Memo: Analysis of Green Water Infrastructure and its viability in achieving financially sustainable, effective sewer and water systems

Greater Ohio Policy Center

April 2016

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) recently released its Clean Watershed Needs Survey in January 2016, which estimates about $271 billion in funding will be needed nationally for upgrades and maintenance for wastewater and stormwater treatment and collection needs to bring communities into compliance with the Clean Water Act.[1] Over $14.5 billion is needed for Ohio with over 56% of that amount anticipated for combined sewer overflow (CSO) correction and stormwater management. Over three-quarters of the facilities in need of upgrades serve small and medium-sized towns and cities (i.e. municipalities with less than 200,000 residents).[2] In an era of contracting resources, municipalities are forced to make difficult decisions, often in favor of immediate needs while delaying long-term updates and upgrades. As the Greater Ohio Policy Center found in its recent report, "An Assessment of Ohio Cities' Water and Sewer Infrastructure and Brownfield Sites Redevelopment" there are several factors undermining many Ohio cities' ability to adequately pay for repairs to systems, including: population decline, stagnant tax bases, inability of municipalities to take on additional debt, and the enormous cost of upgrading water infrastructure.

In areas where finances for infrastructure upgrades are scarce, aging water and sewer systems, often referred to as "gray infrastructure,"[3] remain the status quo until the effects of their age become more apparent and in need of immediate attention. Unfortunately, this delay can cause significant health, environmental, and economic distress, as recent events in Flint, MI and Sebring, OH demonstrate.[4] As cities, districts, counties, and states begin to upgrade and improve stormwater management systems, many have incorporated green infrastructure into their designs, realizing there are unused inherent resources available that will eliminate gallons of runoff. Green infrastructure includes a wide variety of techniques to restore the hydrologic function of an urban landscape in order to capture more stormwater, thereby reducing pollution, sedimentation, and erosion.[5] Early adopters have demonstrated that green infrastructure is a viable and cost effective alternative when incorporated into infrastructure improvements and planned investments.

Green infrastructure generally includes:

- Porous pavement, often found in alleys, parking lots, or streets
- Green roofs
- Bioswales and other catchments that hold stormwater run-off
- Bio-infiltration systems

OBSTACLES & BENEFITS OF GREEN INFRASTRUCTURE IN OHIO AND NATIONALLY

Nationwide, green infrastructure is gaining ground as a complementary system that enhances and improves stormwater mitigation and filtration. However, questions about the financial viability of

---

1 Clean Water Needs Survey 2012, <www.epa.gov/cwns>.
2 CWNS, <https://ofmpub.epa.gov/apex/cwns2012/f?p=121:2:>
3 Grey infrastructure, green infrastructure and other terms are defined in the Appendix.
4 (Kleine, 2016; Wines and Schwartz 2016)
5 U.S. EPA, Green Infrastructure Opportunities that Arise During Municipal Operations, EPA 842-R-15-002 (January 2015), http://www.epa.gov/sites/production/files/2015-09/documents/green_infrastructure_roadshow.pdf

green infrastructure and its long-term effectiveness have slowed its adoption. Financial worries are especially palpable in legacy cities with histories of extractive and industrial economies, brownfields, declining populations, and concentrated poverty. However, green infrastructure for stormwater abatement is also argued to be cost effective with the added benefits of environmental health, stable economic activity, and social/community improvement. Projects have been shown to have quantifiable economic and environmental benefits, as well as potential challenges that are not present with gray infrastructure. The objections to and benefits of green infrastructure are described below.

Green Infrastructure Cannot Completely Replace Gray Infrastructure

The effectiveness of green infrastructure at capturing stormwater depends on the landscape and the specific sewer and water infrastructure demands of a municipality. In most instances, it is unrealistic to expect that green infrastructure alone will meet all of city's stormwater needs. Green infrastructure seeks to mimic natural systems and better incorporate the sewer system into natural hydrological cycles. In urban areas, the speed at which runoff and overflow accumulate can be high and therefore are best mitigated through a combined green and gray infrastructure system. Most cities that have incorporated green infrastructure have done it in conjunction with gray improvements or as a supportive intervention to bolster "traditional" infrastructure.

