivers. Since that time, the city has invested billions of dollars to build modern, state-of-the-art Water Pollution Control Plants (WPCPs) to treat the wastewater to levels cleaner than the river water itself. Today, cities like Philadelphia operate some of the most advanced, complex, and efficient wastewater facilities in the world.

But no matter how sophisticated the facilities, the overflow problem persists. The capacity of the sewer network and the pumping and treatment facilities proves insufficient to capture and treat all of the polluted rainwater that is generated nearly every time it rains. In fact, for Philadelphia, only about 67% of the combined sewage/rainfall is "captured" – the rest continues to pollute rivers and streams. This is not only disgusting, but also is legally unacceptable under the Clean Water Act. The cost of managing the rainfall is no longer a hidden fee or tax paid by direct discharge to our streams, but rather is a new cost to cities and suburbs for years of urbanization.

Today, the US water sector is moving toward a newer, softer, greener, more decentralized approach of managing runoff. Instead of increasing sewer capacities to meet runoff capture requirements, a new paradigm has been introduced to limit the demand on our infrastructure by managing rain water more locally, by allowing the rainwater to be captured and managed on-site. Put simpler, rainwater will no longer be treated as a waste product to be discharged as expediently as possible to a sewer drain. Instead, rainwater runoff has been recognized to have significant beneficial impacts on the environment and economy. More importantly, rainwater has a value that can be used to not only rejuvenate the environment, but also the city's economy and infrastructure.

