Photos: Sherry Wilkins.

Plants Not Pipes: Promoting Green Infrastructure and its Side Benefits in Region VI

Prepared by:
Downstream Strategies
219 Wall Street
Morgantown, WV 26505
www.downstreamstrategies.com

Evan Hansen, Anne Hereford,
Fritz Boettner, Sera Zegre

Prepared for:
Region VI Planning and Development Council
Jim Hall, Executive Director
34 Mountain Park Drive
White Hall, WV 26554

Downstream Strategies
building capacity for sustainability

August 25, 2010

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

ABBREVIATIONS

Al	aluminum
AML	abandoned mine land
ARRA	American Reinvestment and Recovery Act
ASLA	American Society of Landscape Architects
BMP	best management practice
CDOT	Chicago Department of Transportation
CDP	census-designated place
CAN	condition not allowable
CNT	Center for Neighborhood Technology
CSO	combined sewer overflow
CUH	Center for Urban Horticulture
CWSRF	Clean Water State Revolving Fund
FCI	Federal Correctional Institution
Fe	iron
FISRWG	Federal Interagency Stream Restoration Working Group
FOCUS	Foundation for Overcoming Challenges and Utilizing Strengths
FODC	Friends of Deckers Creek
FSU	Fairmont State University
GI	green infrastructure
GIS	geographic information system
IPCC	Intergovernmental Panel on Climate Change
ITRC	Interstate Technology Regulatory Council
KML	keyhole mark language
LEED	Leadership in Energy and Environmental Design
LID	low impact development
MKA	Magnusson Klemencic Associates
Mn	manganese
MS4	municipal separate storm sewer system
MUB	Morgantown Utility Board
NA	not available
NPDES	National Pollutant Discharge Elimination System
NRDC	Natural Resources Defense Council
Pb	lead
PCB	polychlorinated biphenyl
PCWA	Piney Creek Watershed Association
PWD	Philadelphia Water Department
SD1	Sanitation District 1
TE	Transportation Enhancement
TIF	tax increment financing
TMDL	total maximum daily load
UNHSC	University of New Hampshire Stormwater Center
US	United States
USDOJ	United States Department of Justice
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
WDNR	Wisconsin Department of Natural Resources
WRWA	West Run Watershed Association
WVDEP	West Virginia Department of Environmental Protection
WVDO	West Virginia Development Office
WVDOF	West Virginia Division of Forestry
WVDOH	West Virginia Division of Highways
WVU	West Virginia University
Zn	zinc

ABOUT THE PROJECT

This project, originally called "Promoting green infrastructure and its side benefits in Region VI watersheds" and subsequently referred to as "Plants Not Pipes: Promoting Green Infrastructure and its side benefits in Region VI," was funded through green set-aside funds from the West Virginia Department of Environmental Protection's Clean Water Act Section 604(b) program. Research began in September 2009.

This final report is one of several deliverables. Other deliverables include (1) conceptual designs for green infrastructure projects that have been delivered to local partners; (2) fact sheets and a project Web site, which help disseminate information about the project and green infrastructure more generally; and (3) GoogleEarth and GoogleMap keyhole mark language (KML) files, which include information about existing and proposed green infrastructure projects in Region VI, along with selected results from the stormwater opportunity analysis in this report.

The project Web site can be found at www.downstreamstrategies.com/GreenInfrastructure. Our conceptual designs, fact sheets, and GoogleEarth and GoogleMap files will all be accessible via this Web site.

ACKNOWLEDGEMENTS

We thank the Region VI Planning and Development Council and the West Virginia Department of Environmental Protection for funding this research. In particular, Region VI Planning and Development Council Executive Director Jim Hall has played an important role in initiating this project and in seeing it through to completion. Steve Gergely and Darek Potter at Harbor Engineering in Manheim, Pennsylvania created the conceptual designs that are reproduced in this report and that have been delivered to our local partners.

We thank Scott Copen, Staff Engineer, Morgantown Utility Board; Chris Haddox, Visiting Assistant Professor of Sustainable Design, West Virginia University; and Sherry Wilkins, Municipal Separate Storm Sewer System Coordinator, West Virginia Department of Environmental Protection for reviewing a draft of this report and providing useful feedback. Throughout the course of this project, we met and spoke with a wide variety of local government leaders, municipal staff and volunteers, university staff, and interested citizens. We thank the following people and organizations for their time and assistance.

3 Rivers Wet Weather, Tracy Schubert, *Public Outreach Manager*
Board of Park and Recreation Commissioners (City of Morgantown), Ralph LaRue, *Associate Director of Park Operations*
Cabell County Schools, Mike O'Dell, *Assistant Superintendent of Operations*
Canaan Valley Institute, Dan Wheeler, *Operations*; Sarah Deacon, *Educator*; Cindy Phillips; Vicki Fenwick, *Education Coordinator*
City of Clarksburg, Martin Howe, *City Manager*; Anthony Bellotte, *Public Works*
City of Fairmont, Mike DeMary, *Stormwater Manager*; Kathy Wyrosdick, *City Planner*
City of Morgantown, Marchetta Maupin, *Urban Landscape Technician*; Jeff Mikorski, *Assistant City Manager*
Fairmont State University Physical Plant, Jamie Colanero, Doug Decker, Stephanie Slaubaugh, Tom Tucker
Friends of Deckers Creek, Sarah Veselka, *Executive Director*
Morgantown Urban Landscape Commission, Kara Hurst, *Chair;* Marilyn Bowers; Anne Cumming; Ralph LaRue; Marchetta Maupin; Bill McDonald; Sandy Poulson; Jennie Selin; Jerry Steketee; Annette Tanner
Morgantown Utility Board, Doug Smith, *Senior Engineer;* Scott Copen, *Staff Engineer*
Nine Mile Run Watershed Association, Lisa Brown, *Outreach Coordinator*
Preston County Economic Development Authority, Robbie Baylor, *Executive Director*
Reedsville Revitalization Committee, Martin Christ, *Friends of Deckers Creek Water Remediation Director*
Region VI Planning and Development Council, Jim Hall, *Executive Director*
Reinforced Aggregates/Mechanical Concrete, Sam Bonasso, *Owner*
SRA International, Kate Marshall
Taylor County Development Authority, Bob Gorey, *Director*
Town of Flemington, Bradley Mayle, *Mayor*; Town Council
Town of Star City, Jim Konchesky, *Mayor*
Westover Civic Club, Ruth Spangler, *President*
West Run Watershed Association, Annie Simcoe
West Virginia Botanic Garden, Linda Bagby, *Development Director*
West Virginia House of Delegates, Mike Manypenny, *District 42*
West Virginia Department of Environmental Protection, Sherry Wilkins, *West Virginia MS4 Coordinator*
West Virginia University Department of Landscape Architecture, Ashley Kyber, *Professor*
West Virginia University Office of Sustainability, Clement Solomon, *Director* and Amelia Martin, *Sustainability Associate*
West Virginia University Office of Transportation and Parking, Hugh E. Kierig, *Director*

1. INTRODUCTION

Rain events, particularly in developed areas, produce a significant amount of runoff, or stormwater. Most stormwater flows directly into rivers or streams or is channeled there through storm sewers. This untreated stormwater transports various pollutants from the ground surface to the waterways. Stormwater is one of the leading causes of pollution in all types of water bodies in the United States (US) (USEPA, 2007).

In natural systems, most precipitation is absorbed or infiltrated into the ground where it replenishes aquifers, supplies water to nearby streams during low flows, filters pollutants, and nourishes trees and other vegetation. This process is important for the long-term maintenance of drinking water supplies and greenspace. While allowing for continued development, green infrastructure (GI) provides several techniques that mimic natural systems by providing infiltration and filtering mechanisms for stormwater runoff.

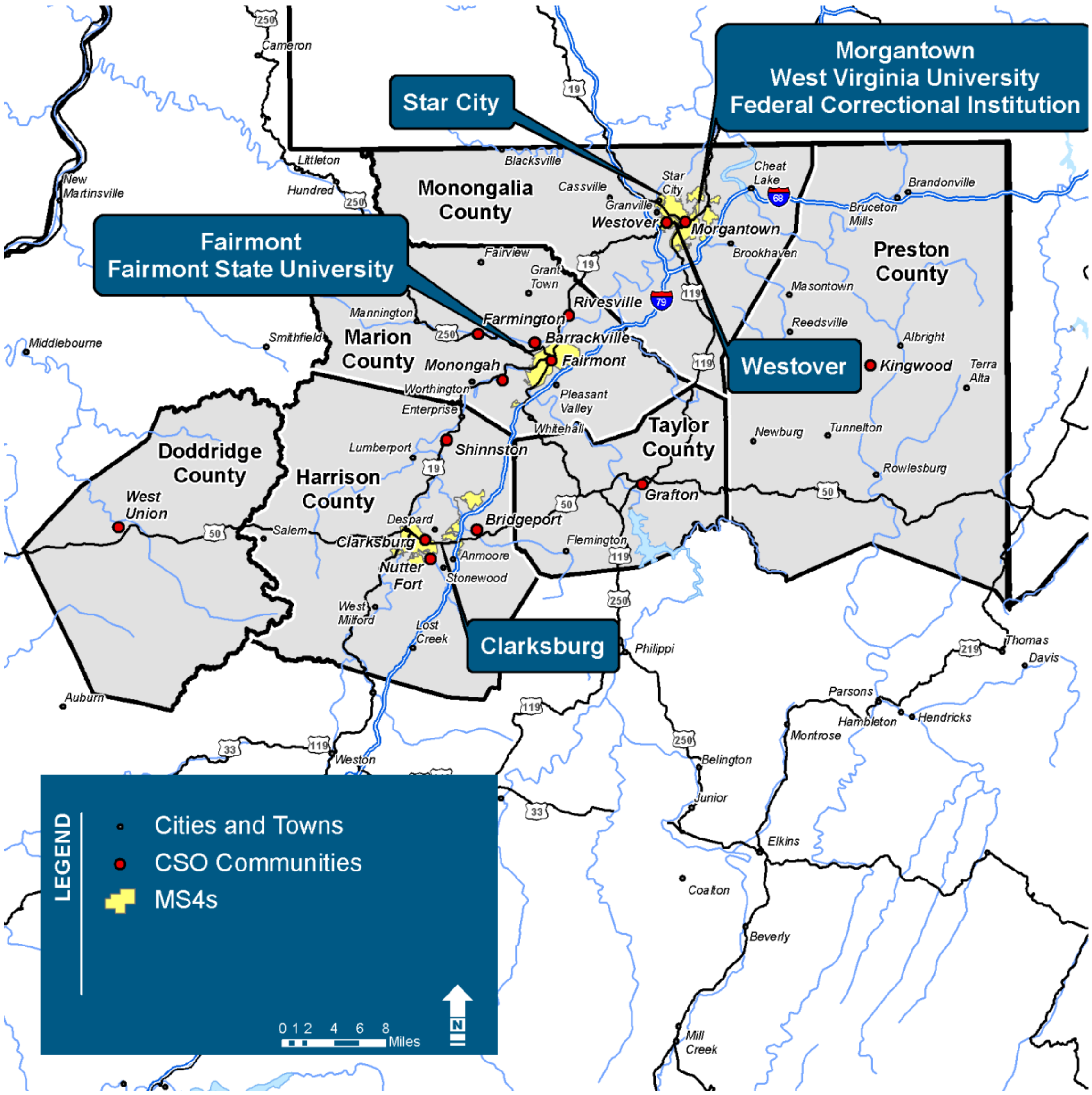
Different types of development generally replace open space with roads, sidewalks, parking lots, and rooftops. These impervious surfaces can decrease the system's ability to infiltrate stormwater, resulting in greater runoff. Development can also bring higher levels of pollutants including fertilizers, automotive fluids, pet waste, and litter. As stormwater flows over developed areas, it picks up these pollutants and transports them—often untreated—through the storm sewer system and into the waterways (WVDEP, 2009b).

GI projects such as green roofs, grassy swales, and rain gardens are being used more and more across the country to infiltrate, evapotranspire, and capture and reuse stormwater to mimic natural water systems. In addition to water quality improvements, implementing GI typically provides many side benefits. For example, GI techniques can help prevent flooding as well as increase energy efficiency in buildings; these physical benefits also provide financial savings to communities.

Conventional stormwater management approaches include combined and separate storm sewers, curb and gutter systems, detention basins, and end-of-pipe treatment devices. These approaches, also known as "grey" infrastructure, can be expensive to install and maintain. Increased use of GI techniques can reduce wear and tear on existing grey infrastructure, providing savings to operations and maintenance budgets. Beyond the physical and economic benefits, GI provides other important but less tangible advantages—beautifying downtowns, improving air quality, and offering other health benefits.

This report focuses on GI in West Virginia's Region VI Planning and Development Council service area, which includes Doddridge, Harrison, Marion, Monongalia, Preston, and Taylor Counties. As shown in Figure 1 and Table 1, this six-county area in north-central West Virginia includes 12 cities, 27 towns, and five census-designated places (CDPs). Several of these local areas are growing, thus presenting opportunities for private developers and local governments to implement GI.

Figure 1: Region VI municipal separate storm sewer system and combined sewer system communities



Note: The eight MS4s in the region are highlighted in the blue call-outs. CSO=combined sewer overflow. MS4= municipal separate storm sewer system.

Also shown in Figure 1 and Table 1 are the eight municipal separate storm sewer systems (MS4s) within Region VI: Clarksburg, Fairmont, Morgantown, Star City, Westover, Fairmont State University (FSU), West Virginia University (WVU), and the Federal Correctional Institution (FCI) in Morgantown. These MS4s are required, via a permit, to implement stormwater best management practices (BMPs) as part of a stormwater management program.

Prior to about 1950, it was a common practice in the eastern US to construct systems that direct stormwater runoff into a combined sewer system, mixing stormwater with sanitary sewage. Many of these combined systems are still in use. When it rains too hard, the increased runoff overwhelms the sewer system, resulting in the release of the combined sewage directly into streams through discharges known as combined sewer overflows (CSOs). There are 14 CSO communities in Region VI and a total of 56 across West Virginia (USEPA, 2009c). Region VI communities that have CSOs are shown along with MS4s in Figure 1 and Table 1.

Table 1: Region VI municipalities

County	Place	Designation	1990 population	2000 population	2009 population	Population change	MS4	CSO
Doddridge	West Union	Town	830	806	775	-7%		✓
Harrison	Anmoore	Town	686	685	767	12%		
	Bridgeport	City	6,739	7,306	7,935	18%		✓
	Clarksburg	City	18,059	16,743	16,408	-9%	✓	✓
	Despard	CDP	1,018	1,039	NA	2%		
	Enterprise	CDP	1,058	939	NA	-11%		
	Lost Creek	Town	413	467	501	21%		
	Lumberport	Town	1,014	937	966	-5%		
	Nutter Fort	Town	1,819	1,686	1,625	-11%		✓
	Salem	City	2,063	2,006	2,047	-1%		
	Shinnston	City	2,543	2,295	2,240	-12%		✓
	Stonewood	City	1,996	1,815	1,856	-7%		
	West Milford	Town	519	651	651	25%		
Marion	Barrackville	Town	1,443	1,288	1,292	-10%		✓
	Cassville	CDP	1,458	1,586	NA	9%		
	Fairmont	City	20,210	19,097	19,031	-6%	✓	✓
	Fairview	Town	513	435	447	-13%		
	Farmington	Town	414	387	388	-6%		✓
	Grant Town	Town	694	657	638	-8%		
	Mannington	City	2,184	2,124	2,086	-4%		
	Monongah	Town	1,018	939	959	-6%		✓
	Pleasant Valley	City	NA	3,124	3,134	0%		
	Rivesville	Town	1,064	913	906	-15%		✓
	White Hall	Town	NA	595	610	3%		
	Worthington	Town	233	170	170	-27%		
Monongalia	Blacksville	Town	168	175	179	7%		
	Brookhaven	CDP	3,836	4,734	NA	23%		
	Cheat Lake	CDP	3,992	6,396	NA	60%		
	Granville	Town	798	778	834	5%		
	Morgantown	City	25,879	26,809	30,330	17%	✓	✓
	Star City	Town	1,251	1,366	1,695	35%	✓	
	Westover	City	4,201	3,941	4,144	-1%	✓	✓
Preston	Albright	Town	195	247	247	27%		
	Brandonville	Town	73	102	107	47%		
	Bruceton Mills	Town	132	74	74	-44%		
	Kingwood	City	3,243	2,944	3,045	-6%		✓
	Masontown	Town	737	647	651	-12%		
	Newburg	Town	378	360	360	-5%		
	Reedsville	Town	482	517	534	11%		
	Rowlesburg	Town	648	613	611	-6%		
	Terra Alta	Town	1,713	1,456	1,506	-12%		
	Tunnelton	Town	331	336	347	5%		
Taylor	Flemington	Town	352	287	289	-18%		
	Grafton	City	5,524	5,489	5,380	-3%		✓

Source: Populations from US Census Bureau (2009). CSO data from USEPA (2009c). Note: The FCI and WVU, both in Morgantown, and FSU are also designated MS4s. FCI currently houses 1,119 inmates (USDOJ, 2009); WVU fall 2009 enrollment is 28,839 (WVU, 2009); FSU shares a campus with Pierpont Community and Technical College, with a combined enrollment of approximately 7,200 (FSU, 2009). Rivesville is served by the Greater Paw Paw Publiic Service District. Population change is based on oldest and most recent available data. MS4=municipal separate storm sewer system. CSO=combined sewer overflow. CDP=census-designated place. NA=not available.

2. BACKGROUND

In natural, undeveloped landscapes, only about 10% of precipitation becomes runoff, with 50% infiltrating into the ground and 40% returning to the atmosphere through evapotranspiration[1] (FISRWG, 1998). The construction of buildings and infrastructure on previously undisturbed lands adds to impervious cover—roofs, roads, sidewalks—and shifts the balance of the natural system, as shown in Figure 2 (Arnold and Gibbons, 1996).

For example, when a landscape is 35 to 50% impervious, about 30% of precipitation becomes runoff and only about 35% of precipitation infiltrates into the ground; this is illustrated by the bottom-left chart in Figure 2. In short, increases in impervious surfaces result in increased runoff. The increase in runoff is primarily at the expense of infiltration, but also has an effect on evapotranspiration. As population and development increase, stormwater runoff volumes will continue to rise unless techniques shift toward those that maintain the ability of sites to infiltrate and store stormwater. Increased stormwater runoff pollutes streams and rivers, and also contributes to flooding. Research demonstrates a strong correlation between basin imperviousness and stream health (Arnold and Gibbons, 1996).

Figure 2: The effect of increased impervious area on stormwater

Source: Data from FISRWG (1998).

[1] Evapotranspiration includes moisture released into the atmosphere through plant leaves as well as evaporation from the ground surface.

Traditional stormwater infrastructure is designed to efficiently transport runoff off-site for treatment or discharge to natural drainages (Molloy, 2009). While some Region VI communities have separate storm sewer systems, others funnel stormwater into combined sewer systems, mixing stormwater runoff with sanitary sewage. Many municipal sewer systems were first constructed in the mid- to late-1800s (USEPA, 2004). While the transition to underground sewers was driven by a concern for human health, wastewater treatment facilities were not conceived until a few decades later. For this reason, there was no health advantage to separate storm and sanitary sewer systems. Large communities with greater volumes of stormwater viewed combined systems as beneficial for flood control, while smaller communities generally constructed systems just for sanitary waste (USEPA, 2004). Toward the end of the 19^{th} century, it became apparent that discharging untreated sanitary waste into streams was resulting in cholera and typhoid in downstream communities; municipalities, therefore, began building treatment facilities for their combined or separate systems (USEPA, 2004).

Building design and GI

New approaches to building design may sometimes inadvertently inhibit the use of GI. For example, many new buildings are designed to internalize stormwater infrastructure—keeping roof downspouts inside the exterior walls of the building for a sleeker design aesthetic.

This approach undermines green infrastructure in two ways—first by eliminating a physical reminder of the connection between stormwater and impervious surfaces, and second by making it more difficult to later fit the building with capture and reuse systems.

In combined sewer systems, low volumes of stormwater are treated along with the sanitary sewage during dry weather periods. The additional rainwater from larger storm events, however, fills the combined systems beyond capacity. CSO outlets were added to alleviate sewer system back-ups during these wet weather periods by discharging some of the combined sanitary and storm sewage. Poor management of stormwater, therefore, can be directly linked to the discharge of human waste into streams and rivers. Conversely, controlling stormwater runoff can reduce the volume and frequency of overflow events (NRDC, 2006; Templeton, 2009), in effect reducing the net amount of untreated sanitary waste discharged into public waterways.

In the past, stormwater management has primarily consisted of detention ponds with a goal of reducing peak discharge rates. However, this technique fails to address total volume, frequency, duration, and temperature of discharge events (Molloy, 2009). GI addresses all of these stormwater issues, as well as water quality, by focusing on keeping stormwater out of the pipes and treating it onsite (WVDEP, 2009b). By implementing techniques that capture and reuse stormwater or allow it to infiltrate or evapotranspire, GI works to maintain or restore natural water systems. Some GI practices are best suited for use in new development to maintain the natural hydrology. Retrofitting existing sites can also be a cost-effective way to address stormwater management, especially when stormwater utility fees are structured in a way to provide incentives for owners to retrofit their properties.

Different GI practices are often used in concert. This allows for maximum benefits without relying too heavily on any single strategy. For example, in parking lots with permeable pavement, vegetated strips may be installed to capture and infiltrate rainwater that exceeds the infiltration rate of the pavement during major storm events. Rain gardens and bioswales are often constructed to manage runoff generated by downspout disconnection.

2.1 Types of green infrastructure

Many different GI practices are available to reduce stormwater runoff and provide side benefits. These GI techniques can be divided into four general strategies:

- infiltration,
- evapotranspiration,
- capture and use, and
- managed conveyance.

GI projects can be implemented at different scales—site, neighborhood, and watershed or regional. Site-level GI projects are presented in Table 2, along with estimated costs and side benefits. Depending on precipitation patterns and site characteristics, different practices may be more practical or beneficial in different localities. USEPA recommends meeting stormwater management goals by evaluating the potential of GI practices in order from most- to least- cost-effective: bioretention (rain gardens, planters, swales); permeable pavements and pavers; cisterns and rain barrels; and green roofs (USEPA, 2009f). Specific practices will be discussed in more detail, with examples given in Section 4.

Table 2: Site-level green infrastructure strategies, techniques, costs, and side benefits

Strategy	Technique	Description	Cost	Side benefit
Infiltration	Pervious or permeable pavement	Paved surfaces designed to allow water to flow through	Pavers: $5-12/square foot Porous asphalt: $6-8/square foot Porous concrete: $6-12/square foot	Reduced maintenance costs
	Rain gardens	Depressed vegetated areas designed to infiltrate	$5-16/square foot	Improved aesthetics; wildlife habitat
Evapotranspiration	Urban trees	Trees in developed areas	$175-400/tree	Recreational area; wildlife habitat; improved air quality; carbon sequestration
	Stormwater planters	Depressed vegetated areas in sidewalks, parking lots, and streets	Planters: $1-25/square foot Native plants: $0.02-0.13/square foot	Improved aesthetics; urban heat-island reduction; traffic calming
	Green roofs	Lined vegetated areas on rooftops	$9-32/square foot	Longer life than traditional roof; energy savings
	Green walls	Vertical planters on the sides of buildings	$100-125/square foot	Added greenspace without loss of land area; energy savings
Capture and use	Rain barrels	Smaller containers to capture runoff for re-use	$1-3/gallon capacity	Water utility savings
	Cisterns	Larger containers to capture runoff for re-use	$1-3/gallon capacity	Water utility savings
Managed conveyance	Bioswales	Vegetated shallow ditch	$6-24/square foot	Improved aesthetics
	Downspout disconnection	Disconnecting roof drainage from sewer system	$8-156/spout	Reduced landscaping water costs
	Terraced planter systems	Series of planter boxes stepped into a sloped surface	Unavailable	Improved aesthetics; wildlife habitat
	Level spreaders	Stormwater structures that support filtering action of riparian buffers	Unavailable	Diffuse runoff; reduce sediment; wildlife habitat

Source: Cost estimates from CNT (2009) except green walls from Nephin (2009).

2.1.1 *Infiltration*

Some GI techniques seek to counter the heightened runoff that accompanies impervious surfaces by engineering systems that promote infiltration of stormwater. Infiltration contributes to the recharge of aquifers, reduces the temperature and contaminants of water entering the stream network (as compared to overland flow), and reduces the volume of runoff, resulting in a reduced need for infrastructure (USEPA, 2007). Rain gardens and pervious pavement are two examples of GI techniques that promote infiltration.

Investing in alternative transportation infrastructure can also have a significant impact on impervious surfaces by reducing the amount of parking spaces needed. Strategies may include expanded bus service, more miles of bike paths and bike lanes, rideshare programs, and monetary or programmatic incentives to relinquish parking permits. While these programs will likely not be implemented as stormwater techniques, other benefits include traffic reduction, improved human health, improved air quality, and employment opportunities.

2.1.2 *Evapotranspiration*

While some GI planting projects offer increased infiltration potential, others rely more heavily upon evapotranspiration as a means of preventing stormwater from entering storm drains. Most GI practices offer some degree of evapotranspiration. While this may be the primary goal of urban trees, green roofs, and green walls, evapotranspiration is at work anywhere that plants are growing.

2.1.3 *Capture and use*

In areas with intense storms, steep slopes, and impervious surfaces, storing runoff may be feasible when infiltration is not. Stored rainwater can be used for non-potable uses such as washing cars, doing laundry, flushing toilets, and watering lawns and gardens. Rain barrels and their larger counterparts, cisterns, are the most common means of capturing and storing runoff from roofs.

Other types of storage facilities allow for slow infiltration or plant uptake and evapotranspiration. Green roofs, landscape islands, and rain gardens can all be designed to store runoff (USEPA, 2007).

2.1.4 *Managed conveyance*

When site characteristics or budget constraints preclude large-scale infiltration, evapotranspiration, and capture and use, modifying stormwater pathways can help to slow runoff, allowing more time for evaporation and for the settling out of suspended solids (USEPA, 2007). Conveyance modification measures are also often used in concert with other GI practices because it may be impractical to design for rare high-volume storm events (USEPA, 2007). Like traditional pipes and trenches, GI conveyance structures are designed to guide stormwater away from sites. The GI approach toward conveyance, however, utilizes permeable or natural, vegetated surfaces. These characteristics allow for some infiltration, and also provide a rough surface that slows the flow of water.

2.2 Low impact development

To protect water quality and stream stability, stormwater must be managed at various scales, including site, development, and watershed scales. Moreover, stormwater management has important implications for other issues such as the protection of source water, preservation of habitat quality and contiguity, flood control, and built infrastructure costs. Rules to reduce stormwater impacts on specific sites can, if improperly designed, create incentives for increased lot sizes and sprawl, thereby increasing built infrastructure costs per capita, fragmenting important habitats, and consuming open space. For these reasons, the various levels and approaches to stormwater management should be considered in concert with one another.

The specific GI practices described in the previous section can be effective in reducing stormwater discharges to sewer systems, as well as to local streams and rivers. A more holistic approach, however, looks beyond individual sites to neighborhood, regional, or watershed levels. Low impact development (LID) encompasses GI techniques in addition to a more comprehensive development philosophy. Beyond the GI strategies discussed above, LID also includes the principles of conservation design, low impact landscaping, and re-development.

2.2.1 *Conservation design*

A fundamental component in the planning and construction stages of LID is the principle of conservation—preserving open space. Several techniques can be used on-site to minimize stormwater runoff that occurs with the conversion of pervious surfaces to impervious ones.

Preservation of open space during construction. During construction, greenspace, even when an integral part of final site design, is often compacted, stripped of topsoil, and reduced in area more than necessary. Conservation design promotes careful construction planning to site buildings away from wetlands and other ecologically important areas, reduce road widths, and clear the minimum amount of land necessary to accommodate the construction. Utilizing the principles of conservation design can curb construction costs by reducing the need for traditional stormwater management (USEPA, 2007).

Shared, reduced width, and two-track driveways. In some watersheds, rooftops and driveways account for up to 72% of total impervious area (USEPA, 2008c). Shared driveways, reduced driveway widths, and two-track driveways are all ways to preserve some degree of open space, without compromising the functionality of a driveway.

Cluster development. In addition to preserving open space at the site scale, neighborhoods and municipalities can take steps to encourage cluster development and redevelopment of previously developed sites. Focusing new development in areas that are already densely developed and redeveloping sites that are no longer in use allows for the preservation of open space that might otherwise be developed to accommodate urban growth.

2.2.2 *Low impact landscaping*

Plant and soil selection. The types of plants used for landscaping projects can have a significant impact on runoff reduction. Plants with more extensive root systems provide better stabilization, reducing erosion and thus sediment levels in runoff. Deeper roots also contribute to increased infiltration capacity by breaking up the soil (Christian, 2009). Additionally, soils can be specially chosen for their high infiltration capacity. Clay-rich soils are much less permeable than sand-rich soils and compaction reduces infiltration in any soil type—by up to 90% even in sandy soils (Christian, 2009). Tilling or fluffing the soil can help ameliorate this problem. Different types of plants require different volumes of water. Ryegrass, a common lawn cover, uptakes and transpires approximately 1-2 gallons per day for every 10 square feet of lawn, whereas a single mature weeping willow tree transpires 200-800 gallons daily (Christian, 2009; ITRC, 2009). Replacing lawn with wildflowers or trees reduces maintenance as well as runoff (CCLC, 2007).

2.2.3 *Infill development and brownfields redevelopment*

Infill development. Concentrating new development in urban areas rather than expanding into surrounding undeveloped areas reduces the need for additional road and sewer systems, saving municipalities money and preserving open space for recreation. Fewer roads means less stormwater runoff.

Brownfields redevelopment. Brownfields are properties that often formerly contained commercial ventures, whose development is hindered by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Abandoned and dilapidated buildings, unused industrial facilities, and former gas stations and glass factories are a few examples of brownfields. Although the redevelopment process of these properties is often drawn out, the cleanup and reuse of the sites can benefit from federal, state, and private assistance. Converting abandoned buildings and constructing residential or commercial buildings can reduce the net impervious surface associated with new construction. In addition to reducing runoff, redevelopment revitalizes communities by repurposing dilapidated buildings and unmaintained lots.

2.3 Side benefits

The side benefits of GI range considerably. In some cases, capital costs of GI are less than those of more traditional management strategies. Additionally, operation and maintenance costs for GI are often minimal in comparison to grey infrastructure. Beyond the financial benefits, GI also offers environmental and human health benefits, while contributing to community beautification.

2.3.1 *Direct monetary savings*

Many municipalities and businesses that have elected to use GI have found that the associated project and maintenance costs are often lower than the costs of traditional stormwater management practices (Estornell, 2009). In 2007, USEPA evaluated 17 case studies of LID practices in cities across the US and Canada and found that capital costs of LID projects were usually 15-80% lower than those of conventional approaches, with a few exceptions (USEPA, 2007). Additionally, LID projects were found to be more effective at ameliorating environmental issues associated with excess stormwater runoff.

Savings associated with urban trees

The longevity and performance of paved surfaces is dependent on traffic, temperature, and precipitation patterns (Hugo and Martin, 2004; McPherson and Muchnick, 2005; Smith et al., 2008). GI can help reduce damage caused by heat and water. A California study found that a well-shaded street saves up to $0.66 per square foot in preventive road maintenance costs over a 30-year period (McPherson and Muchnick, 2005). This translates to a savings of $5,000 per city block.

Urban trees also provide indirect savings in other sectors. Atlanta has 27% tree cover; this tree cover has saved the city an estimated $15 million annually by improving air quality. Additionally, the trees have allowed for the avoidance of $883 million in costs associated with stormwater retention infrastructure (The Trust for Public Land, 1999).

When tree-planting goes beyond street trees to become an urban forest, even more benefits are seen. Forest cover, and other GI techniques that filter pollutants, reduce water treatment costs. A study of 27 water suppliers found a 20% decrease in water treatment costs for every 10% increase in forest cover up to 60% (Ernst, 2004).

While the exact savings will vary by locality, it is clear that trees have more than just aesthetic value.

2.3.2 *Indirect monetary savings*

In addition to the direct monetary savings, GI projects often provide indirect savings and other side benefits as well. Depending on the specific situation in a municipality, reduction in stormwater volume may lead to the following savings:

- ***Reduction in water treatment costs.*** Stormwater does not require the same treatment as sanitary sewage. The two are mixed in combined systems, resulting in the treatment of a larger volume of water than necessary.
- ***Reduction in upgrade/maintenance cost of existing grey infrastructure.*** While some routine maintenance is time-dependent rather than volume-dependent, larger volumes of water wear more heavily on systems. Reducing treated volume will reduce maintenance costs. Also, costly expansion of treatment facilities may be delayed or avoided with efficient stormwater management.
- ***Avoidance of stream channel restoration.*** Increased runoff affects the natural hydrologic system by increasing the volume and duration of peak flow events, and reducing base flow (Molloy, 2009). These volume extremes alter stream morphology and often result in severe erosion of the streambanks. Streambank erosion harms riparian landowners' land and also discharges additional materials into the streams, harming fish habitat. Restoring streambanks can be a significant and ongoing expense; using GI to avoid the problem may be cheaper and more effective.
- ***Reduction in costs associated with treating/repairing roads.*** Water is a very effective destructive force. When water gets into the pore spaces of asphalt and freezes, this causes cracks and weaknesses in the road. Storm runoff in combination with freeze-thaw events contributes to the formation of potholes, a perennial expense to roads departments.

Effects on real estate

The Wharton School at the University of Pennsylvania is conducting a multi-year study of over 200,000 home sales to determine the effect of various factors on real estate prices. A pilot study looking at the New Kensington neighborhood (Wachter, 2005) returned the following findings:

1. New tree plantings on the sidewalk increase house price by 9% or more.
2. Properties increase in value by 30% when adjacent vacant lots are "cleaned and greened."
3. Houses located within one-quarter mile of a park are valued 10% higher.