Lower Installation Costs, but Labor-Intensive Maintenance

Green Infrastructure, such as rain gardens, stream daylighting, and bioswales tend to be more cost- effective than installing large pipelines.[6] Cincinnati reduced its anticipated costs by over 40% when it reworked its consent decree to include significant green infrastructure improvements in its citywide improvement plan. This experience has been commonplace as other cities have also used green methods to lower the cost of consent decrees.[7] The EPA has best practice guides available on its website to help communities develop economical, but effective, green infrastructure responses.[8]

Taken individually, there are some forms of green infrastructure that cost more than their counterparts, such as porous pavement compared to asphalt, and green roofs compared to traditional roofs. However, their ability to divert stormwater from the sewer system offsets the need for additional gray infrastructure and so reduces costs and, thus, long term debt. It is also important not to focus on upfront costs of infrastructure without considering their long-term effects and efficiencies. For example, green roofs can cost $10.30-$12.50 more per square foot but the lifespan of a green roof is more than double that of a traditional.[9]

Even with the upfront cost of materials for a green roof, bioswales, retention ponds and other interventions, green infrastructure usually pales in comparison to the costs of installing a deep tunnel. Though the cost of green infrastructure components for water system long-term control plans (LTCPs) in total is less expensive than gray, city officials and agencies cite the cost of

---

[6] Odefey et al., American Rivers and American Society of Landscape Architects 2016

[7] Cincinnati, Cleveland, Columbus, and Philadelphia are among the many cities that have reevaluated consent decrees to capture more gallons of runoff and overflow at a lower cost with green rather than more expensive gray infrastructure alternatives.

[8] CSO Control Plans and Remedies 2015. <http://www.epa.gov/green-infrastructure/cso-control-plans-and-remedies>, 2016; U.S. EPA "Green Infrastructure Case Studies" 2010.

[9] City of Camden, "Green Infrastructure Design Handbook," p. 11.

maintenance for green as a large financial burden.[10] Gray infrastructure requires a few highly skilled and technical laborers to maintain and monitor the "traditional" systems underground including tunnels, pipes, and reservoirs. Green infrastructure requires a larger labor force in general to maintain green systems (working with plants and green space, paving alleyways, etc). However, these jobs tend to be unskilled and semi-skilled, and, in many cities, have created employment opportunities for local residents, which could be of interest to Ohio's legacy cities and metro regions that have high unemployment and few job opportunities.

When considering cost and comparing estimates, it is important to consider the context in which a city is upgrading its infrastructure. Wealthier cities often have more financial capacity to keep up with periodic upgrades, repairs, and replacements of grey infrastructure systems. This keeps gray infrastructure costs lower in comparison to cities that postpone repairs due to financial restrains. Also, depending on the age of the infrastructure, the cost can vary significantly. For example, the average age of one of Philadelphia's water lines is about 78 years old with some pipes dating back to 1824.[11] In Cincinnati, it is estimated that over 50% of the city's water works infrastructure is over 100 years old.[12] When a city is under a consent decree with the EPA and is given roughly 20 years to bring everything up to code, large-scale replacement of gray pipes and facilities, as compared to green alternatives, can be cost ineffective and will have limited long term impact under the typical lifespan of traditional infrastructure. Philadelphia found that the gray infrastructure plan would cost close to $8 billion compared to their integrated green-gray plan at $2.4 billion.

Aggressive Implementation Timeframe, but political will is needed for long-term projects

Green infrastructure begins working to mitigate stormwater and runoff almost immediately. The timeline for implementation is negligible compared to that of gray infrastructure, which can takes years to decades. Green infrastructure upgrades are completed within months, at most years, depending on the size of the project. Once implemented, because green infrastructure mimics the natural hydrological cycle, it effectively mitigates runoff immediately.

Though green infrastructure takes less time to implement than gray, most often, gray and green infrastructure are incorporated into one plan and tied to multi-year timelines of the plan. Because green infrastructure can require cooperation among individual property owners, partisan legislatures, and private and public sector coordination, it is difficult to complete in a short period of time. Within that time, political personnel and climates change within municipalities, regions, states, and on the federal level.

Benefits are widespread, but sometimes hard to measure

Conventional gray infrastructure has set geometries, calculable surface friction, degree slopes, and alignments, while the effectiveness of green infrastructure effectiveness cannot be calculated in the same way. Green infrastructure mimics and integrates into the existing environment. The effectiveness of a "green" parcel in one year will improve the next because plants and trees grow, expand, soak up more water, and produce other dynamic changes creating many more variables that make it hard to predict exact impact.

---

[10] Atassi and Tobias Feb. 2014

[11] Philadelphia Water Homepage, "Water Infrastructure Management" 2016.

[12] Interview with Marylynn Lodor. Metropolitan Sewer District of Greater Cincinnati, Nov. 7, 2014.

Some of the most compelling arguments for green infrastructure are economic and environmental, but the contributions to neighborhood improvement may only be realized in the long-term. In areas of economic distress, cleaning up and repurposing vacant land for green infrastructure can also revitalize neighborhoods, attract populations, stimulate economic activity, as well as increase incomes and property values.[13] In cities with brownfields and abandoned property, green infrastructure is a welcome alternative to letting the space remain unused.

