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Green Infrastructure in the Community Ratings System: A Proposed Path to National Flood Insurance Program Recognition

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About the Virginia Coastal Policy Center

The Virginia Coastal Policy Center (VCPC) at the College of William & Mary Law School provides science-based legal and policy analysis of ecological issues affecting the state's coastal resources, providing education and advice to a host of Virginia's decision-makers, from government officials and legal scholars to non-profit and business leaders.

With two nationally prominent science partners – the Virginia Institute of Marine Science, one of the largest marine research and education centers in the United States, and Virginia Sea Grant, a nationally recognized broker of scientific information – VCPC works with scientists, local and state political figures, community leaders, the military, and others to integrate the latest science with legal and policy analysis to solve coastal resource management issues. VCPC activities are inherently interdisciplinary, drawing on scientific, economic, public policy, sociological, and other expertise from within the University and across the country. With access to internationally recognized scientists at VIMS, to Sea Grant's national network of legal and science scholars, and to elected and appointed officials across the nation, VCPC engages in a host of information exchanges and collaborative partnerships.

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EXECUTIVE SUMMARY

As rising global temperatures contribute to more extreme weather patterns, many communities are experiencing higher flood risks. For coastal communities in particular, this results in higher flood insurance premiums through the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program (NFIP). The NFIP lowers premiums by acknowledging stormwater and flood management programs through a crediting procedure called the Community Ratings System (CRS). However, the CRS does not properly address a growing phenomenon among communities and municipalities: the installation of sustainable, green infrastructure designed to treat water quality, reduce runoff volume during storms, and supplement or replace traditional infrastructure.

Traditional infrastructure systems (also called "gray infrastructure") include sewers, gutters, and stormwater pumps. Gray infrastructure is typically installed where there are large areas of impervious surfaces, such as urban areas. These systems direct the flow of water to a single point, and discharge it into nearby waterways. Green infrastructure, however, is designed to mimic natural water processes by reducing the amount of impervious surface and retaining water on-site or encouraging groundwater infiltration, which reduces runoff quantity and velocity, and has several other environmental and economic co-benefits.

Currently, the CRS credits gray infrastructure significantly more than green infrastructure. Moreover, green infrastructure must be required by ordinance or regulation to receive any credit at all, whereas gray infrastructure can be credited without codification under certain Activities of CRS. When communities install comprehensive green infrastructure projects that are not required by any regulation, they lose out on a potentially significant reduction in homeowner flood insurance premiums, even though green infrastructure may reduce flood risk.

This paper argues that (1) the CRS should be amended to include voluntary installation of green infrastructure as a source of credit; and (2) FEMA, the United States Environmental Protection Agency (EPA), and other groups should conduct further studies on the effectiveness of individual green infrastructure practices in major storm events. Many communities have already implemented green infrastructure and promising research has shown that these practices can significantly reduce flood risk. The NFIP should further encourage widespread implementation of green infrastructure by increasing the number of credits available to communities.

I. INTRODUCTION

Green infrastructure, also known as low impact development (LID) practices (the terms are used interchangeably in this paper), is an alternative approach to flood and stormwater management that mimics natural floodplain processes to capture and treat water on-site by either infiltration into the groundwater or evapotranspiration.[1] Green infrastructure techniques include living shorelines, bioretention cells, constructed wetlands, green roofs, and pervious surfaces.[2] These are in contrast with traditional infrastructure practices, such as storm pumps and piped drainage, which were designed to quickly move water away from the built environment into adjacent waterways.[3] Both designs reduce runoff and improve water quality; however green infrastructure has a greater water quality impact and provides localities with a variety of economic and environmental co-benefits that make such designs desirable to communities.[4]

Green infrastructure is often used when localities design stormwater management plans to satisfy water quality regulations and accommodate increasing stormwater quantity due to sea level rise and increasingly frequent and intense storm events. At the same time, communities across the United States, particularly coastal communities, are facing rising stormwater fees (to finance replacement of aging and insufficient infrastructure) and increasing Congressionally-mandated flood insurance rates. To assist with these costs, the Federal Emergency Management Agency (FEMA) offers a voluntary incentive program, the Community Rating System (CRS), which awards credits to communities that implement proactive flood damage prevention measures.[5] Although LID practices are credited in some parts of the CRS, such practices do not receive equivalent credits to traditional infrastructure designs. If data supports that flood risk reduction targets are met equally by green infrastructure as gray infrastructure, then the designs should be credited equally under the CRS.

However, several differences between traditional infrastructure and green infrastructure make it difficult for LID practices to fit neatly into the CRS. First, there is an absence of uniform data demonstrating the flood risk reduction benefits of green infrastructure. This is partially because green infrastructure is often implemented by combining multiple projects throughout a development site or community, which makes it difficult to quantify the flood reduction capacity of individual projects. Additionally, communities most often implement green infrastructure as a means for water quality improvement, which disincentivizes studying the practices for water quantity reduction. For green infrastructure to be appropriately credited in the CRS, further studies

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[1] *See* EPA, *What is Green Infrastructure?*, https://www.epa.gov/green-infrastructure/what-green-infrastructure [hereinafter *What is Green Infrastructure?*] (last visited May 6, 2016).
[2] *Id.*
[3] *See* FEMA, *Climate Resilient Mitigation Activities Green Infrastructure Methods Fact Sheet*, 1 (2015), https://www.fema.gov/media-library-data/1449244221588-e054671affe09301e3b819d213a64ce7/GI_FactSheet_Sept2015_Dec508.pdf [hereinafter *Green Infrastructure Fact Sheet*].
[4] EPA, *Reducing Stormwater Costs through Low Impact Development Strategies and Practices*, 2 (2007), https://www.epa.gov/green-infrastructure/stormwater-costs [hereinafter *Reducing Stormwater Costs*].
[5] *See* FEMA, *The National Flood Insurance Program*, https://www.fema.gov/national-flood-insurance-program (last visited July 12, 2016).

should be conducted that measure the flood reduction capacity of green infrastructure using measurements that match the criteria in the CRS. Second, many localities and neighborhood organizations implement green infrastructure voluntarily (not mandated by regulation or ordinance), which is not credited under the existing CRS, while gray infrastructure can receive credit when implemented voluntarily.[6] This creates a policy problem under the CRS that needs to be reconsidered, either by encouraging localities to pass ordinances that set green infrastructure requirements or by reevaluating the regulatory requirement within the CRS.

This paper provides an overview of the CRS, as well as its procedure for crediting stormwater infrastructure generally. It then discusses the overall benefits of green infrastructure, its implementation by communities, and the limited number of CRS credits currently available for these projects. Finally, the paper argues that green infrastructure projects not required by regulation or ordinance should be eligible to receive credits under the CRS. To do so, further studies are required to determine the flood reduction effectiveness of individual green infrastructure practices, as well as to develop an adequate method of enforcement.

II. THE NATIONAL FLOOD INSURANCE PROGRAM'S COMMUNITY RATINGS SYSTEM.

The National Flood Insurance Program (NFIP), administered by FEMA, provides flood insurance to property owners in localities that meet minimum flood risk management requirements established by FEMA.[7] As is typical with insurance, flood insurance premiums increase as the risk of flooding increases. To incentivize risk reduction that goes above and beyond the minimum requirements, the NFIP uses the CRS program to offer lower flood insurance rates. Essentially, the CRS allows participating communities to earn credits by implementing specific flood mitigation activities. After earning a certain number of credits, the NFIP subsidizes flood insurance rates for high-risk property owners.[8] These flood risk reduction practices fall under broad categories including improving stormwater management, preserving open space in the floodplain, and providing educational materials for residents.[9]

When a community earns 500 credits from NFIP-approved flood mitigation practices, the community will move up one "class." This move means flood insurance premiums for all NFIP policyholders in that community's Special Flood Hazard Area (SFHA), or 100-year floodplain, will receive an additional 5% discount on their flood insurance rates. Policyholders that are not in

[6] *See* 44 C.F.R. § 60.1(d) (stating that any community may exceed the minimum criteria of the FEMA regulations by adopting more comprehensive flood plain management regulations).
[7] *Id.*
[8] FEMA, *National Flood Insurance Program Community Rating System*, http://www.fema.gov/national-flood-insurance-program-community-rating-system (last visited July 12, 2016).
[9] Adele Young & Kristen Clark, *Go Green, Save Money: Lowering Flood Insurance Rates in Virginia with Stormwater Management and Open Space*, VA. ENVTL. ENDOWMENT, 11 (2015).

a SFHA receive a lesser discount.[10] This is reflected in the following chart:[11]

CRS Class	CRS Credits	Rate Reduction
1	4,500+	SFHA – 45% Other – 10%
2	4,000-4,499	SFHA – 40% Other – 10%
3	3,500-3,999	SFHA – 35% Other – 10%
4	3,000-3,499	SFHA – 30% Other – 10%
5	2,500-2,999	SFHA – 25% Other – 10%
6	2,000-2,499	SFHA – 20% Other – 10%
7	1,500-1,999	SFHA – 15% Other – 5%
8	1,000-1,499	SFHA – 10% Other – 5%
9	500-999	SFHA – 5% Other – 5%
10	0-499	SFHA – 0% Other – 0%

A. The CRS offers significant credit for stormwater management and flood protection activities.

Communities are eligible to earn significant amounts of credit for implementing or renovating stormwater management infrastructure. The CRS credits these practices under two activities: Activity 450, Stormwater Management, and Activity 530, Flood Protection Activities.

