Green Infrastructure: Strengthening Federal Policy for Flood Mitigation, Ecosystems, and Community Well-Being

McKenzie Brandon*

Table of Contents

* J.D. Candidate, 2021, University of Colorado Law School. I would like to thank the incredible staff of the *Colorado Natural Resources, Energy, & Environment Law Review* for their kind and thorough feedback on this Note. Thank you for helping me to grow as a writer and persuader in this process.

INTRODUCTION

At 5:00 p.m. on August 23, 2005, the National Hurricane Center in Miami, Florida issued an advisory about a tropical storm forming over the Bahamas.[1] To those who live along the southern coast of the United States, a tropical storm advisory, and even a hurricane advisory, is not typically a huge concern. Alerts come in frequently, but a large weather disturbance only occurs every twenty to thirty years.[2] In New Orleans, Louisiana, directly in the path of the oncoming storm, the governor stated that she attended a baseball game two days before its landfall.[3] About 700 people were also in attendance, either unaware or unconcerned about the storm's severity.[4] Unfortunately, this weather system would be one worthy of concern.[5] Two days following the game, on August 29, Hurricane Katrina

1 Willie Drye, *Hurricane Katrina: The Essential Timeline*, NAT'L GEOGRAPHIC (Sept. 14, 2005), https://www.nationalgeographic.com/news/2005/9/weather-hurricane-katrina-timeline/.

2 In Louisiana, for example, one source lists memorable hurricanes as Andrew in 1992, Camille in 1969, Betsy in 1965, Audrey in 1957, the August Hurricane of 1940, the September Hurricane of 1915, the Cheniere Caminanda hurricane of October 1893, the Isle Dernieres storm of 1856, and the Racer's Storm of 1837. David Roth, *Louisiana Hurricane History*, WEATHER, https://www.weather.gov/media/lch/events/lahurricanehistory.pdf (last visited Mar. 29, 2020).

3 PRESIDENT GEORGE W. BUSH, THE WHITE HOUSE, CHAPTER 3: HURRICANE KATRINA – PRE-LANDFALL (Aug. 17, 2005), https://georgewbush-whitehouse.archives.gov/reports/katrina-lessons-learned/chapter3.html.

4 *Id.*

5 In New Orleans, eighty percent of the city flooded, and 1,800 people lost their lives. CITY OF NEW ORLEANS, RESILIENT NEW ORLEANS 2 (2015).

hit New Orleans.[6] By 8:00 a.m. that day, storm surge water was flowing over New Orleans' artificial levees and flooding the city.[7]

New Orleans primarily uses a pump system to remove floodwater from the city.[8] The pump system was built in the 1830s to counteract the natural swamp hydrology of the area.[9] New Orleans added onto and improved the system over the years with 148 pumps by 2005.[10] However, this seemingly powerful network of pumps could not prevent Hurricane Katrina from flooding eighty percent of New Orleans,[11] with water exceeding a depth of fifteen feet in some areas.[12]

Following Hurricane Katrina, New Orleans Mayor Mitch Landrieu announced that the city would be rebuilt "better and stronger than before."[13] Over the next decade, New Orleans worked with engineers and urban planners to design a more durable city, publishing its Resilient New Orleans Strategy ("Strategy") in 2015.[14] The Strategy plans for thirty-five years and includes actions to prevent coastal erosion and improve infrastructure.[15] Part of the Strategy includes introducing green infrastructure into New Orleans's existing gray infrastructure system of pumps and levees.[16]

New Orleans is one of many cities considering green infrastructure as an alternative means of flood control. Historically, municipalities within the United States used gray infrastructure to mitigate flooding.[17] Gray infrastructure generally consists of pipes and tunnels constructed of concrete and steel. Although these tools have value in the context of flooding, their impervious nature can actually increase flooding and

---

6 *Id.*

7 *Id.*

8 SEWERAGE & WATER BOARD OF NEW ORLEANS, GREEN INFRASTRUCTURE PLAN 3 (2014) [hereinafter ("SWBNO")].

9 R.B. SEED ET AL., INDEP. LEVEE INVESTIGATION TEAM, FINAL REPORT: INVESTIGATION OF THE PERFORMANCE OF THE NEW ORLEANS FLOOD PROTECTION SYSTEMS IN HURRICANE KATRINA ON AUGUST 29, 2005 4–14 (2006).

10 IVOR VAN HEEDEN & MIKE BRYAN, THE STORM: WHAT WENT WRONG AND WHY DURING HURRICANE KATRINA 187 (2007).

11 CITY OF NEW ORLEANS, *supra* note 5, at 2.

12 U.S. ARMY CORP OF ENGINEERS, PERFORMANCE EVALUATION OF THE NEW ORLEANS AND SOUTHEAST LOUISIANA HURRICANE PROTECTION SYSTEM I-49 (2009).

13 CITY OF NEW ORLEANS, *supra* note 5, at 2.

14 *Reliance and Sustainability*, CITY OF NEW ORLEANS (Mar. 10, 2020).

15 CITY OF NEW ORLEANS, *supra* note 5, at 36.

16 *Id.* at 38.

17 WILLIAM BOGERT & TERRY TIEDEMANN, CITY OF CEDAR RAPIDS, STORMWATER MASTER PLAN UPDATE 2 (2016).

pollution from stormwater.[18] In contrast, green infrastructure uses absorbent surfaces to alleviate flooding and reduce the amount of polluted stormwater in a city.[19] This method generally consists of strategically placed vegetation. Cities can implement green infrastructure based on their own specific needs, using it to either replace or supplement existing stormwater structures.[20] Green infrastructure can reduce damage from flooding caused by high rainfall and storm surges.[21] It is a flexible tool for cities to implement in stormwater programs,[22] but it can bring more to a city than additional flood protection.[23] Green techniques can decrease fragmentation, or the breaking apart of areas of natural land cover into smaller pieces.[24] These techniques can also increase community well-being by providing more vegetation in cities.[25]

New Orleans began implementing green infrastructure with demonstration projects.[26] These projects show New Orleans residents how unused spaces can be designed in a way that retains stormwater and makes neighborhoods more attractive.[27] One project illustration is a green roof installed in 2016 on one of the city's administrative buildings.[28] A green roof is covered in vegetation which can store rainfall through absorption, and evapotranspires that stored water.[29] This one roof in New Orleans is capable of managing more than 15,000 gallons of water during each

18 GREG BROWDER ET AL., WORLD BANK GROUP, INTEGRATING GREEN AND GRAY 15 (2019).

19 *What is Green Infrastructure?*, EPA (Dec. 4, 2019), https://www.epa.gov/green-infrastructure/what-green-infrastructure#Greenroofs.