For example, Buffalo, NY is addressing its problem of population shrinkage by using abandoned and vacant land to "right-size", incorporating green infrastructure into its urban core. In Ohio, Youngstown has adopted a shrinking city policy as a part of their comprehensive land-use plan, which has allowed them to incorporate more porous surfaces and be an attractive site for companies that need to create wetlands to offset development and sprawl.[14] This practice is called mitigation banking and resides in Section 404 of the Clean Water Act. Under the Act, a mitigation bank may be created when a government agency, corporation, nonprofit, or other entity engages in developments that detract from natural streams, wetlands or other aquatic resources. The entity transfers liability of the effects of its development by purchasing compensatory mitigation credits through a third party. This third party is then liable for the ecological effects and therefore needs to develop a man-made wetland or aquatic resource, fitting ecological specification of quality, to replace what the original development had taken from the landscape. Youngstown is acting as the physical geographic site for the mitigation banks to produce adequate replacements on behalf of the original entity.

Green infrastructure is not only cost effective but also efficient and adds benefits to the human experience, environment, and health far beyond fiscal viability.[15] The permanency and visibility of green infrastructure will presumably push residents to stay because they see stability in the thoughtful investments in infrastructure and the longevity of their environment. Due to neighborhood beautification and reducing the number of abandoned parcels, property values increase and generate a needed boost to struggling legacy city economies.

In the long term, green infrastructure upgrades will not only provide stormwater runoff and CSO benefits but create resilient and long-lasting communities that house more permanent residents, leading to economic, human, and environmental health.

The following case studies make the arguments that green infrastructure, as an asset integrated into existing and new sewer infrastructures, can be cost effective, implemented quickly, and economically beneficial in the long run.

COMMUNITIES AND METRO REGION CASE STUDIES FOR CONSIDERATION

PHILADELPHIA, PA: National Model for extensive use of green infrastructure and stormwater fee systems

Philadelphia, PA, one of the largest and first municipalities to meet consent decree requirements by integrating green and gray infrastructure, is dedicating close to 70% of its proposed $2.4 billion

---

[13] Shillling 2008.
[14] Schilling 2009; Hollander 2009; Shetty 2009.
[15] Copeland 2014.

Long Term Control Plan (LTCP) budget to green infrastructure.[16] The "traditional" gray infrastructure plan would cost close to $8 billion. The city plans to replace 30% of its roads with porous material, is giving rain barrels to residents for free, and strategically placing rain gardens in the city to name a few uses of the "green" money.[17] Philadelphia estimated jobs to increase, human and environmental health to improve, and overall quality of life for its residents to positively reflect the investments in greening the city for stormwater and CSO abatement purposes.[18]

Pennsylvania also has a unique financing structure for infrastructure projects. PENNVEST, the state infrastructure investment authority awarded Philadelphia a $30 million low-interest loan specifically for green projects in 2009.[19] Philadelphia also changed their stormwater fee system from a meter-based rate to one correlated to the total parcel area and impervious surface area: from 1976 to 2008, the larger the meter, the larger the stormwater fee. With rising inflation from 1980-2000, total water, stormwater and sewer bills rose significantly, reaching $50 per month or more. In the early 2000s, Philadelphia began feeling pressure from environmental regulators to reduce non-point source pollution as well as pressure to adjust stormwater charges to reflect runoff produced, not water usage. Between 2008 and 2013, the city phased in an area-based charge while phasing out the meter-based charge in 25% increments. Today, the monthly baseline charge is around $13 for stormwater fees. This fee applies to both residential and commercial spaces but the stormwater credit program is only available to commercial properties. Through the program, commercial property owners can retrofit buildings and reduce impervious surfaces, ultimately decreasing their stormwater bill by almost 100 percent. Through the new stormwater charge, the city found it is more accurately targeting the largest producers of stormwater runoff while also enlisting private entities in its reduction through the stormwater credit program.[20]

LANCASTER, PA & MILWAUKEE, WI: Incorporating green infrastructure into existing budgets

Through green infrastructure, cities and metros have an opportunity to add environmentally sensitive and effective infrastructure in a more efficient way. A municipality must submit a new project proposal that demonstrates the metrics to be met by the green infrastructure and how they will match those of the grey it will be replacing. The EPA then decides whether the modified proposal is or is not necessary and until then, the municipality cannot move past a 30 percent design phase. Upon approval, the previous consent decree is modified and the process of reporting on progress to the EPA continues as usual.[21] The agency encourages cities to modify their plans to take better advantage of opportunities for green infrastructure.[22]

