Protecting Water Quality With Smart Growth Strategies and Natural Stormwater Management in Sussex County, Delaware

EPA-NOAA Smart Growth Implementation Assistance for Coastal Communities For Sussex County, Delaware

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Contents

Appendices

Executive Summary

Sussex County residents care deeply about their home. They value the county's beautiful natural landscapes, marshes, ocean beaches, farms, and the small-town atmosphere that gives Sussex County its identity and a sense of place. By 2030, the county's population is estimated to grow by 44 percent. This growth will bring change. Many county residents are concerned that more development will change the things about Sussex County that they care about. They want thoughtful development that is balanced and that improves the quality of their lives. They want growth that preserves the county's natural landscape and scenic beauty. They want development that reflects the county's coastal and agricultural heritage. And they want development that gives them choices how where they live and how they get around.

Sussex County is in a good position to shape future development patterns. It has taken an important first step to supporting growth patterns that meet community goals and values by updating its comprehensive plan. As the county moves forward with implementing the plan and revising its development rules and regulations, county leaders have the opportunity to develop in a way that is more consistent with local values and traditions and that provides the amenities that residents desire—more local-serving stores, more jobs, more housing choices, and more transportation choices.

Identifying and protecting the county's open spaces and resource lands will help guide development decisions. Lands to consider protecting include areas that give the county its identity and that perform key ecological functions such as protecting water quality and providing habitat. Maintaining the county's small-town character and scenic beauty will require decision-makers and residents to decide together where they want growth to occur. One option is to direct new growth and development to existing town centers and already developed properties, including infill, brownfield, and greyfield locations. Doing so uses land more efficiently, saves taxpayer money, can create jobs, and is good for water quality because it does not add to impervious surface.

County residents are very concerned about traffic congestion and want more choices in how they get around. County leaders can help expand transportation choices by encouraging compact, mixed-use development and supporting pedestrian-friendly streets and a more connected street network. Compact, mixed-use development provides the critical mass of people that makes places and streets lively and safe and that also makes public transit such as bus or rail more economically viable. Sussex County is familiar with mixed-use development. Some of its oldest and most cherished places, such as Lewes and Milton as well as new neighborhoods like Paynter's Mill, are walkable, compact, and mixed use. County leaders can also support more connected street networks, such as those in Georgetown or Seaford. These grids give residents more route options to avoid congestion and disperse traffic over multiple roads. A connected street network makes walking and bicycling safer and more convenient because helps to slow traffic speeds and offers more direct routes.

A defining characteristic of Sussex County is its coastal environment. At the most basic level, keeping coastal and inland waters clean means reducing or preventing pollution. How Sussex County develops in the future and how it manages stormwater will have a tremendous impact on the health of the coast and inland waters. The county can protect water quality by adopting a sustainable approach to stormwater management, addressing stormwater at the regional, community, and site scales. At the regional scale, the county could direct development to locations where growth makes sense—town centers, underused parking lots, and already degraded sites—and away from undeveloped natural lands—forests, wetlands, riparian buffers, and open spaces—that naturally absorb, filter, and clean stormwater. At the community scale, the emphasis is on minimizing impervious surface by encouraging compact development. Compact development may reduce building footprints and result in less impervious coverage per unit or per capita than dispersed units. Compact development also often requires fewer miles of roads and parking lots than low-density development, which further reduces total impervious cover. Managing stormwater at the site scale involves strategically integrating green infrastructure (plants, soils, landscaping) into the design of the site to help slow, filter, and absorb stormwater. The county can more effectively manage stormwater at the site level by encouraging green infrastructure techniques, such as rain gardens, pervious paving, or swales into new construction or retrofits of existing streets, parking lots, and buildings. These approaches help manage stormwater runoff in a way that mimics natural processes, is aesthetically pleasing, and can be less expensive to build and maintain.

County leaders have a clear opportunity to respond to their residents' desire for more environmentally friendly development patterns. As the county considers integrating the smart growth and stormwater management strategies discussed in this report, some potential next steps include:

- Adopt land conservation strategies to direct development to land best suited for it while preserving farmland and environmentally sensitive areas. Strategies include conservation easements and transfer or purchase of development rights.
- Increase incentives for compact and location-efficient development to make it easier and more cost effective for developers to build the type of projects residents want. Incentives include streamlined permitting procedures and fast-tracking development proposals that meet the county's goals.
- Reach out to the public to get stakeholder and public support for the site-level stormwater management solutions, many of which may be new to the county. Education and outreach strategies include frequent public workshops on sustainable stormwater management and public tours of existing projects.
- Pursue demonstration projects to showcase site-level sustainable stormwater management solutions and educate people about their benefits. This could involve reaching out to developers and landowners who want such a project on their property or applying approaches to underused paved areas, such as parking lots or vacant properties.

1. Introduction

Sussex County is the southernmost of Delaware's three counties. It is the largest and least densely populated county in the state, yet it accounted for almost half the state's building permits in 2006,[1] a sign of the growth the county is experiencing.

In the western part of the county are agricultural lands and scattered small towns. Along the Atlantic Ocean beaches, which attract millions of visitors every year, there is more development. More and more retirees are moving to the area, drawn by the natural beauty, the small-town lifestyle, and the proximity to Philadelphia, Baltimore, and Washington, DC. The appeal of the coast and the countryside has brought tremendous population growth, which could threaten tourism, agriculture, and natural resources if it is not planned for and designed well.

1.1 Charge to the Team

The University of Delaware Sea Grant program worked with Sussex County to request help through the U.S. Environmental Protection Agency (EPA) and National Oceanic and

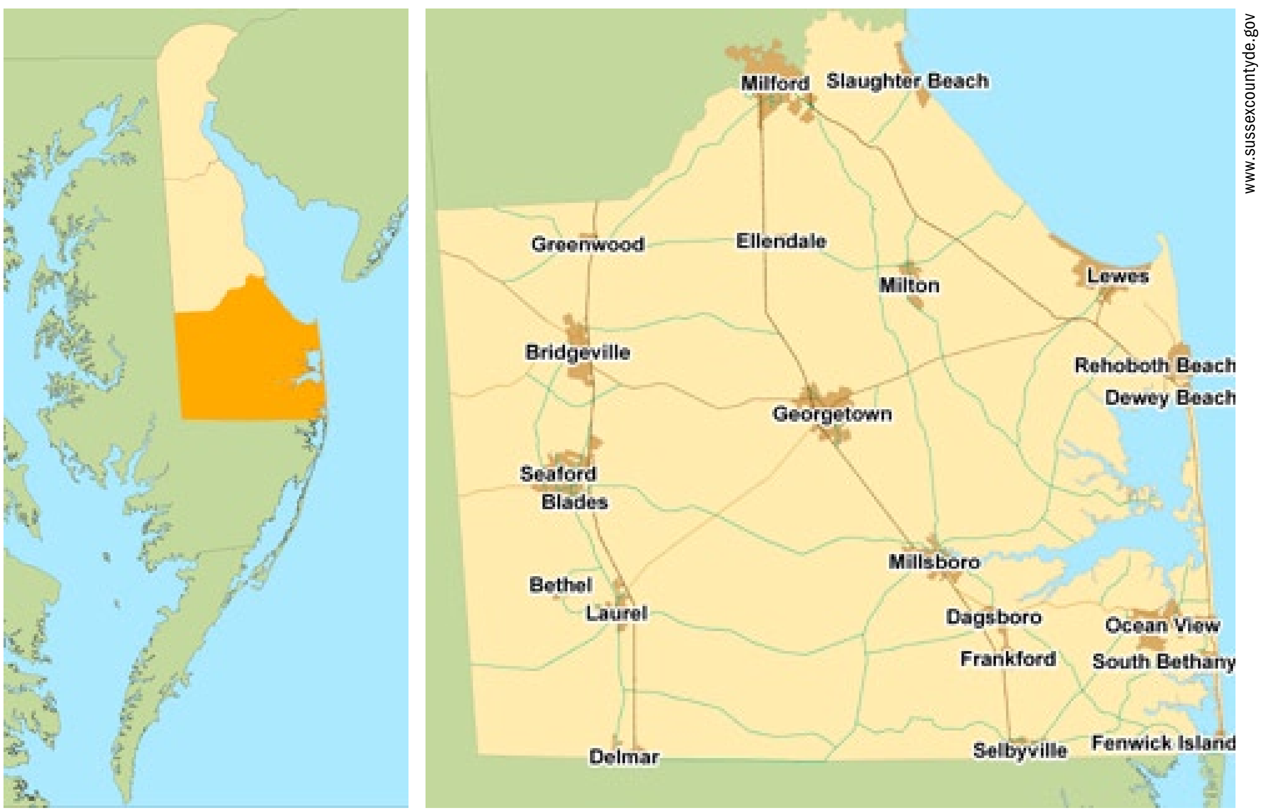

Figure 1. Maps of Sussex County, Delaware.

[1] U.S. Census Quickfacts, *quickfacts.census.gov/qfd/states/10/10005.html*, accessed January 10, 2008.

Atmospheric Administration (NOAA) Smart Growth Implementation Assistance for Coastal Communities (SGIA-CC) program (more information about the SGIA-CC program is in Appendix A). The team's charge was to develop design guidance that incorporates smart growth and sustainable stormwater management approaches.

It should be noted that Sussex County was in the process of revising its comprehensive plan during the team visit and subsequent writing of this report. As the plan was not final, the team did not link any of the options presented in the report directly to the revised plan. However, the report's options can be implemented under any comprehensive plan that promotes more sustainable, compact growth.

During a three-day site visit, from August 6 to 8, 2007, the team met with approximately 50 members of the community, including municipal officials and staff, developers, realtors, designers and engineers, businesspeople, and interested citizens, through public meetings, stakeholder interviews, and informal discussions. The team also toured a portion of the county near Lewes to see the development patterns that already exist.

The purpose of this report is to:

- Describe how smart growth and sustainable stormwater management approaches could be applied to Sussex County; and
- Provide site-level stormwater design strategies that could be used to manage stormwater at the scale of a front yard, neighborhood street, parking lot, or development parcel.

2. Context

Sussex County residents speak with passion about the joy of being in the middle of a quiet salt marsh at sunset, the thrill of watching an osprey soar over their street, the pleasure of driving past waving fields of corn, or the enjoyment they get from being able to bike around the area easily. The things that attract new residents to Sussex County and that keep lifelong residents here must be preserved to keep Southern Delaware the place that people love. Good, thoughtful development can help preserve the natural landscape, the wildlife, the coastal and the rural landscapes, the agricultural lifestyle, and the distinctive housing styles that have been seen around the county for a hundred years or more.

That said, change is coming to Sussex County, and many aspects of life that current residents are used to will change. There will be more residents; there will be more development; there will be more traffic. It's up to Sussex County residents to make development bring the amenities they want—like more local-serving stores, more jobs, more housing choices, and more transportation options—and to make the increase in traffic as bearable as possible by diffusing it over a wider network and by giving people other choices, like walking, biking, or taking transit.

Some neighborhoods in Sussex County already show how more sustainable development can look in this area. In the Villages of Five Points, for example, a mix of uses makes it possible for residents to walk to the grocery store when they just need to pick up a few items, instead of having to get in the car and deal with traffic just to buy a gallon of milk. Places like Milton and downtown Lewes show the value of preserving what you have and making sure that new development and renovation of existing properties fit with the character of the community. Tourism is very important to the county, and tourists want to visit destinations that look and feel unique, like downtown Lewes.

EPA

Figure 2. Marsh in Prime Hook Wildlife Refuge.

EPA

Figure 3. Town center in the Villages of Five Points.

There is pent-up demand for other housing options in the county, including less expensive housing for teachers, nurses, and other essential community workers, and condos and apartments as second homes and retirement options for people used to living in a setting where they can walk to most of their daily needs and interact with their neighbors. The predominant housing option in the county has been single-family homes on relatively large lots. But young people just starting out, service workers, teachers, nurses, and other workers can't afford those homes and have to commute from a long way away.

EPA

Figure 5. The historic and small-town character of Lewes.

2.1 Population and Other Growth Trends

Sussex County's population in 2005 was estimated at 176,192 people. By 2030, the Delaware Population Consortium estimates, it will grow to 253,240,[2] a 44 percent increase. The biggest change will be in the population aged 65 years and over, which is projected to more than double.

Age group	2005	2030	Change in absolute numbers	Percentage change
0–19 years	40,366	56,169	15,803	39%
20–64 years	100,167	122,809	22,642	23%
65 years and up	35,659	74,262	38,603	108%

Figure 4. Population change in Sussex County by age group, 2005 to 2030. (Source: Delaware Population Consortium, Annual Population Projections, 2007.)

These demographic trends have significant implications for community design. Communities around the nation are starting to wake up to the wave of baby boomers that will be retiring in the next decade or two and are trying to accommodate these retirees with community design that gives them the amenities they want and lets them stay independent for as long as possible. Sussex County is an attractive destination for retirees,[3] particularly from large nearby cities like Washington, Baltimore, or Philadelphia. As these people look for a vacation home—and, eventually, a home to live in full-time after retirement—they seek places that offer the same amenities as the urban neighborhoods they have lived in all their lives: a lively sense of community; stores, parks, churches, restaurants, and other attractions within easy walking distance; and safe and pleasant sidewalks and biking and walking paths. They may not want to have to mow a lawn or take care of a big house. They may want to be assured that they can continue to get around on foot or with public transit if they no longer feel comfortable driving.

2 Delaware Population Consortium. Annual Population Projections. October 23, 2007. Data tables available at *stateplanning.delaware.gov/information/dpc/dpc_2007v0_final.xls*. Accessed January 11, 2008.

3 For example, see Sarah Mahoney, "Dream Towns," *AARP Magazine*, July and August 2006. Available at *www.aarpmagazine.org/lifestyle/dream_towns.html/page=3*. Accessed January 11, 2008.

Nationally, about 21 percent of Americans aged 65 and older don't drive—for health or safety reasons, because they don't have access to a car, or out of personal preference. Because so many communities around the country are designed for automobile use, these non-drivers find themselves having to stay home, which makes them feel isolated and cuts them off from the community and from participating in the economy, or having to ask someone for a ride, something that about half of them are reluctant to do because they do not want to impose on others or feel dependent. Compared to older adults who drive, non-drivers make 15 percent fewer trips to the doctor, 59 percent fewer restaurant and shopping trips, and 65 percent fewer trips for social, family, and religious reasons.[4] The potential physical and mental health ramifications of this isolation are troubling.

Where older non-drivers have the option to walk or use public transportation, they do so, but in areas where they can only get around by car, they are left with the unappealing choice of staying at home or asking for a ride. A community that gives all its residents options besides driving will help these older residents avoid having to make such choices, something that even drivers will appreciate as they anticipate a time when they can't or don't want to drive.

Of course, these types of walkable, amenity-rich communities appeal to all ages, not just senior citizens. Children also enjoy the freedom of

Older non-drivers who...	in a compact, walkable community	in a spread-out, automobile-dependent community
... stay home on a given day	43%	61%
... use public transportation at least occasionally	1 in 2	1 in 20
... walk on a given day	1 in 3	1 in 14

Figure 6. Mobility for older non-drivers in compact communities versus spread-out communities. (Source: Bailey, Linda. *Aging Americans: Stranded Without Options*. Surface Transportation Policy Project. April 2004.)

EPA

Figure 7. People enjoying the different ways to get around Lewes.

[4] Bailey, Linda. *Aging Americans: Stranded Without Options*. Surface Transportation Policy Project. April 2004. p.4. Available at *www.transact.org/report.asp?id=232*.

being able to get around the neighborhood without needing a ride. Many other people want to live in a place where a coffee shop or ice cream parlor is a short walk from their home, where they can choose whether to drive to work or to bike, and where they can run into their neighbors walking around the neighborhood.

2.2 Smart and Sustainable Growth

Sustainable communities need to be successful in three areas: economy, equity (social issues), and environment.

Economy

Economic success includes making sure good jobs are available, jobs that offer people opportunities and a living wage. Development could benefit the whole community by providing new opportunities. For example, one idea suggested during a stakeholder discussion with the team was to encourage light-industrial structures to allow live/work units where artisans—boat builders, furniture makers, weavers, and tailors—could live on upper floors and work in ground-floor workshops with storefront windows. Passersby could watch beautiful objects being created and then come in and buy them.

Economic success also means preserving and enhancing Sussex County's existing industries. In the eastern part of the county, the beautiful beaches, salt marshes, and historic towns are what attract tourists. Preserving these assets in the face of growth will protect the county's distinctive character and appeal. In the western part, agriculture needs not only land on which to raise poultry and other livestock and grow crops, but also a buffer between farm fields and houses. Otherwise, farmers may find themselves dealing with complaints from neighboring homes about smells from livestock, spraying on fields, or loud machinery being used early in the morning.

EPA

Figure 8. The Lewes and Rehoboth Canal.

Rural economies also include small cities and towns that provide stores, services, and civic institutions and can serve as transportation hubs. Much of what people like about rural life involves these small towns and their relationship to the land surrounding them. As a different type of economic development advances into rural areas, people may feel like things are changing for the worse, but they might not be able to pinpoint how or why. Preserving a rural community—just like preserving any other type of community—depends on the local residents deciding what they like about their community and what they want it to be, and then finding the tools and resources to fulfill that vision. To succeed, rural communities must help existing places to thrive and build great new places.

The team did not have the opportunity to explore rural growth strategies, but team members did hear throughout the site visit that residents in western Sussex County want to keep the jobs and other benefits from agriculture, and landowners want to retain economic use of their land. Appendix E contains some resources to help the county preserve what people love about the rural areas and find new development strategies that are appropriate for the rural lifestyle.

Uncontrolled, dispersed growth in rural areas is expensive to serve. A 2006 American Farmland Trust study found that Delaware's capital budget increased by almost 250 percent from 1986 to 2005, eight times greater than the state's population increase and six times greater than the growth in housing units. The land consumption per new housing unit grew at about the same rate as the capital budget, and the relationship is not coincidental: as houses use more and more land, they are spread farther and farther apart. The state has to spend more on extending utility lines, roads, and other infrastructure to these dispersed homes, and it has to spend more on associated expenses, like transporting children to school. The study also found that the state spending on school transportation per student rose 235 percent from 1970 to 2005, even though the number of students declined. Although many factors are behind that rise, at least part of it is the increased distance school buses must drive to reach all the students they serve.[5]

Equity

Equity, or social issues, refers to giving everyone the same basic opportunities to succeed. In terms of community development, this means making sure that a wide range of housing options are available, so that people can choose among single-family homes, townhouses or condos, and apartments. They can choose to rent or own. They can find a safe, comfortable home that they can afford without having a long commute to work. Of course, some people will choose a longer commute as a trade-off for having a larger home or more land, but they should be able to make that trade-off because they want to, not because they have no other option.

Just as people need choices in housing to have a fair chance at success, they also need options for getting around. Not everyone can afford a car; others may not want or be able to drive. As the price of gas rises, some drivers may want to drive less to save money on gas. By creating walkable communities with amenities to make biking and walking safe and pleasant, and offering public transit options like buses and shuttles, Sussex County can help its residents find less expensive and more environmentally friendly ways of getting around. In the process, the county is giving its residents more freedom by expanding their mobility and giving them more access to jobs and educational opportunities.

Fairness and equity mean balancing individual rights with community benefits. Property owners in Sussex County, particularly farm owners, are concerned that changes in land use policies could diminish their land's value or limit what they can do on their land. They appreciate the benefits to the community of preserving open space or directing development to certain areas, but they want to make sure that they can still get economic value from their land. Many other places around the country have dealt with similar issues and have found solutions that protect both the rights of property owners and the rights of the community as a whole. Some of these solutions are discussed in Section 6.1; other resources can be found in the rural development section of Appendix E.

Social equity considerations also include public health issues. Some health problems are caused by environmental factors, like air or water pollution, that can be mitigated through smarter development. A major problem in much of the nation is lack of daily physical activity, which can lead to obesity, heart disease, high blood pressure, and diabetes, as well as contributing to depression, respiratory problems, and other ailments. Delaware has an adult obesity rate of about 24 percent (ranking 29th in the nation) and a child obesity rate of about 15 percent (ranking 19th in the nation). More than 22 percent of

[5] American Farmland Trust. "Trends in Delaware's Growth and Spending: Technical Report." May 2006. Available at *www.farmlandinfo.org/delaware*.

adults in Delaware do not engage in any physical activity.[6]

In response to what many health experts are calling an epidemic of inactivity, some communities are designing neighborhoods to make it easy for residents to get physical activity as part of their daily routines. For example, a person could get the recommended 30 minutes per day of activity just by walking to and from a store ten minutes away and then walking five minutes to and from a park near his or her home. Children can walk to school, their friends' houses, a park, or after-school activities without relying on a parent to chauffeur them.

Environment

Many people move to Sussex County because of its beautiful natural environment. Keeping the environment healthy means, at the most basic level, reducing or preventing pollution. The stormwater management solutions presented in this report are one way of keeping pollutants out of the water.

Climate change and energy use are rising concerns for many state and local governments and their constituents. By building more compactly and offering more transportation options besides driving, the county can help reduce its energy use and greenhouse gas emissions. Studies have found that building more compact, walkable communities can reduce driving by 20 to 40 percent, which in turns reduces air pollution and greenhouse gas emissions.[7]

Sussex County's coast is vulnerable to projected sea-level rises and to the more frequent and more severe storms forecast as the climate changes. Beach erosion, flooding, wind damage, and heat waves could all increase in the coming decades.[8] The county may also want to consider how it could adapt to the changing climate. Measures to consider include building more wind- and water-resistant homes, adapting flood maps to new projections and prohibiting building in the newly designated flood plains, and keeping development away from wetlands and beaches to allow a buffer for storm surges. The projected increase in frequency and severity of precipitation will affect the county's storm sewers and other infrastructure. Stormwater management solutions that hold and filter runoff are one way to reduce the volume of water flowing into the storm sewers; these measures are discussed more in Section 5.

The natural landscapes of Sussex County are attractive, but they also provide environmental functions by creating wildlife habitat and filtering stormwater runoff. The county can protect these open spaces by determining where it makes sense to grow and where the natural landscape should not be disturbed. Preserving natural lands gives people places for recreation and relaxation and helps keep the county's air and water cleaner.

2.3 Managing Stormwater Through Smart Growth Strategies

For the last few decades, stormwater management has meant control and treatment strategies that use hard infrastructure, focus on the "end of the pipe" instead of the source, and concentrate on site-specific practices that mainly

6 Trust for America's Health. *F as in Fat: How Obesity Policies Are Failing in America, 2007*. Delaware-specific highlights available at *healthyamericans.org/reports/obesity2007/release.php?StateID=DE*. Accessed January 11, 2008.

7 For more information, see Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen. *Growing Cooler: The Evidence on Urban Development and Climate Change*. Urban Land Institute: Washington, DC. 2008. The book's executive summary is available for free at *www.smartgrowthamerica.org/gcindex.html*.

8 For more details on potential effects of climate change, see U.S. Climate Change Science Program. *Weather and Climate Extremes in a Changing Climate*. 2008. Department of Commerce, NOAA's National Climatic Data Center.

EPA

Figure 9. Pond in the Prime Hook National Wildlife Refuge.

address flood control. Conventional practices, however, fail to address the widespread and cumulative hydrologic modifications within watersheds that result in increased stormwater volumes and runoff rates and cause excessive erosion and stream channel degradation. Existing practices also do not adequately treat for other pollutants of concern, such as nutrients, pathogens, and metals.

While conventional stormwater approaches drain individual sites, expanding development over the past years means that too much water, carrying too much pollution, is running into drains and receiving water bodies. The results are poor water quality, especially at drain outlets, and a dramatic drop in the refill rate of aquifers and streams. The 20 regions in the country that developed the most land between 1982 and 1997 now lose between 300 and 690 billion gallons of water annually that could otherwise have filtered through the earth and been captured as groundwater.[9]

Today, stormwater management is evolving beyond engineered approaches applied at the site level to an approach that manages stormwater at the regional (or watershed), community (or neighborhood), and site (or block) scales through natural approaches. Commonly referred to as green infrastructure, these strategies manage stormwater in a cost-effective, sustainable, and environmentally friendly way. Green infrastructure is the use of soil, trees, vegetation, wetlands, and open space to reduce total runoff and treat what is produced through capture and reuse or infiltration of rainwater. A comprehensive green infrastructure approach to stormwater management seeks to:

- **Preserve**: Protect and enhance natural features, such as undisturbed forests,

[9] American Rivers and Smart Growth America. *Paving Our Way to Water Shortages: How Sprawl Aggravates The Effects of Drought*. 2002.

meadows, wetlands, and other natural areas.

- **Recycle**: Recycle land by directing development to already degraded land like parking lots, vacant buildings, or abandoned malls.
- **Reduce**: Reduce land consumption and development footprints by using land efficiently.
- **Reuse**: Capture and reuse stormwater by directing it back into the ground through infiltration, evapotranspiration, or reuse techniques.

Conventional wisdom and common practice assume that lower-density development, such as large-lot zoning, provides sufficient open space to minimize any development-related impacts on water quality. However, recent research has found that dispersed, low-density development can exacerbate nonpoint source pollution by converting absorbent open space into compacted lawns and increasing impervious surface with numerous driveways, parking lots, and roads. Smart growth strategies encourage more compact development, with natural areas protected for their aesthetic, recreational, or ecological value.

3. Regional Growth and Development

The first step in protecting water quality resources and achieving more sustainable development is to put development where it best meets the county's economic, social, and environmental and water quality goals. The county should consider where growth makes sense, and where it wants to protect farms, open space, and other land from being developed. The basic steps are:

- Deciding where not to grow;
- Deciding where to grow; and
- Deciding how to grow.

3.1 Deciding Where Not to Grow

Preserving open space is critical to maintaining water quality at the regional level. A green infrastructure network of large, continuous areas of open space will reduce and slow runoff, absorb sediments, filter out debris and pollutants, serve as flood control, and help maintain aquatic communities. Some types of land, such as wetlands, buffer zones, riparian corridors, and floodplains, are better than others at protecting water quality. Wetlands naturally filter runoff by slowing water flow and allowing sediments to settle and the water to clarify. Strips of vegetation along streams and around reservoirs are important buffers, with wooded buffers offering the best protection. Tree and shrub roots hold stream banks in place, reducing erosion and the resulting sedimentation and turbidity. Organic matter and grasses slow the flow of runoff, giving the sediment time to settle and water time to percolate, filter through the soil, and recharge underlying groundwater. Research has shown that wetlands and buffer zones, by slowing and holding water, increase groundwater recharge, which reduces the potential for flooding.[10] By identifying and preserving these critical ecological areas, communities can protect and enhance their water quality.

3.2 Deciding Where to Grow

If growth and development are not planned and the pattern of development is determined by the defaults of current zoning, Sussex County will get a concentration of development along the coast, a few inland towns, and a veneer of low-density development (one to four units per acre) that will quickly eat up the rest of the county. This pattern will not preserve agricultural lands or open space. But, if the county and its residents decide that they want to preserve open space and keep the agricultural economy strong, directing development to existing towns will accommodate growth while protecting the rural landscape and lifestyle.

New development near existing towns and on key transportation corridors will require less new infrastructure and will be better connected to the economy of the region. Development that is compact and has a mix of uses is more resilient to economic hardship. If gas prices rise, people in compact, walkable communities have the option of walking or biking to the store and other destinations instead of driving.

In addition, directing development to already developed land, such as infill and brownfield or greyfield sites, uses land efficiently, makes the most of previous public investments by reusing existing infrastructure, and is good for stormwater management because it does not add

[10] Schueler, Tom. "The Importance of Imperviousness." *Watershed Protection Techniques*. 1994.

impervious surface. In fact, it can even reduce the amount of impervious surface, depending on how it is redeveloped. Putting new development near existing towns or building in already developed areas also supports a comprehensive stormwater management approach by allowing an interconnected network of open spaces and natural areas. One study found redeveloping one acre of brownfields preserves 4.5 acres of open space.[11] These natural lands not only improve water quality, they also protect wildlife habitat and enhance quality of life.

3.3 Deciding How to Grow

When the county decides where to grow, it also needs to determine things like what densities to allow, what type of design to encourage, and other considerations that will determine how the development looks, functions, and feels. Denser development will use land more efficiently, create less impervious area, protect more open space, and make it easier for people to get around without a car if they choose.

Public officials sometimes worry that proposing denser development will spark public opposition. And it's true that poorly designed dense development that offers no benefits to the community will not be well received. However, good design and new amenities can make denser development appealing to the community. Ten units per acre can be a small-town setting of houses with small yards, interspersed with stores and parks.[12] The way the new homes look, how they are arranged on the street, how well they fit in with their surroundings, and the amenities that come with them will all determine how the community reacts to the development proposal.

Density is essential for supporting public transit and a mix of uses, but it is also important in protecting water resources. Low-density development has a considerable effect on watersheds. Studies have found that covering just 10 percent of the watershed's land area with impervious surface can impair hydrological function and water quality. Research by EPA,[13] the Center for Watershed Protection,[14] and other environmental agencies and organizations shows that higher density projects may protect water quality better than low-density development. Two key findings from the research are:

- Higher density does not necessarily mean more impervious surface overall. In fact, compactly arranged units may reduce the building footprint and result in less impervious coverage per unit or per capita than dispersed stand-alone units. (See Figure 10 for an illustration.) In addition, more compact development requires fewer miles of roads and parking lots than low-density development, further reducing total impervious cover.
- Not all pervious surfaces are equal—many disturbed surfaces that appear pervious, such as lawns, golf courses, or other maintained lands, may be compacted, which greatly reduces their ability to infiltrate runoff. Therefore, developing less total land, including for lawns or other developed "green space," and maintaining more land in its natural, undisturbed condition is better for water quality.

[11] Deason, Jonathan et al. "Public Policies and Private Decisions Affecting the Redevelopment of Brownfields: An Analysis of Critical Factors, Relative Weights and Area Differentials." Prepared for EPA Office of Solid Waste and Emergency Response. The George Washington University, Washington, DC. September 2001. Available at *www.gwu.edu/~eem/Brownfields/project_report/report.htm*.

[12] A good resource for comparing well-designed density with poorly designed density is the Lincoln Land Institute's "Visualizing Density" web site: *www.lincolninst.edu/subcenters/VD*.

[13] EPA. *Protecting Water Resources with Higher-Density Development*. 2006. EPA 231-R-06-001. Available at *www.epa.gov/smartgrowth/water_density.htm*.

[14] Cappiella, Karen and Kenneth Brown. "Impervious Cover and Land Use in the Chesapeake Bay Watershed." Center for Watershed Protection. January 2001. Available at *www.cwp.org/Downloads/elc_imperv.pdf*.

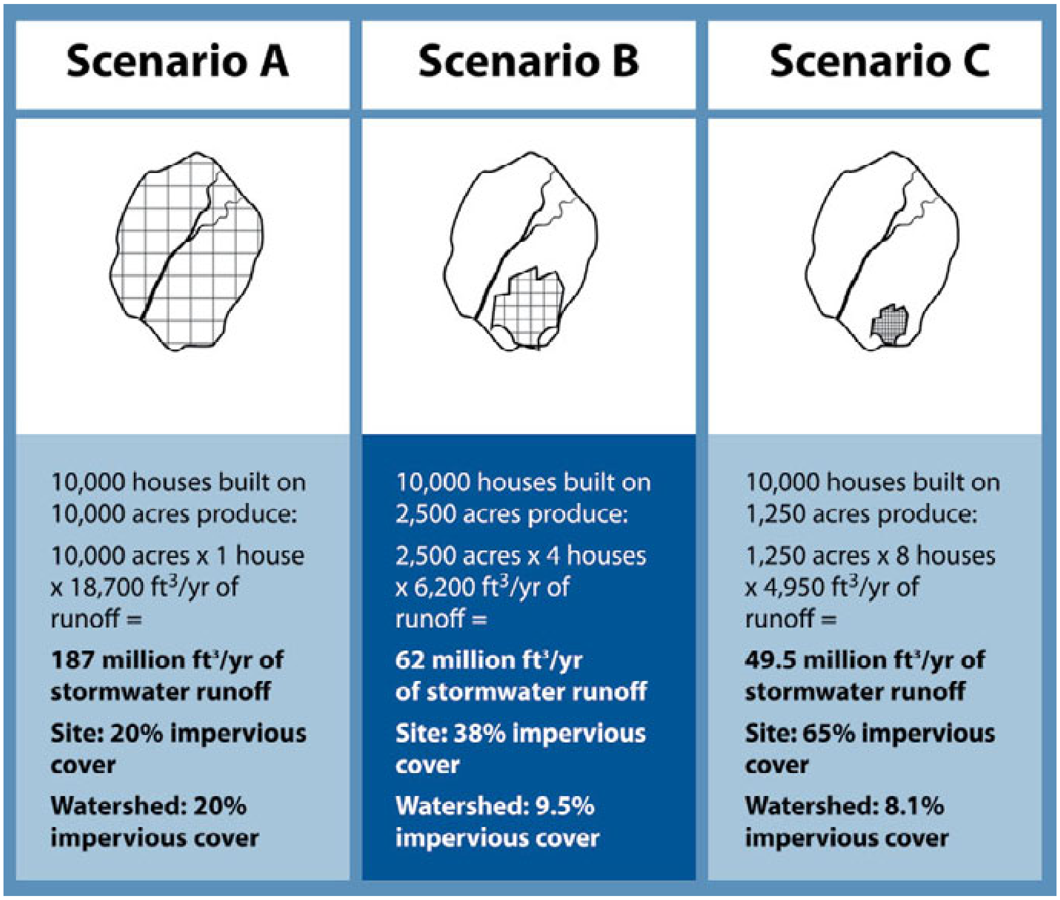

Figure 10. Building at higher densities uses less land, protects more ecologically important land, and creates less stormwater runoff. (Source: EPA. *Protecting Water Resources With Higher-Density Development*.)