To understand the requirements of Activities 450 and 530, one must first understand the

[10] *Id.* However, not all policyholders get a discount. "SFHA: Zones A, AE, A1-A30, V, V1-V30, AO, and AH. Outside the SFHA: Zones X, B, C, A99, AR, and D. Preferred Risk Policies are not eligible for CRS premium discounts because they already have premiums lower than other policies. Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage. Some minus-rated policies may not be eligible for CRS premium discounts. Premium discounts are subject to change." PARTICIPATION IN THE COMMUNITY RATING SYSTEM PROGRAM, http://www.myguilford.com/planning-and-development/watershed-protectionstormwater-management/floodplain-management/participation-in-the-community-rating-system-program/ (last visited Feb. 4, 2017).

[11] Chart derived from FEMA, *National Flood Insurance Program Community Rating System: A Local Official's Guide to Saving Lives, Preventing Property Damage, Reducing the Cost of Flood Insurance*, 3, http://www.fema.gov/media-library-data/1444398921661-5a1b30f0f8b60a79fb40cefcaf2bc290/2015_NFIP_Small_Brochure.pdf.

concept of the "design storm." Flood management is measured in terms of controlling runoff for a certain period of time (usually 24 hours) from a hypothetical storm that a specific geographic area has a given probability of experiencing in any year. For example, a 100-year storm is a storm event that will occur once in 100 years; in other words, there is a 1% chance that such a storm will occur in any year.[12] The chosen size and recurrence storm is used to determine the appropriate best management practices (BMPs) to control runoff for a site and is known as the "design storm." Design storm size and water output over a 24-hour period varies from place to place and is estimated by evaluating rainfall data from a specific geographic location.[13] A typical flood management regulation will require flood systems to control runoff from a design storm over a 24-hour period—whether a 10-year storm, 25-year, 50-year, or so on—by ensuring runoff from a developed piece of property is no higher for a design storm than it was before the property was developed.

Activity 450 provides credits for regulations that "prevent future development from increasing flood hazards to existing development and to maintain or improve water quality."[14] This Activity provides a maximum of 755 credits if a locality meets all or some of the requirements of four elements: (1) stormwater management regulations; (2) watershed master plan; (3) erosion and sediment control regulations; and (4) water quality regulations.[15]

In terms of creditable stormwater infrastructure, the first element—stormwater management regulations—is the most important. This element has four sub-elements: (a) size of the development; (b) design storm used; (c) low-impact development regulations; and (d) requirements for public inspection and maintenance of all facilities constructed to comply with the ordinance.[16] In other words, a regulation that requires future development or redevelopment to control runoff from at least a 10-year design storm, and provides for future maintenance, is eligible to receive credit.[17] Moreover, the design storm sub-element requires that a CRS coordinator submit calculations proving that the stormwater management system will reduce post-development runoff to pre-development levels during a minimum 10-year storm.[18]

Activity 530 is designed to protect buildings from flood damage by retrofitting so that the buildings suffer little or no damage when flooded, or by constructing small flood control projects that reduce the risk of floodwater reaching the buildings.[19] This Activity offers a maximum of 1,600 credits, of which 1,000 credits are granted for flood control techniques.[20] The only flood

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[12] *See* FLOODS: RECURRENCE INTERVALS AND 100-YEAR FLOODS (USGS), https://water.usgs.gov/edu/100yearflood.html (last visited Feb. 4, 2017).
[13] *Id.*
[14] FEMA, CRS COORDINATOR'S MANUAL 450-2 (2013), http://www.fema.gov/media-library-data/1406897194816-fc66ac50a3af94634751342cb35666cd/FIA-15_NFIP-Coordinators-Manual_2014.pdf [hereinafter CRS COORDINATOR'S MANUAL].
[15] *Id.* at 450-3.
[16] *Id.* at 450-4.
[17] *Id.*
[18] *Id.*
[19] *Id.* at 530-2.
[20] *Id.* at 530-1.

protection techniques credited are: elevation; dry floodproofing; wet floodproofing; sewer backup; barrier, levee, or floodwall; channel modification, storm sewer improvements, or diversions; and storage facilities.[21] To receive any credit, the technique must meet a variety of criteria, including the following that are applicable to all retrofitting or flood control projects:

- The project must protect the building(s) from at least the 25-year flood;
- All required permits must have been issued for the project or the local permit officer must state in writing that the project complies with all federal, state, and local codes and regulations;
- If the project requires human intervention, there must be at least one hour of flood warning time plus the time it takes to install the measure. "Human intervention" means that a person is needed at the site to close an opening or install or operate a protection device before flood waters reach the building; and
- Credit is not provided for a retrofitted building or flood control project that is in disrepair or does not appear to be maintained.[22]

Flood control projects are required to meet additional criteria, including:

- The design and construction of the project must have been certified by a licensed professional engineer;
- The responsible agency must be implementing an operations and management plan that was prepared for the project by a licensed professional engineer; and
- The community must ensure that the impact of future development will not adversely affect the project's flood protection level. This can be done by either:
  - Enforcing watershed-wide regulations that prevent increases in stormwater runoff under Activity 450; or
  - Designing the project so that it will perform to its design protection level based on a watershed that is fully built out or developed in accord with an adopted long-range land use plan. The community must document that the protection level is still valid at each cycle verification.[23]

Multiple steps are required to calculate the number of credits for this Activity. First, each type of technique is given a value according to its general effectiveness on a scale of zero to one.[24] Second, flood protection levels are each given a value on the same scale: for example, a technique designed to protect at the 100-year design storm level is given a value of 0.8.[25] Third, a CRS coordinator multiplies the technique's effectiveness value by the flood protection value for every building that has received a listed modification, and adds those numbers together.[26] Credits are

[21] *Id.* at 530-6 tbl. 530-1.
[22] *Id.* at 530-3.
[23] *Id.* at 530-3 to -4.
[24] *Id.* at 530-6.
[25] *Id.* at 530-9 to -10.
[26] *Id.* at 530-11.

awarded based on a multiple of the final number.

Finally, Activity 530 does not require a specific regulation—in other words; developers and private homeowners can install these techniques voluntarily. However, there are a number of steps involved to properly verify that the flood management techniques meet the required specifications to receive credit.[27] Activity 530 could serve as a model for recognition and crediting of voluntary green infrastructure measures, for these reasons.

Activities 450 and 530 provide significant credit under the CRS that could lower flood insurance premiums for entire communities. New stormwater management techniques have outpaced the regulatory requirements in the CRS, however. Many communities favor a new form of sustainable stormwater infrastructure, called LID techniques or, more commonly, green infrastructure. The CRS almost exclusively credits traditional forms of infrastructure, and should be changed to reflect communities' growing interest in new techniques. For example, Activity 530, which credits voluntary flood management techniques, could be used as a model for crediting voluntary green infrastructure projects.

III. GREEN INFRASTRUCTURE IS A POPULAR, SUSTAINABLE ALTERNATIVE FOR TRADITIONAL FLOOD MANAGEMENT INFRASTRUCTURE, BUT IT IS ELIGBLE FOR LITTLE, IF ANY, CREDIT IN THE CRS.

Green infrastructure is a nature-based, alternative design to traditional storm and floodwater management techniques that provides many social, economic, and environmental benefits. In a natural, undeveloped, open space, rainwater is absorbed and naturally filtered by soil and vegetation.[28] However, in developed, urban areas, rain falls on roofs, streets, and parking lots, and then flows into storm drains because the impervious surfaces prevent water from soaking into the ground, as it would have pre-development.[29] This can cause flood damage to property and infrastructure, which is expensive to repair. Green infrastructure practices mitigate this damage by incorporating vegetation and other natural elements into the built environment to restore and replicate pre-development natural water processes.[30]

Green infrastructure is designed to increase the available water storage capacity across a landscape by recreating pre-development processes through a comprehensive approach.[31] Green infrastructure practices range from small-scale elements—incorporated in residential development, such as green roofs, rain gardens, and downspout disconnection—to large-scale elements that span entire watersheds—such as habitat corridors.[32] The practices also vary as to how the water is detained and then removed through either reuse, evapotranspiration, or infiltration

[27] *Id.* at 530-3 to -4.
[28] *What is Green Infrastructure?*, *supra* note 1.
[29] *Id. See also*, *Reducing Stormwater Costs*, *supra* note 4, at 2.
[30] *Reducing Stormwater Costs*, *supra* note 4, at 2.
[31] *Id.*
[32] *Id.*

to groundwater.[33] Conservation designs, such as open space preservation, minimize the generation of runoff.[34] Infiltration practices, such as porous pavement and bioretention ponds, capture and filter runoff, which recharges groundwater.[35] Runoff storage practices, such as green roofs and rain barrels, capture runoff and store it for reuse.[36] These on-site methods of capture and infiltration allow green infrastructure to slow down or prevent runoff, which mitigates peak flows and the associated flooding damage.[37] Additionally, these practices have a variety of co-benefits for localities not offered by traditional infrastructure, such as improved water quality, reduced urban heat, improved natural floodplain functions, and adaption to climate change and sea level rise. For these reasons, many localities have incorporated green infrastructure into new development projects and redevelopment plans.[38]

A. Green infrastructure is preferred by some communities because it has multiple environmental, economic, and social benefits as compared with traditional stormwater management designs.

