Sierra Club
Founded 1892

Explore, enjoy and protect the planet

Curbing Pollution from Stormwater

What is stormwater runoff?


EPA

Normally we think of rain as a good thing. Rain brings with it water that is necessary for sustaining human life, plants and wildlife. But when it rains in an urban area, with its many roads, sidewalks, rooftops and other paved areas, the rainwater picks up harmful pollutants and becomes a major source of water pollution.

Urban and suburban areas contain varying degrees of impervious surface. Development, including roofs, driveways, giant parking lots, sidewalks and streets, all add to the amount of impervious surface in a watershed or region. Impervious surfaces prevent rain and other precipitation from naturally soaking into the ground. Instead, the precipitation flows over impervious surfaces and makes its way to the nearest stormwater drain or surface water. When this happens, it is called "stormwater runoff" or "runoff." According to the Environmental Protection Agency (EPA), a typical city block generates more than five times more runoff than a woodland area of the same size.[1]

More than 100 million acres of land have been developed in the United States, and development and sprawl are increasing faster than population growth. The U.S. population grew 15% between 1982 and 1997, yet the amount of developed land in the continental U.S. grew by 25 million acres or 34%.[2,3] If development continues at this alarming rate, a significant amount of land will be developed in the future, leaving our waters in greater risk of pollution.

Conventional, 'brick and mortar' solutions to stormwater pollution are extremely expensive. Recently, many low-technology, lower-cost techniques have emerged to control stormwater at its source.

Why is stormwater harmful?

As stormwater makes its way over streets, sidewalks and driveways, it can pick up debris, chemicals, dirt and other pollutants. It can then carry these pollutants into a storm sewer system or directly to a lake, stream, river, wetland or coastal water. If the stormwater enters a storm sewer system, it is then discharged untreated into the waterbodies we use for swimming, fishing and drinking water.

According to the EPA, stormwater pollution is the largest source of coastal water pollution in the US.[4] In areas where there is a lot of impervious surface, stormwater volumes tend to be higher and stormwater scours streams, destabilizes streambanks and carries polluting sediment downstream. When the impervious surface in a watershed reaches a mere 10% of the total area, research shows that the result is water quality degradation in receiving waterbodies.[5]


City of Palo Alto, CA

EPA

Examples of stormwater problems

Stormwater can contain any of these constituents, which are generally discharged, untreated, into our waters:

- Sediment
- Nutrients (phosphorus and nitrogen) that can cause harmful algal blooms
- Bacteria and other pathogens from pet waste, failing septic systems and other sources
- Street litter and other debris
- Household hazardous waste
- Oil, grease and toxic chemicals from motor vehicles
- Pesticides, fertilizers and nutrients from lawns
- Road salts
- Heavy metals from roof shingles, motor vehicles, and other sources
- Thermal pollution from dark impervious surfaces such as streets and rooftops

All of these pollutants are harmful to our environment and potentially our health. When these pollutants enter our water untreated, they harm fish and wildlife populations, destroy native vegetation, dirty our sources of drinking water supplies and make recreational areas unsafe and unpleasant.[6]

Solutions

Traditional stormwater management practices too often focus on the *result* of development, large stormwater volumes, instead of addressing the *source* of the problem, impervious surface. Individuals, municipalities and private companies can take action to control stormwater impacts from new development, redevelopment and existing development by creating more pervious surfaces. Capitalizing on those opportunities incrementally, over time, can improve water and air quality, reduce urban 'heat island' effects and improve urban aesthetics.

Starting at Home: What Individuals Can Do

Lawn Care

Excess fertilizers and pesticides end up in our streams. Lawn clippings and leaves can end up in storm drains, contributing nutrients and organic matter to streams.

- Don't overwater the lawn.
- Don't overuse fertilizers and pesticides. If possible, don't use them at all. If they are necessary, follow the directions and use the recommended amounts. If available, organic mulch and safer pest control products are better alternatives.
- Consider replacing some grass with trees or shrubs which return more water to the ground.
- Don't put yard clippings and leaves in the street or in storm drains or streams. Instead compost or mulch it.
- Make sure to cover piles of dirt and mulch when landscaping. This prevents it from entering drains or streams when it rains.

Residential Landscaping/Rain Barrels

- When possible, direct stormwater from the roof to vegetated areas instead of to the sidewalk or street.
- Using rain barrels to collect rainwater from rooftops saves water that can be used later to water the lawn or garden. The estimated cost of a rain barrel and installation for the average family is $216.[7] In some cases, local governments may have programs to help residents install rain barrels and pay for a portion of the cost.

Septic Systems

Stormwater conveys pollution — nutrients, bacteria and viruses — from leaky septic systems to groundwater and eventually to nearby streams and other waterbodies.