In addition to density, a mix of uses is important to creating neighborhoods that have the small-town atmosphere people enjoy. A neighborhood can have sidewalks, but if there are no shops, parks, schools, or other destinations to walk to, residents will still have to drive for every errand. In addition, research has shown that mixing land uses decreases impervious cover by approximately 25 percent compared to conventional retail patterns because fewer parking spaces are required.

Over the last half-century, development patterns—both in Sussex County and across the country—have changed from the walkable neighborhoods found in small towns to individual subdivisions. When development was contiguous to towns and villages, roads were extended, blocks developed, and the new residents had easy access to all the amenities and businesses, plus multiple ways to get around. When development shifted to individually approved and developed subdivisions, residents usually had no connections to surrounding neighborhoods and often just one entrance onto the main road.

State and local agencies often have established standards to actually require this new pattern. State transportation officials thought that limiting connections to existing roads protected the capacity and safety of those roads; local officials thought that limiting connections to neighboring subdivisions protected those residents from extra traffic. This was a valid concern because, at the same time, roads were becoming much wider to make driving easier—which also increased speeding. Builders started to set houses farther back from the road, creating longer driveways. The extra pavement significantly increased stormwater runoff.

What planners didn't foresee is that eliminating connections between neighborhoods forces all traffic onto the main roads for even the short trips, requiring greater public investment to widen those roads and intersections—and making it far less likely people will walk or bike.

Because local land use and state transportation decisions are inextricably linked, creating more efficient, sustainable development patterns will require close cooperation among the county, local governments, developers, builders, and other parties. The county could work with these stakeholders to review policies, guidelines, and legislation and help determine any changes to allow and encourage new development to be more compact and connected—with less water quality impact and safer, more convenient transportation choices. Although state standards are not under the county's control, the Delaware Department of Transportation (DelDOT) and other state agencies could be invited to participate in the discussions. In addition to interagency coordination, one goal could be to identify potential improvements to state standards (such as street and access management standards and drainage standards) to make it easier for developers and builders to deliver more sustainable and environmentally sensitive communities and also help the county and state meet their water quality goals.

The county and this group of stakeholders could also review redevelopment standards and regulations to identify obstacles, determine possible incentives, and encourage redevelopment of properties along existing roadways. This corridor-based redevelopment approach is an effective way to add new housing, shopping, and community facilities near existing neighborhoods, provide new road and trail connections through adjacent parking lots, and start making connections for local travel without major neighborhood impacts. This approach could allow Sussex County communities to enjoy the benefits and opportunities associated with growth while minimizing water quality impacts.

4. Neighborhood/Community-Level Development

Community-level development decisions determine the look and feel of a neighborhood as well as how it connects to the rest of the area. This report discusses some of the major issues involved in neighborhood design decisions:

- Overall community design, including a mix of uses and open space preservation;
- Transportation issues, including street design;
- Parking requirements; and
- Stormwater management strategies, including "Green Streets."


EPA

Figure 11. The town green at Paynter's Mill, a recent development in Sussex County.

4.1 Overall Community Design

Putting a mix of land uses, like homes, workplaces, stores, schools, houses of worship, and recreational facilities, in close proximity has several benefits. People can walk or bike to more destinations instead of having to get in their cars for every errand and every recreation. As a result, they can choose to drive less, which reduces air and water pollution, as well as traffic congestion. Mixed-use neighborhoods can use parking lots and transportation infrastructure more efficiently, requiring less pavement and reducing stormwater runoff. When buildings contain more than one use, like offices or apartments above retail shops and restaurants, the roads and parking lots that support the building are used at different times of the day. This shared use is a more efficient use of resources and can reduce the costs of development, which in turn can reduce rents or sale prices.

By encouraging people to walk, bike, and use transit rather than drive, mixed-use development patterns reduce the number of miles people must drive. Reducing the miles we drive is a critical component in achieving energy security and cutting greenhouse gas emissions. On a more personal level, when you live in a community where you can walk or bike to daily activities, you spend less money on gas and other automobile-related expenses, and you can improve your health with more regular physical activity.

Open space in neighborhoods is important for encouraging physical activity, but also for environmental reasons. Parks and other open space incorporated into the fabric of a community can serve essential stormwater management functions. In addition, neighborhoods with parks are more appealing; people pay a premium to live near or next to parks and open spaces.[15] Some municipalities require open space within walking distance of new development. For example, Davidson, North Carolina, requires all new housing to be within a five-minute walk of a park.[16]

4.2 Transportation

Traffic and transportation are at the top of many Sussex County residents' minds. With few arterial roads and little connection among non-arterial roads, drivers have few choices, so everyone ends up on the major roads. Summer tourism traffic compounds the problem.

On a regional level, the state and the county have considered many different options. Regional transportation solutions are beyond the scope of this report; however, the development patterns and neighborhood-level design discussed here are compatible with any future public transit that might come to the county. In fact, they might even make rail—which some participants in the public workshops wanted—more likely. Rail lines require a certain population concentration around stations; Sussex County isn't there yet, but if the county promotes development in towns, it might eventually have the population density to make rail feasible. Getting rail will require long-term planning.

This section of the report addresses streets in neighborhoods, not arterial roads. For traveling long distances around the county, residents will still not have many options besides the arterials. However, to make it easier for residents to get around a neighborhood or between two developments, the county could consider:

- Connecting streets within and between neighborhoods;
- Making streets safe and comfortable for pedestrians and bicyclists; and
- Designing streets that enhance the neighborhood feel.

Connecting streets within and between neighborhoods

Towns in Sussex County, like Georgetown or Seaford, generally have a grid network of local streets, as most places built before World War II do. If a resident wants to go from one end of town to the other and the main road is congested, he or she can choose from three or four parallel streets to reach the same destination. So can all the other local drivers, which means traffic is dispersed over several streets instead of being concentrated on one road.

On the other hand, many of the new developments built in Sussex County over the past several years are poorly connected. They have one or two entry/exit points to main roads, and within the development, cul-de-sacs and disconnected streets mean that traveling two blocks as the crow flies could require driving or walking many times that distance. Children can't easily walk to a friend's house, even if they can see it from their backyard. Instead, they have to find someone to drive them.

The goals that participants expressed in the workshop suggest that the county and its towns should think of traffic circulation in terms of a network, not just one road. One reason traffic gets heavy on the main roads is that most of the local traffic must use it, even for very short trips, because there are few other options.

The lack of connectivity isn't just inconvenient—it can be dangerous. Few entry and exit points to a development also mean that emergency response vehicles can take longer to respond to a call because they may have to take a circuitous route. Just as residents have no options besides

[15] de Brun, Constance T.F. (editor). *The Economic Benefits of Land Conservation*. Trust for Public Land. 2007. Available at *www.tpl.org*.

[16] EPA. *National Award for Smart Growth Achievement, 2004*. EPA 231-F-04-001. 2004. Available at *www.epa.gov/smartgrowth/sg_awards_publication_2004.htm*.

Figure 12. **Many suburban developments are being designed in ways that make trips longer and make it difficult for residents to walk or bike.**

the arterials, emergency responders can't take a different route if the main road is congested.

One option for addressing this issue is to create a more connected network of streets. Connected street networks help alleviate auto traffic on the main roads by:

- Giving local drivers more route choices;
- Giving bikers and walkers safer, quieter, and perhaps more direct streets to use; and
- Allowing more access from side and back streets to parcels along the main roads.

Giving locals a choice of other ways to get to stores, homes, and work means less time waiting in traffic for residents and for visitors. Tourist traffic could continue to use the major roads; locals could avoid the congestion.

Some developers noted during the workshop that they had tried to get more access points from main roads to their developments, but DelDOT did not allow them to do so. This is typical in places like Delaware, where the state DOT has control over all public roads through design and access management standards, as well as acceptance requirements (roads have to be built to requirements or DelDOT will not "accept" them from developers). It can be difficult for individual developers to obtain case-by-case exceptions to these standards. If the development is adjacent to destinations that are walkable (i.e., near an existing town, shopping center, or school), a case can be made that added connections will convert some auto trips to walking or biking and will reduce traffic on the main roads. Under current regulations, if developers also want to build narrower, more walkable streets, those streets generally have to remain private. Existing regulations were developed for reasons that were valid at the time. It is only relatively recently that research, modeling, and results from newly built examples have demonstrated that returning to a pattern of a connected grid of narrower streets will be safer and more efficient, have less environmental impact, and provide more transportation choices.

Virginia, which like Delaware owns most local roads, realized that current development patterns were inefficient from a transportation perspective and has undertaken several related initiatives to change state regulations, require localities to consider more compact development patterns, and encourage development of a more cost-effective network of local roads. At the direction of the General Assembly, the Virginia Department of Transportation is nearing adoption of new Subdivision Street Acceptance Requirements, which will ensure connectivity of road and pedestrian networks with the existing and future transportation network.[17] The legislation also required provisions to minimize stormwater runoff and impervious surface area.

Making streets safe and comfortable for pedestrians and bicyclists

During the public meetings and in stakeholder interviews, residents said that they enjoyed being able to walk and bike around their neighborhoods. Many streets in the county's towns and in some of the newer developments near the coast, like Paynter's Mill and the Villages of Five Points, have sidewalks. The team saw several bicyclists on these streets as well, and even a few cyclists braving Route 1. But being physically able to walk or bike and feeling safe and comfortable doing so are two different things.

Narrower streets are safer and more comfortable for pedestrians and bicyclists. Not only are they easier to cross, which is especially important for children, older people, and others who move more slowly, but they also naturally slow down traffic. Slower traffic means drivers have more time to react if a pedestrian or bicyclist enters the travel lane, and it also increases the chance of a pedestrian surviving a collision (see Figure 13). Narrower roads also have less impervious cover, thereby decreasing runoff. Indeed, EPA now views narrowing streets and roads as a stormwater best management practice. In addition, some of the stormwater management solutions discussed in Section 5 could be used to narrow existing streets, thereby improving stormwater management and making pedestrians and bicyclists safer at the same time.

Vehicle speed	Chance of survival
20 mph	95%
30 mph	55%
40 mph	15%

Figure 13. A pedestrian's chance of surviving a collision with a vehicle decreases as the vehicle's speed increases. (Source: Charlier Associates)

EPA

Figure 14. Bicyclist on Route 1.

[17] Virginia Acts of Assembly – 2007 Session, Chapter 382. "An Act to amend the Code of Virginia by adding a section numbered 33.1-70.3, relating to taking certain streets into the state secondary highway system." [S 1181] Approved March 15, 2007. See *www.vdot.virginia.gov/projects/ssar.*

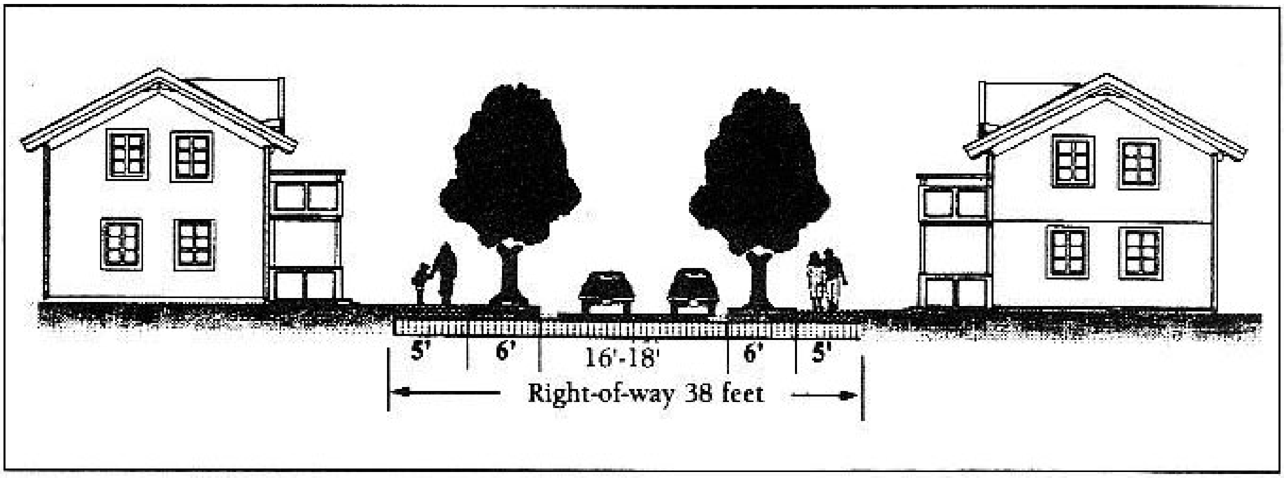

Figure 15. Sample cross-section of a neighborhood street. (Source: Dan Burden et al., *Street Design Guidelines for Healthy Neighborhoods*, Local Government Commission, 1999)

Designing streets that enhance the neighborhood feel

Residents can get nervous when they hear about plans to add new roads to their neighborhood. If the new roads are going to be like the existing roads—too wide to cross comfortably, no sidewalks, few or no trees along the road, designed to get cars where they're going as quickly as possible with little regard for people or aesthetics—then it's hard to see how a neighborhood could benefit from more roads. But if the new streets are quiet, attractive, and safe, while also offering more route choices and less congestion, residents may find the idea more appealing.

Good street design is crucial if the county decides it wants better-connected neighborhoods. Most of these new connecting streets could be narrow neighborhood streets, designed for a mostly residential area with low traffic volume at slower speeds. They could have sidewalks, on-street parking, and strips of grass, trees, or other vegetation between the sidewalk and the street. The vegetated strips could also serve as stormwater management (see Section 5 for more details).

Figure 15 shows how one of these streets might look. Each design element supports a more pleasant neighborhood street for both driver and pedestrian. The narrow lanes and on-street parking encourage drivers to drive slowly and look out for oncoming cars. The on-street parking and vegetation between the sidewalk and street protect the sidewalk to make bikers and pedestrians feel more comfortable. The street could be 8 to 10 feet wider if the county wants to allow parking on both sides of the street.

4.3 Parking

When a community has a mix of uses and a road network that allows shorter trips and makes walking and biking safer, it can also consider revising parking requirements to better balance parking supply with demand. Most of the United States is "overparked"—that is, there are more parking spaces than are needed, and these spaces require developments to be more spread out—creating longer distances between stores, roads, homes and businesses. Developers have to pay to create parking spaces—one estimate found that, depending on land and construction costs, engineering considerations, and other variables, it can cost anywhere from $20 to $200 per month to finance, build, operate, and maintain a parking space.[18] Reducing

[18] EPA. *Parking Spaces/Community Places*. 2006. EPA 231-K-06-001. pp. 9-10. Available at *www.epa.gov/smartgrowth/parking.htm*.

the number of parking spaces that developers are required to build could translate into lower housing prices for tenants. Reducing the amount of pavement for parking also helps better manage stormwater runoff by using less impervious surface.

Although probably everyone has had the experience of searching for a parking space in a full lot, what people perceive as too few parking spaces can actually be a misallocation of spaces. Correctly determining the demand for parking and exploring alternatives to the conventional way of designing parking can help reduce the number of parking spaces without inconveniencing people.

One technique being used more often in communities around the country is shared parking. With shared parking, two or more uses that need parking at different times of the day or week can share a parking area instead of having to each maintain separate parking lots. For example, offices need parking mainly on weekdays, so the same parking area can be used for restaurant traffic on evenings and weekends.

A "park once" strategy similarly relies on a mix of uses; a parking area is close enough to a variety of uses that users can park once and walk from there to several destinations. Neighborhoods with enough destinations to employ a park-once strategy can allow lower parking requirements per use, which saves property owners money. This strategy can be effective at reducing congestion in resort areas.

On-street parking can also be allowed to count toward a business or residence's parking requirement. Cars parked on the street buffer pedestrians from moving traffic. In some shopping districts, on-street spaces have relatively short time limits to encourage quicker turnover of the spaces, which brings more people into the area. Longer-term parkers can use parking areas behind the buildings and walk to different stores.

Design of parking areas is important for aesthetic and environmental reasons. No one likes a vast, unbroken parking lot with no vegetation—it's unpleasant to walk across and offers pedestrians no protection from the elements or the traffic. Likewise, these large expanses of asphalt do nothing to slow the rush of water after a storm; the runoff swiftly washes all the debris and pollutants off the lot and often into surface waters or a sewer drain.

By contrast, a parking lot with areas of trees and plants is not only more appealing, offering shade and a respite from gray pavement, it also handles stormwater better. The runoff can be channeled into vegetated areas that slow the water flow and filter out the pollutants. In many cases, an existing parking lot can be redesigned to use space more efficiently, allowing room for rain gardens without losing parking spaces. Specific ideas for parking lot design appear in Section 5.2.

4.4 Stormwater Management

These transportation and street design techniques are also stormwater management strategies. The narrower streets described above have less paved surface, and they provide vegetation along the road that can filter runoff. The new neighborhood development standards developed by the U.S. Green Building Council[19] set an objective of reducing impervious area and street runoff by 25 percent. Communities can meet this goal by reducing lane widths and by using natural infiltration techniques in medians, parking spaces, and lane edges to reduce runoff from streets.

[19] LEED ND—Leadership in Energy and Environmental Design—Neighborhood Development, *www.usgbc.org/DisplayPage.aspx?CMSPageID=148*.

One technique for designing streets that work well for people, cars, and stormwater management is "Green Streets," a streetscape design strategy with multiple functions that integrates the natural and the manmade to create a distinctive community identity. Green streetscapes facilitate natural infiltration wherever possible by using fewer impervious surfaces, such as concrete and asphalt, and allowing for more vegetation and other attractive materials, such as crushed stone and pavers. In addition to infiltration, green street practices also reuse, or evapotranspire (allow water to evaporate back into the air), stormwater runoff and can be less expensive than traditional methods of stormwater control.[20] This design approach, together with an interconnected street system and a properly funded maintenance program, can provide a streetscape that reduces the negative impacts typically associated with poorly designed streets—unappealing aesthetics, noise, and traffic congestion—and ensures long-term stewardship of natural resources.

Section 5.2 demonstrates how street-edge infiltration practices could be used on a range of street types in Sussex County, from small residential streets to busy commercial corridors. This captured runoff could serve many useful purposes, such as recharging groundwater resources where appropriate while providing aesthetic and traffic-calming benefits.

The Belle Hall study, by the South Carolina Coastal Conservation League, is an example of the water-quality and other benefits that comprehensive stormwater approaches at the neighborhood level can offer. The study examined the water quality impacts of two development alternatives for a 583-acre site in Mount Pleasant, South Carolina: one that used a conventional suburban pattern of large lots, wide roads, and separation of land uses; and one that incorporated traditional neighborhood patterns of higher densities, mixed uses, and narrower roads. In each scenario, the overall number of homes and the square feet of commercial and retail space were held constant. The results found that the conventional scenario consumed eight times more open space and generated 43 percent more runoff, four times more sediment, almost four times more nitrogen, and three times more phosphorous than the scenario that incorporated traditional neighborhood patterns.[21]

[20] Kloss, Christopher and Crystal Calarusse. *Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows*. Natural Resources Defense Council. 2006.

[21] South Carolina Coastal Conservation League, Environmental Protection Agency, National Oceanic and Atmospheric Administration, South Carolina Department of Health and Environment, Town of Mount Pleasant. 1995. *The Belle Hall Study: Sprawl vs. Traditional Town: Environmental Implications*. South Miami, FL: Dover, Kohl, and Partners.

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5. Site-Level Stormwater Design Strategies

5.1 Introduction to Site-Scale Design

Just as small amounts of rain add up quickly to large volumes of water downstream, individual sites' measures to manage stormwater can accumulate to significant and noticeable improvements in the overall health of a watershed. Site-scale stormwater management strategies complement regional and community-level stormwater management efforts with tangible tools that can be used throughout a community to help protect water quality.

This section focuses on managing stormwater at the scale of a front yard, neighborhood street, parking lot, or development parcel. It introduces a toolbox of site-level stormwater management strategies that can help Sussex County better manage stormwater while also creating appealing streetscapes that are safe and comfortable for drivers, bicyclists, and pedestrians. The design ideas presented are simple, easy to implement, and cost effective. Individually, they are small and manageable to build, and when reproduced throughout a city or watershed, they accumulate to make significant improvements in downstream water quality. The ideas presented here are meant to be a starting point for discussions about design. This is not a technical manual for engineering and construction.

Communities across the U.S. have implemented many of these design strategies to protect their watersheds, calm traffic, beautify streetscapes, and educate residents about natural resource protection.

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Figure 16. Site-level design begins with the first drops of rain.

EPA

Figure 17. Sustainable stormwater design balances the needs of our communities with the needs of our natural environment.

EPA

Figure 18. Prime Hook National Wildlife Refuge is one of the beautiful natural places that Sussex County residents value.

5.1.1 Conventional Stormwater Design in Sussex County

Sussex County has some sustainable stormwater projects, but most development follows the conventional philosophy of conveying stormwater "out of sight, out of mind." In most cases, untreated runoff is quickly whisked away through a system of underground pipes to the back corner of a development, or it is carried off site to eventually spill into a stream, river, or bay. Stormwater is treated as a waste rather than a resource.

Some Sussex County developments employ landscape-based stormwater facilities in the form of wet or dry ponds. Most of these traditionally engineered approaches rely on underground pipe systems for stormwater conveyance and are often expensive to build. Stormwater management methods that quickly drain stormwater ignore and counteract the landscape's ability to act as a sponge and to slow, filter, and absorb water where it falls. They allow substantial volumes of runoff to accumulate, which necessitates larger facilities. In addition, wet ponds and dry ponds are difficult to build in more densely developed areas and on land-constrained sites.

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Figure 19. Conventional stormwater design is common in both new and existing development in Sussex County.

Nevue Ngan Associates

Figure 20. Typical dry pond design solution in new development in Sussex County.

EPA

Figure 21. Typical wet pond design solution in new development in Sussex County.

5.1.2 What Is Sustainable Stormwater Design?

Sustainable stormwater design strives for a balanced and cost-effective approach to stormwater management. It incorporates the landscape's inherent ability to slow, filter, and absorb water into the development and redevelopment of streets, parking lots, and buildings. At the site scale, sustainable stormwater management can dramatically reduce pollution, decrease runoff volume, reduce runoff temperature, protect aquatic habitat, and create more interesting places to walk, ride, drive, and visit. Sustainable stormwater management works best in conjunction with a shift in attitude: from stormwater as a waste that is dealt with by someone else somewhere downstream, to stormwater as a resource and a local responsibility for everyone to steward.

Figure 22. Sustainable stormwater design model.

Four guiding principles of sustainable stormwater management are:

1. **Reduce impervious surfaces and preserve natural resources** through efficient site design. Build on already degraded sites whenever possible.
2. **Sustainable stormwater design begins with a raindrop.** Manage stormwater at the source and on the surface. As soon as rain falls on a street, parking lot, or rooftop, begin to slow, filter, and absorb the water. Allow it to infiltrate into the ground as soon as possible.
3. **Use plants and soil** to slow, filter, and absorb runoff. Let nature do its work.
4. **Design stormwater facilities that are simple and cost effective and enhance the community.** Stormwater facilities can be beautiful!

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Figure 23. A residential green street. Plants slow filter and absorb stormwater as it flows on the landscape surface.

5.2 Site-Scale Stormwater Management Strategies

Sustainable, site-scale stormwater management involves two fundamental steps: 1) design sites efficiently (i.e., locate streets, parking lots, and buildings in ways that minimize their footprint and their impact on the landscape); and 2) increase the amount of stormwater that is captured and absorbed on site. This section introduces both concepts and explores their application. Where possible, this section provides detailed guidance and examples to demonstrate how streets, alleys, and parking lots in Sussex County could be designed or retrofitted to manage stormwater using more sustainable approaches.

The specific site strategies and techniques discussed in this section are separated into three categories:

1) Site Layout Strategies

Site layout strategies are the first step in managing stormwater in a way that mimics natural hydrology. Using land more efficiently for development, preserving critical ecological areas, and reducing runoff through better site design are vital to maintaining a healthy watershed. This section introduces the following site layout strategies:

5.2.1 Design Sites Efficiently

5.2.2 Protect and Enhance Natural Resources

5.2.3 Protect and Plant Trees

5.2.4 Design Interconnected Surface Stormwater Management

5.2.5 Provide Transportation Choices

2) Rain-Absorbing Footprint Strategies

Rain-absorbing footprint strategies design streets, parking lots, and buildings to absorb as much stormwater as possible, outside of the use of rain gardens. These strategies use surface materials to make otherwise impervious surfaces pervious or to collect water for reuse. This section discusses the following strategies:

5.2.6 Use Pervious Paving

5.2.7 Harvest and Reuse Rainwater

5.2.8 Use Green Roofs

3) Rain Garden Strategies

"Rain garden" is the general term used to describe stormwater strategies that use plants and soils to filter, absorb, and slow stormwater on the landscape surface. Rain gardens come in many forms and can be incorporated into a wide range of site conditions. This section discusses the following strategies:

5.2.9 Use Swales

5.2.10 Use Planters

5.2.11 Use Infiltration Gardens

5.2.12 Use Curb Extensions

5.2.13 Disconnect Residential Downspouts

These site-scale stormwater strategies can apply to a range of development contexts within Sussex County, including streets, alleys, parking lots, and buildings.

Residential streets: Residential streets in Sussex County vary. Some are simply 20-foot-wide strips paved with asphalt; others are more elaborate with attractively landscaped medians and street trees that signal entrance to a neighborhood. However, multiple opportunities exist in Sussex County for new construction and for retrofitting existing streets to green streets. Many residential streets in Sussex County have long, uninterrupted stretches of space that can support rain gardens. Some streets have medians or curb extensions that can be retrofitted to manage stormwater. Other streets have travel lanes or shoulders that could be narrowed to integrate stormwater features and support a more comfortable and safer walking environment.

Commercial main streets and town centers: Many of the historic main streets in Milton, Lewes, Georgetown, and other towns in Sussex County have a community-oriented, small-town character that the residents cherish. However, like most towns in the United States, it can be difficult to find space for stormwater management when the town must also find room for cars, parking, bikes, pedestrians, street trees, lighting, and other amenities. Transforming commercial streets into green streets requires creativity and balancing multiple objectives. Design strategies that the county could consider to integrate stormwater into its most active streets include combinations of swales, planters, curb extensions, and pervious paving.

Highways and arterial streets: Many of the highways and arterial streets in Sussex County would be well suited to sustainable stormwater management strategies. The long, linear stretches of uninterrupted space along highways and arterial streets create opportunities for rain gardens. Highways and arterials also have large landscape areas adjacent to the roadway or included in the right of way, such as grassy medians and side strips, that could be retrofitted for stormwater management. Some roadways may not have landscape space in place but do have travel lanes or paved shoulders that could be narrowed to create space for features such as swales. This space could also be used for sidewalks, on-street bike lanes, or landscape-separated bike greenways. If Sussex County would like to see its highways retrofitted in this way, it would have to work with DelDOT.

Alleys: Sussex County has some residential alleys designed in the neo-traditional or new urbanist style, including in Paynter's Mill and Cannery Village. With alleys, garages can be put behind a home, allowing the street to be more pedestrian friendly, and the architectural detail of the home is no longer dominated by a front-loading garage. Providing alley access and eliminating the driveways at the front of homes not only enhances the overall streetscape, but also allows a more contiguous landscape area along the street frontage and front yards. This extra landscape space presents an opportunity to employ various green street strategies. Many communities are applying site-level stormwater management strategies to alleys. For example, Chicago, Illinois, has a green alley program that retrofits public alleys throughout the city with pervious paving. Objectives of the city's program include improving stormwater management and reducing flooding.

Parking lots: Large or small, parking lots offer many opportunities for applying sustainable stormwater management strategies. Designing lots efficiently by reducing parking stalls and drive aisles can yield significant space for landscape areas. Even if landscape areas are not considered for rain gardens, they remove

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Figure 24. Flexibility in the design of this parking lot preserved existing trees and natural resources. Simply preserving these trees and maximizing landscape area help achieve better water quality even if stormwater facilities are difficult to build.

impervious area and can be used for planting large canopy trees, native shrubs, and groundcovers. Pervious paving is widely accepted in parking lots and is particularly useful in small parking lots where space is tight. Stormwater swales are the most universal rain garden strategy used in parking lots. Long, linear swales fit well between rows of parking. Even curb extensions and infiltration gardens can be used in parking lots. As in street applications, rain gardens in parking lots should be carefully designed to ensure safe pedestrian circulation.

Buildings: Sussex County has many different building types, ranging from historic town center buildings in places like Georgetown, Lewes, and Milton, to newer commercial centers and residential communities. Managing stormwater from buildings involves dealing with stormwater generated from roofs, either on or off the building. On-building techniques include using green roofs, rainwater harvesting, and flow-through planter systems. Off-building strategies employ infiltration planters, swales, and gardens. Each strategy or combination of strategies depends on the building type, its surrounding context, and the amount of landscape space surrounding the building.

5.2.1 Design Sites Efficiently

One of the first questions designers, developers, or municipal or county staff should ask about a project is: Has the site been designed in the most efficient way possible? Examples of efficient site design include higher or vertical density, vertical integration of land uses, structured parking lots when appropriate, connected street network with narrower street and road designs, and parking spaces that meet expected demand. However, sometimes what makes sense from a design perspective is not allowed under existing regulations. For this reason, designers and policy makers work together to achieve better site-specific stormwater management. Efficient site design is an important first step if the site will include rain gardens because carefully laying out the site makes it easier to find room for these stormwater facilities. This is especially evident with street and parking lot retrofit projects.

Richard Drdul-www.flickr.com

Figure 25. This street could be narrowed to create space for rain gardens and sidewalks.

Efficient Site Design and Streets

Some ideas for designing streets more efficiently include:

- Narrowing travel lanes from 12 feet to 10 feet (or less) reduces impervious area, can reduce new development infrastructure costs, can calm traffic in pedestrian-oriented areas, and can help create room for stormwater applications.
- Consolidating travel lanes and on-street parking can yield space for rain gardens, bike lanes, or wider sidewalks. Designers, developers, and county officials could consider whether a travel lane on a multi-lane street could be eliminated, or whether some parking spaces could be reduced to increase landscape area along a street.
- Unused asphalt next to travel lanes can be converted into landscape. Figures 26 and 27 illustrate how underused impervious street edge could be redesigned to maximize the landscape area along the street.

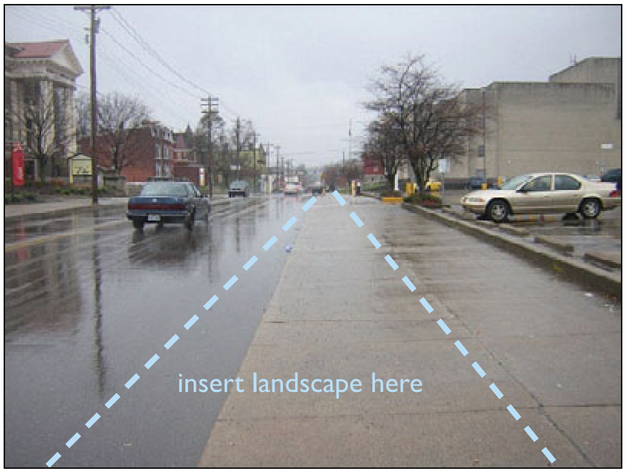

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Figure 26. Underused space on this street could be converted into conventional landscape space or used for rain gardens.

Nevue Ngan Associates

Figure 27. The same street with additional landscaping, a stormwater swale, and street trees.

Efficient Site Design and Parking Lots

To use parking lots more efficiently in sites, consider these options:

- Shortening parking stall lengths from 18 feet to 15 feet still allows a standard SUV to fit in the stall's striping. Shortening the drive aisles from 24 feet to 22 feet allows cars to comfortably back up and travel within the parking lot. Portland, Oregon, and other cities have similar or stricter parking lot sizing standards that accommodate drivers while also protecting pedestrians and providing room for stormwater management. For retrofits, shortening parking stalls and drive aisles often provides the space needed to add stormwater swales and planters.
- Consider how much parking is needed on an average day. Too often, parking lots sit half full for most of the year. This is especially true with shopping mall and big box store parking lots. For more discussion of parking standards, see Section 4.3.