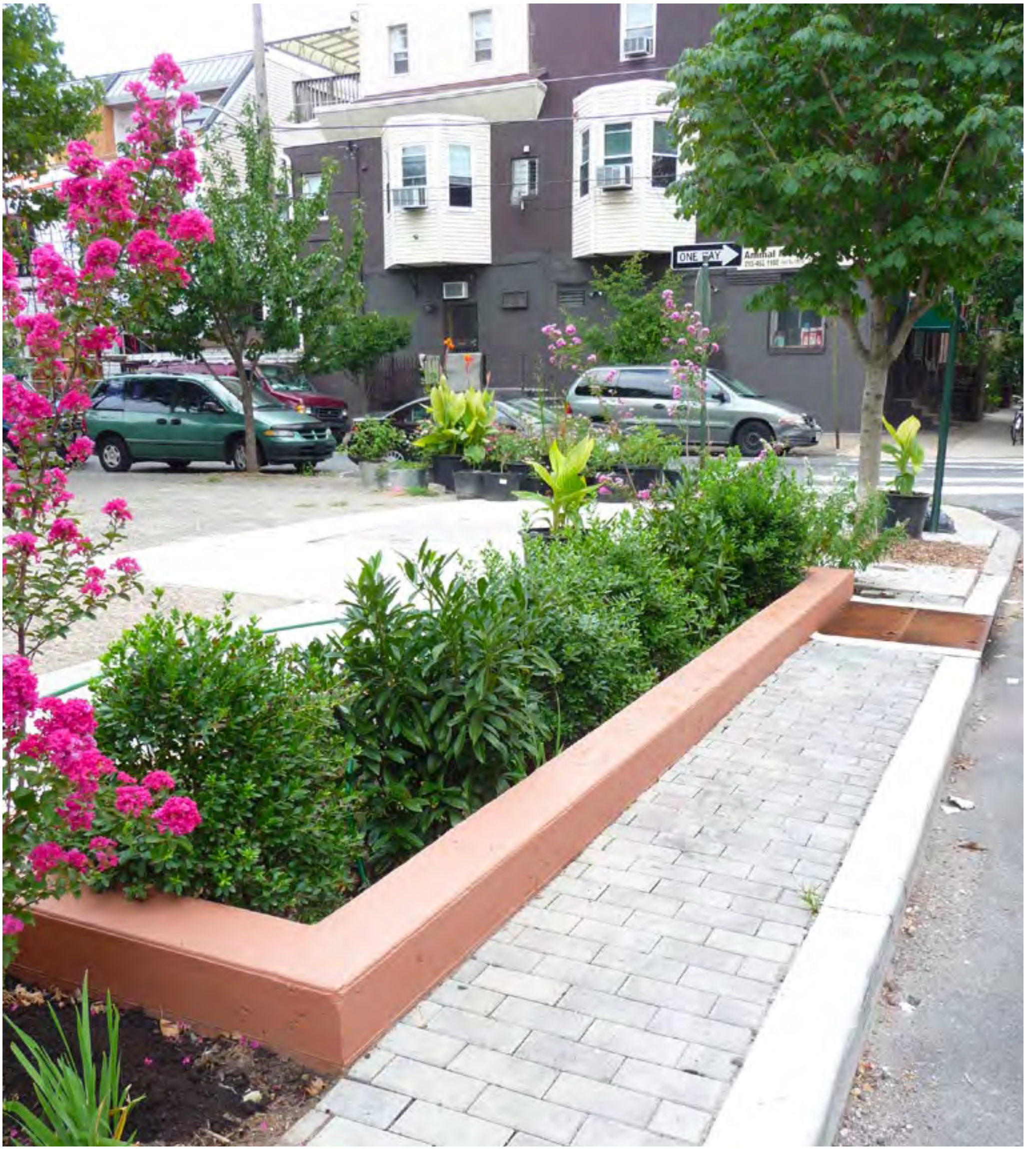

Figure 2: Rain garden corner bump out installed by Philadelphia Water.
Source: Philadelphia Water Department

Figure 3: Students playing on new GSI playground. Source: Philadelphia Water Department

CITY-FOCUSED SUSTAINABILITY INITIATIVES

The 2008 inauguration of Mayor Michael Nutter brought with it a revolution of green progressive thinking for Philadelphia. Fulfilling a campaign promise, he formed a Mayor's Office of Sustainability, which spent its first years developing a policy and benchmarking document for meeting new sustainability goals that addressed issues of energy, green space, and water.

This timing was extremely fortunate for Philadelphia Water, which was negotiating with the USEPA on the details of its stormwater program. Most importantly, the city's political emphasis on sustainability and the Department's focus on stormwater got the citizens of Philadelphia involved at all levels and all ages. From rain barrel programs and home-situated rain gardens, to science, engineering, and math lessons in water management in our schools, to community groups repairing vacant lots and protecting their new neighborhood parks, increased community involvement and engagement with sustainable water practices has greatly increased the capacity of the GCCW.

GREENER CITY, CLEANER WATER

"Green City, Clean Waters" (GCCW), created in 2009, aims to reduce the amount of polluted runoff that enters the city's water system. Unlike conventional stormwater management programs in the US and elsewhere, it does not rely solely on increasing sewer and treatment plant capacity to manage a seemingly ever-increasing load of rainwater[2]. GCCW aims to "conserve rainwater", meaning that we now value our rainwater as an urban asset and not as a wastewater product. Rather than discard the rainwater down a sewer drain as swiftly as possible, we now look to use it to improve the quality of urban life. We want to use water management techniques to balance nature, development, and people in the urban setting.

As America's first capital, the city of Philadelphia was among the world's great industrial cities at the turn of the 20th Century. Now, following a 25% loss of population over the past 50 years, Philadelphia is transforming again, this time into a beautiful, vibrant, green city, destination for tourists, and hub for innovation, healthcare, and education. However, because of its industrial history, the city remains marred with environmental challenges and has needed to place special focus on sustainable development as the city revitalizes.

Despite the positive changes Philadelphia has seen, the storm sewer system can surcharge during even small rain events, and result in sewage, trash, and flooding in our rivers and streams. Increasing sewer capacity (through the construction of bigger and bigger pipes, tunnels, and

Figure 4: Raingarden installed in Philadelphia's public school, Greenfield Elementary School. Source: Philadelphia Water Department

pumping stations) can no longer be considered affordable, justifiable, or sustainable.