- Inspect and pump the septic tank regularly.
- Do not put household hazardous wastes into sinks or toilets.

Auto Care

Washing the car and cleaning auto parts at home means that detergents and other pollutants can end up in the storm sewer system. Dumping fluids from vehicles into storm drains is the same as dumping them directly into a waterbody.

- Bring cars to a commercial car wash that treats or recycles its wastewater. Alternatively, let the rain wash your car, or wash cars on the lawn, with biodegradable cleaner, so that the wastewater will infiltrate into the ground.
- Bring used automotive fluids and batteries to designated disposal or recycling stations.

Pet waste

Pet waste contains bacteria and nutrients and can be a major contributor to contamination of local waters.

- Remember to always pick up after pets. The best disposal method is to flush the pet's waste.

What Governments and Developers Can Do

Towns and cities should ensure that stormwater protections are incorporated into the design of the community. Whenever there are proposals for new development or redevelopment, communities should advocate for some of the strategies and techniques described below. This will minimize costs to wastewater treatment facilities and improve the water quality in local streams.

Controlling Impacts of New Development, Existing Development and Taking Advantage of Redevelopment Opportunities:

Communities' best opportunity to control stormwater runoff is to provide for ample greenspace to absorb excess rainwater. Communities also have many options to lessen the impact of stormwater runoff when planning and configuring new neighborhoods. The term "Low Impact Development" (LID) encompasses a variety of techniques that can reduce the harmful effects and loss of natural resources associated with traditional development. Planners and stormwater managers have a number of tools at their disposal, from roof gardens, rain gardens and grassy swales to vegetated filter strips.

What is Low Impact Development?

Low Impact Development is an approach to managing stormwater that preserves the original hydrologic regime and natural resources of the site as possible. The idea behind it is that nature knows how to manage water and stormwater runoff best. With site-design techniques minimizing site disturbance and applying stormwater management measures that mimic natural systems, LID techniques can limit the impacts on hydrology, water and air quality. LID-designed sites use natural and often native vegetation and small-scale treatment systems to treat and allow rain to infiltrate the soil close to where it hits the ground. In contrast, traditional techniques usually collect and convey stormwater runoff through storm drains, pipes and other conveyances to a centralized stormwater facility. LID reduces impervious surfaces and the amount of stormwater runoff generated.

Communities across the country are using LID to meet stormwater control requirements, reduce the infrastructural costs of new development and redevelopment and protect water quality.

Examples of Low Impact Development Techniques

Rain Gardens and Bioretention – Planting areas with native plants can provide natural places for rainwater to collect and soak into the ground.

Generally, residential rain gardens cost between $3 to $4 per square foot, depending on soil conditions and the density and types of plants used.[8] Commercial, industrial and institutional site costs vary from $10 to $40 per square foot.[9]

Low Impact Development Center, Inc.

These costs depend on the need for control structures, curbing, storm drains and underdrains. Because the cost of plants varies substantially, this can make up a significant portion of the facility's expenditures. The cost estimates for bioretention cells may appear slightly greater than those of typical landscaping treatment. This is because bioretention cells require an increased number of plantings, additional soil excavation and backfill material and the use of underdrains. But those landscaping expenses that would be required regardless of the bioretention installation must be subtracted when determining the net cost for a proper comparison between the two options.[10]

EPA

Bioretention cells are less costly than traditional stormwater conveyance systems. For example, a medical office building in Maryland was able to reduce the amount of required storm drain pipe from 800 to 230 feet, saving the company $24,000.[11] In addition, a new residential development used bioretention cells on each lot at a cost of approximately $100,000, whereas the traditional stormwater ponds that were originally planned would have cost nearly $400,000.[12] One other cost-saving component of bioretention cells that is often forgotten is that, in residential areas, these stormwater management controls become a part of each property owner's landscape, thereby reducing the public burden to maintain large, often costly, centralized facilities.

Vegetated Filter Strips and Grassy Swales — Vegetated filter strips are areas planted with native grass or plants and placed along roadways or streams. The filter strips slow stormwater flow and trap the pollutants stormwater picks up as it flows across driveways and streets. This allows the stormwater to soak slowly into the ground, which naturally filters it. Trees, shrubs, grasses and other ground covers can also be incorporated into the landscape systems. Vegetated swales can serve as part of the stormwater drainage system, often replacing curbs, gutters and storm sewer systems.[13] Because of this, swales are most appropriate for residential, industrial and commercial areas with low flow and smaller populations.[14]

One benefit of grassy swales is that they are easy to design and incorporate into a site drainage plan.[15] Typically, grassy swales are sited near property boundaries along a natural grade. They can also be used effectively wherever a site provides adequate space.