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Figure 28. This parking lot has large areas of wasted space.

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Figure 29. The same parking lot redesigned to efficiently use space yielded a parking lot swale, sidewalk, and landscape zone for street trees.

Figure 30. This apartment complex allows cars to park under the building's second floor, which uses the site more efficiently.

Efficient Site Design and Building Envelopes

Buildings and their immediate surroundings can also be designed to efficiently use space. For new construction, buildings can be designed to allow parking stalls under the second-floor podium. This provides additional space on the project site for rain garden applications. Buildings that already have conventional landscaping that does not have any additional function other than screening or aesthetics offer great opportunities to convert the landscape area into functional rain gardens, thereby using the land more efficiently.

5.2.2 Protect and Enhance Natural Resources

For any kind of land development where protecting natural resources is a goal, attention should be paid to designing "with nature" and not against it. When designing a particular development, protecting a site's natural resources can have the same importance as planning and designing streets, residences, and commercial centers. Existing stands of trees, wetland areas, riparian buffers, and open spaces can be protected, enhanced, and integrated into a site's development. Not only do a site's natural resources provide habitat area and help naturally manage stormwater runoff, but when well-integrated into a site's design, these preserved features can provide a distinctive identity and can help market the project.

Some strategies to help preserve and protect natural resource areas include:

- Identify resource areas early in the design process and overlay their boundaries over the development programming.
- Large stands of trees can be protected by carefully designing them into street medians or traffic circles or simply preserving them next to buildings. Roads, sidewalks, parking lots, and buildings can be designed around existing trees to protect them.
- A site's wetland areas can be used as natural overflow points for stormwater. However, runoff can be filtered through rain gardens before entering the natural wetland areas.

Figure 31. The existing vegetation and natural resources on the site of this development have been eliminated.

Figure 32. Protecting riparian buffers like this one can help protect and integrate natural resources into a site's development.

In forested areas, it may be next to impossible to save all existing trees and vegetation and still have a plausible development project. In these situations, developers can save extensive "clusters" of natural vegetation to balance the need for development and resource protection.

5.2.3 Protect and Plant Trees

Preserving healthy trees wherever possible is important to managing stormwater runoff. Trees slow, absorb, and filter rainwater by intercepting raindrops on leaf surfaces, slowing the flow of water through the landscape, and drinking water that has infiltrated into the soil. Some steps to consider include:

- An inventory of existing trees prior to design provides a baseline and can help guide the design and location of streets, buildings, parking lots, and rain gardens. The inventory can include the species, age, typical life span, and health of trees. Also important is whether the tree species can tolerate frequent inundations. Consider whether the facility can be designed around the trees and whether the trees can tolerate construction around the roots.

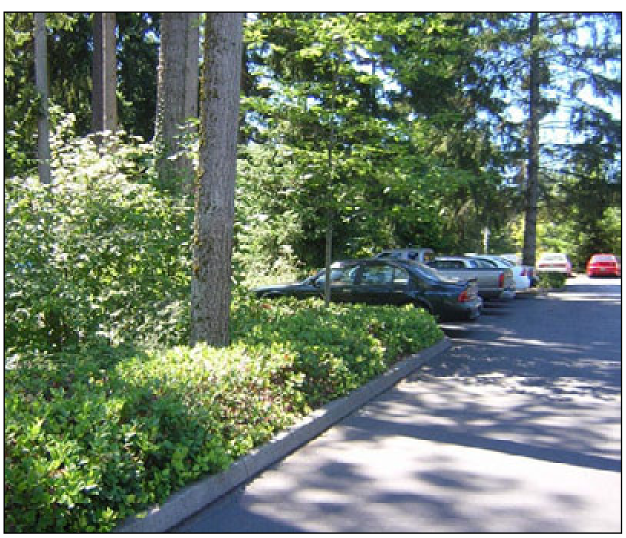

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Figure 33. A parking lot with mature landscaping and trees.

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Figure 34. These trees will help soak up stormwater, cool the parking lot, provide an aesthetic amenity, and filter pollutants out of the air and water.

- Mature trees may be able to soak up water at a comparable rate that it can be infiltrated in a swale, so, in terms of overall stormwater benefit, it may be worth reducing stormwater facility size to save a mature tree.

Planting new trees where possible will help slow, filter, and absorb stormwater runoff.

5.2.4 Design Interconnected Surface Stormwater Management

In natural conditions, once rain fell on the land, it would slowly infiltrate into the ground or would flow to interconnected low spots in the landscape. To mimic a more natural hydrologic condition, a site can have a similar interconnected stormwater system. Large development projects that want to use a more natural approach to stormwater management could consider designing multiple small-scale rain gardens rather than relying solely on a "pipe to pond" system. Reducing the amount of underground pipe infrastructure and encouraging minimal pipe design (MPD) promote the use of landscape swales and surface runnels to interconnect and slowly convey stormwater to each downstream rain garden. Using an MPD design approach not

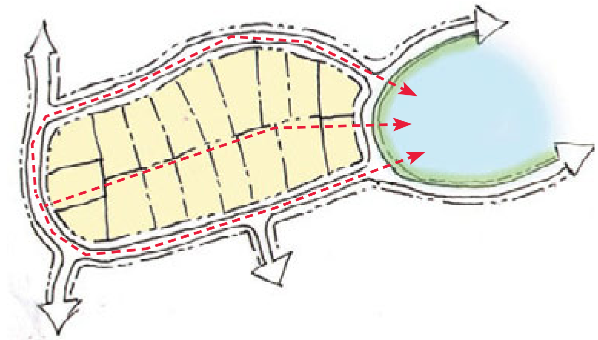

Figure 35. **A conventional residential site plan. Stormwater is whisked away quickly via underground pipes into a large storage pond.**

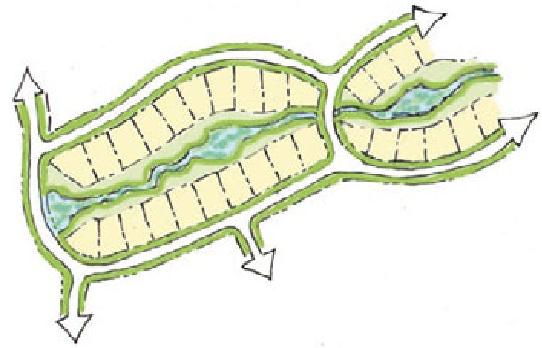

Figure 36. **A redesigned site plan with a well-connected stormwater system. Rainfall is collected and conveyed through interconnected rain gardens, creating a more natural condition while still allowing development to occur.**

Figure 37. **A well-integrated residential rain garden.**

only mimics a more natural drainage condition, it also has the potential to save the project significant infrastructure costs.

Sometimes having an overflow pond system to manage large storm events will be necessary. However, by designing the site to first manage stormwater on the surface and within smaller interconnected rain gardens, the footprint of the overflow pond might be reduced to allow for more developable land and a more aesthetically pleasing project. This was the case in the High Point development in Seattle, Washington. By using an interconnected network of natural infiltration techniques, the development was able to use a one-acre wet pond instead of a five-acre pond. This “saved” four acres that could then be developed. A smaller wet or dry pond allows more flexibility to design the facility so it blends in better and becomes a neighborhood amenity.

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Figure 38. A conventional strip mall site. Is there any incentive to walk along this streetscape?

npgreenway-www.flickr.com

Figure 39. A separated bike path gives people a choice to walk, bike, or drive.

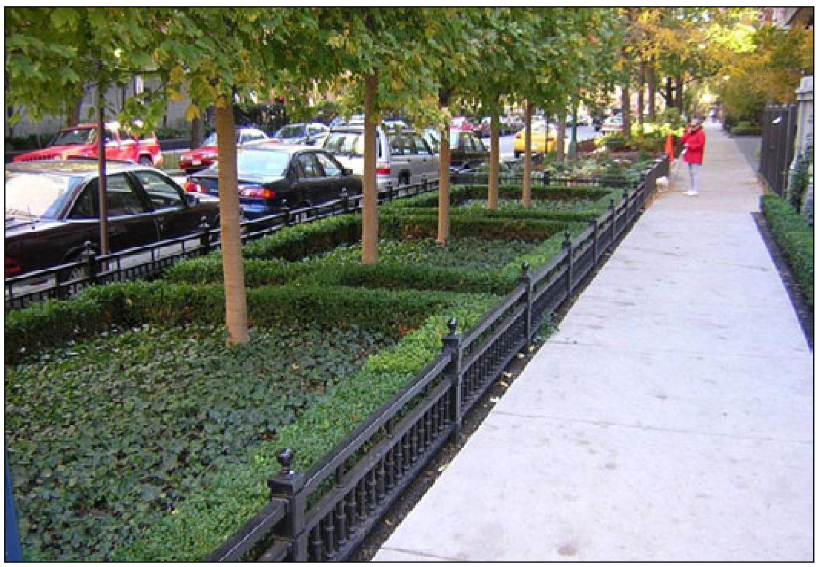

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Figure 40. In a pedestrian-friendly streetscape, streets are designed to make walking safe, comfortable, and convenient.

5.2.5 Provide Transportation Choices

Designing stormwater management systems that allow plants and soils to clean pollutants running off of streets and parking lots addresses pollution at the end point. The beginning point, and a more indirect water quality improvement strategy, is to tackle the pollution at the source by reducing the pollutants from motor vehicles. Communities can accomplish this goal by giving people more transportation choices, such as walking, biking, and public transit. The equation is simple: a reduction in automobile use equals a reduction in the pollution associated with automobiles. In many communities, the street environment makes it difficult, inconvenient, or unsafe for people to walk, ride their bikes, or hop on a bus. Section 4.2 discussed some neighborhood-level ways that give people choices in how they move around, thereby making it easier for people to leave their cars at home. The design of individual streets can help reinforce neighborhood-wide planning for more bike- and pedestrian-friendly streets by protecting pedestrians and bicyclists from traffic and by adding trees and other vegetation to shade the sidewalks and make them more appealing. Both strategies offer stormwater management benefits as well when they include rain gardens as described in Sections 5.2.9–12.

Another important component of sustainable stormwater design is to increase the amount of stormwater that is managed on site—that is, to use plants and soil to slow, filter, and absorb stormwater on site. This section introduces strategies that increase on-site stormwater capture, absorption, and filtration. Before-and-after sketches are provided to illustrate the potential application of these techniques to the redesign of streets and parking lots in Sussex County. The sketches are based on sites that the team saw during its August 2007 visit to the area around Lewes. The goal of illustrating these strategies in context is to provide a broad range of potential site-scale applications. Many of the concepts illustrated can be applied broadly across Sussex County.

5.2.6 Use Pervious Paving

Pervious paving refers to paving materials (asphalt, concrete, pavers, grass-pave) that allow water to drain through the paving system and into soils below. These systems are alternatives to conventional, impervious pavement and can provide the structural integrity needed for cars, trucks, and high-traffic pedestrian areas.

This section introduces the use of pervious paving systems. It discusses the potential applications of these systems and the pros and cons of different paving systems. Before-and-after sketches show complete and partial applications of pervious paving to a residential alley and residential street in Paynter's Mill. This section concludes with a discussion of how pervious paving could be applied to a parking lot.

Good places for pervious paving:

- Streets
- Parking lots
- Parking strips
- Alleys
- Patios

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Figure 41. This street shows how permeable pavers can help define the streetscape.

Community benefits:

- Can be safer than traditional paving because puddles are less likely to accumulate.
- Provides aesthetic appeal.
- Defines a distinctive community character.
- Delineates parking areas or pedestrian zones.
- Introducing a pattern in a large area of paving can give the illusion of narrower or smaller spaces and help slow traffic.

Pervious Asphalt and Concrete

Pervious asphalt and concrete production is similar to that of standard asphalt and concrete; the main difference is that the fine-grained sediments that typically fill the pores between the larger aggregates are left out of the aggregate added to the mixture. This leaves small holes in the concrete that allow water to drain through the surface.

Advantages:

Pervious paving has been successfully used on interstates and other limited access roads. Pervious paving reduces the accumulation of puddles and danger of hydroplaning on high-speed roads.

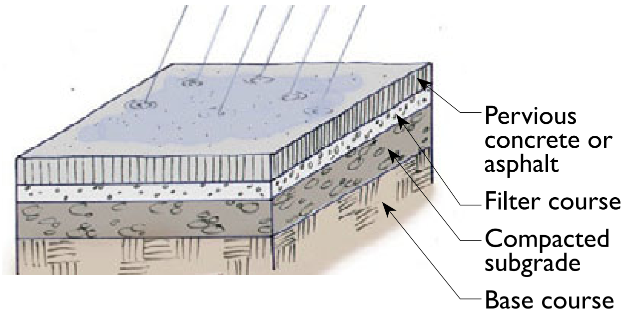

Figure 42. Pervious concrete profile.

Figure 43. Porous concrete allows water to pass through pore spaces in the aggregate.

Figure 44. A pervious asphalt parking lot. The force applied by tires at turning, stopping, and starting locations can be hard on the paving surface.

Figure 45. There is no wet sheen on the pervious asphalt in the parking stalls in this parking lot, compared to the conventional asphalt paving in the drive aisles.

In snowy conditions, pervious paving allows melted snow and ice to drain and the surface to dry faster, so there is less danger of re-freezing.

Issues to consider:

Pervious asphalt is somewhat malleable, so the force that is applied by a turning tire, as well as vehicles stopping and starting, can create depressions and tear up the paving surface (see Figure 44). This can be avoided by using a different surface where most of the tire turning, stopping, and starting occurs.

When installing pervious asphalt and concrete, the subgrade must be properly prepared and the surface poured correctly. Where pervious asphalt and concretes fail, it is usually due to incorrect installation.

Pervious asphalt and concrete are most economical in large batches. They work well for large roadway or parking lot applications and accept higher vehicle traffic loads and speed. However, the price makes it more difficult to use them for small applications or to repair small areas. Pervious asphalt is less expensive than pervious concrete.

Figure 46. Pervious pavers in a parking lot application. Any overflow from the pervious pavers drains into a swale.

Permeable Pavers

Any pavers can create a porous surface if there are spaces between them that are filled with sand or other aggregate that allows water to drain. The pavers discussed here are interlocking concrete pavers, which are designed specifically for stormwater management applications. Interlocking concrete unit pavers are designed to allow water to pass through joint gaps that are filled with sand or gravel and infiltrate into a thick gravel sub-grade. This system can be used for small or large paving applications and allows a small section to be removed when repairs are needed. They can be installed with trucks designed to efficiently install large areas of pavers, and they have been used successfully in industrial sites, including the port of San Francisco. Pervious interlocking pavers have a lot of design flexibility in color, style, joint configuration, and paving pattern. Interlocking concrete pavers tend to be more costly to install than pervious asphalt or pervious concrete.

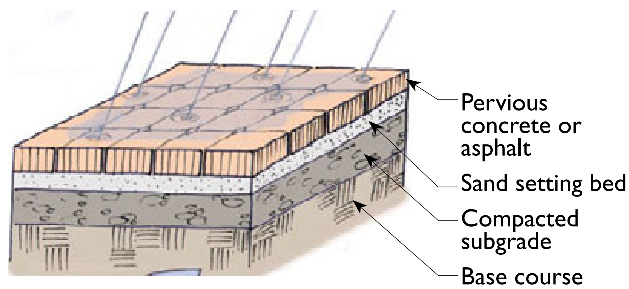

Figure 47. Sand-set pervious paver profile.

Figure 48. Interlocking concrete unit pavers create gaps between adjoining pavers, allowing water to soak into the ground.

Reinforced Gravel Paving

A gravel pave system uses gravel without the fines and a structure that helps provide support and create a rigid surface. Gravel can be a viable alternative to a traditional paved surface in areas of lower use that need a rigid surface.

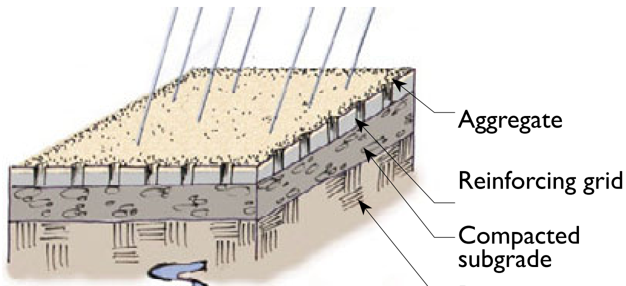

Figure 49. Reinforced gravel paving profile.

Figure 50. Reinforced gravel paving in parking stalls.

Reinforced Grass Paving

In the right situations, grass-pave, or other hybrids between paving and planting, could be an option. Reinforced grass paving provides structural support but also allows some plants to grow and water to soak through into the soil. Grass paving cannot always be used interchangeably with standard asphalt or concrete, but it may be appropriate in the right low-use areas.

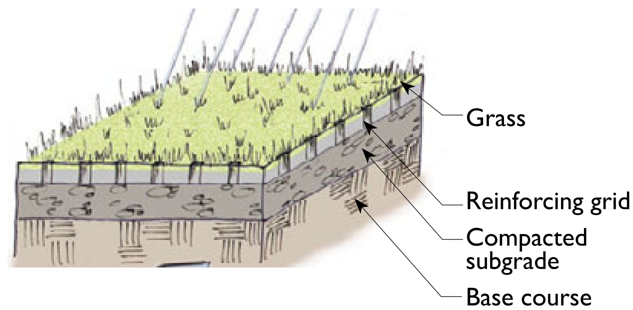

Figure 51. Reinforced grass paving profile.

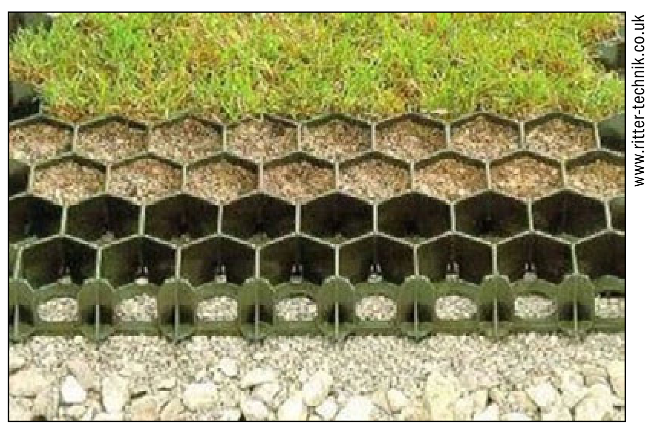

Figure 52. Reinforced grass paving allows water to pass through the grass root zone and into the underlying soil while still maintaining a hard surface for vehicular travel.

Figure 53. Residential alley in Paynter's Mill.

Option for Pervious Pavers—Complete Application

This example shows pervious pavers as an alternative to traditional asphalt. A concrete band on both sides of the alley creates an edging material for the pavers. In this example, the street profile is flat (see Appendix C for a discussion of street profiles), so when rain falls, it soaks directly through the pavers without concentrating sediments in one location. Pervious asphalt or concrete could also be used instead of pervious pavers.

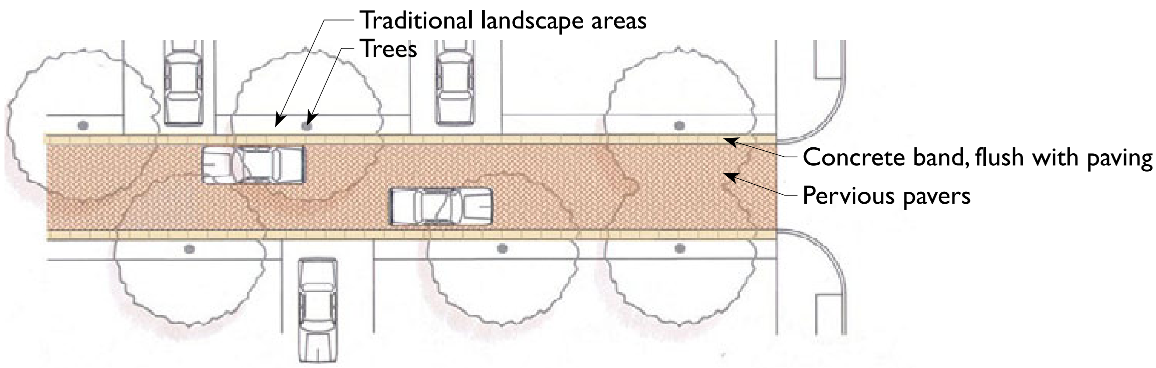

Figure 54. Complete application of pervious paving–plan view.

Figure 55. ***Retrofit potential:*** Complete application of pervious paving in a residential alley.

Figure 56. Residential alley in Paynter's Mill.

Option for Pervious Pavers—Center Strip

In this example, the alley is transformed with a strip of pervious pavers down the center. The alley is graded to drain towards the center strip of pavers. Note that when water is directed to pervious pavers from another surface, it can carry sediments with it and can clog pervious pavers more quickly. In this situation, pervious paving must be well maintained and sized appropriately.

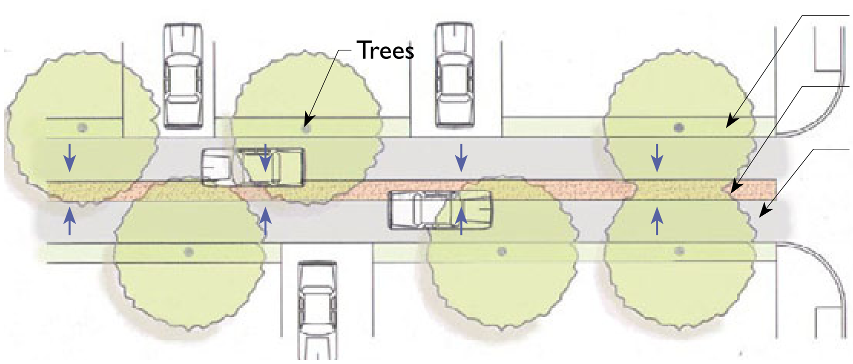

Figure 57. Center strip application of pervious paving–plan view.

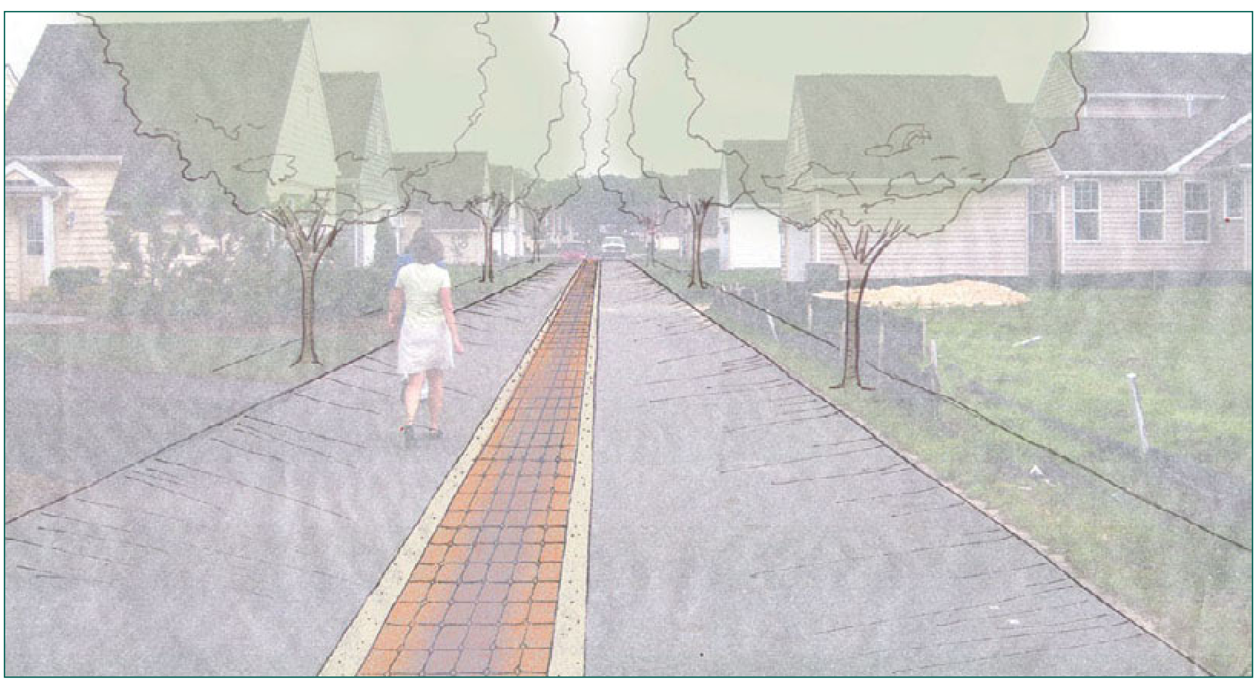

Figure 58. *Retrofit potential:* Center strip of pervious paving in a residential alley.

Figure 59. Residential street in Paynter's Mill.

Option for Pervious Paving—Parking Zone

This example illustrates pervious paving in the parking zone of a low-density residential street. Pervious paving can be used in new construction or retrofitted in existing streets. Pervious paving can also be applied to the entire street surface. One of the advantages of using pervious concrete or sand-set pervious pavers strictly in the parking zone of a street is that there is a perceived narrowing of the street due to the contrast between the conventional asphalt and the pervious paving material. This effect can reduce traffic speeds in residential areas.

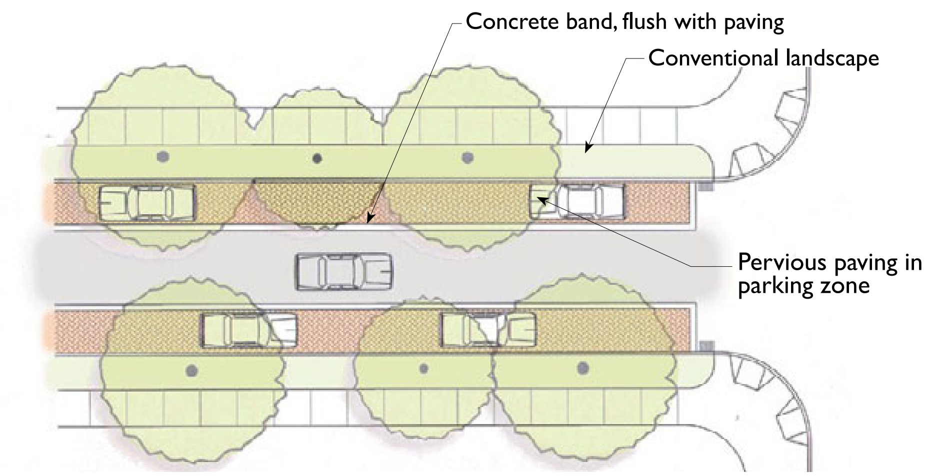

Figure 60. Pervious paving in parking zone—plan view.

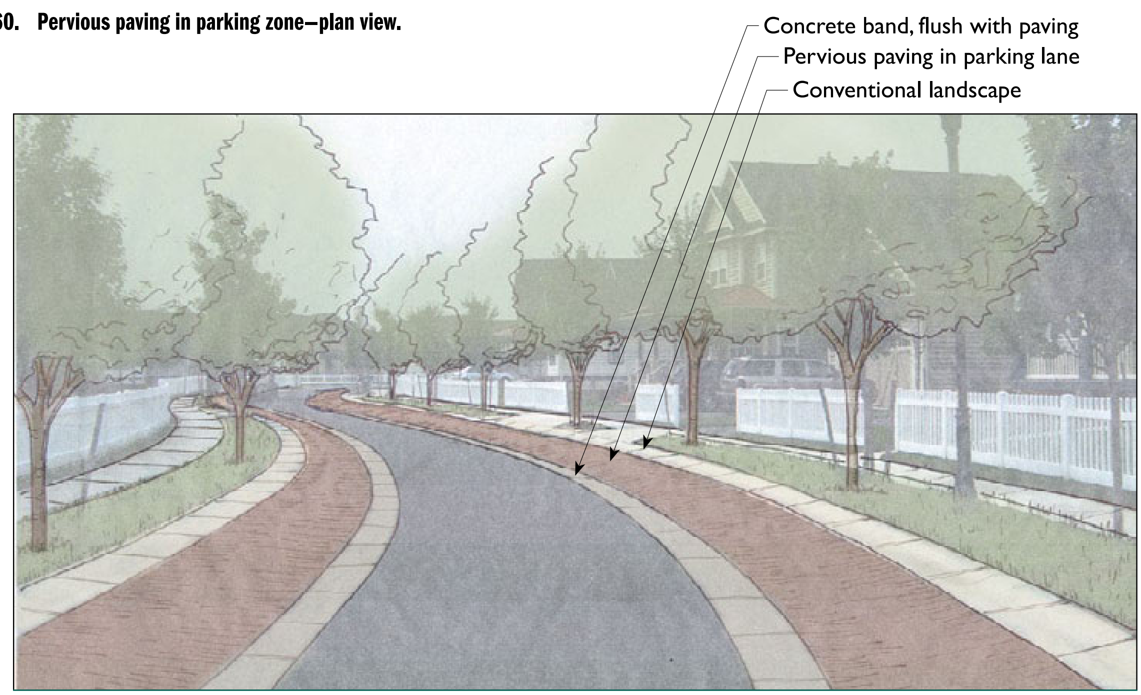

Figure 61. ***Retrofit potential:*** **Adding pervious paving on both sides of this residential street allows two-way travel and parking on both sides of the street.**

Figure 62. This parking lot uses pervious concrete in the parking stalls.

Option for Pervious Paving—Parking Stalls

The example below employs pervious paving in the parking stalls and allows overflow to drain into the existing storm inlet. Using pervious paving in parking stalls can reduce impervious area by up to 50 percent. A parking lot could be designed entirely with pervious paving, but it may be most cost effective to use it only in parking stalls, especially in larger parking lots. The example below illustrates a parking lot that is internally drained, but pervious paving can also be used in parking lots that drain runoff to the periphery of the site.

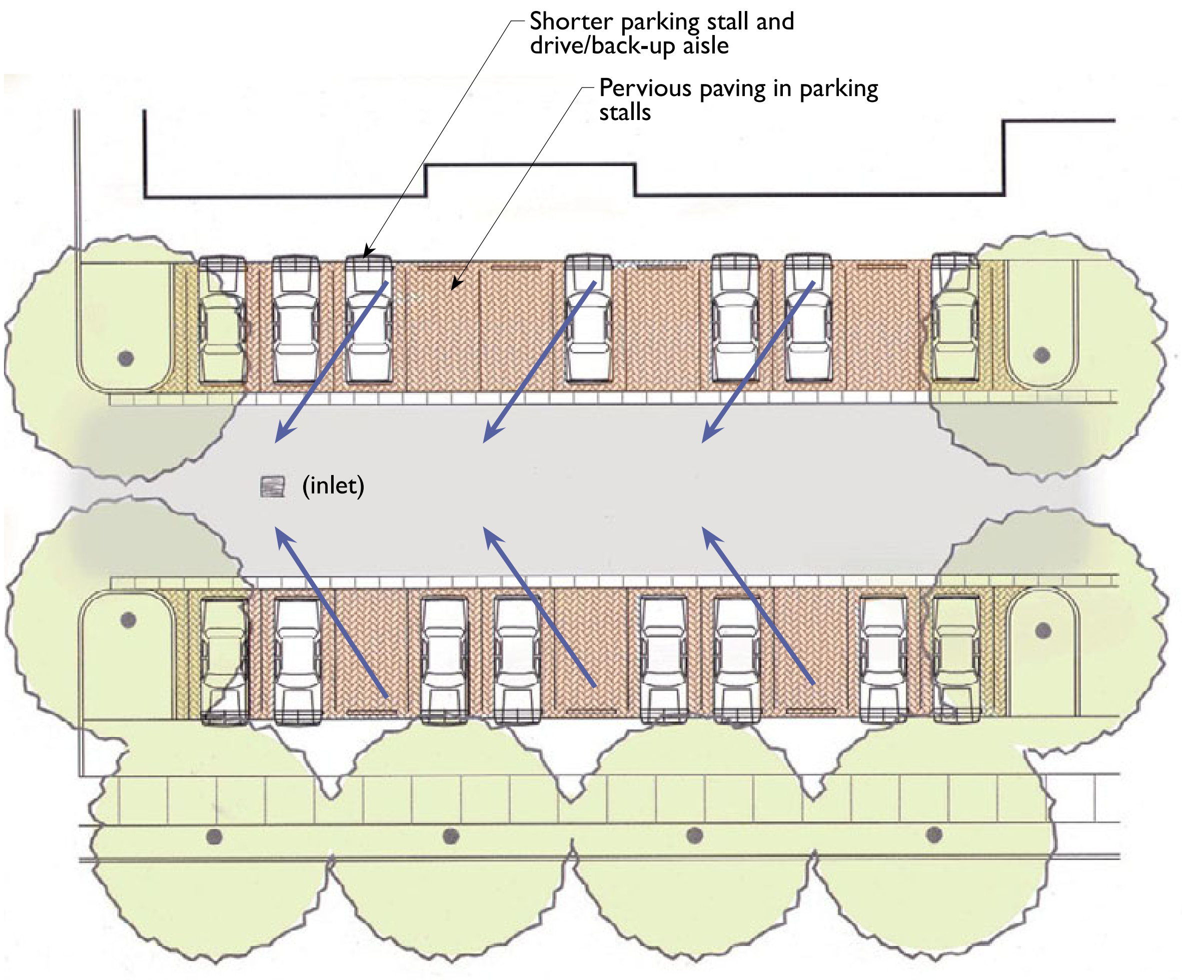

Figure 63. Pervious paving in parking stalls—plan view.