20 FED. EMERGENCY MGMT. AGENCY, INNOVATIVE DROUGHT AND FLOOD MITIGATION PROJECTS 3–72 (2017).

21 David Rouse, *Green Infrastructure and Post-Disaster Recovery*, AMERICAN PLAN. ASS'N (June 1, 2014), https://planning-org-uploaded-media.s3.amazonaws.com/legacy_resources/research/postdisaster/briefingpapers/pdf/greeninfrastructure.pdf.

22 *Id.*

23 BOGERT & TIEDEMANN, *supra* note 17, at 2.

24 Mitchell et al., *Reframing Landscape Fragmentation's Effects on Ecosystem Services*, 30 TRENDS ECOLOGY & EVOLUTION 190, 190 (2015).

25 Mark A. Benedict & Edward T. McMahon, *Green Infrastructure: Smart Conservation for the 21st Century*, 20 RENEWABLE RES. J. 13, 14 (2002); JAMES MACADAM, WATERSHED MANAGEMENT GROUP, GREEN INFRASTRUCTURE FOR SOUTHWESTERN NEIGHBORHOODS 9 (2012).

26 CITY OF NEW ORLEANS, *supra* note 5, at 39.

27 *Id.*

28 *Using Green to Aid the Gray*, SEWERAGE & WATER BOARD OF NEW ORLEANS (Mar. 25, 2020, 11:41:44 AM), https://www.swbno.org/Projects/InteractiveGuideToGreen Infrastructure.

29 *What is Green Infrastructure?*, *supra* note 19.

weather event.[30] Another project consists of two rain gardens which feed into each other on either side of the bio-retention site.[31] Rain gardens are "shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks, and streets."[32] The New Orleans rain garden site manages stormwater while also providing a location for students to learn about water management issues.[33] Other projects the city considered in the Strategy include bioswales and permeable pavement.[34] Bioswales are essentially rain gardens placed in long, narrow channels.[35] Permeable pavement is made of pervious concrete, porous asphalt, or permeable interlocking pavers that move rain into the soil.[36] Currently, New Orleans works with multiple non-profit organizations that help with green infrastructure education and installation.[37]

New Orleans identified multiple sources of funding for green infrastructure projects in the Strategy. In 1998, the Department of Justice, the Environmental Protection Agency ("EPA"), and other Plaintiff-Intervenor organizations brought action against the City of New Orleans and the Sewerage and Water Board of New Orleans ("SWBNO") for violations of unauthorized and non-compliant discharges.[38] In the second modified consent decree that followed from this suit, SWBNO and New Orleans committed to spend $2.5 million on green infrastructure.[39] SWBNO funds the demonstration projects, green infrastructure education in elementary schools, workshops for professionals, businesses, residents, and community groups, and studies on green techniques.[40] Projects on private property are funded by the property owner with incentives.[41] The city-run Property-Assessed Clean Energy program provides loans for improvements that are then repaid through property taxes.[42] Because the

30 *Using Green to Aid the Gray*, *supra* note 28.

31 *Id.*

32 *What is Green Infrastructure?*, *supra* note 19.

33 *Using Green to Aid the Gray*, *supra* note 28.

34 CITY OF NEW ORLEANS, *supra* note 5, at 39.

35 *What is Green Infrastructure?*, *supra* note 19.

36 *Id.*

37 *Green Infrastructure*, NOLA READY, https://ready.nola.gov/green-infrastructure/ (last visited Mar. 29, 2020).

38 SWBNO, *supra* note 8, at 5; Second Modified Consent Decree, United States v. New Orleans Sewerage & Water Bd., No. 93-3212, at 5 (E.D. La. 2013).

39 *Id.*

40 CITY OF NEW ORLEANS, *supra* note 5, at 39; *Using Green to Aid the Gray*, *supra* note 28.

41 CITY OF NEW ORLEANS, *supra* note 5, at 40.

42 *Id.*

loans are low interest and residents may also receive a reduction in flood insurance, residents are incentivized to participate.[43]

Numerous cities across the country are incorporating green techniques into existing gray infrastructure or replacing gray with green.[44] While the effort of these individual cities is valuable locally, coordination among cities to use green techniques can greatly improve ecosystems at a wider scale. The citywide implementation of green infrastructure in one municipality cannot influence the environmental quality of large regions. For this reason, state programs are beneficial. But, because watersheds cross state lines, federal policy is needed to realize the broad benefits of green infrastructure and to decrease the pollution effects of gray infrastructure. Current federal green infrastructure laws exist, but these laws merely promote the use of green infrastructure in city stormwater plans. Federal policy should be strengthened to coordinate state efforts at the watershed level and to require municipalities to actively demonstrate their consideration of green techniques.

This Note will first detail the background of gray infrastructure by discussing the statutory framework that led to its implementation across the country and factors which make gray techniques less effective on their own. Next, this Note will argue that the best way to improve the United States' flood infrastructure is to strengthen federal policy regarding green infrastructure, specifically policy relating to best management practices ("BMP") required when applying for a National Pollutant Discharge Elimination System ("NPDES") permit. Finally, this Note will address positive and negative implications of requiring demonstrated green infrastructure consideration on a federal level.

I. BACKGROUND

Understanding gray infrastructure use and its effects on the environment requires an analysis of the existing statutory framework, a look at increasing urban flood concerns, and an understanding of this method's negative impact on the environment and humans' understanding of the environment.

---

43 *Id.*

44 This site lists a few larger cities implementing green techniques and is not comprehensive. *See Other Green Cities*, CLEAN RIVERS CAMPAIGN, http://www.cleanriverscampaign.org/resources/green-cities/ (last visited Sept. 18, 2020).

A. Statutory Framework

Historically, legislators focused on the waste control component of flood mitigation rather than floodwater reduction.[45] Under the Clean Water Act ("CWA"), the EPA regulates pollution from "point sources," which flow through a discrete source such as a pipe or ditch.[46] All point sources are required to obtain a NPDES permit. To capture the possible thousands of point sources in one municipality, the EPA developed a general permit.[47] Congress then directed the EPA to regulate pollutants from stormwater discharges.[48] The regulatory definition of stormwater is "storm water runoff, snow melt runoff, and surface runoff and drainage"[49] that forms during precipitation-related weather events.[50] The EPA promulgated its NPDES stormwater program in two phases, starting with larger municipalities before including smaller municipalities.[51]

The NPDES stormwater program regulates municipal stormwater for the purpose of waste control.[52] The United States uses two types of gray infrastructure systems to control municipal wastewater: Combined Sewer Systems ("CSS") and Municipal Separate Storm Sewer Systems ("MS4").[53] CSSs use an older design that allows for combined sewage overflows, where stormwater and raw sewage flow into a local river during times of flooding.[54] MS4s differ in that sewage is treated during floods, but stormwater remains untreated.[55] The NPDES requires cities with populations of 100,000 people or more to use MS4s.[56] Around 860 cities still use CSSs.[57]

---

45 NAT'L RES. COUNCIL, URBAN STORMWATER MANAGEMENT IN THE UNITED STATES 39 (2008).

46 *Id.* at 42.