Reduction in pollutants associated with stormwater runoff may also lead to:

- ***Lower drinking water treatment costs.*** Ninety-seven percent of the municipally-supplied customers in Region VI are sourced from surface water such as rivers and reservoirs (USGS, 2005). Keeping pollutants out of the water by infiltrating and thus filtering stormwater runoff may reduce water treatment costs.
- ***Avoidance of pollution cleanup.*** Water pollution can be unsightly and unhealthy. Keeping pollutants out of the waterways by addressing stormwater runoff reduces the need for clean-up efforts downstream, and is likely easier than removing the pollution once it enters streams.

GI generally leads to:

- ***Increased real estate value and property tax revenue.*** Residents tend to be willing to pay more for property situated near greenspace (USEPA, 2007). Increased property values associated with GI and LID result in more tax revenues for municipalities.
- ***Reduced energy costs.*** Some GI techniques directly affect energy costs. Green roofs and walls provide extra insulation to buildings, reducing heating costs in winter and cooling costs in summer.

Urban trees and greenspaces have an indirect effect on energy costs by lessening the urban heat-island effect.

- ***Increased commercial district revenue.*** Research has shown that consumers rate amenities, maintenance, merchant interactions, and product quality higher in shopping districts with trees than in those without. Furthermore, consumers are willing to travel farther, shop longer and more frequently, and pay more for parking in the presence of trees (Wolf, 2005).
- ***Increased development potential.***GI often requires less land than grey stormwater management techniques, leaving more area for development or other uses.

2.3.3 *Other side benefits*

- ***Increased recreational opportunities and use.*** Greenspace, including pocket parks, provides a place for community gatherings and recreation. Street trees and other sidewalk landscaping shade sidewalks and provide a buffer from busy streets, encouraging walking.
- ***Reduced downstream flooding.*** Allowing stormwater to infiltrate and evapotranspire helps to approximate the natural system, as discussed above. This reduction of runoff extends the time between storm events and peak flows in streams, and reduces peak flow volumes. This results in less severe and less frequent floods.
- ***Improved urban aesthetics and community livability.*** Several studies have shown that people prefer working and shopping in areas with trees and other planned landscaping (Wolf, 2005). Using vegetated strips to separate streets from sidewalks helps increase pedestrian traffic by providing shade and a sense of increased safety.
- ***Improved human health and wellness.*** Studies have shown that greenspace contributes positively to human health (CUH, 2000; Tzoulas et al., 2007). Natural landscapes have been found to lower stress levels in drivers, whereas strip malls slow recovery from stressful situations (CUH, 2000). People benefit from the recreational opportunities afforded by greenspace, the improved air quality, and the reduced heat island effect. Furthermore, reports from parents suggest that "attention deficit symptoms" are less severe when children's play areas include more greenspace (Tzoulas, et al., 2007).
- ***Urban heat island mitigation.*** The shade and evaporative cooling associated with trees and other vegetation serve to cool the surrounding air in the summer. The added moisture in the soil and air moderate winter temperatures as well. With fewer trees, additional dark asphalt surfaces absorb the summer sun, radiating it in the evening hours, contributing to the urban heat island effect.
- ***Decreased salt and sand on roads.*** Reducing sheet-flow over streets leads to less ice formation on the roadways. This allows for reduced application of sand and salt, saving money on materials and labor, and reducing the levels of these pollutants in streams.
- ***Noise reduction.*** The added insulation of green roofs and walls serves to reduce noise transmission into buildings (Lagström, 2004).
- ***Improved air quality.*** Trees and plants improve air quality. Trees take up nitrogen dioxide, carbon monoxide, ozone, and particulate matter from the air (USFS, 2005). Both trees and green roofs can improve air quality indirectly by providing energy savings, thus reducing power plant emissions.

Jobs: A side benefit of public transit investments

Public transportation is not normally considered a GI technique; however, transit options can help minimize the need for parking spaces and wider roads, thereby increasing stormwater infiltration.

A 2009 analysis of the first 10 months of the effects of the American Reinvestment and Recovery Act (ARRA) found benefits of investing in public transportation: 1.6 to 2.5 times more jobs were created for every ARRA dollar invested in public transportation than a dollar invested in the highway system (CNT et al., 2009). Furthermore, growing public transportation will create more long-term jobs.

- ***Increased carbon sequestration.*** Plants and trees absorb and use carbon dioxide, removing it from the atmosphere where it contributes to global climate change (IPCC, 2005).
- ***Moderation of climate change impacts.*** As climate change progresses, both temperature and precipitation are projected to increase in West Virginia (IPCC, 2005). Storms are expected to be more intense, resulting in more frequent flooding and consequent changes to stream morphology. Using GI to reduce runoff will help moderate these flood events.
- ***Additional wildlife habitat.*** Adding greenspace, even in pockets, provides refuge to small wildlife including birds, butterflies, and squirrels.

3. STREAM IMPACTS

GI techniques reduce the quantity of stormwater runoff, while improving water quality (Estornell, 2009). Decreasing overland flow by increasing infiltration helps restore the pre-development hydrology of an area, resulting in reduced frequency and intensity of floods, and reduced sediment and pollutant loads to streams. Infiltration also contributes significantly to the recharge of local and regional aquifers. Although much of the stormwater will still eventually reach the streams, the natural retention properties of soils and vegetation increase travel time and filter pollutants from the runoff.

3.1 Stormwater pollutants

There are a number of pollutants associated with stormwater runoff in developed areas. Some of these create conditions that are harmful to aquatic plants and animals, others threaten human health, and a few are simply unsightly.

Fecal coliform. The presence of fecal coliform bacteria is an indication that water has been contaminated by human or animal waste. High concentrations of fecal coliform are associated with the presence of viruses and other pathogens in the water that may cause human disease. Waters that contain concentrations above state standards are not suitable for human recreation. In urban areas, animal waste is introduced to streams through stormwater runoff; human waste through combined sewer systems and failing onsite septic systems.

Sediment. Excess sediment is carried to streams in stormwater runoff, particularly from construction sites where the earth is often exposed without vegetation to hold soils in place. Sediment is also added to streams in times of high flow as the stream cuts away its banks. Suspended sediment gives water a cloudy appearance, blocks needed sunlight from aquatic plants, and interferes with gill function in fish (StormwaterAuthority, undated). Sediment in streams will eventually settle out, and can bury fish and insect habitat and change the shape of streams.

Temperature. Trout and other aquatic species are sensitive to high water temperatures. Particularly in brief, intense summer storms, when large volumes of runoff from hot roofs and asphalt are forced through pipes in a short path to streams, temperatures in streams can rise (Herb et al., 2008).

Nitrogen and phosphorous. Excess nutrients such as nitrogen and phosphorous cause algal blooms in natural waters (Boesch et al., 2001). These sudden growths of algae deplete oxygen and cloud the water, harming various forms of aquatic life (Boesch, et al., 2001).Both are associated with decaying vegetation, fertilizers, and animal waste (StormwaterAuthority, undated).

Oil and grease. Runoff from streets, driveways, parking lots, and gas stations carries automotive fluids including motor oil to streams. Along with kitchen waste grease, which may enter the system through CSOs, these fluids can form a film over surface waters, inhibiting oxygen transfer and creating a toxic environment for aquatic life (StormwaterAuthority, undated).

Litter. Carelessly discarded trash is often swept through storm drains into local streams and rivers. In addition to degrading the visual quality of the water, toxins released as the litter breaks down can be harmful to aquatic species.

Salt. Deicers and fertilizers commonly contain salt. High levels of salt in streams can harm aquatic life and contribute to water treatment costs.

These pollutants are summarized in Table 3 along with common sources and potential impacts.

Table 3: Common stormwater pollutants

Pollutant/impairment	Sources	Impact
Fecal coliform	Combined sewer overflows, failing onsite septic systems, pet waste	Threatens human health
Sediment	Construction sites, eroding streambanks	Harms aquatic life
High temperature	Storm drains, both combined and separate	Harms aquatic life
Nitrogen and phosphorous	Grass clippings, treated wastewater, fertilizer, animal waste	Promotes algal blooms
Oil and grease	Parking lots, roads, industrial areas, kitchen waste through combined sewer overflows	Contaminates drinking water; harms aquatic life
Litter	Intentional and accidental littering	Degrades aesthetics; harms aquatic life

Source:StormwaterAuthority (undated).

3.2 Current status of Region VI surface waters

Region VI primarily drains to the Monongahela River, except for Doddridge County, which drains to the Ohio River through the Little Muskingum and Little Kanawha Rivers. The major streams and watersheds of Region VI are shown in Figure 3.

Following the federal Clean Water Act, every two years each state must compile a list of streams that do not meet water quality standards. This report of impaired streams is referred to as the 303(d) list. Total maximum daily loads (TMDLs) are then developed for the impaired streams, providing prescriptions for pollutant load reductions from categories of point- and nonpoint-sources throughout the watershed. In general, point sources such as wastewater treatment plants discharge pollutants through pipes or other discrete conveyances. In contrast, nonpoint sources such as farms typically discharge pollutants from land surfaces when it rains.

Appendix A shows impaired Region VI streams, including those appearing on West Virginia’s 2008 303(d) list,[2] and those for which a TMDL has been written. A summary of impairments found in Region VI is presented in Table 4.

[2] West Virginia’s 2010 303(d) list has not been finalized yet; therefore, we use the 2008 list for this report.

Figure 3: Region VI rivers and watersheds

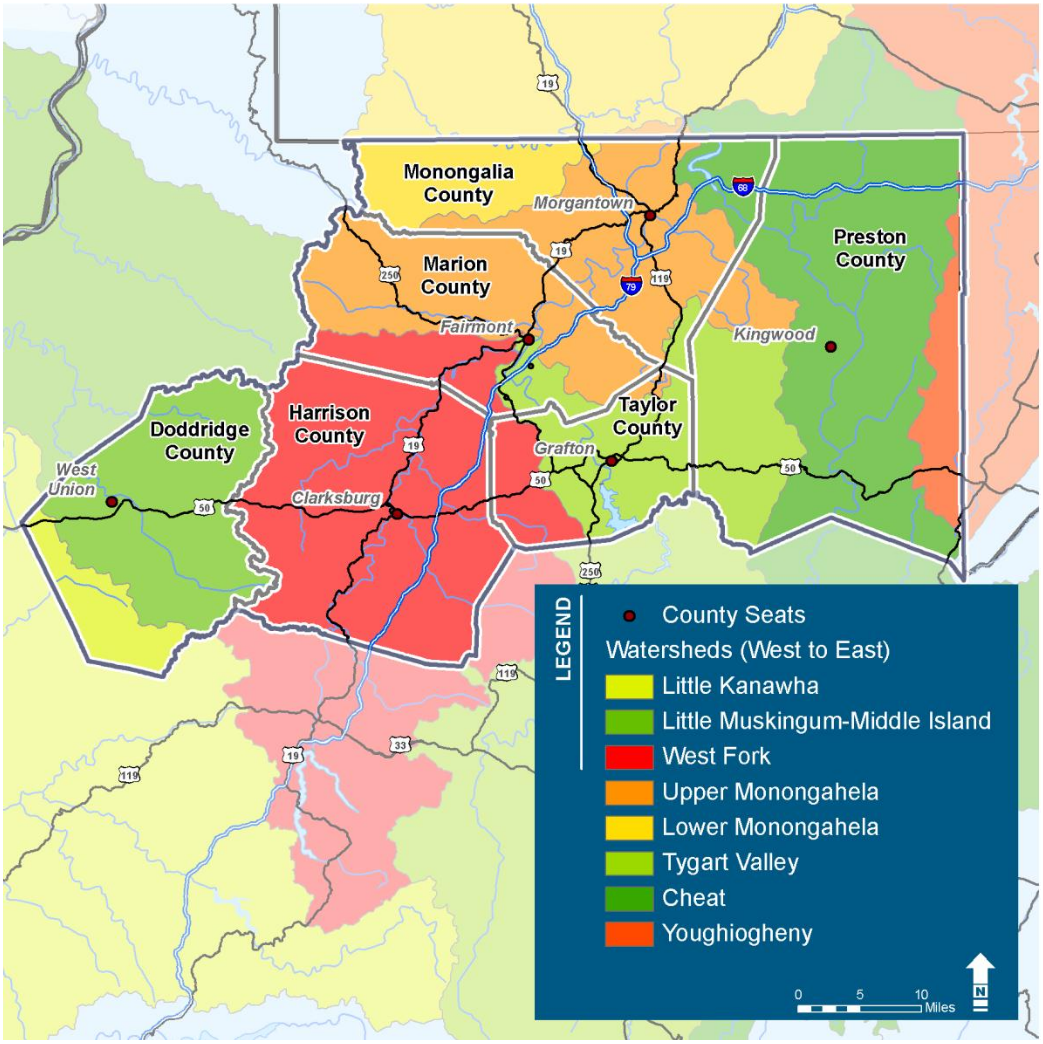


Table 4: Region VI stream impairments

Impairment	Streams affected
Iron	207
Condition not allowable-biological	196
Manganese	175
Fecal coliform	67
Aluminum	53
Chloride	3
Polychlorinated biphenyls (PCBs)	3
Zinc	2
Lead	1
Mercury	1

Source: WVDEP (2008).

Most of the watersheds in Region VI are included in approved TMDL reports (Table 5); however, several of these were done early in the TMDL program and are scheduled to be revised in the next few years. This is the case for the West Fork, Cheat, Little Kanawha, and Monongahela River watersheds (WVDEP, 2009d). The most recent Region VI TMDLs were approved in 2009; these include the Dunkard Creek and Youghiogheny River watersheds.

Table 5: Region VI total maximum daily loads

Watershed	Impairments	Allocations	TMDL year
Cheat	pH, metals	Mine drainage	2001
Dunkard (selected streams)	Fecal coliform, metals, CNA-biological	Failing onsite systems, straight pipes, agricultural and residential runoff, roads, oil and gas operations, streambank erosion, mining activities, stormwater from construction and industrial facilities	2009
Tygart Valley	pH, metals	AMLs, revoked mines	2001
Little Kanawha (Steer Creek, South Fork of Hughes River, Goose Creek, Tanner Creek, Leading Creek)	Fecal coliform, pH, metals, Pb, CNA-biological	AMLs, forestry, oil and gas operations, roads, agricultural runoff, stream bank erosion, onsite septic, stormwater runoff	2000
Little Kanawha (selected streams)	Fecal coliform, metals, sediment	AMLs, forestry, oil and gas operations, roads, agricultural runoff, stream bank erosion, onsite septic, stormwater runoff	2000, 2008
Monongahela River	pH, metals	AMLs, revoked permitted facilities	2002
Unnamed tributary of the Monongahela at Sharon Steel	Metals	Sharon Steel	2001
West Fork	pH, metals	AMLs, revoked permitted facilities	2002
Youghiogheny	Fecal coliform, pH, metals, CNA-biological	Failing onsite systems, straight pipes, agricultural and residential runoff, AMLs, roads, oil and gas operations, timbering, streambank erosion, stormwater from construction and industrial facilities	2009

Source: WVDEP (2008). Pb=lead. PCBs=polychlorinated biphenyls. CNA=condition not allowable. AML=abandoned mine land.

As illustrated in Table 5, there are many causes of stream impairments across Region VI, including coal mines, oil and gas operations, forestry, failing onsite wastewater systems, and industrial plants. However, some TMDLs specifically target stormwater. In addition, whether or not stormwater sources are explicitly targeted for pollutant reductions in TMDLs, many of the impairments in Table 4 can be associated with stormwater pollution.

4. GREEN INFRASTRUCTURE IN THE UNITED STATES

The degree of stormwater volume and pollutant reduction achieved by GI practices may vary based on design, precipitation patterns, slope, and other factors. However, GI has been successfully implemented throughout a variety of climates and terrains in US cities of various sizes. As discussed in Section 2.1, GI can be roughly divided into four general strategies: capture and use, infiltration, evapotranspiration, and managed conveyance. This section describes GI techniques and their strategies, and offers examples of these techniques from across the country.

4.1 Downspout disconnection

Downspouts route stormwater directly from roofs into sewer systems. Disconnecting downspouts reduces the total amount of impervious surface that feeds into a community's grey infrastructure. A single disconnected downspout can keep thousands of gallons of water annually out of the CSO or stormwater system. While caution must be used not to disconnect downspouts at sites with steep slopes or high water tables (Seattle Public Utilities, 2009), downspout disconnection programs have been successful at reducing CSO events in many communities, including Seattle; Portland, Oregon; Chicago; and Pittsburgh (NRDC, 2006).

Figure 4: Downspout disconnection

Photo: City of Seattle.

The City of Portland, Oregon has been promoting downspout disconnection since 1995. Some areas are excluded from the program due to unsuitable site characteristics such as steep slopes and low-permeability soils; eligible property owners, however, are reimbursed up to $53 per downspout if they choose to perform the disconnection. To date, the city has registered over 50,000 downspout disconnections, eliminating an estimated 1.2 billion gallons of stormwater from the combined sewer system annually (Portland BES, 2009).

Disconnecting downspouts results in reduced sewer system maintenance and upgrade costs and may also reduce basement flooding resulting from sewer backups. Additionally, if the runoff is captured and used for landscaping or other non-potable uses, consumers can save money in utility costs.

4.2 Rain barrels and cisterns

These storage systems are often connected to downspouts to harvest runoff from roofs. Collecting and reusing runoff from roofs can result in substantial savings for property owners and stormwater management departments alike. Nearly 80% of domestic water use is for landscaping or indoor non-potable use including flushing toilets and washing clothes (USEPA, 2008b). Runoff from a 40 foot by 30 foot roof will generate 75 gallons of water for every 0.1 inch of rainfall. Capturing and reusing runoff can keep thousands of gallons of water out of the sewer system while saving money on water use.

Figure 5: Rain barrels and cisterns

Photos: USEPA.

A closed department store building in Columbus, Ohio has been renovated to Leadership in Energy and Environmental Design (LEED) Gold standards.[3] Included in the renovations is a pair of cisterns—one on the roof and one in the basement—to collect rainwater for reuse in the building's toilets, landscaping, and heating and cooling systems (USEPA, 2008b).

Closer to West Virginia, calculations conducted as part of the Nine Mile Run rain barrel initiative in Pittsburgh suggest that a 40% participation rate amongst residences in the watershed would reduce CSO volume by 11% annually. If 40% of businesses were also to install rain barrels, this reduction would increase to 16% (3 Rivers Wet Weather, 2005). To date, approximately 1,270 132-gallon barrels have been installed in the watershed. Although this is still far short of the 10,800-barrel goal, a 40% participation rate has been achieved in one sewer sub-basin and flows in that sub-basin are currently being monitored to determine if the rain barrels will have the calculated effect (Brown, 2009).

[3] LEED is a rating system administered by the non-profit United States Green Building Council to recognize buildings that meet requirements in the categories of "energy savings, water efficiency, carbon dioxide emissions reduction, indoor environmental quality, and stewardship of resources and sensitivity to their impacts" (USGBC, 2009).

4.3 Rain gardens

Rain gardens, also known as bioretention cells, are a more decorative means of increasing infiltration. They often use engineered soils and carefully chosen plants to infiltrate up to 30% more rainfall than typical turf lawns (WDNR, 2003).

Figure 6: Rain Garden at Habitat for Humanity in Charleston, West Virginia

Photo: Sherry Wilkins.

Burnsville, Minnesota, a suburb of Minneapolis-St. Paul with a population of approximately 60,000 (US Census Bureau, 2009), has installed a series of rain gardens in two similar watersheds in order to study their potential efficacy in reducing phosphorous and high stormwater volumes to a nearby lake (Barr Engineering Company, 2006). In one watershed, approximately 80% of residents agreed to participate, resulting in the installation of 17 road-side rain gardens with curb cut-outs to accept runoff from the streets; the other watershed remained traditional curb and gutter. The study found a 90% reduction in runoff in the neighborhood with the rain gardens (Barr Engineering Company, 2006).

The right plant choices can attract butterflies, birds, and other desirable wildlife. The gardens are also good neighborhood beautification projects, with volunteer maintenance serving to build community involvement.

4.4 Bioswales

Vegetated conveyances called bioswales help filter contaminants from stormwater runoff, and may also allow for biological uptake of pollutants (USEPA, 2007). Other strategies for GI conveyance include terraces and sinuous or rough-bottomed channels. Bioswales are not retention facilities; they are designed to infiltrate or drain within 12 to 24 hours.

Bioswales differ from traditional vegetated stormwater conveyance by utilizing plants and engineered soils that are specially chosen to increase infiltration and filter pollutants from the runoff. Bioswales are widely used in parking lots and along roadways.

Photo: USEPA.

4.5 Terraced planter systems

Terracing steep slopes allows for the management of stormwater runoff by slowing or preventing it. The upper-most terrace will detain stormwater until it reaches capacity; additional runoff will overflow to the next level below. This system slows stormwater runoff and allows for ground infiltration and plant uptake.

Terraced rain gardens at the Sidwell Friends School in Washington, DC offer stormwater control, while providing wildlife habitat in the middle of an urban campus. Students, faculty, and staff have reported seeing Snowy Owls, Monarch Butterflies, and baby American Robins, among other wildlife in various places around campus (Sidwell Friends School, 2010).

Figure 7: Terraced rain gardens at the Sidwell Friends School, Washington DC

Photo: USEPA.

4.6 Green roofs

Green roofs and green walls are separated from the ground surface and incorporate an impermeable lining in order to protect the building from leaks. Thus, much of the water captured by a green roof evaporates or transpires through plants. Even when larger storm events exceed the retention capacity of green roofs, studies have shown that runoff to storm drains is reduced in volume and delayed for up to three hours (Templeton, 2009), allowing local sewer systems and streams to recover from the initial storm surge before processing the runoff.

> **Ecoroofs in Portland, Oregon**
>
> The city of Portland has taken several steps to encourage the spread of ecoroofs. In addition to offering development incentives, the city sponsors free workshops for the general public. Workshops cover topics including plant selection, design, operations and maintenance, cost considerations, permitting, and construction. In addition, the city stormwater Web site includes a fact sheet, plant list, ecoroof monitoring data, and a list of local professionals who provide services related to ecoroofs. (Portland BES, 2010)

In 2005, five green roofs of varying designs were installed around Seattle. A consulting firm has been monitoring the effectiveness of the roofs, with particular attention to varying weather conditions. For the eighteen months of data reported, the study found cumulative volume reductions of 65%-94% (MKA, 2007). In November 2006, the wettest month on record in the city, volume reductions were 47%-99%, with peak flows from the worst storm being reduced 6%-79% (MKA, 2007). Soil moisture data were also collected in order to evaluate the relative effectiveness of different soil types and thicknesses. On average, across the US, green roofs reduce runoff by about 75% over conventional roof surfaces (USDOE, 2004).

Green roofs in Allegheny County, Pennsylvania provide effectiveness data for weather conditions similar to those found in Region VI. In 2010, a green roof was installed on the county office building, along with a suite of monitoring equipment (Barcousky, 2010). The county will monitor both the green and conventional sides of the roof in order to provide the public with more information on the benefits of green roofs. The University of Pittsburgh has also analyzed green roof systems around the city (Templeton, 2009).

In addition to stormwater management, green roofs are also highly effective at moderating temperatures, resulting in energy savings and longer roof-life. The National Research Council of Canada has constructed a divided roof in an attempt to quantify these benefits. Half of the 800 square foot surface is roofed with an extensive green roof, while the other half uses a more conventional bituminous material. On a typical summer day, the conventional roof reached a temperature of 158°F, while the green roof remained around 77°F. Temperature variation was also significantly less on the green roof: a median daily variation of 11°F versus 81°F for the conventional roof. While snow cover acted to insulate both roof surfaces in the winter, reducing the advantage of the green roof, summertime observations showed a 95% reduction in heat gain through the green roof as compared with the conventional roof (Liu and Baskaran, 2003).

4.7 Green walls

Because of their vertical orientation, green walls tend not to have the same water retention capacity as green roofs. However, they can be designed to accept roof runoff. They also provide the aesthetic and health benefits of plants in dense cities where horizontal real estate is at a premium.

In September 2009, PNC Financial Services Group headquarters in Pittsburgh installed the largest green wall in the US—covering 2,380 square feet of the building's south wall (Tascarella, 2009). The wall is comprised of over 15,000 plants, contained in 602 two-foot by two-foot panels, making up a 6-story living sculpture that will bloom in spring (Lombardi, 2009; Nephin, 2009). Initial calculations suggest that the temperature in the offices behind the wall will be 25% cooler than those behind the remaining original granite portions of the wall, reducing energy costs (Nephin, 2009).

Figure 8: Green wall in Pittsburgh

Photo: Anne Hereford.

4.8 Urban trees

The tree canopy catches some precipitation as it falls, a first step in reducing stormwater runoff. Even if stormwater planters for street trees, shrubs, or wildflowers are disconnected from the natural soil, runoff directed into the planters will be taken up by the plants and released into the atmosphere.

Preserving existing trees is a low-cost way to achieve stormwater- and side benefits. In addition to air quality benefits, trees provide shade and release moisture, reducing the urban heat-island effect and providing energy savings. A common concern of streetside trees is the damage caused to hardscapes by tree roots. These concerns are being addressed through more careful assessment of soil volume requirements and by new technologies that support heavy loads while making larger volumes of soil available to the trees.

A study of urban tree cover in the Washington, DC area found that tree canopy cover decreased from 51% to 37% between 1973 and 1997, increasing runoff by an estimated 19% and reducing pollutant uptake by 9.3 million tons annually. The same study calculated that managing this amount of increased runoff would cost the region an estimated $1.08 billion in infrastructure upgrades and that the increased air pollution came at a cost of $24 million per year (USFS, 2005).

In a separate study, public trees in Boulder, Colorado were counted and benefits and maintenance costs quantified. The city's Urban Forestry Division is responsible for 25,281 street trees and 10,221 park trees—0.34 public trees per capita. Each tree was calculated to contribute $15 in stormwater management savings and $5 in electricity savings annually. Considering these benefits, along with property value increases and air pollution reduction, Boulder reaps $3.64 in benefits for every $1 spent on tree care (CUFR, 2005).

In Maryland, the Potomac Conservancy has worked with Frederick County public schools to assess tree canopy cover and work to increase tree cover (Montgomery, 2009). The US Forest Service (USFS) provided in-kind assistance to complete a land cover assessment for the system's 62 schools. The Conservancy then took these data to the facilities division of the school system along with information about the financial, educational, health, and wellness benefits more trees could provide. Together, the Conservancy and school system came up with a goal of increasing tree cover on school property from the USFS estimated value of 12% to 20% by 2038 (Montgomery, 2009). The project is involving interested teachers, and is engaging students to learn about the benefits and participate in the planting of the new trees.

4.9 Traffic islands, curb extensions, and sidewalk landscaping

Curb extensions on a residential street in Portland, Oregon were installed in just two weeks at a cost of approximately $15,000 (Molloy, 2009). The vegetated areas capture runoff from 10,000 square feet of impervious surface, retaining virtually all runoff from small storms and up to 85% from 25-year storms[4] (ASLA, 2007). The curb extensions have the added benefits of slowing traffic on the residential street, reducing or eliminating local basement flooding, and adding aesthetic appeal (ASLA, 2007).

[4] Storm intensity is often discussed in terms of frequency. Small storms are not unusual, but larger events tend to occur less frequently. A 25-year storm is one that is so large that, on average, it will occur only once every 25 years.

Photo: USEPA.

4.10 Pervious pavement

Pervious pavement has been available for decades, but is now gaining in popularity as a stormwater control measure. Porous asphalt and concrete are poured over "an aggregate base…which provides structural support, runoff storage, and pollutant removal through filtering and adsorption" (USEPA, 2008a, p 5). Studies at the University of New Hampshire have documented very high efficacy in porous asphalt installations. In order to compare porous asphalt with conventional asphalt, adjacent parking lots were constructed in 2004. Extensive studies have demonstrated that the material can reduce peak runoff by an average of 68% while offering better traction when wet than conventional asphalt and requiring less than one-quarter as much salt in the winter for deicing (UNHSC, undated; 2008). Less freezing also means that the porous surface is less likely to heave and crack, reducing maintenance costs (UNHSC, 2008). All of the infiltrated stormwater from the test lot is stored in a reservoir beneath the lot and allowed to percolate slowly into the earth below (UNHSC, 2008).

Porous asphalt and concrete are ideal for parking lots, low-traffic streets, and basketball courts. Other pervious pavement technologies include interlocking pavers and plastic grid paving. Both of these can be planted with grass or filled with gravel to promote infiltration. These technologies can be used for parking lots, sidewalks, and driveways.

Pervious pavement recommendations

1. Soil permeability between 0.25 to 3.0 inches per hour.
2. Drainage time of 24 to 48 hours.
3. To minimize frost damage, use sub-drains where proper drainage may be an issue.
4. Most appropriate for use with parking lots, low-use roadways, and sidewalks.
5. Necessary 3 to 5 feet of vertical separation from seasonal high groundwater (UNHSC, 2008a).

The City of Chicago has taken a GI approach to managing their approximately 3,500 acres of alleys (CDOT, undated). The program is using permeable pavers and porous concrete containing recycled aggregate and ground rubber tires to address stormwater runoff (CDOT, undated). The concrete used in the project is more reflective than traditional pavement, reducing the amount of heat absorbed from the sun and helping to cool the city in the summer (CDOT, undated). By the end of 2007, the city had completed 46 alley retrofits, saying that in light of the benefits, all future alley refurbishing in Chicago will use similar GI designs (Saulny, 2007).

Chicago's "pilot alley" for their green alleys program retains the volume of a 3-inch, 1-hour storm event (Molloy, 2009).

Figure 9: Examples of pervious pavement

Photo: Sherry Wilkins.

Photo: New Columbia Pictures.

5. GREEN INFRASTRUCTURE IN WEST VIRGINIA AND REGION VI

There are several examples of GI projects throughout West Virginia, including some in Region VI. These projects include rain gardens, rain barrels, green roofs, and bioswales. Projects have been implemented by non-profit organizations, universities, and city groups. We have listed all known GI projects relevant to this report at time of printing, regardless of whether they serve as models for future projects. We suggest that interested readers contact references listed for each project to learn more about realized successes and suggested improvements on each project.

While not specifically designed as GI, many existing beautification projects around Region VI are contributing to stormwater reduction. These include pocket parks, flower baskets, street islands and triangles, butterfly gardens, planter boxes, and tree replacement and restoration projects among others (Leroy, 2009; Maupin, 2009a). Additionally, there are at least 54 municipal park facilities in the region's five MS4 communities.

5.1 Downspout disconnection

Downspout disconnection in Region VI's 14 CSO communities could prove to be a cost-effective way to help reduce CSO events. In cases where slopes are steep or infiltration capacity is low, however, it is often necessary to use downspout disconnection in concert with storage systems such as rain barrels or terraced planter systems (USEPA, 2009e). These techniques could prove useful in Region VI, where steep slopes in developed areas are common. Where steep slopes are not a factor, adding permeable pavement or rain gardens may be sufficient to accommodate roof runoff.

Downspout disconnection is occurring in conjunction with the installation of rain barrels and some rain gardens as discussed in Sections 5.2 and 5.3.

5.2 Rain barrels and cisterns

In West Virginia, WVDEP supports the collection and storage of rainwater to use for watering lawns and gardens by providing education as to how to build and install a rain barrel.

- **Visit:** www.dep.wv.gov/insidedep/Documents/instructions%20parts.pdf

In Raleigh County, Piney Creek Watershed Association (PCWA) is fulfilling its mission—to improve and protect the water resources within the Piney Creek watershed through education and service—by providing rain barrel workshops, construction, and sales. They are currently working on a "Somewhere over the Rain Barrel" program, which partners with local artists to design and create artistic renderings on rain barrels for auction as a fundraiser for the watershed group.

- **Contact:** PCWA, pineycreekwatershedassociation@gmail.com
- **Visit:** www.pineycreekwatershed.org

In Region VI, Friends of Deckers Creek (FODC) youth volunteers have converted and sold over 60 rain barrels since winter 2008 (Veselka, 2009). Reusing barrels donated from the Monongalia County Solid Waste Authority, the project serves as a fundraiser for the watershed group, but also helps reduce runoff volumes to 303(d)-listed Deckers Creek and other area streams.

- **Contact:** FODC, 304-292-3970, info@deckerscreek.org
- **Visit:** www.deckerscreek.org

Figure 10: Friends of Deckers Creek making rain barrels to sell as a fundraiser

Photo: FODC.

5.3 Rain gardens

WVDEP installed a rain garden at its headquarters in Charleston. The rain garden soil is 50% sand and planted with drought-tolerant plants. It has 12 inches of walnut-sized gravel, 6 inches of pea gravel, and an underdrain/outlet pipe because the surrounding soil was clay.

- **Contact:** WVDEP, Sherry Wilkins, Sherry.L.Wilkins@wv.gov

Figure 11: Rain garden at West Virginia Department of Environmental Protection headquarters

Photo: Evan Hansen.

PCWA partnered with Beckley Sanitary Board, Appalachian Farming System Research Laboratory, and New River Master Gardeners to construct a demonstration rain garden at the Exhibition Coal Mine in Beckley. This rain garden controls stormwater runoff and filters pollutants. According to the watershed association, this rain garden was the second built in the state. PCWA obtained funding for the rain garden through state grants and support of the Beckley Area Foundation. Laboratory researchers helped specify the soil medium, and plan to research the garden. New River Master Gardeners and PCWA volunteers planted the space with native plants.

- **Contact:** PCWA, pineycreekwatershedassociation@gmail.com
- **Visit:** www.pineycreekwatershed.com

At WVU in Morgantown, a rain garden was installed to help retain and filter runoff from a parking lot at the Evansdale campus.

- **Contact:** Clement Solomon, 304-293-7916, Clement.Solomon@mail.wvu.edu
- **Visit:** WVU Office of Sustainability, http://wecan.wvu.edu/

Figure 12: Rain garden at West Virginia University

Photo: Evan Hansen.

The Urban Landscape Commission in Morgantown used funds provided through tax increment financing (TIF) to install a rain garden near the Caperton Rail-Trail in the Wharf District along the Monongahela River. Downspouts from the recently constructed Upper Mon River Center feed into the garden. The Urban Landscape Commission has also begun planning for a pedestrian corridor in the Suncrest neighborhood (Maupin, 2009b).