Foundation Industries

Figure 64. Large-scale commercial cisterns can hold large volumes of rainwater for reuse in toilets and irrigation systems.

www.arttec.net

Figure 65. A residential rain barrel can collect water for later reuse in the home garden.

5.2.7 Harvest and Reuse Rainwater

Rainwater harvesting captures stormwater runoff from rooftops and stores it in a durable container for later use. This helps to absorb water from the drainage system and slow and filter runoff that does eventually reach drainage.

Good places for rainwater harvesting:

- Large industrial buildings
- Office buildings
- Homes and garages

Community benefits:

- Water can be used for non-potable purposes, which leaves more water in public reservoirs to fill drinking water needs.
- Systems can be artfully designed in concert with the building's architecture.
- Systems can be a good educational tool to teach about watersheds.
- Harvesting rainwater can help create an awareness of water as a precious resource and promote its conscientious management.

Rainwater harvesting has been used for thousands of years. Today, in developed countries where drinking water is plentiful from the tap, rainwater harvesting captures rainfall primarily for non-potable uses such as supplemental irrigation, flushing toilets, car washing, and clothes washing. Capturing rainfall and treating it for potable water is also possible.

Harvesting rainwater can be used at various scales: from households harvesting water for personal use in a rain barrel to larger commercial applications where water is captured for irrigation. One can capture as much rainfall as a particular container can hold. Systems can be as simple as disconnecting a residential downspout and directing the water to a rain barrel.

5.2.8 Use Green Roofs

Green roofs are rooftop landscapes that intercept rain as it falls on a building. Water that normally runs off the roof and into a sewer system is absorbed by soils and plants on the roof or evaporates. The water that does run off the surface takes longer to do so. Any water that does run off the surface can then be treated in a rain garden or used in the building for landscaping and irrigation.

Good places for green roofs:

- Dense areas where land value is at a premium
- Large industrial buildings
- Office buildings
- Homes and garages
- In retrofit projects if building structure can support the added weight

Community benefits:

- Decreases heating and cooling costs by insulating and shading buildings.
- Helps reduce the urban heat island effect.
- Provides wildlife habitat.
- Improves the overall aesthetics of buildings.
- In more densely developed areas where land value is at a premium, provides additional green spaces for people to enjoy.

Green roofs can thrive on flat or sloped roofs, residential or commercial buildings, and small or large building footprints. A green roof can host a thin and simple palette of plants or thick, intensely planted landscapes. A green roof's ability to manage stormwater runoff depends on its vegetation and the type and thickness of the soil mixture. Green roofs tend to cost more to install than conventional roofs, but long-term energy savings from insulating the building can help mitigate the initial costs.

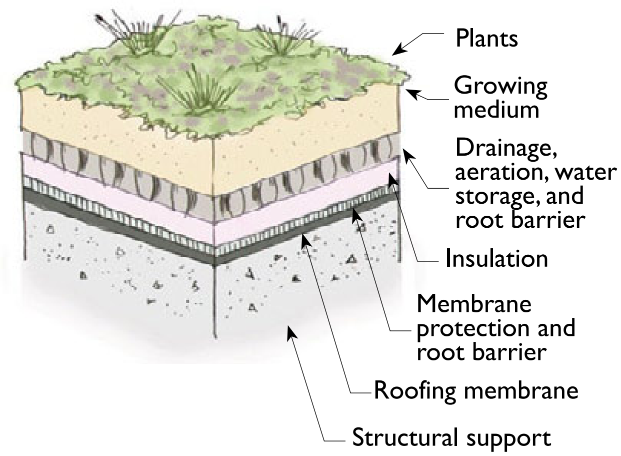

Figure 66. Green roof profile.

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Figure 67. Green roof on a parking garage.

www.nemo.uconn.edu

Figure 68. Green roof on a commercial building.

Green roofs work well for industrial uses where building footprints account for a large amount of the impervious surface. In industrial areas, it can be difficult to find enough land to manage stormwater on the surface. Designing buildings in these industrial areas to absorb more rainwater means less land is needed for rain garden strategies.

Though their benefits shine in highly built environments because they decrease the overall impervious surface of a site, green roofs can also be used in low-density residential settings. The versatility in the design of green roofs has encouraged their use throughout the United States.

5.2.9 Use Swales

Swales can be integrated into streets, parking lots, and buildings to better manage stormwater while also creating an aesthetic amenity and making streets safer and more comfortable for residents to walk and bicycle. Sample applications of swales are shown in this section with potential applications to streets and alleys in Sussex County.

Good places for swales:

In new design:

- Subdivisions
- Arterial streets
- Parking lots

In retrofits:

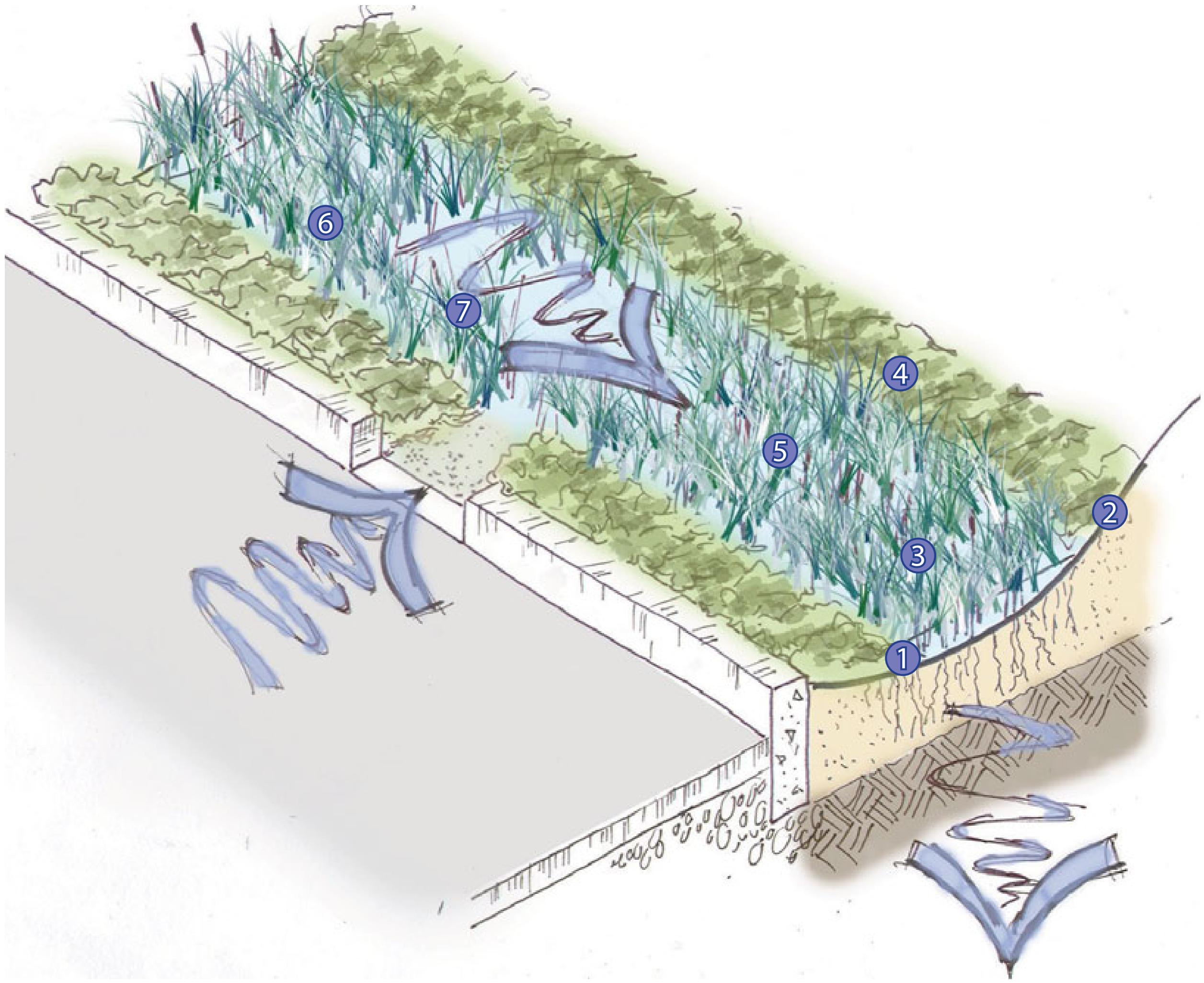
- Rural roads
- Parking lots
- Between buildings
- Planting strips

Community benefits:

- Attractive neighborhood amenity

EPA

Figure 69. A residential street with a stormwater swale.



1	Depth:	Maximum depth of 6”
2	Side slopes:	4:1 ideal, 3:1 maximum slope
3	Bottom:	3’ minimum, 7’ maximum, rounded or flat
4	Plants - side slopes:	Drought-tolerant ground covers and shrubs, 3’ maximum height
5	Plants - bottom:	Rushes, sedges, and trees adapted to inundation and drought
6	Longitudinal slope:	6% maximum
7	Check dams:	At least 1 check dam for every 6” of vertical drop
	Trees (not shown):	In bottom of swale, drought tolerant, wet tolerant

Figure 70. Design and construction characteristics of a swale.

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Figure 71. **The dashed lines show where a swale could be added in an existing planting strip on a residential street in Paynter's Mill.**

As water flows through a swale, plants and soils slow its flow, allowing sediments and pollutants to settle out. Some water soaks into the soil and is absorbed by plants or infiltrates into the ground if native soils are well drained. The water that continues to flow downstream travels more slowly than it would through pipes in a traditional system. Swales can be planted with a variety of plants, ranging from mown grass or a simple palate of grasses, sedges, and rushes, to a mixture of trees, shrubs, and groundcovers.

Swales are best implemented in areas of continuous landscape. A longer continuous swale allows more time for filtering to occur. Rural roads, arterial streets, and medians commonly offer this type of uninterrupted linear space. New subdivisions and parking lots can also offer good opportunities for swale design.

Stormwater swales are relatively inexpensive, simple to construct, and widely accepted as a stormwater management strategy.

Swales and Streets

On a new street:

Streets can be ideal places to incorporate swales. The long and linear character of streets can accommodate a swale's need for long uninterrupted stretches of landscape. Often streets have long stretches of underused right-of-way.

On an existing street:

- Look for long, unplanted, unused median strips or planting strips between the sidewalk and the street.
- Is the center turn lane necessary? Can turn lanes be removed, travel lanes moved to center, and swales added on sides?
- How is water currently moving in pipes through the site? Is there a way to move that water on the surface?
- Can the travel lane widths on a particular street be reduced? Sometimes reducing a lane by just a few feet can make a swale work alongside a street.

Options for Swales—Residential Street

The street shown in Figure 72 uses conventional lawn in the planting strips between the street and the sidewalks. The design could have substituted swales in the planting strips, with a curbless condition to allow water to sheet flow into the swales. Using this approach could reduce the space needed for a facility to treat all the runoff from this development in one location and allow more developable land parcels. Having no driveway curb cuts along the street, with garage access via alleys behind the homes, provides the long, continuous landscape space that swales need.

The designs on the following two pages show additional options for introducing swales on residential streets, depending on how the street drainage is designed and whether on-street parking exists.

Figure 72. Residential street in Paynter's Mill.

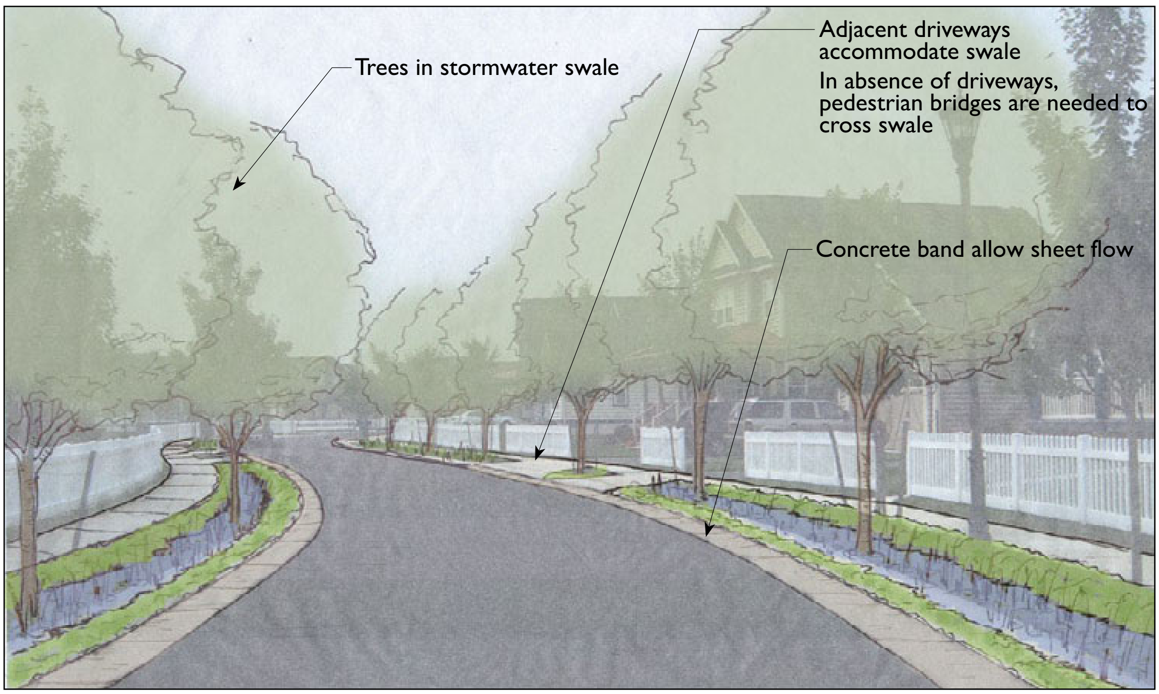

Figure 73. *Retrofit potential:* Swales on both sides of "curbless" street to accept sheet flow of runoff.

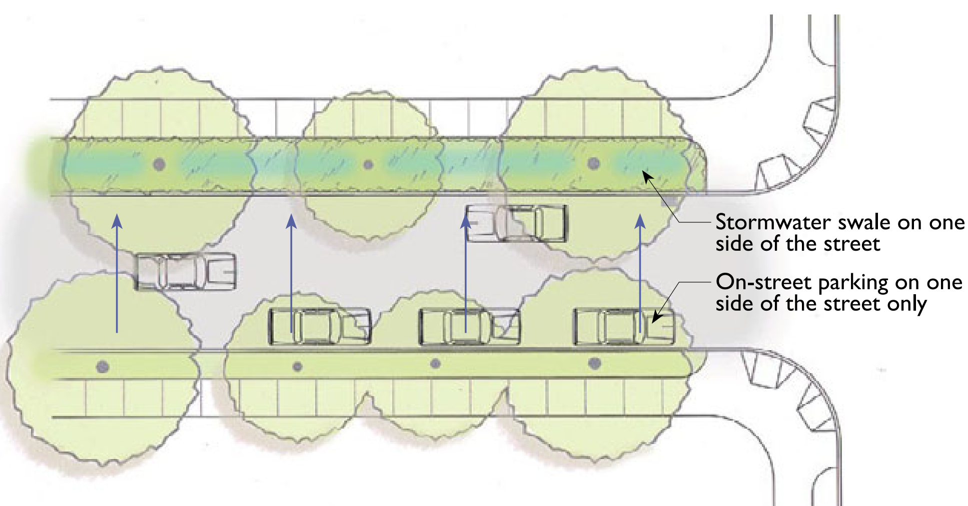

Figure 74. One side swale (parking on one side)—plan view.

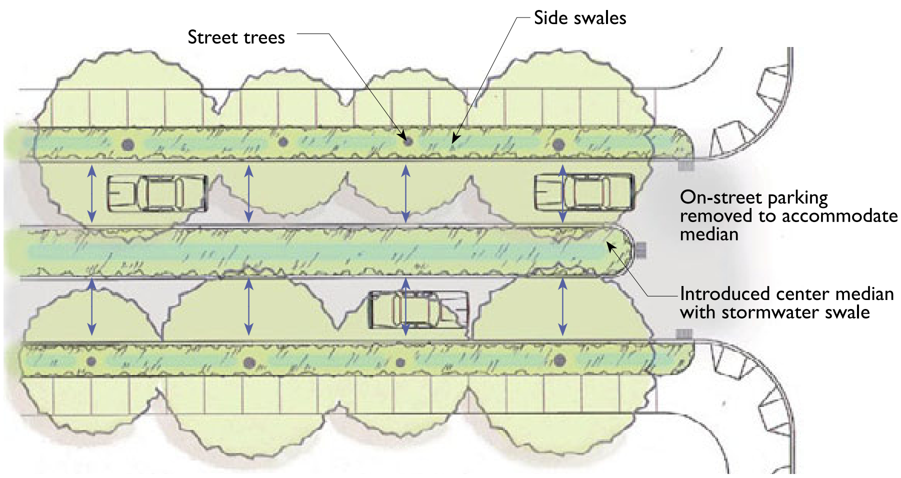

Figure 75. Two side swales and median swale (no parking)—plan view.

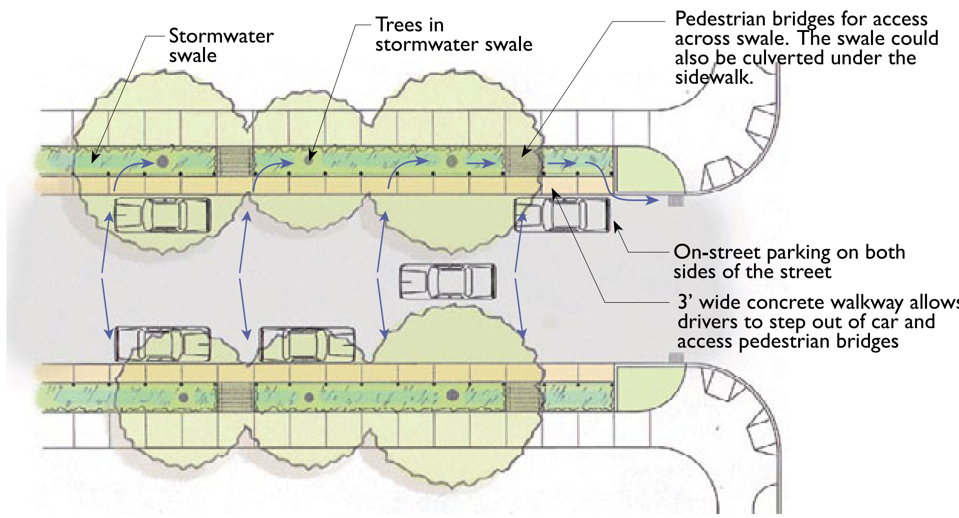

Figure 76. Two side swales (parking on both sides)—plan view.

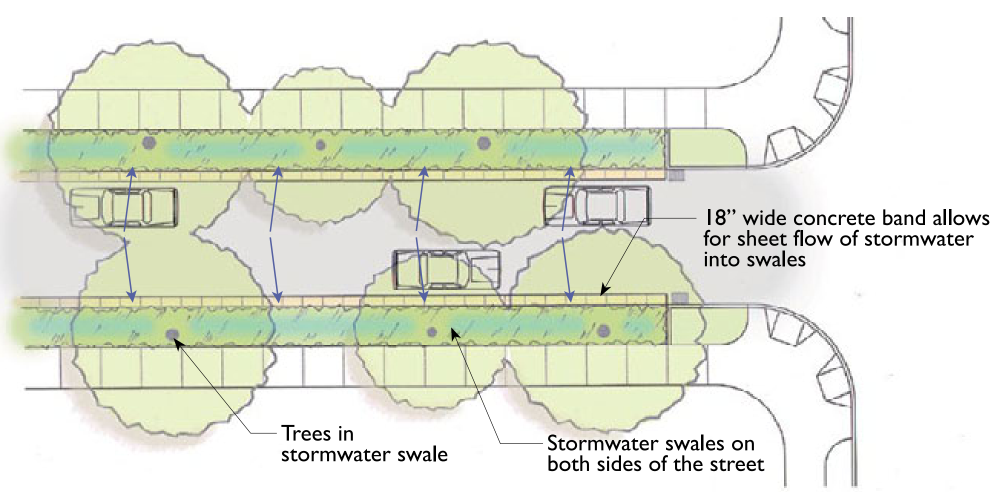

Figure 77. Two side swales (no parking)—plan view.

Figure 78. Residential alley in Paynter's Mill.

Option for Swales—Residential Alley

This example transforms the alley by draining water to the sides into narrow swales. An alternative could be to drain the whole alley to a swale on one side. This example shows a curbless condition, with sheet flow of stormwater into the swales. Driveways can intersect with the swales either by a culvert or by having runoff flow through a driveway valley gutter. Small pedestrian bridges can be added to provide access directly between back yards and the alley or a place to put trash and recycling for pickup.

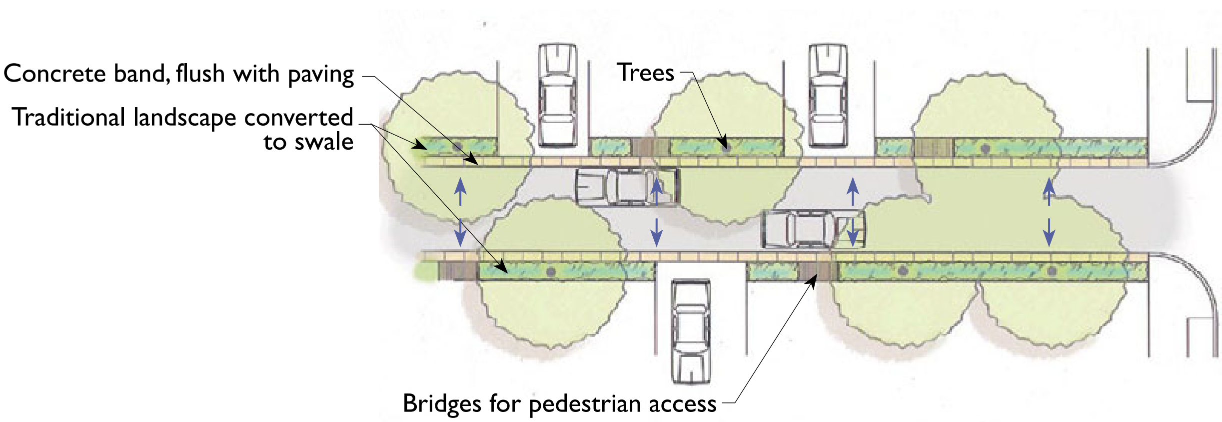

Figure 79. Side swales–plan view.

Figure 80. *Retrofit potential:* Side swales in a residential alley.

Option for Swales—Commercial Area

This option shows a commercial area with on-street parking and high pedestrian activity. Here, short curb extensions are added to calm traffic and shorten street crossing distances at the intersection. A bike lane is added to make biking safer. A 3-foot-wide sidewalk zone is provided for people to access parked cars. This example shows a curbless condition, where water sheet flows into the swales in the planter strip, but a swale could also be implemented with a curbed street with curb cuts to provide stormwater inlets.

Sussex County is a coastal community. One way in which that history and tradition can be incorporated and reflected in the stormwater management system is by designing pedestrian walkways as boardwalks (see Figure 81).

Figure 81. Stormwater swale in a mixed-use community. Boardwalks link pedestrians to the sidewalk zone of the street.

Figure 82. Boardwalks, such as this one in Cape May, New Jersey, are a common example of coastal vernacular.

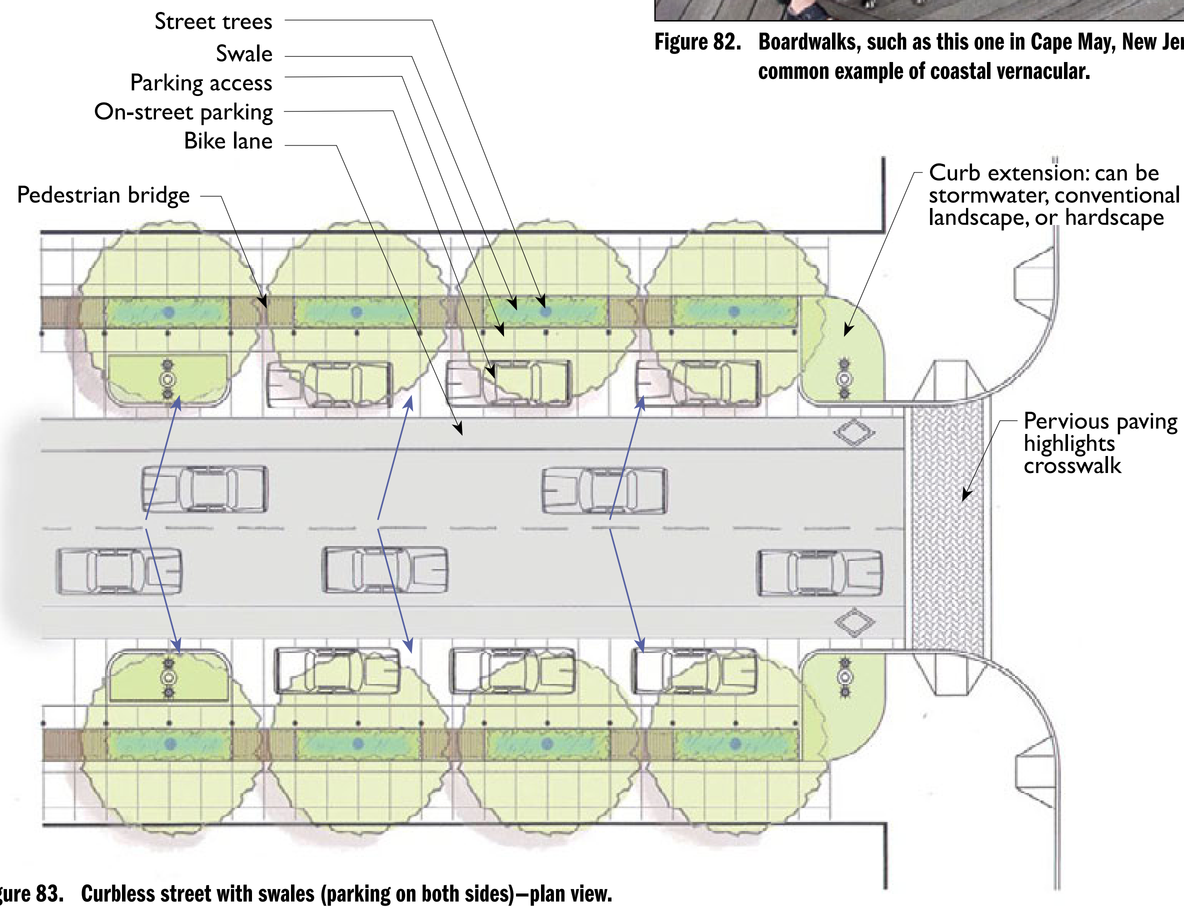

Figure 83. Curbless street with swales (parking on both sides)—plan view.

Figure 84. Commercial area in The Villages of Five Points in Lewes.

Option for Swales—Commercial Area

This design narrows a vehicular travel lane and converts a portion of the existing sidewalk zone into a stormwater swale. In a commercial area like the one shown in Figure 84, pedestrians need to access the stores from cars parked on the street. The illustration below depicts how pedestrians can access their destinations while still allowing stormwater to flow underneath these access points through a series of trench drains.

For a more detailed discussion of how to maintain safe and effective pedestrian circulation and access when introducing stormwater facilities, see Appendix C.

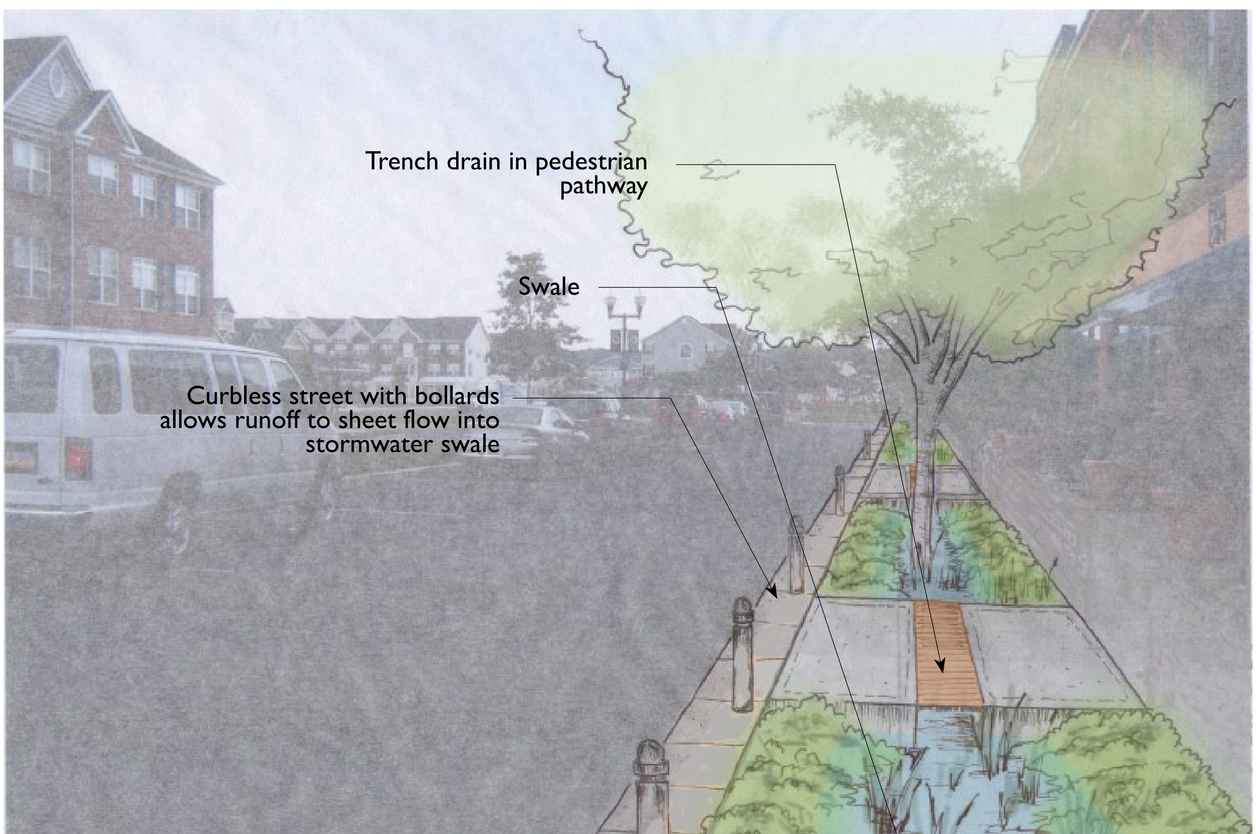

Figure 85. ***Retrofit potential:*** **Commercial street with a stormwater swale with pedestrian pathways.**

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Figure 86. Multi-lane boulevard with wide sidewalk in Kentucky.

Option for Swales—Boulevard

This example shows how part of a wide sidewalk could be reclaimed and used for a street swale. This example is next to a park, which makes it an ideal place for an interpretive sign to educate passers-by about watershed health and stormwater management.