In order to alleviate the demand on the city's sewer system, the GCCW program proposed a variety of "green stormwater infrastructure" (GSI) systems to intercept stormwater, using soil, water, and plant catchment systems to infiltrate water into the ground, evaporate and transpire water into the air, and, in some cases, slowly release a portion back into the sewer system. Through this new green infrastructure, the city seeks to not only improve water quality for residents, but also to improve the regional environment and create a more resilient, threat-resistant system.

In addition to increasing resilience and environmental quality, the city sought opportunities to use urban redevelopment to increase the integration of key system services so as to create a more sustainable, attractive and livable city. Philadelphia Water has started to partner, coordinate, and integrate its water infrastructure operations and capital improvements into the very fabric of the city. By doing this, it can use its water capital to improve not only the city's tunnels and sewage but also parks, school, businesses, homes, public facilities, universities, and much more.

CREATING 10,000 GREEN ACRES

In partnership with the US Environmental Protection Agency (USEPA), the GCCW program has agreed to build 10,000 Green Acres (GAs) over the next 25 years. One GA is defined as the conversion of one acre of impervious land to one acre that manages the first one-inch (2.5 cm) of each rainfall. Table 1 shows the five-year benchmarks for the program. As of this writing, the program has surpassed its first five-year goal of 750 acres by 130%.

These GAs, combined with certain improvements in wet weather capacity at the wastewater treatment plants and sewer systems, are intended to increase the efficiency of the sewer system from managing just 67% of overflows to 85%, or, said another way, more than a 33% increase in the working capacity of the system (9 billion gallons of additional runoff management).

Since this program called for the conversion of 10,000 acres of impervious land that was managed in an environmentally sensitive manner, everyone seemed to get on board, including: the Streets Department with litter control, "complete streets[3]" and bicycle lane projects; Parks and Recreation began a million tree planting campaign with its non-profit cohort, the Pennsylvania Horticultural Society; the school district became interested in our schemes to "green" asphalt schoolyards; and our City Planning department developed an environmentally friendly "Plan 2035".

METRIC	YEAR 0	YEAR 5	YEAR 10	YEAR 15	YEAR 20	YEAR 25
TOTAL GREENED ACRES	0	750	2100	3800	6500	10000

Table 1: Green Acre Goals by Year (year 0 began June, 2011)

Land management strategies used to achieve 1000 GAs during the first five years of the GCCW program are shown in Textbox 1 and will be discussed further in this document:

- → Green and/or porous pavement street improvements following water/sewer reconstruction projects
- → Improvements to schoolyards, parks, vacant land and other open space areas
- → Improvements to public facilities
- → Instituting a parcel-based stormwater fee system to encourage rainwater conservation
- → Creating a stormwater credits system for on-site stormwater management
- → Competitive grants to public and private entities to improve properties
- → Development regulations requiring private management of the first 1.5 inches (3.8 cm) rain

Textbox 1: Land Management Strategies for achieving Green Acres

FINANCIAL AND SOCIAL INCENTIVES TO CREATE CHANGE

Taking advantage of the spread of progressive green thinking in Philadelphia, the water utility institutionalized several important programs, regulations, and policies that not only supported its own goals of water quality, but also the city's goals to improve livability, jobs, and sustainability.

The most important driver for change began with new stormwater development regulations[4]. Under the new regulations, developers needed to provide measures to abate runoff on their properties.

These new regulations did add to the design and construction cost of new buildings and created some friction within the development community. Everyone accepted that they needed plumbing to run drinking water into the premises and wastewater out, but stormwater management was considered "free" - to be collected by the landowner and discharged to the sewer. It has taken careful talks, encouragement and cooperation to dispel the traditional philosophy on water management - that the sewer capacity was practically unlimited, since any overflow "just went to the river".