- **Contact:** Marchetta Maupin, Morgantown Urban Landscape Commission, 304-284-7422

Figure 13: Rain garden at the Upper Mon River Center

Photo: Anne Hereford.

A rain garden in the Suncrest neighborhood was installed in 2009 through a joint effort by the West Run Watershed Association (WRWA), WVDEP, Morgantown Utility Board (MUB), and West Virginia Conservation Agency (WRWA, 2009). The garden collects runoff from the roof of the adjacent MUB facility with the goal of reducing flooding and educating the public about stormwater management. The project was accomplished with funding from WVDEP. Planned improvements to the garden include a walking path, benches, and educational signage (Cowles, 2009).

- **Contact:** WRWA, info@westrun.org

Figure 14: Building a rain garden in the Suncrest neighborhood

Photo: WRWA.

FODC has also installed a rain garden as part of an outdoor learning space along the Deckers Creek rail-trail in the Sabraton area of Morgantown (Veselka, 2009).

- **Contact:** Mary Luckini, 304-292-3970, mary@deckerscreek.org
- **Visit:** www.deckerscreek.org

Figure 15: Rain garden along the Deckers Creek Rail-Trail

Photo: FODC.

5.4 Bioswales

The West Virginia Division of Highways (WVDOH) has mitigated highway runoff by planting native vegetation. Since 1992, West Virginia Operation Wildflowers has planted over 200 acres of wildflowers on roadsides throughout the state. To encourage the preservation of natural stands of native wildflower vegetation along roadside corridors typically mowed, the West Virginia Garden Club partnered with WVDOH and WVDEP.

In the Sabraton area of Morgantown, the United States Department of Agriculture has recently moved into a new LEED-certified building. Included in the energy efficiency and water conservation measures are bioswales along the front and sides of the building that capture runoff from the parking lot. On one side of the building, the bioswales also receive water from roof downspouts.

Figure 16: Bioswale along United States Department of Agriculture building in Morgantown

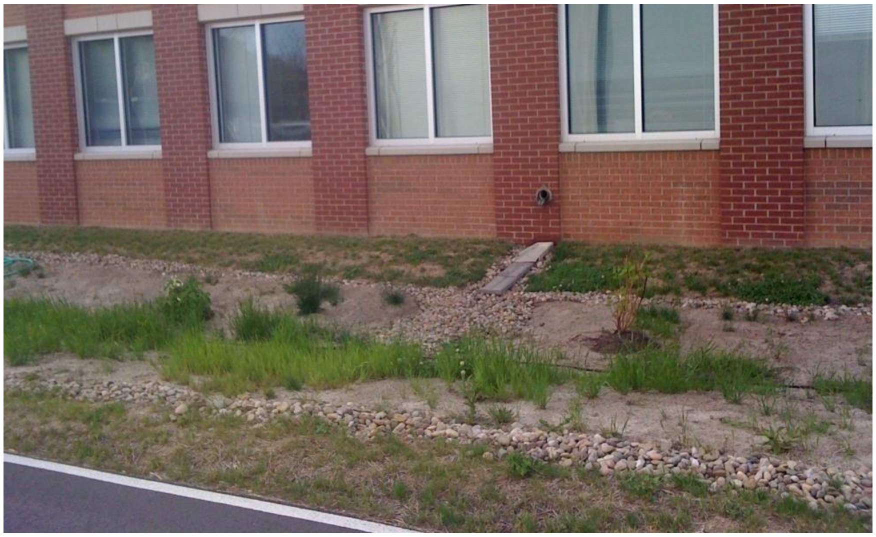


Photo: Anne Hereford.

A few known projects that incorporate this type of GI practice are planned in the Morgantown area. FODC plans to design and install a bioswale near the Deckers Creek Rail-Trail behind the Sabraton Kroger to catch stormwater runoff (Veselka, 2009). FODC is partnering with MUB, and hopes to partner with WVU Landscape Architecture students, to reduce the excessive flooding caused by development along the floodplain. In addition, street widening and beautification plans for Boyers Avenue in Star City include the use of bioswales (Konchesky, 2010).

5.5 Green roofs

Very few green roofs are known to exist in West Virginia, and even fewer in Region VI. Within West Virginia, a high school in Berkeley County installed 700 square feet of green roof in May 2009. With the support of two teachers as well as an alumnus in the green roof business, the Cacapon Institute helped students at Musselman High to install the green roof.

- **Contractor:** Emory Knolls Farm, www.greenroofplants.com
- **Contact:** Frank Rodgers, Director of Education & Outreach, Cacapon Institute, 304-856-1385
- **Visit:** www.cacaponinstitute.org/PHLOW/Green%20Roof/Green_Roof.htm

Also not in Region VI, CVI in Davis completed construction of its Research and Education Center in October 2009. This construction follows the completion of a 3,700 square foot Research Support Building. Both buildings are designed to blend with the existing landscape and are LEED-certified. A demonstration green roof on the Research and Education Center showcases CVI's sustainable building policy, and also offers an educational component to the building. While the roof is currently planted with sedum, CVI plans to experiment with native plants.

- **Contractor:** Manheim Corporation, Pittsburgh
- **Contractor:** J.F. Allen Company (access roadways and utility installations)
- **Contact:** Dan Wheeler, Operations, CVI, dan.wheeler@canaanvi.org
- **Contact:** Sarah Deacon, Educator, CVI, sarah.deacon@canaanvi.org

Figure 17: Demonstration green roof at Canaan Valley Institute

Photo: CVI.

A green roof was part of renovations to Brooks Hall, completed in 2007 on the WVU campus in Morgantown. The roof is 85% vegetated, and two years after completion, the construction manager reports that the roof is contributing to energy savings and effectively addressing site drainage issues (Offredo, 2009).

- **Contact:** WVU Office of Sustainability, 304-293-7916, Clement.Solomon@mail.wvu.edu
- **Visit:** www.as.wvu.edu/onlinemedia/archives/2007/June/brooks.html

Figure 18: Green roof on West Virginia University's Brooks Hall

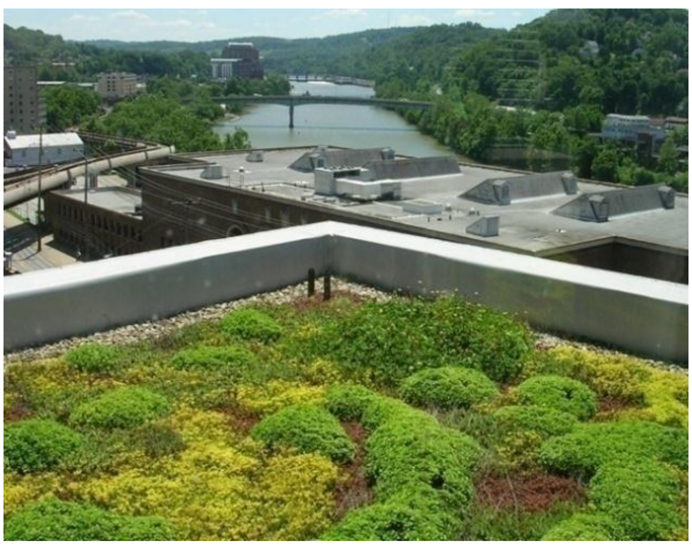


Photo: Sherry Wilkins.

Clarksburg is exploring the possibility of constructing a green roof on the city hall, or adding one to an existing brownfields revitalization project (Bedard Consulting, 2010; Bellotte and Howe, 2010).

5.6 Green walls

No green walls are known to exist in Region VI or West Virginia.

5.7 Urban trees

Urban forests form a significant part of the 54 municipal parks in Region VI MS4 communities. Trees exist in riparian buffer zones, on university and grade-school property, and in neighborhoods.

5.8 Traffic islands, curb extensions, and sidewalk landscaping

Clarksburg maintains several planter-boxes and landscaped hillsides and islands throughout the city. These areas are planted with shrubs, trees, and flowers (Leroy, 2009). Morgantown has similar projects, and also has constructed vegetated curb extensions on High Street through downtown. Street trees in Morgantown's South Park neighborhood and along High Street provide shade and offer buffers for pedestrians from traffic. Similar projects exist in other places around the city, and throughout Region VI.

Few if any of these planters are designed to collect stormwater from surrounding impervious surfaces, but minor modifications such as curb cutouts and slight re-grading of surfaces would allow for their transformation into GI planters.

5.9 Porous pavement

Although several streets and walkways throughout West Virginia are bricked without grout, allowing for some infiltration, the use of porous pavement with the intent of reducing stormwater runoff has been documented in only one location. When Milton Middle School in Cabell County moved to a new building in 2009, part of the parking lot was poured with porous concrete. Cabell County Schools had some hesitations about the material—the special maintenance necessary, and the effects of wintertime melt—but as of spring 2010, they are pleased with the performance of the surface, noting that the surface did not puddle and re-freeze in the winter the way traditional asphalt does (O'Dell, 2010).

- **Contact**: Mike O'Dell, Cabell County Schools, 304-528-5069
- **Engineer**: ZMM Architects and Engineers, Charleston, West Virginia
- **Contractor**: Hayzlett Construction, Putnam County

Figure 19: Porous pavement in Cabell County

Photos: Sherry Wilkins.

5.10 Level spreaders

These engineered structures spread out stormwater runoff and support the filtering action of riparian buffers. By reducing the velocity of the runoff, level spreaders prevent erosion and reduce sediment load into adjacent waterbodies. CVI installed level spreaders along with its access roadways and utilities.

- **Contractor:** designed by Parsons Brinkerhoff, built by J.F. Allen Corporation
- **Contact:** Dan Wheeler, Operations, CVI, dan.wheeler@canaanvi.org

Figure 20: Level spreaders during construction and storm events

Photos: CVI.

6. EXISTING POLICIES AND RULES ACROSS THE UNITED STATES

A range of policies and ordinances are used across the country to promote or mandate the use of GI. Incentives in the form of fee discounts, development incentives, rebates, grants, and award programs are ways to encourage voluntary use of GI, allowing communities to ease into this new way of thinking about stormwater management. MS4 permits and other regulations can also play a role in incentivizing or requiring the installation of GI practices. This chapter includes general strategies to promote GI as well as specific examples from communities around the country.

Green infrastructure in Pittsburgh

Several pilot projects have been funded by the city of Pittsburgh. In 2005, Pittsburgh boasted the most LEED-certified buildings in the US (O'Toole, 2009). In September 2009, the G-20 summit was held in the world's first LEED-certified convention center. Built in 2003, the David Lawrence Convention Center is still the country's largest certified green building (Young, 2009).

6.1 Fee discounts

Stormwater fees are often used to pay for the implementation of MS4 programs in urbanized areas. Because stormwater runoff is proportionally related to the amount of impervious surface, a fee based on impervious area is parallel to the conventional structure of other utility rates. A number of communities base stormwater fees on impervious area and onsite BMPs. Incentives may vary depending on the type of control measure being promoted. Examples of fee reduction strategies are presented in Table 6.

Table 6: Stormwater fee reduction strategies

Outcome promoted	Basis of fee reduction	Implementation measure
Reduce imperviousness	• Percent fee reduction • Per-square-foot credit	• Percent reduction in imperviousness • Square feet of pervious surfaces
Onsite management	• Percent fee reduction • Quantity and quality credits	• List of practices with associated credits • Total area (square feet) managed • Performance-based
Volume reduction	• Percent fee reduction • Quantity reduction credits	• Percent reduction in imperviousness • Performance-based • Total area (square feet) managed • Pre-assigned performance values
Use of specific practices	• Percent fee reduction • One-time credit	• List of practices with associated credits

Source: Modified from Table 1 in USEPA (2009b).

Innovative approaches to creating stormwater fees that reflect the volume of runoff generated by a site include the following:

- Denver: Impervious area is determined by aerial photography (USEPA, 2009b).
- Gainesville, Florida: The stormwater fee formula considers the use of conventional and permeable pavement and a credit is given for onsite retention systems (USEPA, 2009b).
- Gwinnett County, Georgia: There is a stormwater fee credit for stewardship, water quality, peak flow, and channel protection projects (USEPA, 2009b).
- New Brighton, Minnesota: There is a fee discount for having below-average stormwater runoff when compared to sites with the same land use. A separate fee discount is available for rain gardens meeting certain criteria. (New Brighton, undated)

- Charlotte, North Carolina: Stormwater fee credits are based on total volume reduction and on peak flow reduction (USEPA, 2009b).
- Columbus, Ohio: Reduced stormwater fees are offered in exchange for maintaining the public portion of the drain through one's property (USEPA, 2009b).
- Philadelphia: The stormwater fee is based 20% on gross area and 80% on impervious area (Abrams, 2009).
- Chattanooga, Tennessee: The city's stormwater fee, known as the "water quality fee," is based on total impervious area, but customers can receive up to 85% discounts by providing water quality education, constructing or maintaining stream buffers, using rain barrels or cisterns, and implementation of various other approved practices (City of Chattanooga, 2010).

6.2 Development incentives

Many municipalities have provisions for reducing stormwater runoff by offering streamlined permitting. For example, Chicago, Indianapolis, Philadelphia, and Sarasota County, Florida each maintain a list of green practices that, if included in a development plan, result in expedited permit review (Abrams, 2009; City of Indianapolis, 2009; USEPA, 2009b).

Phoenix, Arizona incentivizes infill housing development by waiving certain fees and considering cost-share agreements for nearby off-site improvements and blight control (City of Phoenix, 2006).

Other local governments have elected to loosen zoning restrictions for developers that integrate GI into their design. Portland, Oregon allows up to an additional three square feet of floor area for each square foot of installed ecoroof (USEPA, 2009b). Seattle offers similar floor area bonuses as well as height bonuses for buildings meeting LEED Silver or higher requirements (USEPA, 2009b). Other strategies include awarding points for various GI techniques that can then be "traded" for reduced lot size, alternative road standards, or increased density (Redmond City Council, 2009).

A third way to incentivize GI development is through tax credits. New York City and Philadelphia both offer up to $100,000 in one-time tax credits for the installation of green roofs. New York offers $4.50/square foot; the Philadelphia credit is for 25% of incurred costs (USEPA, 2009b). Tax incentives can also be used to encourage other forms of GI including broad initiatives such as infill development and redevelopment.

6.3 Rebates and installation financing

Portland, Oregon incentivizes different practices in different geographical areas. This allows the city to target areas according to their water usage and neighborhood characteristics and also to test the incentives' efficacy at a small scale (USEPA, 2009b). In Portland, and around the country, rebates are available for downspout disconnection, tree planting, rain gardens, rain barrels, cisterns, bioswales, permeable pavement or pavers, and green roofs (USEPA, 2009b).

A unique installation financing program was recently conducted by USEPA in a Cincinnati, Ohio watershed. This pilot study conducted a sealed-bid auction in which residents indicated if they would like to receive free rain barrels or rain gardens, and if so, how much monetary compensation they would require in exchange. A cost-benefit analysis was then performed, considering the bid amounts, GI costs, and potential reduction in stormwater volume based on site characteristics—impervious area, downspout connectivity, soils, and proximity to the nearest stream. In 2007 and 2008, the program installed 85 rain gardens and 174 rain barrels, with approximately 30% of eligible properties in the watershed participating. Ongoing monitoring will determine the impact of program on stormwater quality and quantity (Thurston et al., 2008).

6.4 Tax increment financing

Municipalities use TIF for redevelopment projects more often now than in the past, because federal and state funding for redevelopment is generally less available. This public financing method uses future gains in taxes to finance current improvements. Future gains such as increase in real estate value or new investment often occur after completion of a public project, and can generate increased tax revenues. This type of financing uses those tax increments to finance projects, funding projects that improve distressed areas such as brownfields.

6.5 Grants

Various grant programs throughout the US incentivize the building of green roofs. A green roofs grant in Chicago, for example, is awarded based on visibility and impact (USEPA, 2009b). Santa Monica, California offers grants for landscaping that utilizes native plants to reduce water consumption and stormwater runoff (USEPA, 2009b). Other community grants help schools implement GI onsite, which can then be used as an educational tool; offer cost-share for impervious surface reduction and other retrofitting; and fund volunteer training programs (USEPA, 2009b).

One grant program incentivizing green roofs within the combined sewer area of the Anacostia River watershed in Washington, DC, was a product of a negotiated a settlement to a lawsuit. The Chesapeake Bay Foundation initiated a green roof demonstration project, which provided grants to building owners in Washington, DC to improve stormwater management in this urban area (Johnson, 2007).

6.6 Awards and recognition

Certificates, promotional advertising, and awards are means of recognizing businesses, organizations, and residents for voluntary implementation of GI. Such programs can be a low-budget and unobtrusive supplement to other GI promotion programs.

6.7 Municipal separate storm sewer system requirements

In 1999, USEPA finalized a rule expanding the National Pollutant Discharge Elimination System (NPDES) stormwater program to include MS4s (USEPA, 1999). The rule requires that MS4s develop a stormwater management program that includes the following components, at a minimum:

- public education and outreach,
- public involvement,
- illicit discharge detection and elimination,
- construction site runoff control,
- post-construction stormwater management in new development and redevelopment, and
- pollution prevention and good housekeeping of municipal operations (USEPA, 1999, p 68736).

The post-construction stormwater management requirements encourage the use of GI for everyday long-term reduction of stormwater volumes and pollution. Suggested BMPs include vegetated islands in cul-de-sacs, curb-less streets, green roofs, stormwater wetlands, bioswales, and redevelopment (USEPA, 2006). West Virginia's MS4 permit is discussed in Section 7.7.

6.8 Model development principles

Model development principles have been adapted from a series of nationally-endorsed principles developed by the Site Planning Roundtable, a national cross-section of planning, environmental, home builder, fire, safety, public works, and local government personnel. These principles outline areas for consideration to change the standard approach to site design, and include the following:

Residential streets and parking lots.

1. Reduce residential street width
2. Reduce residential street length
3. Reduce residential street right-of-way widths
4. Minimize cul-de-sacs
5. Use vegetated open channels
6. Lower required parking ratios
7. Reduce parking ratios for mass transit or shared parking
8. Reduce parking lot imperviousness
9. Provide meaningful incentives to encourage structured and shared parking
10. Provide stormwater treatment for parking lot runoff

Lot development.

1. Advocate open space development (or cluster design)
2. Relax setbacks and frontages
3. Promote more flexible sidewalk standards
4. Promote alternative driveway surfaces and shared driveways
5. Specify management of open space
6. Direct rooftop runoff to pervious areas

Conservation of natural areas.

1. Create aquatic buffers along all perennial streams
2. Maintain buffers over time, through all stages of development
3. Minimize clearing and grading of native vegetation
4. Conserve and promote trees and other native vegetation
5. Encourage conservation incentives and flexibility
6. Provide stormwater management (CWP, 1998; 2004)

A handbook developed by the Center for Watershed Protection (CWP) provides additional tools: "this handbook details the technical support for the 22 Model Development Principles and outlines current and recommended practices along with research data on the economic, market, legal, safety, and social benefits of better site designs. Also featured is a codes and ordinance worksheet designed to help communities target the development rules most in need of change in their localities" (CWP et al., 2007, p 3).

6.9 Abandoned and dilapidated structures programs

Abandoned buildings and dilapidated structures programs serve to facilitate the inventory, cleanup, and revitalization of these structures. City demolition programs identify blighted properties by using the International Code Council as a standard. Inventory and revitalization of these properties can contribute to land recycling in urban corridors, as well as reductions in overall stormwater runoff.

Land banks offer means to control abandoned and dilapidated buildings; the primary inventory of properties entering a land bank is through the tax foreclosure process. In many states, however, the law that governs this process allows property to sit vacant for years before foreclosure. Michigan offers a good example to streamline this process by allowing its land banks to recapture 50% of the property tax revenues for the first five years after transfer of a property to a private party. This recapture provides an ongoing revenue stream for the land bank. Michigan also permits land banks to borrow money, issue tax exempt financing, and select properties to acquire from tax delinquency roles. As a result, the Genesee County Land Bank in Flint, Michigan has transferred 700 lots as side yards, 90 affordable rental units, and 80 single family homes (Scruggs, 2009).

6.10 Other regulations

Encouraging GI can be as simple as eliminating or revising regulations such as storm sewer connection requirements, minimum parking and street width requirements, and construction material requirements.

Some localities have taken a more aggressive approach, adopting new ordinances and regulations mandating pollutant and/or stormwater volume reductions, and in some cases specifically requiring GI as a means to achieve these reductions (Denzin, 2008; Veatch, 2008). Toledo, Ohio and San Francisco, California have both set maximum parking restrictions. Toledo's is 150% of the minimum parking requirement; San Francisco chose to set the maximum parking lot size at 7% of the retail area (Denzin, 2008). Madison, Wisconsin has no such maximum parking limit, but if parking lots are more than 60% larger than the minimum required, the development must include bioswales, permeable pavement, structured parking, extra landscaping, or other measures to reduce runoff (City of Madison, undated).

Rather than implementing specific construction restrictions, some municipalities, including Chapel Hill, North Carolina; Grand Traverse County, Michigan; and Clayton, Ohio have adopted pre-existing hydrology ordinances, requiring that developers design new sites to have the same runoff volume, temperature, flow, and infiltration rates as pre-development (Denzin, 2008).

Santa Fe, New Mexico adopted an ordinance in 2003 mandating rainwater harvesting for all new development. Commercial developments must harvest all rainwater, while residential structures are required to capture rainwater from 85% of the roof area.

In 2009, the Illinois Legislature passed a Green Infrastructure for Clean Water Act. The language of the act acknowledges the pollution and damage to infrastructure brought on by stormwater in the presence of large expanses of impervious surfaces, and the water quality, flood control, and other benefits of GI. The act charges the state Environmental Protection Agency with conducting a study to better understand the present use of GI in Illinois, the potential cost and effectiveness of increased GI, and the feasibility of adopting an urban stormwater regulatory program, among other goals.

In a more pointed move, the General Assembly of North Carolina ratified a bill limiting parking lots to 80% impervious cover. The balance can either be permeable pavement or other approved management techniques designed to infiltrate or capture stormwater (GANC, 2007).

Federal development and redevelopment projects of 5,000 square feet or larger are required to maintain or restore the site's natural hydrology to the maximum extent technically feasible "to ensure that receiving waters are not negatively impacted by changes in runoff temperature, volumes, durations and rates" (USEPA, 2009f, p 1). As mandated in a recent Executive Order, USEPA has released a document to aid federal agencies in meeting the stormwater reduction requirements set forth in the Energy Independence and Security Act of 2007 (USEPA, 2009f). Particular practices are not dictated; rather, satisfactory implementation will be measured by performance.

7. EXISTING POLICIES AND RULES IN REGION VI

While the previous chapter summarizes a range of policies and rules across the US, this chapter focuses on Region VI.

7.1 Fee discounts

In Morgantown, MUB charges non-residential customers a stormwater fee based on impervious surface area: $2.12/1,000 square feet (City of Morgantown, 2007). Charging per square foot incentivizes development that does not create unnecessary impervious surfaces. Permeable pavement is not considered impervious area; therefore, the stormwater fee would be cheaper for a site that uses permeable pavement or geogrids.

Fairmont plans to institute a similar per-foot charge at some point in the near future (DeMary, 2010).

7.2 Development incentives

No specific development incentives related to GI are known to exist in Region VI at this time.

7.3 Rebates and installation financing

No specific rebates or installation financing related to GI are known to exist in Region VI at this time.

7.4 Tax increment financing

TIF has been used to finance redevelopment projects in West Virginia and Region VI. Because this public financing method uses future gains in taxes to finance current improvements, this type of financing can be used alongside efforts to boost economic and community growth. These efforts can include brownfields redevelopment, as well as Main Street or neighborhood revitalization programs.

7.5 Grants

No specific grants related to GI are known to exist in Region VI at this time.

7.6 Awards and recognition

Morgantown is one of 15 Tree City USAs in West Virginia, and over 3,400 nationwide. This designation is awarded by the Arbor Day Foundation to communities that have established a tree board and tree care ordinance, a community forestry program with an annual budget of at least $2 per capita, and an official Arbor Day observance (Arbor Day Foundation, undated). The program also recognizes communities that expand their forestry programs and complete various activities in outreach, management, and tree planting and maintenance.

No specific GI implementation awards for businesses, organizations, or residents are known to exist in Region VI at this time.

7.7 Municipal separate storm sewer system requirements

West Virginia's first MS4 permit was issued in 2003, and a revised permit was issued in 2009. The revised permit includes several innovative requirements for controlling runoff from new development and redevelopment. For example, the permit requires several watershed protection elements, including minimizing the creation, extension, and widening of parking lots, roads, and associated development.

The site and neighborhood design elements require, among other things, that all new or redevelopment keep and manage on-site the first inch of rainfall from a 24-hour storm. Several GI techniques are specifically listed in the permit as options, including bioretention, cisterns, soil amendments, downspout disconnections, permeable pavement, and green roofs (WVDEP, 2009c).

7.8 Abandoned and dilapidated structures programs

Programs and policies that address abandoned properties and dilapidated buildings throughout West Virginia can promote infill development and reduce development footprints. Policies that help address these properties can be found at the state, county, and local levels. Cleaning up these properties provides multiple benefits to communities, including crime reduction, neighborhood beatification, economic development, contamination reduction, and reduced stormwater runoff.

Clarksburg's demolition program serves as an example within Region VI, as well as on the national level. The program limits the time period for owners to pay back taxes and liens, which accelerates the acquisition of blighted structures (CCPU, 2000).

Most city and county governments have systems in place to address vacant and blighted properties; these systems allow some form of control over the condition of vacant properties. One way to obtain control over vacant properties is through land banks, which have the authority to extinguish taxes and other liens on a property. Huntington, West Virginia established the first land bank in West Virginia under Home Rule (Scruggs, 2009).

7.9 Other regulations

USEPA's water quality scorecard lists general categories of ordinances that affect impermeable coverage:

- zoning ordinances,
- subdivision codes,
- street and sidewalk standards,
- parking requirements,
- minimum setbacks,
- site coverage limits,
- height limits,
- natural resource plans, and
- comprehensive plans (USEPA, 2009g).

In Region VI, there are currently no known regulations or ordinances prescribing the use of GI. There are, however, several ordinances that contribute to increased impervious surface, and some that may even hinder the implementation of GI.

Several common ordinances in Region VI place minimums on impervious surfaces, potentially resulting in greater impervious area than is necessary to meet community needs (Table 7). Minimum parking requirements are often calculated to meet peak parking needs. These conditions may only occur a few days out of the year, leaving the space underutilized most of the time. Minimum street and sidewalk widths may also contribute to greater impervious area. Some municipalities explicitly state materials requirements for paved surfaces, roofs, and walls. This may discourage the use of GI techniques that use alternative materials.

One principle of better site design to reduce overall site imperviousness is reducing minimum setbacks. Narrower side yards reduce total road length; relaxing front setback requirements minimizes driveway length, reducing impervious cover (CWP, et al., 2007). Minimum building setback distances may further increase impervious area by encouraging wide sidewalks.

Height limits on buildings are often instituted for aesthetic reasons, but they result in larger building footprints to achieve the same total floor area when compared to taller buildings. Maximum floor area ratios have the same effect—restricting vertical development. Similarly, minimum building footprints may result in greater impervious area per square foot of development.

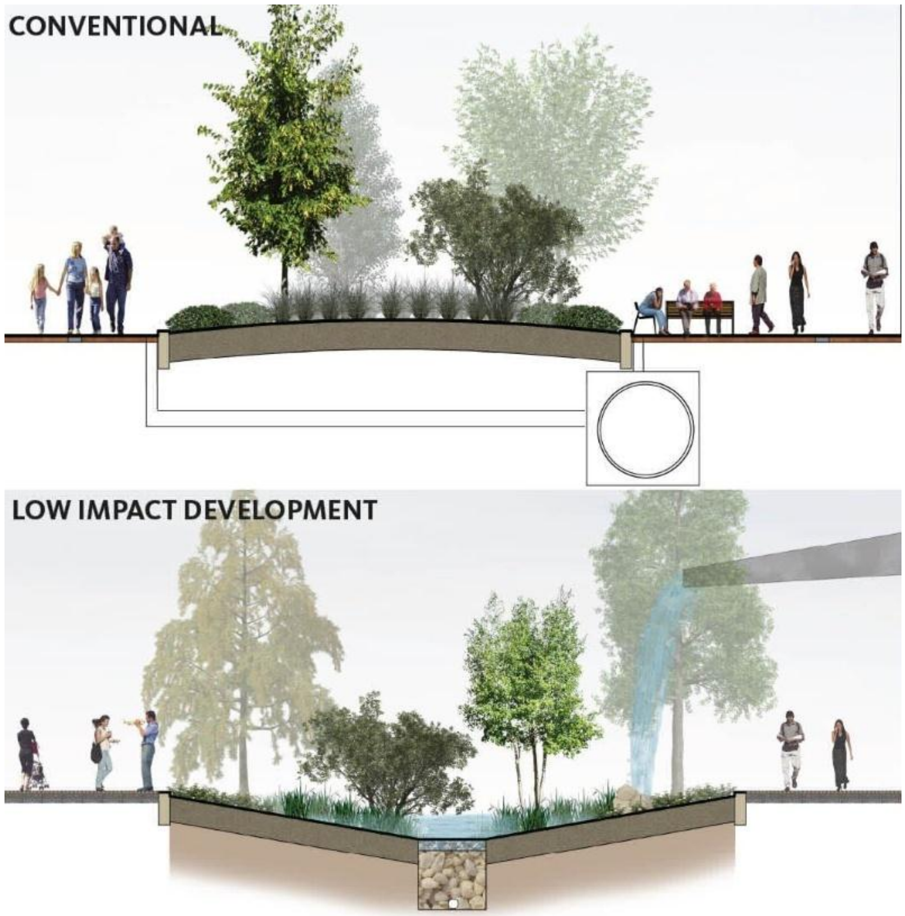
Table 7: Ordinances that may increase runoff

Ordinance	Clarksburg	Fairmont	Morgantown	Star City	Westover
Minimum parking requirements	✓	✓	✓	✓	✓
Minimum parking space size	✓	✓	✓	✓	✓
Minimum street width	✓	✓	✓		
Minimum sidewalk width	✓	✓	✓		✓
Materials requirements	✓		✓		✓
Minimum setback distance	✓	✓	✓	✓	✓
Maximum floor area ratio			✓		
Maximum building height	✓	✓	✓	✓	✓
Minimum building footprint	✓			✓	
Raised island and curb requirements for landscaping	✓				

Source: Local ordinances for Clarksburg, Fairmont, Morgantown, Star City, and Westover.

In addition to ordinances that result in greater imperviousness, others may inadvertently preclude the use of certain GI practices. For example, ordinances requiring curbs around raised vegetated islands in parking lots make it difficult to engineer a landscaping plan that captures runoff from the surrounding paved areas. Figure 21 illustrates the difference between conventional raised islands and those designed to capture runoff.

Figure 21: Conventional raised versus depressed vegetated islands



Source: Walter P Moore et al. (2010).

While some ordinances may hinder the use of GI techniques, there are already several types of ordinances in Region VI that serve to reduce stormwater runoff. Some have been developed specifically to address runoff, but many are implemented for aesthetic reasons, with runoff control as a side-benefit. Stormwater management plans are now required of new- and re-development construction projects of a certain size. These management plans generally include restrictions on post-development peak runoff volumes and pollutant loads.

Other ordinances that may reduce runoff include several that are the opposite of those listed in Table 7—maximum parking limits and provisions for compact parking stalls for smaller vehicles; maximum building setbacks; minimum building heights; and maximum lot coverage. Additionally, many municipalities have landscaping requirements to ensure the inclusion of trees and greenspace in development plans.

Table 8: Ordinances that may reduce runoff

Ordinance	Clarksburg	Fairmont	Morgantown	Star City	Westover
Stormwater management	✓	✓	✓	✓	✓
Post-development peak runoff	✓	✓	✓	✓	✓
Maximum parking limit	✓		✓		✓
Compact parking defined					✓
Maximum setback distance		✓	✓		✓
Minimum building height		✓	✓		
Maximum lot coverage				✓	✓
Neighborhood park requirement		✓			
Landscaping requirement	✓	✓	✓		
Landscaping plan	✓	✓	✓		
Topsoil preservation	✓	✓			

Source: Local ordinances for Clarksburg, Fairmont, Morgantown, Star City, and Westover.

West Virginia code has an entire chapter devoted to land use planning (State of West Virginia, undated). This code has relevance to GI in terms of preserving greenspace and controlling the expansion of impermeable surfaces. The code suggests the creation of local or regional planning commissions and the adoption of a comprehensive plan to “promote the health, safety, morals, order, convenience, prosperity and general welfare of the inhabitants, as well as efficiency and economy in the process of development” (State of West Virginia, undated, p 3-1). The code specifically encourages cluster-, infill-, and re-development; promoting a sense of community; making sound use of resources; and promoting conservation easements. In addition to reducing impervious surfaces, shared open spaces and shady pedestrian walkways, for example, can create opportunities for neighbors to interact and linger and foster a sense of community.

8. GREEN INFRASTRUCTURE TOOLS

As GI catches on across the country as a strategy for stormwater management and general community improvement, cities, agencies, and organizations are developing and sharing tools related to GI. These tools include internet-based planning assistance based on desired runoff reductions, spreadsheets to calculate energy savings and carbon dioxide reductions, rain garden design templates, and many others.

8.1 Catching the Rain Resource Guide

American Rivers developed this resource guide to natural stormwater management. Although it was developed for the Great Lakes region, the tools and information are relevant beyond that region. The guide addresses imperviousness and conventional stormwater management, as well as natural stormwater techniques referred to in this report as GI techniques.

Visit: http://act.americanrivers.org/site/DocServer/CatchingTheRain.pdf

8.2 Green roof GreenSave Calculator for long-term costs and benefits

Green roofs are an expensive investment, but provide a range of long-term benefits. The GreenSave Calculator estimates construction, operations and maintenance, and energy costs to determine whether the benefits of a proposed green roof outweigh the costs.