---

16 Atassi and Tobias, Feb. 2014.
17 Houston 2010.
18 Philadelphia CSO LTCPU, Financial Feasibility 2009; Philadelphia LTCP, Development of Alternatives 2009; Philadelphia CSO LTCPU, Executive Summary 2009; Philadelphia CSO LTCPU, Supplemental Documentation Volume 2, Triple Bottom Line Analysis 2009.
19 American Rivers, *Green Infrastructure in Pennsylvania*, p. 15.
20 Valderrama et al., 2012, page 11
21 U.S. EPA factsheet on *Consent Decree Language Addressing Green for Grey Substitutions*.
22 EPA offers an integrated planning approach that allows cities to address stormwater and wastewater needs together, including by using green infrastructure. https://www.epa.gov/npdes/integrated-planning-municipal-stormwater-and-wastewater

For example, with projects already allocated funding in the budget, such as road maintenance and other improvements to gray systems, green components can be added or even replace traditional gray using those budgeted funds, therefore saving the municipality money. Lancaster, PA saved millions by incorporating green technology and infrastructure into existing city projects and planned upgrades as a part of the Green Infrastructure Stormwater Plan.[23] In Milwaukee, WI, the city is systematically taking advantage of opportunities to install green infrastructure assets as alleys, streets, and sidewalks are repaired or replaced.[24] Similar to Philadelphia, Milwaukee also has a stormwater fee system that reflects the amount of impervious surface on properties with greater than four units. The fee per square foot comes out to be $0.045/square foot or $19.22 for every Equivalent Residential Unit (ERU) of 1,610 square feet of impervious surface.[25]

CINCINNATI, OH: Cost savings through green infrastructure
In Cincinnati, the default gray solution for the Lower Mill Creek CSO control plan was estimated to cost $414,400,000 (2006 dollars), capturing 1,780,000,000 gallons a year.[26] As a follow-up to the CSO control plan, the metropolitan sewer district explored alternative green options to achieve the same goal, developing a green alternative plan. They found the stormwater entering the system would decrease if caught on the surface through green infrastructure improvements. This new plan is projected to cost $244,367, 000, saving $170,033,000.[27] In 2013, the EPA also approved Cincinnati's plan to "daylight" the Lick Run stream, a tributary of the Mill Creek that runs through the city and empties into the Ohio River. The "gray" infrastructure alternative to exposing Lick Run would require new pipes 25 feet wide costing about $312 million -- $117 million more than it will cost to create the Lick Run watershed. Lick Run, as an above ground stream, will absorb 1.5 billion gallons of stormwater each year, reducing overflows by 369 million gallons annually.[28]

CLEVELAND, OH: Green-Gray Infrastructure Solution to Stormwater
Even though the Northeast Ohio Regional Sewer District (NOERSD) was initially more cautious to incorporate green infrastructure in Cleveland's updated Long Term Control Plan, the sewer district added green infrastructure components to an updated proposal approved by the EPA so as to mitigate the cost of expanding the gray infrastructure plan.[29] The sewer district did so because it was tasked with capturing an additional 44 million gallons of stormwater previously not accounted for in the gray plan. The new green-gray plan will cost an additional $95 million and include upsizing some gray infrastructure while adding $42 million worth of green.[30] The green additions such as troughs, cisterns, rain gardens, and wetlands will capture an extra 63 million gallons per year. The alternative gray-only infrastructure upgrades to capture the extra 44 million gallons would have cost $182 million, $87 million more than the higher capacity green-grey solution. Like Philadelphia, Cleveland has a stormwater fee system based on the impervious surface area, but allows the property owner to claim credits for projects that reduce stormwater runoff. In Cleveland's case, as is typical in most cities, green infrastructure could not hope to solve the overflow and runoff problems alone but it is used to complete the job along with gray.

---

[23] Harris 2014.
[24] Hittman 2013.
[25] Milwaukee Code of Ordinances 309-54.5
[26] Great Lakes Regional Pollution Prevention Roundtable
[27] Lower Mill Creek Watershed <http://projectgroundwork.org/projects/lowermillcreek/>.
[28] Bentley 2013.
[29] Atassi and Tobias, Mar. 2014.
[30] Environmental Protection Agency press release of settlement with NOERSD, 2010.