In general, vegetated filter strips and grassy swales cost less to construct than hard infrastructure like curbs and gutters and underground storm sewers. A sampling of estimates range from $4.90 to $9 per linear foot for a 15-foot wide channel (top width).[16] Costs can be higher and often depend on the extent of activities such as clearing, leveling, filling and sodding the swale. In addition, there may be specific site considerations and local costs for labor and materials that can affect costs. Annual costs for maintaining vegetated swales are approximately $0.58 per linear foot.[17]

Roof Gardens/Green Roofs — Roof gardens or green roofs use foliage and a lightweight soil mixture to absorb, filter and detain rainfall.[18] Typically, the construction of green roofs involves a lightweight soil media, underlain by a drainage layer, and a high-quality impermeable membrane that protects the building structure.[19] Green roofs use a specialized mix of plants that thrive in the harsh, dry, hot conditions of a roof and tolerate short periods of intense rain from storm events.[20] Green roofs have been in use for some time in Europe, but are just now gaining popularity in the United States. There are now an estimated 150 green roof projects in development in Chicago, with one on top of Chicago's City Hall. Other well-known green roofs include those on top of a Ford Motor Co. facility in Dearborn, Michigan, a prairie-covered library in Evansville, Indiana and the top of the Multnomah County Building in Portland, Oregon.

Green roofs are a little more complex than other LID techniques because one must take into account the load-bearing capacity of roof decks, the ability of the roof membrane to resist moisture and root penetration, hydraulics and wind shear. Green roofs provide a multitude of benefits besides reducing stormwater and providing an aesthetically-pleasing space. Green roofs help buildings stay cool in the summer and retain heat in the winter. They reduce the urban "heat island" effect, carbon dioxide impacts, summer air conditioning costs and winter heat demand. In addition, green roofs can lengthen the life of the roof by 20 years or more[21], treat nitrogen pollution in rain, negate acid rain effect and help reduce volume and peak rates of stormwater. A study by Casey Trees and DC Greenworks found that an estimated 56% reduction in rooftop runoff would occur in Washington, DC's commercial core if 80% of rooftop space were covered with green roofs.[22]

It is most cost effective to plan green roofs into the initial design of a new building. Next, it makes sense to install a green roof when a traditional roof is being replaced. Because the conventional roof needs to be replaced anyway, the incremental costs are minimized. The least cost-effective option is to retrofit a roof. Costs will also vary depending on the type of green roof installed. Extensive green roofs, those with soil depths of two to three inches, cost significantly less than intensive green roofs, which have soil depths of at least six inches and greater plant variety. In the US, the estimates for green roofs vary widely, from $7 to $20 per square foot.

1425 K Street, NW, Washington DC: This green roof project was a 3,500 square foot retrofit project and one of the first green roofs in the region. Installed in June 2004, the green roof is a research and demonstration project. In the end, the costs totaled $14.43 per square foot. The green roof is a little more than a year old and research is currently underway to examine information about air and roof temperatures. There is a 1,000 square foot section of the roof that was not converted to a roof garden, and it will be the control site used to demonstrate the differences between the two roofing approaches. Temperature and rainfall data from two weather stations on the roof will be available online.

Navis Bermudez

Fencing Academy of Philadelphia, PA: The green roof at the Fencing Academy of Philadelphia was a demonstration project installed in the spring of 1998. It is an extensive 3,000 square foot retrofit vegetated rooftop with a meadow-like setting and its appearance changes with the seasons. This roof system was designed to perform like the natural hydrologic processes of interception, storage, and detention to control a 2-year, 24-hour storm event. The roof has kept temperature fluctuations to a minimum. During the spring and summer, temperatures on a neighboring black tar roof varied by as much as 90 degrees Fahrenheit.[23] In contrast, the variation in temperature under the vegetated roof was only 18 degrees Fahrenheit.[24] The green roof is also beneficial in winter, insulating the roof and protecting the roof membrane from the elements.

Permeable pavement and low impact parking — Permeable pavement systems let rain and snowmelt soak through to the ground, decreasing stormwater runoff from the site and surrounding areas. Permeable pavement systems can be used in parking lots, sidewalks and even roads.

There are two types of porous pavement: porous asphalt and pervious concrete. Porous asphalt pavement consists of an open-graded coarse aggregate, which is held together by asphalt cement. Interconnected voids allow water to seep through it. Pervious concrete is specially formulated from mixtures of Portland cement, uniform, open-graded coarse aggregate and water. A highly permeable layer of open-graded gravel and crushed stone is under the porous pavement surface. These void spaces provide storage space for stormwater runoff. A filter fabric is placed beneath the gravel and stone layers to screen out fine soil particles.[25] There is enough void space in pervious concrete to allow water to percolate rapidly through it.[26]