Green infrastructure and traditional infrastructure work to meet the same goals—to catch and manage runoff, and minimize pollutant discharge.[39] However, they achieve this goal by different means. Traditional "gray" infrastructure includes conventional piped drainage, curbs and gutters, stormwater grates, and stormwater sewer systems that discharge water into an adjacent waterway.[40] It is designed for the sole purpose of moving stormwater quickly away from the built environment to an adjacent waterway.[41] In contrast, green infrastructure slows down the flow of water, reduces and treats stormwater at the source, and provides additional environmental benefits, land value benefits, and compliance incentives.[42] Another difference between green infrastructure and gray infrastructure is that in practice, green infrastructure incorporates a combination of multiple projects to form an integrated system that substitutes for a single traditional structure.[43]

Independently, green infrastructure projects are most effective for high frequency, low impact events because such projects tend to focus on smaller scale, localized water storage.[44] In contrast, because traditional infrastructure is designed solely for large flood events, one stormwater pump can manage intense, peak flood events. For example, a traditional subdivision may use one extended detention wet pond, but when a developer implements a green infrastructure design, the plan may integrate small scale practices throughout the site to substitute for the single wet pond;

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33 *Green Infrastructure Fact Sheet*, *supra* note 3, at 1.
34 *Reducing Stormwater Costs*, *supra* note 4, at 3.
35 *Id.*
36 *Id.* at 4.
37 *Green Infrastructure Fact Sheet*, *supra* note 3, at 1.
38 *See generally*, *Reducing Stormwater Costs*, *supra* note 4; Martin Jaffe et al., *The Illinois Green Infrastructure Study* (2010), http://www.epa.state.il.us/green-infrastructure/docs/draft-final-report.pdf [hereinafter *Illinois Study*].
39 *Illinois Study*, *supra* note 38, at 6.
40 *Id.* at 22.
41 *Green Infrastructure Fact Sheet*, *supra* note 3, at 1.
42 *Reducing Stormwater Costs*, *supra* note 4, at 6-10.
43 *Id.* at 2.
44 *Id*.

this may include installing a bioretention area in each yard, disconnecting downspouts from driveway surfaces, removing curbs, and installing grassed swales in the common areas.[45] To meet community specific goals, the design may incorporate both green and gray infrastructure techniques.[46] Because green infrastructure is implemented on an integrated, site-wide scale, measuring the costs and capacity of each individual practice is difficult, especially as compared to traditional designs.[47] Further, it is difficult to change the standards of practice without certain and uniform data about the capacity and effectiveness of these practices.[48]

i. The multiple benefits of green infrastructure.

Traditional infrastructure's single purpose is to reduce and manage stormwater runoff; however, green infrastructure has many co-benefits including "improving air and water quality, reducing urban heat island effects, and providing or restoring native plant and wildlife conservation and habitat."[49] Green infrastructure also recharges the groundwater supply, creates investment opportunities and green jobs, and improves community aesthetics.[50] Another benefit of using green infrastructure in urban settings is that the project design can be customized to the locality so that the infrastructure does not impede existing uses and may include "dual-uses," such as creating green space or recreational areas.[51] These co-benefits make green infrastructure investment desirable for many localities designing a stormwater plan that meets multiple goals.[52] Because of these benefits, federal, state, and local governments actively promote green infrastructure for improved stormwater management.[53] The EPA recently published a study finding that green infrastructure "can reduce flood losses when applied watershed-wide as a co-benefit to the primary objective of water quality protection."[54] However, this study only evaluates the implementation of green infrastructure generally; it does not discuss the effectiveness of any

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[45] *Id.*
[46] Melissa G. Kramer, *Enhancing Sustainable Communities with Green Infrastructure*, U.S. ENVIRONMENTAL PROTECTION AGENCY, 6-7 (2014), https://www.epa.gov/sites/production/files/2014-10/documents/green-infrastructure.pdf.
[47] *Reducing Stormwater Costs*, *supra* note 4, at 3.
[48] *Id.* at 3. *See also Illinois Study*, *supra* note 38, at 6.
[49] *Green Infrastructure Fact Sheet*, *supra* note 3, at 2.
[50] Kramer, *supra* note 46, at 1.
[51] *Green Infrastructure Fact Sheet*, *supra* note 3, at 2 (noting that a retention basin may be "located between roadways or underneath existing sidewalks so it does not reduce the area used for vehicle or pedestrian traffic").
[52] Kramer, *supra* note 46, at 7.
[53] *Illinois Study*, *supra* note 38, at 25. The U.S. EPA has issued several policy memos encouraging the use of green infrastructure to manage stormwater. *Integrating Green Infrastructure into Federal Regulatory Programs*, U.S. EPA, https://www.epa.gov/green-infrastructure/integrating-green-infrastructure-federal-regulatory-programs#PolicyMemos.
[54] EPA, *Flood Loss Avoidance Benefits of Green Infrastructure for Stormwater Management*, xv (2015) https://www.epa.gov/sites/production/files/2016-05/documents/flood-avoidance-green-infrastructure-12-14-2015.pdf [hereinafter *Flood Loss Avoidance Benefits*]; *see* William J. Taylor, *Low Impact Development Techniques*, ASSOCIATION OF WASHINGTON CITIES AND WASHINGTON STATE DEPARTMENT OF ECOLOGY (2013), http://www.ecy.wa.gov/programs/wq/psmonitoring/ps_monitoring_docs/SWworkgroupDOCS/LIDWhitePaperFinalApril2013.pdf.

specific green infrastructure practice. [55]

ii. Policies and justifications communities rely on when implementing green infrastructure projects.

Many communities choose to implement green infrastructure polices because of a desire to invest in stormwater management practices that have multiple benefits.[56] Philadelphia implemented green infrastructure to be effective in meeting compliance standards for combined sewer overflows.[57] Other cities, such as Lenexa, Kansas and San Jose, California, used green infrastructure to meet National Pollutant Discharge Elimination System (NPDES) permit requirements.[58] Chicago invested in green infrastructure as a cost-effective way to address the extreme summer heat.[59] A report to the Illinois Environmental Protection Agency recommended implementing green infrastructure policies because green infrastructure is as effective as traditional practices in achieving water quality standards, but less costly than traditional infrastructure.[60] Many cities also implement green infrastructure because of long-term sustainability goals or the resulting increased quality of life.[61] The most common way for cities to implement these policies is through stormwater regulations that require new development and redevelopment projects to use green infrastructure, usually driven by the NPDES permit requirements.[62] Other methods are through municipal code review, agency coordination programs, demonstration projects, education and outreach, stormwater fees, and fee discounts.[63]

Twelve case studies reviewed by the EPA show that localities are implementing green infrastructure because of the variety of benefits in water management and smart growth development that result, without considering the potential for flood insurance credits through the CRS.[64] This is likely because the CRS does not have many available credits for LID practices. However, if data supports that flood reduction targets are met equally by green infrastructure as by traditional infrastructure, then the two design approaches should be credited equally in the CRS.

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[55] *See id.*
[56] *Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure*, U.S. EPA, 4 (2010), http://www.sustainablecitiesinstitute.org/Documents/SCI/Report_Guide/Guide_EPA_GICaseStudiesReduced4.pdf [hereinafter *Green Infrastructure Case Studies*].
[57] *Id.* at 8.
[58] *Id.*
[59] *Id.* at 37.
[60] *Illinois Study*, *supra* note 38, at 8.
[61] *Green Infrastructure Case Studies*, *supra* note 56, at 10-11.
[62] *Id*. at 13.
[63] *Id.* at 25-30.
[64] *See id.* (including twelve case studies: Alachua County, Florida; Chicago, Illinois; Emeryville, California; Lenexa, Kansas; Olympia, Washington; Philadelphia, Pennsylvania; Portland, Oregon; San Jose, California; Santa Monica, California; Seattle, Washington; Stafford County, Virginia; Wilsonville, Oregon).

B. Activities 450 and 530 do not reflect communities' growing interest in green infrastructure, because green infrastructure is awarded little credit if required by statute or regulation, and no credit if undertaken voluntarily.

The CRS Coordinator Handbook provides that:

> LID techniques can significantly reduce or eliminate the increase in stormwater runoff created by traditional development, encourage aquifer recharge, and promote better water quality. Communities are encouraged to use these techniques to minimize the need for more traditional stormwater management.[65]

However, in practice, the CRS does far too little to encourage LID techniques. The CRS grants up to 1,355 credits for stormwater management infrastructure projects involving only traditional techniques.[66] In contrast, most LID techniques are eligible to receive a maximum of just 45 credits. Living shorelines can receive additional credit under Activity 420, Open Space Preservation, but it would be exceedingly difficult to receive the maximum number of credits available.