To support the development community, Philadelphia Water recognized that time equals money and worked to compensate for the new costs by issuing "expedited permits" for projects which included on- site stormwater abatement systems, such as green roofs and porous pavement projects. In addition, engineering support services were provided free of charge to developers and engineers early on in the conceptual project design phase which helped increase efficiency and ease costs. Though it was a long process to find reasonable procedures that allowed for stormwater management as well as development, it ultimately resulted in

Figure 5: Green roof installed on Golkin Hall of the University of Pennsylvania's Law School. Source: Philadelphia Water Department

Figure 6: Rendering of stormwater tree trenches created by Clean Water, Green Cities Plan. Source: Philadelphia Water Department

a new modern building designs that led to LEED certifications and increased market value and a city exporting its architectural and engineering prowess to other cities across the US.

In 2011, perhaps the most important element of a green stormwater program was put in place, a parcel based billing system for deriving revenues to pay for the Philadelphia Water US $150 million “stormwater utility”. Philadelphia Water commoditized the rain in order to remediate this negative externality from the true cost of managing that rainfall. In effect, the impervious and gross areas of every property parcel in Philadelphia was analyzed and priced so that each property owner paid their “fair share” for managing the rainwater.

This created an incentive for private landowners and government agencies to reduce their stormwater fees by personally managing the runoff from their property. In effect the city created a credit incentives program for property owners to move off of the city stormwater system, thereby decentralizing stormwater management. In order to facilitate the conversion of land into green stormwater management systems, Philadelphia Water also created grant opportunities for landowners to further motivate them to retrofit their systems.

With these policies came a wave of community support that turned out to be the most rewarding and sustainable return on investment for the city. Community groups vocalized their desire to make changes – from school yards to vacant lots, so much so that Philadelphia Water

Figure 7: Philadelphia Water encourages residents to implement green infrastructure in their homes, like pervious surfaces for backyards and patios. Source: Philadelphia Water

was accused of "inciting the masses" despite the ability to execute the projects due to funding restraints. For example, controversy arose over the fact that the specific funding could only support water projects, but when picnic tables or play equipment are involved, other funding sources was required. This forced politicians and government agencies to collaborate and fundraise.

In 2015, Philadelphia Water worked with the development community in a very democratic process to revise the regulations, provide more management of runoff (1.5 inches (3.8 cm) of rainfall), and create new incentives for developers to use "green" alternatives for stormwater management. The city worked to be widely supportive throughout the change in regulation, from providing educational materials regarding the changes, to working with the community to make sure their viewpoints were heard. One stakeholder even described their experience as, "democracy the way it was intended to be."

The city has seen significant progress since the inception of GCCW. In 2006, Philadelphia had one green roof. By the end of 2015, the city boasted over 150 green roofs, creating a new industry; Design, construction, and maintenance of green roofs became a new business for Philadelphia and green jobs expanded across the city. At its core, the investment in Green City, Clean Waters has certainly met its triple bottom line goals of improving the environment while making Philadelphia a greener, more viable place to live and work.

RE-ENVISIONING INFRASTRUCTURE

As noted earlier, urban land management and control has remained an area largely outside the purview of the water industry. As Philadelphia Water learned more about the full impact of urban land use decisions on water quality and quantity, it is becoming increasingly more difficult to integrate water issues without addressing the complexity of the urban systems of land management. Questions arose such as, how do we integrate and coordinate the construction and rebuilding of public roads, public spaces, and private development in a manner that most efficiently and effectively manages our water resources, prevent pollution, and create a cohesive and leveraged and sustainable city system?

It will take vision and leadership to overcome the multiple barriers that confront the city to find local solutions for our global water problems, *and* to do so in a way that supports a livable, sustainable city. With urban water systems as a national focal point for reform and financial support, there is no better time to integrate environmental protection strategies, responsible land use, and dynamic zoning reform with infrastructure improvements through the use of integrated urban systems thinking.