47 *Id.*

48 *Id.* at 42–43.

49 40 C.F.R. § 122.26(b)(13) (2011).

50 National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges, 55 Fed. Reg. 47,990, 47,995 (Nov. 16, 1990) (codified at 40 C.F.R. pts. 122, 123, and 124).

51 NAT'L RES. COUNCIL, *supra* note 45, at 43.

52 *See id.* at 39, 43.

53 *Combined Sewer Overflows (CSOs)*, EPA (Aug. 30, 2018), https://www.epa.gov/npdes/combined-sewer-overflows-csos; *Municipal Wastewater*, EPA (Aug. 30, 2018), https://www.epa.gov/npdes/municipal-wastewater.

54 *Combined Sewer Overflows (CSOs)*, *supra* note 53.

55 *Municipal Wastewater*, *supra* note 53.

56 BOGERT & TIEDEMANN, *supra* note 17, at 3.

57 *Combined Sewer Overflows (CSOs)*, *supra* note 53.

Because stormwater systems are constructed to conform to NPDES standards, cities built these structures with the goal of preventing pollution during flooding instead of preventing flooding altogether. Flood control is a consideration when designing gray infrastructure systems, but it is the background concern in conforming to federal wastewater standards. Through the use of levees and stormwater transport systems, gray infrastructure seemingly served its primary purpose of pollution control for years and has served its secondary goal of protecting cities from flooding better than if the city had nothing in place. Regarding the primary goal, cities are now aware that moving stormwater pollution from the city to nearby waterbodies damages ecosystems.[58] Regarding the secondary goal, many municipal leaders realize that gray techniques are not enough to combat the intense flooding brought on by climate change.[59]

Recognizing gray infrastructure's drawbacks, the EPA encouraged the use of green infrastructure in flood control over the last decade.[60] The EPA has helped cities to incorporate green techniques while also complying with strict federal water pollution standards.[61] In January 2019, Congress passed the Water Infrastructure Improvement Act ("WIIA") in an effort to give cities more flexibility in implementing stormwater pollution mitigation systems.[62] The WIIA also includes provisions that promote the use of green infrastructure.[63] Although the United States is moving towards greater promotion of green infrastructure, cities still have a choice in whether or not to consider green techniques.[64]

---

58 *See, e.g.,* OLGA LYANDRES & LYMAN C. WELCH, ALLIANCE FOR THE GREAT LAKES, REDUCING COMBINED SEWER OVERFLOWS IN THE GREAT LAKES (2012), https://greatlakes.org/wp-content/uploads/2016/08/AGL_Reducing_CSO__14_FINAL-1.pdf.

59 *See* BROWDER ET AL., *supra* note 18, at 14.

60 Nancy K. Stoner, *Foreword* to EPA, A HANDBOOK FOR WATER AND WASTEWATER UTILITIES (2012), https://www.epa.gov/sites/production/files/2016-01/documents/planning-for-sustainability-a-handbook-for-water-and-wastewater-utilities.pdf [hereinafter A HANDBOOK FOR WATER AND WASTEWATER UTILITIES].

61 *See* EPA, INTEGRATED MUNICIPAL STORMWATER AND WASTEWATER PLANNING APPROACH FRAMEWORK 1–2 (2012), https://www.epa.gov /sites/production/files/2015-10/documents/integrated_planning_ framework.pdf [hereinafter INTEGRATED MUNICIPAL STORMWATER AND WASTEWATER PLANNING APPROACH FRAMEWORK].

62 Water Infrastructure Improvement Act, Pub. L. No. 115-436, 132 Stat. 5558 (2019).

63 *Id.* § 5.

64 NAT'L RES. COUNCIL, *supra* note 45, at 85.

B. Increasing Urban Flood Concerns

Flood risks are increasing in urban areas likely due to climate change effects of heavier precipitation, stronger and more frequent storms, and seal-level rise.[65] There is evidence that 100- and 500-year floods occur more often than their respective historical frequencies.[66] A 100-year flood area is an area predicted to flood once every 100 years, so these areas have a one percent chance of flooding in any year.[67] 500-year flood areas have a 0.2 percent chance of flooding in any year.[68] Recently, cities such as Houston, Texas and Cedar Rapids, Iowa experienced multiple 100- and 500-year floods in the span of ten years or so; while the odds are not impossible, these events suggest that the probability for severe flooding is increasing.[69]

This increased flooding is also happening during a time of increased urbanization.[70] By 2030, more than sixty percent of people globally are expected to live in urban areas.[71] Despite a steady flow of people into cities, development is happening at an even faster rate.[72] More people are moving into areas constructed primarily of gray infrastructure, and these impervious "gray" surfaces in urban areas can facilitate high storm-flow volumes.[73] To exacerbate the problem, it is likely that most sewer systems currently work outside of their life expectancy and capacity.[74] With more people crowding into areas with failing flood systems, cities will need to consider upgrading their existing structures sooner rather than later.

---

65 INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014 SYNTHESIS REPORT 15 (2015).

66 *See, e.g.*, Dara Lind, *The "500-Year" Flood, Explained*: *Why Houston Was So Underprepared for Hurricane Harvey*, VOX (Apr. 28, 2017), https://www.vox.com /science-and-health/2017/8/28/16211392/100-500-year-flood-meaning; *see also* BOGERT & TIEDEMANN, *supra* note 17, at 7.

67 Lind, *supra* note 66.

68 *Id.*

69 *Id.*

70 Per Bolund & Sven Hunhammar, *Ecosystem Services in Urban Areas*, 29 ECOLOGICAL ECON. 293, 293 (1999).

71 *Id.*

72 Benedict & McMahon, *supra* note 25, at 12.

73 Melissa Keeley et al., *Perspectives on the Use of Green Infrastructure for Stormwater Management in Cleveland and Milwaukee*, 51 J. ENVTL. MGMT. 1093, 1094 (2013).

74 *Id.* at 1104.