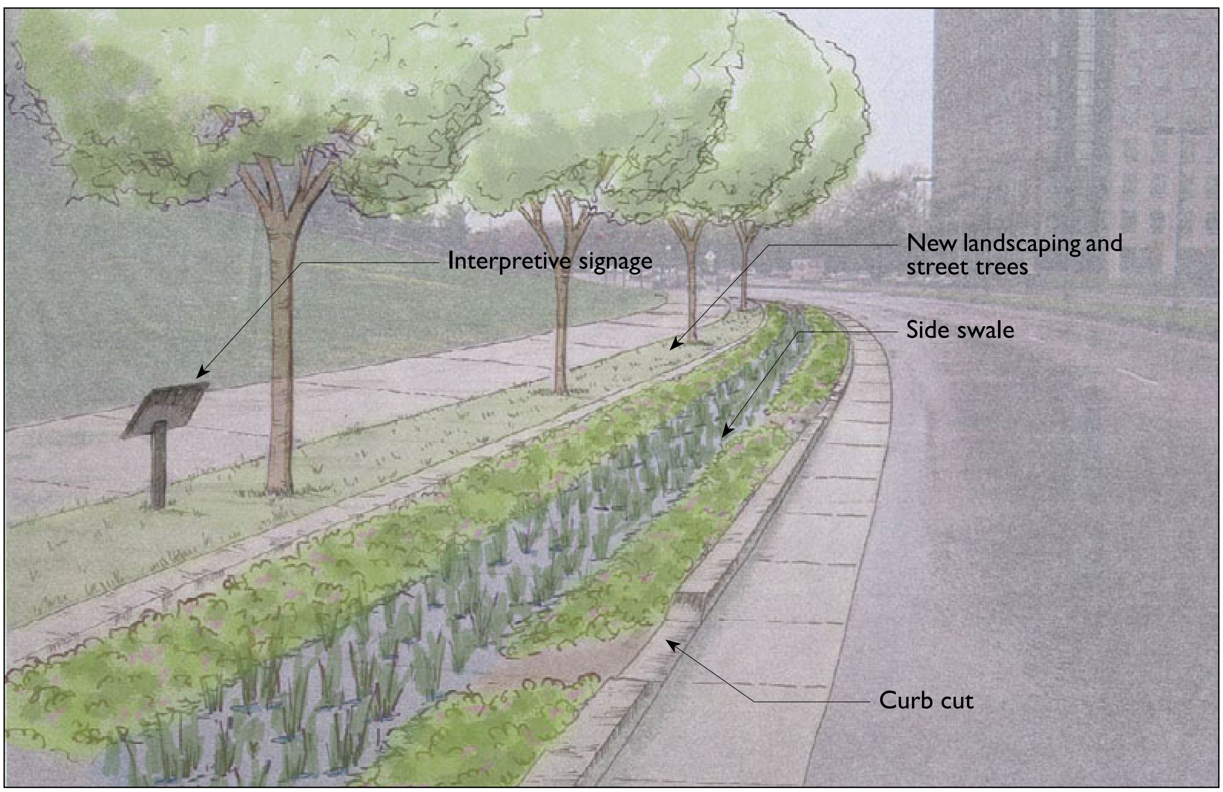

Figure 87. ***Retrofit potential:*** **Consolidating sidewalk space allows for a stormwater swale and street trees along this boulevard.**

Figure 88. Highway 113 near Selbyville, Delaware. The wide shoulder and utility zone could be used more efficiently.

Option for Swales—Arterial or Highway

This four-lane arterial has enough room in the shoulder and utility zone to build a bike lane, sidewalk, safety buffer, and swale. Variations can be made to this design to preserve the shoulder if it is critical.

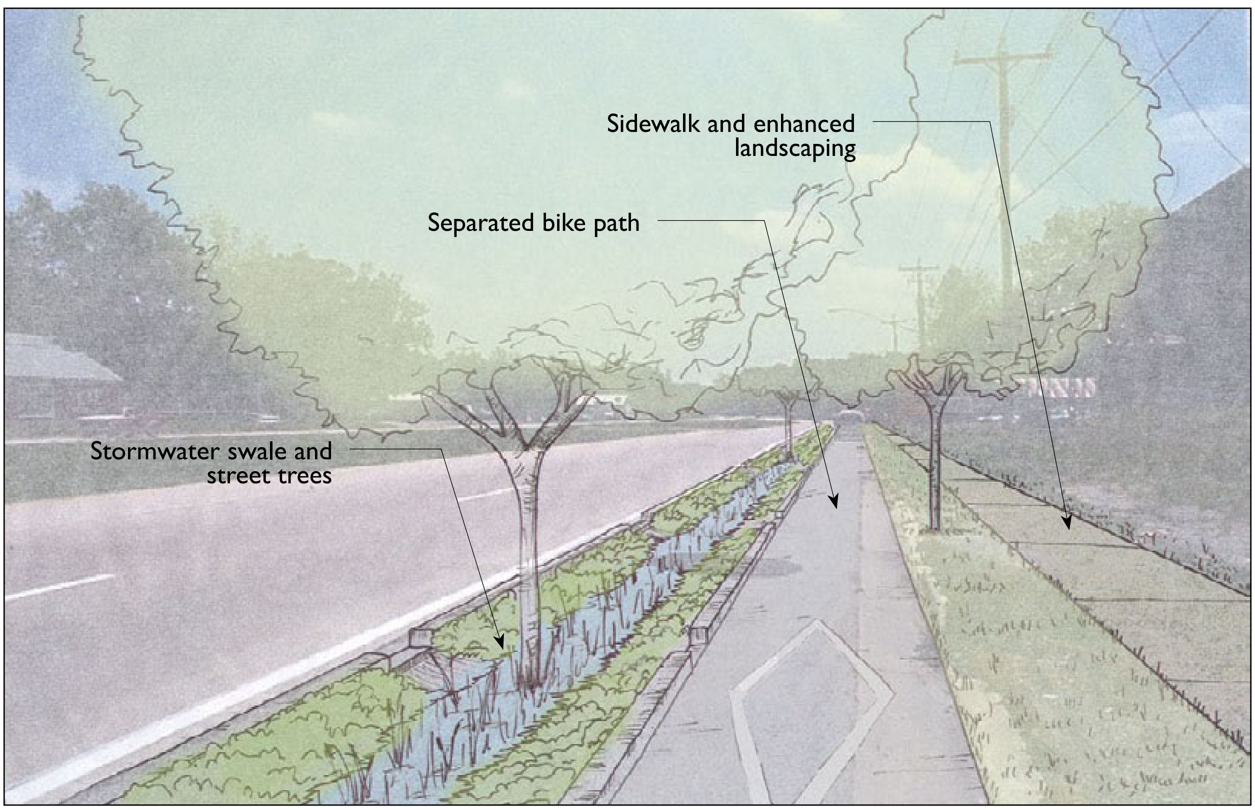

Figure 89. ***Retrofit potential:*** **A new stormwater swale and street trees combined with a separated bike path and sidewalk system.**

Kevin Robert Perry-City of Portland

Figure 90. A stormwater swale retrofit at an elementary school parking lot.

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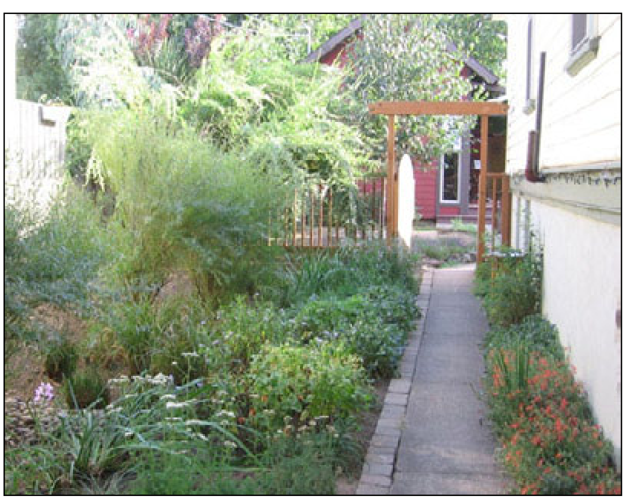
Figure 91. These oversized parking stalls could be made a few feet shorter to make room for swales.



Olena Turula

Figure 92. A stormwater swale retrofit in a residential side yard.

Swales and Parking Lots

In a new parking lot:

Parking lots are a great fit for swales. Long drive aisles lend themselves well to the continuous spaces swales need. There are many creative ways to include swales in parking lots. For example, shorter parking stalls can yield a few extra feet of area, especially when a high number of parking spaces are required by code. Consolidating travel lanes is often another option.

In an existing parking lot:

Often parking lots can be retrofitted without losing any parking spaces. It may not always be obvious how a parking lot might be retrofitted; look for:

- Parking lots with very long stalls;
- Wider than necessary travel lanes; or
- Angled parking with unused space in front of or behind each space.

Swales and Buildings

Near a new building:

Swales can treat stormwater runoff captured from buildings. The most important design considerations are getting water away from the building foundation and lining swales to prevent foundation damage. Usually a minimum of 10 feet of clearance from the building is required. Lining swales with a waterproof material protects building foundations by preventing infiltration and achieves the benefits of plants and soil slowing and filtering stormwater.

Near an existing building:

In more densely developed areas, swales can be a good option for the linear spaces between buildings, provided that foundations and basements are protected. Look for:

- Long, narrow, underused spaces between buildings;
- Spaces between buildings and the public right-of-way; or
- Narrow side yards.

Option for Swales—Parking Lot

A perimeter side swale is one of the most common and effective means of managing stormwater runoff in a parking lot. In many cases, simply employing a better site design and reducing parking lot stall lengths can help yield the 4 to 6 feet of space needed for a stormwater swale.

The top consideration for parking lot design is the grading of the parking lot and how the water flows into the rain gardens. It is best to sheet flow the water across the surface of the lot and get it into swales or planters as soon as possible. When grading a parking lot, remember that it doesn't take much effort to redirect sheet flow of water. Figure 93 shows a small speed bump that helps direct water into a swale.

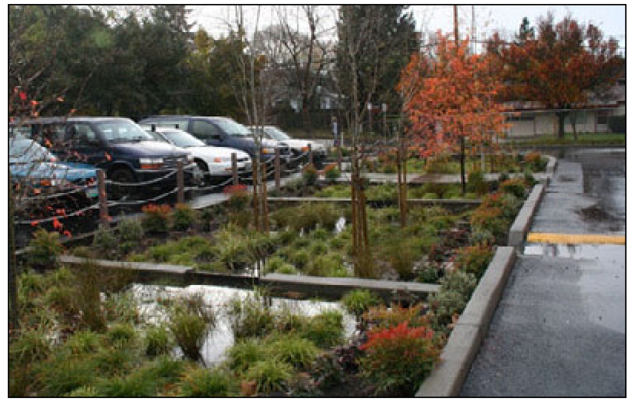


Figure 93. Parking lot swale with curb cuts and a speed bump used to direct stormwater flow.

Figure 94. Parking lot swale with sheet flow between parking wheel stops.

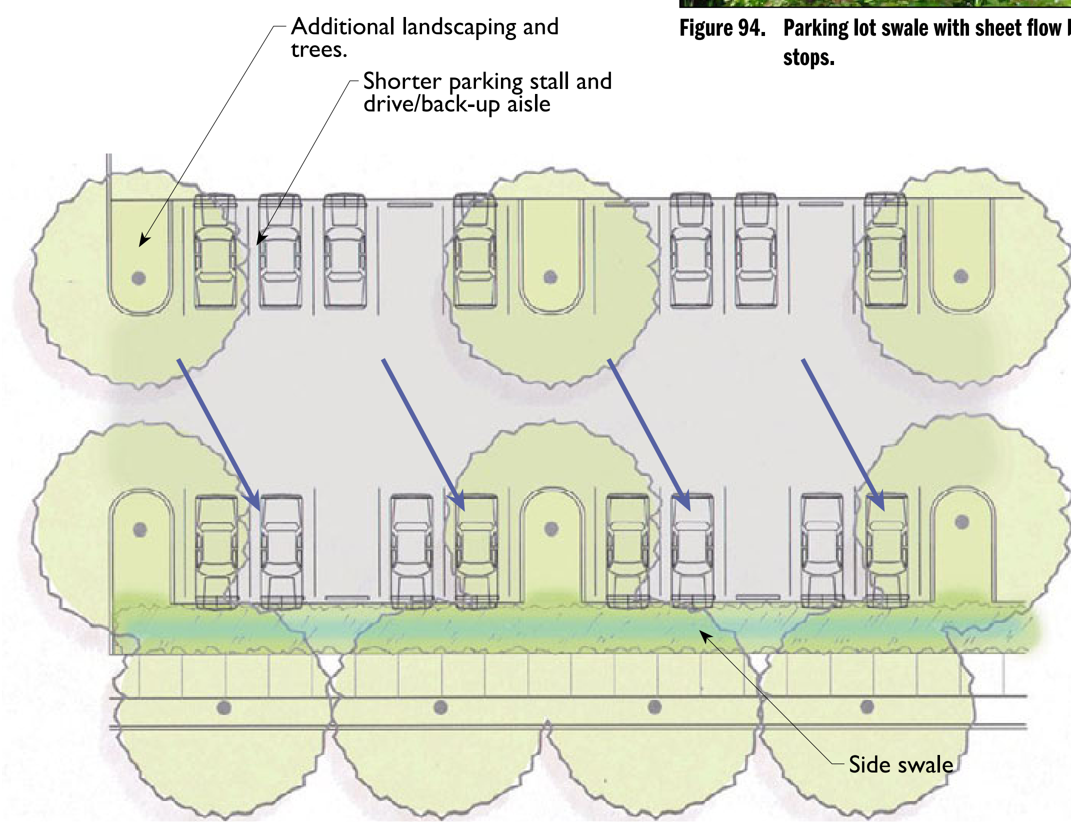


Figure 95. Perimeter side swale in parking lot—plan view.

Figure 96. An existing restaurant and parking lot site in Lewes.

Option for Swales—Parking Lots

This example shows how swales can be combined with other stormwater management techniques such as planters (discussed in Section 5.2.10).

This existing commercial site has oversized parking stalls and travel aisles as well as an adjacent street frontage with no sidewalks or street trees. By making simple design adjustments, this site could be retrofitted with several stormwater amenities. Building runoff could be directed into a series of stormwater planters. A new plaza space could be created for outdoor seating. A large stormwater swale could collect runoff from the parking lot, and a new sidewalk and stormwater curb extension could be added along the street frontage.

While this is a real site in Sussex County, the conceptual illustration below is only a hypothetical situation and showcases the potential for site improvements, not an actual demonstration project.

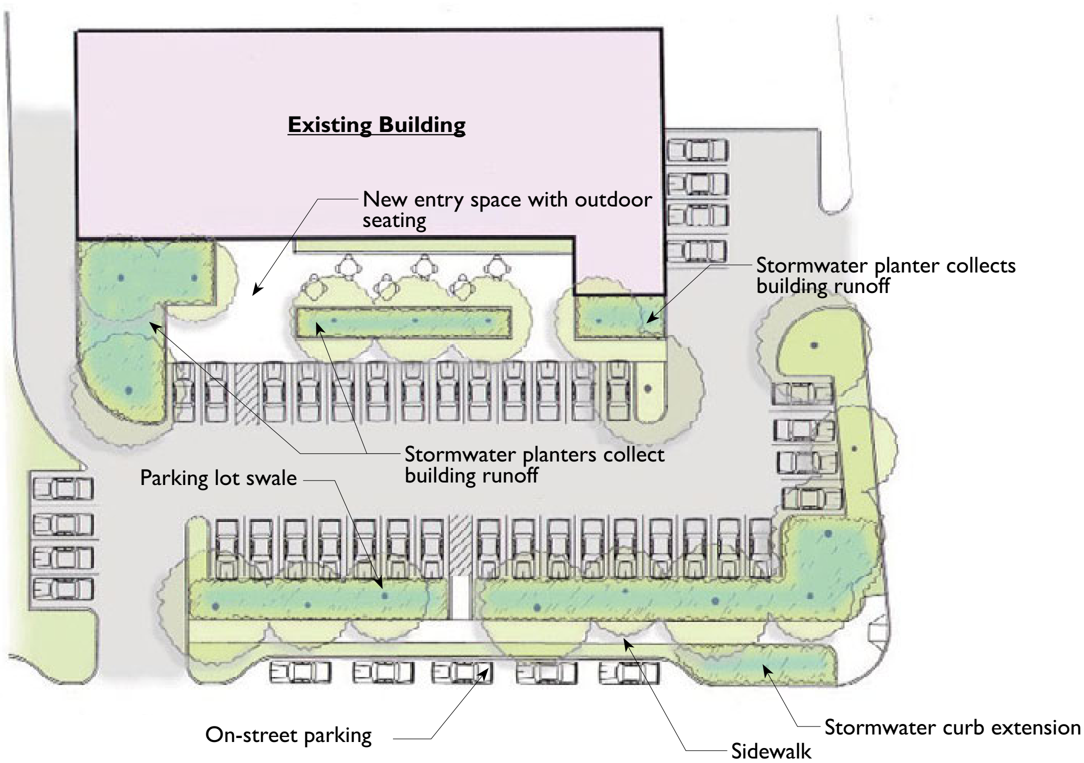


Figure 97. *Retrofit potential:* A more efficient site design allows several stormwater strategies to be employed on this site, such as a parking lot swale, building planters, and a stormwater curb extension.

Figure 98. Commercial main street in Portland, Oregon, with stormwater planters.

5.2.10 Use Planters

Planters can be integrated into commercial areas and parking lots. Particular attention should be paid to balancing on-street parking and planters and retrofitting planters into underused parking lot islands and parking stalls. A before-and-after sketch illustrates how a planter could be integrated into Bank Street in Lewes.

Good places for planters:

In new design:

- Urban areas
- Furnishing zones
- Next to buildings

In retrofits:

- Near condominiums
- Street furnishing zones

Community benefits:

- Buffer between street and sidewalk calms traffic and makes pedestrians feel safer.
- Beautifies urban spaces with trees and plants.

Planters are best used where space is limited or where the cleaner look of a clearly defined rain garden is desirable. Flow-through planters are a viable alternative when infiltration is not possible, such as close to building foundations or in areas of poorly drained soils. Planters can store more water than swales because they are often deeper and have vertical side walls that provide additional capacity compared to side slopes. Water flows into the planter, absorbs into the topsoil, fills to a predetermined overflow elevation, and overflows into the system provided. Infiltration planters infiltrate stormwater, while flow-through planters absorb only as much water as they are designed to hold within their walls. Planters are very versatile and can be connected one after the other to gain lots of stormwater benefit.

Planters can cost more to build than swales because they rely on more hardscape infrastructure, but they are still relatively inexpensive. They are easily incorporated in places where space is limited. They can be built to fit between driveways, utilities, trees, and other existing site elements.

Planters and Streets

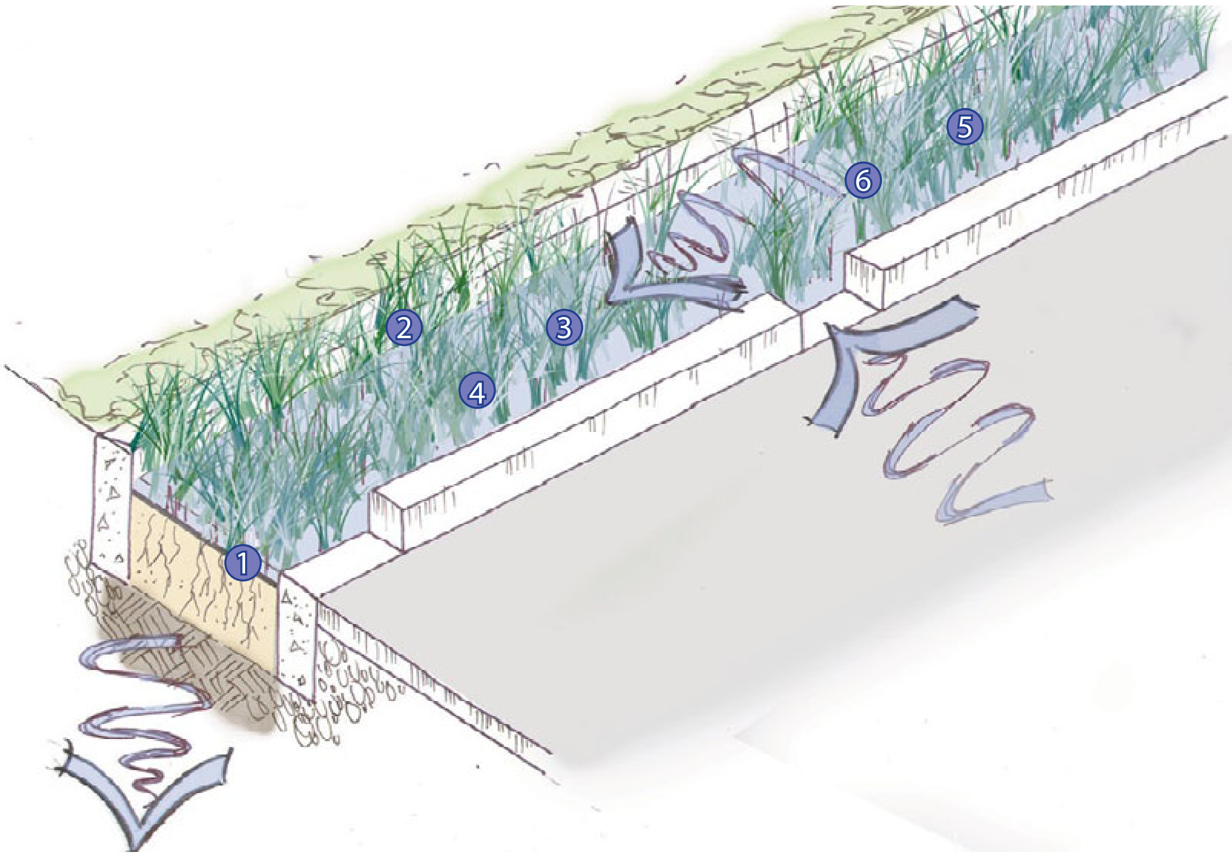
On a new street:

When planters are built along streets, they are usually in an urban setting. Planters take up less space than other rain garden strategies and therefore are a good candidate for tricky urban places where parking, signs, and other street furnishings vie for valuable real estate.

On an existing street:

Planters are commonly used to retrofit urban streets. They are relatively straightforward to retrofit because they can treat a lot of water in a relatively small footprint, and so can be squeezed into places other rain gardens cannot fit. Look for:

- Dense areas where parking is critical; or
- Furnishing zones with extra space and sidewalk areas that are wider than necessary.



1	Depth:	Retains no more than 8" of runoff
2	Side slopes:	None - vertical
3	Bottom:	Flat. Sealed in flow-through planter, open in infiltration planter
4	Plants:	Wet- and drought-tolerant rushes, sedges, shrubs, and trees
5	Longitudinal slope:	Up to 6%. If hillside is sloped more than 6%, several planters can be terraced.
6	Check dams:	At least one check dam for every 6" of vertical drop
	Trees (not shown):	Drought tolerant, wet tolerant

Figure 99. Design and construction characteristics of a planter.

Figure 100. Stormwater planters along a downtown street allow on-street parking to be retained. A strip of pervious pavers allows access to parked cars.

Option for Stormwater Planters With On-Street Parking

This design adds stormwater planters to the furnishing zone while retaining on-street parking. A band of paving, which can be pervious paver, concrete, or another paving material, allows access to cars parked on the street.

This design links a series of flow-through planters or infiltration planters. Water flows into the first one; when it fills up, water can flow back out to the street gutter and into the next planter, and so on. If any stormwater overflows at the end, after the last planter, it flows into the existing storm drain. An advantage of using planters in downtown areas is that they treat a given amount of water in tighter spaces because of their vertical walls. In addition, they add greenery and can make the streetscape more appealing.

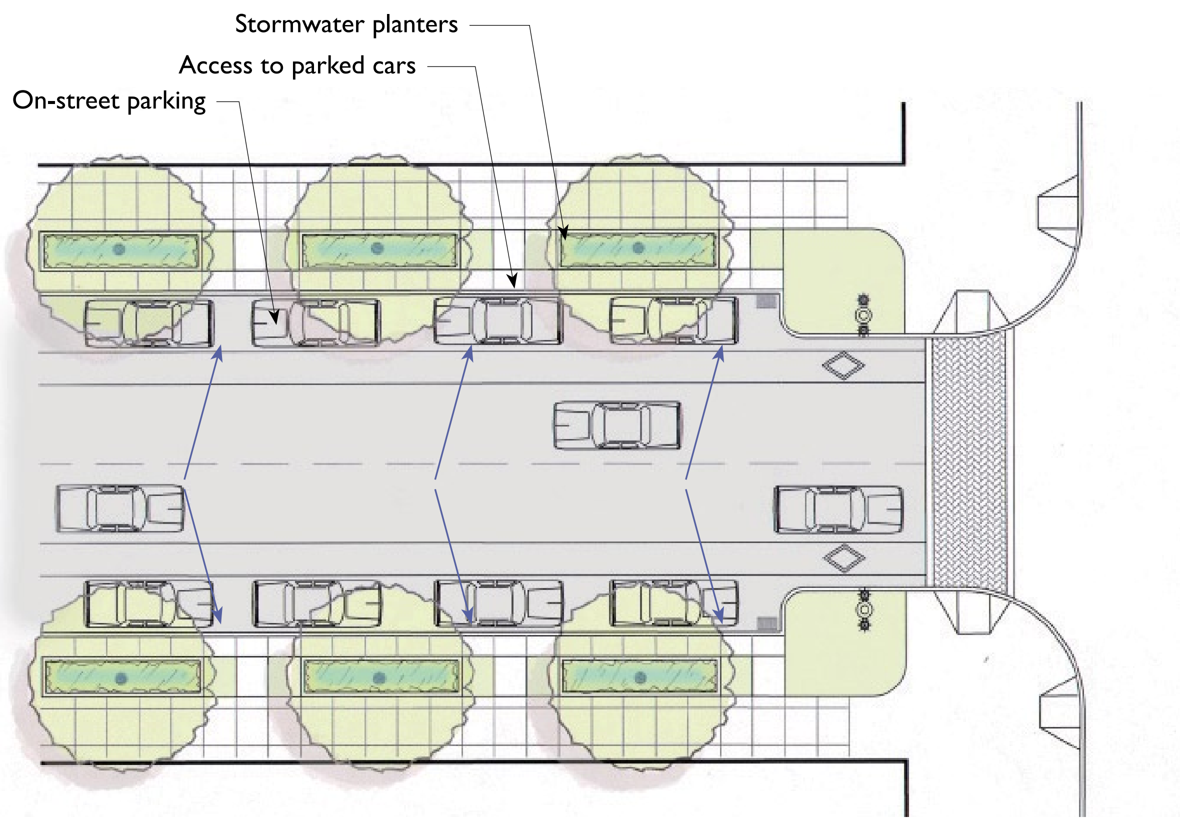


Figure 101. Stormwater planters (parking on both sides)—plan view.

Option for Stormwater Planters and No On-Street Parking

This example shows stormwater planters on a two- or four-lane road without on-street parking. The stormwater planter can be designed to fit in between street furnishings or utility lines. With no on-street parking, stormwater planters can be built right up to the edge of the curb and do not need to accommodate an egress space for pedestrians to get in and out of their vehicles. This allows more design freedom for stormwater management in tight spaces.

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Figure 102. **Planters can be retrofitted on urban streets with overly wide sidewalk zones. Dashed lines show where a planter could be added.**

Kevin Robert Perry-City of Portland

Figure 103. **Stormwater planters accepting runoff from a commercial street.**

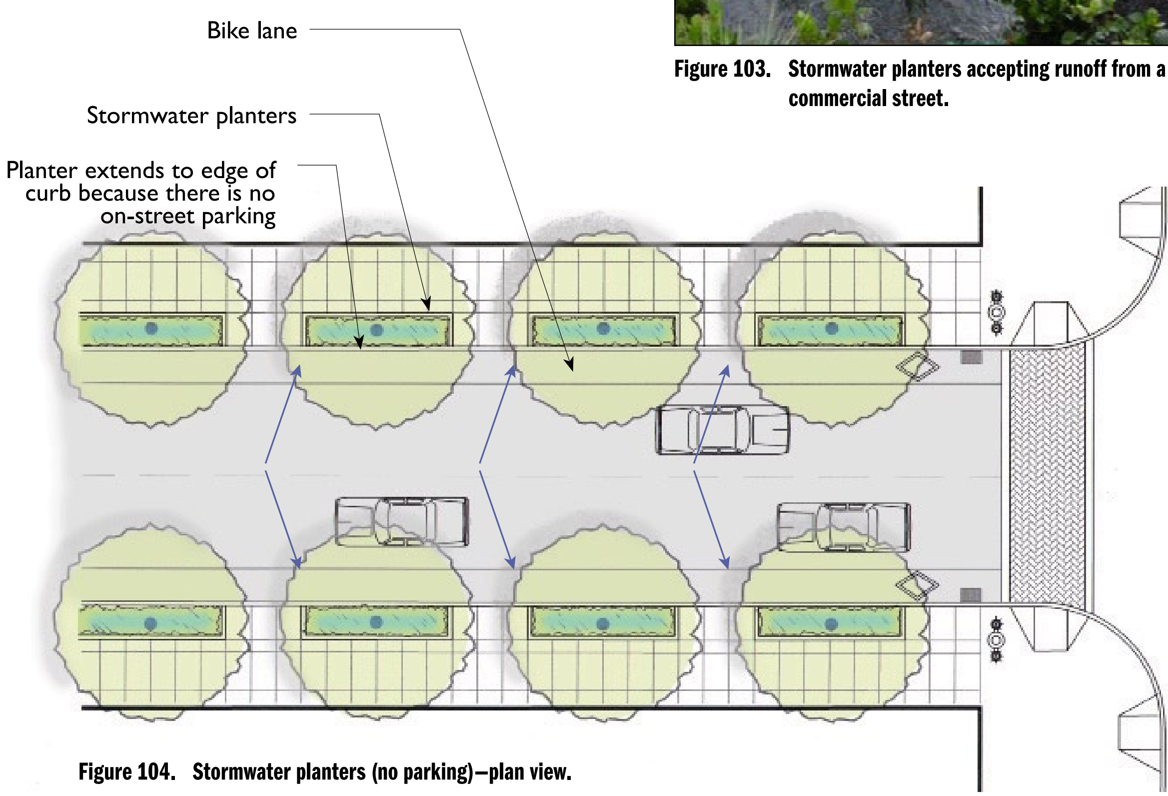


Figure 104. **Stormwater planters (no parking)—plan view.**

Figure 105. Bank Street in Lewes.

Option for "Green Gutter" Narrow Planter

This example shows how a narrow street could be retrofitted for stormwater management. By narrowing this one-way street by a couple of feet, a narrow and shallow planter, or "green gutter," can be implemented. The parking side of the street could be retrofitted with pervious paving. Water flowing into green gutters is best designed as sheet flow curbless condition; however, Figure 106 shows a standard curb with frequent curb cut openings. Introducing even smaller stormwater facilities can provide water quality benefits.

Figure 106. ***Retrofit potential:*** A "green gutter" and permeable paving in the parking zone.

Planters and Parking Lots

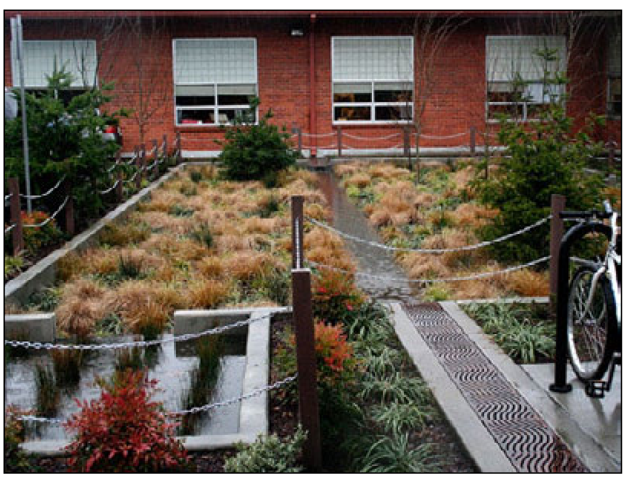
In a new parking lot:

Planters are easy to incorporate into parking lot designs. Parking lot planters can be designed to take the place of one parking spot. Water can be designed to flow into one planter, overflow, and flow across the parking lot surface into the next planter.

In an existing parking lot:

As with swales, parking lots can often be retrofitted to include planters without losing any parking spaces. Planters take up less space than swales and thus may be a better choice in parking lots where less space is available. Look for:

- Parking lots with very long stalls;
- Travel lanes that are wider than necessary; or
- Angled parking with unused space in front of or behind each space.



Kevin Robert Perry-City of Portland

Figure 107. A large stormwater planter at a middle school accepts water from both a parking lot and the building's rooftop.

Planters and Buildings

Next to a new building:

Flow-through and infiltration planters are a great way to capture and treat rainwater off of buildings. They can be designed to fit the architecture of a building. They offer many opportunities for artistic expression through the design of scuppers and interesting gutters.

Next to an existing building:

Flow-through planters are a good way to freshen up an old foundation planting. While they are not as simple to retrofit onto buildings as they are to integrate initially, all it takes is the ability to dig a deep enough hole next to the building to be able to line the planter. Look for:

- Old foundation plantings; or
- Leftover spaces between buildings and parking lots.

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Figure 108. A stormwater planter next to a multi-family residential complex.