Visit: http://www.greenroofs.org/index.php/greensavecalc

8.3 Green roof Tree of Knowledge

This database on research and policy related to green roofs includes practical information about plant survival and economic benefits as well as socioeconomic and biophysical benefits.

Visit: http://greenroofs.org/grtok

8.4 Rain garden design considerations

The University of Wisconsin provides a detailed guide for rain garden design, complete with instructions for measuring slopes, estimating size needs, and evaluating soils. The guide includes tips that will help ensure your finished rain garden functions properly.

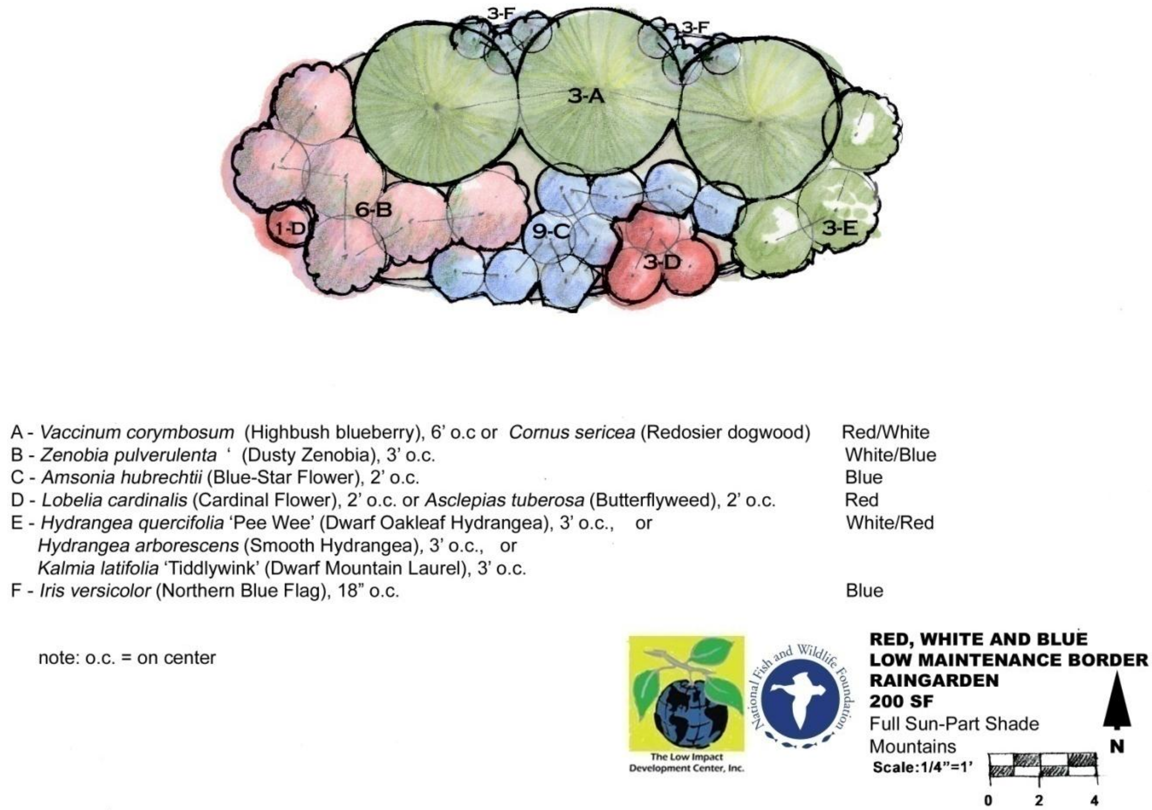
Visit: http://learningstore.uwex.edu/pdf/GWQ037.pdf

8.5 Rain garden templates

Rain garden design templates have been developed by the Low Impact Development Center for watersheds that drain to the Chesapeake Bay. The templates provide layout suggestions and recommend plant species based on local climate and whether the site is predominantly in the sun or in the shade. While Region VI is outside of the Chesapeake watershed, the templates suggested for the mountains province are appropriate. Figure 22 shows an example template for a garden in the sun.

Visit: http://www.lowimpactdevelopment.org/raingarden_design/templates.htm

Figure 22: An example of the Low Impact Development Center's rain garden templates



Source: Low Impact Development Center (2007).

8.6 Tree carbon calculator

The USFS Center for Urban Forest Research has developed a spreadsheet tool to calculate energy and carbon savings of trees considering tree size and species, local climate, electricity fuel type, proximity to buildings, and heating and air conditioning units.

Visit: http://www.fs.fed.us/ccrc/topics/urban-forests/ctcc

8.7 Certified pervious concrete contractors

A listing of certified pervious concrete contractors exists on the internet.

Visit: http://ohioconcrete.org/perviouscontractors.htm

8.8 Green Values Stormwater Toolbox

The Center for Neighborhood Technology has designed a series of Internet-based tools to calculate predicted stormwater reduction volumes possible with various GI practices. The tools consider pre-development land use, slope, soil characteristics, precipitation patterns, and stormwater reduction goals as they guide the user through options for GI projects at the site and neighborhood scales. The results compare the stormwater reduction volumes and project costs of chosen GI with conventional stormwater management practices.

Visit: http://greenvalues.cnt.org

8.9 MS4 stormwater management spreadsheet

To help ease the transition to the new permit requirements, WVDEP is developing a spreadsheet tool to assist in calculating reductions achieved by stormwater management techniques, including GI. This tool is scheduled for release in 2010 (WVDEP, 2010).

8.10 Water quality scorecard

As part of its municipal handbook series, USEPA has developed a water quality scorecard. "The two main goals of this tool are to: (1) protect water quality by identifying ways to reduce the amount of stormwater flows in a community, and (2) educate stakeholders on the wide range of policies and regulations that have water quality implications"(USEPA, 2009g, p 2). The scorecard is designed to evaluate local and regional policies and ordinances. Through a guided process, agencies can identify policy barriers to GI and address any inconsistencies. The scorecard then provides recommendations in different policy areas and at different levels of government involvement including: planning and education, removal of policy barriers, adoption of incentives, and enactment of regulations.

Visit: http://www.epa.gov/smartgrowth/pdf/2009_1208_wq_scorecard.pdf

8.11 Case Study: Sanitation District 1 of northern Kentucky

Kentucky's Sanitation District 1 (SD1) was faced with aging sewers, CSOs, sanitary sewer overflows, and stream erosion and channelization (Schmitt, 2009). The service area includes 36 cities in three northern Kentucky counties along the Ohio River with a population of 354,000. An assessment of mitigation strategies found that the residential stormwater fee, currently $4.40/month, would have to increase to $55/month by 2025 to fix the system using grey infrastructure. SD1 found that GI would save ratepayers more than 50%, with rates increasing to $22/month by 2025. SD1 determined that GI is not only a cost-effective strategy for addressing CSOs and other problems; GI also improves the quality of stormwater runoff, provides tangible community benefits, generates partnerships and cost-sharing opportunities, and will promote economic development. With this in mind, SD1 has implemented several projects in their service area (Schmitt, 2009).

SD1 initiatives include demonstration rain gardens at a local hospital and high school as well as larger-scale projects such as reforestation of a section of interstate right-of-way, a constructed wetland in a riparian zone, and a project to harvest rainwater for use irrigating a city golf course. Several of the projects have been funded by ARRA (Schmitt, 2009).

Visit: www.sd1.org (Search for "Implementing a GI plan")

In association with USEPA, a handbook has been developed to promote implementation of GI in SD1's northern Kentucky service area (USEPA, 2009e). The document includes many figures demonstrating how GI can be integrated into urban landscapes. The handbook also discusses design considerations for different techniques.

Visit: http://www.epa.gov/npdes/pubs/gi_stormwatermanagementhandbook.pdf

SD1 created a BMP Fact Sheet Series that describes various GI techniques used at its headquarters. The Public Service Park (Figure 23) is meant to be an educational tool for students, engineers, planners, and the general public. It includes a green roof, cisterns, porous asphalt and concrete, permeable pavers, a wetland, vegetated swales, terraced pools, an oil-water separator, and a forested area. SD1 conducts monitoring of the various systems to evaluate their effectiveness and maintenance requirements (SD1, undated).

Visit: http://www.sd1.org/resourcehandler.aspx?id=34

Figure 23: Sanitation District No. 1's Public Service Park

Source: Courtesy Sanitation District No. 1 of Northern Kentucky.

9. FUNDING AND TECHNICAL ASSISTANCE FOR GREEN INFRASTRUCTURE

9.1 State programs

9.1.1 *West Virginia Development Office*

The Community Development Division of the West Virginia Development Office (WVDO) provides information for communities on how to acquire state and federal technical and financial assistance through a variety of programs, including: Economic Infrastructure Bond Program, Main Street West Virginia, Governor's Community Partnership, Small Cities Block Grant, Land and Water Conservation Fund, and Office of Coalfield Community Development.

Visit: http://www.wvcommerce.org/people/communityresources/default.aspx

9.1.2 *West Virginia Division of Forestry*

The West Virginia Division of Forestry (WVDOF) administers several programs promoting urban forestry. Some of these programs are detailed below.

Visit: http://www.wvforestry.com/urban.cfm?menucall=urban

Mountaineer Treeways program

Through the Mountaineer Treeways program, organizations can request up to 300 tree seedlings for planting on public property within West Virginia. Trees are provided through donations by corporations and foundations. A funding match is not specifically required by this program, but tree planting and maintenance is the responsibility of the applicant organization. An application and program details are available online.

Visit: http://www.wvforestry.com/2010%20Mountaineer%20TreeWays%20Grant%20Application.pdf

Tree City USA

As mentioned in Section 7.6, Tree City USA is a national program sponsored by the National Arbor Day Foundation. It is administered in West Virginia by WVDOF.

West Virginia Project CommuniTree

Project CommuniTree links local and regional organizations to promote urban forestry growth through volunteerism. The CommuniTree program started in 2008, with the Potomac Valley Chapter. The Eastern Panhandle Chapter was founded in 2009. CommuniTree has a goal of public education through hands-on projects. The program facilitates the implementation and maintenance of urban forestry initiatives while educating citizens as to proper tree selection and care, project prioritization, and watershed health.

9.1.3 *Municipal Tree Restoration Program*

Initiated in 1999, the Municipal Tree Restoration Program is a cooperative effort between WVDOF, Allegheny Power, Appalachian Power, and communities across West Virginia. The program addresses issues between tall trees and utility lines by encouraging the planting of trees that are compatible with utility lines. Allegheny Power and Appalachian Power provide funding for removing problem trees and planting low-maturing replacement trees. WVDOF provides technical assistance to community leaders in the tree and contractor selection processes. Among other aesthetic and environmental values, this program can helps return trees to urban places where they have been removed to increase water storage capacity and reduce urban stormwater runoff.

Visit: http://www.wvforestry.com/MTRP%20brochure%206-08.pdf

9.2 Federal Programs

9.2.1 *Clean Water State Revolving Fund*

The Clean Water State Revolving Fund (CWSRF) is a federal program, administered through state environmental protection departments, that provides low-interest loans to address water quality. In total, the US budget for CWSRF grants is $2.1 billion for fiscal year 2010 (Baer, 2009). The grants are available to a wide range of stakeholders, including publicly owned treatment works, communities, individuals, citizen groups, and non-profit organizations (Baer, 2009). GI projects are eligible for funding; in fact ARRA specifies that 20% of funds should be set aside for green projects (USEPA, 2009a). West Virginia's "Green Reserve" share of CWSRF money for FY2010 is approximately $6.4 million (Baer, 2009).

Visit: http://www.dep.wv.gov/WWE/Programs/SRF/Pages/default.aspx

In Ohio, CWSRF loans have enabled conservation easements and vegetated swales in a residential development in the prized Big Darby watershed (OEPA, 1999). Educational programs for residents on stormwater management are also part of the initiative.

9.2.2 *Green Infrastructure for Clean Water Act of 2009*

The federal government has recently acknowledged the significant potential of GI for enhancing water quality and supply, providing employment opportunities, and maintaining healthy communities through the introduction of the Green Infrastructure for Clean Water Act. In recognition of the nation's declining water resources, and rapid development in urban areas, and with consideration to a National Research Council study expounding upon the benefits of GI, the bill was introduced in December 2009, and has been referred to the House Committees on Transportation and Infrastructure, and Science and Technology (Participatory Politics Foundation and Sunlight Foundation, 2010). If passed, the bill would establish between three and five regional research centers, authorize a competitive grant program, and fund a GI program within the Office of Water at USEPA.

The centers for excellence for GI would conduct research on GI practices and benefits relevant to their respective geographies and would work with educational institutions and state and local governments to promote GI and develop related curricula and training programs.

Grants would be available for planning and development, and for implementation. Preference in awarding the grants would be given to CSO communities, and low-income or disadvantaged communities.

The USEPA GI program would be charged with promoting GI within the agency, through state and local government, and in the private sector. Regional USEPA offices would assist in integrating GI into permitting and regulatory programs.

The total budget for the bill is $350 million annually for fiscal years 2011-2014, with the bulk of the money designated for the grant program.

Visit: http://www.opencongress.org/bill/111-h4202/show

9.2.3 *Transportation Enhancement funds*

Communities are using Transportation Enhancement (TE) funds to expand travel choice, strengthen the local economy, improve the quality of life, and protect the environment. The National Transportation Enhancements Clearinghouse helps communities understand their federally funded opportunities to enhance transportation experiences. TEs are federally funded, community based projects that improve transportation opportunities, as well as cultural, historic, aesthetic and environmental aspects. TE projects must relate to surface transportation, and also be one of 12 eligible activities. The following eligible activities are directly related to use of GI: (a) Activity #1: Pedestrian and bicycle facilities (i.e., sidewalks, walkways, or curb ramps); (b) Activity #5: Landscaping and scenic beautification (i.e., landscaping, enhanced roadside vegetation such as restoring native plants); and (c) Activity # 11: Environmental mitigation of runoff pollution and provision of wildlife connectivity.

Visit: http://www.enhancements.org

9.2.4 *Brownfields programs*

USEPA defines brownfields as "real property, the expansion, redevelopment or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (USEPA, 2009d, p 38). Practically, brownfields can include the following: former gas stations, former glass factories, former mills and manufacturing plants, former salvage yards, former dry cleaners, vacant lots and warehouses, buildings with asbestos, underutilized properties, abandoned railroads and rail yards, and mine-scarred lands (Carico, 2009). Brownfields redevelopment can transfer blighted properties into productive assets and reduce community safety and environmental concerns; it can also, however, preserve and create greenspace, as well as reuse existing utilities and infrastructure.

Brownfields redevelopment can support the intent of GI—to reduce runoff—in two major ways. First, recycling previously developed land reduces the increasing urban footprint and associated stormwater runoff. Second, GI techniques are incentivized to be used in brownfields redevelopment to minimize stormwater runoff associated with development. Incentivizes are provided through various grant programs.

Visit: http://www.wvbrownfields.com/webResources.cfm

Federal assistance: USEPA brownfields grants

USEPA funds brownfields projects with viable end-uses. Property reuse and redevelopment can include industrial, commercial, recreational, housing, and greenspace development. USEPA brownfields grants are awarded through a nationwide competition, and include the following types: (a) community-wide or site-specific site assessment, (b) clean-up, (c) revolving loan fund, (d) job training, and (e) research and technical assistance.

USEPA's cleanup and assessment grants are ranked on four main criteria. One of the ranking criteria is "project benefits," which assesses the environmental benefits from infrastructure reuse and sustainable reuse, including water, sewer, electricity, roads, storm drains, public transit, and building. Applicants must describe anticipated environmental benefits—beyond the assessment or cleanup of contaminants—associated with the sustainable reuse of sites assessed under the grant. Applicants are encouraged to incorporate the following elements, many of which are linked to GI techniques: green building, LEED certification, building renovation, green cleanup, conserve resources, infill, transit, smart growth principles, energy efficiency, innovative stormwater controls, low impact development, and sprawl (USEPA, 2009d).

Eligible entities include local and regional governments, quasi-government organizations, state agencies, and non-profit organizations (eligible for clean-up grants only) (USEPA, 2009d).

Federal assistance: Department of Housing and Urban Development Brownfields Economic Development Initiative grants

The US Department of Housing and Urban Development Brownfields Economic Development Initiative awards grants with a particular emphasis on brownfields redevelopment that enhances low-and moderate-income residential areas.

Visit: http://www.hud.gov/offices/cpd/economicdevelopment/programs/bedi/index.cfm

State brownfields assistance

The two main sources of state brownfields assistance in West Virginia are WVDEP and the state Brownfields Assistance Centers. WVDEP provides assistance through its Division of Land Restoration. One site-specific grant available in the state is the Targeted Brownfield Assessment grant, funded through WVDEP or USEPA Region III. WVDEP also provides assistance through their state voluntary remediation program.

Visit: http://www.dep.wv.gov/dlr/oer/voluntarymain/Pages/default.aspx

To support WVDEP in community efforts to revitalize the state's brownfields, the Legislature created two regional Brownfields Assistance Centers in 2005. The Northern West Virginia Brownfields Assistance Center serves the 33 northern counties, and is located at the West Virginia Water Research Institute at WVU. The Southern West Virginia Brownfields Assistance Center at Marshall University serves the 22 southern counties, and is located in the Center for Environmental, Geotechnical and Applied Sciences. The centers work closely together and collaborate with partners at WVDEP and WVDO. The centers assist communities in identifying technical assistance from WVDEP and provide education, outreach, and planning assistance to communities. The centers also help groups solicit grants and low-interest loans for site assessments, cleanups, and environmental job training (Zegre and Kirby, 2009).

Visit: www.wvbrownfields.org

Private brownfields assistance

The Foundation for Overcoming Challenges and Utilizing Strengths (FOCUS) West Virginia Brownfields Program helps communities statewide access financial and technical assistance to work on redevelopment efforts. Funded by the Claude Worthington Benedum Foundation, the program is administered by the Northern West Virginia Brownfields Assistance Center. Although the program's first year in 2009 focused on sites in northern West Virginia, the 2010 program partnered with the Southern West Virginia Brownfields Assistance Center to provide grants statewide. The FOCUS grant program helps communities cultivate and implement redevelopment visions for specific brownfields properties in two stages. In Stage I, the applicants receive $5,000 and technical assistance to generate site-specific redevelopment plans and to coordinate outreach plans. Stage I grantees are eligible to apply for additional $12,000 for Stage II to implement the redevelopment plans from the first stage (Zegre and Kirby, 2009). Stage II evaluation criteria for the 2009 program included whether the applicant integrated environmentally sustainable practices such as green design (NBAC, 2009).

Visit: www.wvbrownfields.org (Click on "FOCUS WV")

9.2.5 *Appalachian Regional Commission*

The Appalachian Regional Commission provides federal grants to support economic and community development in West Virginia and 12 other Appalachian states. The Appalachian Regional Commission's mission is to be a strategic partner and advocate for sustainable community and economic development in Appalachia. Strategic Objective 3.4, to build and enhance environmental assets, is linked to GI development.

Visit: http://www.arc.gov/grants

9.2.6 *Tax increment financing*

TIF is a financial tool that is widely used across the US. When a project is constructed to benefit the community, nearby property values will increase, and new businesses or residents may be more likely to move to the area. TIF borrows against these future increased tax revenues to finance improvement projects today. The rain garden in Morgantown's Wharf District, for example, was funded through the TIF program (Maupin, 2009b).

9.3 Non-governmental programs

9.3.1 *Nonpoint Education for Municipal Officials network*

Nonpoint Education for Municipal Officials is a University of Connecticut program created in 1991 for local land use officials addressing the relationship of land use to natural resource protection. Its Web site houses publications and other technical resources. The program's basic approach is via face-to-face workshops for local officials. The national network is a confederation of programs with the same mission; although West Virginia is not active, surrounding states such as Pennsylvania, Ohio, and Virginia have active programs.

Visit: http://nemo.uconn.edu/tools/publications.htm

9.3.2 *Center for Watershed Protection*

CWP maintains The Stormwater Manager's Resource Center with a plethora of resources in support of its mission to protect, restore, and enhance our streams, rivers, lakes, wetlands, and bays. Resources include model ordinances, better site design resources, a post-construction stormwater guidance manual, a program self-assessment, and budget/planning tools.

Visit: http://www.cwp.org

9.3.3 *Green Roofs for Healthy Cities*

Green Roofs for Healthy Cities is a nonprofit industry association working to promote green roofs throughout North America. It provides marketing, resources, and education related to green roofs.

Visit: http://greenroofs.org

10. GREEN INFRASTRUCTURE OPPORTUNITIES IN REGION VI

Developing GI projects can significantly decrease pollution to waterbodies from stormwater runoff. A geographic information system (GIS)[5] analysis is used to examine areas that have the highest potential contribution of pollution from stormwater runoff to receiving streams across Region VI. This analysis (1) identifies areas where stormwater is likely to have the greatest impact on water quality; (2) identifies GI project opportunities; and (3) provides information for local governments, MS4s, or interested organizations and individuals to use to help prioritize new GI projects.

In addition to the maps in this report, GoogleEarth and GoogleMap KML files are used to disseminate the data and results to a broader audience. These files are part of a system that includes information about all known GI projects in Region VI.

Visit: www.downstreamstrategies.com/greeninfrastructure

A variety of readily-available datasets were used as the foundation for the GIS analysis. As shown in Table 9, these data describe the soils, streams, and land cover across Region VI, as well as key information about stormwater-related infrastructure such as MS4 areas, CSO locations, and large buildings.

10.1 Areas where stormwater is likely to have the greatest impact on water quality

To identify areas where stormwater is likely to have the greatest impact on water quality, we use three steps: (1) an infiltration model, (2) infrastructure weighting, and (3) a polluted stream weight. Each step uses a scoring mechanism help identify catchments—or segment-level subwatersheds—with the greatest potential impact from stormwater runoff. These areas could then be prioritized for GI projects. This method presents just one way of using region-wide datasets to rank catchments for action.

The infiltration model focuses on three primary influences on stormwater pollution runoff: (1) percent impervious surface (Figure 24), (2) soil permeability (Figure 25), and (3) percent slope (Figure 26). In order to focus on areas with the greatest likelihood of GI project implementation, we eliminate catchments from the analysis that are mostly undeveloped and that have less than 5% impervious areas.

Using readily available data, we score these three datasets at the catchment level. Each catchment receives a normalized score of zero to 100 for each dataset. In all cases, scores of zero are least likely to cause stormwater problems, and scores of 100 are most likely. For example, for imperviousness, we assign a score of 100 to the catchment with the highest percentage of impervious area and a score of zero to the catchment with the lowest percentage.

[5] GIS is a computer-based mapping and spatial analysis technology that provides the ability to analyze geographical features related to the user's concerns. We apply GIS in an analysis of GI opportunities across Region VI.

Table 9: Data used in the GIS analysis

Data	Scale	Description	Date	Source
Soil characteristics	1:250,000	STATSGO provides a generalized inventory of the kinds and distribution of soils on the landscape. The soil maps are compiled by generalizing more detailed soil survey maps by soil scientists from the Natural Resources Conservation Service, as part of the National Cooperative Soil Survey.	1994	Natural Resources Conservation Service
Hydro-lines and segment-level catchments	1:100,000	The National Hydrography Dataset is a national framework for assigning reach addresses to water-related entities, such as industrial discharges, drinking water supplies, fish habitat areas, and wild and scenic rivers. In 2003, the Natural Resource Analysis Center at WVU completed high-resolution mapping by conflating USGS digital line graphs and USFS cartographic feature files across West Virginia.	2003	USGS and Natural Resource Analysis Center
Impaired streams	1:24,000	This dataset contains all West Virginia streams that appeared on the 2008 303(d) list. The impairment is included as one of the attributes.	2009	WVDEP
Impervious surfaces	1:50,000	The National Land Cover Database dataset was produced by the Multi-Resolution Land Characteristics Consortium, a consortium of nine federal agencies.	2001	USGS
Combined sewer overflow locations	1:24,000	This layer was created through data gathered through WVDEP's *Water Resources Permit Search* at http://www.dep.wv.gov/insidedep/Pages/ WaterResourcesPermitSearch.aspx.	2009	Downstream Strategies
MS4 boundaries	1:100,000	Because true MS4 boundaries are not readily available, we approximate these boundaries using the West Virginia subset of Census 2000's *Places* coverage posted by the West Virginia GIS Technical Center from US Census Bureau's Cartographic Boundary Files.	2000	West Virginia GIS Technical Center
Public buildings and structures	1:4,800	This dataset contains points for all buildings in West Virginia, and polygons for buildings over a certain size. The data were collected from 2003 natural color ortho-photography by the West Virginia Statewide Addressing and Mapping Board. These datasets contain all buildings, regardless of occupancy status, and the data have not been validated.	2004	Geographic Names Information System
Slope	1:24,000	Slope data were derived from the USGS National Elevation dataset.	1990	USGS

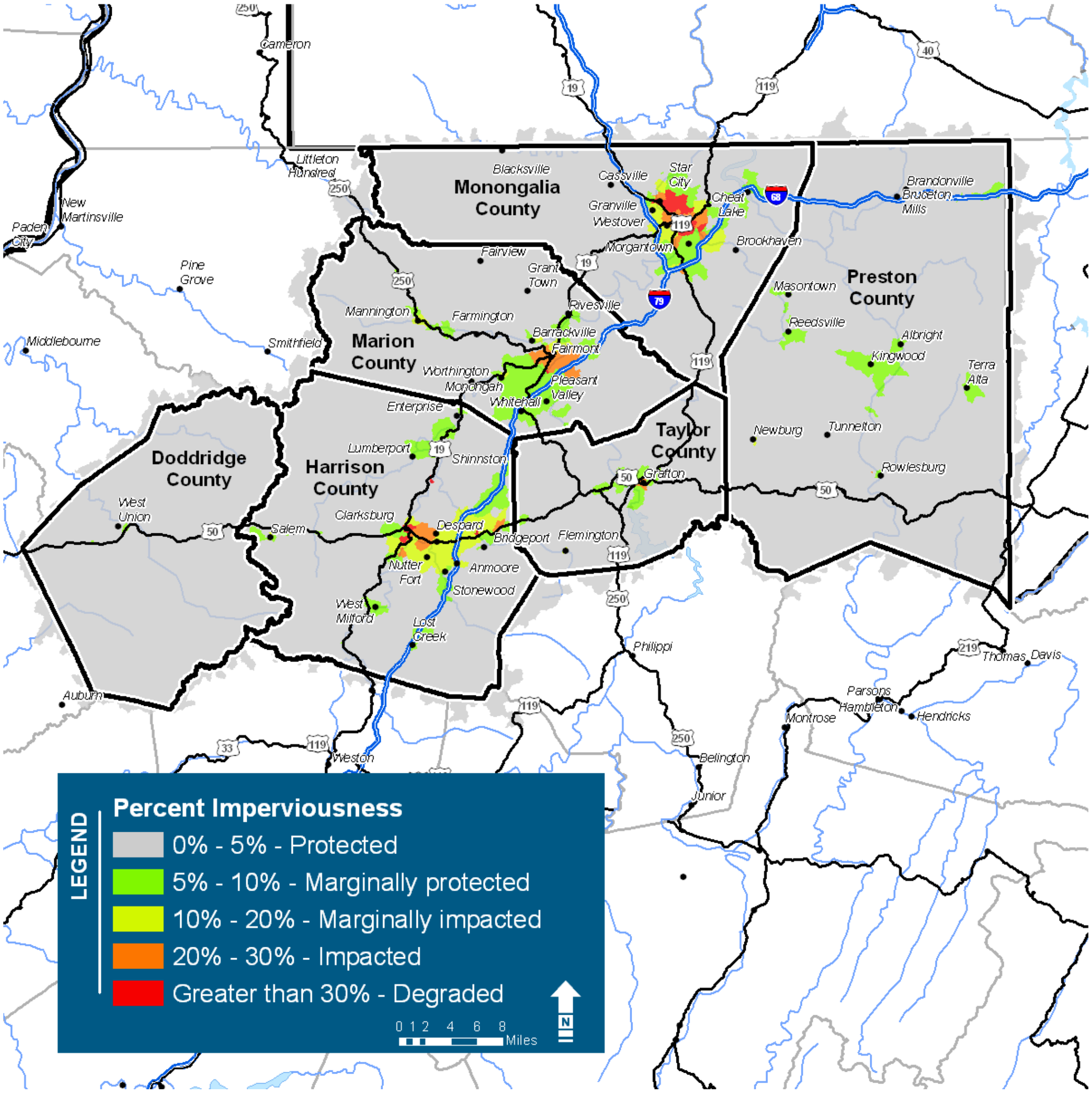
10.1.1 *Impervious surfaces*

Impervious surfaces convey stormwater runoff directly to local streams because they prevent or limit the infiltration of water into the soil. Examples include rooftops, roads, barren areas, sidewalks, and other hard surfaces. Imperviousness is an important indicator of water quality, and the quantification of imperviousness threshold levels directly assists in understanding the negative effects of urban runoff on in-stream water quality.

Generally, research indicates that streams in catchments with greater than 10% imperviousness have a higher likelihood of experiencing water quality degradation. Common thresholds include catchments that are protected (less than 10%), impacted (10-30%), and degraded (greater than 30%) (Arnold and Gibbons, 1996; Brabec et al., 2002). These thresholds are still being refined; a more recent educational tool, for example, describes streams with catchments at 8-10% imperviousness as stable but with erosion apparent. This tool also notes a threshold at 20%, at which stream substrate quality decreases and erosion is active (CWP, 2004).

We calculate percent imperviousness for each catchment, and color-code each catchment according to the following thresholds: 5%, 10%, 20%, and 30% (Figure 24). Catchments with less than 5% imperviousness are shaded grey; we consider these catchments to be outside of urban areas, which are the focus of this report.

Figure 24: Imperviousness



10.1.2 *Soil permeability*

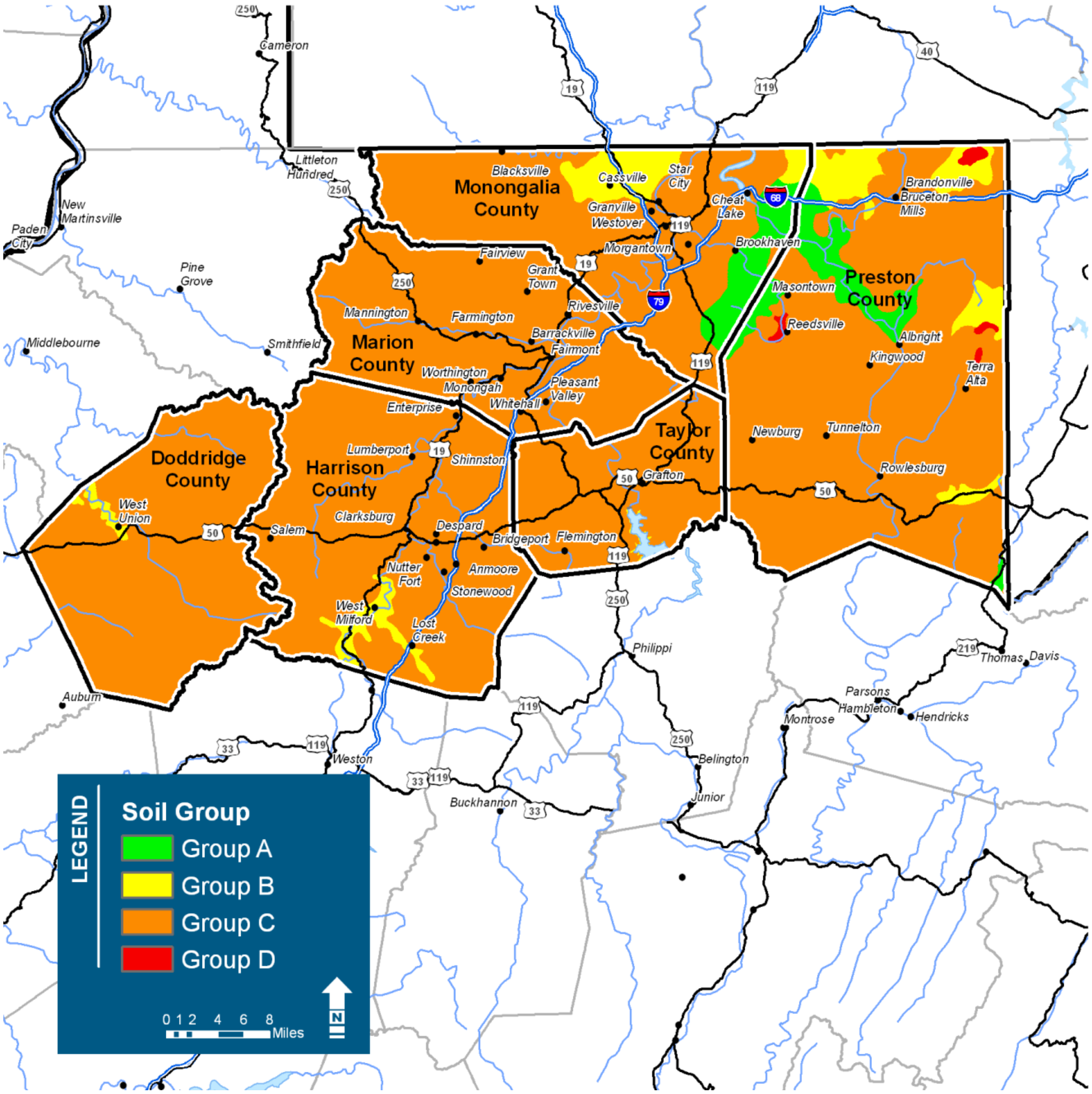
The soils data have many different attributes, indicating depth to bedrock, erosivity, and permeability. For this analysis, we use the hydrological group to assign scores to catchments based on permeability: zero for the highest permeability and 100 for the lowest. Table 10 lists the soil grouping and relative scores.

Table 10: Soil scores

Soil hydrological group	Texture	Permeability
A	Sand Loam	High
B	Silt/Loam	Moderate
C	Sand/Clay/Loam	Mid-low
D	Clay	Low

Source: Rokus (2007).