Under Activity 450, the CRS offers twenty-five credits for regulatory language that "requires the implementation of LID techniques when new development occurs."[67] For example, the Virginia Stormwater Management Act[68] would qualify because it requires new developments to adopt certain BMPs to mitigate stormwater runoff, some of which are considered LID techniques.[69] Moreover, under the water quality regulations sub-element of the same Activity, communities could receive up to twenty points for BMPs that are considered LID techniques, such as vegetated swales.[70]

Activity 420 provides an additional source of credits. It credits activities that promote open space preservation, including natural shoreline protection.[71] This Activity provides the most credits for green infrastructure, allowing up to 120 points. Living shorelines fall within this category,[72] but in practice, coastal communities likely will not be able to receive the maximum number of credits, especially if neighborhoods install them voluntarily. To receive credit, substantial amounts of land must be preserved as open space, which is likely unfeasible in a residential setting.

Even assuming a community could earn the maximum number of credits for LID practices, 185 credits is too little to encourage voluntary practices. The problem for purposes of the CRS,

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[65] CRS COORDINATOR'S MANUAL, *supra* note 14, at 450-4.
[66] Assuming a stormwater management plan earned the maximum number of credits available for using only traditional infrastructure, then it would earn 355 credits under Activity 450, and 1,000 credits under Activity 530. *See id.* at 450-1, 530-1.
[67] *Id.* at 450-8.
[68] VA. CODE ANN. § 62.1-44.15:24 *et seq.*
[69] VA. CODE ANN. § 62.1-44.15:28(8); 9 VA. ADMIN. CODE § 25-870-65; Va. Dep't of Envtl. Quality, *Virginia Stormwater BMP Clearinghouse*, http://vwrrc.vt.edu/swc.
[70] 9 VA. ADMIN. CODE § 25-870-112(A); CRS COORDINATOR'S MANUAL, *supra* note14, at 450-21.
[71] CRS COORDINATOR'S MANUAL, *supra* note 14, at 420-28.
[72] *Id.*

however, is two-fold. First, green infrastructure is not listed as a creditable activity under Activity 530. Currently, the only way green infrastructure may be credited is if it is required by state or local regulation under Activity 450. Second, there is no data to show how a specific type of green infrastructure must be built to reduce flood damage. This in turn makes enforcement difficult, because FEMA requires standardized measurements to ensure that green infrastructure is properly built and maintained. If future studies are able to fill this data gap, however, individual green infrastructure techniques ought to be credited at least as much as traditional infrastructure, and the CRS should be amended to specifically include green infrastructure as a flood prevention technique.

IV. VOLUNTARILY INSTALLED GREEN INFRASTRUCTURE PROGRAMS SHOULD BE LISTED AS CREDITABLE TECHNIQUES UNDER ACTIVITY 530, BECAUSE EPA FLOOD ESTIMATES SUGGEST THAT COMPREHENSIVE, COMMUNITY-WIDE GREEN INFRASTRUCTURE INSTALLATIONS EXHIBIT FLOOD LOSS AVOIDANCE BENEFITS ON PAR WITH TRADITIONAL INFRASTRUCTURE.

The CRS grants credits based on community-wide flood reduction benefits. For example, Activity 450 requires stormwater management regulation for all new development or redevelopment, and Activity 530 provides credits based on the number of protected buildings. However, even though green infrastructure protects buildings from flood damage, it is not eligible for credits under Activity 530 because only enumerated traditional infrastructure designs are credited.[73] Activity 530 should include green infrastructure practices once the individualized benefits are determined, because EPA has estimated that a community-wide system of green infrastructure will provide flood risk mitigation at least as well as traditional infrastructure.[74] Inclusion of green infrastructure would thus serve the underlying premise of the CRS.

Many LID projects are not required by ordinance or regulation, but instead are undertaken voluntarily by community groups or local governments.[75] This prohibits receiving credits under several activities in the CRS, such as Activity 420 for living shorelines and Activity 450 for low impact development and water quality. An example of this type of voluntary program is Philadelphia's Green Acre Retrofit Program, which incentivizes owners to install green infrastructure on private property.[76]

Recently, the EPA conducted a modeling study that estimates the flood loss avoidance

[73] CRS COORDINATOR'S MANUAL, *supra* note 14, at 530-6 tbl. 530-1.
[74] *See generally Flood Loss Avoidance Benefits*, *supra* note 54.
[75] *See, e.g.*, Directory of Residential BMP Assistance Programs, CHESAPEAKE STORMWATER NETWORK, http://chesapeakestormwater.net/be-bay-friendly/directory-residential-bmp-programs/ (listing several voluntary BMP programs in the Chesapeake Bay watershed).
[76] Alisa Valderrama, *Wanted: Green Acres*, Nat. Resources Def. Council (2015), https://www.nrdc.org/sites/default/files/philadelphia-green-infrastructure-retrofits-IB.pdf.

benefits of green infrastructure practices.[77] EPA worked in consultation with FEMA, utilizing the agency's flood loss estimation model.[78] It generated an estimate of the monetary value of flood loss avoidance that could be achieved by using LID techniques to capture a specified volume of runoff.[79] The study applied green infrastructure only to new development and redevelopment, not to existing development.[80]

In the study, the EPA ran flood models for the 2-, 5-, 10-, 25-, 50-, and 100-year storm events.[81] EPA then used FEMA's Hazus model, which applies flood depth models to various types of infrastructure, to estimate losses caused by the flood events, and compared the results of scenarios that employed green infrastructure and those that employed traditional infrastructure over twenty years. EPA found that green infrastructure "can reduce flood losses when applied watershed-wide as a co-benefit to the primary objective of water quality protection."[82] In other words, green infrastructure as currently implemented—with its primary goal being to maintain water quality, and not flood reduction—will also increase flood loss avoidance. The study indicated "that the savings to the nation in terms of flood losses avoided in the year 2040 would range from $63 to $136 million (2011 dollars) if [green infrastructure] practices were more widely adopted on new development and redevelopment."[83]

The study reveals the promise of comprehensive green infrastructure stormwater management systems in reducing flood damage. Moreover, it confirms other entities' literature reviews that suggest the same result.[84] Providing credits for individual practices, however, requires a more rigorous study of individual green infrastructure practices. This study does not provide information about what types of green infrastructure are employed, or how effective individual practices are; it simply points out that green infrastructure is promising when considering flood loss avoidance.

Because EPA has tentatively recognized the flood protection benefits of community-wide implementation of LID practices, they ought to be credited alongside traditional techniques in Activity 530 once the benefit of each green infrastructure practice is studied and quantified. Activity 530 already provides a suitable verification and enforcement mechanism to ensure that any installation will produce standard flood reduction benefits.[85] Traditional infrastructure is credited without a regulatory requirement based on a showing of verification either from a local

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[77] *See generally Flood Loss Avoidance Benefits*, *supra* note 54.
[78] *Id.* at ix.
[79] *Id.*
[80] *Id.*
[81] *Id.* at xi.
[82] *Id.* at xv.
[83] *Id.*
[84] *See, e.g.*, Martin Jaffe, *Using Green Infrastructure to Manage Urban Stormwater Quality: A Review of Selected Practices and State Programs*, Il. EPA (2010); Syracuse University, *Green Infrastructure: Lessons from Science and Practice*, Science Policy Exchange (2015) (gathered and analyzed water quantity and quality performance data for commonly used green infrastructure technologies from existing literature and databases).
[85] *See* CRS COORDINATOR'S MANUAL, *supra* note 14, at 530-6.

authority (such as the state dam safety office) or certification.[86] Voluntary practices could be credited based on a similar verification certificate from a local authority or design professional. This would be a sufficient substitute to ensure that the voluntary BMP met the design criteria to qualify for the credit.

Such a procedure faces an additional hurdle, however: the lack of data as to the flood prevention effectiveness of individual practices. This (1) prevents communities from receiving credit under Activity 450's design storm sub-element; and (2) prevents communities from receiving credit under Activity 530 even if green infrastructure were included in this program, because all those buildings the LID practice is intended to protect against flooding must be protected up to the 25-year design storm and because data is required to properly assign effectiveness values under Activity 530 for enforcement and crediting purposes.

V. FIVE GREEN INFRASTRUCTURE PRACTICES ARE PROMISING FLOOD MITIGATION SOLUTIONS, BUT FURTHER STUDIES ARE REQUIRED TO DETERMINE THEIR EFFECTIVENESS IN DESIGN STORMS, AND TO PROPERLY DEVELOP AN ENFORCEMENT MECHANISM FOR PURPOSES OF ACTIVITY 530.

Quantifying the flood risk reduction benefits of green infrastructure is essential to convincing FEMA to expand the CRS credits for LID practices. However, in reviewing the available literature on the benefits of green infrastructure, there is an absence of data that quantifies the flood risk reduction capability of independent green infrastructure practices separately from the comprehensive LID design. It is necessary to study each practice individually because the comprehensive designs vary too much in the combination of green infrastructure techniques implemented to accurately compare them. The five practices that have been studied most extensively are: living shorelines, bioretention cells, constructed wetlands, green roofs, and pervious surfaces. Much of the data comes from the New Hampshire University Stormwater Center, a long-term research center dedicated to understanding and measuring the effects of stormwater management systems.[87] Other studies compile data from cities and other sites that have implemented certain techniques,[88] which makes it hard to isolate variables and conduct rigorous studies.