Figure 109. This parking lot manages a portion of its stormwater runoff in multiple landscape islands.

Option for Stormwater Planters—Parking Lot Islands

Like streets, parking lots can also use planters to manage stormwater runoff when space is tight. The example below shows how planters can be used in parking lot islands. Converting parking stalls into new landscape islands that can accept stormwater runoff is a relatively inexpensive retrofit. However care can be taken to assure than water can effectively move in and out of the landscape island, and that there is adequate space for people to get in and out of their vehicles without walking on the stormwater facility. A 2-foot clear space at the side of a parking lot island planter will provide better access for pedestrians to safely enter and exit their vehicles.

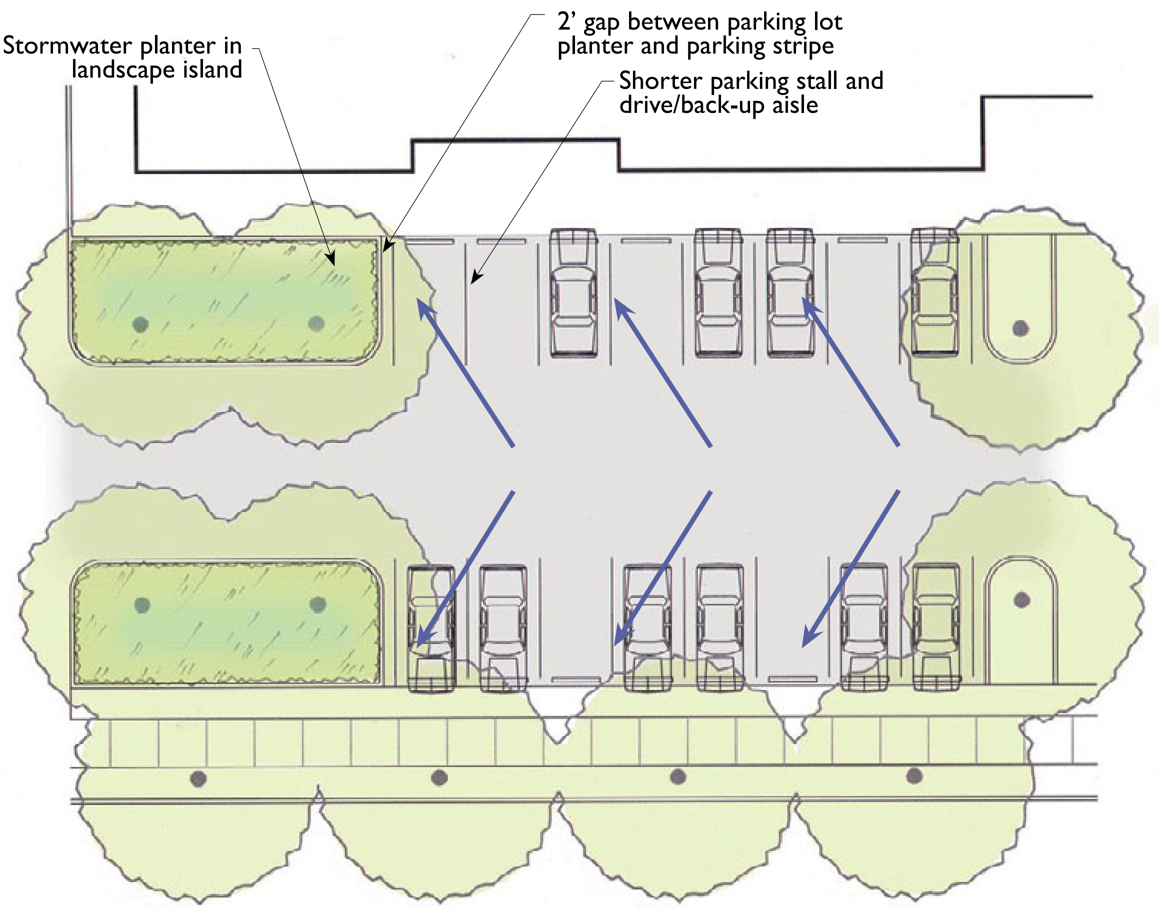

Figure 110. Stormwater planters in parking lot–plan view.

Figure 111. Long parking stalls can be a good opportunity to reclaim a few feet for a stormwater facility.

Option for Shorter Parking Stalls for a Center Median Swale/Planter

Shortening the length of the stalls can create space to infiltrate stormwater and plant trees. The parking lot is also made safer by creating narrower drive aisles that help minimize reckless driving. Trees help keep the asphalt cooler and reduce the heat island effect.

Figure 112. ***Retrofit potential:*** 18-foot-long parking stalls are converted to 15 feet, which yields enough space for a 6-foot parking lot swale or planter.

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Figure 113. Angled parking creates an unused space between the wheel stop and the edge of the planter strip.

Option for Planters Using Leftover Space in Front of Angled Parking Spaces

Conventional angled parking creates an unused space between the wheel stop and the edge of the planter strip. This space could be converted to a swale (or could have been designed as a swale initially). This retrofit creates space for a stormwater swale without decreasing the number of parking spaces or altering vehicular circulation in the parking lot. Trees can make this a friendlier atmosphere and help to absorb stormwater.

Figure 114. *Retrofit potential:* The space in front of angled parking stalls can easily be combined with other landscaping and converted into a stormwater swale.

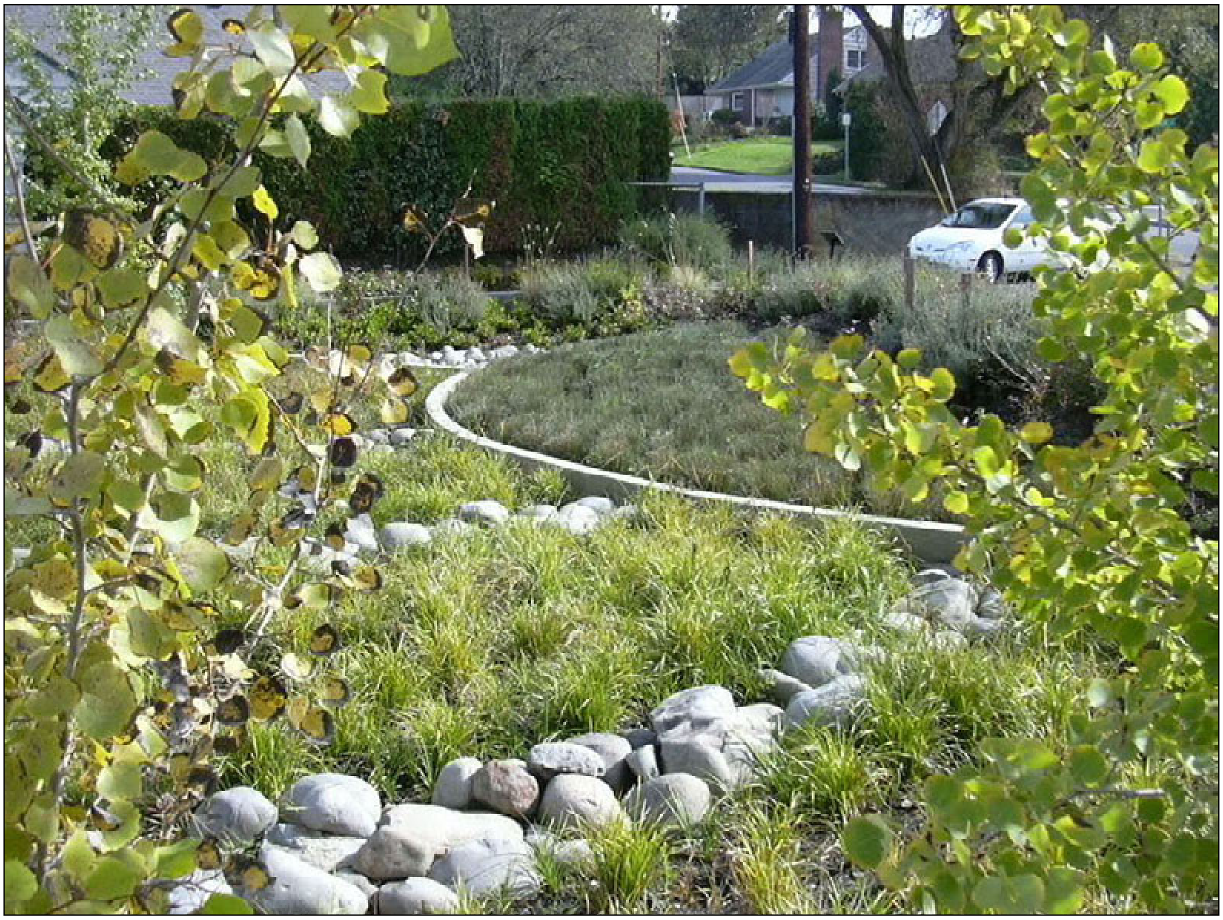


Figure 115. Infiltration garden in a residential neighborhood.

5.2.11 Use Infiltration Gardens

Infiltration gardens are shallow, vegetated depressions in the landscape. They can be rectilinear or rounded and are often as wide as they are long.

As the name suggests, infiltration gardens infiltrate stormwater. Because they cover more surface area, they can accommodate a larger volume of water.

Good places for infiltration gardens:

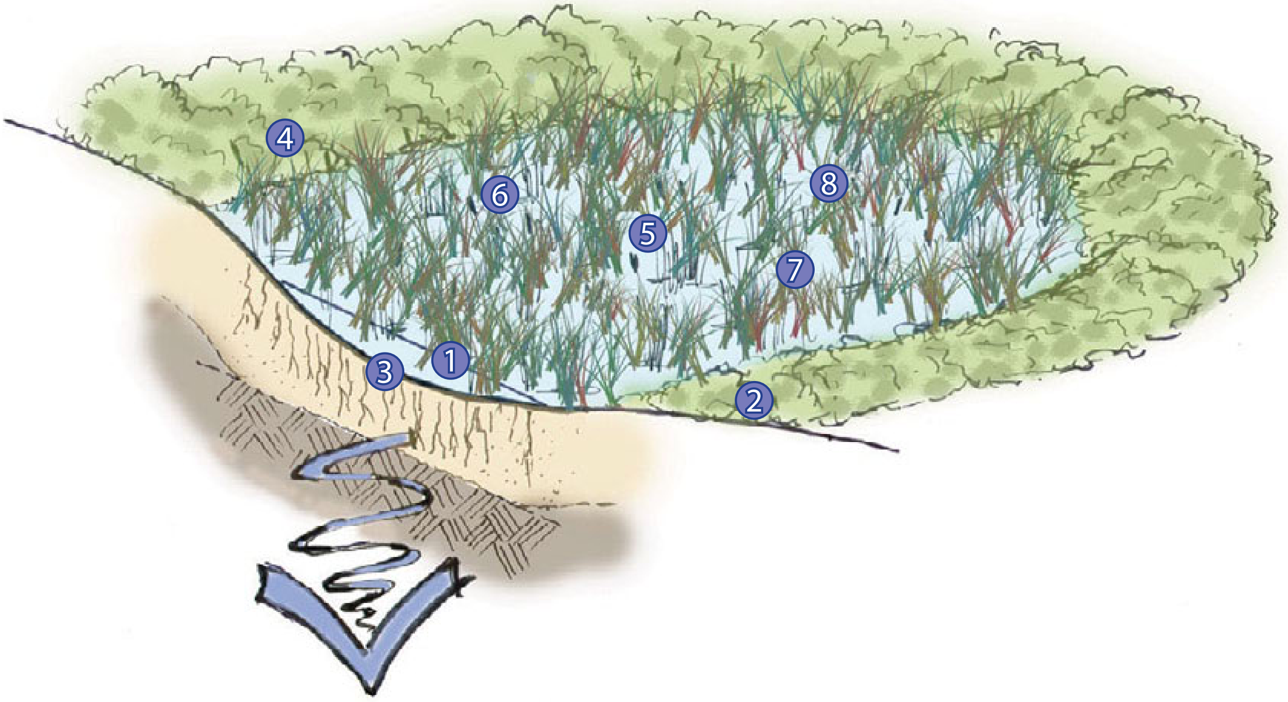
- Parking lots
- Awkward intersections
- Leftover spaces

Community benefits:

- Beautifies and softens parking lots and streets by adding plants, reducing overall impervious surface area.

Infiltration gardens share similarities with swales and planters. However, they are described as a separate strategy based on the spaces in which they fit. Their primary advantage is their versatility. They can be any size or shape and are often molded to fit into “leftover” landscape spaces in parking lots, at intersections with diagonal streets, or in underused areas around buildings.

Construction costs of infiltration gardens vary greatly depending on their size, shape, and use. Generally, because they cover more surface area, they cost more, but they can also hold, filter, and absorb a large volume of stormwater.



1	Depth:	Retains no more than 8" of runoff
2	Side slopes:	Can be vertical or have side slopes
3	Bottom:	Flat, open to native soil
4	Plants - side slopes:	Drought-tolerant ground covers and shrubs, 3' maximum height
5	Plants - bottom:	Wet- and drought-tolerant rushes, sedges, shrubs, and trees
6	Slope:	None - used to pond and infiltrate water
7	Check dams:	Used to promote ponding of water and aid in grading if facility is not in a flat location
8	Trees:	Drought tolerant, wet tolerant

Figure 116. Design and construction characteristics of an infiltration garden.

www.ia.nres.usda.gov

Figure 117. A residential street infiltration garden.

Infiltration Gardens and Streets

On a new street:

In new design, infiltration gardens can be incorporated at street intersections, in the centers of roundabouts, or similar places.

On an existing street:

Infiltration gardens can be retrofitted in a variety of areas. Many downtowns, industrial areas, neighborhoods, and rural areas have large areas of pavement on streets and parking lots that could be converted to infiltration gardens. Look for:

- Unused or inefficiently used pavement; or
- Lawn areas at street intersections.

Infiltration Gardens and Parking Lots

In a new parking lot:

Infiltration gardens can be used in parking lots in conditions where swales and planters cannot handle all the runoff and where they can overflow into a larger infiltration garden. Infiltration gardens are also a good option if there is a focal area that could be beautified and be used as an interpretive area.

In an existing parking lot:

Parking lots sometimes have more spaces than necessary, and those spaces could be used for infiltration gardens. Look for parking lots with:

- Excess spaces;
- Underused areas nearby; or
- Very long stalls or wider than necessary travel lanes that could be redesigned more efficiently to create space for an infiltration garden.

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Figure 118. Large, underused areas of asphalt can easily be converted into infiltration gardens.

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Figure 119. An infiltration garden at an elementary school.

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Figure 120. Unused landscape space is a prime retrofit opportunity.

Infiltration Gardens and Buildings

Near a new building:

New development is a great opportunity for integrated design of buildings and infiltration gardens. Imagination is the limit to the ways in which infiltration gardens can complement building architecture and use of indoor-outdoor space. Many opportunities exist for integrating infiltration gardens with rain-absorbing footprint strategies such as rainwater harvesting.

Near an existing building:

Infiltration gardens can be designed as an amenity to existing buildings by redesigning surrounding landscapes or by reclaiming unused paved areas near buildings. Look for:

- Unused space in industrial areas;
- Schools, churches, and other public buildings with excess space;
- Spaces between buildings;
- Courtyards; or
- Garden areas that can be redesigned to accommodate stormwater.

City of Portland-Environmental Services

Figure 121. An infiltration garden treats roof runoff from a commercial building.

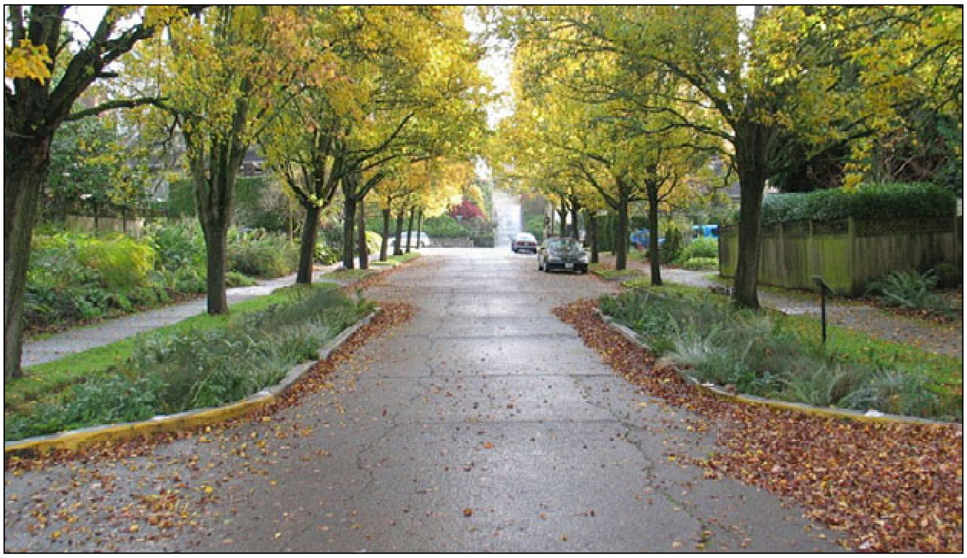

Kevin Robert Perry-City of Portland

Figure 122. This stormwater curb extension project in Portland, Oregon, provides stormwater management and traffic calming benefits.

5.2.12 Use Curb Extensions

Curb extensions extend the street edge into the street. Within their boundaries, they share the characteristics of swales, planters, or infiltration gardens, depending on the site. Curb extensions intercept water running along a curb and gutter before it reaches the catch basin. This section discusses the application of curb extensions to residential and commercial streets and the retrofitting of existing curb extensions with stormwater management features. Before-and-after sketches illustrate potential curb extensions in Paynter's Mill and along a historic main street in Milton.

Good places for curb extensions:

- Any streets that can afford some on-street parking loss
- Awkward street intersections
- Streets needing traffic calming

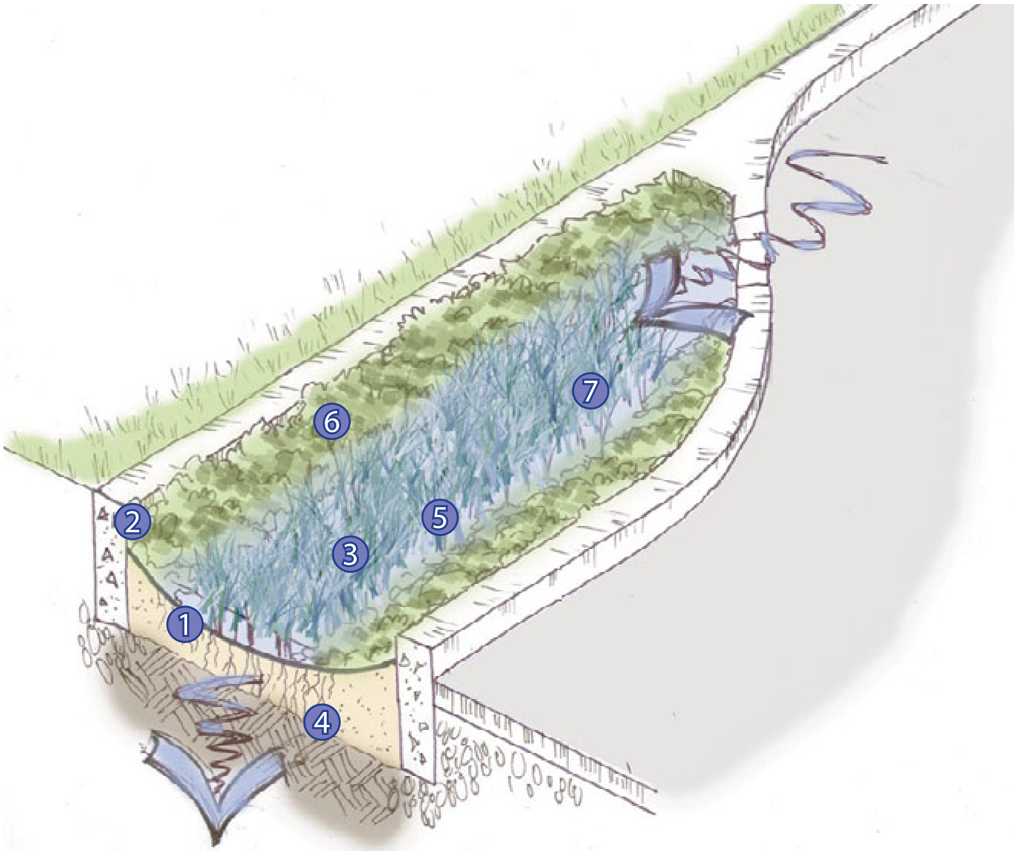
Community benefits:

- Beautifies streets with trees and vegetation.
- Creates shorter street crossing distances for pedestrians.
- Calms traffic.
- Creates a distinctive community identity.

Like infiltration gardens, stormwater curb extensions are discussed independent of swales and planters because of their unique street application. Conventional curb extensions, also known as bulb-outs, chokers, or chicanes, have been used for decades to protect pedestrians and help calm traffic. Communities can add a stormwater benefit by allowing water to flow into a curb extension.

Plants slow and filter rainwater flowing through curb extensions so that it moves more slowly than it would in a traditional storm sewer pipe system. Water flowing through curb extensions has a chance to soak into the ground before excess water flows back out to the curb and into a catch basin.

Using curb extensions is particularly advantageous in retrofits because they can often be added to existing streets with minimal disturbance. The relatively small footprint of stormwater curb extensions allows for an efficient stormwater management system, and hence they often perform well at a relatively low implementation cost.



1	Depth:	Retains no more than 6" of runoff
2	Side slopes:	Can have vertical walls or side slopes, depending on street context
3	Bottom:	3' wide minimum, rounded or flat. Can be sealed, as in flow-through planter, or open as shown.
4	Plants - side slopes:	Drought-tolerant ground covers and shrubs, 3' maximum height
5	Plants - bottom:	Wet- and drought-tolerant rushes, sedges, shrubs, and trees
6	Longitudinal slope:	6% maximum
7	Check dams:	At least one check dam for every 6" of vertical drop
	Trees (not shown):	Drought tolerant, wet tolerant

Figure 123. Design and construction of a curb extension.

Curb Extensions and Streets

Curb extension shapes and sizes:

Stormwater curb extensions are commonly added to residential streets because they are simple, easy to retrofit, inexpensive to construct, and can be built in many different shapes and sizes. Figures 124 and 125 show simple curb extensions that take up one or two parallel parking spaces.

On a new street:

In new design, curb extensions can be incorporated at street intersections or at mid block. Making curb extensions as long as possible will maximize stormwater management.

On an existing street:

Curb extensions are useful in retrofitting existing streets. They are placed wherever there is available space and the existing drainage works well. To find places to retrofit curb extensions in residential areas and commercial town centers, look for:

- Wide streets where parallel parking zones are underused;
- Intersections with diagonal streets;
- Wide, unused paved areas;
- Traffic circles; or
- Planted landscapes that can be converted to rain gardens.

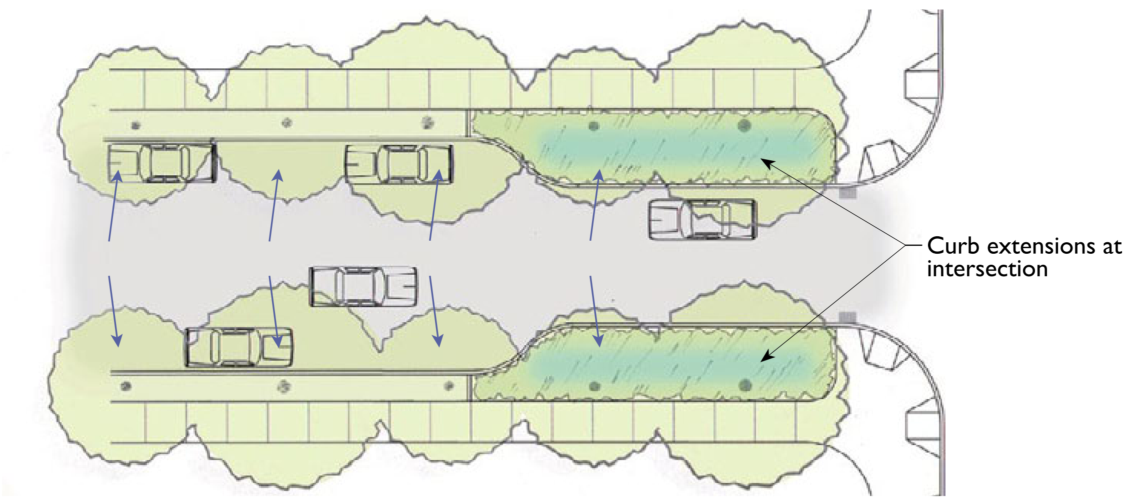


Figure 124. End-block curb extension—plan view.

Figure 125. Mid-block curb extension (staggered layout)—plan view.

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Figure 126. Curb extensions in Paynter's Mill.

Option for Curb Extensions at Intersections

In Paynter's Mill, intersections have curb extensions that calm traffic and increase landscape area. Including planters or swales in these curb extensions could improve the quality and quantity of stormwater discharging from the area.

Figure 127. ***Retrofit potential:*** Planters or swales in these curb extensions could significantly improve stormwater quality and quantity.


EPA

Figure 128. Typical small-town main street in Milton.

Option for Mid-Block Curb Extensions

The curb extensions shown for residential streets can be adapted to commercial streets. These curb extensions have planters in them and are about the size of one parking space, much shorter than the curb extensions shown in the residential examples. They can be implemented mid-block, at the ends of a block, and in a series. Symmetrical placement of mid-block curb extensions helps calm traffic by narrowing the street at specific points.

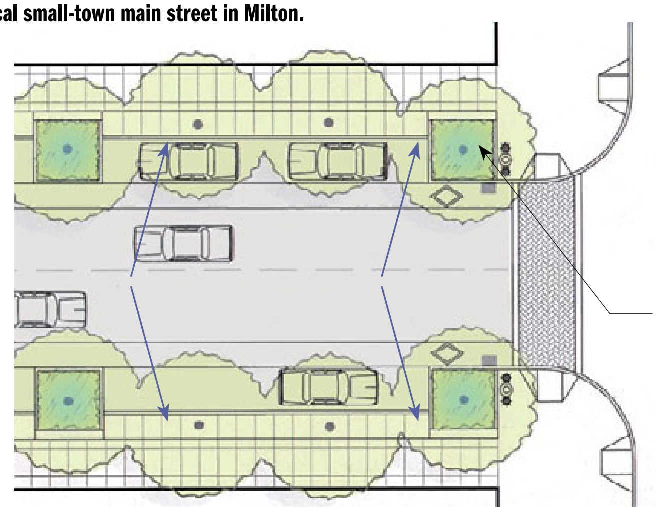

Figure 129. Mid-block curb extensions—plan view.

Figure 130. *Retrofit potential:* Commercial main street with mid-block stormwater curb extensions.

EPA

Figure 131. Conventional curb extensions in Lewes.

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Figure 132. A commercial street with curb extensions and a landscaped median in Eugene, Oregon.

Option for Curb Extensions and a Median Swale

This example shows how stormwater can be managed in a swale in the landscaped median of the street. This option is more viable in new construction or if the entire street is being rebuilt. The primary advantage of having a median swale is that the stormwater is directed into facilities in the center of the street, allowing more room for parking, pedestrians, and utilities on the sides of the street. The disadvantage is that many streets don't have enough right-of-way for this scenario. Also, the median swale, in using a reversed-crown profile, will need to be large enough to manage the runoff for the entire street instead of only half of the street. To help better allocate the management of stormwater, a combination of a median swale and curb extensions can be used in a double-crowned street profile, as illustrated below in Figure 133.

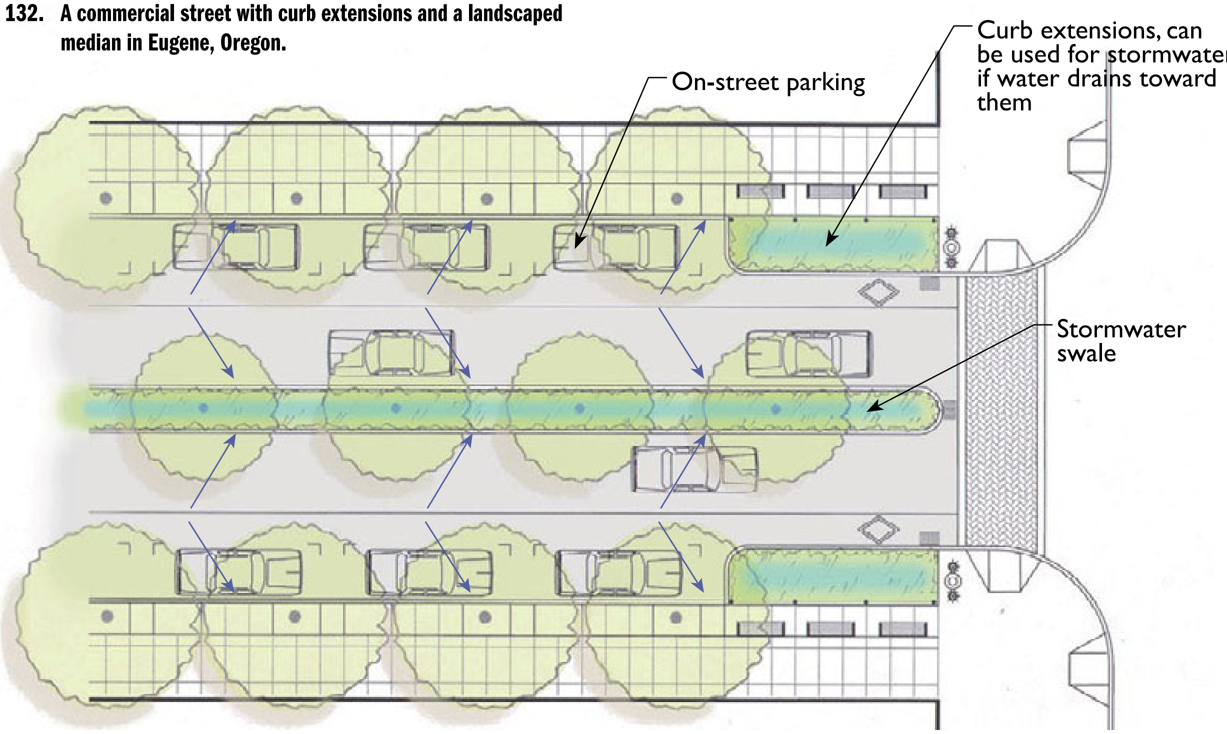

Figure 133. Stormwater curb extensions with a median swale—plan view

Option for Curb Extensions at Intersection and Pervious Paving in Parallel-Parking Zone

This example shows end-block curb extensions combined with pervious paving in the parking zone of the street. Stormwater curb extensions in commercial streets help "green" the streetscape and provide a distinctive identity. However, losing on-street parking to accommodate the stormwater facility can be a concern. To help minimize the parking loss, pervious paving can be used to manage a portion of the runoff. In the scenario shown in Figure 134, pervious paving is used to initially manage runoff, and stormwater curb extensions capture overflow. Because of this combined effort, the curb extensions can be smaller than if there were no pervious paving.

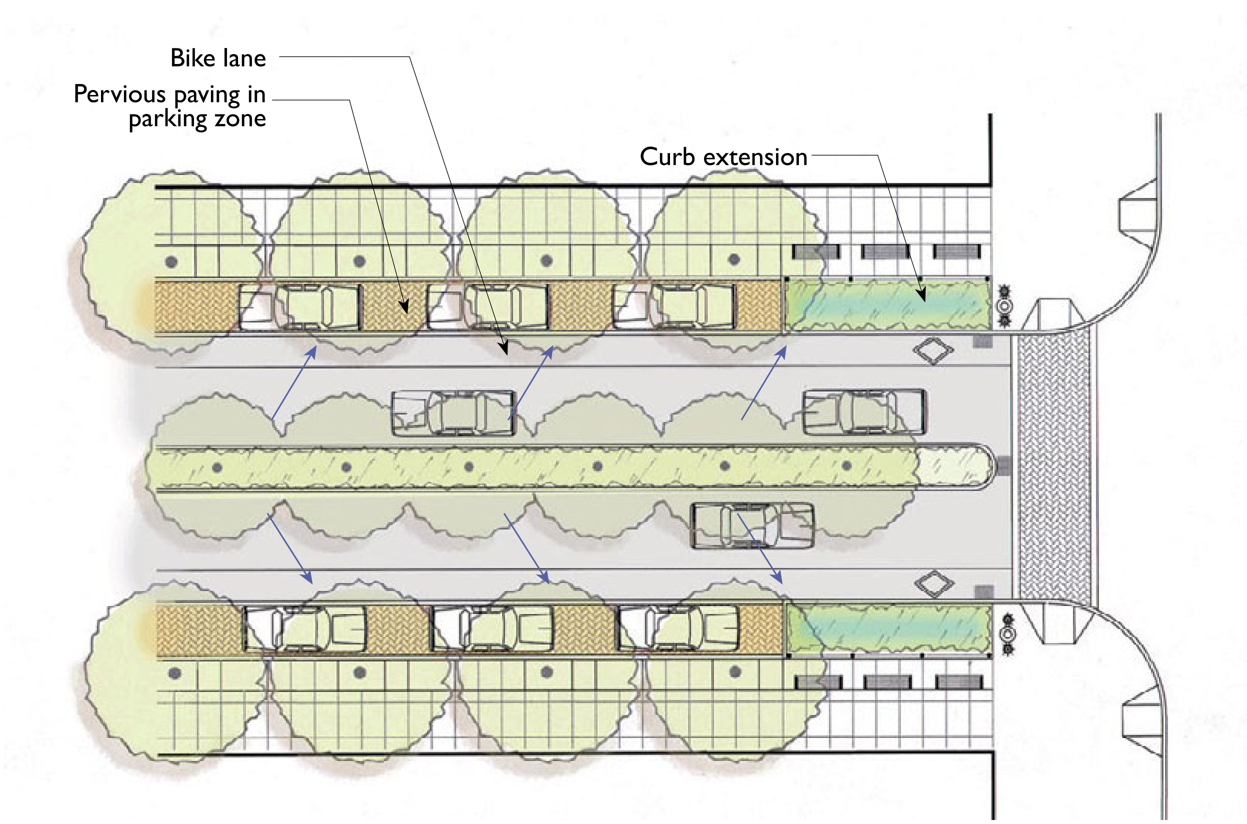

Figure 134. Stormwater curb extensions with pervious paving in parking zone—plan view.