COLUMBUS, OH. Reducing the Need for Deep Tunnels

In 2012, Columbus, Ohio's "Blueprint Columbus" plan was proposed as a replacement to the original Wet Weather Management Plan (WWMP) of 2005. Blueprint was an alternative to a newer gray plan (WWMP 2015) with fewer tunnels than its predecessor (WWMP 2005). The Blueprint plan is projected to cost a total of about $1.77 billion and green infrastructure is allocated $373 million in the proposed budget. The Gray plan would cost $1.6 billion while the original 2005 WWMP with 28 miles of deep tunnels would have cost $2.47 billion. Columbus has also been periodically separating its combined sewer systems over the last 30 years by installing sanitary sewer systems when making other infrastructure upgrades. Moving forward from 2015, the city maintains that the cost of the green and gray plans are about the same because of the cost of maintaining green roofs, alleyways, streets, and rain gardens, and the cost of making improvements such lining laterals and installing sump pumps to thousands of individual properties. Blueprint Columbus will also perform better than the traditional grey plan. Blueprint is expected to eliminate runoff and overflow over the next 20 years by more than 2 billion gallons than its grey counterpart, the 2015 WWMP, would have.[31] Areas of the city that allow for consolidation of vacant properties into a park may prove to be more cost-effective than replacing the sewer pipes beneath the properties.[32] However, the traditional gray plan would do little to address the city's stormwater runoff, which impairs over 58% of the Columbus Facility Planning Area (FPA).[33]

CONCLUSIONS & RECOMMENDATIONS

Through the preliminary research and analysis conducted by GOPC, the following can be concluded and recommended for municipalities faced with upgrading water and sewer infrastructure:

- Use both green and gray infrastructure when upgrading.
- Design and coordinate green with gray infrastructure from the onset of stormwater and CSO plan development.
- Creatively utilize budgets to reallocate funding toward green infrastructure when possible.
- Include projected costs for operations and maintenance of green and grey infrastructure when developing project proposals
- Implement stormwater fee systems based on impervious surface area instead of water meter usage.
- When appropriate, form regional networks and share resources to efficiently coordinate with neighboring metros for needed upgrades.
- Understand the limits of rebuilding with only gray infrastructure – it will ensure significant future financial stress on utility customers.

---

[31]City of Columbus Department of Public Utilities. *The Integrated Plan and 2015 WWMP Update Report*, p. 241, Exh. 8.1.4

[32] Interview with Susan Ashbrook, Assistant Director, Columbus Department of Utilities, March 21, 2016.

[33] *The Integrated Plan and 2015 WWMP Update Report* 2015, p. 35, Exh. 2.3.5; Rush 2014. Dax Blake, administrator of the Division of Sewerage and Drainage in reference to the WWMP of 2005 states, "…as we looked to the future components of the program, we saw that they were basically convey-and-treat solutions that only addressed sanitary sewer overflows but ignored stormwater and provided no benefit in the neighborhoods… "

- Maximize opportunities latent in repurposing abandoned parcels for green infrastructure.

Ultimately, incorporating green infrastructure relies on synchronization between multiple factors and entities; favorable political, natural, and economic environments, and usually coordination between city/metro, county, regional, and state governments, as well as federal and state EPAs. In legacy cities and regions, of which Ohio has many, the economic, demographic, and political environments have been under stress causing them to be in the most need of infrastructure upgrades but also being the least able to bear that financial burden. Though the cost, whether direct or indirect, of implementing green infrastructure remains a large concern, the examples above demonstrate compelling economic advantages with related health and environmental benefits in the short and long-term.[34]

Objections to green infrastructure are not without basis but in order to truly think in the long-term and endeavor to build resilient communities, green infrastructure components are imperative. It is pertinent when developing infrastructure plans to accurately account for the operations and maintenance costs in the short and long term. This will provide accurate projections to be used in financial planning, ultimately ensuring the follow through of the proposed plan.

The problems we face today in our cities and metros are the result of outdated gray infrastructure under stress of age, population decline, and economic fluctuations, and climate change-related weather patterns. To rebuild with only gray infrastructure will likely add financial strain to municipalities in the future when those systems need replacing. It will also stymie focused efforts for improving and restoring natural systems surrounding municipalities, removing pollutants from the air and water, and reducing urban heat island indices.

Green infrastructure is not the sole recourse for municipalities but it adds immense short and long-term economic, health, environmental, and social benefits that attract new residents and help stabilize many of these areas. Therefore, from the evidence gathered, we recommend integrated and thoughtful plans for green and gray sewer and water infrastructure as the best options for municipalities looking to upgrade CSO and stormwater infrastructure and also revitalize blighted communities.

More information on creative public-private funding mechanisms for Ohio's communities will be discussed in the next phase of GOPC's research on green CSO and stormwater infrastructure (delivery date July 2016).