C. Environmental and Social Consequences of Gray Infrastructure

Alongside concerns for their capacity to counteract floods, gray infrastructure flood systems come with environmental and social consequences. Neither CSSs nor MS4s are able to treat all the water that flows through them during floods, so many United States waterbodies are impaired by stormwater overflows.[75] For instance, New York City identified twenty-eight waterbodies impaired by stormwater runoff and illicit discharges in 2019.[76] Types of impairments in these waterbodies include pathogens, floatables, and nutrients.[77] Pathogen pollution includes bacteria, viruses, and other microorganisms that cause disease.[78] Pathogens pose risks for humans and for the ecology of a waterbody.[79] Floatables are plastic, paper, or other human-made materials.[80] At best, floatables degrade the aesthetics of a waterbody.[81] At worst, they can cause a navigational hazard for boats and endanger marine species and their habitats.[82] Nutrient pollution typically consists of phosphorus or nitrogen.[83] Although naturally occurring in aquatic systems already, excess addition of these nutrients through runoff and illicit discharge can lead to reduced clarity and oxygen levels in a waterbody.[84]

Traditional development also leads to increased landscape fragmentation,[85] or the breaking apart of areas of natural land cover into smaller pieces.[86] If a particular area of cover provides flood regulation, then fragmenting that cover affects the area's natural ability to regulate flooding.[87] Fragmentation also has social consequences because a gray

---

75 Impairment of a waterbody occurs when the current pollution control technologies alone cannot meet the water quality standards that a state set for that waterbody. *See Impaired Waters and TMDLs*, EPA (Sept. 10, 2018), https://www.epa.gov/tmdl/statute-and-regulations-addressing-impaired-waters-and-tmdls; *id.* at 1094.

76 CITY OF NEW YORK, NYC STORMWATER MANAGEMENT PLAN 159 (2019).

77 *Id.* at 157–58.

78 *Id.* at 157.

79 *Id.*

80 *Id.*

81 *Id.*

82 *Id.*

83 *Id.* at 158.

84 *Id.*

85 Robert H.G. Jongman, *Connectivity and Ecological Networks*, 1 ENCYCLOPEDIA ECOLOGY 366, 367 (2019).

86 Mitchell et al., *Reframing Landscape Fragmentation's Effects on Ecosystem Services*, 30 TRENDS ECOLOGY & EVOLUTION 190, 190 (2015).

87 *Id.* at 194.

infrastructure environment affects our ability to understand degraded environments.[88]

For children, contact with native plants and animals is important for maintaining human awareness and concern for environmental look and function. To elaborate, fragmentation can cause a specific phenomenon known as environmental generational amnesia.[89] Environmental generational amnesia is based on the idea that humans often define a baseline nondegraded environment as the environment they grew up in.[90] If a child has little to no opportunity to experience natural areas, and is only familiar with "gray" urban landscapes, the child will carry a skewed baseline of nondegradation into adulthood.[91] Considering the environmental damage and flood risk associated with gray infrastructure, creating a generation of people who do not recognize degradation harms public welfare.

Gray infrastructure is no longer enough to control stormwater[92] and comes with external consequences. By fortifying existing stormwater systems with green infrastructure, municipalities can control flooding, protect the surrounding environment from polluted floodwater, and improve community well-being.

II. CONGRESS AND THE EPA SHOULD STRENGTHEN FEDERAL GREEN INFRASTRUCTURE POLICY

Demonstrated green infrastructure consideration should be a requirement in NPDES permitting because it is a strong tool for providing mitigation and restoration. Green techniques can be used to absorb stormwater and neutralize its pollutants while adding to the native landscape. These methods can protect neighborhoods while also making them more attractive, and funding for projects can be achieved in innovative ways. When implemented on a watershed level, green techniques can provide substantial flood protection.[93] Watersheds are not

88 Manuela Di Giulio et al., *Effects of Habitat and Landscape Fragmentation on Humans and Biodiversity in Densely Populated Landscapes*, 90 J. ENVTL. MGMT. 2959, 2960 (2009).

89 *Id.*

90 *Id.*

91 *Id.*

92 BROWDER ET AL., *supra* note 18, at 14.

93 Daniel Medina et al., *Green Infrastructure Benefits for Floodplain Management: A Case Study*, STORMWATER (Nov. 2, 2011), https://www.stormh2o.com/bmps/article/13006579/green-infrastructure-benefits-for-floodplain-management-a-case-study.

contained within one state, so federal involvement is necessary to have all states within a watershed participate.[94]

The EPA and Congress implemented policies that encourage green infrastructure use, but the safety of United States citizens requires more than encouragement. Specifically, the EPA should require states to acknowledge their consideration of green methods in each of the six BMP categories.

A. The Safety of U.S. Citizens Requires More than Mere Encouragement of Green Infrastructure Use

The EPA embraces the use of green infrastructure, but merely encouraging its use is not enough to persuade municipalities to implement green techniques. The EPA's encouragement of green methods began around 2012, when the EPA published guidance entitled the Integrated Municipal Stormwater And Wastewater Planning Approach Framework.[95] This framework allows cities to focus on their most pressing water quality issues first when applying for a NPDES permit.[96] Part of the framework includes the promotion of green techniques.[97] The guidance states that "[i]ntegrated planning can . . . facilitate the use of sustainable and comprehensive solutions, including green infrastructure, that protect human health, improve water quality, manage stormwater as a resource, and support other economic benefits and quality of life attributes that enhance the vitality of communities."[98] According to the guidance, integrated plans should "evaluate and incorporate . . . sustainable technologies, . . . particularly including green infrastructure measures."[99]

The EPA further encourages the use of green infrastructure by publishing guides on how to implement, maintain, and fund projects.[100] The agency helps cities get started on planning their green projects with a

94 A USGS watershed map of America shows thirteen watersheds covering the forty-eight contiguous states. *Watershed Map of America*, U.S. GEOLOGICAL SURV. (Apr. 10, 2019), https://www.usgs.gov/media/images/watershed-map-north-america.

95 INTEGRATED MUNICIPAL STORMWATER AND WASTEWATER PLANNING APPROACH FRAMEWORK, *supra* note 61.

96 *Id.* at 2.

97 *Id.* at 2–3.

98 *Id.* at 2.

99 *Id.* at 3.

100 The EPA has a green infrastructure website with guidance on planning, designing, maintaining, and funding green infrastructure, as well as other related guidance. *Green Infrastructure*, EPA (Mar. 12, 2020), https://www.epa.gov/green-infrastructure.

Green Infrastructure Modeling Toolkit.[101] Using the Storm Water Management Model, cities can model the effectiveness of multiple green techniques when combined.[102] The National Stormwater Calculator estimates the amount of stormwater a city receives, which a city can then use to determine how to most effectively retain stormwater in the area.[103] The National Stormwater Calculator also includes cost estimation and future climate scenario modules so that cities are further equipped to handle cost-benefit analyses.[104] Although the main focus of the toolkit is on individual communities, at least one tool is designed to be used on a regional or watershed level. The Watershed Management Optimization Support Tool facilitates water resources management across wet and dry climate regions, allowing water resources managers to evaluate various practices over entire watersheds.[105]

Congress has also played a role in strengthening green infrastructure use in the United States. In 2019, Congress codified the Integrated Municipal Stormwater And Wastewater Planning Approach Framework by passing the Water Infrastructure Improvement Act ("WIIA").[106] As part of the WIIA, the EPA is mandated to promote the use of green techniques in NPDES permitting, as well as coordinate planning efforts, research, technical assistance, and funding.[107] EPA regional offices are directed to conduct outreach and training on green infrastructure implementation.[108]

Although nice additions to green infrastructure policy, the EPA Toolkit and WIIA only obligate the EPA to continuously promote green infrastructure: whatever the EPA produces amounts to nothing more than recommendations. Municipalities are not obligated to follow the EPA's suggestions.