A. Living Shorelines

i. Description

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[86] *Id.* at 530-16 (requiring copies of the Elevation Certificate for each elevated building and a letter from the state dam safety office for buildings protected by reservoirs or detention basins).
[87] University of New Hampshire Stormwater Center, *2012 Biennial Report*, 2 (2012), https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/UNHSC.2012Report.10.10.12.pdf [hereinafter UNH (2012)].
[88] *See* Taylor, *supra* note 54.

Living shorelines are an erosion management technique used to moderate wave energy and mimic natural coastal processes by incorporating wetland grasses and submerged rock to maintain the continuity between the aquatic, intertidal, and terrestrial habitats to protect coastal property from erosion and flooding damage.[89] Living shorelines are encouraged by the National Oceanic and Atmospheric Administration (NOAA) as an alternative to traditional shoreline stabilization structures such as seawalls, revetments, and bulkheads, where feasible.[90] A few localities in Florida and Maryland have codified living shorelines as the preferred method for erosion management, [91] and the Commonwealth of Virginia has adopted a general permit that authorizes and encourages the use of living shorelines as the preferred alternative for stabilizing tidal shorelines.[92]

Living shoreline designs should be conditioned on site-specific conditions such as "wave energy, tidal currents and amplitude, elevation and underlying geomorphology."[93] Living shoreline designs typically incorporate native shoreline vegetation or other living, natural elements either alone or in combination with traditional, hardened shoreline structures, such as oyster reefs, wooden breakwaters, or rock sills, for added stability.[94] Examples include coastal wetlands, salt marshes, and mangrove forests.

Shoreline erosion and coastal property damage is a challenge for coastal communities that are subject to storm damage, wave erosion, and sea level rise.[95] These areas are generally very valuable assets to communities because of the large number of people and total property value in coastal habitats.[96]

Studies have shown that shorelines with intact natural coastal habitats such as wetlands, dunes, mangroves, and coral reefs, "experience less damage from severe storms and are more resilient than hardened shorelines."[97] This is because living shorelines are able to absorb wave

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[89] C.A. Currin, *Developing Alternative Shoreline Armoring Strategies: The Living Shoreline Approach in North Carolina*, *in Puget Sound Shorelines and the Impacts of Armoring—Proceedings of a State of the Science Workshop, May 2009: U.S. Geological Survey Scientific Investigations Report 2010-5254*, 91, 95 (2010), http://pubs.usgs.gov/sir/2010/5254/pdf/sir20105254.pdf.
[90] *Guidance for Considering the Use of Living Shorelines*, National Oceanic and Atmospheric Administration, 4 (2015), http://www.habitat.noaa.gov/pdf/noaa_guidance_for_considering_the_use_of_living_shorelines_2015.pdf [hereinafter NOAA Guidance] (stating that ". . . NOAA encourages the use of living shorelines as a shoreline stabilization technique along sheltered coasts to preserve and improve habitats and their ecosystem services at the land-water interface. . . NOAA has a broad interest in maintaining existing natural habitats that provide shoreline protection, like coral reefs, oyster reefs, mangroves, seagrass beds and marshes, along all coasts").
[91] *See, e.g.*, BREVARD COUNTY, FL. CODE § 62-3666(9)(a); Kent County Department of Planning and Zoning, *Wetlands Interagency Planning Group* (2006), http://dnr2.maryland.gov/ccs/Documents/training/worcesterls_am.pdf.
[92] VA. CODE ANN. § 28.2-104.1.
[93] Currin, *supra* note 89, at 95.
[94] NOAA Guidance, *supra* note 90, at 7.
[95] *Id.* at 4.
[96] Arkema et al., *Coastal habitats shield people and property from sea-level rise and storms*, NATURE CLIMATE CHANGE, July 14, 2013, at 913, http://www.nature.com/nclimate/journal/v3/n10/pdf/nclimate1944.pdf ("In the United States—where 23 of the nation's 25 most densely populated counties are coastal—the combination of storms and rising seas is already putting valuable property and large numbers of people in harm's way.").
[97] NOAA Guidance, *supra* note 90, at 5.

energy, which reduces wave impacts and erosion caused by severe storms.[98] The wave energy attenuation ability of a living shoreline increases in value as the living shoreline matures and becomes more stable.[99]

ii. Demonstrated or Potential Flood Loss Prevention Capability

Coastal marshes and wetlands act as natural buffers to wave energy and serve to mitigate erosion, which prevents significant damage to coastal structures.[100] Coastal wetlands in the United States have been estimated to provide $23.2 billion per year in storm protection services and the loss of one hectare of wetland has been found to correspond with an average increase in storm damage of $33,000.[101] Coastal wetlands protect coastal communities by absorbing storm energy created by hurricanes.[102] They do this by "decreasing the area of open water (fetch) for wind to form waves, increasing drag on water motion and hence the amplitude of a storm surge, reducing direct wind effect on the water surface, and directly absorbing wave energy."[103] Coastal wetlands have the potential to reduce storm surges with attenuation rates from 1m per 60km to 1m per 4km depending on the landscape and storm characteristics.[104] Studies have shown that salt marshes can dissipate wave energy by 50 percent within the first 2.5 meters.[105]

Although coastal wetlands are very effective at preventing gradual erosion, some living shoreline designs are susceptible to damage during extreme storm events.[106] However, during extreme storm events, bulkheads can also fail.[107] A study of the North Carolina shoreline, after Category 1 Hurricane Irene hit in 2011, found that 75% of surveyed bulkheads along the coastline were damaged.[108] In contrast, living shorelines were found to better stabilize and protect the shoreline; the hurricane had no effect on the surface elevation of the marsh and vegetation damage recovered within a year.[109] In addition to reducing damage and erosion, living shorelines simultaneously conserve natural habitats and their ecosystem functions.[110]

iii. CRS Credit Opportunities for Living Shorelines

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[98] *Id.* at 10.
[99] *Id.*
[100] Rachel K. Gittman et al., *Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during a Category 1 hurricane*, 102 OCEAN & COASTAL MANAGEMENT 94, 94 (2014).
[101] Costanza, R. et al., *The value of coastal wetlands for hurricane protection*, 37 *AMBIO* 241, 241 (2008), http://urizen-geography.nsm.du.edu/~psutton/AAA_Sutton_WebPage/Sutton/Publications/Sut_Pub_12.pdf.
[102] *Id.*
[103] *Id.*
[104] Ty v. Wamsley, *The Potential of Wetlands in Reducing Storm Surge*, 37 OCEAN ENGINEERING 59, 67 (2010), http://cirp.usace.army.mil/Downloads/PDF/JP-OE-Rosati-2010a.pdf.
[105] NOAA Guidance, *supra* note 90, at 10.
[106] Shannon Cunnif, Aaron Schwartz, *Performance of Natural Infrastructure and Nature-based Measures as Coastal Risk Reduction Features*, ENVIRONMENTAL DEFENSE FUND, at 11 (Sept. 2015).
[107] NOAA Guidance, *supra* note 90, at 11.
[108] Gittman, *supra* note 99, at 99.
[109] *Id.*
[110] LaDon Swann, *The Use of Living Shorelines to Mitigate the Effects of Storm Events on Dauphin Island, Alabama, USA*, AMERICAN FISHERIES SOCIETY, at 2 (2008).

Activity 420—Open Space Preservation:

Living shorelines can receive up to 1450 credits under Activity 422a, Open Space Preservation, and up to 350 credits under Activity 422c, Natural Functions Open Space, if owners prohibit development and open space is preserved or restored.[111] This can be difficult because owners must prove that development is prohibited on the land and obtain a large enough space to make it worthwhile for a floodplain manager to include the open space acreage count. This likely means that it will not be practical to credit a narrow strip of coastline at a single residential property.

Living shorelines can also be credited under Activity 422g, the Natural Shoreline Protection (NSP) category of Activity 420, for up to 120 credits based on the length of the shoreline.[112] FEMA notes that "NSP credit is for allowing these areas to follow their natural processes, such as channel meandering and beach erosion."[113] Credits are given for both conservation and restoration programs that are required by ordinance or regulation.[114]

Activity 452—Low Impact Development:

Living shorelines can get 25 credits under Activity 452a, Low Impact Development, and Activity 452d, Water Quality Regulations, for 20 credits.[115] However, the living shoreline must be required by ordinance or regulation to be eligible for credits under these Activities.[116]

Activity 532—Flood Protection:

Living shorelines could potentially be eligible for credits under Activity 532, Flood Protection, if it can be demonstrated that living shorelines can protect to the 25-year flood level.[117] This would be difficult to show without a study that measures the ability of living shorelines to provide such flood protection. An additional barrier to credit under this section is that the techniques used only credit structural designs.[118] Natural shoreline protection would need to be added to the list of creditable techniques to qualify for this credit.[119]

iv. Conclusion

Peer reviewed studies show that living shorelines are capable of attenuating wave energy and mitigating shoreline erosion and storm damage equivalent with traditional structures, such as bulkheads. They are estimated to save thousands of dollars in damage to property along the coastline each year. And they are the preferred method for shoreline erosion management in

[111] CRS COORDINATOR'S MANUAL, *supra* note 14, 420-3, -30.
[112] *Id.*
[113] *Id.*
[114] *Id.*
[115] *Id.* at 450-8, -21.
[116] *Id.*
[117] *Id.* at 530-6.
[118] CRS COORDINATOR'S MANUAL, *supra* note 14, at 530-6.
[119] *Id.*

several localities and encouraged by NOAA and the EPA. Still, living shorelines are not credited the same in the CRS as a levee or floodwall under Activity 432 and are limited in available credits depending on whether localities have passed living shoreline regulations.