APPENDIX OF TERMS

Combined Sewer Overflows (CSOs): CSOs refer to the locations of an overflow as well as the event itself. CSOs occur in a system that uses combined sewer systems meaning, the stormwater

[34] Center for Neighborhood Technology and American Rivers 2010; Neukrug 2009; Rouse and Bunster-Ossa 2013.

flows into the same systems of pipes as residential and commercial sewer systems. These systems were built to handle a large quantity of water flow, but in many instances, cities still experience billions of gallons of untreated liquid overflow into rivers and storms a year. This is partly because of increased demand via from growing populations since the systems were first built, inflow and infiltration from aging pipes, as well as climate change-related weather events producing more severe storms and heavier precipitation. Over burdening this system, excess runoff pipes cannot handle is directed towards natural water sources such as rivers, lakes, and streams.[35]

Day-lighting: The act of bringing a previously buried water stream or river to the surface of the earth again. The intention is for it to return to its natural path and serve its purpose in the environment as it did before it was buried.

EPA Consent Decree: An EPA consent decree is an agreement mandated by the federal government through the EPA. It involves a municipality in violation of the EPA's federally mandated standards and the EPA as the oversight agency tasked with making sure the appropriate changes are made. In the case of stormwater runoff and CSOs, the EPA is operating under the Clean Water Act of 1972. In 1994 the EPA issued a national CSO control policy. Congress amended the CWA to incorporate this policy into federal standards in 2000. [36]

Gray Infrastructure: Often considered "hard" or "traditional" infrastructure, gray infrastructure are the man-made engineering components of a system. It includes gutters, tunnels, pipes, and treatment plants.

Green Infrastructure: Environmentally sensitive and alternative infrastructure that has a net zero or beneficial impact on the natural systems a population inhabits. In the case of water infrastructure, green infrastructure includes rain basins, sidewalks, including strips of grass and trees, green roofs, porous surfaces, etc.

Sanitary System Overflows (SSOs): SSOs are releases of undiluted sewage from manholes and pipes. In 2004, Columbus reported over 500 SSOs in over 90 locations.

Stormwater Runoff: Stormwater runoff occurs when an event of precipitation occurs over impervious surfaces (surfaces that do not absorb water) and causes unplanned flooding and pooling of stormwater.

Rain Garden: Planted depressions in the landscape that allow rainwater runoff from impervious areas like parking lots, roofs, streets, and driveways to be absorbed into the natural hydrologic cycle of the environment.

Retention Basin: These basins look like grassy divots and pits and turn into pond like landscapes when full of stormwater runoff. They are used to manage runoff and prevent flooding and downstream erosion as well as improve water quality by acting as a natural filter for runoff that

---

[35] "Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer System Overflow (CSO) Control." U.S. EPA. 2015.

[36] 33 U.S.C. §1251 et seq. 1972; Combined Sewer Overflow (CSO) Control Policy, U.S. EPA, Office of Water 1994.

accumulates debris. Retention basins also slow the flow of water to the combined sewer and sanitary sewer systems so that they do not overflow.