---

101 *Green Infrastructure Modeling Toolkit*, EPA (Dec. 6, 2019), https://www.epa.gov/water-research/green-infrastructure-modeling-toolkit.

102 *Id.*

103 *Id.*

104 *Id.*

105 *Id.*

106 Water Infrastructure Act, Pub. L. No. 115-436, § 3, 132 Stat. 5558 (2019) (codified as amended at 42 U.S.C. § 4370(j)).

107 Water Infrastructure Improvement Act § 519.

108 *Id.*

B. Green Infrastructure Should Be Incorporated into the Six BMP Categories

In 1987, Congress directed the EPA to require stormwater sources to use BMPs in order to receive an NPDES permit.[109] In 2000, the EPA created a list of BMPs from which municipalities are encouraged to select when developing stormwater management plans.[110] The list of BMPs is not all-inclusive, but the EPA states that the listed practices successfully achieve control standards.[111] Green infrastructure techniques make up only one group of options in a wide range of BMPs from which municipalities may choose.[112]

BMPs span six categories: (1) Public Education; (2) Public Involvement; (3) Illicit Discharge Detection and Elimination; (4) Construction; (5) Post-construction; and (6) Pollution Prevention and Good Housekeeping.[113] Municipalities are required to include BMPs in every category of their stormwater management plans.[114] Municipalities are also required to develop measurable goals for each category to assess effectiveness.[115] The EPA provides MS4 operators with fact sheets for each category stating what is required of them and the EPA's suggestions to fulfill those requirements.[116] Because of the nature of the NPDES program, BMPs focus on stormwater pollution as opposed to flood mitigation, but flood mitigation is one optimal step in preventing stormwater pollution.[117] The EPA recommends green infrastructure use in the post-construction category, but these techniques can and should be used in all six categories.

---

109 NAT'L RES. COUNCIL, *supra* note 45, at 42–43.

110 *Id.* at 85.

111 *National Menu of Best Management Practices (BMPs) for Stormwater*, EPA (Dec. 11, 2019), https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater#edu.

112 *Id.*

113 *National Menu of Best Management Practices (BMPs) for Stormwater Documents*, EPA (July 31, 2019), https://www.epa.gov/npdes/national-menu-best-management-practices-bmps-stormwater-documents.

114 EPA, FACT SHEET 2.3 1 (2005) [hereinafter FACT SHEET 2.3].

115 EPA, MEASURABLE GOALS GUIDANCE for Phase II Small MS4s 1 (2016) [hereinafter MEASURABLE GOALS GUIDANCE].

116 *National Menu of Best Management Practices (BMPs) for Stormwater*, *supra* note 111.

117 *Id.*

1. Public Education BMPs

Municipalities are required to provide public education because individual citizens may not realize the significance of their behavior in contributing to stormwater pollution.[118] Public support is also important for funding programs or drawing in volunteers.[119] To satisfy the public education requirement, the operator of an MS4 must inform the public about the impacts of stormwater discharges on local waterbodies and how to reduce that impact.[120] The EPA suggests three areas that are important in developing a successful public education program: forming partnerships, using educational materials and strategies, and reaching diverse audiences.[121]

In developing a public education program, operators should communicate with other governmental entities.[122] One of these entities may already have a program in place that the operator can implement in its city.[123] By connecting with other governments, a regional or statewide program can be developed instead of numerous local programs.[124] For educational materials, operators may use information provided by their state, tribe, EPA Region, or an organization.[125] However, educational materials should be tailored to local situations and issues.[126] Lastly, the program should reach a variety of audiences and communities, including minorities, children, and business owners. Including green infrastructure in this step could be valuable in providing the public with a well-rounded stormwater control education and in enhancing involvement in the "Public Involvement" BMP category.

2. Public Involvement

On top of the requirement to educate the public, municipalities are also required to involve their citizens.[127] People must be aware of local issues, but their participation through public comment, identification of concerns and values, development of consensus among stakeholders, and

118 *Id.*

119 FACT SHEET 2.3, *supra* note 114, at 1.

120 *Id.*

121 *Id.* at 1–2.

122 *Id.* at 2.

123 *Id.*

124 *Id.*

125 *Id.*

126 *Id.*

127 *National Menu of Best Management Practices (BMPs) for Stormwater*, *supra* note 111.

creation of solutions are the next required steps in stormwater control.[128] The EPA suggests reaching stakeholders on a watershed level in an effort to blend science and statutory responsibilities with social, economic, and cultural considerations.[129] Since cities are already encouraged to work with public involvement on a watershed level, emphasis on green infrastructure techniques at this step would work towards restoring natural hydrology across a watershed.

3. Illicit Discharge Detection and Elimination

In deciding which BMPs to use, municipalities must figure out how to prevent illicit discharges.[130] An illicit discharge is defined in the EPA's NPDES regulations at 40 C.F.R. § 122.26 as "any discharge to [an MS4] that is not composed entirely of stormwater." MS4s do not treat stormwater,[131] so prevention of these discharges is important so that affected waterbodies are not polluted.[132] Illicit discharge detection and elimination programs are required to include: (1) a stormwater system map showing all water bodies that receive discharges; (2) an ordinance prohibiting non-stormwater discharges into the MS4; (3) a plan to detect and address non-stormwater discharges; (4) public education about the hazards of illicit discharges; and (5) BMPs that will be used to combat illicit discharges.[133]

BMPs in this category focus on prohibiting entities from causing illicit discharges, but one should note that green infrastructure can play a role in protecting waterbodies from these discharges. Illicit discharges into drains along streets and sidewalks can be filtered out with the use of green infrastructure.[134] Open-section streets can be used to drain stormwater into grassed swales, where it is filtered by vegetation.[135] Pervious materials can be used for sidewalks to further reduce the amount of polluted stormwater flowing into an MS4.[136] The addition of green infrastructure as a BMP to

128 EPA, ENGAGING AND INVOLVING STAKEHOLDERS IN YOUR WATERSHED 1 (2013) [hereinafter ENGAGING AND INVOLVING STAKEHOLDERS].

129 *Id.* at 9.

130 EPA, FACT SHEET 2.5 1 (2005) [hereinafter FACT SHEET 2.5].

131 *Combined Sewer Overflows (CSOs)*, *supra* note 53.

132 FACT SHEET 2.5, *supra* note 130, at 1.

133 *Id.* at 2.