Figure 25: Soil permeability



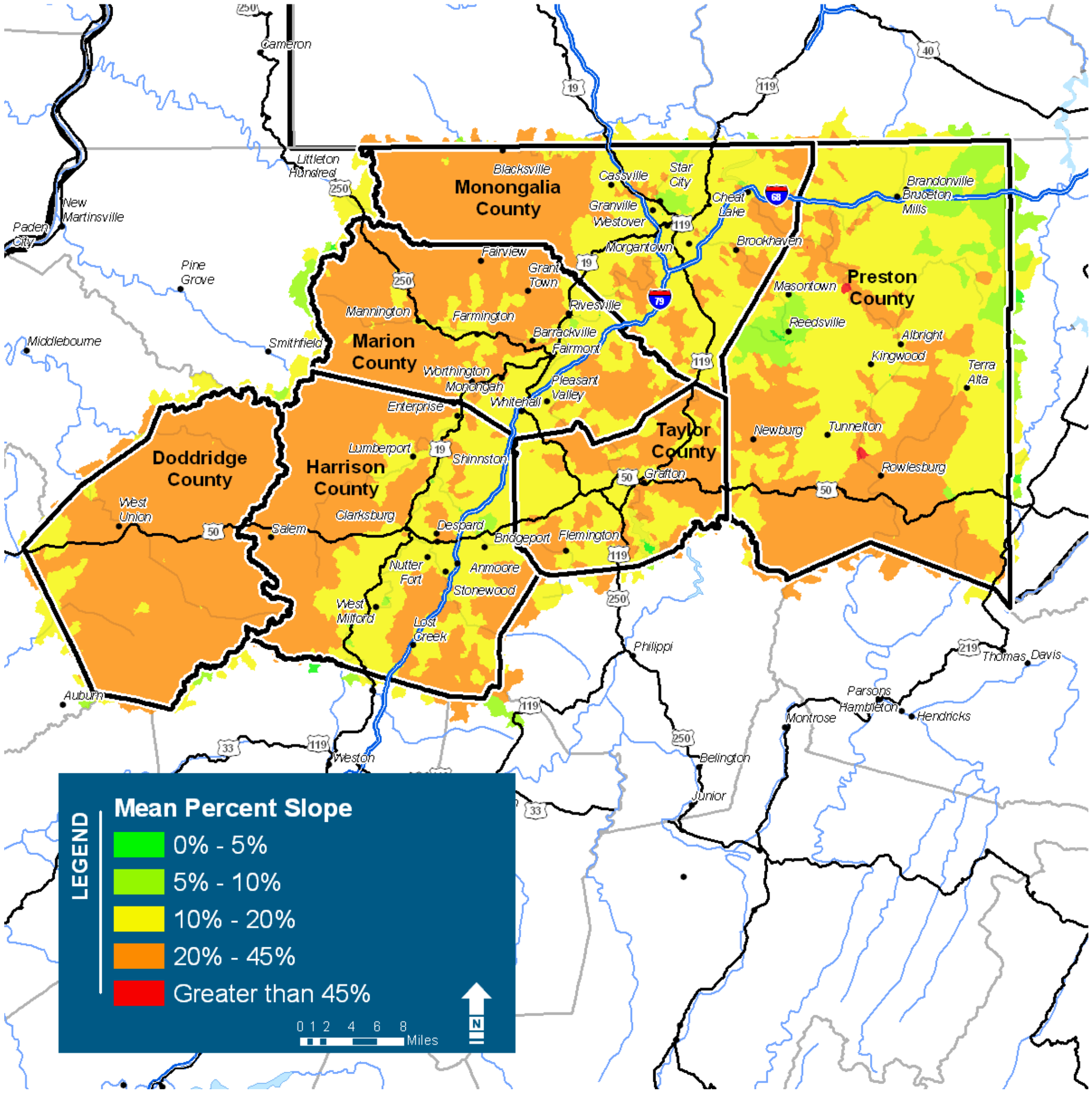
10.1.3 *Slope*

Slope can have a considerable impact on the potential infiltration of stormwater into the soil. Slope can be a complicated metric to calculate at the catchment scale. However, this study uses the mean percent slope for each catchment to get a general idea of how steep a given catchment is and how that may affect stormwater infiltration. We categorize slopes as shown in Table 11.

Table 11: Slope categories

Category	Percent slope
Level/Nearly level	0% - 5%
Sloped	5% - 10%
Moderately steep	10% - 20%
Steep	20% - 45%
Very steep	Greater than 45%

Figure 26: Mean percent slope

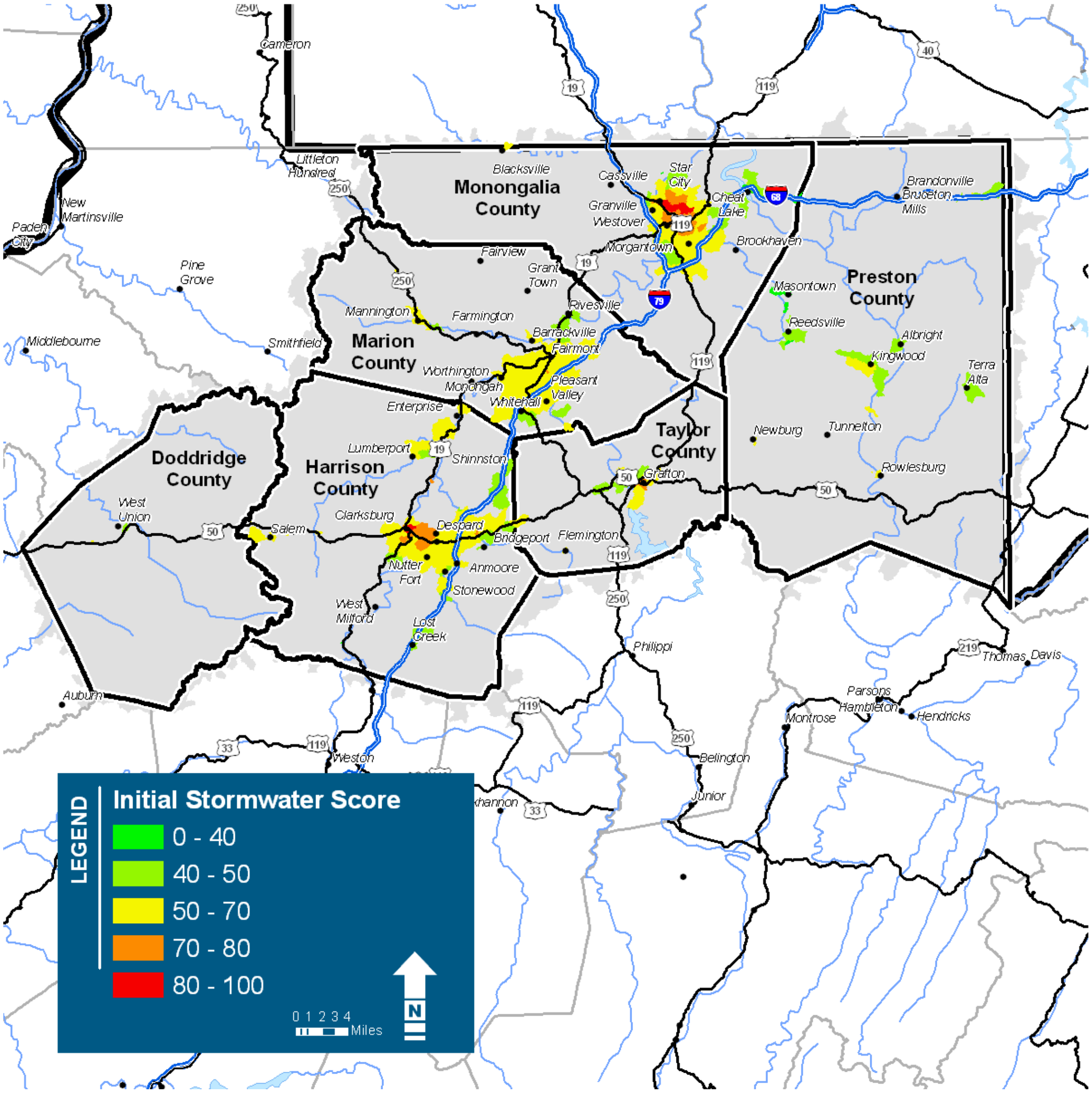


10.1.4 *Initial stormwater score*

For each catchment, we combine the scores for each of the three metrics to create an initial stormwater score. Because we consider imperviousness to be the primary factor, we multiply the imperviousness metric by 1.5 and then sum the three metrics. We then normalize the sum to be between zero and 100.

Figure 27 illustrates these results. As expected, the areas where stormwater is likely to have the greatest impact on water quality are located near the largest cities and towns across Region VI. The Morgantown, Fairmont, and Clarksburg/Bridgeport areas, in particular, have the most potential stormwater concerns when accounting for imperviousness, soil permeability, and slope.

Figure 27: Initial stormwater scores



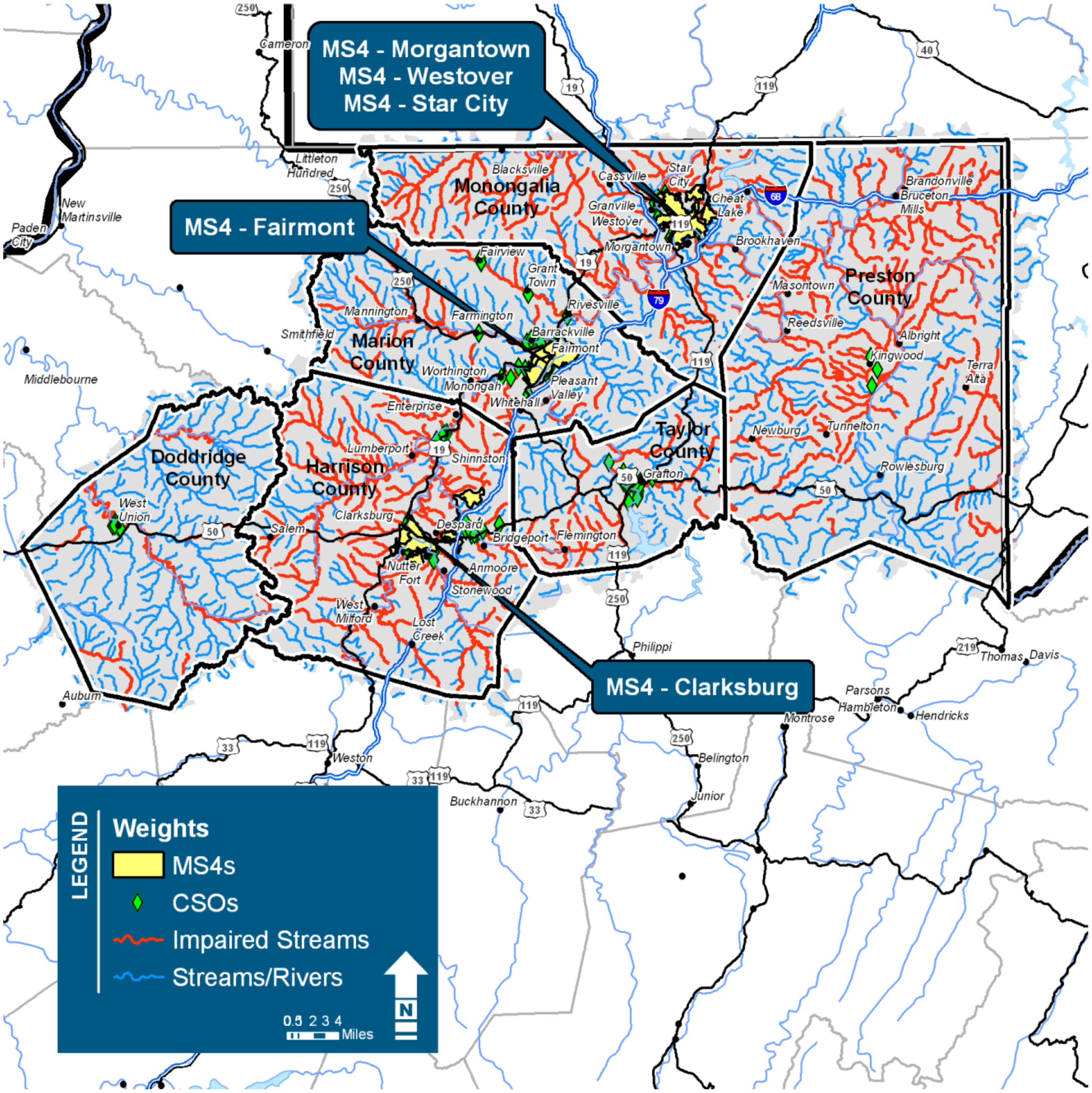
10.1.5 *Final weighted stormwater score*

While the initial stormwater scores shown in Figure 27 provide useful first steps in identifying areas with potential stormwater problems, they do not account for characteristics of the built communities that make water quality problems even more likely. They also do not account for known water quality problems in local streams. We therefore broaden our analysis to include three weighting mechanisms for each catchment:

1. **The number of CSOs within the catchment.** When CSOs are present, high volumes of stormwater cause raw sewage to discharge untreated into local streams.
2. **The overlap of catchments with MS4s.** MS4s only exist in the larger urbanized areas within Region VI.
3. **The miles of impaired streams within the catchment.** If local streams are already impaired, they may already be suffering from stormwater pollution, and/or they may be more sensitive to future increases in stormwater pollution.

Figure 28 displays the three new weighting factors. CSOs are shown as green diamonds, MS4s are shown as yellow areas, and impaired streams are highlighted in red.

Figure 28: Weighting factors



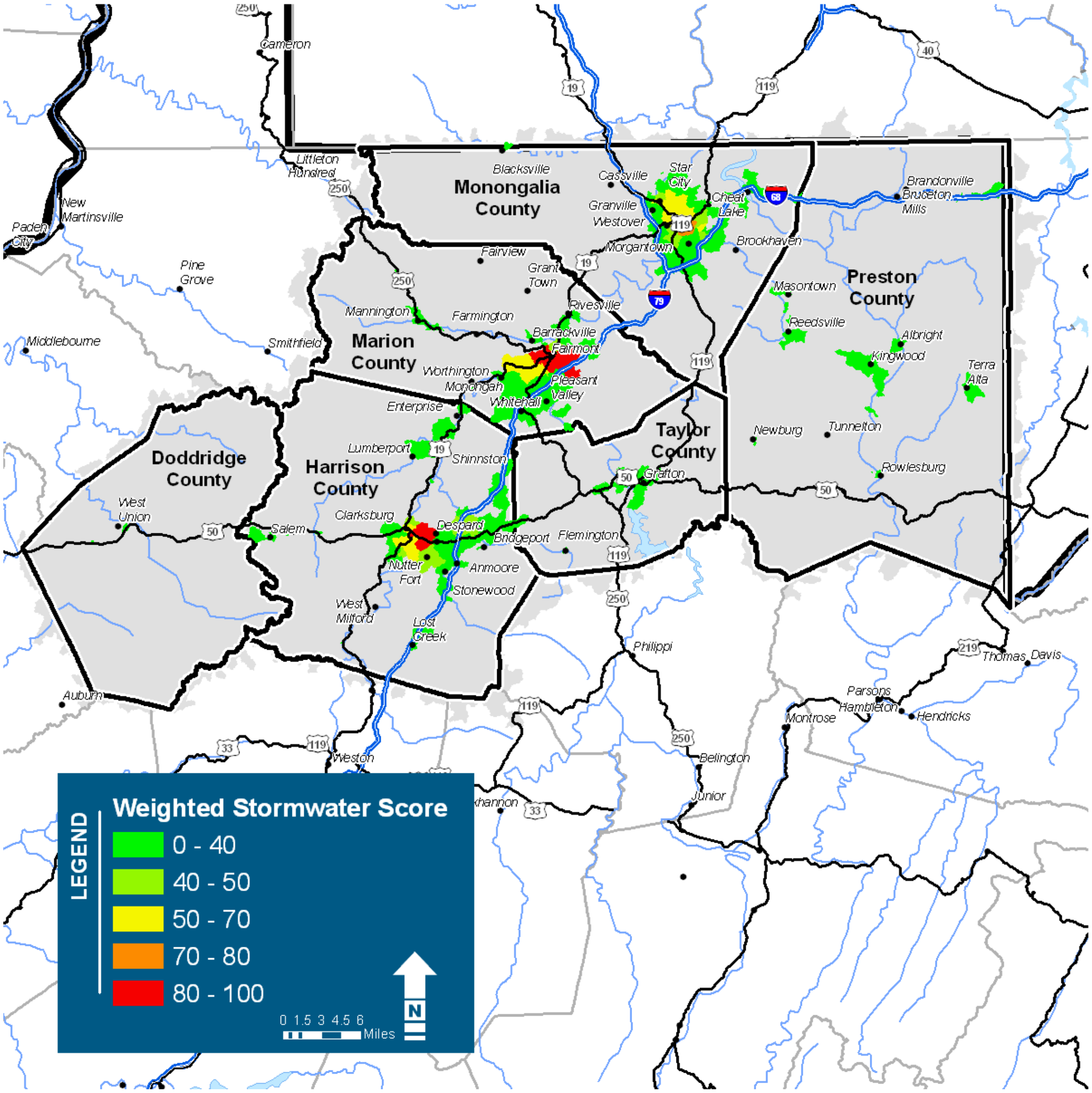
Note: This map highlights the five municipal MS4s in Region VI, and does not show WVU, FSU, or the FCI.

For CSOs, we assign a score of 100 to the catchment containing the highest number of CSOs, and we assign a score of zero to catchments with no CSOs. Other catchments receive scores in between, in proportion to the number of CSOs. For MS4s, we assign an additional 50 points to catchments that intersect MS4 boundaries. For impaired streams, we assign a score of zero to 100 to each catchment, based on the length of impaired streams within the catchment.

To apply these weights, we add them together to get a range from zero to 250, normalize the results to a range from zero to 100, and add the weights to the initial stormwater score. We then normalize this weighted stormwater score one more time so that the final result, again, falls within the zero to 100 range.

The final weighted stormwater scores are shown in Figure 29. These scores are similar to the initial scores in Figure 27; however, specific catchments within the Morgantown, Fairmont, and Clarksburg/Bridgeport areas stand out even more significantly as areas of concern.

Figure 29: Final stormwater scores



10.2 Green infrastructure opportunities

To gain a better understanding of where GI projects could have the greatest impact, we analyze several metrics useful for helping to identify potential GI project sites. While other factors are also important, this analysis begins the process of systematically assessing available data to determine the potential for GI projects.

We rank each subwatershed based on three simple metrics: (1) residential concentration, (2) number of public buildings, and (3) number of large buildings.

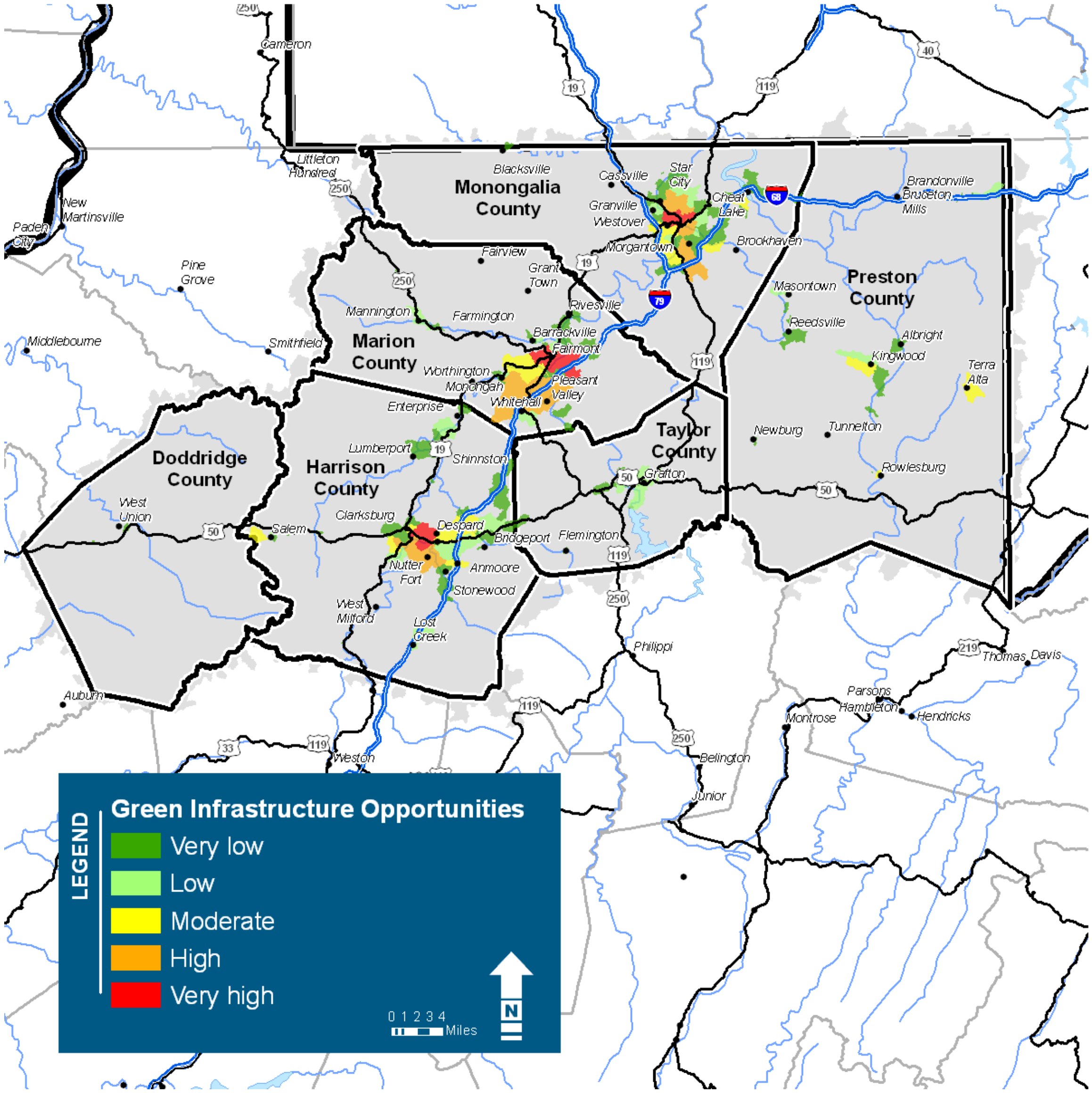
Residential concentration pinpoints areas where individual or community GI projects could most easily be targeted. In addition, areas with high residential concentration can benefit most from local ordinances related to stormwater, because these areas have the highest concentration of people and buildings. We quantify residential concentration as the percent of each catchment with high intensity development. These values are then normalized such that the catchment with the highest residential concentration receives a score of 100, and the lowest receives a score of zero.

Public buildings such as fire stations, schools, prisons, and city buildings are natural targets for GI projects based on access, the possibility of using public funds, and the potential to showcase projects as public demonstrations. A simple count of public buildings is used, normalized to a scale of zero to 100.

Large buildings (we use 20,000 square feet as our threshold) offer opportunities to develop GI projects that may help to alleviate stormwater runoff. Large structures include office buildings, shopping centers, industrial complexes, university buildings, or other types of buildings. In addition to their large rooftops, they are often accompanied by impervious parking lots. These facilities are prime candidates for private GI projects that provide a significant decrease in stormwater runoff. Again, a simple count of large buildings is used, but normalized.

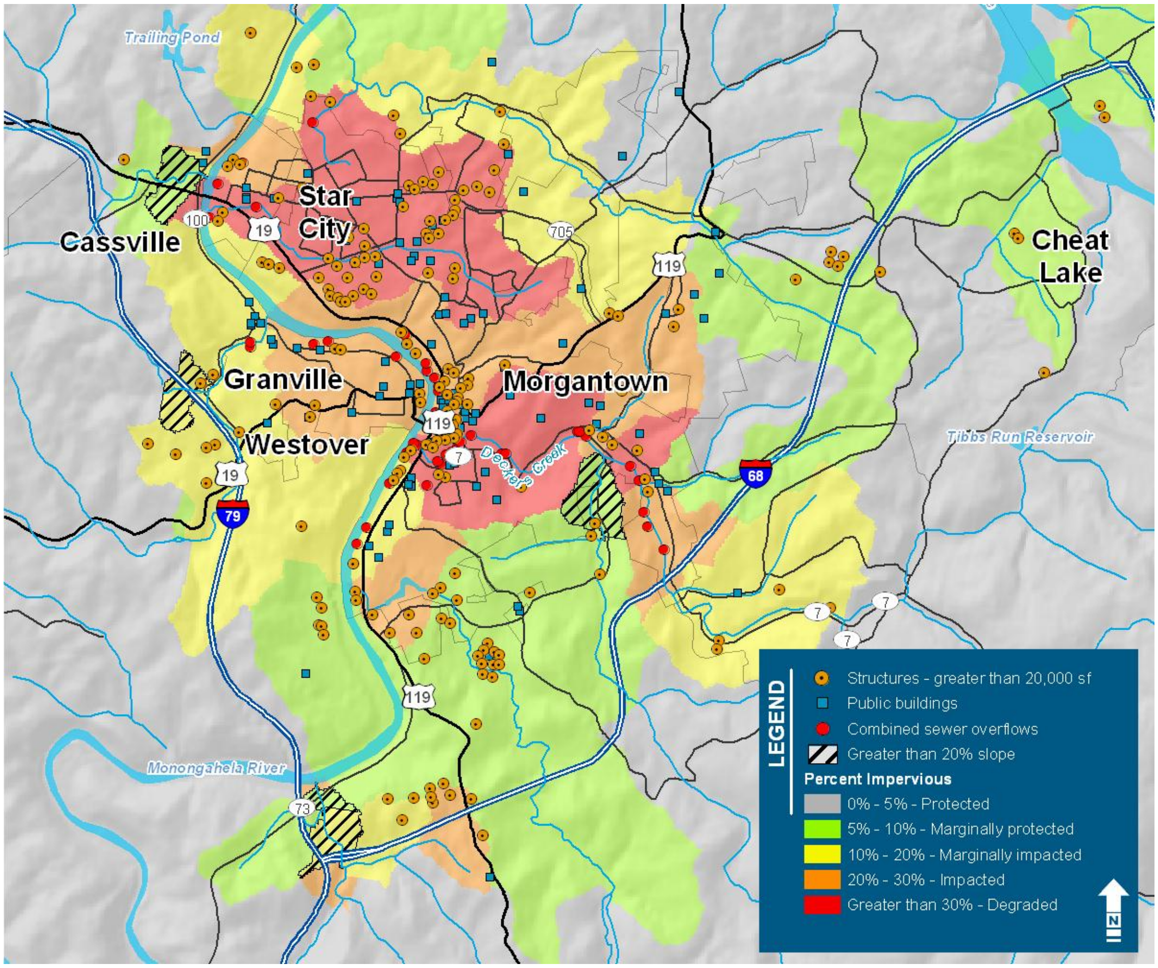
We calculate the final GI opportunity score by summing these three metrics, then normalizing the result to a scale of zero to 100. According to these results, the Fairmont area has the most significant opportunities for GI projects (Figure 30). Subwatersheds in Morgantown and Clarksburg provide many opportunities as well.

Figure 30: Green infrastructure opportunities



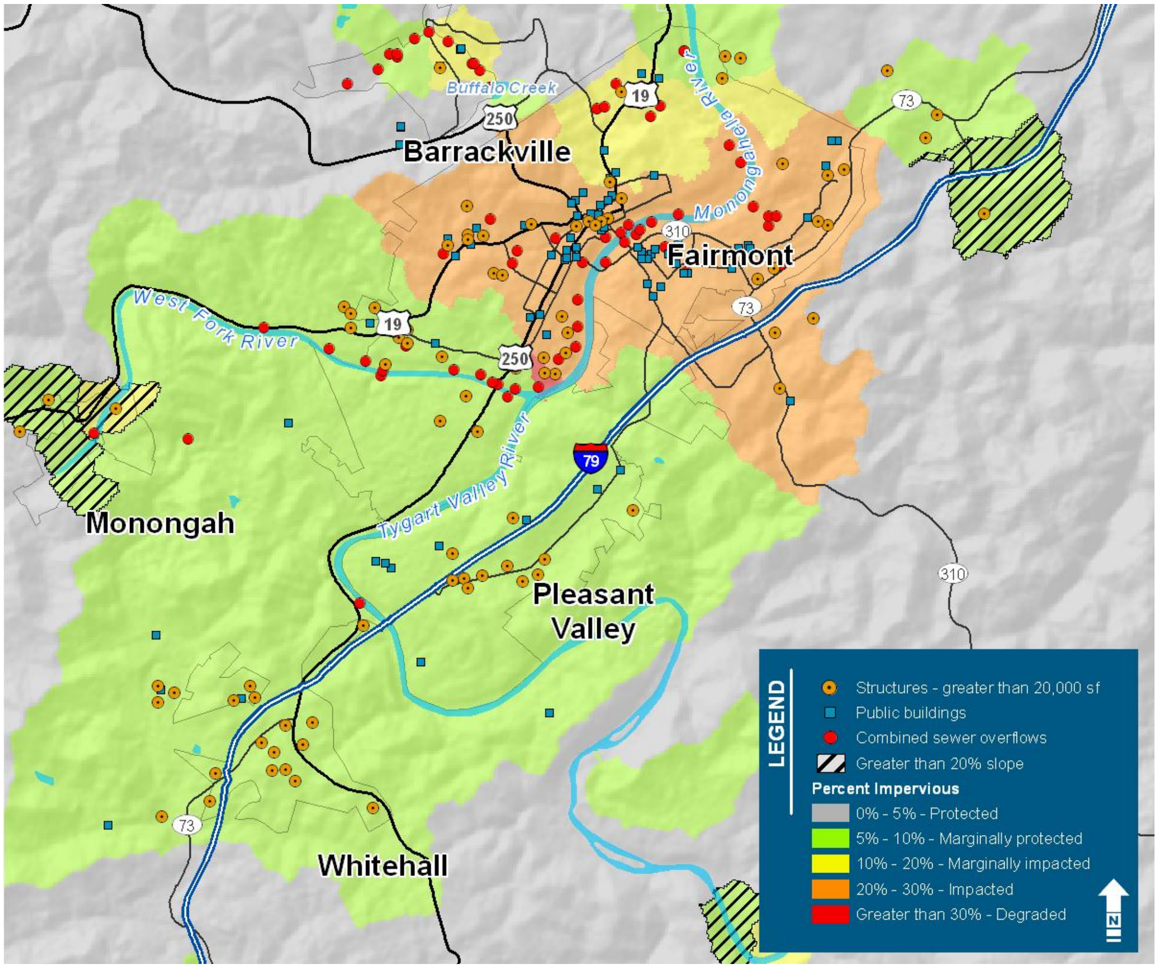
To help identify actual neighborhoods and sites for the potential development of GI projects, we zoom into the Morgantown, Fairmont, and Clarksburg/Bridgeport areas in Figure 31 through Figure 33. For each area, we map the percent imperviousness, steep slope areas, and CSOs. In addition, we map the locations of public buildings and large buildings, because these are potential GI project locations.

Figure 31: Morgantown green infrastructure opportunities



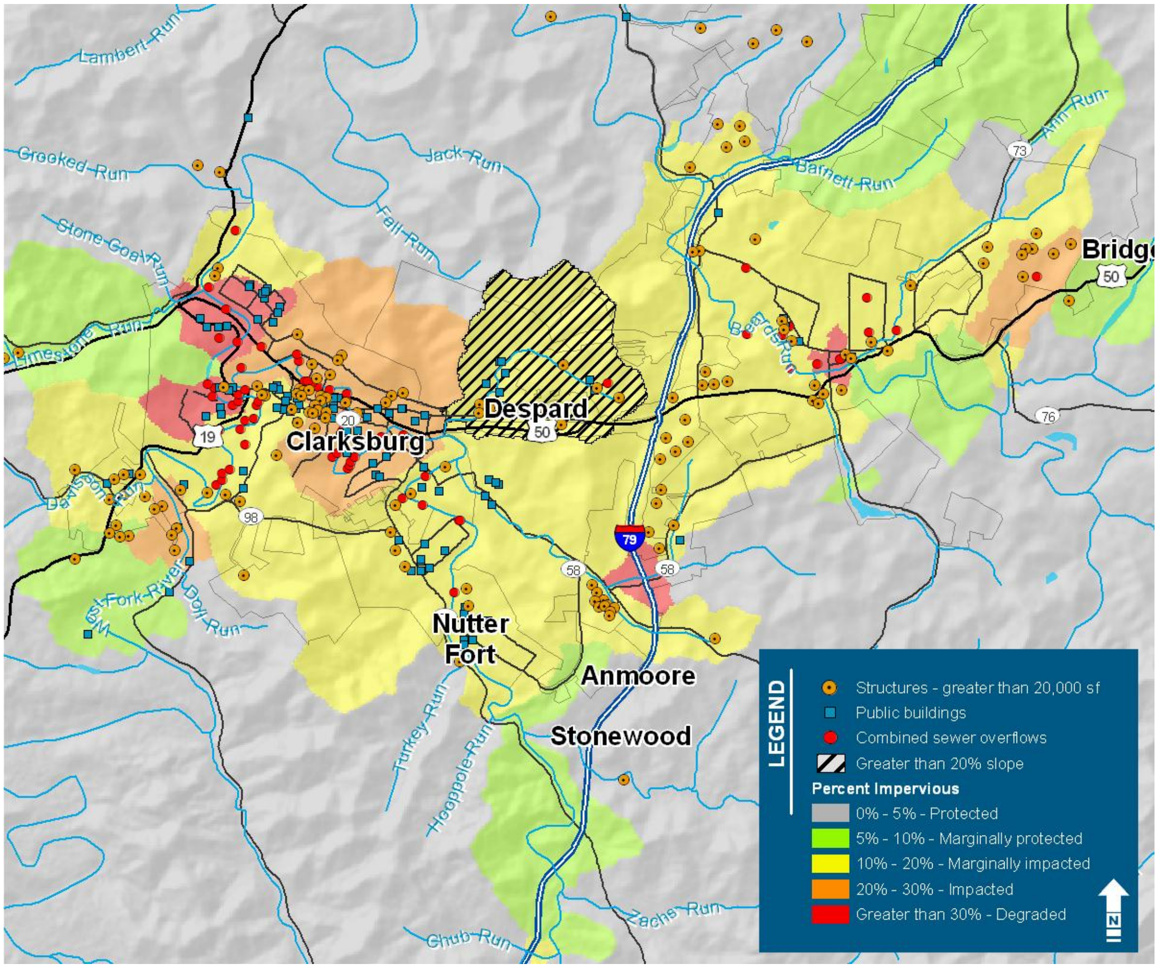
As shown in Figure 31, Morgantown and the surrounding areas have over 4.5 square miles classified as degraded due to high percentages of impervious area. These catchments are shaded red. Most of these areas fall within the Morgantown, Star City, and WVU MS4 boundaries, where GI techniques are now strongly encouraged for new development and redevelopment. A total of 45 CSOs discharge raw sewage to streams and rivers in the Morgantown area. These discharges are directly tied to high levels of stormwater in combined sanitary/stormwater sewers and could be mitigated in part by retrofitting some of the area's many public and large buildings to reduce their stormwater runoff. Clusters of buildings located in downtown Morgantown and in the Star City area could begin the process of developing GI projects.