As to the future, cities across the world must recognize that GSI is a very new field. Innovations are occurring daily. Regular analyses and modeling of these systems along with adaptive management at the water and city levels are essential to achieve the correct future balance of clean, abundant water and green, sustainable, and resilient cities. ◆

→ A recent study found that the new regulations helped catalyze a best-in-class GSI industry cluster in Philadelphia, with meaningful consequences for the local economy. The study found that the local GSI industry is experiencing double-digit annual growth and conservatively represents annual economic impact of almost US $60 million, supporting 430 local jobs and generating nearly $1 million in local tax revenues. The innovative solutions birthed for the GCCW program also produced export opportunities for the benefit of the local economy and established Philadelphia as a leader in stormwater management, positive media coverage, national awards, and emulation from such cities as New York City and Washington DC.

ENDNOTES

1 http://gsipartners.sbnphiladelphia.org/wp-content/uploads/2016/02/SBN_FINAL-REPORT.pdf

2 Like many global cities, Philadelphia is experiencing unusually heavy intensity, short duration but more frequent rain events over its highly impervious ground cover so the concern for rainwater runoff burden has increased significantly.

3 In June 2009, Mayor Nutter issued the Complete Streets Executive Order, requiring all City departments and agencies to balance the needs of pedestrians, bicyclists, public transit users, and motorists when making decisions regarding the transportation system and development projects. The Order places a high priority on increasing safety and convenience for those traveling in the public right-of-way, particularly children, the elderly, and persons with disabilities (City of Philadelphia Complete Streets Handbook)

4 In old, industrial cities like Philadelphia, most development is actually re-development of a previously purposed and built site; not the development of "green" (previously undisturbed) sites. (This has allowed Philadelphia to actually reduce impervious cover in the city by about 0.4% per year, just through the demolition and re-building of properties.)

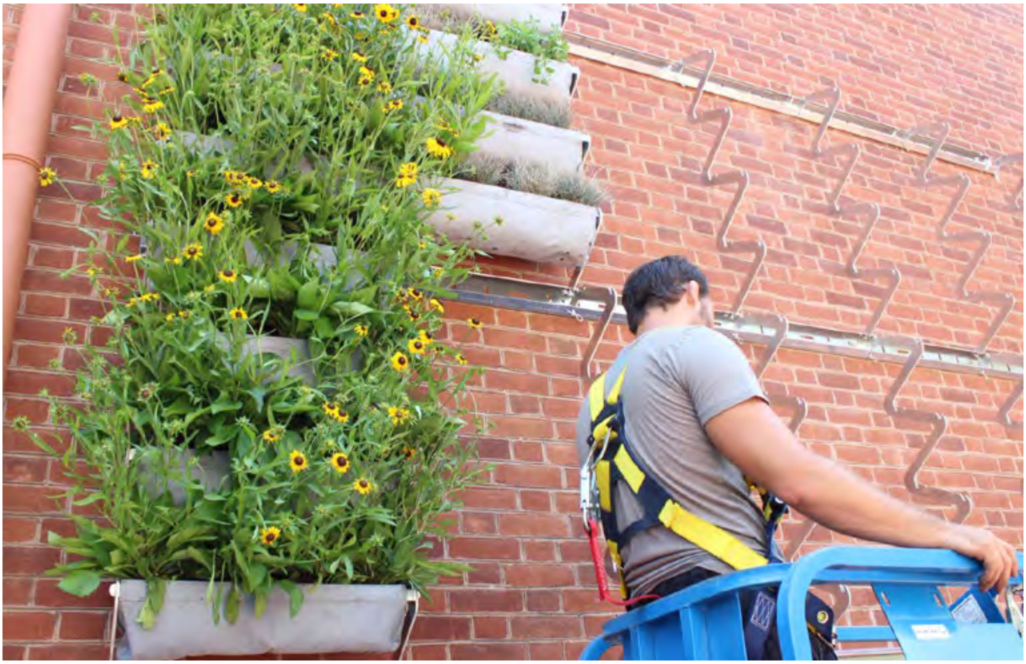

Figure 8: "Drainspotting" initiatives use temporary art work by Frank McShane to decorate storm drains in Schuylkill River Park and Vernon Park. Source: Philadelphia Water Department

Figure 9: Living wall installation on the Park Institute building. Source: Philadelphia Water