B. Bioretention Cells

i. Description

Bioretention cells are also known as bioretention basins, biofilters, bioswales, or, most commonly, rain gardens. These systems are among the most common types of green infrastructure. Essentially, bioretention is a landscaped depression that captures and treats stormwater runoff.[120] They are typically used to filter water through a soil mix, providing substantial water quality benefits, and recharging sources of groundwater. The technique functions much like a traditional gutter, but also collects stormwater upstream from a storm sewer, interrupting much of the erosion caused by traditional stormwater systems.[121] Bioretention sites are typically designed to capture and hold the "first flush"—in other words, the runoff from the first inch of stormwater.[122] The first flush typically contains large amounts of pollutants.[123]

Bioretention systems vary widely from community to community. They use different types of vegetation cover, soil mixes, and cover different drainage areas, allowing for variations in climates.[124] Unfortunately, there is little agreement within the stormwater community as to how bioretention should be sized and what types of soils should be used, and, therefore, communities lack any standardized system of quality control for these systems.[125]

Bioretention cells have the added benefit that they are aesthetically pleasing, require minimal maintenance, and may be used in a variety of locations. On the other hand, they tend to be small, requiring many raingardens throughout a neighborhood to produce significant effects.[126]

ii. Demonstrated or Potential Flood Loss Prevention

Bioretention cells are primarily designed for purposes of water quality, and only for small, frequent rain events. Because of this, studies typically focus on bioretention's effects on water

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[120] *Rain Garden (BioRetention Cells)—a Stormwater BMP*, PENN. STATE. UNI., http://extension.psu.edu/natural-resources/water/watershed-education/stormwater/rain-gardens-bioretention-cells-a-stormwater-bmp [hereinafter *Rain Garden (BioRetention Cells)*].

[121] Syracuse University, *Green Infrastructure: Lessons from Science and Practice*, SCIENCE POLICY EXCHANGE, 13 (2015), http://projects.iq.harvard.edu/files/science-policy/files/gi_report_surdna_6_29_15_final.pdf?m=1437149385.

[122] *Rain Garden (BioRetention Cells), supra* note 120.

[123] *Id.*

[124] UNH (2012), *supra* note 87, at 20.

[125] *See* E. Stander et al., *The Effects of Rain Garden Size on Hydrologic Performance*, *in* Proceedings, World Environmental Water Resources Congress 2010 (2010).

[126] *City of Falls Church Watershed Management Plan*, Dep't of Public Works at 5-5 fig. 5-1 (2012).

quality.[127] Some of these studies have shown that bioretention systems incidentally provide ground water recharge and runoff detention, however.[128] In terms of small rain events, bioretention typically produces some of the best results with respect to average peak flow reduction, as well as total runoff reduction, second only to pervious surfaces.**[129]** Rain gardens are designed to hold a certain capacity, generally for small rain events.[130] If an event produces rainfall less than this amount, the bioretention cell will hold the entire volume and produce no runoff discharge.[131]

Moreover, even though the technology must be adapted for use in many different climates, the data reveal high average peak flow reduction regardless. This may be due to the variation across sites of the bioretention cell itself,[132] but a collection of peer-reviewed studies found that bioretention can reduce peak flow between 40% and 70%.[133] In some areas, average peak flow reduction can far exceed that. For different types of soil, one study found that bioretention can range in average peak flow reduction from 75% to 95%.**[134]** These studies show that bioretention is likely promising for flood reduction, but their conclusions are limited to small rain events. More study is required to determine their effectiveness with respect to design storms.

iii. CRS Credit Opportunities for Bioretention Cells

Activity 450—Stormwater Management:

Where required for new development by statute or ordinance, bioretention cells can receive 25 credits under the low impact development sub-element, as well as 20 credits under the water quality regulations sub-element.[135] Although further study is necessary, if bioretention cells can be designed to reduce runoff of design storms to predevelopment levels, then they would be able to receive additional credits under the design storm sub-element.[136] However, many communities implement these practices voluntarily, and thus are unable to receive credits under this Activity.[137]

Activity 530—Flood Protection:

Pending additional data on their effectiveness, bioretention cells during at least the 25-year

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[127] *E.g.*, Allen P. Davis et al., *Laboratory Study of Biological Retention for Urban Stormwater Mangement*, 73 Water Environment Research 5 (2001); H. Li & A.P. Davis, *Water Quality Improvement through Reductions of Pollutant Loads Using Bioretention*, 17 J. of Hydrologic Eng'g 604 (2011).
[128] *Performance of Green Infrastructure*, EPA, https://www.epa.gov/green-infrastructure/performance-green-infrastructure#raingardens.
[129] UNH (2012), *supra* note 87, at 21.
[130] *Rain Garden (BioRetention Cells)*, *supra* note 120.
[131] *Bioretention and Stormwater Research*, UNIV. OF MD, http://www.ence.umd.edu/~apdavis/Bioret.htm; Syracuse University, *supra* note 84, at 26.
[132] Soil type can alter the effectiveness of bioretention. *See generally* W.D. Shuster et al., *Prospects for Enhanced Groundwater Recharge via Infiltration of Urban Stormwater Runoff: A Case Study*, 62 J. OF SOIL & WATER CONSERVATION 129 (2007).
[133] Jaffe, *supra* note 84, at 35.
[134] UNH (2012), *supra* note 87, at 21.
[135] CRS COORDINATOR'S MANUAL, *supra* note 14, at 450-8.
[136] *See supra* Part III.
[137] *Id.*

storm, along with constructed wetlands, should be credited under Activity 530. This would require amending the list of structural techniques to include bioretention cells.[138] It would also require data to create a value for its effectiveness, which would be difficult given the variability of performance from place to place, and disagreement over the most effective composition of soils and sizing.

iv. Conclusion

Rain gardens are promising methods of flood control. Assuming that a community implements these structures comprehensively, they would likely have a significant effect on flood management systems. There is currently no data to suggest how effective they are in terms of design storms, however, and so it is unclear to what specifications they must be built in order to credit them effectively under the CRS. Even so, they remain a favorite technique among communities for aesthetic and water quality purposes, and any potential water quantity benefits should be credited under Activities 450 and 530 accordingly.

C. Constructed Wetlands

i. Description

Constructed wetlands mimic natural wetlands as habitats for animals and filtration systems for stormwater runoff. They are "frequently installed in areas adjacent to known tributaries or seasonal rivulets, or in pockets of low-lying, poorly draining soils."[139] Although their main function has been to control water quality, they contribute to stormwater management by providing additional surface storage, by allowing stormwater to infiltrate groundwater, and by allowing groundwater to discharge.[140]

The most important function of wetlands is to filter nutrients and minerals from water. Water flows through wetlands like a stream, but vegetation and soil slow down the flow. Particles are trapped by the vegetation and either settle or are absorbed. Moreover, wetlands host microorganisms that break down pollutants in water.[141]

Wetlands are often built by excavating, backfilling, grading, and installing water control structures to alter the flow of water to mimic natural wetlands. The developer then plants vegetation typical of wetlands. Constructed wetlands provide significant benefits to developed areas: they provide wildlife habitat, allow reuse of water, provide wastewater treatment, and serve as a beautiful addition to a typical urban landscape.[142]

ii. Demonstrated or Potential Flood Loss Prevention

In addition to its many other benefits, both constructed and natural wetlands provide flood

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[138] *See supra* Part IV.
[139] Syracuse University, *supra* note 84, at 27.
[140] *Id.* at 27.
[141] *Constructed Treatment Wetlands*, EPA (2004), http://nepis.epa.gov/Exe/ZyPDF.cgi/30005UPS.PDF?Dockey=30005UPS.PDF.
[142] *Id.*

and inclement weather protection.[143] The value of constructed wetlands is that they reduce average peak flow, rather than total runoff.[144] Wetlands exhibit "a tremendous capacity to reduce peak flows of stormwater entering the system."[145] The overall effect is to decrease the negative impacts of stormwater flow—such as riverbed scouring. By reducing erosion and slowing floodwaters, the deleterious impacts of small rainfall events that are realized over time and contribute to increased risk of flooding may be reduced significantly. One study found that the annual average peak flow reduction provided by constructed wetlands is 87%.[146] Unfortunately, studies of constructed wetlands' effectiveness in terms of water volume management are even less prevalent than those for other forms of green infrastructure.[147]