BIBLIOGRAPHY

- American Rivers. *Green Infrastructure in Pennsylvania: Funding the Future of Stormwater Management.* Liz Garland, not dated. <http://www.americanrivers.org/newsroom/resources/funding-green-infrastructure-in-pennsylvania/>
- City of Camden. *Green Infrastructure Design Handbook: Integrating Sustainable Stormwater Management into Urban Design*. Rep. no. EPA 830-R-13-008. N.p.: USEPA, 2013. Print.
- Cincinnati Metropolitan Sewer District. "Lower Mill Creek Watershed." *Lower Mill Creek Watershed*. Project Groundwork: Your Guide to Clean Water, n.d. Web. 11 Feb. 2016. <http://projectgroundwork.org/projects/lowermillcreek/>.
- Atassi, Leila, and Andrew Tobias. "Philadelphia leads 'green' movement to address sewer overflows, Northeast Ohio sewer officials call plan impractical." *Cleveland.com*. Northeast Ohio Media Group, 25 Feb. 2014. Web. 11 Feb. 2016.
- Atassi, Leila, and Andrew Tobias. "Regional Sewer District Chooses Costly Tunnels over 'green' Infrastructure, Though Vacant Land Abounds in Cleveland." *Cleveland.com*. Northeast Ohio Media Group, 4 Mar. 2014. Web. 09 Feb. 2016.
- Bentley, Chris. "In Cincinnati, Unearthing an Old River Instead of Digging Deep Tunnel." (n.d.): n. pag. *WBEX91.5*. Chicago Public Media, 5 June 2013. Web. 11 Feb. 2016. <http://www.wbez.org/blogs/chris-bentley/2013-06/cincinnati-unearthing-old-river-instead-digging-deep-tunnel-107548>.
- Center for Neighborhood Technology and American Rivers, *The Value of Green Infrastructure: A Guide to recognizing Its Economic, Environment and Social Benefits*, 2010 pg. 80 Print.
- City of Columbus Department of Public Utilities. *The Integrated Plan and 2015 WWMP Update Report*. Rep. Columbus: City of Columbus Department of Public Utilities, 2015. Print.
- Clean Water Act: 33 U.S.C. §1251 et seq. (1972)
- *Clean Water Needs Survey 2012 Report to Congress*, U.S. Environmental Protection Agency Office of Water Management, 6 January 2012, Accessed 9 February 2016, Available online <http://water.epa.gov/scitech/datait/databases/cwns/2008reportdata.cfm>.
- *Combined Sewer Overflow* (CSO) Control Policy. Washington, D.C.: United States Environmental Protection Agency, Office of Water, 1994. Print.
- Copeland, Claudia. "Green Infrastructure and issues in managing urban stormwater." (2014).
- Dreiseitl, Atelier. "How The Chicago City Hall Green Roof Is Greening the Concrete Jungle - Landscape Architects Network." *Landscape Architects Network*. Landscape Architects Network, 30 Mar. 2015. Web. 30 Mar. 2016.
- Fiegel, Erin. "Chicago's Green Alleys: Permeable Pavement Used to Alleviate Flooding." *Concrete Thinking for a Sustainable World*. Portland Cement Association, 2016. Web. 30 Mar. 2016.
- Harris, Bernard. "Lancaster City a National Model for "green" Infrastructure." *Lancasteronline.com*. Lancaster Online, 4 Mar. 2014. Web. 9 Feb. 2016.

- Hittman, Elizabeth. "Stormwater Management." *Official Website of the City of Milwaukee*. Environmental Collaboration Office, 23 May 2013. Web. 11 Feb. 2016. <http://city.milwaukee.gov/sustainability/City-Operations/Stormwater.htm#.VryaU8dDk7Y>.
- Hollander, Justin B., et al. "Planning shrinking cities." *Progress in Planning* 72.4 (2009): 223-232.
- Houston, Feather O'Connor. "From Grey to Green in the Concrete Jungle." *Governing: The States and Localities*. N.p., 21 July 2010. Web. 09 Feb. 2016.
- Kleine, Robert J. "Former Treasurer of Michigan: The Flint Water Crisis Was 'decades in the Making'" *The Washington Post* [Washington, DC] 1 Feb. 2016: n. pag. *Business Insider*. Web. 22 Feb. 2016. <http://www.businessinsider.com/former-treasurer-of-michigan-says-flint-water-crisis-was-decades-in-the-making-2016-2>.
- Milwaukee, Wisconsin, Municipal Code chapter. 309-54.5 (2012)
- Neukrug, Howard M. *A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds Final Report*. Boulder, CO: Stratus Consulting, 2009. Print.
- Northeast Ohio Regional Sewer District. "Project Clean Lake." *Retrieved from* (2012). < http://www.neorsd.org/projectcleanlake.php>.
- Odefey, Jeffery, Stacey Detwiler, Katie Rousseau, Amy Trice, Roxanne Blackwell, Kevin O'Hara, Mark Buckley, Tom Souhlas, Seth Brown, and Pallavi Raviprakash. *Banking on Green: How Green Infrastructure Saves Municipalities Money and Provides Economic Benefits Community-wide*. Rep. N.p.: American Society of Landscape Architects, n.d. Web. 11 Feb. 2016. < http://www.americanrivers.org/assets/pdfs/reports-and-publications/banking-on-green-report.pdf>.
- Philadelphia Water Department. *Philadelphia Combined Sewer Overflow Long Term Control Plan Update*, Supplemental Documentation Volume 2, Triple Bottom Line Analysis, September 2009.
- Philadelphia Water Department. *Philadelphia Combined Sewer Overflow Long Term Control Plan Update: Development and Comparison of Alternatives*, Section 9, Alternatives, September 2009.
- Philadelphia Water Department. *Philadelphia Combined Sewer Overflow Long Term Control Plan Update Section 11*. Vol. Section 11. N.p.: City of Philadelphia, September 2009.
- Philadelphia Water Department. "Water Infrastructure Management." (2016). Web. 14 Mar. 2016. <http://www.phillywatersheds.org/watershed_issues/infrastructure_management>.
- Rouse, David C., and Ignacio F. Bunster-Ossa. *Green infrastructure: a landscape approach*. No. 571. 2013.
- Rush, Jim. "City of Columbus, Ohio, Designs 'Blueprint' to Control Overflows." *Trenchless Technology*. N.p., 13 Nov. 2104. Web. 17 Mar. 2016. <http://trenchlessonline.com/columbus-ohio-blueprint-control-overflows/>.
- Shetty, Sujata. "Shrinking cities in the industrial belt: A focus on small and mid-size cities in northwestern Ohio." *Informally published manuscript, Department of Geography and Planning, University of Toledo, Toledo, OH. Retrieved from http://uac. utoledo. edu/Publications/WORC-UAC-Shrinking-Cities. pdf* (2009).