134 U.S. DEP'T OF HOUSING & URB. DEV., THE PRACTICE OF LOW IMPACT DEVELOPMENT 90 (2003).

135 *Id.*

136 *Id.* at 92.

address illicit discharges has the added benefit of reducing the volume of runoff in a city, adding to flood protection.[137]

4. Construction

In their stormwater management programs, cities are required specifically to address construction site runoff.[138] The main concern with construction sites is the amount of sediment these sites can deposit into waterbodies during rain events.[139] Construction sites can contribute more sediment to a waterbody than would occur naturally over several decades.[140] Sediment pollution degrades drinking water and wildlife habitat.[141] Increased sediment levels in water can decrease water clarity, prevent natural vegetation growth in water, and cause large declines in fish populations.[142] Aside from water quality issues, sediment pollution can also clog storm drains and increase flooding.[143]

To address construction issues related to MS4s, cities are required to have an ordinance which instructs construction sites to implement erosion, sediment, and waste controls, as well as impose sanctions for sites which do not comply.[144] Cities must also consider potential water quality impacts of construction, inspect construction sites, and enforce control measures.[145] Lastly, cities must consider the appropriate construction related BMPs to use. One green infrastructure BMP the EPA suggests using at construction sites is a compost blanket.[146] A compost blanket is "a layer of loosely applied composted material placed on the soil in disturbed areas."[147] Compost blankets control the erosion of sediment into waterbodies and drains, reducing pollution and flood volume.[148]

137 *Id.*

138 EPA, FACT SHEET 2.6 1 (2005) [hereinafter FACT SHEET 2.6].

139 *Id.*

140 *Id.*

141 MID-AMERICA REGIONAL COUNCIL, WHAT IS SEDIMENT POLLUTION?, https://cfpub.epa.gov/npstbx/files/ksmo_sediment.pdf (last visited Sept. 17, 2020).

142 *Id.*

143 *Id.*

144 FACT SHEET 2.6, *supra* note 138, at 1–2.

145 *Id.* at 2.

146 EPA, COMPOST BLANKETS 1 (2012) [hereinafter COMPOST BLANKETS].

147 *Id.*

148 *Id.*

5. Post-construction

In the fifth category, cities are required to manage stormwater runoff from new development and redevelopment.[149] The EPA emphasizes the use of green infrastructure in this category. Post-construction stormwater management can be achieved with traditional gray infrastructure, but the EPA encourages use of low impact development ("LID").[150] LID practices for stormwater treatment include infiltration systems that move water down into the ground instead of out over impervious surfaces,[151] filtering systems that use soil and vegetation to remove pollutants from water,[152] and alternate conveyance systems that move water to treatment areas more slowly than conventional conveyance systems.[153]

LID reduces the need for gray infrastructure by treating water at its source.[154] Developers benefit from relying less on gray methods by reducing development costs, and municipalities benefit by reducing maintenance costs.[155] LID works better than gray infrastructure for stormwater control because it mimics the hydrologic functions that a site possesses pre-development.[156] Essentially, LID allows an area inhabited by people to continue to function naturally. To facilitate LID, cities are encouraged to reword any ordinances that would prevent its use by developers.[157] Instead of forcing environmentally conscious developers to obtain variances or waivers to get around old ordinances, cities can make the process easier by eliminating restrictive development laws.[158]

6. Pollution Prevention and Good Housekeeping

The sixth required component of a stormwater management plan is pollution prevention and good housekeeping.[159] After educating the public

149 EPA, NATIONAL MANAGEMENT MEASURES TO CONTROL NONPOINT SOURCE POLLUTION FROM URBAN AREAS MANAGEMENT MEASURE 5: NEW DEVELOPMENT RUNOFF TREATMENT (2005), https://www.epa.gov/sites/production/files/2015-09/documents/urban_ch05.pdf.

150 *Id.* at 5–52.

151 U.S. DEP'T OF HOUSING & URB. DEV., *supra* note 134, at 150.

152 *Id.* at 39.

153 *Id.* at 43.

154 *Id.* at x.

155 *Id.*

156 *Id.* at 13.

157 *Id.* at 15.

158 *Id.*

159 EPA, NATIONAL MANAGEMENT MEASURES TO CONTROL NONPOINT SOURCE POLLUTION FROM URBAN AREAS, MANAGEMENT MEASURE 6: NEW AND EXISTING ON-SITE

and developing plans to prevent illicit discharges and stormwater pollution during construction and post-construction, cities must determine housekeeping BMPs to maintain the plan's effectiveness. Some BMPs in this area include pavement cleaning; litter control; proper waste disposal; proper storage of materials such as grease, paints, detergents, and metals; and vehicle maintenance to avoid leaks or spills.[160] These ongoing practices can be improved with green infrastructure. For example, water contaminated with detergent from pavement cleaning can be filtered with the infiltration systems constructed during LID.[161]

The EPA has concluded that BMPs should be site-specific, so the EPA gives stormwater sources flexibility in creating their own stormwater pollution plan.[162] Although municipalities should have freedom to create stormwater plans that fit their specific needs, the EPA must develop a process where municipalities communicate with the EPA on how they have considered green infrastructure in their plans and, when relevant, why they chose to forgo green techniques. This process would ensure that cities are aware of green infrastructure options, and the EPA would have a way to check that these options were considered.

In addition to this added process, the EPA should promote green techniques in all six BMP categories. In its guidance documents, the EPA mainly refers to green infrastructure as a BMP option for post-construction. Due to the interconnected nature of the six categories, green methods can be incorporated into all of them. The EPA stated that BMPs are most effective when used in combination with each other,[163] so municipalities should be required to consider all possibilities and not just traditional gray infrastructure practices.

III. IMPLICATIONS OF STRENGTHENING FEDERAL GREEN INFRASTRUCTURE POLICY

If the United States implements green infrastructure policy at the federal level, the benefits of green techniques can be optimized, bolstering ecosystem health and services and improving flood control. However,

---

WASTEWATER TREATMENT SYSTEMS (2005), https://www.epa.gov/sites/production/files/2015-09/documents/urban_ch06.pdf.

160 EPA, GOOD HOUSEKEEPING PRACTICES (1999), https://www.epa.gov/sites/production/files/2015-11/documents/goodhousekeepingbusiness.pdf.

161 *See* U.S. DEP'T OF HOUSING & URB. DEV., *supra* note 134, at 33.

162 NAT'L RES. COUNCIL, *supra* note 45, at 43.

163 EPA, NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) STORM WATER PROGRAM: QUESTIONS AND ANSWERS - VOLUME III 8 (2004) [hereinafter NPDES STORM WATER PROGRAM].

there are areas for concern in implementing this powerful tool. Issues regarding costs, ecosystem service tradeoffs, and the ability to fit green infrastructure requirements into the existing statutory framework must be addressed when considering the use of this method on a large scale.