Constructed wetlands tend to be connected to sources of groundwater, and can therefore result in increased total runoff. This is normal, and constructed wetlands' effectiveness comes from delaying and reducing peak runoff rather than total runoff.[148] In terms of flood management, this technique would likely be most effective in addition to other techniques that better reduce total runoff during storms.

iii. CRS Credit Opportunities for Constructed Wetlands

<u>Activity 450—Stormwater Management:</u>

Constructed wetlands are eligible to receive 25 credits under the low impact development sub-element, and twenty credits under the water quality regulations sub-element.[149] If constructed wetlands can be designed to reduce runoff from at least a 10-year storm to predevelopment levels, then they would be able to receive additional credits under the design storm sub-element. This will require further studies, however. Moreover, the technique must be required by ordinance or regulation to be eligible for credits under these Activities.[150]

<u>Activity 530—Flood Protection:</u>

If future studies reveal that constructed wetlands can reduce runoff during at least the 25-year storm, they should be credited under Activity 530. This would require amending the list of structural techniques to include constructed wetlands. It would also require data to create a value for its effectiveness.[151]

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143 Syracuse University, *supra* note 84, at 27.
144 *Compare* UNH (2012), *supra* note 87, *with* Syracuse University, *supra* note 84, at 7-9.
145 UNH (2012), *supra* note 87, at 19.
146 *Id.*
147 *See, e.g.*, *Performance of Green Infrastructure*, EPA, https://www.epa.gov/green-infrastructure/performance-green-infrastructure#constructed%20wetlands (listing several studies of constructed wetlands, all of which discuss only water quality benefits).
148 UNH (2012), *supra* note 87, at 7.
149 CRS COORDINATOR'S MANUAL, *supra* note 14, at 450-8.
150 *Id.* at 450-1.
151 *See supra* Part II.

iv. Conclusion

Like other forms of green infrastructure, constructed wetlands are likely effective as part of a comprehensive flood management system. They are a popular form of water quality treatment , and have been implemented in urban as well as rural areas to treat agricultural runoff. Although they have not been studied systematically to assess their flood management qualities, they likely have a beneficial impact on the velocity of runoff and reduction in peak flow. Further, they reduce many of the negative impacts associated with traditional infrastructure, such as stream-bed erosion, which will exacerbate flood risk over time. Accordingly, pending positive additional study on the specific impact of each infrastructure practices, the CRS should credit constructed wetlands under Activities 450 and 530.

D. Green Roofs

i. Description

A green roof, also known as a rooftop garden, is a vegetative layer on top of a building that captures stormwater and filters it through the soil, which slows down stormwater runoff and provides other benefits, such as water quality filtration and urban heat reduction.[152] EPA supports the use of green roofs as a stormwater mitigation tool.[153] Green roofs serve a similar retention and filtration function as other retention designs, but are especially suitable for urban areas where there is limited space available to implement other stormwater management mechanisms.[154]

Typically, a green roof consists of several layers: a protective layer to prevent water damage to the building structure, a drainage layer, the soil medium layer, and, on top, the vegetation layer.[155] Green roofs retain stormwater in the soil media and typically reduce runoff through evapotranspiration.[156] The stormwater volume captured by a green roof is directly correlated with the depth of the soil and the surface area of the roof.[157] Thus one limitation of green roofs is that flow rates are only reduced up until the point of saturation.[158] However, according to a 2009 EPA study, even once green roofs are saturated, they still significantly increase the time to peak prior to producing runoff as compared to flat control roofs, and they delay and often attenuate stormwater flow.[159] Thus, the benefits of green roofs for stormwater control are that flow is delayed at the start of storms because of the direct retention, and then runoff from green roofs is delayed and decreased because rain must fall through the vegetation, root zone, and the media before it

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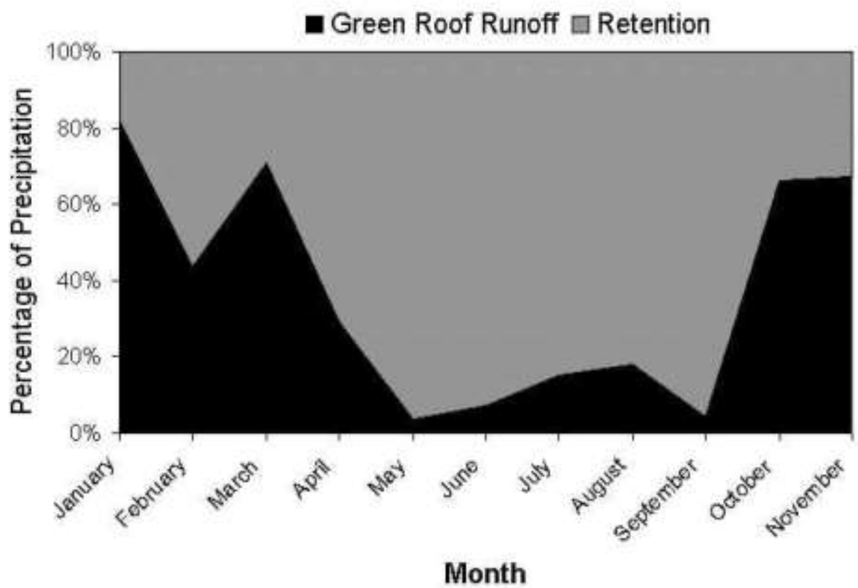
[152] EPA, *Using Green Roofs to Reduce Heat Islands*, https://www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands.
[153] EPA, *Green Roofs for Stormwater Runoff Control*, 2 (2009), available at https://ipcc-wg2.gov/njlite_download2.php?id=9237 [hereinafter *Green Roofs*].
[154] *Id.* at 1-3.
[155] *Id.* at 1-2.
[156] C.T. Driscoll et al., *Green Infrastructure: Lessons from Science and Practice,* SCIENCE AND POLICY EXCHANGE, at 26 (2015).
[157] *Id.*
[158] *Green Roofs, supra* note 153, at 3-12.
[159] *Id.*

reaches the drainage system.[160]

ii. Demonstrated or Potential Flood Loss Prevention Capability

In the 2009 EPA study, green roofs retained over 50% of the total precipitation during the study period.[161] In other studies, green roofs have been shown to retain as much as 70%[162] to 85%[163] of annual rainfall precipitation depending on regional climate. The 2009 EPA study found that during the drier, summer months nearly all the precipitation was retained.[164] However, during the wetter, winter months, retention was decreased (down to 20% in January).[165] In larger storm events, the green roof could only retain storage capacity before runoff started. However, because of the delayed start of runoff, green roofs are beneficial, even in large storms that produced green roof runoff, because the peak flows rates were delayed and peak flow volumes were attenuated.[166]

Retention rate of green roofs from EPA study:[167]



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[160] *Id.* at 1-1, 3-12.
[161] *Id.* at 3-6 - 3-14.
[162] Nicholaus D. VanWoert et al., *Green Roof Stormwater Retention: Effects of Roof Surface, Slope, and Media Depth*, 34 J. ENVIRON. QUAL., 1036, 1041 (2005).
[163] Driscoll, *supra* note 156, at 12.
[164] *Green Roofs*, *supra* note 153, at 3-5. However, during the warm months the difference between asphalt roofs and green roofs is not significant. *Id.*
[165] *Id.* During these colder months, the rate of evapotranspiration is likely decreased, which also contributes to the performance of green roof retention. Driscoll, *supra* note 156, at 12.
[166] *Green Roofs*, *supra* note 153, at 3-12.
[167] *Id.* at 3-6. "For 26.9 in. of recorded precipitation, there was a corresponding mean value of 12.7 in. with a standard deviation of 2.8 in. of green roof runoff compared to a mean of 23.1 in. with a calculated standard deviation of 1.7 in. for the flat asphalt roofs." *Id.* at 3-5.

iii. CRS Credit Opportunities for Green Roofs

Activity 450—Stormwater Management:

Green roofs can get 25 credits under Activity 452a, Low Impact Development, and 20 credits under Activity 452d, Water Quality Regulations.[168] However, the green roof must be required by ordinance or regulation to be eligible for credits under these Activities.[169]

Activity 530—Flood Protection:

If future studies reveal that green roofs can reduce runoff during at least the 25-year storm, they should be credited under Activity 530. This is unlikely unless there is a way to determine the effect of multiple green roofs in combination. This also would require amending the list of structural techniques to include green roofs, and require data to create a value for their effectiveness.[170]

iv. Conclusion

The EPA has found that green roofs have the ability to retain the majority of precipitation throughout the year. Although green roofs are limited in storage capacity depending on the design and size of the roof, they provide benefits even during peak flows by reducing the volume and time to peak flow. However, green roofs are limited in their eligibility for CRS credits. Green roofs are eligible for the LID credit and the Water Quality credit under Activity 450, but these require that the practice be required by ordinance, which creates a barrier for receiving credits if developers or communities construct a green roof voluntarily, as is common with green roof implementation.