Figure 32: Fairmont green infrastructure opportunities



As shown in Figure 32, Fairmont does not have any areas categorized as degraded; however, areas do exist that are reaching a level of concern. Northern West Virginia is growing, and steps can be taken now to lessen the impact of future development by implementing GI techniques for new projects across the region. In the Fairmont area, 63 CSOs contribute pollution to the West Fork, Tygart Valley, and Monongahela Rivers. While imperviousness is not as much of a concern as it is Morgantown, the number of CSO outfalls are significantly more numerous. In addition, Fairmont is an MS4 community.

Figure 33: Clarksburg/Bridgeport green infrastructure opportunities



Clarksburg and Bridgeport both have small pockets of degraded catchments based on imperviousness (Figure 33). These catchments are located adjacent to streams, which will receive increased amounts of pollution from stormwater runoff. Additionally, 70 CSOs are located in this general area. GI projects can play an important role in fulfilling the requirements of Clarksburg's MS4 permit.

It is important to note the overlap between areas that are modeled to be severely impacted by stormwater runoff and the areas that are recommended for GI project development. Often, the very conditions that contribute to stormwater problems—steep slopes and low-permeability soils—make it more difficult to implement GI measures. However, several techniques—including green roofs, cisterns and rain barrels, and trees—are unaffected by these conditions. Terraced planter systems are examples of GI techniques that are modified for use on steeper slopes.

11. REGION VI PROJECT IDENTIFICATION

A key component of this project was to talk with local leaders and stakeholders about how GI could help them meet stormwater goals and provide other benefits to their communities. Meetings were organized to engage with key local and regional organizations and officials. Participants included MS4 leaders, city officials, parks department employees, school officials, town councils, planning department members, watershed group volunteers, and others. State and regional agencies such as WVDEP and the Preston and Taylor County economic development councils were also interviewed.

These outreach opportunities provided a venue for the exchange of information and ideas in two directions. To explain the status of GI use and its potential benefits, we communicated the results from our research to local leaders. These meetings also provided opportunities to discuss potential projects and future needs. Local leaders brainstormed with project team members about specific projects in their communities that could benefit from the use of GI techniques. Particular emphasis was placed on projects that would also provide side benefits to local communities.

Out of these discussions, several potential projects were identified as being good candidates for GI (Table 12). Most of the projects were in the discussion phase before our meetings. However, in most cases, the project planners had not been considering GI in their designs.

Table 12: Region VI projects for which conceptual designs were created

Organization	Project	Contacts
West Virginia University	Creative Arts Center Parking Lot	Clement Solomon, *Director of Sustainability* Hugh E. Kierig, *Director of Transportation & Parking*
Fairmont State University	Bioswale, Rain Garden, Hardway Hall	Stephanie Slaubaugh, *Construction Project Manager*
Morgantown Urban Landscape Commission	Rawley Lane	Kara Hurst, Jerry Steketee, *Urban Landscape Commission* Jeff Mikorski, *Assistant City Manager, Morgantown*

Downstream Strategies partnered with Harbor Engineering, Inc. from Manheim, Pennsylvania to provide additional expertise on the selected projects. Together, we offered conceptual designs, preliminary cost estimates, and suggested project funding mechanisms.

The conceptual designs for the potential projects were disseminated to all project contacts to help generate funding and to build support. Because these designs serve as useful examples of visualized GI techniques, they are also shared in Appendix D of this report to disseminate to leaders within Region VI and beyond.

11.1 West Virginia University Creative Arts Center parking lot

The WVU Departments of Sustainability and of Transportation and Parking are working together on modifications to the Creative Arts Center parking lot. This lot has required frequent repairs in the past due to drainage issues. Puddles in low spots of the lot and freeze-thaw events have resulted in potholes and in cracking and buckling of the pavement. To mitigate the drainage issues and make use of stormwater runoff, a new parking lot conceptual design includes porous pavement, rain gardens, a cistern, and a native plant meadow. The Creative Arts Center's central location on the WVU campus and its popularity as a music and theater venue present a great opportunity to showcase GI in the community.

11.2 Rawley Lane pedestrian corridor

Morgantown would like to make improvements to an informal trail that has been worn on one of the city's "paper streets."[6] Particularly since the nearest through-street is lacking a sidewalk, Rawley Lane is a natural connector from the Suncrest neighborhood to popular businesses on busy Patteson Drive. The Rawley Lane design includes a bioswale along one side of the trail and shade trees along the other. Additionally, the design proposes modifying the playing field at the adjacent middle school so that runoff from the field can be directed to the swale. The field presently experiences frequent drainage problems.

11.3 Fairmont State University bioswale

The FSU campus includes some steep slopes. In major storms, one of the primary drainage pathways is often overwhelmed. Wetland plants over a stone base along with a vegetative filter strip will help slow and infiltrate runoff. An underdrain is included in the plans to address flow from the largest storms. Establishing wetland vegetation in the swale will also serve to improve aesthetics of the drain facility.

11.4 Fairmont State University rain garden

A small grass triangle between sidewalks is the chosen location for this demonstration rain garden. The plants will take up runoff from the surrounding impervious surfaces, while encouraging pedestrians to stay on the sidewalks.

11.5 Fairmont State University landscaping at Hardway Hall

Landscaping work in front of this historic building has been postponed due to other construction projects; however, the university will consider replacing grass with native trees, shrubs, and groundcover to help infiltrate more of the area's stormwater.

[6] While "paper streets" are technically streets and owned by the city, they have not been developed and are not open to vehicular traffic.

12. INSTITUTIONALIZING GREEN INFRASTRUCTURE

Although this project identifies examples of GI techniques used throughout the state and in Region VI, institutionalization of these techniques has not yet occurred. As found in the 2008 survey of West Virginia's MS4s, GI techniques are not being widely used in the state; MS4 officials, however, recognize their potential to meet water quality and other goals (Hansen et al., 2008). There is a tremendous opportunity within Region VI to jumpstart the use of GI techniques for water quality benefits, as well as side benefits.

To institutionalize GI techniques in Region VI, we have identified three major categories of needs: (a) incentives and pilot projects; (b) planning and regulations; and (c) education, training, and research. Filling these needs can help shift ideas like rain gardens and permeable pavement from novel to normal.

12.1 Incentives and pilot projects

As identified in the interviews (see Appendix C), local leaders and residents seek incentives and pilot projects to spur the use of GI across Region VI. While incentives help implement both new and existing GI techniques, pilot projects serve as demonstrations to trouble-shoot and study new techniques. Incentives are discussed in Sections 6 and 7 and include, for example, fee discounts, development incentives, rebates, and loans.

Pilot projects can be implemented at government buildings, universities, county parks, or other locations, and are sometimes promoted when government agencies adopt formal commitments to sustainable practices. For example, guidance related to reducing runoff from federal development (See Section 6.10) includes several case studies of sites from around the country, including a 0.7-acre facility in Charleston, West Virginia with 73% impervious cover (USEPA, 2009f, p 39). USEPA determined that the site would require between 0.03 and 0.06 acres of bioretention to meet the stormwater management goal, depending on the dominant soil type (USEPA, 2009f, p 39). If built, this project could serve as a visible pilot project to demonstrate the feasibility of achieving federal goals using GI.

12.2 Planning and regulations

While no single best method exists to solve stormwater issues, impervious surface coverage can be a useful tool for local planners and regulators seeking to address water pollution at the community and site-specific planning scales (Arnold and Gibbons, 1996). Impervious surfaces both indicate urbanization and contribute to its impacts. As was accomplished in Olympia, Washington (City of Olympia, 1995), comprehensive planning at a large scale is often the most effective way to achieve large-scale reductions in water pollution. Planning at the neighborhood or site levels, however, can also offer valuable means to pollution reduction in more rural counties and cities of West Virginia.

At community and neighborhood scales, planning efforts can preserve existing greenspace, guide urban growth, and reduce the water impacts of development. Comprehensive planning at the community level, such as the City of Clarksburg plan update (Bedard Consulting, 2010), can address infill development, brownfields redevelopment, cluster development, alternative transportation, regulations, and incentives. An urban tree canopy goal is an example of a tangible and well-defined target that allows city officials to measure progress toward stormwater reduction. Planning at the neighborhood level, such as the subdivision planning tool called cluster development, offers reduction in impervious surfaces, as well as social and aesthetic side benefits. By grouping built structures together around an open space, cluster development preserves open space in residential areas. Beyond the aesthetic value of this practice, it can also eliminate curbs and gutters, which reduces impact on combined sewer systems (Bedard Consulting, 2010). Cluster development can also reduce site imperviousness by 10-50 percent (Schueler, 1994).

These planning approaches can be supported by ordinances and regulations at the neighborhood, community, and regional scales. Planners, for example, can revisit imperviousness requirements for new development to ensure lot coverage limits include roofs as well as parking spaces, sidewalks, and driveways. Regulating future development on measures of land use intensity such as impervious surface ratios is an effective means to address stormwater management and promote groundwater recharge (Jaffe, 1993).

Performance-based standards offer flexibility in meeting impervious surface reduction goals; this flexibility has the side benefits of encouraging mixed uses and sparking innovation to meet goals. Sliding scales of impervious surface limits can also offer flexibility, varying by such factors as land use and protection objectives. If the protection of an important resource is desired, for example, stricter impervious surface limits can be imposed (Arnold and Gibbons, 1996).

Current Region VI city ordinances related to parking, buildings, and streets were not written in the context of stormwater management. While stormwater management techniques can be written into ordinances, as demonstrated in some of the examples in Section 6.7, a first, less-aggressive step is to eliminate ordinances that preclude the use of GI. Relaxing or eliminating minimum parking and stall size requirements can reduce impervious cover. Minor modifications to landscaping requirements may allow runoff to infiltrate, rather than be directed around curbs to stormwater drains. Allowing a wider range of building materials could encourage the use of green roofs and green walls. Many of these modifications could be made with no adverse impact to development.

12.3 Education, training, and research

While individual stormwater management projects are a step in the right direction, a paradigm shift will be necessary to achieve the complete vision of more beautiful and sustainable communities in Region VI and West Virginia. Such a shift toward sustainability begins with education: “move minds before bricks and mortar”(Clement Solomon, 2009) (Clement Solomon, 2009; Clement E Solomon and Fisher, 2009).

GI concepts can be brought into schools. Grade school students, for example, can participate in field trips; older students can participate with community groups in volunteer opportunities such as planting rain gardens. Schools and teachers can build curricula around, for example, tree cover programs. Students can create tree diameter measuring tapes, measure the size of trees, develop longitudinal databases, and graph tree size and percent growth based on past years’ data. They can also monitor survival rate, canopy cover, and root area and estimate runoff reduction and carbon sequestration. University students can participate in research projects to evaluate and refine GI techniques.

Educational signage at local parks and schools can inform entire communities; public service announcements on the radio and in the newspaper can, for example, foster knowledge about stormwater issues and solutions.

Workshops and other training opportunities for city employees, local landscaping companies, and community leaders can also institutionalize GI. Alternative maintenance protocols may be necessary. Training, therefore, must be offered in order for the practices to be successfully implemented. Federal financial assistance such as Brownfield Job Training Grants can provide the financial backing to train workers for “green” jobs; West Virginia communities throughout the state are using this opportunity. In addition, WVDO offers training to communities through the West Virginia Sustainable Communities program. The Riverside Sustainability Awareness Training provides similar opportunities for communities to reduce economic, social and environmental impacts.

Research can serve to highlight, as well as improve upon, existing projects. By researching design details and effectiveness of past projects, we are able to capitalize on our successes and create new and innovative ways to solve problems. Pilot projects can serve as test cases, providing data to refine GI techniques to better serve the needs and conditions of Region VI communities. Housing universities such as WVU and FSU, Region VI can serve as a hub for GI research in West Virginia.

REFERENCES

3 Rivers Wet Weather (2005) Nine Mile Run rain barrel initiative: final report. Pittsburgh.
Abrams G (2009) Case study: Philadelphia, Pennsylvania. Presented at Managing wet weather with green infrastructure, Charleston, WV. Jul 21-22.
Arbor Day Foundation (undated) Tree City standards. http://www.arborday.org/programs/treeCityUSA/standards.cfm Accessed Jan 27, 2010.
Arnold CL, Jr, Gibbons CJ (1996) Impervious surface coverage: the emergence of a key environmental indicator. Journal of the American Planning Association 62: 243-258.
American Society of Landscape Architects (ASLA) (2007) 2007 Professional Awards: General design honor award. http://www.asla.org/awards/2007/07winners/506_nna.html Accessed Sep 28, 2009.
Baer K (2009) Funding green infrastructure and water efficiency in the Chesapeake: results from the stimulus and new opportunities. American Rivers.
Barcousky L (2010) Allegheny County Office Building roof going green. Pittsburgh Post-Gazette, Jun 1.
Barr Engineering Company (2006) Burnsville stormwater retrofit study. Prepared for City of Burnsville.
Bedard Consulting, LLC (2010) Draft Clarksburg comprehensive plan update 2010.
Bellotte A, Howe M (2010) Clarksburg Public Works (AB) and City Manager (MH). Meeting with authors Hereford and Zegre. Mar 23.
Boesch DF, Brinsfield RB, Magnien RE (2001) Chesapeake Bay Eutrophication: scientific understanding, ecosystem restoration, and challenges for agriculture. Journal of Environmental Quality 30: 303-320.
Brabec E, Schulte S, Richards PL (2002) Impervious surfaces and water quality: a review of current literature and its implications for watershed planning. Journal of Planning Literature 16: 499-514.
Brown L (2009) Outreach Coordinator, Nine Mile Run Watershed Association. Email to author Hereford. Oct 9.
Carico G (2009) Brownfields 101. Presented at Annual West Virginia State Brownfields Conference, Morgantown. Oct 8-9.
Chesapeake Conservation Landscaping Council (CCLC) (2007) Conservation landscaping guidelines: the eight essential elements of conservation landscaping. Working draft. http://www.chesapeakelandscape.org/Guid1207%20.pdf Accessed Jun 18, 2010.
Chicago Department of Transportation (CDOT) (undated) The Chicago green alley handbook: an action guide to create a greener, environmentally sustainable Chicago.
Christian D (2009) Design considerations. Presented at Managing wet weather with green infrastructure, Charleston, WV. Jul 21-22.
City of Chattanooga (2010) Water quality program: water quality fee credits. http://www.chattanooga.gov/Public_Works/70_WQ_Credit_Outline.htm Accessed Jun 23, 2010.
City of Indianapolis (2009) Sustainindy: sustainable infrastructure initiative. http://www.sustainindy.org/sustainable-infrastructur.cfm Accessed Aug 14, 2009.
City of Madison (undated) Parking lots. Municipal code sec. 33.24(4)(f)9.b.
City of Morgantown (2007) Charges based on land area. Municipal code 929.06.
City of Olympia (1995) Impervious surface reduction study: final report. Public Works Department.
City of Phoenix (2006) Infill housing program incentives. http://phoenix.gov/BUSINESS/inflinct.html Accessed Jun 23, 2010.
Center for Neighborhood Technology (CNT) (2009) Green Values national stormwater management calculator: cost sheet. http://greenvalues.cnt.org/national/cost_detail.php Accessed Oct 10, 2009.
Cowles T (2009) Intern, West Run Watershed Association. Email to author Hereford. Aug 20.
Center for Urban Forest Research (CUFR) (2005) City of Boulder, Colorado municipal tree resource analysis. USDA Forest Service, Pacific Southwest Research Station. Prepared by EG McPherson, JR Simpson, PJ Peper, SL Gardner, KE Vargas, J Ho, Qingfu Xiao.
Center for Urban Horticulture (CUH) (2000) The calming effect of green: roadside landscape and driver stress. Fact sheet #8. University of Washington, College of Forest Resources.
Center for Watershed Protection (CWP) (1998) Better site design: a handbook for changing development rules in your community.
_______________ (2004) The do-it-yourself local site planning roundtable CD-ROM.

Center for Watershed Protection, Virginia Naturally, Virginia Department of Conservation and Recreation (CWP, VaNaturally, DCR) (2007) Better site design: an assessment of the better site design principals for communities implementing Virginia's Chesapeake Bay Preservation Act. Grant #NNA770Z0204.

DeMary M (2010) Stormwater Manager, City of Fairmont. Meeting with authors Boettner and Hereford. Jan 19.

Denzin B (2008) Local water policy innovation: a road map for community based stormwater solutions. American Rivers, Midwest Environmental Advocates.

Estornell P (2009) Benefits of Green Infrastructure. Presented at Managing Wet Weather with Green Infrastructure, Charleston, WV. Jul 21-22.

Federal Interagency Stream Restoration Working Group (FISRWG) (1998) Stream corridor restoration: principles, processes, and practices. GPO Item No. 0120-A; SuDocs No. A 57.6/2:EN3/PT.653. http://www.nrcs.usda.gov/technical/stream_restoration/newtofc.htm Accessed Aug 24, 2009.

Fairmont State University (FSU) (2009) FSU and Pierpont predict enrollment increases. http://www.fairmontstate.edu/node/6220 Accessed Nov 6, 2009.

General Assembly of North Carolina (GANC) (2007) Current operations and capital improvements appropriations act. Session Law 2007-323. 6.22(a). H1473.

Hansen E, Shrecongost A, Hunter S, Herd R, Schilz M, Boettner F, Bassage D (2008) West Virginia's municipal separate storm sewer system (MS4) National Pollutant Discharge Eliminaation System permit program. Prepared for USEPA Region 3, Office of Water. WV Water Research Institute, Downstream Strategies, WVU Political Science Department.

Herb WR, Janke B, Mohseni O, Stefan HG (2008) Thermal pollution of streams by runoff from paved surfaces. Hydrological processes 22: 987-999.

Intergovernmental Panel on Climate Change (IPCC) (2005) Carbon dioxide capture and storage. Working Group III.

Interstate Technology Regulatory Council (ITRC) (2009) Phytotechnology technical and regulatory guidance and decision trees, revised. Phytotechnologies Team.

Jaffe M (1993) Performance zoning: a reassessment. Land Use Law 45: 3-9.

Johnson PA (2007) A green roof grant program for Washington, DC. Presented at Greening Rooftops for Sustainable Communities Conference, Minneapolis. May 1.

Konchesky J (2010) Mayor, Star City. Meeting with author Zegre. Apr 9.

Lagström J (2004) Do extensive green roofs reduce noise? International Green Roof Institute, University of Malmö.

Leroy DA (2009) City of Clarksburg Public Works Foreman. Current list of beautification projects: letter to author Hereford. Oct 2.

Liu K, Baskaran B (2003) Thermal performance of green roofs through field evaluation. Presented at First North American green roof infrastructure conference, awards, and trade show: greening rooftops for sustainable communities, Chicago. May 29-30.

Lombardi C (2009) Pittsburgh gets its own Green Monster. http://news.cnet.com/8301-11128_3-10359553-54.html Accessed Oct 12, 2009.

Low Impact Development Center (2007) Rain garden design templates. http://www.lowimpactdevelopment.org/raingarden_design/templates.htm Accessed Jun 21, 2010.

Maupin M (2009a) Landscape Technician, City of Morgantown. Morgantown Beautification Commission project sites. Provided to author Hereford. Sep 29.

Maupin M (2009b) Landscape Technician, City of Morgantown. Telephone conversation with author Hereford.

Magnusson Klemencic Associates (MKA) (2007) Seattle green roof evaluation project: final report.

Molloy J (2009) Introduction to Green Infrastructure. Presented at Managing Wet Weather with Green Infrastructure, Charleston, WV. Jul 21-22.

Montgomery H (2009) Frederick County Public Schools greening initiative. Presented in the Urban Watershed Forestry webcast. Center for Watershed Protection. Nov 18.

Northern West Virginia Brownfields Assistance Center (NBAC) (2009) Final report and Stage II application. FOCUS WV Brownfields mini grant program.

Nephin D (2009) PNC installs 'green wall': company headquarters in Pittsburgh uses vegetation in its latest building design. http://www.timesleader.com/news/PNC_installs__lsquo_green_wall_rsquo__10-12-2009.html Accessed Oct 12, 2009.

New Brighton (undated) Stormwater utility credit application form. http://www.ci.new-brighton.mn.us/vertical/Sites/%7B2CF34F28-6DFB-45DA-AF59-36896254F224%7D/uploads/%7B00521E30-C211-44C8-A5DD-B0CB0E41DF03%7D.PDF Accessed Oct 7, 2009.

National Resources Defense Council (NRDC) (2006) Rooftops to rivers: green strategies for controlling stormwater and combined sewer overflows.

O'Dell M (2010) Assistant Superintendent, Cabell County Schools. Telephone call with author Hereford. Apr 29.

O'Toole CH (2009) The greening of Pittsburgh. The New York Times, Mar 31.

Ohio Environmental Protection Agency (OEPA) (1999) Ohio CWSRF provides loans for development best management practices. Update CWSRFA.

Offredo J (2009) Up on the roof: WVU's Brooks Hall goes 'green' with colorful foliage. The Charleston Gazette, Charleston, West Virginia. August 6.

Participatory Politics Foundation, Sunlight Foundation (2010) OpenCongress: HR 4202 - Green Infrastructure for Clean Water Act of 2009. http://www.opencongress.org/bill/111-h4202/show Accessed Jan 1, 2010.

Portland Bureau of Environmental Services (Portland BES) (2009) Downspout disconnection program. http://www.portlandonline.com/bes/index.cfm?c=43081&a=177712 Accessed Oct 7, 2009.

_______________ (2010) Sustainable stormwater. Ecoroof program. http://www.portlandonline.com/bes/index.cfm?c=44422 Accessed Jun 21, 2010.

Redmond City Council (2009) Green building and green infrastructure incentive program. Ordinance 2447.

Rokus D (2007) GIS analysis of potential storm water infiltration and runoff modeling for BMP construction in Hadley Valley watershed, Rochester, Minnesota. Volume 9, Papers in Resource Analysis 19.

Saulny S (2007) In miles of alleys, Chicago finds its next environmental frontier. The New York Times, Nov 26.

Schmitt S (2009) Case study: Sanitation District #1, Kentucky. Presented at Managing wet weather with green infrastructure, Charleston, WV. Jul 21-22.

Schueler T (1994) Use of cluster development to protect watersheds. Watershed Protection Techniques 1: 3-5.

Scruggs M (2009) Vacant and abandoned properties. Presented at Annual West Virginia State Brownfields Conference, Morgantown. Oct 8-9.

Sanitation District 1 (SD1) (undated) Public Service Park's BMP fact sheet series.

Seattle Public Utilities (2009) Disconnecting downspouts from the sewer system - safely! Factsheet series: Rain wise--managing storm water at home.

Sidwell Friends School (2010) Wildlife sightings. http://www.sidwell.edu/wildlife-sightings/index.aspx Accessed May 7, 2010.

Solomon CE (2009) WVU Director of Sustainability. Meeting with authors Boettner, Hansen, and Hereford. Nov 4.

Solomon CE, Fisher JC (2009) Envisioning sustainability: a systemic institutional innovation paradigm. Presented at 8th Greening of the Campus Conference, Ball State University, Indianapolis. Sep 20-23.

State of West Virginia (undated) Code: Chapter 8A. Land use planning.

StormwaterAuthority (undated) Pollutants commonly found in stormwater runoff. http://www.stormwaterauthority.org/pollutants/default.aspx Accessed Oct 16, 2009.

Tascarella P (2009) PNC to build green 'living wall' at Pittsburgh HQ. Pittsburgh Business Times, Jul 22.

Templeton D (2009) Pitt study shows green roofs help delay rainwater and sewage overflow. Pittsburgh Post-Gazette, July 22.

Thurston HW, Roy AH, Shuster WD, Morrison MA, Taylor MA, Cabezas H (2008) Using economic incentives to manage stormwater runoff in the Shepher Creek watershed, part 1. US Environmental Protection Agency. EPA/600/R-08-129

Tzoulas K, Korpela K, Venn S, Yli-Pelkonen V, Kaźmierczak A, Niemela J, James P (2007) Promoting ecosystem and human health in urban areas using green infrastructure: a literature review. Landscape and Urban Planning 81: 167-178.

University of New Hampshire Stormwater Center (UNHSC) (2008) Treatment unit fact sheets: porous asphalt.

_______________ (undated) Porous asphalt pavement for stormwater management.

US Census Bureau (2009) American FactFinder. Census 2000 data. http://factfinder.census.gov Accessed Oct 6, 2009.

US Department of Energy (USDOE) (2004) Federal technology alert: green roofs. DOE/EE-0298. Federal Energy Management Program. http://www1.eere.energy.gov/femp/pdfs/fta_green_roofs.pdf Accessed Jun 21, 2010.
US Department of Justice (USDOJ) (2009) Federal Bureau of Prisons. Weekly population report: October 1, 2009. http://www.bop.gov/locations/weekly_report.jsp Accessed Oct 6, 2009.
US Environmental Protection Agency (USEPA) (1999) National pollutant discharge elimination system--regulations for revision of the water pollution control program addressing storm water discharges. Vol 40 CFR Parts 9, 122, 123, and 124, 68722-68802. 64.
_______________ (2004) Report to Congress: impacts and control of CSOs and SSOs. EPA 833-R-04-001. Office of Water.
_______________ (2006) Office of Wastewater Management. Post-construction stormwater management in new development and redevelopment. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5 Accessed Jun 21, 2010.
_______________ (2007) Reducing stormwater costs through low impact development (LID) strategies and practices. EPA 841-F-07-006. Prepared under contract no. 68-C-02-108. Nonpoint Source Control Branch.
_______________ (2008a) Green streets. EPA-833-F-08-009. Managing wet weather with green infrastructure municipal handbook series.
_______________ (2008b) Rainwater harvesting policies. EPA-833-F-08-010. Managing wet weather with green infrastructure municipal handbook series.
_______________ (2008c) Retrofit policies. EPA-833-F-08-008. Managing wet weather with green infrastructure municipal handbook series.
_______________ (2009a) Attachment 7: CWSRF project descriptions and examples for green project reserve. Office of Water. http://www.epa.gov/ow/eparecovery/docs/STIMULUS_Guidance_Green_Reserve.pdf Accessed Jan 6, 2010.
_______________ (2009b) Incentive mechanisms. EPA-833-F-09-001. Managing wet weather with green infrastructure municipal handbook series.
_______________ (2009c) Region 3. Mid-Atlantic combined sewer overflows quick finder. http://www.epa.gov/reg3wapd/cso/index.htm Accessed Oct 6, 2009.
_______________ (2009d) Proposal guidelines for Brownfields cleanup grants. RFP: EPA-OSWER-OBLR-09-05. Office of Solid Waste and Emergency Response.
_______________ (2009e) Stormwater management handbook: implementing green infrastructure in northern Kentucky communities. Prepared by Nevue Ngan Associates, Eisen|Letunic, Van Meter Williams Pollack LLP, and ICF International.
_______________ (2009f) Technical guidance on implementing the stormwater runoff requirements for federal projects under section 438 of the Energy Independence and Security Act. EPA 841-B-09-001. Office of Water.
_______________ (2009g) Water quality scorecard: incorporating green infrastructure practices at municipal, neighborhood, and site scales. Managing wet weather with green infrastructure municipal handbook series.
US Forest Service (USFS) (2005) Urban watershed forestry manual. Part 1: methods for increasing forest cover in a watershed. NA-TP-04-05. Northeastern Area State and Private Forestry. Prepared by Center for Watershed Protection.
US Green Building Council (USGBC) (2009) Intro - what LEED is. http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1988 Accessed Oct 15, 2009.
US Geological Survey (USGS) (2005) Estimated use of water in the United States: county-level data for 2005. West Virginia. http://water.usgs.gov/watuse/data/2005/index.html Accessed Jun 21, 2010.
Veatch B (2008) KC-one city-wide comprehensive stormwater management plan executive summary (draft). Prepared for City of Kansas City, Water Services Department.
Veselka S (2009) Executive Director, Friends of Deckers Creek. Email to author Hereford. Oct 8.
Wachter S (2005) The determinants fo neighborhood transformation in Philadelphia. Identification and analysis: the New Kensington pilot study. The Wharton School, University of Pennsylvania.

Walter P Moore, Gensler, Clark Condon Associates, Dan Pope Associates (2010) Urban redevelopment design challenge. Prepared for Houston Land/Water Sustainability Forum. Team 21184.
Wisconsin Department of Natural Resources (WDNR) (2003) Rain gardens: a how-to manual for homeowners. PUB-WT-776 2003.
Wolf KL (2005) Business district streetscapes, trees, and consumer response. J For 103: 396-400.
West Run Watershed Association (WRWA) (2009) News http://westrun.org/news.html Accessed Aug 14, 2009
West Virginia Department of Environmental Protection (WVDEP) (2008) West Virginia integrated water quality monitoring and assessment report. Division of Water and Waste Management.
_______________ (2009a) ArcGIS shapefile: WV2008_Impaired_by_pollutant_draft_20090520.
_______________ (2009b) Fact sheet, rationale and information for General WV/NPDES Permit for small Municipal Separate Storm Sewer Systems (MS4s). Division of Water and Waste Management.
_______________ (2009c) General National Pollution Discharge Elimination System water pollution control permit. Permit no. WV0116025. Division of Water and Waste Management.
_______________ (2009d) Division of Water and Waste Management. Water and waste management news. http://www.wvdep.org/item.cfm?ssid=11 Accessed Aug 25, 2009.
_______________ (2010) Water and Waste Management. Upcoming MS4 workshops. http://www.dep.wv.gov/WWE/Programs/stormwater/MS4/workshops/Pages/default.aspx Accessed Apr 30, 2010.
West Virginia University (WVU) (2009) Division of University Relations. WVU sets record fall enrollment on opening day. http://wvutoday.wvu.edu/n/2009/8/26/7986 Accessed Oct 13, 2009.
Young J (2009) The steel city builds green. Living on Earth. National Public Radio.
Zegre SJ, Kirby P (2009) Building visions of almost heaven: an innonvative program helps redevelop brownfield sites in West Virginia. Environmental Practice 11: 320-321.