A. Green Infrastructure Strengthens Ecosystem Services and Flood Control

Green techniques increase the ability of a landscape to store water and better mitigate flooding.[164] These methods can also help to prevent combined sewage overflow events.[165]

Whereas traditional gray infrastructure is constructed to move water off-site as quickly as possible, green infrastructure keeps as much water as possible on-site.[166] Hence, rainwater is immediately filtered instead of being displaced to pollute water bodies.[167] Cities are able to use green mechanisms to reduce flooding while also increasing their ability to follow federal stormwater pollution requirements.

Moreover, by implementing green methods, a city is able to incorporate its stormwater mitigation system into the natural ecosystem instead of having a separate, artificial system.[168] Green infrastructure works to enhance and maintain natural ecosystem services falling into four categories: (1) provisioning; (2) regulating; (3) cultural; and (4) supporting.[169] Provisioning services provide natural products, such as water and trees. Regulating services maintain the functioning of an ecosystem, such as flood and climate control. Cultural services provide recreational and aesthetic benefits. Supporting services sustain the other three.[170] Through each of these categories, green infrastructure has the capability to provide clean drinking water, regulate flood control, enhance the aesthetics of an area, increase an area's recreational value, and overall create a more green, sustained environment.[171]

---

164 FED. EMERGENCY MGMT. AGENCY, *supra* note 20, at ES-8.

165 *Id.*

166 *Id.* at 3–72.

167 *See id.*

168 *See generally id.*

169 Donghyun Kim & Seul-Ki Song, *The Multifunctional Benefits of Green Infrastructure in Community Development: An Analytical Review Based on 447 Cases*, SUSTAINABILITY, July 16, 2019, at 1–2.

170 *Id.*

171 Margaret A. Palmer et al., *Manage Water in a Green Way*, 349 SCIENCE 584, 584 (2015); EPA, GREEN INFRASTRUCTURE IN PARKS 2 (2017) [hereinafter GREEN INFRASTRUCTURE IN PARKS].

By contrast, gray infrastructure can hinder an ecosystem's services and natural ability to recover from disasters.[172] Gray mechanisms can cause water pollution and degrade drinking water and ecosystems.[173] Because these structures are constructed of impervious surfaces, water cannot infiltrate the ground where they are located, negatively affecting an area's natural flood storage function.[174] During large rain events, cities composed of predominantly impervious surfaces, like concrete and asphalt, can be overwhelmed by water.[175] Urban flooding is an event characterized as more than just "flooding in an urban area."[176] Instead, urban flooding is a specific type of catastrophe that gray infrastructure causes and green infrastructure mitigates.[177]

B. National Implementation Ensures That Green Infrastructure is Most Effective

Green infrastructure is most effective when applied on a large scale.[178] Federal policy requiring states to coordinate on these projects can maximize green infrastructure's benefits. The primary goal of green stormwater technology is to protect or restore the hydrology and overall integrity of a watershed,[179] and watersheds across state lines.[180] For NPDES permits, stormwater infrastructure is implemented at the city level. This means that more than 39,000 separate, local government entities regulate flood control on seventy percent of United States land.[181] Although most people would prefer to make land-use decisions that restore

---

172 Benedict, *supra* note 25, at 14.

173 Leda Zimmerman, *Greening Gray Infrastructure*, MASS. INST. OF TECH.: SPECTRUM (2014), https://spectrum.mit.edu/winter-2014/greening-gray-infrastructure/.

174 AMERICAN PLAN. ASS'N, GREEN INFRASTRUCTURE AND POST-DISASTER RECOVERY: PLANNING FOR POST-DISASTER RECOVERY (2014), https://planning-org-uploaded-media.s3.amazonaws.com/legacy_resources/research/postdisaster/briefing papers/pdf/greeninfrastructure.pdf.

175 Jake Varn, *Hurricane Harvey and the Critical Importance of Stormwater Infrastructure*, BIPARTISAN POL'Y CTR. (Sept. 5, 2017), https://bipartisanpolicy.org/blog/hurricane-harvey-and-the-critical-importance-of-stormwater-infrastructure/.

176 Anna Weber, *What is Urban Flooding?*, NAT. RES. DEF. COUNCIL (Jan. 15, 2019), https://www.nrdc.org/experts/anna-weber/what-urban-flooding.

177 *Id.*; *Manage Flood Risk*, EPA (May 22, 2019), https://www.epa.gov/green-infrastructure/manage-flood-risk.

178 FED. EMERGENCY MGMT. AGENCY, *supra* note 20, at ES-8.

179 *Id.* at 3–73.

180 USGS watershed map of America shows thirteen watersheds covering the forty-eight contiguous states. *Watershed Map of America*, *supra* note 94.

181 KAREN FIREHOCK, NORTH CAROLINA FOREST SERV., EVALUATING AND CONSERVING GREEN INFRASTRUCTURE ACROSS THE LANDSCAPE 5 (2013).

rather than deplete the environment, local planners and decision makers may overlook natural resources.[182] If green infrastructure policy is left to states, there could still be forty-eight uncoordinated policies within the contiguous states, assuming every state participates. With green infrastructure policy at the state level, there is no guarantee that policymakers will focus on watersheds outside of their state's own boundaries. Segmenting watersheds could reduce the environmental benefits of any one municipality's policy.

States and cities have made efforts to implement green techniques, but federal policy can ensure consistency and high standards. States may emulate federal policies but are unlikely to match them in a way necessary for watershed protection. As an illustration, in 2007, Congress enacted the Energy Independence and Security Act requiring all new federal developments with a footprint of 465.5 square meters or more to restore the site to predevelopment hydrologic characteristics.[183] States have enacted similar standards, but state standards vary widely and tend to be less stringent.[184] Three-fourths of states have a footprint requirement of 4,046.86 square meters, whereas other states have a threshold closer to the federal development requirements.[185] When deciding between natural resource protection and economic development, states and the cities within them may prioritize development without a federal incentive to do otherwise.

Regional watershed governance should be established so that green infrastructure policy is not piecemeal.[186] Local governments have come together before on their own to form regional alliances on other matters, such as economic development and social policy.[187] Some of these alliances even focused on environmental issues.[188] However, allowing states a choice in forming regional governance for green stormwater structures does not necessarily incentivize them to do so. Implementing

182 *Id.*

183 Krishna P. Dhakal & Lizette R. Chevalier, *Managing Urban Stormwater For Urban Sustainability: Barriers And Policy Solutions For Green Infrastructure Application*, 203 J. ENVTL. MGMT. 171, 176 (2017).

184 *Id.*

185 *Id.*

186 *Id.* at 178.

187 Julie Cencula Olberding, *Diving into the "Third Waves" of Regional Governance and Economic Development Strategies*, 16 ECON. DEV. Q. 251, 251–52 (2002). Examples of economic development activities that regional alliances work on include creating marketing materials such as brochures, attending trade shows, or purchasing advertisements.

188 *Id.* at 252.

green mechanisms on a national watershed scale depends on national cooperation.