Option for Using Curb Extensions With Angled Parking

Some commercial streets in Sussex County use angled on-street parking. One green street design scenario consolidates one or more parking spaces into large curb extension areas. This can be a relatively simple retrofit application if a few parking spaces can be lost. Using curb extensions in angled parking spaces can add more landscaping to the street, which in turn can make storefronts more attractive.

Tim Kiser- www.wikimedia.org

Figure 135. Angled parking along Second Street in Lewes.

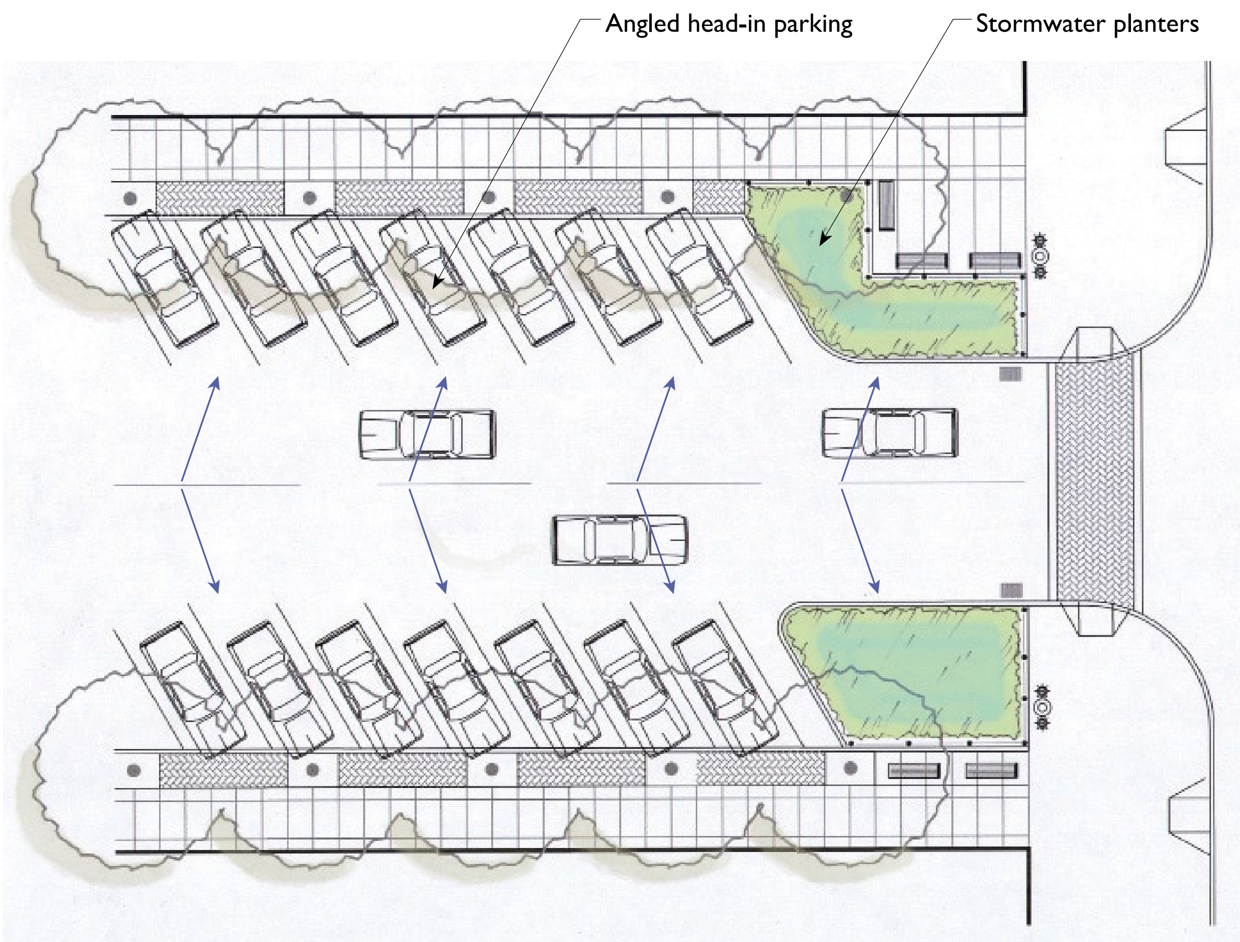

Figure 136. Stormwater curb extensions with angled parking—plan view.

Nevue Ngan Associates

Figure 137. A disconnected residential downspout.

5.2.13 Disconnect Residential Downspouts

Most gutters and downspouts are connected to the public storm sewer or a combined sewer system. Downspouts can be disconnected from the sewer systems and redirected onto lawn areas, into rain gardens, or a rainwater harvesting system such as described in Section 5.2.7. Directing runoff onto lawn areas slows and filters rainwater and lets it absorb into soils locally instead of sending it in a pipe to stormwater treatment downstream.

Good places for downspout disconnection:

- Single-family homes
- Small multifamily buildings
- Small office buildings

Community benefits:

- Educates homeowners about watershed system.
- Is a simple action that almost any home or property owner can take to contribute to comprehensive stormwater management strategies in a community.

6. Next Steps

Thanks to the updating of its comprehensive plan and the implementing ordinances that will go along with it, Sussex County is in a good position to make changes to the way it develops land. Based on the citizens' desire to protect natural resources, to have walkable and bikable communities, and to preserve the small towns and the agricultural lands of the county, the team offers some ideas for the county to consider as it moves forward in implementing regional and neighborhood-level growth decisions and site-level stormwater management strategies.

6.1 Tools to Help Implement Growth Decisions

Other communities that have dealt with similar issues have developed several tools to protect valuable land while allowing growth in already developed areas. Sussex County has already discussed some of these tools but may want to reconsider them as the stormwater management and other benefits come to light, and as the county debates new ordinances to fulfill the revised comprehensive plan. The tools fall into three categories:

- Land conservation and efficiency;
- Incentives for compact, location-efficient development; and
- Zoning and related ordinances.

6.1.1 Land Conservation and Efficiency

These tools can help the county preserve land with ecological, agricultural, recreational, or aesthetic value, while directing development to areas that are better suited for growth.

- Transfer of development rights (TDR) or purchase of development rights (PDR) allow a community to direct development to built-up areas while preserving land elsewhere. For example, a developer buys the "right" to develop a farmer's land, yet can only use that right (usually expressed as an allowable number of houses or development density) in designated areas where the community has determined it wants development. The farmer gets value from his land without having to develop it, and the developer respects the wishes of the community by building in areas designated for growth.

- Some communities have used up-zoning and down-zoning to lower allowable development densities—for example, from 2 units an acre to one unit per 10 acres. The "saved" development densities are then "allowed" in another designated part of the community. This strategy protects water quality by keeping development out of critical ecological areas and encouraging efficient land use in areas that allow development. These zoning tools can be used with, or separately from, TDR and PDR programs.

- A conservation easement or restriction is a legal agreement between a landowner and a land trust or government agency that permanently conserves land. It allows the landowner to continue to own and use the land and to sell it or pass it on to heirs. The landowner, however, gives up some of the rights associated with the land, such as the ability to build additional houses. Most easements are in perpetuity, meaning that future owners are bound by the easement's terms.

- Buffer ordinances can protect water quality and aquatic habitat. Vegetated buffers along water bodies serve as natural boundaries between the water and development and protect resources by filtering pollutants, providing flood control, reducing stream bank erosion, mitigating stream warming, and providing room for lateral movement of the stream channel. Sussex County's code requires a 50-foot buffer along water bodies, but enforcement of this ordinance appears to be inconsistent.

6.1.2 Incentives for Compact, Location-Efficient Development

To get the type of development it wants where it wants, the county can make it easier and more cost effective for developers to build the type of projects its citizens want. Sending price signals to private developers through incentives can be a powerful tool to encourage them to build in a way that meets the county's environmental and community goals.

- Priority funding areas (PFA) are areas defined by state or local governments that will receive state funding for infrastructure, such as roads, schools, water, and sewer, associated with new development or redevelopment. State and local governments have used PFAs as a financial incentive to direct development to designated growth areas. If development occurs outside the PFA, no state funding is available for infrastructure. Similarly, sewer and water authorities can play a major role in directing a region's growth by determining when and where new infrastructure investment will occur. Well-drafted facility planning areas can direct growth by providing sewer service in areas least likely to harm water resources. In theory, this is how the state of Delaware determines where it will pay for infrastructure for development; in practice, however, because of taxpayer pressure, the state has tended to pay for infrastructure even in areas designated for no development.

- Time is money for developers. To encourage the type of development it wants in areas where it wants growth, the county could offer a streamlined permitting process for development projects that meet certain criteria—for example, a convenient location, efficient use of resources, better stormwater management, compact design that creates less impervious surface, and safe streets for walking and biking. A streamlined permitting process brings together all the necessary departments and permit processes at one time, allowing a developer the opportunity to resolve all the permitting questions and issues at the same time. Some communities have even fast-tracked development proposals that meet the criteria for the type of development they want.

- The county could prioritize infrastructure upgrades, such as sidewalks, road improvements, street lamps, and street furniture, for areas targeted for growth or redevelopment. This would support new development activity and signal to developers the areas where the county wants to see new and additional growth and development occur.

6.1.3 Zoning and Related Ordinances

Zoning ordinances will fulfill the vision of the comprehensive plan. As Sussex County redoes its implementing ordinances to match the updated comprehensive plan, it has the opportunity to include some of the tools below, which can make it easier for developers who are trying to provide the type of development the county wants.

- Mixed-use zoning codes encourage compact, walkable neighborhoods. In specific areas such as a town center, a mixed-use zone can promote a range of housing and transportation options that make the neighborhood socially and economically stronger, as well as more appealing to both residents and visitors. One example of a mixed-use code is Traditional Neighborhood Development (TND). A TND zone provides street connectivity, short blocks, open space, and natural best management practices.
- Another potential zoning tool is a form-based code. Instead of regulating land by uses, a form-based code describes a block, street, parcel, or neighborhood by its form—the way the buildings look instead of the types of activities they house. This flexibility enables a mix of uses, reusing buildings for different purposes as community needs change, and planning for how a building can best manage stormwater.
- Planned unit development (PUD) overlay is a planning mechanism that allows the local government and the developer to negotiate. The benefit for stormwater management is that the county and the developer can set as parameters for development key requirements and innovative practices, such as those described in Sections 4 and 5, which may not be part of the underlying zoning. This flexibility lets both parties meet the needs of the site and the public interest.
- Overlay districts can be superimposed on the existing zoning, adding different requirements because of the ecological sensitivity or other special characteristics of the area. An overlay generally does not alter basic zoning standards, such as use, lot size, or setbacks. However, it can add design requirements or stormwater management standards or increase density to allow the zoning authority to get development that fits what the community wants. The county has some overlay districts in effect now but may wish to review and alter them based on the new comprehensive plan and on the stormwater management strategies presented in this report.
- Local governments can offer density bonuses for development, which allow a developer to add more housing units in exchange for some benefit to the community, such as reserving a certain number of units for lower income residents or providing and maintaining green space in the development. If the county wants to increase density in certain areas, a density bonus is a good way of doing so while also getting new community amenities.
- Design guidelines and standards help developers understand what is acceptable to the community and help guide municipal staff and project review boards that approve new projects. It is particularly helpful—to developers, government staff, and citizens—to have images that show exactly what type of design the community wants.

6.2 Tools to Help Implement Site-Level Stormwater Management Strategies

In addition to the steps noted in Section 5 for implementing specific strategies, Sussex County may want to undertake education and outreach efforts to get stakeholder and public support for these new design solutions.

6.2.1 Public Education and Outreach

Confusion and misconceptions about rain gardens and similar strategies abound. People may think of rain gardens as "swamps" or "mosquito nests" and may not know about the benefits of well-designed stormwater management facilities. If the county chooses to implement some of the site-level strategies described in Section 5, it could also consider a public education campaign to teach residents about the benefits of these designs, including water quality and wildlife habitat protection, aesthetics, traffic calming, pedestrian and bicyclist safety, and efficient use of taxpayer money.

Some ideas for public and stakeholder education include:

- Conduct public tours of successful demonstration projects in the area.
- Offer frequent public meetings or workshops on sustainable stormwater management.
- Create brochures, fact sheets, or online materials that describe the different ways to manage stormwater runoff and the costs and benefits of each strategy.
- Install interpretive signs for stormwater demonstration projects that describe the project's elements and offer sources for additional information.
- Conduct field trips for school children to teach them about environmental sustainability.

6.2.2 Demonstration Projects

Building a successful county-wide strategy for stormwater management often begins by starting relatively small with demonstration projects that showcase designs such as those illustrated in Section 5.2. Starting with small-scale demonstration projects can make it easier to reach consensus among various municipal departments and agencies. Demonstration projects not only educate the public, they also allow the county to gauge what resources it will need to institute a more ambitious stormwater management program.

Many opponents of these design strategies may have seen only poorly designed stormwater management systems and may not realize that well-designed rain garden projects can look just as good as—if not better than—conventional landscaping. They may not realize the other benefits these designs can bring. Therefore, showing the public successful demonstration projects (ideally, but not necessarily, local projects) can be a powerful tool to show them how rain gardens can not only help protect the environment, but also serve as a distinctive and attractive neighborhood amenity.

Some of the best demonstration projects are retrofits that show how, through good design, gray space can be converted into green space for stormwater management, community amenities, pedestrian and bicyclist safety, and other benefits. Here are a few suggestions for finding good candidate sites for a retrofit demonstration project:

- Streets, sidewalks, parking stalls, and parking lot driveway aisles that could be narrowed without sacrificing safe and efficient movement;
- Underused on-street parking areas; or
- Streets with aging infrastructure (utilities, pavement, curbs, etc.) that need to be repaired or replaced.

The county could also look for projects that offer the opportunity to combine new or improved transportation choices, like safer sidewalks or bike lanes, with better stormwater management. Projects that can seamlessly integrate the building, street, and site stormwater runoff into one project are also desirable. To measure the effect of these strategies, the county may want to choose projects that can easily be monitored for data collection.

For both retrofits and new development projects, the county can improve its chances of success by reaching out to developers, landlords, business owners, homeowners associations, and community groups, tapping their interest and knowledge of potential sites in their neighborhoods or projects. A developer who wants a demonstration project on his or her site will be a better partner than one who feels like a project is being imposed. To encourage participation, the county could use incentives, such as an expedited approval process or technical assistance.

6.3 Conclusion

Sussex County is facing relatively rapid and large growth in population, particularly in demographics like senior citizens who want the convenience and appeal of walkable communities. The county has valuable environmental resources and rich cultural, natural, and agricultural heritage to protect as it considers new opportunities for sustainable economic growth. As the county and its citizens continue to discuss where to direct development and how to grow in a way that preserves the natural beauty and small-town atmosphere that residents and visitors treasure, this report may help them find solutions that meet a wide range of economic, public health, social, and environmental goals.


EPA

Figure 138. The Lewes and Rehoboth Canal.

Appendix A: EPA-NOAA Smart Growth Implementation Assistance for Coastal Communities

Populations and developed areas in coastal watersheds are growing rapidly, with 55 percent of the U.S. population already living within 50 miles of the coasts. The environmental impacts of development directly affect communities' ability to balance natural resource protection with sustainable economic growth. The pressures of coastal growth also profoundly affect the ability of the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Environmental Protection Agency (EPA) to achieve national goals for sustainable management of coastal resources and protection of human health and the environment. This challenge was highlighted in the U.S. Commission on Ocean Policy's report,[1] which called for improvements in program planning, coordination, and implementation to more effectively manage coastal growth.

Addressing this challenge will require more integrated and coordinated partnerships among all levels of government. In January 2005, EPA and NOAA agreed to work together to help coastal communities grow in ways that benefit the economy, public health, and the environment.[2] The EPA-NOAA partnership provides training for local government staff and officials; outreach and education on successful policies, ordinances, and initiatives; and assessments of local development rules and policies.

As part of this agreement, EPA and NOAA are working together to provide smart growth implementation assistance to coastal communities. A competitive process selected six communities with NOAA Sea Grant partners. Working with the Sea Grant partner, the local community host, and its prime contractor, ICF International, EPA assembled contractor teams whose members have expertise that meets a particular community's needs. While working with Sea

Smart Growth Principles

Based on the experience of communities around the nation, the Smart Growth Network developed a set of ten basic principles:

- Mix land uses.
- Take advantage of compact building design.
- Create a range of housing opportunities and choices.
- Create walkable neighborhoods.
- Foster distinctive, attractive communities with a strong sense of place.
- Preserve open space, farmland, natural beauty, and critical environmental areas.
- Strengthen and direct development towards existing communities.
- Provide a variety of transportation choices.
- Make development decisions predictable, fair, and cost effective.
- Encourage community and stakeholder collaboration in development decisions.

Source: ***www.smartgrowth.org/about/principles/default.asp***

1 U.S. Commission on Ocean Policy. *An Ocean Blueprint for the 21st Century*. 2004. Available at *www.oceancommission.gov*.

2 For more information on the EPA-NOAA partnership, please see *www.epa.gov/smartgrowth/noaamoa.html*.

Grant and community participants to understand their aspirations for their community's future, the teams bring experience from working in other parts of the country to help the community explore new options for smarter growth. The goal of the program is to help participating communities attain their goals while producing a report that can be useful to other communities facing similar challenges.

The EPA-NOAA Smart Growth Implementation Assistance for Coastal Communities Program is designed to help communities achieve growth that supports economic, community, public health, and environmental goals. People in communities around the country are frustrated by development that gives them no choice about driving long distances between where they work, live, and shop; that requires costly public expenditures to extend sewers, roads, and public services to support new development; that uses up natural areas and farmland for development while land and buildings lie empty in already-developed areas; and that makes it difficult for working people to rent or buy a home because of development that provides only one or two costly housing types.

Smart growth strategies create new neighborhoods and maintain existing ones that are attractive, convenient, safe, and healthy. They foster design that encourages social, civic, and physical activity. They protect the environment while stimulating economic growth. Most of all, they create more choices for residents, workers, visitors, children, families, single people, and older adults—choices in where to live, how to get around, and how to interact with the people around them. When communities undertake this kind of planning, they preserve the best of their past while creating a bright future for generations to come.

Appendix B: Site Visit Details

The EPA-led team visted Sussex County August 6-8, 2007. Team members were:

- Jim Charlier, Charlier Associates
- Kevin Robert Perry, Nevue Ngan Associates
- Megan Susman, U.S. EPA
- Lynn Richards, U.S. EPA
- Julie Damon, U.S. EPA

The consultants were assisted by a local team, which included:

- James Falk, University of Delaware Sea Grant Program
- Richard Kautz, Sussex County Department of Planning
- Joe Farrell, University of Delaware Sea Grant Program

Consultant Biographies

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Jim Charlier is the founder and owner of Charlier Associates, Inc., a transportation planning firm based in Boulder, Colorado. Mr. Charlier is a nationally recognized transportation planning professional with more than 30 years of experience in local, regional, and statewide settings across the country. He is a frequent speaker, lecturer, and facilitator on urban transportation planning challenges and opportunities. Mr. Charlier and his firm have provided transportation consulting services to clients throughout the U.S., including federal agencies and state departments of transportation, as well as many cities and counties, transit agencies, and metropolitan planning organizations. Over the past ten years, the firm has been increasingly active in guiding development projects for private-sector clients, including cutting-edge sustainable design projects in Colorado, Hawaii, and elsewhere.

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Kevin Robert Perry has designed several award-winning green street and rain garden projects while working for the city of Portland, Oregon's Sustainable Stormwater Management Program. His work helped city policy-makers develop a "toolbox" of design strategies for successful green street implementation. In 2006, Mr. Perry joined the Portland-based landscape architecture firm Nevue Ngan Associates and leads the firm's sustainable stormwater design efforts. Nevue Ngan Associates specializes in integrating sustainable stormwater management with high-quality urban design. The firm works to create solutions that are responsive to community values, sensitive to natural systems, and contextually appropriate.

Schedule

Monday, August 6

9:00 to 11:00 am	Meeting with Low-Impact Development Roundtable
11:00 am to 12:00 pm	Stakeholder meetings
1:00 to 5:00 pm	Tour of local area
6:30 to 8:00 pm	Public meeting

Tuesday, August 7

9:00 am to 12:00 pm	Working session
1:00 to 5:30 pm	Working session open to public
5:30 to 7:00 pm	Open house

Wednesday, August 8

9:00 am to 6:30 pm	Working session
6:30 to 8:00 pm	Public meeting

The team would like to thank all the stakeholders who met with us and all the attendees at the public meetings.

Stakeholders interviewed during the site visit included:

Wendell Alfred – Board of Public Works, Lewes, Delaware

Wendy Baker – Ocean Atlantic Associates and Sussex County Land Trust

Ted Becker – Councilman, Lewes, Delaware

Jennifer Campagnini – DNREC, Sediment and Stormwater Program

Rich Collins – Positive Growth Alliance

Mark Davidson – Contour Group

Nicolas DiPasquale – Duffield Associates

Dick Drevo – Resident, Lewes, Delaware

Pret Dyer – Dyer McCrea Properties, LLC

Todd Fritchmann – Envirotech Environmental Consulting, Inc.

Jim Grayhardt – Board of Public Works, Lewes, Delaware

Conway Gregory – Town Manger, Ocean View, Delaware

Bryan Hall – Delaware Office of State Planning Coordination

Jody Hudson – Positive Growth Alliance

Dave Kenton – Positive Growth Alliance

Ed Lewandowski – Center for the Inland Bays

Mike Lynn – RDM, Inc.

John Mateyko – John Mateyko Architects, LLC

Kevin McBride – Morris and Ritchie Associates, Inc.

Nicole Minni – University of Delaware, Institute for Public Administration, Water Resources Agency

Rachel Greer Reynolds – Resident, Lewes, Delaware

Jim Richmann – Resident, Lewes, Delaware

Rodney Smith – Sussex County Planning and Zoning

Gary Stabley – Board of Public Works, Lewes, Delaware

Barbara Vaughan – Councilwoman, Lewes, Delaware

Jessica Watson – Sussex Conservation District, Stormwater Program

Nate Zimmerman – Sussex Conservation District, Stormwater Program

Appendix C: The Nuts and Bolts of Stormwater Management Strategies for Streets and Parking Lots

This appendix discusses some of the key design considerations to keep in mind when implementing green streets and parking lots. The information is not overly technical; however, it does emphasize areas that should receive specialized design attention:

- **Pedestrian circulation:** One of the most over-looked design issues is not providing good pedestrian circulation in conjunction with stormwater facilities. It is uncomfortable and inconvenient for people to to walk through vegetation to reach their destination.

- **Getting water in and out:** Another key design element in stormwater design is assuring that water will be able to enter and exit rain gardens as designed.

- **Dealing with sediment:** Removing sediment in rain gardens is an ongoing maintenance activity that can be less of a burden when applying certain design techniques.

- **Controlling the ponding of water:** Using check dams and weirs dictates how much water will be retained in a rain garden. Allowing flexibility in design options is a key consider-ation in areas with variable soil conditions.

- **Long-term maintenance:** Frequent mainte-nance of rain gardens is critical for their long-term acceptance and health.

Nevue Ngan Associates

Figure C-1. Careful design allows water to move through pedestrian walkways.

Pedestrian Circulation

On-Street Parking and Pedestrian Circulation

Pedestrian circulation is a priority in dense urban areas, and access, such as bridges or walkways between the street and sidewalk, is critical. In busy commercial downtowns or town centers, on-street parking might appear to be an obstacle to green streets. However, rain gardens can be integrated into commercial rights-of-way without losing on-street parking, provided the right-of-way is wide enough. When on-street parking is next to planters or swales in the furnishing zone, it is critical to consider where people will walk when they get out of their cars. Likewise, when people get out of their cars, they need to have a place to step that does not interfere with the stormwater facility. The green street example illustrated in Figure C-3 accommodates on-street parking and allows efficient flow of pedestrians between the street and sidewalk.


Kevin Robert Perry-City of Portland

Figure C-2. A street using stormwater planters. Notice the 3-foot egress zone between the parked cars and the edge of the stormwater planter.

On-Street Parking and Pedestrian Circulation—Swales

Because swales require long linear areas, they are often built between the street and the sidewalk. Swales can be integrated along streets with on-street parking. However, it is important to allow adequate space for pedestrian egress and circulation.

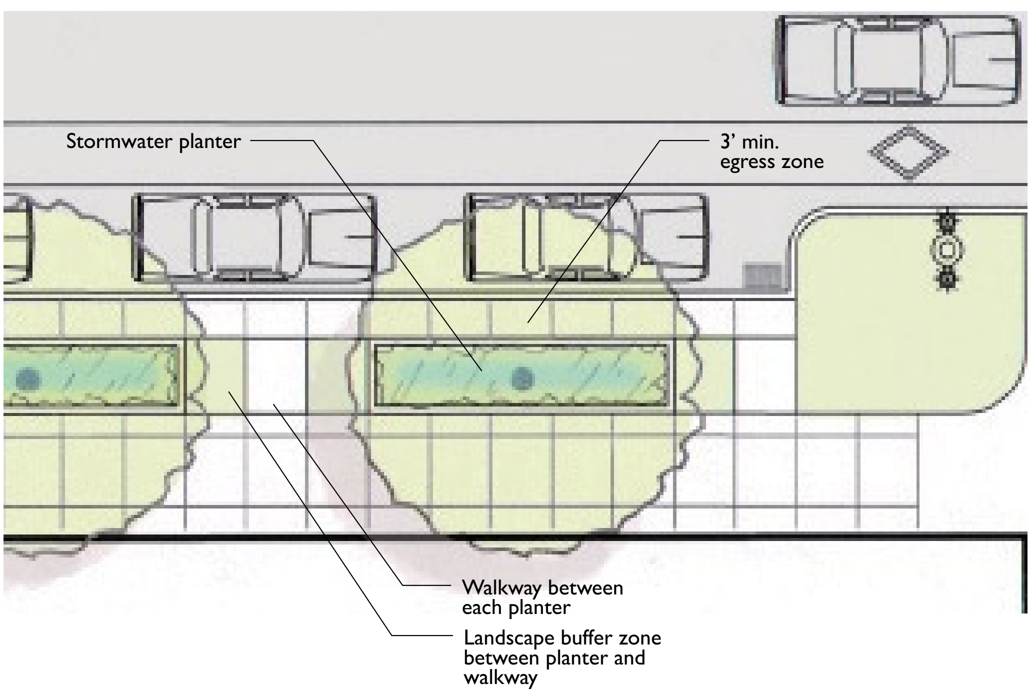

Figure C-3. Pedestrian circulation in street applications—plan view.

On-Street Parking and Pedestrian Circulation—Planters

Planters are a good choice for commercial areas where on-street parking is a priority. They can be designed to fit within the street's furnishing zone, often between existing signs, trees, and driveways. If on-street parking is required, planters can be designed to include a narrow paved strip next to the curb to allow passengers a place to step out of their cars.

On-Street Parking and Pedestrian Circulation—Curb Extensions

One disadvantage of curb extensions is that they usually take the place of one or more parking spaces. Planners can carefully consider this against curb extensions' other benefits that are desirable in dense areas, such as traffic calming and creating shorter crossing distances for pedestrians. Curb extensions can be designed to be smaller and more efficient by designing them as planters (with vertical walls). They may also be used in combination with planters in the furnishing zone or with pervious paving so they don't need to take up as much parking.

On-Street Parking and Pedestrian Circulation—Infiltration Gardens

Because infiltration gardens are typically built in larger areas off the street edge, they don't usually affect on-street parking. When infiltration garden areas reclaim unused pieces of the right-of-way, the ways that pedestrians may cross or access them is something to consider. Creating a "pocket park" for pedestrians at infiltration gardens—at a bus stop, for example—is a great tool for community outreach and education about stormwater.

Nevue Ngan Associates

Figure C-4. Pedestrians can access their vehicles by using pathways that lead to the sidewalk zone.

Nevue Ngan Associates

Figure C-5. Bridges over stormwater facilities allow access and maximize space to manage runoff.

Nevue Ngan Associates

Figure C-6. A raised curb alerts pedestrians of a grade change in the rain garden.

Nevue Ngan Associates

Figure C-7. Failed circulation in parking lot. Due to poor design, people have trampled this parking lot swale to the point that the landscape cannot thrive.

Nevue Ngan Associates

Figure C-8. Good circulation in parking lot. This parking lot swale allows pedestrians to access their destinations without walking through the swale.

Pedestrian Circulation in Parking Lots

When using rain gardens in parking lots, pedestrian circulation is an important design consideration. Designers should consider where the primary pedestrian destination(s) are in relation to the parking lot. For stormwater management, it is best to align rain gardens perpendicular to the sheet flow of water to maximize the potential for capturing runoff. However, this optimum alignment may conflict with the desired pedestrian flow. If this is the case, bridges or pathways over the rain garden or sidewalks alongside the rain gardens can be provided to give people a safe place to walk while protecting the rain garden.

If convenient, prescribed crossing points are not provided, people will probably cut through the rain gardens. This often results in trampled plants, compacted soil, increased erosion, and an overall unhealthy rain garden.

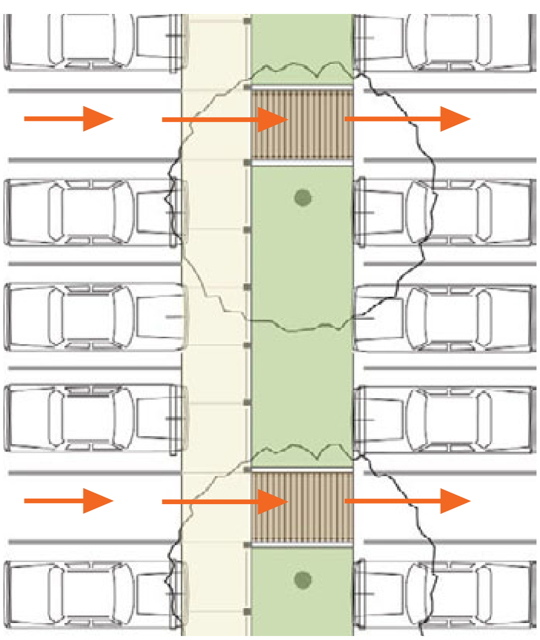

Figure C-9. Pedestrian flow perpendicular to rain garden.

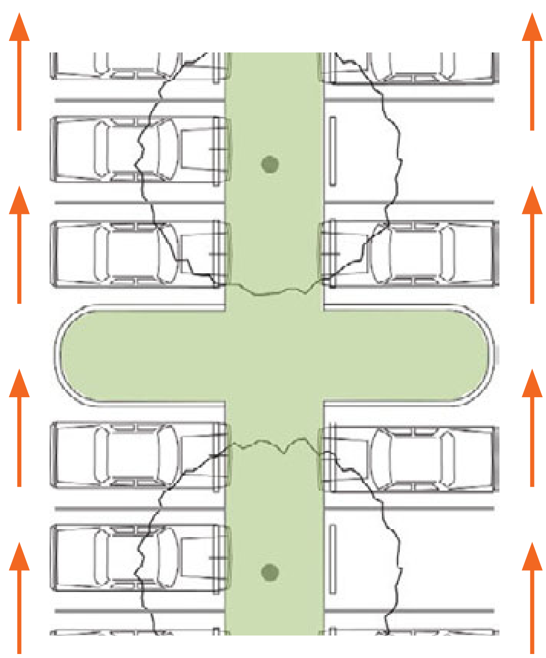

Figure C-10. Pedestrian flow parallel to rain garden.