Although the storage capacity of a green roof is limited by the square footage of the building that it is situated on, the capacity of multiple green roofs added together may have a significant impact on reducing runoff volume commensurate with traditional practices credited under Activity 450, Stormwater Management, and Activity 530, Flood Protection. Green roofs are consistent with the objective of Activity 530, which is: "to protect buildings from flood damage by retrofitting the buildings so that they suffer no or minimal damage when flooded, and/or constructing small flood control projects that reduce the risk of flood waters' reaching the buildings."[171] However, Activity 530 requires that projects protect buildings from at least the 25-year flood to be eligible for credits.[172] Therefore, further study is necessary to determine the capacity of green roofs to protect against this level of flooding.

E. Pervious Surfaces

i. Description

[168] *Id.* at 450-8, -21.
[169] *Id.*
[170] *See supra* Part II.
[171] CRS COORDINATOR'S MANUAL, *supra* note 14, at 530-2.
[172] *Id.* at 530-3.

Most surfaces in urban environments are impervious: they prevent water from being reabsorbed into the ground, exacerbate flooding, and are detrimental to water quality by allowing stormwater to accumulate all impurities that collect on the surface. [173] To combat these detrimental effects, many localities install permeable surfaces in some areas, mainly to improve water quality.[174] By allowing water to permeate into the ground, as well as slowing the speed of runoff, pervious surfaces can have a significant impact on flood risk reduction.

A pervious surface is typically one of three types: (1) porous asphalt; (2) pervious concrete; or (3) permeable interlocking concrete pavement.[175] They are essentially open-jointed systems of blocks or pavers that allow water to infiltrate through gaps.[176] These surfaces are installed over gravel and sometimes include an underdrain. Much of the stormwater they capture infiltrates groundwater or simply evaporates.[177] Moreover, they are extremely efficient in terms of pollutant removal.[178]

Other than its potential flood loss prevention and water quality benefits, pervious surfaces have the added benefits of taking up little space. On the other hand, clogging can increase maintenance costs, and pervious surfaces are usually best suited for low-traffic areas.[179] Pervious surfaces are more difficult to maintain in colder climates, due to frequent plowing during the winter.[180] Moreover, the design's effectiveness depends on the type of soil where it is implemented.[181] Nonetheless, many areas install pervious surfaces.

ii. Demonstrated or Potential Flood Loss Prevention

Pervious surfaces would aid in flood management by allowing water to pass through the surface rather than increasing runoff. Though nearly all studies focus on the water quality benefits of the practice,[182] some describe the ancillary water volume management benefits as well.[183] In ordinary rain event conditions, porous surfaces allow for "[s]ignificant groundwater recharge . . . far in excess of predevelopment conditions."[184] Moreover, even when pervious surfaces are totally saturated, they can slow the flow of stormwater significantly.[185] Two separate reviews of literature

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[173] UNH (2012), *supra* note 87, at 12-17.
[174] *See, e.g.*, *Pervious Pavement*, LAKESUPERIORDULUTHSTREAMS.ORG, http://www.lakesuperiorstreams.org/stormwater/toolkit/paving.html.
[175] UNH (2012), *supra* note 87, at 12-17.
[176] *City of Falls Church Watershed Management Plan*, *supra* note 126, at 5-3 fig. 5-1.
[177] Syracuse University, *supra* note 84, at 26.
[178] *Performance of Green Infrastructure*, *supra* note 147.
[179] *City of Falls Church Watershed Management Plan*, *supra* note 126, at 5-3 fig. 5-1.
[180] *See, e.g.*, *Pervious Pavement*, *supra* note 174.
[181] *Id.*
[182] *E.g.*, A. Rowe et al., *Environmental Effects of Pervious Pavement as a Low Impact Development Installation in Urban Regions*, *in* The Effects of Urbanization on Groundwater (2010); T. Boving et al., *Potential for Localized Groundwater Contamination in a Porous Pavement Parking Lot Setting in Rhode Island*, 55 ENVTL. GEOLOGY 571 (2008).
[183] *E.g.*, E. Bean et al., *Evaluation of Four Permeable Pavement Sites in Eastern North Carolina for Runoff Reduction and Water Quality Impacts*, 133 J. OF IRRIGATION & DRAINAGE ENG'G 583 (2007).
[184] UNH (2012), *supra* note 87, at 17.
[185] *See, e.g.*, *Pervious Pavement*, *supra* note 174.

and databases have confirmed these results.[186]

Pervious surfaces have generally been regarded as "exceptional" when testing their ability to manage runoff.[187] In a University of New Hampshire study, the research team observed no surface runoff when studying porous asphalt during normal storm events. Moreover, the period of observation actually included "100-year storm events that New Hampshire experienced in 2006 and 2007."[188] Although there has been no intentional, formal study of porous surfaces in design storm scenarios, the New Hampshire study demonstrates the technique's likely effectiveness in such situations. The team observed similar data with respect to pervious concrete and permeable interlocking concrete pavement, although those systems were installed after the 100-year storm events. Annual average runoff reduction for all types of pervious surfaces fell between 82% and 99%.[189] A separate review conducted by the Illinois Environmental Protection Agency found a range of roughly 60-80% average peak flow reduction, though these studies did not include design storm data.[190]

iii. CRS Credit Opportunities for Pervious Surfaces

Activity 450—Stormwater Management:

If required by state or local regulations for future development, pervious pavement can receive up to 45 credits under the Activity 450 low impact development and water quality sub-elements. Pending further research, if pervious pavement can reduce runoff of at least a 10-year storm to predevelopment levels, then the practice could be credited even more under this Activity.

Activity 530—Flood Protection:

Pending additional data on the effectiveness of pervious surfaces during at least the 25-year storm, they should be credited under Activity 530. This would require amending the list of structural techniques to include pervious surfaces. It would also require data to create a value for its effectiveness, which would be difficult given the variability of pervious pavement's performance from place to place. This can be done on a case-by-case basis, though, with help from local governments. For example, for purposes of water quality, the Arlington County government has created guidelines for construction of pervious pavement that are tailored to the region.[191]

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186 Syracuse University, *supra* note 84 (gathering and analyzing water quantity and quality performance data for commonly used green infrastructure technologies from existing literature and databases); Jaffe, *supra* note 84, at 35 (2010) (defining permeable surfaces broadly and finding that the technology provides roughly 60-80% average peak flow reduction).
187 UNH (2012), *supra* note 87, at 13.
188 *Id.*
189 *Id.* at 15, 17.
190 Jaffe, *supra* note 84, at 35.
191 *See Pervious Surface Options*, ARLINGTON CTY., *available at* http://environment.arlingtonva.us/stormwater-watersheds/stormwater-at-home/pervious-surface-options/.

iv. Conclusion

Although their effectiveness and maintenance costs will vary from location to location, pervious surfaces are an excellent addition to a flood management system using green infrastructure designs. By reducing the amount of impervious surfaces in a community, flood risk might be significantly reduced by preventing damaging runoff. Like the other types of green infrastructure, however, pervious surfaces have not been studied for their flood management benefits. They are the only method that has been observed in design storm settings, however, and the results were promising. The practice should therefore be included for credit under Activities 450 and 530.

CONCLUSION

Summary of Existing Benefits and Challenges of Green Infrastructure

Green infrastructure practices are being implemented by localities nationwide because of their ability to address multiple community goals in one investment. Green infrastructure is effective at water quality management, as well as reducing heat island effects, creating green jobs, restoring plant and wildlife habitat, and improving community aesthetics and property values. In addition, green infrastructure practices—particularly living shorelines, bioretention cells, constructed wetlands, green roofs, and pervious surfaces—have demonstrated, in peer reviewed studies, the capacity to effectively prevent flood and stormwater damage. However, these projects are only eligible to receive minimal CRS credits because of an absence of uniform data that measures the capacity of green infrastructure projects to prevent flood damage, and because credits under many activities are only available for activities that are required by regulation or ordinance.

Needed Data for Informed Analysis and Policy Making

For the NFIP to appropriately credit green infrastructure, data is necessary that measures the flood risk reduction benefits of green infrastructure techniques in a manner that coincides with the CRS. One difficulty in measuring this is that green infrastructure works as an integrated system rather than as a standalone project, like traditional infrastructure. For example, to substitute one storm water pump with green infrastructure may require a combination of green roofs, rain gardens, downspout disconnections, and pervious pavement. The integrated nature of LID design makes it difficult to measure the effectiveness of each practice based on data compiled from existing case studies. Therefore, further studies, similar to the University of New Hampshire Stormwater Center's report, are necessary to support the expansion of CRS credits for green infrastructure.

Suggested Modifications that FEMA Should Implement in the CRS Program

Where green infrastructure is equally as effective at meeting flood risk reduction targets, it should be equally credited in the CRS. Several Activities in the CRS, such as 422g for living shorelines, 452a for Low Impact Development, and 452d for Water Quality, require that practices be required by ordinance or regulation to be eligible for CRS credits, though several localities implement LID projects voluntarily and not because they are required by ordinance. This requirement should be reconsidered in the CRS criteria for LID practices because green infrastructure addresses the goals of the CRS—to reduce flood damage and provide comprehensive floodplain management. Expanding the CRS credits to voluntary practices is possible using a verification system similar to the certification system currently used for traditional infrastructure under Activity 530.