Although municipalities should still be granted discretion in determining which BMPs to use in their stormwater management plans, they must have a requirement to demonstrate to the EPA that they considered green techniques. Restoring the natural hydrology of ecosystems will take the effort of more than a few scattered cities across the country. Ecosystems and watersheds do not stop at city or state boundaries.

C. Green Infrastructure Concerns and Drawbacks

Although monetizing improved ecosystem and social services can be difficult, green infrastructure is potentially more cost-effective than gray infrastructure.[189] The EPA compiled twelve case studies showing the cost comparison between conventional and green infrastructure approaches.[190] Eleven of the twelve spent less money implementing green infrastructure than they would have using gray infrastructure methods.[191] Some green projects have cost more to implement than gray infrastructure projects due to the cost of materials, site preparation, increased project management, and the amount of land required to implement a management practice.[192] Maintenance costs should also be considered,[193] but maintenance needs for green structures decrease as plants establish and the site stabilizes.[194]

The initial higher costs to implement may be offset by reduced costs later. In a case study based in Kensington Estates, Washington, the city spent more to implement green techniques than anticipated. Assumed costs were somewhat offset by savings on stormwater utility and water bills, saving residents approximately $175 per year.[195] The city also realized benefits which were less simple to monetize, such as reduced stormwater peak flows, reduced soil erosion, preservation of open space

189 EPA, REDUCING STORMWATER COSTS THROUGH LOW IMPACT DEVELOPMENT (LID) STRATEGIES AND PRACTICES 6–9 (2007) [hereinafter REDUCING STORMWATER COSTS].

190 *Id.* at 12.

191 *Id.*

192 *Id.* at 9.

193 *Id.* at 10.

194 FED. EMERGENCY MGMT. AGENCY, *supra* note 20, at ES-9.

195 REDUCING STORMWATER COSTS, *supra* note 189, at 19; CH2M HILL, INC., PIERCE COUNTY LOW IMPACT DEVELOPMENT STUDY 38 (2011).

to create a more walkable community, and a decrease in traffic speeds and accident rates due to narrower roads implemented by the plan.[196]

The EPA has also struggled to identify a baseline to compare green infrastructure costs and benefits with gray infrastructure practices.[197] One study attempted to conduct a cost-benefit analysis of green infrastructure techniques by establishing a resource unit for the benefit provided by a technique (e.g. kilowatt hours for energy benefits), then determining the monetary value of a benefit based on the amount of resource units saved (e.g. the money a resident would save on electricity bills).[198] For stormwater runoff benefits, the study used gallons of rainwater retained on a site as the resource unit.[199] The study then applied this resource unit to multiple green infrastructure techniques that reduce stormwater runoff, such as green roofs, tree planting, and permeable pavement.[200] For instance, the study found that the addition of one green roof in an area with 38.01 inches of rain per year (based off of Chicago rainfall) would reduce 71,100 gallons of runoff per year.[201] Chicago spends $0.0000919 per gallon to treat wastewater, so the city would save $6.53 per green roof.[202] When applied to hundreds or thousands of roofs, cities can realize significant savings.

Although green infrastructure has the ability to improve ecosystem services, some benefits may come with tradeoffs. Specifically, for regulating services such as flood control, provisioning services can be affected.[203] For example, green roofs reduce runoff volume, but by flowing through vegetation, the runoff is exposed to more nutrients.[204] Excess nutrients can affect a waterbody's provisioning service of providing marine habitat. A high amount of nutrients can cause nuisance algae blooms, and these blooms decrease clarity and dissolved oxygen levels.[205]

Implementing green infrastructure may also require educational programs for the public to accept projects.[206] Besides becoming familiar

196 REDUCING STORMWATER COSTS, *supra* note 189, at 19.

197 *Id.* at 6.

198 CTR. FOR NEIGHBORHOOD TECH., THE VALUE OF GREEN INFRASTRUCTURE 15 (2010).

199 *Id.* at 17.

200 *Id.* at 17–19.

201 *Id.* at 18.

202 *Id.* at 21.

203 Liana Prudencio & Sarah E Null, *Stormwater Management and Ecosystem Services: A Review*, ENVTL. RES. LETTERS, Jan. 12, 2018, at 4.

204 *Id.*

205 CITY OF NEW YORK, *supra* note 76, at 168.

206 FED. EMERGENCY MGMT. AGENCY, *supra* note 20, at 3–74

with green infrastructure practices within the community, the public should be educated on the connection between unmanaged stormwater and environmental degradation.[207] Citizens must be able to appreciate their role or their neighborhood's role in fixing a shared problem of stormwater pollution.[208]

Lastly, green infrastructure's benefits are best realized on a national level. While the objective of federal stormwater policy under the CWA is to "restore and maintain chemical, physical, and biological integrity of the Nation's waters," the NPDES permit scheme tends to only focus on the chemical integrity aspect.[209] Restoration of hydrological processes and vegetation is not an objective of the CWA[210] and neither is urban flood protection. In order for the EPA to require cities to consider green infrastructure in their stormwater plans, an amendment to the CWA requiring these broader objectives may be necessary.[211] Accordingly, improving United States flood infrastructure will require efforts by the EPA and Congress. Both entities have already shown an interest in green infrastructure, so this feat may be less intimidating than it first appears.

CONCLUSION

Depending on the situation, green and gray infrastructure can both accomplish the same goals of flood mitigation, but one is better for conservation and community well-being. Gray infrastructure can contribute to flooding instead of preventing it, is aging and outdated in many areas, is at best neutral to natural ecosystems, and does not improve the aesthetics of communities. In times of heavy precipitation, cities do need a way to drain and divert water away from homes and businesses, so traditional gray systems of pipes and drains have value. It is unlikely that a city is able to completely rely on green techniques for flood mitigation, but green infrastructure can help tremendously in making gray structures more effective. Additionally, green infrastructure blends into natural ecosystems to enhance an area's natural capabilities and aesthetics.

The EPA must require cities to demonstrate their consideration of green techniques in stormwater mitigation plans. Cities may decide that green infrastructure is not cost effective or necessary for their jurisdiction,

---

207 Keeley et al., *supra* note 73, at 1103.

208 *Id.*

209 Dhakal & Chevalie, *supra* note 183, at 174 (quoting Clean Water Act of 1977 § 101(a), 33 U.S.C §§ 1251–1387 (2006)).

210 *Id.*

211 *Id.* at 176.

but they should at least weigh the costs and benefits before continuing with gray infrastructure implementation alone. The EPA should promote green techniques in every category of best management practices, not just the post-construction stage. Green infrastructure provides local benefits of flood mitigation and community well-being through an increased presence of vegetation, but its use can also have broader ecosystem effects when implemented on larger scales. A focus on watersheds or ecosystems will require the cooperation of multiple municipalities in multiple states. Complex coordination of different levels of government calls for the EPA and Congress to pass a national policy.