Nevue Ngan Associates

Figure C-11. Curbless street allows for sheet flow of stormwater.

Kevin Robert Perry-City of Portland

Figure C-12. A typical curb cut allows water to enter a curb extension.

Nevue Ngan Associates

Figure C-13. Sheet flow of stormwater runoff enters a stormwater swale from a public plaza.

Getting the Water In and Out

The primary consideration for designing stormwater facilities with streets and parking lots is how the water enters a rain garden. Runoff is directed into rain gardens in one of two ways: sheet flow or curb cuts. Sheet flow describes stormwater runoff to a rain garden evenly distributed on the pavement surface without concentrating flow. Curb cuts allow stormwater to enter a rain garden at specific points along a curbed condition, thus concentrating runoff both in velocity and in volume.

Of the two methods, sheet flow is the better design because it mimics the natural flow of water across the landscape, it employs a less complicated design, and it is less prone to failure. The sheet flow of "curbless" streets and parking lots typically involves a concrete band edging that is flush with both the rain garden and the street/parking lot surface. This concrete band creates a clean separation between the more malleable asphalt surface, and it is easier to fine-grade concrete to direct water into the rain garden.

Using curb cuts within a raised curb system is a common way for water to flow into rain gardens, However, this approach channelizes water flow and can be prone to failure if the curb cut is poorly designed and/or there sediment or debris builds up at the curb cut. If curb cuts are used, the design requires careful attention, and they should be spaced as frequently as possible to distribute the water flow evenly.

In new street design, typically the decision to have curbed or uncurbed streets depends on the street's desired traffic capacity and speed. In general, the higher the traffic speed and the less pedestrian-oriented the street is, the more likely that it will require a raised curbed street edge. Conversely, streets that have slower traffic and are more pedestrian friendly are good candidates for a curbless condition. Even commercial streets with on-street parking can be designed as curbless streets if there is enough right-of-way space and traffic speeds are relatively low.

Curb cuts along rain gardens should be as wide as possible to accept flow from along the street or parking lot edge. A common flaw in curb cut design is to try to "cover" or create a notched curb cut. These designs often fail because the opening for stormwater runoff is too restricted and encourages the trapping of sediment and debris. Sediment in a covered or notched curb cut can often unnoticed. An 18-inch minimum width "open" curb is a good standard to accept stormwater flow. On steeper streets, a small, low-profile asphalt or concrete berm at each curb cut inlet will force stormwater to make the 90-degree turn into the curb cut and into the rain garden. Without such a measure during intense storm events, runoff can easily slip past the curb cut and not enter the stormwater facility. Grated curb cuts are often used in street applications to allow water to flow underneath pedestrian walkways. Grated curb cuts for green streets need special design attention and maintenance to assure water will flow into the stormwater facility. Also, grates need to be slip resistant and compliant with the Americans with Disabilities Act requirements.

Whether a sheet flow or a curb cut is used, there must be a minimum of a 2-inch drop in grade between the street or parking lot grade and the finish grade of the rain garden. This drop in grade assures that water will freely enter the rain garden even if some sediment accumulates.

Curb Cut Examples to Avoid

Figure C-14. Notched curb cut.

Figure C-15 Curb cut right next to the overflow.

Figure C-16. Curb cut that is too small for the amount of runoff entering it.

Street Profile

The street profile determines how a particular street allows stormwater to flow. Streets can be crowned or reverse crowned, drain to one side, or be flat.

The most common street profile is a crowned street with stormwater draining to the sides. The water runs to the sides of the street, often within a concrete gutter along the curb, and enters a storm drain. Storm drains are located at the middle or end of each block depending on the block length.

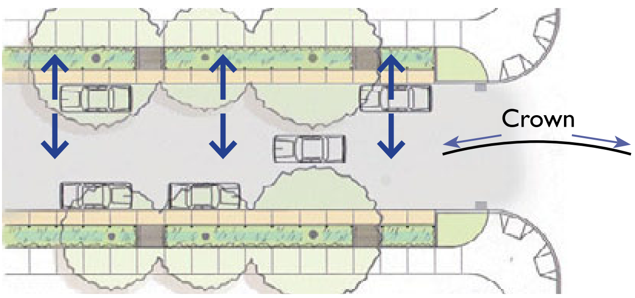

Figure C-17. Crowned street.

A variation of the crowned street is a “double crowned street.” This type of street profile is essentially two crowned streets next to each other with a median in the middle. It is common in arterial streets.

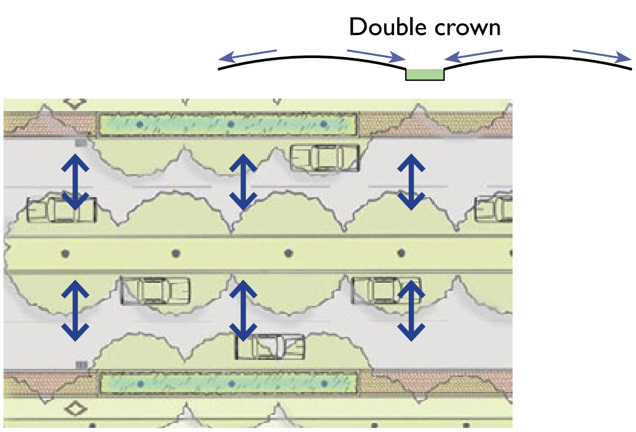

Figure C-18. Double crowned street.

A reverse crowned street directs water to the center line of the street. This type of street is common in alleys.

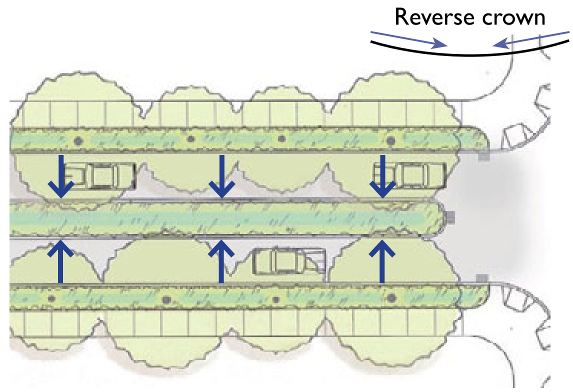

Figure C-19. Reverse crowned street.

Streets can be also be designed to shed all the water to one side.

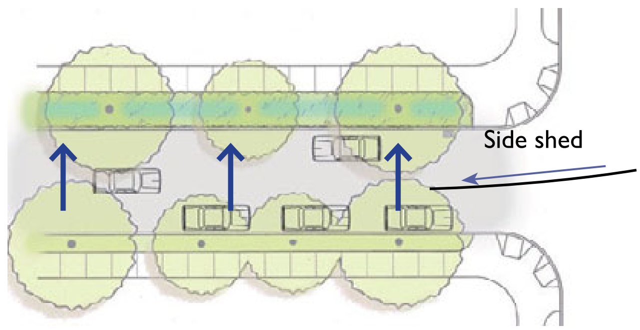

Figure C-20. Shed street (drain to one side).

Flat drainage is referred to in this document in the context of pervious paving. With pervious paving, water drains primarily through the paving surface into the subsoil. Typically these streets are slightly graded so they drain to the sides or center if there is too much water to filter through the paving.

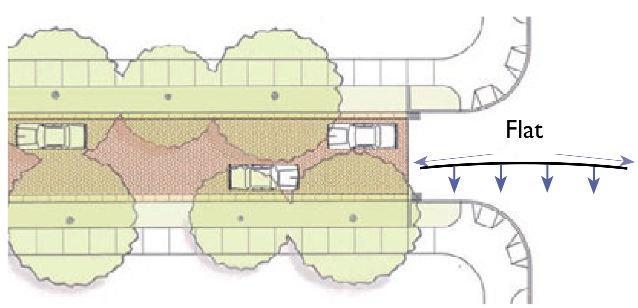

Figure C-21. Flat street.

New Construction:

When building new streets, deciding what kind of street profile a particular street will have is one of the first steps in determining what kind of rain garden to use. Ultimately, a street's design should allow as much stormwater as possible to enter a rain garden, keeping in mind the physical capability for the landscape to effectively manage the stormwater. New construction offers more flexibility because the street profile can be designed in a variety of ways. Retrofit projects do not offer as much flexibility.

Retrofits:

When retrofitting existing streets, one of the first details to look for is where the street drains. It can be prohibitively expensive to rebuild the street profile and underground infrastructure. Hence, the simplest and most cost-effective approach to retrofitting a street to include rain gardens is a design solution that conforms to the existing street profile. This greatly minimizes the amount of street reconstruction.

Figure C-22 illustrates a common street condition: a crowned street with a median at the high point of the crown. Retrofitting this landscape median is a good opportunity for stormwater management; however, the existing profile of the street drains water away from the median to the outside curb of the street. Regrading the street could turn a simple retrofit into an expensive project. In this case, a better option could be to build rain gardens between the street and sidewalk or use stormwater curb extensions. If this example was a new street rather than a retrofit, the center median would be a good place for a swale to collect stormwater.

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Figure C-22. An existing landscaped median on a crowned street can be a difficult retrofit project because water flow is directed away from the middle of the street.


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Figure C-23. Typical sediment forebay.


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Figure C-24. Sediment forebay in a street planter.


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Figure C-25. Sediment forebay in a street infiltration garden.

Dealing With Sediment

When choosing between a curbed system with curb cuts or a curbless system allowing the sheet flow of water into a rain garden, one consideration is the need for a sediment forebay. In sheet flow situations, sediments drop out evenly along the length of the rain garden, which can reduce the need for frequent removal of sediment. When curb cuts are used and the water enters the rain garden in concentrated locations, so too does the sediment load. In most curb cut conditions, a sediment forebay can be used to allow material to collect at one spot and make sediment removal easier.

Sediment forebays help define a space at the entry of a rain garden for sediment and debris to collect and be periodically removed. Providing this space can help reduce maintenance burdens by trapping sediment before it is transported into established landscape areas. The goal of a sediment forebay is to help minimize the amount of sediment, not to completely eliminate it.

A sediment forebay can be sized and designed so that it is seamlessly integrated into the landscape area. It can be as simple as leaving a small, shallow-graded, non-planted area right after the entry curb cut. Because stormwater flows can be fast as the water enters a curb cut, mulching the sediment forebay with pea gravel can minimize erosion. High-density planting on the downstream side of a sediment forebay can act as a containment dam for sediment and debris. The use of sediment forebays depends on how much sediment debris the street typically produces. Some rain gardens may not need a sediment forebay. Others, particularly those on streets that have high traffic loads or substantial leaf drop, would likely benefit from having a sediment forebay and a regular maintenance schedule to clear debris from it.

Controlling the Ponding of Water

Check dams and weirs can be made of any durable material, including rock, concrete, metal, or wood. The best check dam designs and material choices allow for flexibility so that the ponding depth can be easily manipulated. Weirs allow maximum flexibility by having an adjustable system to dictate ponding depth.

Check dams and weirs can be strategically placed in rain gardens to dictate the ponding depth of runoff. The standard is that a check dam or weir be placed in a rain garden facility for every 4 to 6 inches of longitudinal fall. Check dams can also be placed in swales and planters that have little or no longitudinal slope to help slow water flow and/or promote infiltration.

Check dams can retain stormwater to relatively shallow depths, with a maximum ponding depth of 6 to 8 inches of runoff during storm events. On sites that have a particularly high water table, or where soil infiltration potential is relatively low, a good option is to have the stormwater facility retain less runoff, allow water to simply slow down, and allow sediments and pollutants to settle out. Retaining water at shallower depths in poor soil conditions will allow a shorter duration of ponding water and more potential for evapotranspiration.

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Figure C-26. Concrete check dam with an adjustable weir.

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Figure C-27. Stacked concrete check dam.

Kevin Robert Perry-City of Portland

Figure C-28. River rock check dam.

Kevin Robert Perry-City of Portland

Figure C-29. Log check dam.

Kevin Robert Perry-City of Portland

Figure C-30. A curb notch allows overflow to re-enter the street.

Overflow Options

Overflow within stormwater curb extensions can be managed in several ways, depending on what type of stormwater infrastructure is already in place. In retrofit conditions, the most cost-effective and least intensive option is simply allowing water to overflow the landscape area through a curb cut and exit back onto the street to where it can eventually be captured by an existing storm inlet. Another option is to allow overflow runoff to enter a new storm inlet either in the curb extension or immediately adjacent to an exit curb cut.

City of Portland

Figure C-31. A small-scale overflow stand pipe.

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Figure C-32. A curb cut serves as the only overflow in this infiltration garden.

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Figure C-33. A weir retains stormwater to a 8" depth before overlowing into the storm system.

Long-Term Maintenance

Maintenance plans are specific to each type of stormwater facility and are outside the scope of this report. However, as a starting point, here are some key points to consider in designing rain garden systems.

The first and foremost consideration for assuring long-term success of rain gardens is to determine early on during the design process who will be conducting maintenance activities and how they will be funded. Because rain gardens are designed on both public land (such as streets) and private land (such as parking lots and buildings), confusion can arise as to who is responsible for what. Once the responsible party is identified, that party can determine how much maintenance will be required, keeping in mind not to design a stormwater facility that can't realistically be maintained by the party responsible for it. In some cases, a maintenance agreement might be needed between a public agency and a private entity (e.g., property owners, neighborhood associations, developers, etc.) to assure collaboration on maintenance tasks.

Because most of the rain garden design strategies illustrated in section 5.2 have a strong landscape component, it is important for the maintenance crew to understand how to maintain landscape systems, not pipe systems. Note that the simpler the rain garden design is, the greater ability residents have to maintain the space themselves without considerable effort.

Taking care of rain gardens is similar to taking care of people. During the first years of life, the initial investment is higher to assure that the "infant" rain garden can grow up healthy and achieve a long life. The two predominant maintenance activities that will occur during the first years of the establishment (infancy) period include weeding (by non-chemical means) and summer irrigation as needed. Supplemental maintenance activities during the establishment period could include periodic plant trimming, plant replacement, and mulching. An aggressive and regular maintenance program during the first establishing years gives a rain garden the best opportunity of thriving in the long term. A general rule of thumb is to conduct quarterly maintenance visits for the first two years.

Ongoing maintenance activities for rain gardens, performed both during and after the establishment period, include sediment removal, keeping stormwater entry and exit points clear of debris, and removing litter. The schedule of these activities may vary depending on the type of rain garden and where it is sited. For example, stormwater planters accepting rooftop runoff will typically have much less sedimentation than a stormwater planter managing runoff from a parking lot or street. Hence, street and parking lot stormwater applications will need more frequent maintenance visits to remove sediment from rain garden entry points. The maintenance plan needs to be specific to the type of rain garden involved and the origin of the runoff.

Developing a Maintenance Plan

A maintenance plan should be organized into two sections:

- The functional component describes what is needed to ensure that the site functions correctly for stormwater management and site safety. It discusses keeping the entry and exit points (i.e., curb cuts, downspouts, and overflow points) free of debris to allow stormwater to freely enter and potentially exit the rain gardens. This is particularly important during the spring and fall months when tree debris and street sediments can build up against curb cut openings and overflow points. Check dams and weirs need to be inspected regularly to ensure that they are retaining the correct water depth and that there are no erosion or standing water issues. Check dam and weir heights should be adjusted as necessary to retain as little or as much as the natural hydrologic conditions can handle. There should be no standing water in rain gardens 48 hours after the end of a storm event.

- The landscape component describes what is needed to ensure adequate plant and soil health as well as site aesthetics. The landscape component involves taking care of the plant material so that it will consistently thrive. The best designed rain garden projects will need very little additional landscape attention after the establishment period. However, this goal is often difficult to achieve. A good post-establishment landscape maintenance goal is to have semi-annual visits to weed the rain gardens and possibly trim plants.

Design Tips for Easier Maintenance

There are several ways that a rain garden's design can help ease the maintenance burden:

- To help out-compete weed growth, rain gardens should be planted in high densities and with the largest plantings that the project can afford.
- Use a sediment forebay for parking lots and streets that typically have high sediment loading.
- Plant at least 80 percent of a rain garden with evergreen plants. Evergreen plants tend to need less pruning or trimming than deciduous plants.
- When possible, design the landscape plan with a variety of plant species so that if weeds do appear, they blend into the mixture of textures and colors.

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Appendix D: Integrating Stormwater Management With Buildings

Sussex County has many different building types, ranging from historically rich town center buildings in places like Georgetown, Lewes, and Milton, to newer commercial centers and residential communities. Regardless of the building type, there are essentially two ways of dealing with the stormwater generated from roofs: manage the stormwater on the building, or manage it off the building. On-building techniques include using green roofs, rainwater harvesting, and flow-through planter systems. Off-building strategies employ downspout disconnection, infiltration planters, swales, and gardens. Each strategy or combination of strategies depends on the building type, its surrounding context, and the amount of landscape space surrounding the building. In some sites, the lack of landscape area next to buildings may mean that the only feasible stormwater strategies might be green roofs or narrow flow-through planters.

EPA

Figure D-1. Shop on Second Street in Lewes.

Most of these strategies were discussed in Sections 5.2.7 through 5.2.13 of the main report. This appendix illustrates some further variations of these techniques that Sussex County could consider to manage building runoff.

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Figure D-2. Downspout disconnection into a infiltration garden at the University of Delaware's Lewes Campus.

Stormwater Planters

The foundation planting shown in Figure D-3 could be transformed into a flow-through planter to capture and clean water from the building. The example shown in Figure D-4 illustrates a narrow flow-through planter well-integrated into its perimeter landscaping. Large stores can also use a series of stormwater planters to manage stormwater if a green roof is not feasible.

Figure D-3. Landscaping at Rehoboth Beach Library.

Figure D-4. A building flow-through planter accepts runoff from a fast-food restaurant in Portland, Oregon.

Different Types of Building Stormwater Planters

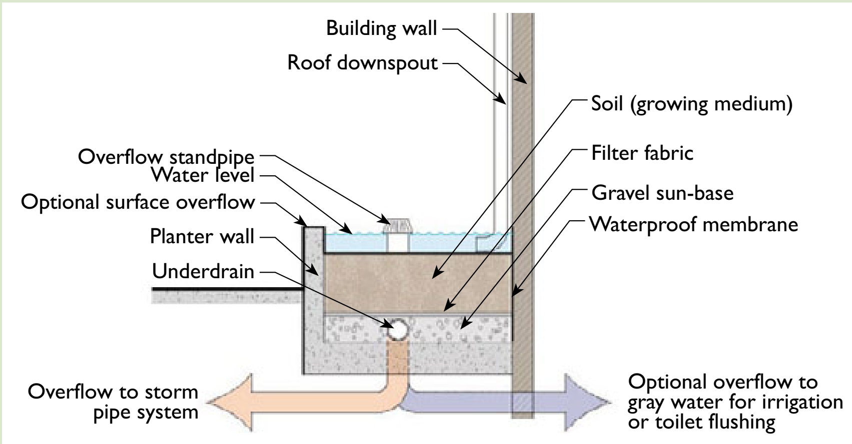

Figure D-5. Typical flow-through planter located next to a building.

Figure D-6. An infiltration planter located away from the building foundation. Notice the surface conveyance of runoff to the planter by using a concrete runnel.

Figure D-7. A flow-through planter adjacent to an apartment complex in Portland, Oregon. This stormwater planter is completely lined to protect the building foundation from migrating water.

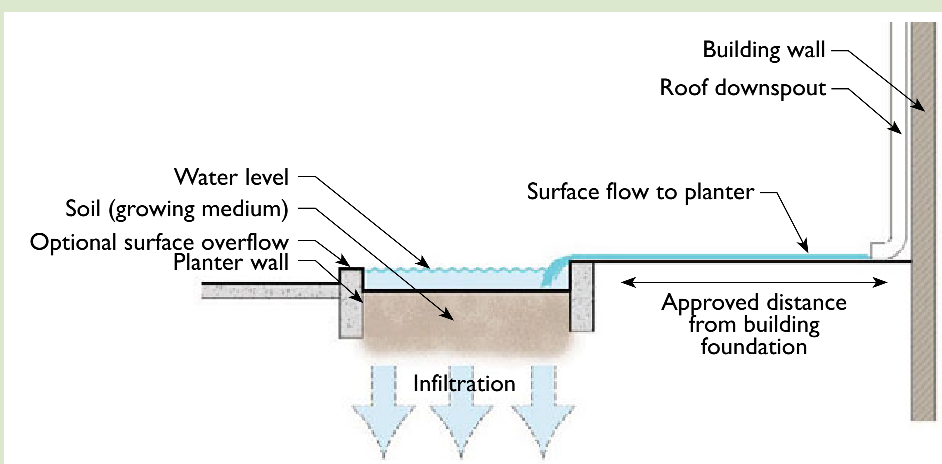

Figure D-8. Typical infiltration planter offset from building foundation.

Rain Art – Scuppers, Gutters, and Stormwater Sculptures

One of the best opportunities for managing runoff from building rooftops is illustrating, through art, the beauty of stormwater management. There are many different ways to capture the beauty of falling water. These pictures illustrate a few successful examples. The opportunities to display artful forms of stormwater conveyance are limited only by the imagination.

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Figure D-9. Water is conveyed on the surface into a stormwater planter via a concrete runnel.

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Figure D-10. The beautiful stair-stepping of runoff from a building rooftop. This effect also helps slow water down.

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Figure D-11. An artful display of a building downspout in Seattle, Washington.

Appendix E: Additional Resources

This appendix includes web sites and publications with more information on some of the topics discussed in this report:

- Smart Growth
- Transportation and Street Design
- Zoning Code
- Stormwater Management
- Aging and Smart Growth
- Rural Development
- Green Roofs

General Smart Growth Resources

EPA's Smart Growth Program includes research, publications, and other resources from the U.S. EPA's smart growth program. *www.epa.gov/smartgrowth*

Smart Growth Online is a web-based catalogue of smart growth-related news, events, information, and resources. The site is a service of the Smart Growth Network, a coalition of more than 35 environmental, real estate, development, academic, historic preservation, equity, and government groups working together to improve the quality of development in America's communities. *www.smartgrowth.org*

Smart Growth America is a coalition of national, state, and local organizations working to improve the ways we plan and build the towns, cities, and metro areas we call home. *www.smartgrowthamerica.org*

The Smart Growth Leadership Institute helps state and local leaders design and implement effective smart growth strategies. *www.sgli.org*

The Affordable Housing Design Advisor was developed to help anyone involved in the production of affordable housing achieve higher design quality. It is full of useful information and shows examples of affordable, well-designed, high-quality homes. *www.designadvisor.org*

This Is Smart Growth. 2006. International City/County Management Association and Smart Growth Network.

This publication shows how communities can turn their visions, values, and aspirations into reality, using smart growth techniques to improve the quality of development. It illustrates and explains smart growth concepts and outcomes using 40 places around the country—cities, suburbs, small towns, and rural communities—where good development has improved residents' quality of life. Available at *www.epa.gov/smartgrowth/tisg.htm*.

Choosing Our Community's Future: A Citizen's Guide to Getting the Most Out of New Development. 2005. Smart Growth America.

This document focuses on the visioning and planning efforts that set the stage for smarter growth and how citizens can engage and make suggestions for better growth and development through collaborative stakeholder meetings and workshops. Available at *sgusa.convio.net/site/PageServer?pagename=guidebook*.

Creating Great Neighborhoods: Density in Your Community. 2003. National Association of Realtors and Local Government Commission.

The document highlights nine community-led efforts to create vibrant neighborhoods through density, discusses the connections between smart growth and density, and introduces design principles to ensure that density improves a community. Available at *www.epa.gov/smartgrowth/density.htm*.

Transportation and Street Design Resources

Context Sensitive Solutions includes resources on designing transportation projects to fit the physical setting and preserve aesthetic, historic, and environmental resources while maintaining safety and mobility. *www.contextsensitivesolutions.org*

Walkable Communities offers a variety of publications and photos on its web site. *www.walkable.org*

*Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communitie*s. 2006. Institute of Transportation Engineers.

This working draft document provides engineers and planners guidance on designing major urban streets to support walking, biking, transit, driving, and a mix of uses. Available at *www.epa.gov/smartgrowth/ite_context.htm*.

Parking Spaces / Community Places: Finding the Balance Through Smart Growth Solutions. 2006. EPA.

This document highlights proven approaches that balance parking with broader community goals. Communities have found that combinations of parking pricing, shared parking, demand management, and other techniques have helped them create vibrant places while protecting environmental quality. Available at *www.epa.gov/smartgrowth/parking.htm*.

Pedestrian- and Transit-Friendly Design: A Primer for Smart Growth. 1999. International City/County Management Association and Smart Growth Network.

This report suggests design elements that make walking and transit use easier and more comfortable. Available at *www.epa.gov/smartgrowth/pdf/ptfd_primer.pdf*.

Creating Livable Streets. 2002. Portland (Oregon) Metro. This handbook describes how communities can design streets to be people friendly and includes detailed illustrations of designs that integrate streets with nearby land uses. Available at *www.metro-region.org/index.cfm/go/by.web/id=26334*.

Traditional Neighborhoods: Street Design and Connectivity. Congress for the New Urbanism.

This image-filled document shows how land use practices and street design can create walkable environments. Available at *www.contextsensitivesolutions.org/content/reading/traditional-neighborhoods-street-design*.

"Balancing Street Space for Pedestrians and Vehicles." Project for Public Spaces.

This article discusses how to balance pedestrian needs and creating lively public spaces while maintaining appropriate space for vehicles. Available at *www.pps.org/civic_centers/info/how_to/transit_tool/balancing_peds_and_vehicles*.

Street Design Guidelines for Healthy Neighborhoods. 1999. Center for Livable Communities, Local Government Commission.

This publication helps communities implement designs for streets that are safe, efficient, and aesthetically pleasing for both people and cars. It features helpful guidelines that specify street widths and implementation strategies. Available at *www.lgc.org*.

Zoning Code Resources

The American Planning Association has model smart growth codes that encourage mixing land uses, preserving open space and environmentally sensitive areas, providing choices in housing and transportation, and making the development process more predictable. Available at *www.planning.org/smartgrowthcodes*.

Smart Growth Zoning Codes: A Resource Guide. 2003. Local Government Commission.

This publication studies codes that have been implemented in communities around the country. Its main areas include "traditional neighborhood design," which encourages walkable, mixed-use neighborhoods; mixed-use and live/work codes, which help diversify land uses; street and block design that makes it easy and comfortable for people to walk, bike, or drive; parking guidelines that use land more efficiently; and design regulations that help maintain or create attractive, distinctive, safe places. Available at *www2.lgc.org/bookstore/detail.cfm?itemId=34*.

Some communities have found a form-based code to be useful. Form-based codes emphasize the appearance and qualities of buildings and blocks rather than their uses. They encourage great public participation because they are more visual than traditional zoning codes, making it easier to understand what type of buildings they will allow. They encourage a mix of uses and a mix of housing types. A good introduction to form-based codes is available at *www.lgc.org/freepub/PDF/Land_Use/fact_sheets/form_based_codes.pdf*.

One example of a form-based code is the Smart Code, developed by urban-design firm Duany Plater-Zyberk. The Smart Code combines zoning, subdivision regulations, urban design, and basic architectural standards. It is intended to be customized to local needs. Available at *www.smartcodecomplete.com*.

Stormwater Management Resources

Stormwater Guidelines for Green, Dense Redevelopment. 2006. City of Emeryville.

The guidelines and an accompanying spreadsheet model were developed to manage stormwater on-site during redevelopment. Available at *www.epa.gov/smartgrowth/emeryville.htm*.

Protecting Water Resources with Higher-Density Development. 2006. EPA.

This report helps communities better understand the impacts of higher and lower density development on water resources. The findings indicate that low-density development may not always be the preferred strategy for protecting water resources. Available at *www.epa.gov/smartgrowth/water_density.htm*.

Using Smart Growth Techniques as Stormwater Best Management Practices. 2006. EPA.

This report reviews nine common smart growth techniques and examines how they can be used to prevent or manage stormwater runoff. Available at *www.epa.gov/smartgrowth/stormwater.htm*.

Protecting Water Resources with Smart Growth. 2004. EPA.

This report, for audiences already familiar with smart growth concepts who seek specific ideas on how techniques for smarter growth can be used to protect water resources, describes 75 policies that communities can use to grow in the way that they want while protecting their water quality. Available at *www.epa.gov/smartgrowth/water_resource.htm*.

The Ahwahnee Water Principles: A Blueprint for Regional Sustainability. 2006. Local Government Commission.

This report provides a practical blueprint for sustainable land-use practices that can improve the reliability and quality of water resources and reduce some of the financial liabilities that new development places on local government. Available at *water.lgc.org/announcements/waterguidebook*.

Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows. 2006. Natural Resources Defense Council.

This report is a policy guide for decision makers looking to implement green strategies in their areas. It includes nine case studies of cities that have successfully used green techniques to create a healthier urban environment. Available at *www.nrdc.org/water/pollution/rooftops/contents.asp*.

Catching the Rain: A Great Lakes Resource Guide for Natural Stormwater Management. 2004. American Rivers.

The publication describes a wide range of low-impact development strategies that can be implemented in various types of built environments. Available at *www.americanrivers.org/site/DocServer/CatchingTheRain.pdf?docID=163*.

Green Streets: Innovative Solutions for Stormwater and Stream Crossings. 2002. Portland (Oregon) Metro.

The handbook describes stormwater management strategies and includes detailed illustrations of green street designs that allow infiltration and limit stormwater runoff. Available at *www.metro-region.org/index.cfm/go/by.web/id=26335*.

Trees for Green Streets: An Illustrated Guide. 2002. Portland (Oregon) Metro.

The guidebook helps communities select street trees that reduce stormwater runoff from streets and improve water quality. Available at *www.metro-region.org/index.cfm/go/by.web/id=26337*.

Seattle's pilot Street Edge Alternatives Project (SEA Streets) is designed to provide drainage that more closely mimics the natural landscape prior to development than traditional piped systems. More information is available at *www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_ Edge_Alternatives/index.asp*.

Aging and Smart Growth Resources

EPA's Aging Initiative runs the "Building Healthy Communities for Active Aging Awards" to recognize communities that develop in ways that help residents age in place. Descriptions of the 2007 winners are at *www.epa.gov/aging/bhc/awards/2007/index.html*.

The International City/County Management Association (ICMA) has several resources for local governments on aging and smart growth. *www.icma.org*

The Aging in Place Initiative has best practices, reports, and other resources to help state, local and community decision makers better meet the needs of an older population, including the publication *A Blueprint for Action: Developing a Livable Community for All Ages*. *www.aginginplaceinitiative.org*

Aging in Place: A Toolkit for Local Governments. 2001. Atlanta Regional Commission and the Community Housing Resource Center.

This tool is designed to help local governments plan and prepare for their aging populations.

It presents programs and zoning practices that expand the alternatives available to older adults living in the community. *www.smartgrowthamerica.org/AgingInPlace.pdf*

Beyond 50.05 A Report to the Nation on Livable Communities: Creating Environments for Successful Aging. 2005. AARP.

This report presents a new agenda for examining, building and retrofitting our communities to support successful aging. It demonstrates the connections among community engagement, housing, transportation, and successful aging and illustrates how persons age 50 and older contribute to, and benefit from, well-designed communities that promote community engagement. Available at *www.aarp.org/research/housing-mobility/indliving/beyond_50_communities.html*.

Rural Development Resources

American Farmland Trust has done some work in Delaware and has useful resources on development that preserves the rural way of life, as well as farmland preservation. *www.farmlandinfo.org*

The National Main Street Center has resources that can help small, rural towns. *www.mainstreet.org*

The Land Trust Alliance can help with land preservation. *www.lta.org*

The Conservation Fund has strategies to help with land conservation and rural towns. *www.conservationfund.org*

The Piedmont Environmental Council in Virginia has descriptions of various tools for rural land preservation. *www.pecva.org*

The Community Growth Institute is a rural land use think tank that helps rural communities to understand the forces affecting their growth and work together to envision, plan for, and attain the future they desire. *www.communitygrowth.com*

The Center for Rural Strategies offers strategic communication in support of rural communities. *www.ruralstrategies.org/default.html*

Green Roofs

Green Roofs for Healthy Cities, the web site for a coalition of private-sector firms, contains recent research, information on green roof demonstration projects, and additional resources. *www.greenroofs.org*

Penn State Green Roof Research Center researches the efficacy and potential of green roofs to mitigate stormwater runoff, capture energy savings, and buffer acid rain. The site highlights current research projects at Penn State and links to green roof-related organizations and businesses. *http://hortweb.cas.psu.edu/research/greenroofcenter/about_ctr.html*