APPENDIX A: IMPAIRED STREAMS IN REGION VI

Table 13: Impaired streams in Region VI

Stream name	County	Stream code	Impairments
Aaron Creek	Monongalia	WVM-8-A	Bio
Ann Moore Run	Harrison	WVMW-21-B	Bio
Ann Run	Harrison	WVMW-15-E	Bio
Barnes Run	Preston	WVMC-12-B-2	Fecal
Barnett Run	Harrison	WVMW-15-C	Bio
Bartlett Run	Taylor	WVMW-15-K	Bio, Fe, Mn, pH
Beards Run	Harrison, Taylor	WVMW-15-G	Fe
Beaver Creek	Preston	WVMC-12-B-1	Fe, Mn, pH
Bennett Run	Harrison	WVMW-13-B-2	Bio, Fe, Mn, pH
Berkeley Run	Taylor	WVMT-11	Bio, Fe, Mn, pH
Berry Run	Taylor	WVMT-11-B-1	Fe, Mn, pH
Berry Run	Taylor	WVMW-15-I	Bio, Fe, Mn, pH
Big Elk Creek	Harrison	WVMW-13-B-6	Bio, Fe, Mn
Big Isaac Creek	Doddridge	WVOMI-46-R	Bio
Big Sandy Creek	Preston	WVMC-12	Al (trout), Bio, Fecal, Fe, Mn, pH
Bingamon Creek	Harrison, Marion	WVMW-7	Bio, Fe
Birch Hollow	Monongalia	WVMC-2.5-A	Fecal
Birchfield Run	Monongalia	WVM-15	Fe, Mn, pH
Birchroot Run	Preston	WVMC-33-C	Fecal
Birds Creek	Preston	WVMT-12-H	Fe, Mn, pH
Birds Run	Harrison	WVMW-21-O	Bio, Fe, Mn
Blacks Run	Monongalia	WVM-1-B.3	Bio
Bonds Run	Harrison	WVMW-26-A	Bio, Fe, Mn
Booths Creek	Monongalia	WVM-10	Al (trout), Bio, Fe, Mn, pH
Booths Creek	Marion, Harrison, Taylor	WVMW-2	Bio, Fe, Mn
Brains Creek	Preston, Monongalia	WVMT-12-G-2	Fe, Mn, pH
Brand Run	Preston, Monongalia	WVM-11	Bio, Fe, Mn, pH
Browns Creek	Harrison	WVMW-23	Bio, Fe, Mn
Browns Run	Harrison	WVMW-10	Bio, Fe, Mn
Brushy Fork	Harrison	WVMW-21-G	Bio, Fe, Mn
Buck Run	Taylor	WVMW-15-J-1	Bio, Fe, Mn, pH
Buckeye Run	Doddridge	WVOMI-47-C	Bio
Buckhorn Run	Preston	WVMC-31	pH
Bucklick Run	Preston	WVMC-32-E	Fecal
Buffalo Creek	Marion	WVM-23	Bio
Buffalo Creek	Harrison	WVMW-27	Bio, Fe, Mn
Buffalo Run	Preston	WVMC-22	Al, pH
Buffalo Run	Preston	WVMY-0.2	Fecal, pH
Building Run	Monongalia	WVM-1-C-3-A	Fecal
Building Run	Monongalia	WVM-1-E-5	Bio
Bull Run	Preston	WVMC-11	Al, Bio, Fe, Mn, pH
Camp Run	Monongalia	WVM-1-F-6-A	Bio, Fecal
Camp Run	Monongalia	WVM-2.1	Bio, Fe, Mn, pH
Campbell Run	Marion	WVM-23-O-7	Bio
Cheat River	Preston	WVMC	Fe, Zn, pH
Cherry Run	Preston	WVMC-12-B-5	Al (trout), Fecal, Fe, Mn, pH
Cherrycamp Run	Harrison	WVMW-13-I-2	Bio, Fe, Mn
Church Creek	Preston	WVMC-23-A	Al, Bio, Fe, Mn, pH
Coal Lick Run	Marion	WVMW-7-F-1	Bio
Cobun Creek	Monongalia	WVM-9	Fe, Mn, pH
Coburn Fork	Harrison	WVMW-13-N	Fe, Mn, pH
Coburns Creek	Harrison	WVMW-24	Fe, Mn
Coles Run	Monongalia	WVMC-2.5	Bio, Fecal
Conner Run	Preston	WVMC-13.5	Al, Fe, Mn, pH
Coons Run	Harrison, Marion	WVMW-3	Bio, Fe, Mn, pH
Coplin Run	Harrison	WVMW-21-G-1	Bio, Fe, Mn
Crab Orchard Run	Preston	WVMC-17-0.7A	Bio, Fe
Crafts Run	Monongalia	WVM-4-A	Bio, Fe, Mn, pH

Stream name	County	Stream code	Impairments
Crammeys Run	Monongalia	WVMC-3	Fecal, Fe, Mn
Crooked Run	Harrison	WVMW-19	Bio, Fe, Mn, pH
Cunningham Run	Harrison	WVMW-7-D	Bio, Fe
Davisson Run	Harrison	WVMW-15-D	Bio
Davisson Run	Harrison	WVMW-22	Bio
Days Run	Monongalia	WVM-1-C	Bio, Fecal
Deckers Creek	Monongalia, Preston	WVM-8	Bio, Fe, Mn, pH
Dents Run	Monongalia	WVM-7	Bio, Fe, Mn
Dents Run	Marion	WVM-23-P	Bio
Dillan Creek	Preston	WVM-8-G	Fe, Mn
Dolls Run	Monongalia	WVM-1-A	Bio, Fecal
Duck Creek	Harrison	WVMW-28	Bio
Dunkard Creek	Monongalia	WVM-1	Bio, Fecal, Fe
Elk Creek	Harrison	WVMW-21	Bio, Fe, Mn
Elk Run	Preston	WVMC-12-B-4	pH
Elklick Run	Harrison	WVMW-7-C	Fe, Mn
Fall Run	Harrison	WVMW-18	Bio, Fe, Mn, pH
Fickey Run	Preston	WVMC-17-A-0.5	Al, Bio, Fecal, Fe, Mn, pH
Flag Run	Harrison	WVMW-13-E.5	Bio
Flaggy Meadow Run	Monongalia	WVM-14	Fe
Flaggy Meadow Run	Monongalia	WVM-7-A	Bio
Fleming Fork	Marion	WVM-23-N-1	Fe, Mn
Gabe Fork	Taylor	WVMW-15-J-3	Bio, Fe, Mn, pH
Glade Fork	Marion	WVMW-7-F	Bio
Glade Run	Preston	WVMC-12-B-1-A	Fecal, Fe, Mn, pH
Glade Run	Preston	WVMC-12-D	Fecal, Fe
Glade Run	Preston	WVMC-12-E	Fecal, Fe
Glade Run	Preston	WVMC-17-A-1	Al, Bio, Fe, Mn, pH
Glade Run	Taylor	WVMT-18-C	Fe, Mn, pH
Glady Run	Preston	WVM-8-D	Bio, Fe, Mn, pH
Gnatty Creek	Harrison	WVMW-21-M	Bio, Fe, Mn
Goose Creek	Marion	WVMT-4	Bio, Fe, Mn, pH
Grassy Run	Marion	WVM-19-E	Bio
Greens Run	Preston	WVMC-16	Al, Bio, Fe, Mn, pH
Gregory Run	Harrison	WVMW-13-D	Bio, Fe, Mn
Guston Run	Monongalia	WVM-6-B	Bio
Hackers Creek	Harrison	WVMW-31	Bio, Fe, Mn, pH
Halls Run	Harrison	WVMW-13-J	Bio
Hartman Run	Monongalia	WVM-8-0.5A	Bio, Fe, Mn, pH
Hazel Run	Preston	WVMC-12-C	Al (trout), Bio, Fecal, Fe, Mn, pH
Heather Run	Preston	WVMC-24	Al, Bio, Fe, Mn, pH
Helens Run	Marion	WVMW-4	Bio
Hog Lick Run	Marion	WVMW-2-A	Bio, Fe, Mn
Hog Run	Preston	WVMC-12-B-3	Fe, Mn, pH
Hooppole Run	Harrison	WVMW-21-F	Fe, Mn
Horners Run	Harrison, Marion	WVMW-2-D	Bio, Fe, Mn, pH
Indian Creek	Monongalia	WVM-17	Bio, Fe
Isaac Creek	Harrison	WVMW-13-C	Bio, Fe, Mn
Isaacs Creek	Harrison	WVMW-29	Bio
Jack Run	Harrison	WVMW-13-0.5A	Bio, Fe, Mn
Jack Run	Harrison	WVMW-15-A	Bio, Fe, Mn, pH
Jack Run	Harrison	WVMW-17	Bio, Fe, Mn
Jakes Run	Monongalia	WVM-1-B.1	Bio, Fecal
Jerry Run	Taylor	WVMW-15-H	Fe, Mn, pH
Joes Run	Preston	WVMC-26	Al, Bio, Fe, Mn, pH
Joes Run	Marion	WVM-23-R	Fe, Mn, pH
Johnson Fork	Harrison	WVMW-20-C	Bio
Jones Creek	Harrison	WVMW-13-A	Bio, Fe, Mn
Jump Rock Run	Preston	WVMC-17-B	Al (trout), Fe, pH
Kanes Creek	Preston	WVM-8-I	Fe, Mn, pH
Katy Lick Run	Harrison	WVMW-13-E	Bio, Fe, Mn
Kelly Run	Monongalia	WVMC-2.7	Bio, Fecal, Fe
Lambert Run	Harrison	WVMW-16	Bio, Fe, Mn, pH
Laurel Run	Preston, Monongalia	WVM-8-H	Fe, Mn, pH

Stream name	County	Stream code	Impairments
Laurel Run	Preston	WVMY-2-0.2A	Al, Fe, pH
Laurel Run	Monongalia	WVM-2.7	Fe, Mn, pH
Laurel Run	Harrison	WVMW-13-B-4	Fe, Mn
Laurel Run	Harrison	WVMW-8	Bio, Fe, Mn
Left Fork Bull Run	Preston	WVMC-11-D	pH
Left Fork/Little Sandy Creek	Preston	WVMT-18-E-3	Fe, Mn, pH
Left Fork/Sandy Creek	Preston	WVMT-18-G	Fe, Mn, pH
Lick Run	Preston	WVMC-11-B-1	Al, Fe, Mn, pH
Lick Run	Preston	WVMC-18-A	pH
Lick Run	Preston	WVMC-25	Al, Bio, Fe, Mn, pH
Limestone Run	Harrison	WVMW-20	Bio
Little Indian Creek	Monongalia	WVM-17-A	Bio
Little Isaac Creek	Harrison	WVMW-13-C-1	Fe, Mn
Little Laurel Run	Preston	WVMC-12-A-1	Al (trout), pH
Little Laurel Run	Preston	WVMY-2-0.2A-1	pH
Little Lick Run	Preston	WVMC-18-A-1	Fecal
Little Raccoon Creek	Preston	WVMT-12-C-2	Fe, Mn
Little Rockcamp Run	Harrison	WVMW-13-F-1	Bio, Fe, Mn
Little Sandy Creek	Preston	WVMC-12-B	Bio, Fecal, Fe, Mn, pH
Little Sandy Creek	Preston, Taylor	WVMT-18-E	Al, Bio, Fe, Mn, pH
Little Tenmile Creek	Harrison	WVMW-13-B	Bio, Fe, Mn
Long Run	Harrison, Marion	WVMW-7-B	Bio
Long Run	Taylor	WVMT-11-B	Bio, Fe, Mn, pH
Lost Creek	Harrison	WVMW-26	Bio, Fe, Mn
Lost Run	Taylor	WVMT-5	Fe, Mn, pH
Mahan Run	Marion	WVM-23-L	Bio
Maple Run	Preston, Taylor	WVMT-18-E-1	Fe, Mn, pH
Maple Run	Preston	WVMY-5	Bio, Fecal
Maple Run	Monongalia	WVMC-5	Al, pH
Martin Creek	Preston	WVMC-17-A	Al, Bio, Fe, Mn, pH
Mays Run	Monongalia	WVM-10-E	Fe, Mn, pH
McElroy Creek	Doddridge	WVOMI-30	Bio
Meathouse Fork	Doddridge	WVOMI-46	Bio
Middle Fork/South Fork/Hughes River	Doddridge	WVLKH-9-AA	Bio
Middle Fork/South Fork/West Virginia Fork/Dunkard Creek	Monongalia	WVM-1-F-7-A	Fecal
Middle Island Creek	Doddridge	WVOMI	Bio, Fecal, Fe, Hg, PCBs
Middle Run	Preston	WVMC-11-A	Al, Fe, Mn, pH
Middle Run/Little Tenmile Creek	Harrison	WVMW-13-B-7	Bio
Mill Run	Preston	WVMC-12-B-6	Al (trout), Fe
Miracle Run	Monongalia	WVM-1-E	Bio, Fecal
Mod Run	Marion	WVM-23-K	Fe, Mn
Monongahela River	Monongalia, Marion	WVM	Fecal, PCBs
Morgan Run	Preston	WVMC-23	Al, Bio, Fe, Mn, pH
Mountain Run	Preston	WVMC-11-B	Al, Fe, Mn, pH
Muddy Creek	Preston	WVMC-17	Al (trout), Bio, Fecal, Fe, Mn, pH
Mudlick Run	Harrison	WVMW-13-B-9	Bio, Fe, Mn, pH
Mudlick Run	Harrison	WVMW-9	Bio, Fe, Mn, pH
Murphy Run	Harrison	WVMW-21-A	Bio, Fe, Mn, pH
North Branch/Snowy Creek	Preston	WVMY-2-A	Fecal, Fe
North Fork/West Virginia Fork/Dunkard Creek	Monongalia	WVM-1-F-6	Bio, Fecal
Nutter Run	Harrison	WVMW-21-D	Bio, Fe, Mn
Owl Creek	Monongalia	WVM-10-D	Bio, Fe, Mn, pH
Parker Run	Preston	WVMC-12-0.7A	Fecal, Fe
Parker Run	Marion	WVM-20	Fe, Mn, pH
Patterson Fork	Harrison	WVMW-13-I-3	Bio, Fe, Mn
Paw Paw Creek	Marion, Monongalia	WVM-22	Bio
Pedlar Run	Monongalia	WVM-1-A-1	Bio, Fecal
Peters Run	Harrison	WVMW-13-B-1	Bio, Fe, Mn
Pharaoh Run	Marion	WVM-21	Fe
Phoenix Hollow	Harrison	WVMW-20-D	Bio
Pigotts Run	Harrison	WVMW-12-A	Bio, Fe, Mn
Piney Run	Preston	WVMC-12-B-4.5	Fecal, Fe, pH
Pringle Run	Preston	WVMC-27	Al, Bio, Fe, Mn, pH

Stream name	County	Stream code	Impairments
Purdys Run	Harrison	WVMW-2-D-1	Bio, Fe, Mn, pH
Pyles Fork	Marion	WVM-23-O	Bio
Raccoon Creek	Preston, Taylor	WVMT-12-C	Al, Bio, Fe, Mn, pH
Range Run	Monongalia	WVM-1-F-5	Bio, Fecal
Rhine Creek	Preston	WVMY-4	Fecal
Right Branch/Miracle Run	Monongalia	WVM-1-E-2	Bio, Fecal
Right Fork Bull Run	Preston	WVMC-11-E	Al, Bio, Fe, Mn, pH
Right Fork/Simpson Creek	Taylor	WVMW-15-J	Bio, Fe, Mn, pH
Roaring Creek	Preston	WVMC-18	Al (trout), Fe, Mn, pH
Roberts Run	Monongalia	WVM-1-D.4	Fecal
Robinson Run	Marion, Monongalia	WVM-22-C	Fe, Mn, pH
Robinson Run	Monongalia	WVM-4	Bio, Fe, Mn, pH
Robinson Run	Harrison	WVMW-12	Bio, Fe, Mn
Rockcamp Run	Harrison	WVMW-13-F	Bio, Fe, Mn
Rooting Creek	Harrison	WVMW-21-M-1	Bio
Rush Run	Doddridge	WVLK-75-K-7	Bio
Salem Fork	Harrison	WVMW-13-I	Bio
Sand Fork	Doddridge	WVLK-75-N-5	Bio
Sand Lick Run	Taylor	WVMW-15-J-2	Bio, Fe, Mn, pH
Sandy Creek	Preston, Taylor	WVMT-18	Bio, Fe, Mn, pH
Scott Run	Monongalia	WVM-1-E-4	Fecal
Scotts Run	Monongalia	WVM-6	Bio, Fe, Mn
Shaw Run	Harrison	WVMW-13-N-1	Fe, Mn, pH
Shelby Run	Taylor	WVMT-11-A	Bio, Fe, Mn, pH
Shinns Run	Harrison	WVMW-11	Bio, Fe, Mn, pH
Shriver Run	Monongalia	WVM-1-C-3	Bio, Fecal, Fe
Simpson Creek	Harrison, Taylor	WVMW-15	Bio, Fe, Mn
Simpson Fork	Harrison	WVMW-20-B	Bio, Fe, Mn
Slabcamp Run	Preston	WVM-8-F	Fe, Mn, pH
Smith Run	Harrison	WVMW-15-B	Bio, Fe, Mn, pH
Smoky Drain	Monongalia	WVM-1-A-2	Bio, Fecal
Snowy Creek	Preston	WVMY-2	Bio, Fecal, Fe
South Branch/Snowy Creek	Preston	WVMY-2-B	Fecal
South Fork/Greens Run	Preston	WVMC-16-A	Al, Bio, Fe, Mn, pH
South Fork/West Virginia Fork/Dunkard Creek	Monongalia	WVM-1-F-7	Bio, Chloride, Fecal, Fe
Sovern Run	Preston	WVMC-12-0.5A	Al, Bio, Fecal, Fe, Mn, pH
Spruce Run	Preston	WVMC-32-B	Fe
Squires Creek	Preston	WVMT-12-H-1	Fe, Mn, pH
Stone Coal Run	Harrison	WVMW-20-A	Bio
Stonecoal Run	Harrison	WVMW-21-G-3	Bio
Stouts Run	Harrison	WVMW-21-N	Bio
Sugar Run	Marion	WVM-22-K	Fe, Mn, pH
Sugarcamp Run	Preston	WVMC-17-C	Al (trout), pH
Sweep Run	Harrison, Marion	WVMW-2-C	Bio, Fe, Mn
Sycamore Creek	Harrison	WVMW-25	Fe, Mn
Sypolt Run	Preston	WVMC-17-0.5A	Fe, pH
Tenmile Creek	Harrison	WVMW-13	Bio, Fe, Mn
Thomas Run	Monongalia	WVM-1-E-1	Fecal
Three Fork Creek	Taylor, Preston	WVMT-12	Al, Bio, Fe, Mn, pH
Turkey Run	Harrison	WVMW-21-E	Bio, Fe, Mn
Tygart Valley River	Taylor, Marion	WVMT	Fecal
UNT/Beaver Creek RM 1.25	Preston	WVMC-12-B-1-B	pH
UNT/Beaver Creek RM 1.68	Preston	WVMC-12-B-1-C	Al, Fe, Mn, pH
UNT/Big Sandy Creek RM 10.23	Preston	WVMC-12-D.4	Fecal
UNT/Big Sandy Creek RM 2.91	Preston	WVMC-12-0.2A	Al, Fe, Mn, pH
UNT/Birds Creek RM 2.57	Preston	WVMT-12-H-4	Bio
UNT/Booths Creek RM 1.39	Marion	WVMW-2-0.1A	Bio, Fe, Mn, pH
UNT/Booths Creek RM 3.58	Marion	WVMW-2-0.5A	Fe, Mn, pH
UNT/Booths Creek RM 4.11	Marion	WVMW-2-0.6A	Bio
UNT/Booths Creek RM 4.81	Marion	WVMW-2-0.8A	Bio
UNT/Booths Creek RM 6.27	Monongalia	WVM-10-F	Fe, Mn, pH
UNT/Booths Creek RM 8.22	Marion	WVMW-2-D.5	Fe, Mn
UNT/Bull Run RM 1.64	Preston	WVMC-11-0.1A	Al, pH
UNT/Bull Run RM 3.73	Preston	WVMC-11-C	Al, Fe, Mn, pH

Stream name	County	Stream code	Impairments
UNT/Camp Run RM 0.79	Monongalia	WVM-2.1-A	Bio
UNT/Cheat River RM 1.85	Monongalia	WVMC-0.1	Al, Fe, pH
UNT/Cheat River RM 4.07	Monongalia	WVMC-0.5	Al, Fe, Mn, pH
UNT/Cheat River RM 7.70	Monongalia	WVMC-2.3	Al, Fe, Mn, pH
UNT/Cheat River RM 8.39	Monongalia	WVMC-2.4	Al, Fe, Mn, pH
UNT/Cherry Run RM 1.96	Preston	WVMC-12-B-5-C	Fe, pH
UNT/Church Creek RM 1.26	Preston	WVMC-23-A-1	Al, Fe, Mn, pH
UNT/Days Run RM 5.8	Monongalia	WVM-1-C-4	Bio, Fecal
UNT/Deckers Creek RM 18.48	Preston	WVM-8-J	Lead
UNT/Deckers Creek RM 5.70	Monongalia	WVM-8-A.7	Bio, Fe, Mn, pH
UNT/Dents Run RM 3.60	Monongalia	WVM-7-C	Fe, Mn, pH
UNT/Dents Run RM 5.82	Monongalia	WVM-7-G	Bio
UNT/Finchs Run RM 1.15	Marion	WVM-23-B-1	Bio
UNT/Glade Run RM 1.06	Preston	WVMC-17-A-1-A	Al, Fe, Mn, pH
UNT/Glade Run RM 1.36	Preston	WVMC-17-A-1-B	Al, Fe, Mn, pH
UNT/Heather Run RM 1.47	Preston	WVMC-24-A	Fecal, Fe, Mn, pH
UNT/Jakes Run RM 2.33	Monongalia	WVM-1-B.1-2	Fecal
UNT/Jakes Run RM 5.5	Monongalia	WVM-1-B.1-12	Fecal
UNT/Kanes Creek RM 2.49	Preston	WVM-8-I-1	Fe, pH
UNT/Lambert Run RM 2.77	Harrison	WVMW-16-B	Bio
UNT/Lick Run RM 1.04	Preston	WVMC-25-A	Al, Fe, Mn, pH
UNT/Little Sandy Creek RM 2.80	Preston	WVMC-12-B-0.6	Fecal
UNT/Little Sandy Creek RM 5.04	Preston	WVMC-12-B-0.8	Fecal
UNT/Little Tenmile Creek RM 1.91	Harrison	WVMW-13-B-1.5	Bio, Fe, Mn
UNT/Lost Creek RM 3.32	Harrison	WVMW-26-0.5A	Bio, Fe, Mn
UNT/Maple Run RM 5.22	Preston	WVMY-5-E	Fecal
UNT/Monongahela River RM 123.45	Marion	WVM-20.2	Fe, Mn, pH
UNT/Monongahela River RM 128.55	Marion	WVM-25.9	Fe, Mn, pH
UNT/Monongahela River RM 93.07	Monongalia	WVM-2.6	Fe, Mn, pH
UNT/Morgan Run RM 1.03	Preston	WVMC-23-0.2A	Bio, Fecal, Fe, Mn, pH
UNT/Muddy Creek RM 9.80	Preston	WVMC-17-A.8	Fecal, Fe
UNT/Patterson Fork RM 0.59	Harrison	WVMW-13-I-3-B	Bio
UNT/Pedlar Run RM 1.20	Monongalia	WVM-1-A-1-B	Fecal
UNT/Pringle Run RM 1.75	Preston	WVMC-27-A	Fe, Mn, pH
UNT/Pringle Run RM 3.17	Preston	WVMC-27-C	Al, Fe, pH
UNT/Pringle Run RM 3.33	Preston	WVMC-27-D	Al, Fe, pH
UNT/Pringle Run RM 3.60	Preston	WVMC-27-E	Al, Fe, Mn, pH
UNT/Ragtavern Run RM 0.81	Preston	WVMC-20-A-1	Fecal
UNT/Right Fork RM 0.33/Simpson Creek	Taylor	WVMW-15-J-0.3	Fe, Mn, pH
UNT/Roaring Creek RM 0.34	Preston	WVMC-18-0.1A	Fecal
UNT/Robinson Run RM 1.08	Harrison	WVMW-12-B	Fe, Mn
UNT/Robinson Run RM 1.09	Monongalia	WVM-4-B	Fe, Mn, pH
UNT/Shinns Run RM 3.69	Harrison	WVMW-11-D	Bio
UNT/Shinns Run RM 4.15	Harrison	WVMW-11-E	Bio
UNT/Shinns Run RM 5.61	Harrison	WVMW-11-F	Bio
UNT/Shinns Run RM 5.97	Harrison	WVMW-11-G	Bio
UNT/Simpson Creek RM 1.23	Harrison	WVMW-15-0.5A	Bio, Fe, Mn, pH
UNT/Simpson Creek RM 21.92	Taylor	WVMW-15-J.5	Bio, Fe, Mn, pH
UNT/South Fork RM 0.63/Greens Run	Preston	WVMC-16-A-1	Al, Bio, Fe, Mn, pH
UNT/South Fork RM 3.0/West Virginia Fork	Monongalia	WVM-1-F-7-F	Chloride
UNT/Tenmile Creek RM 10.82	Harrison	WVMW-13-E.7	Bio, Fe, Mn
UNT/UNT RM 0.12/Church Creek RM 1.26	Preston	WVMC-23-A-1-A	Al, Fe, Mn, pH
UNT/UNT RM 0.12/Muddy Creek RM 9.80	Preston	WVMC-17-A.8-1	Al, pH
UNT/UNT RM 0.34/Morgan Run RM 1.03	Preston	WVMC-23-0.2A-1	Fecal
UNT/Webster Run RM 1.25	Preston	WVMC-12-B-0.5-B	Al, Bio, pH
UNT/West Fork River RM 11.44	Marion, Harrison	WVMW-7.1	Bio, Fe, Mn, pH
UNT/West Fork River RM 13.10	Harrison	WVMW-8.5	Bio, Fe, Mn, pH
UNT/West Fork River RM 13.91	Harrison	WVMW-9.5	Bio, Fe, Mn, pH
UNT/West Fork River RM 20.42	Harrison	WVMW-14.2	Bio, Fe, Mn, pH
UNT/West Fork River RM 37.02	Harrison	WVMW-22.8	Bio
Wades Run	Monongalia	WVM-6-A	Bio
Wardwell Run	Preston	WVMY-2-A-1	Bio, Fecal
Washburncamp Run	Harrison	WVMW-22-A	Bio, Fe, Mn
Webster Run	Preston	WVMC-12-B-0.5	Bio, Fecal, Fe, Mn, pH

Stream name	County	Stream code	Impairments
West Fork River	Harrison, Marion	WVMW	Bio, Fecal, Fe, PCBs, Zn
West Run	Monongalia	WVM-3	Bio, Fe, Mn, pH
West Virginia Fork/Dunkard Creek	Monongalia	WVM-1-F	Bio, Chloride, Fecal, Fe
Whetstone Run	Marion	WVM-23-Q	Bio, Fe, Mn, pH
Whites Run	Monongalia	WVMC-4	Bio, Fecal
Wickwire Run	Taylor	WVMT-8	Bio
Wilhelm Run	Doddridge	WVOMI-40-E	Bio
Wise Run	Monongalia	WVM-1-F-3	Bio, Fecal
Youghiogheny River	Preston	WVMY	Bio

Source: WVDEP (2009a).

APPENDIX B: REGION VI INTERVIEW LIST

Organization	County	Interviewee(s)	Date(s)
Cabell County Schools	Cabell	Mike O'Dell, *Assistant Superintendent of Operations*	4/29/2010
City of Clarksburg	Harrison	Martin Howe, *City Manager* Anthony Bellotte, *Public Works Superintendent*	3/23/2010
City of Fairmont	Marion	Mike DeMary, *Stormwater Manager* Kathy Wyrosdick, *City Planner*	1/19/2010
City of Morgantown	Monongalia	Jeff Mikorski, *Assistant City Manager* Marchetta Maupin, *Urban Landscape Technician*	3/16/2010 4/15/2010
City of Morgantown Urban Landscape Commission	Monongalia	Kara Hurst *(Chair)*, Marchetta Maupin, Jennie Selin, Jerry Steketee, Ralph LaRue, Marilyn Bowers, Annette Tanner, Anne Cumming, Kitty Lozier, Sandy Poulson, Bill McDonald, *Urban Landscape Commission*	11/18/2009 12/16/2009 4/15/2010
City of Reedsville	Preston	Martin Christ, *Reedsville Revitalization Committee, Friends of Deckers Creek*	1/7/2010
Fairmont State University Physical Plant	Marion	James Decker, Tom Tucker, Jamie Colanero, Stephanie Slaubaugh	12/14/2009 4/15/2010
Morgantown Utility Board	Monongalia	Doug Smith, *Senior Engineer* Scott Copen, *Staff Engineer*	12/10/2009
Preston County Economic Development Authority	Preston	Robbie Baylor, *Executive Director*	12/17/2009
Region VI Planning & Development Council	Region VI	Jim Hall, *Executive Director*	11/18/2009
Taylor County Development Authority	Taylor	Bob Gorey, *Director*	1/19/2010
Town of Flemington	Taylor	Bradley Mayle, *Mayor* Town Council	1/14/2010
Town of Star City	Monongalia	Jim Konchesky, *Mayor*	4/9/2010
West Virginia Botanic Garden	Monongalia	Linda Bagby, *Development Director*	4/23/2010
West Virginia Department of Environmental Protection	All counties	Sherry Wilkins, *MS4 Coordinator*	10/29/2009
West Virginia House of Delegates	Taylor	Mike Manypenny, *Delegate, District 42*	12/4/2009
West Virginia University Department of Landscape Architecture	Monongalia	Ashley Kyber, *Professor*	11/18/2009
West Virginia University Office of Sustainability	Monongalia	Clement Solomon, *Director*	11/4/2009 1/20/2010 4/15/2010
West Virginia University Office of Transportation & Parking	Monongalia	Hugh E. Kierig, *Director*	4/15/2010

APPENDIX C: REGION VI INTERVIEWS – GREEN INFRASTRUCTURE PROJECT IDEAS AND NEEDS

C.1 Potential areas for GI technique use

- Potential green roofs for flat-roofed buildings
- New buildings in the state are golden opportunities to use GI techniques: most municipalities have a greenspace requirement that could be utilized to capture stormwater runoff
- WVDOH opportunities to install bioretention (i.e., in greenspace at exit ramps, medians, rest areas)
- Potential green wall around the West Virginia State Capitol, at riverfront
- Utilization of bioretention at the Capitol Grounds, were there is plentiful greenspace
- Parking lot at Region VI
- Consider using porous concrete for green schools

C.2 Knowledge and research needs for Region VI

- Knowledge of location(s) and project success (positive or negative) of GI projects in Region VI
- Contact information to discuss design and construction with people who have done these projects
- Technical information about GI (i.e., pervious pavement, porous concrete, green roofs, rain barrels)
- Research, ability to measure and/or quantify effectiveness of GI techniques
- Calculations of water volumes and costs for rain barrels
- Tours of existing GI techniques (e.g., green roof)
- Need more porous concrete examples throughout the state
- Planter/tree boxes with an open bottom can be designed to catch direct roof drainage
- Define GI practices more explicitly (i.e., for rain gardens, bioswales)
- Highlight side benefits (e.g., recreation brings revenue, abating nuisance and flooding, human health, quality of life, improving aesthetics bring more money to developer/owners of retail space)

C.3 Technical assistance and funding needs for Region VI

- Conceptual designs, perc tests
- Technical support with TIF, funding mechanisms, engineering
- Funding mechanisms to implement GI
- Funding strategies to include educational component

C.4 Regulatory needs for Region VI

- Ordinances with percent greenspace requirements
- Developer incentives
- Pilot projects, incentives for GI projects (e.g., porous concrete and/or pavement)
- State approval and/or endorsement of porous concrete and/or pavement

C.5 Partnerships and coordination ideas for Region VI

- Memoranda of Understanding to connect people and institutions
- Institutionalization of GI (e.g., throughout schools, institutions)
- Incorporate GI techniques (e.g., porous pavement, trees) with “safe routes to school” grant projects
- Partnerships with school groups, universities for design, installation, monitoring, and/or research
- Utilizing universities to research GI technique (i.e., stormwater effluent) efficiencies in West Virginia
- MS4s join together with DEP on a statewide stormwater ad campaign
- Projects for MS4 communities to help meet conditions of the permit, including capture first inch and mapping of outlets/service area/projects
- Alternative transportation to reduce parking lot area

C.7 Harrison County project ideas

- Rain garden, bioswale, or green wall in parking garage at Clarksburg’s downtown entrance
- Green roof to replace Clarksburg city hall roof
- Green roof, infill development, increased greenspace for infill or new development projects (e.g., Adamston Flat Glass brownfields redevelopment)

C.8 Marion County project ideas

- City of Fairmont working with Allegheny Energy on a $51 million LEED-certified building. Plans include bioretention, bioswales, a rain garden, and hydro-carbon filters.
- Pervious pavement possibilities include rail-trail and Palatine Park in Fairmont
- Replant of geogrid system on east side of FSU
- Restructure stormwater swale on west side of FSU as terraced swale
- Disconnect downspouts at FSU, attaching rain barrels or cisterns for water reuse
- Rain garden for sidewalk at intersection between Morrow and Jaynes Halls at FSU

C.9 Monongalia County project ideas

- GI designs for Morgantown’s Rawley Lane, a paper street behind Panera: a pedestrian/bike trail, keep/establish trees, lighting for safety and security, benches at ends of trail, rain garden or bioswale
- GI projects for MUB headquarters
- Adding storm drain markers into MUB’s current stormwater GIS database
- Opportunity for any company to install permeable pavement on MUB’s parking lot to showcase their products
- Planned French-drained rain gardens along uphill side of rail-trail in Morgantown on either side of the culvert crossings—long and narrow, ditch-shaped gardens designed to slow stormwater
- Potential GI such as rain gardens and permeable pavement on MUB project on rail-trial through arboretum in Morgantown
- Potential for permeable pavement and/or terracing on Campus Connector trail from Grant Street through 8th Street to the water tower (near the WVU President’s house) in Morgantown
- High profile residential projects in Morgantown
- Possible GI on steep slope from Collins Ferry Road to Eastern Avenue in Morgantown

- Possible GI at White Park—ponding on Mississippi Street in Morgantown
- Possible GI above Hite Street across from the Board of Park and Recreation Commissioners maintenance building, Mountaineer Heritage Park in Morgantown
- Curbless tree boxes on the 4th block of High Street project in Morgantown
- GI project potential between Krepps Park and the Monongahela River in Morgantown
- Trees, bioswales, and terracing in Star City, Boyers Avenue widening and beautification
- Planning or considering GI techniques in and around new buildings at the Botanic Garden
- WVU: Bioswale on property near Alumni Center
- WVU: Planned parking lot remodel at Creative Arts Center to address stormwater runoff, using underground storage tanks for capture and reuse
- WVU: Start stormwater solutions summer internship program at Department of Landscape Architecture

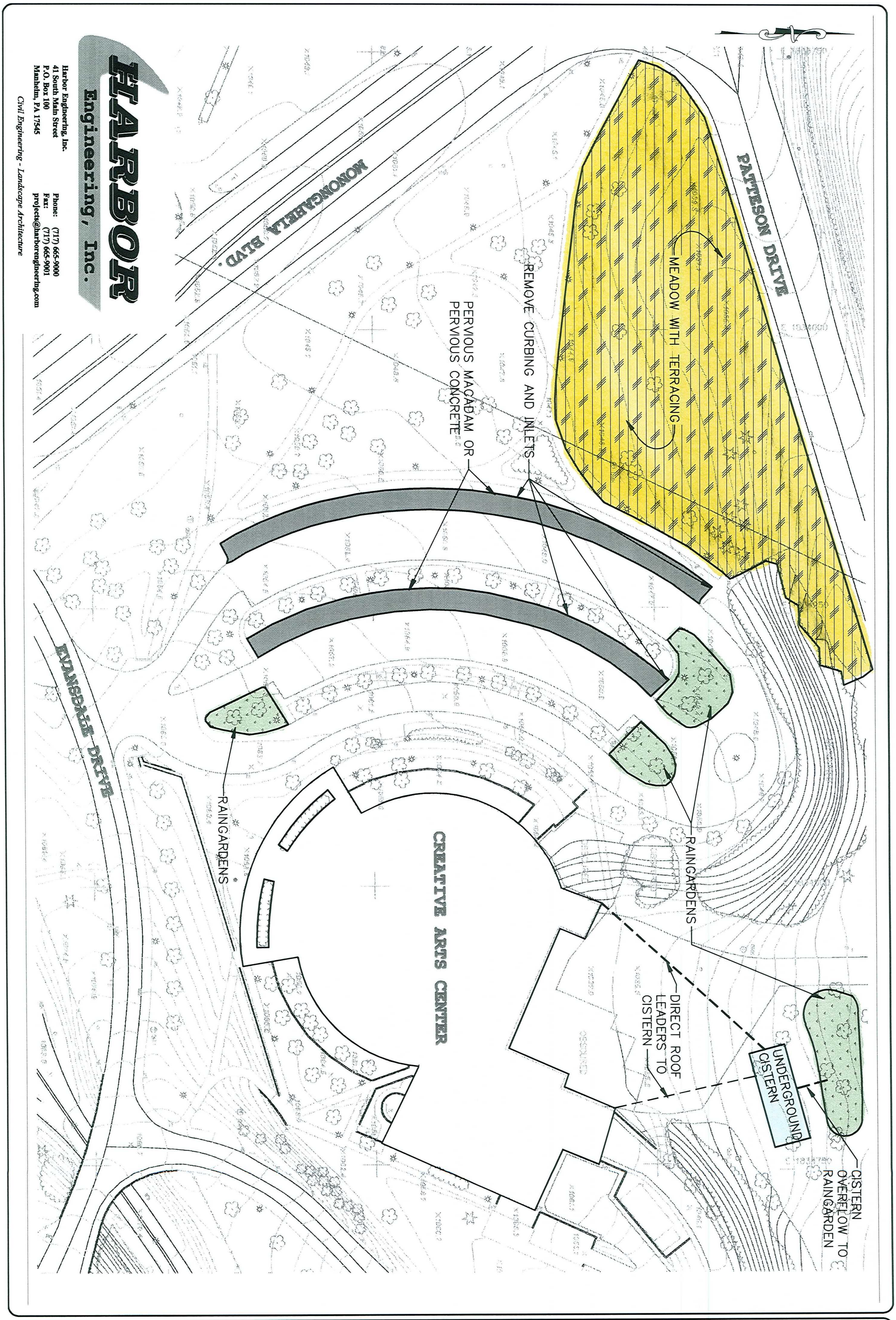
C.10 Preston County project ideas

- Potential green roof, bioswale, rain garden at Reedsville intersection, brownfields redevelopment
- Potential GI (e.g., green roof, plants) on Friends of the Cheat planned brownfields redevelopment at Cheat River Coal Preparation Plant
- Hazelton prison planned construction
- Camp Dawson planned construction
- Planned expansion of the shopping center around the Wal-Mart
- Pocket parks, plantings at Old Rowlesburg School brownfields revitalization

C.11 Taylor County project ideas

- Replant trees on the failing slope in Flemington
- Start a watershed organization to help address stormwater issues in Flemington
- Rain barrel and/or rain garden at elementary school in Flemington
- Grafton re-landscaping/streetscaping project
- GI project to bring attention to Mother's Day Shrine
- Green roofs for flat roofed movie theater, and senior centers in Flemington and on Route 119

APPENDIX D: CONCEPTUAL DESIGNS



SHEET NO.: 1 OF 2	SCALE: N.T.S.	
	DRAWN BY: SPG	CHECKED BY: SPG
	DATE: APRIL 21, 2010	
	PROJECT NO.: 09401-001	

SHEET TITLE

CREATIVE ARTS CENTER
GREEN INFRASTRUCTURE CONCEPTS

HARBOR
Engineering, Inc.