The costs for installing porous asphalt or pervious pavement with subsurface storage vary widely. It is generally best to install porous pavement when completing new construction or a redevelopment project to avoid unnecessary excavation costs associated with a retrofit project. Installation costs for permeable pavers will be higher than those for conventional asphalt, but considering the benefits of decreases in stormwater conveyance and other stormwater management installations, the use of porous asphalt becomes cost-effective. Specifically, one estimate contends that the use of porous asphalt is approximately 10 percent more than using the same amount of non-porous asphalt. But when the cost of site development is totaled, because the porous asphalt is also a part of the drainage system, these permeable systems can save more than 30 percent.[27]

Westfarms Mall, Connecticut: Westfarms Mall installed a turf parking lot, which is more porous than a traditional parking lot, to help curb stormwater pollution from their property. According to the mall's general manager, at about five years, the cost comparison between grass paving and asphalt was about even, with an advantage of turf after that time. Most important, though, in addition to reducing stormwater runoff and improving water quality, the four-acre turf parking lot also met the permeable greenspace requirements that were necessary for mall expansion.

City of Kinston, North Carolina: The City of Kinston recently installed more than 8,500 square feet of turfstone and grass paver parking. With subgrade materials having similar costs for any type of pavement, the in-place cost for 2" asphalt was estimated at $6,500, while material costs for the permeable pavers added up to $6,200. In the end, the cost of the project was comparable or even lower than that of one using conventional asphalt.[28]

The average annual maintenance program for a porous pavement parking lot costs an estimated $200 per acre per year.[29] This includes four inspections each year with appropriate jet hosing and vacuum sweeping treatments required to keep the porous pavement working properly.[30]

Endnotes

1 EPA. *Protecting Water Quality from Urban Runoff.* EPA-841-F-03-003.

2 Beach, Dana, *Coastal Sprawl — The Effects of Urban Design on Aquatic Ecosystems in the United States,* Pew Ocean Commission, 2002.

3 USDA. *Summary Report 1997 National Resources Inventory,* Natural Resources Conservation Service, December 1999 (revised December 2000).

4 EPA. *National Water Quality Inventory Report to Congress.* See http://www.epa.gov/305b.

5 Beach, Dana, *Coastal Sprawl — The Effects of Urban Design on Aquatic Ecosystems in the United States,* Pew Ocean Commission, 2002.

6 EPA. *Protecting Water Quality from Urban Runoff.* EPA-841-F-03-003.

7 See http://lid-stormwater.net/raincist/raincist_cost.htm.

8 See http://lid-stormwater.net/bioretention/bio_costs.htm.

9 Ibid.

10 Ibid.

11 EPA, Office of Water. *Storm Water Technology Fact Sheet: Bioretention.* 1999. EPA 832-F-99-012.

12 *Growing Greener in your Rappahannock River Watershed.* Friends of Rappahannock. See http://for.communitypoint.org.

13 EPA, Office of Water. *Stormwater Technology Fact Sheet: Vegetated Swales.* September 1999. EPA-832-F-99-006.

14 Ibid.

15 Ibid.

16 Ibid.

17 Ibid.

18 EPA, Office of Water. *Vegetated Roof Cover: Philadelphia, Pennsylvania.* October 2000. EPA-841-B-00-005D.

19 See http://lid-stormwater.net/greenroofs/greenroofs_home.htm and *Exploring the Ecology of Organic Green Roof Architecture,* Green Roofs Web Site at www.greenroofs.com

20 Ibid.

21 EPA, Office of Water. Vegetated Roof Cover: Philadelphia, Pennsylvania. October 2000. EPA-841-B-00-005D.

22 Casey Trees and DC Greenworks. *Benefits of Greenroofs.* See http://www.caseytrees.org/pdfs/pdfs/Greenroof%20flyer.pdf.

23 EPA, Office of Water. *Vegetated Roof Cover: Philadelphia, Pennsylvania.* October 2000. EPA-841-B-00-005D.

24 Ibid.

25 EPA, Office of Water. *Storm Water Technology Fact Sheet: Porous Pavement.* September 1999. EPA-832-F-99-023.

26 Ibid.

27 See http://www.lid-stormwater.net/permeable_pavers/permpaver_costs.htm and Ferguson, B.K. "1996: Preventing the problems of urban runoff," *Washington Water RESOURCE, the quarterly report of the Center for Urban Water Resources Management,* 7(4) Fall. See http://depts.washington.edu/cuwrm/ under Subscriptions.

28 See http://www.lid-stormwater.net/permeable_pavers/permpaver_costs.htm.

29 EPA, Office of Water. *Storm Water Technology Fact Sheet: Porous Pavement.* September 1999. EPA 832-F-99-023.

30 Ibid.

Sierra Club
Founded 1892

For more information: Contact Navis Bermudez at navis.bermudez@sierraclub.org or 202-675-2392
www.sierraclub.org