- Schilling, Joseph. "Blueprint Buffalo—Using Green Infrastructure to Reclaim America's Shrinking Cities." *The Future of Shrinking Cities: Problems, Patterns and Strategies of Urban Transformation in a Global Context* (2009): 149-160.
- Schilling, Joseph, and Jonathan Logan. "Greening the rust belt: A green infrastructure model for right sizing America's shrinking cities." *Journal of the American Planning Association* 74.4 (2008): 451-466.
- U.S. Department of Justice. Office of Public Affairs. *U.S. Clean Water Act Settlement in Northeast Ohio to Protect Lake Erie, Revitalize Neighborhoods and Create Green Jobs: Settlement with Northeast Ohio Sewer District to Eliminate or Treat Five Billion Gallons of Sewage*. N.p.: n.p., 2010. Print.
- U.S. Environmental Protection Agency. *Benefits of Green Infrastructure*. Great Lakes Regional Pollution Prevention Roundtable, n.d. Web. 11 Feb. 2016. <http://www.glrppr.org/docs/R5-Green-Infrastructure-Fact-Sheet-and-Case-Study.pdf>.
- U.S. Environmental Protection Agency. *Clean Watersheds Needs Survey 2012 Report to Congress*. Washington, DC: U.S. Environmental Protection Agency, Office of Wastewater Management, Municipal Support Division, Municipal Technology Branch, 2016. Print.
- U.S. Environmental Protection Agency. "CSO Control Plans and Remedies.", 2 Nov. 2015. Web. 11 Feb. 2016. <http://www.epa.gov/green-infrastructure/cso-control-plans-and-remedies>.
- U.S. Environmental Protection Agency*. Report to Congress: Implementation and Enforcement of the Combined Sewer Overflow Control Policy*. Washington, D.C.: Office of Water, 2001. Internet resource.
- U.S. Environmental Protection Agency. Office of Wetlands, Oceans, and Watersheds. *Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure*. Washington, DC: U.S. Environmental Protection Agency, 2010. Print.
- U.S. Environmental Protection Agency. Office of Wastewater Management. *Combined Sewer Overflows Guidance for Financial Capability Assessment and Schedule Development*. Washington, D.C.: U.S. Environmental Protection Agency, Office of Wastewater Management, Municipal Support Division, 1997. Print.
- U.S. Environmental Protection Agency. *U.S. Clean Water Act Settlement in Northeast Ohio to Protect Lake Erie, Revitalize Neighborhoods and Create Green Jobs / Settlement with Northeast Ohio Sewer District to Eliminate or Treat Five Billion Gallons of Sewage*. *Yosemite.epa.gov*. USEPA, 22 Dec. 2010. Web. 11 Feb. 2016. <http://yosemite.epa.gov/ opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/c45efbfb290d215c85257801006a 4199!>.
- U.S. Environmental Protection Agency. *Consent Decree Language Addressing Green for Grey Substitutions*. N.p.: U.S. Environmental Protection Agency, n.d. Print.
- U.S. Environmental Protection Agency. "Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control.", 2 Nov. 2015. Web. 23 Feb. 2016. <http://www.epa.gov/sites/production/files/2015-10/documents/ greening_cso_plans_0.pdf>.
- Wines, Michael, and John Schwartz. "Unsafe Lead Levels in Tap Water Not Limited to Flint." *The New York Times*. N.p., 8 Feb. 2016. Web. 22 Feb. 2016. <http://www.nytimes.com/2016/02/09/us/regulatory-gaps-leave-unsafe-lead-levels-in-water-nationwide.html>.

- Valderrama, Alisa, Larry Levin, Starla Yeh, and Eron Bloomgarden. *Financing Stormwater Retrofits in Philadelphia and Beyond*. Rep. N.p. National Resources Defense Council, February 2012. Print.

This memo was researched and written by Colleen Durfee, Research Assistant, and Jon Honeck, Senior Policy Fellow.