Harbor Engineering, Inc.
41 South Main Street
P.O. Box 100
Manheim, PA 17545

Phone: (717) 665-9000
Fax: (717) 665-9001
projects@harborengineering.com

Civil Engineering - Landscape Architecture

PERVIOUS PAVEMENT

PERVIOUS PAVEMENT SHOULD BE INSTALLED OVER AN 18" THICK MINIMUM STONE RECHARGE BED, WHICH PROVIDES STABILITY AND STORAGE FOR CONTRIBUTING STORMWATER UNTIL IT CAN INFILTRATE INTO THE GROUND. WHEN PROPERLY INSTALLED, POROUS PAVEMENT HAS A RUNOFF COEFFICIENT OF ZERO, MEANING ALL CONTRIBUTING STORMWATER IS CAPTURED WITHIN THE PAVEMENT SECTION. PERVIOUS PAVEMENT SHOULD BE CLEANED WITH A VACUUM TRUCK AT LEAST TWICE A YEAR. A STONE CAPTURE AREA DOWNSTREAM OF THE PERVIOUS PAVEMENT, WITHOUT CURBING, IS RECOMMENDED TO CONVEY STORMWATER TO THE ASSOCIATED STONE RECHARGE PIT IN THE EVENT THAT THE PERVIOUS PAVEMENT LOSES POROSITY OVER TIME OR IS SOMEDAY SEALED WITH STANDARD PAVEMENT.

PERVIOUS PAVEMENT IS GENERALLY 20% HIGHER IN COST THAN STANDARD PAVEMENT. STONE RECHARGE BEDS TYPICALLY COST $20-$25 / CUBIC YARD OF STONE. SAVINGS CAN BE REALIZED WITH THE ELIMINATION OF CURBING AND STORMWATER PIPES AND INLETS.

RAINGARDENS

RAINGARDENS ARE DEPRESSED AREAS PLANTED WITH WATER TOLERANT VEGETATION, AND ARE DESIGNED TO FILTER AND INFILTRATE CONTRIBUTING STORMWATER RUNOFF. PLANTINGS ARE SELECTED BASED ON THE CLIMATE AND EXPECTED RAINFALL AND CONTRIBUTING DRAINAGE AREA, AND CONTEXT (FOR EXAMPLE, LOWER PLANTING IN PARKING LOTS SO AS NOT TO IMPEDE VEHICULAR SIGHT DISTANCE). PRIOR TO INSTALLATION, PERMEABILITY STUDIES ARE IMPORTANT TO DETERMINE INFILTRATION RATES. RAINGARDENS ARE TYPICALLY ASSOCIATED WITH A SHALLOW IMPOUNDMENT DEPTH (18" MAX) AND INCORPORATE OVERFLOW PIPES AND/OR SPILLWAYS TO PROVIDE AN OUTLET FOR STORMWATER IF NECESSARY DUE TO CLOGGING OR A LARGE STORM EVENT.

BESIDES THE COSTS ASSOCIATED WITH GRADING, RAIN GARDEN SOIL MIXTURES TYPICALLY COST $25 / CUBIC YARD.

TERRACED MEADOW

CONVERTING A PORTION OF THE EXPANSIVE LAWN AREA IN FRONT OF THE CREATIVE ARTS CENTER INTO A TERRACED MEADOW CAN PROVIDE WATER QUALITY AND PEAK RATE REDUCTION BENEFITS. CAREFULLY MANAGED, THE MEADOW AREA CAN BE AN AESTHETIC ATTRIBUTE AS WELL AS SERVE AS AN OUTDOOR CLASSROOM FOR STUDENTS IN THE DEPARTMENT OF AGRICULTURE, NATURAL RESOURCES, AND DESIGN. BY TERRACING SECTIONS OF THE MEADOW ADJACENT TO PATTESON DRIVE, PEAK FLOW RATES WILL BE REDUCED. THE MEADOW PLANTS WILL ALSO ABSORB MORE STORMWATER RUNOFF AND PROVIDE A BETTER POLLUTANT FILTER THAN TRADITIONAL LAWN. MAINTENANCE INPUTS ARE ALSO REDUCED WITH LESS MOWING, WATER, AND FERTILIZER.

COST ASSOCIATED WITH INITIAL MEADOW CONSTRUCTION WOULD BE OFFSET OVER TIME CONSIDERING THE REDUCED MAINTENANCE COSTS.

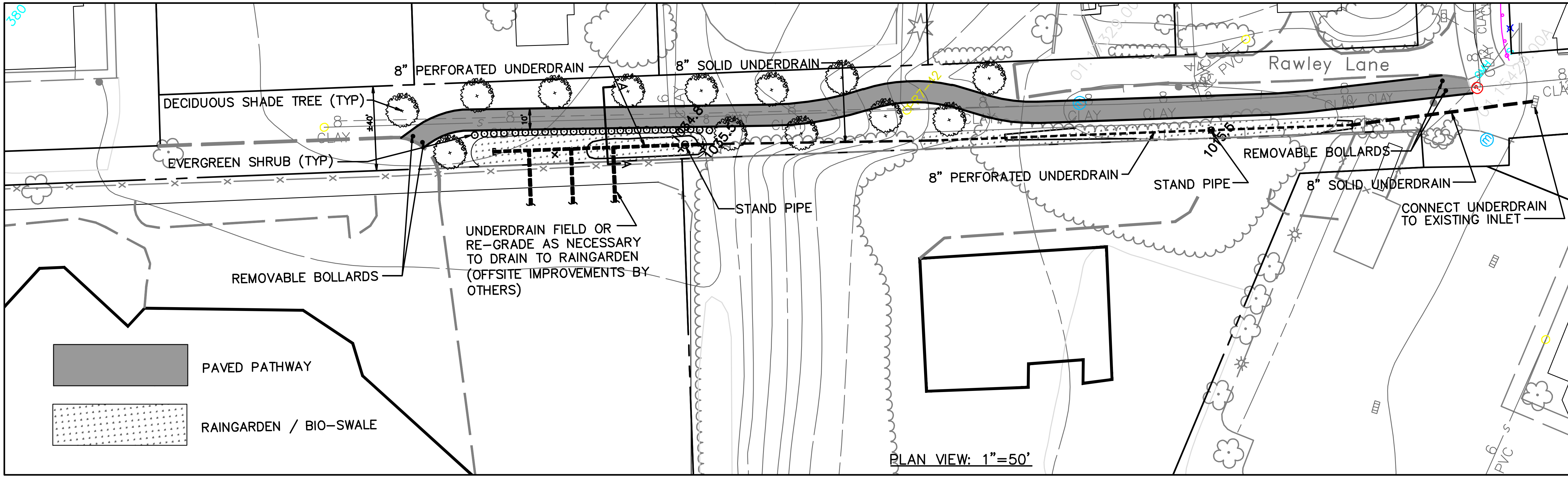
CISTERN

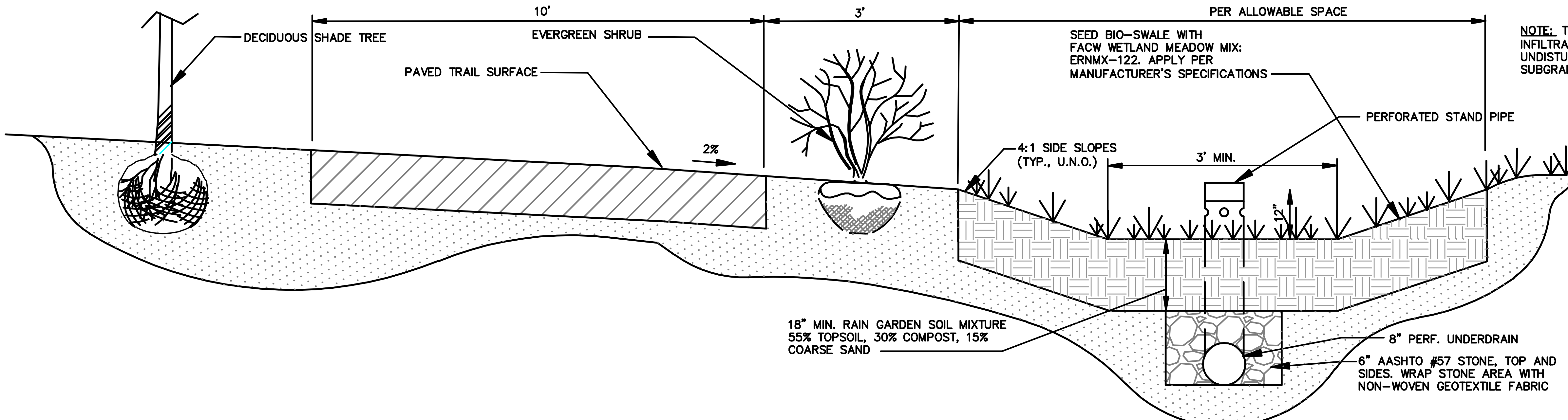
DIRECTING A PORTION OF OR ALL OF THE CREATIVE ARTS CENTER ROOF WATER INTO A CISTERN WOULD PROVIDE CLEAN WATER FOR RE-USE. THE CISTERN WATER COULD BE USED WITHIN THE BUILDING OR FOR OTHER APPLICATIONS ON CAMPUS, SUCH AS WATERING PLANTS AND LAWN AREAS. THE CISTERN SHOULD BE SIZED BASED ON ANTICIPATED NEED, AND AN OVERFLOW SHOULD BE PROVIDED TO A RAINGARDEN OR OTHER BEST MANAGEMENT PRACTICE IN THE EVENT THAT THE CISTERN FILLS UP IN LARGER STORM EVENTS.

COST ASSOCIATED WITH CISTERNS VARY DEPENDING ON THE SIZE AND TYPE (PRE-FABRICATED OR CAST IN PLACE) AS WELL AS THE REQUIRED DISTRIBUTION SYSTEM, IF APPLICABLE.

SHEET TITLE
CREATIVE ARTS CENTER
GREEN INFRASTRUCTURE CONCEPTS

SCALE: N.T.S.
DRAWN BY: SPG
CHECKED BY: SPG
DATE: APRIL 21, 2010
PROJECT NO.: 09401-001
SHEET NO.: 2 OF 2





NOTE: THE BOTTOM OF ALL INFILTRATION BMP'S SHALL BE UNDISTURBED OR UNCOMPACTED SUBGRADE.

RAIN GARDEN / BIO-SWALE NOTES

1. ANY ACCUMULATION OF DEBRIS OR SEDIMENT THAT TAKES PLACE AFTER SUB-GRADE PREPARATION SHALL BE REMOVED PRIOR TO INSTALLATION OF PLANTING SOIL.
2. INSTALL PLANTING SOIL IN 18-INCH MAXIMUM LIFTS AND LIGHTLY COMPACT (TAMP WITH BACKHOE BUCKET OR BY HAND). KEEP EQUIPMENT MOVEMENT OVER PLANTING SOIL TO A MINIMUM – DO NOT OVER COMPACT. INSTALL PLANTING SOIL TO GRADES INDICATED ON THE GRADING PLAN.
3. PROTECT BIO-SWALES FROM SEDIMENT AT ALL TIMES DURING CONSTRUCTION.
4. WATER VEGETATION AT THE END OF EACH DAY FOR TWO WEEKS AFTER PLANTING IS COMPLETED.

1/1 SECTION VIEW A–A

NOT TO SCALE

HARBOR Engineering, Inc.

Harbor Engineering, Inc.
41 South Main Street
P.O. Box 100
Manheim, PA 17545

Phone: (717) 665-9000
Fax: (717) 665-9001
projects@harborengineering.com

Civil Engineering - Landscape Architecture

SHEET TITLE

RAWLEY LANE PEDESTRIAN CORRIDOR STORMWATER BMP CONCEPT PLAN

SCALE: N.T.S.
DRAWN BY: SPG
CHECKED BY: SPG
DATE: APRIL 21, 2010
PROJECT NO.: 09401-001
SHEET NO.: 1 OF 1

HARBOR ENGINEERING, INC.
41 SOUTH MAIN STREET
MANHEIM, PA 17545

Opinion of Probable Cost

Date: ________

Calculated By: ____________

Checked By: ____________

Job: **Rawley Lane**
09401-001

Item No.	Description of Materials, Grades, etc.	Approximate Quantities	Unit		Unit Prices		Amount
A.	**STORM WATER MANAGEMENT FACILITIES**						
1	8" PVC Drain Pipe	200.	LF	$	22.00	$	4,400
2	8" PVC Perforated Pipe	295.	LF	$	24.00	$	7,080
3	Miscellaneous Tees and Fittings	1.	LS	$	500.00	$	500
4	AASHTO #57 Stone	20.	CY	$	22.00	$	440
5	Class 1 Non-Woven Geotextile	180.	SY	$	3.00	$	540
6	Bio-Swale / Rain Garden Soil Mixture	175.	CY	$	25.00	$	4,375
		Storm Water Management Subtotal				$	17,335
B.	**LANDSCAPING**						
1	Shade Trees, 2 - 2 1/2 inch cal.	13.	EA	$	250.00	$	3,250
2	Shrubs, 18 - 24 inch	26.	EA	$	60.00	$	1,560
		Landscaping Subtotal				$	4,810
C.	**ROADWAY IMPROVEMENTS**						
1	1 ½" Superpave Wearing Course*	560.	SY	$	12.00	$	6,720
2	3" Binder Course	560.	SY	$	18.75	$	10,500
3	2A Modified Stone - 6" depth	560.	SY	$	8.00	$	4,480
4	Removable Bollards	4.	EA	$	200.00	$	800
		Roadway Improvements Subtotal				$	22,500
		Grand Subtotal				$	44,645
		Contingencies @ 10%				$	4,465
		TOTAL OPINION OF PROBABLE COST				$	49,110

HARBOR ENGINEERING, INC. is not a construction contractor and therefore probable cost opinions are based solely on our experience with construction. This requires HARBOR ENGINEERING, INC. to make a number of assumptions as to actual conditions which will be encountered on the site; the specific decisions of other design professionals engaged; the means and methods of construction the contractor will employ; the contractor's techniques in determining prices and market conditions at the time of construction; and other factors over which HARBOR ENGINEERING, INC. has no control. Given these assumptions which must be made, HARBOR ENGINEERING, INC. states that the above probable construction cost opinion is a fair and reasonable estimate for the construction costs itemized above.

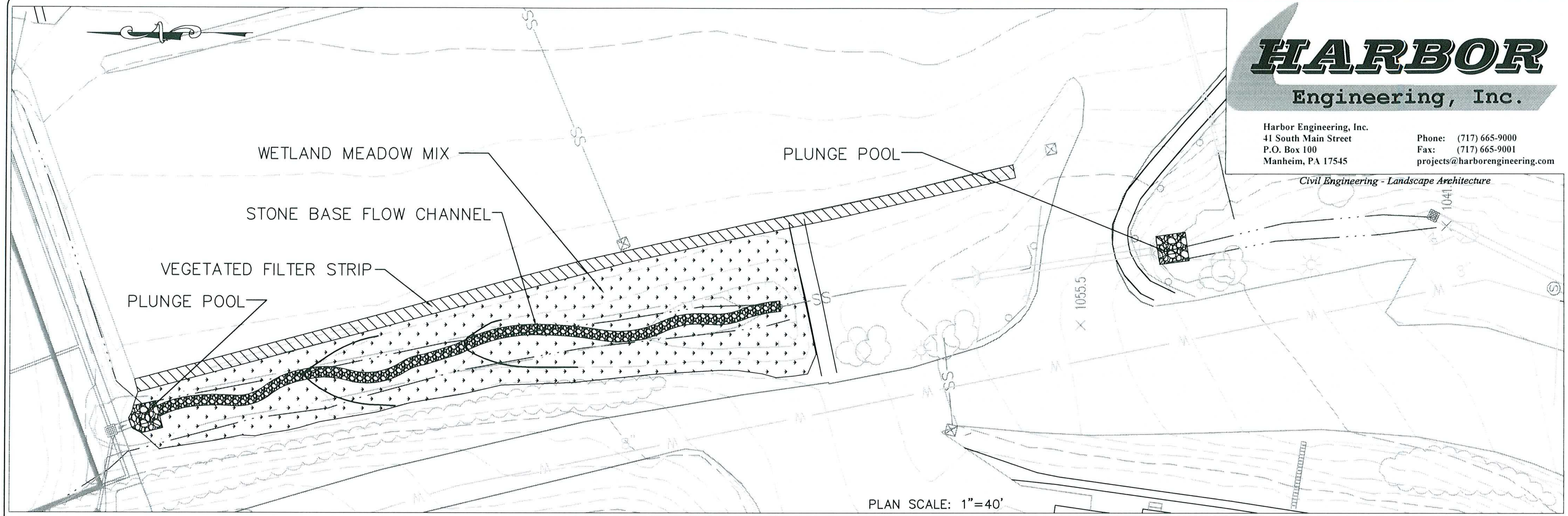
*Pervious pavement for the trail is not advised due to the trail's location over the gas and sewer lines. Encouraging infiltration directly over these facilities could potentially encourage stormwater to follow these existing pipes, which could undercut them and lead inadvertently to additional stormwater in the sanitary sewer system.

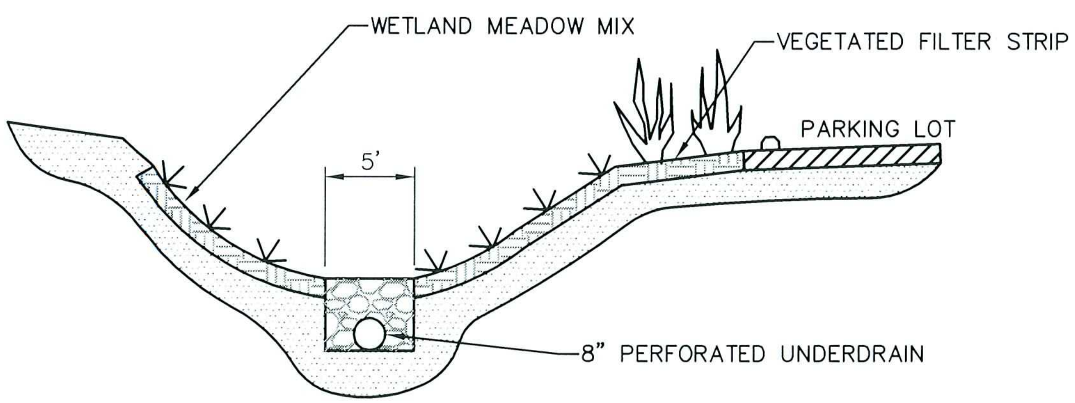
HARBOR Engineering, Inc.

Harbor Engineering, Inc.
41 South Main Street
P.O. Box 100
Manheim, PA 17545

Phone: (717) 665-9000
Fax: (717) 665-9001
projects@harborengineering.com

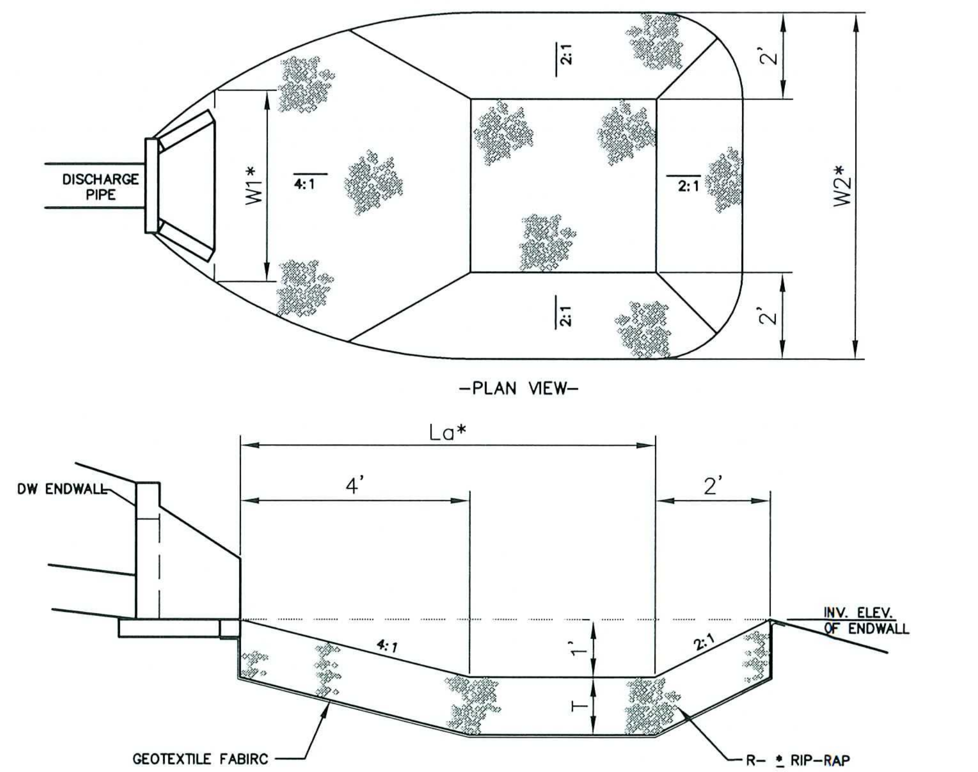
Civil Engineering - Landscape Architecture





SWALE CROSS SECTION

NOT TO SCALE



* PLUNGE POOL DIMENSIONS AND STONE SIZE ARE RECOMMENDED TO BE DESIGNED BY AN ENGINEER

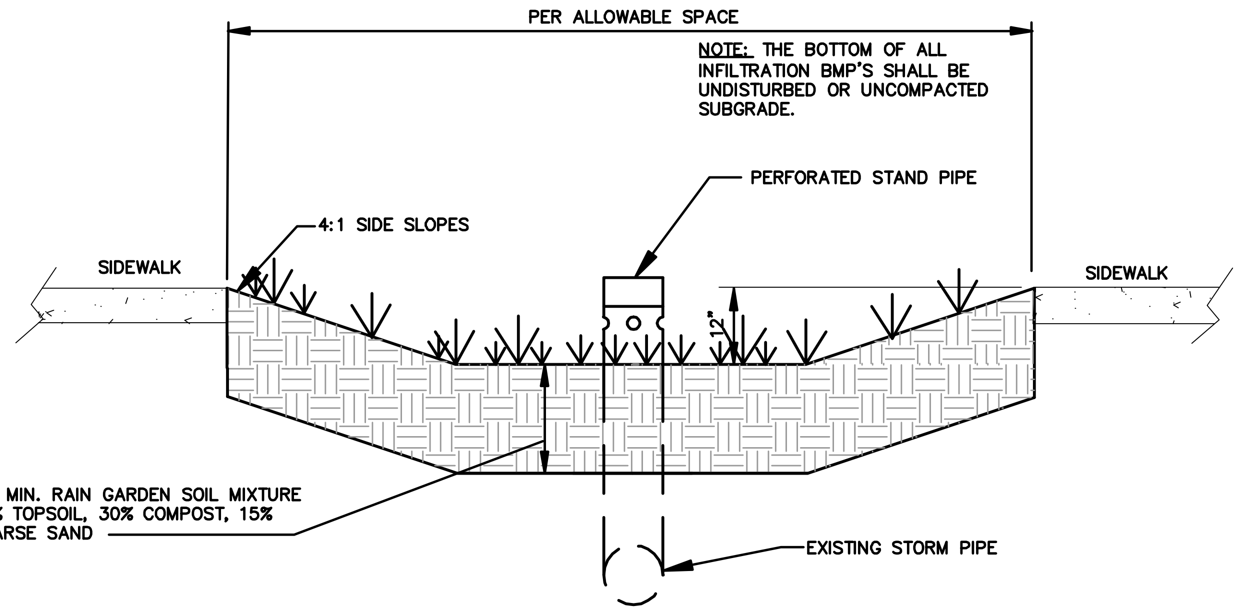
PLUNGE POOL

NOT TO SCALE

SHEET TITLE

FAIRMONT STATE UNIVERSITY SWALE STABILIZATION

SCALE:	N.T.S.
DRAWN BY: SPG	CHECKED BY: SPG
DATE: APRIL 21, 2010	
PROJECT NO.: 09401-001	
SHEET NO.:	1 OF 1



HARBOR Engineering, Inc.

Harbor Engineering, Inc.
41 South Main Street
P.O. Box 100
Manheim, PA 17545

Phone: (717) 665-9000
Fax: (717) 665-9001
projects@harborengineering.com

Civil Engineering - Landscape Architecture

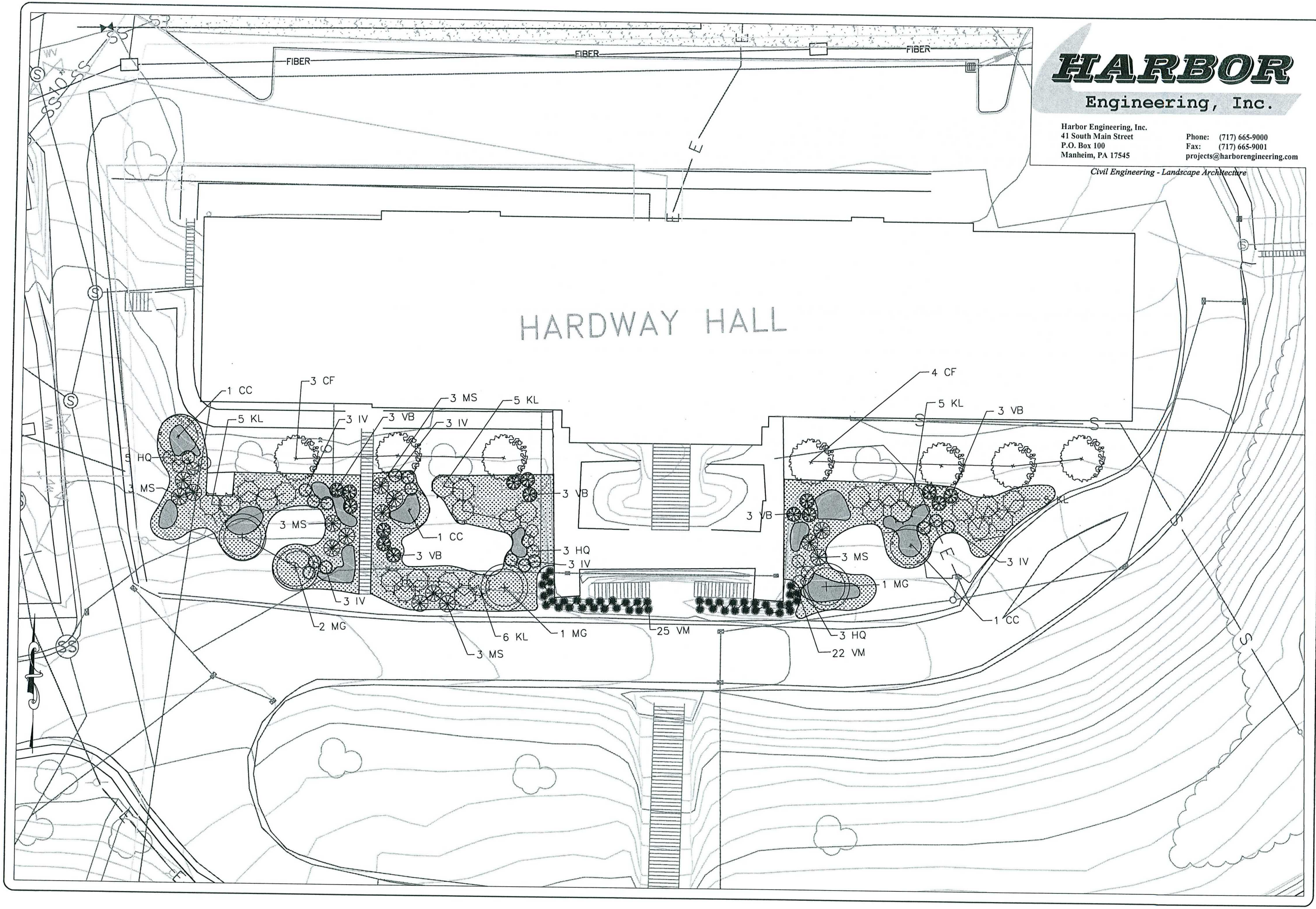
PLOTED: Tuesday, May 04, 2010 @ 05:05PM

FILENAME: P:\Projects\09401-001\CADD\BASE-FSU.dwg

SHEET TITLE

FAIRMONT STATE UNIVERSITY RAIN GARDEN CONCEPT

SCALE:	N.T.S.
DRAWN BY: SPG	CHECKED BY: SPG
DATE: APRIL 21, 2010	
PROJECT NO.:	09401-001
SHEET NO.:	1 OF 1



HARBOR
Engineering, Inc.

Harbor Engineering, Inc.
41 South Main Street
P.O. Box 100
Manheim, PA 17545

Phone: (717) 665-9000
Fax: (717) 665-9001
projects@harborengineering.com

Civil Engineering - Landscape Architecture

SHEET TITLE

FAIRMONT STATE UNIVERSITY
HARDWAY HALL LANDSCAPE PLAN

SCALE: 1"=30'
DRAWN BY: SPG
CHECKED BY: SPG
DATE: APRIL 21, 2010
PROJECT NO: 09401-001

SHEET NO: 1 OF 2

PLANTING LEGEND

QUANTITY	KEY	BOTANICAL NAME	COMMON NAME	SIZE	BB / CONTS
DECIDUOUS TREES					
3	CC	Carpinus caroliniana	American Hornbeam	2" -2 1/2" Cal.	BB
7	CFR	Cornus florida	Flowering Dogwood	2" -2 1/2" Cal.	BB
4	MG	Magnolia soulangiana	Saucer Magnolia	2" -2 1/2" Cal.	BB
SHRUBS					
11	HQ	Hydrangia quercifolia	Oakleaf Hydrangea	15" - 18"	cont.
15	IV	Ilex verticillata	Common Winterberry	15" - 18"	cont.
26	KL	Kalmia latifolia	Mountain-laurel	18" - 24"	cont.
15	MS	Magnolia stellata	Star Magnolia	15" - 18"	cont.
47	VM	Vaccimum macrocarpon 'Lohzham'	Lohzam American Cranberry	No. 1	cont.
15	VB	Viburnum burkwoodii	Burkwood Viburnum	18" - 24"	cont.

GROUNDCOVERS

Pennisetum 'Hamelin'

Liriope 'Big Blue'

HARBOR Engineering, Inc.

Harbor Engineering, Inc.
41 South Main Street
P.O. Box 100
Manheim, PA 17545

Phone: (717) 665-9000
Fax: (717) 665-9001
projects@harborengineering.com

Civil Engineering - Landscape Architecture

SHEET TITLE

FAIRMONT STATE UNIVERSITY
HARDWAY HALL PLANTING PLAN

SCALE: N.T.S.

DRAWN BY: SPG

CHECKED BY: SPG

DATE: APRIL 21, 2010

PROJECT NO.: 09401-001

SHEET NO.: 2 OF 2

PLOTTED: Wednesday, June 23, 2010 @ 01:51PM

FILENAME: P:\Projects\09401-001\CADD\BASE-FSU.dwg