Low Impact Development (LID) and Other Green Design Strategies

Click here to comment on this fact sheet

Minimum Measure: Post-Construction Stormwater Management in New Development and Redevelopment

Subcategory: Innovative BMPs for Site Plans

Urban development significantly alters the natural features and hydrology of a landscape. Development and redevelopment usually creates impervious surfaces like concrete sidewalks and asphalt roadways, commercial and residential buildings, and even earth compacted by construction activities. Prevented from soaking into the ground, rainwater runs across parking lots and streets, collecting used motor oil, pesticides, fertilizers, and other pollutants.

In most cities, a complex system of piping usually feeds contaminated stormwater flows directly into streams and coastal waters. More recently, stormwater control structures (sometimes called Best Management Practices or BMPs) like dry extended detention ponds or wet retention ponds have been installed, most in new development, to intercept stormwater on its way to surface waters.

Historically, the goal of stormwater planning has been to prevent localized flooding by moving large amounts of water offsite as quickly as possible. However, experience has shown that traditional stormwater management has many limitations.

Expensive, ever-expanding storm sewer systems strain municipal budgets. Fast moving stormwater discharges cause downstream flooding, erode stream banks, and contribute to water quality violations. Bacteria and other pathogens carried in stormwater contaminate coastal waters, often requiring beach closures. Rainwater diverted or otherwise unable to soak into the soil cannot recharge aquifers. This reduces stream base flows, which can cause streams to dry-up for extended periods of time. Stormwater that collects in detention basins or flows over impervious surfaces is often much warmer than the streams into which it flows. This is a problem because a temperature increase of just one or two degrees can stress fish and other aquatic organisms.

Mimicking Natural Hydrology

Efforts to address stormwater problems resulting from traditional development methods have produced a number of innovative design alternatives. For example, researchers and developers are experimenting with minimizing the distance between land uses to decrease infrastructure requirements. Another method reduces stormwater runoff by conserving forests and green spaces and protecting stream buffers. Yet another technique diminishes impervious surfaces, narrows road and sidewalk widths, reduces parking lot sizes, minimizes or removes cul-de-sacs, and replaces traditional paving materials with pervious concrete.

Such innovative site design grew out of concerns that rapid urban development was not only impairing water quality but eroding quality of life. Concerned by the development of sensitive agricultural and wetlands, and burdened by the rising costs of stormwater damage, some communities are implementing Green Design strategies, such as LID, Conservation Development, Better Site Design, and Smart Growth. The complementary goals of these design schemes lessen the impact of stormwater while still providing opportunities for development.

LID

Like other alternative development strategies, LID seeks to control stormwater at its source. Rather than moving stormwater offsite though a conveyance system, the goal of LID is to restore the natural, pre-developed ability of an urban site to absorb stormwater.

LID integrates small-scale measures scattered throughout the development site. Constructed green spaces, native landscaping, and a variety of innovative bioretention and infiltration techniques capture and manage stormwater on-site. LID reduces peak runoff by allowing rainwater to soak into the ground, evaporate into the air, or collect in storage receptacles for irrigation and other beneficial uses. In areas with slow drainage or infiltration, LID captures the first flush before excess stormwater is diverted into traditional storm conveyance systems. The result is development that more closely maintains pre-development hydrology. Furthermore, LID has been shown to be cost effective, and in some cases, cheaper than using traditional stormwater management techniques.

LID Techniques

LID can be simple and effective. Instead of relying solely on complex and costly collection, conveyance, storage and treatment systems, LID employs a range of economical devices that control runoff at the source.

- Bioretention cells, commonly known as rain gardens, are relatively small-scale, landscaped depressions containing plants and a soil mixture that absorbs and filters runoff. For more information on bioretention cells, see Bioretention (Rain Gardens) fact sheet and Stormwater Technology: Biorention [PDF - 257 KB - 8 pp] and Bioretention Case Studies [PDF - 133 KB - 3 pp] .
- Cisterns and rain barrels harvest and store rainwater collected from roofs. By storing and diverting runoff, these devices help reduce the flooding and erosion caused by stormwater runoff. And because they contain no salts or sediment, they can provide "soft" chemical-free water for garden or lawn irrigation, reducing water bills and conserving municipal water supplies. More information on rain barrels and cisterns see On-Lot Treatment fact sheet.
- Green roofs are roof-tops partially or completely covered with plants. Used for decades in Europe, green roofs help mitigate the urban "heat island" effect and reduce peak stormwater flows. The vegetated cover also protects and insulates the roof, extending its life and reducing energy costs. More information on green roofs can be found at Green Roofs fact sheet and Vegetated Roof Cover [PDF - 150 KB - 3 pp].
- Permeable and porous pavements reduce stormwater runoff by allowing water to soak through the paved surface into the ground beneath. Permeable pavement encompasses a variety of mediums, from porous concrete and asphalt, to plastic grid systems and interlocking paving bricks suitable for driveways and pedestrian malls. Permeable pavement helps reduce runoff volumes at a considerably smaller cost than traditional storm drain systems. For more information, see Porous Pavement fact sheet and Stormwater Technology: Porous Pavement [PDF - 1.34 MB - 6 pp].
- Grass swales are broad, open channels sown with erosion resistant and flood tolerant grasses. Used alongside roadways for years primarily as stormwater conveyances, swales can slow stormwater runoff, filter it, and allow it to soak into the ground. Swales and other biofiltration devices like grass filter-strips improve water quality and reduce in-stream erosion by slowing the velocity of stormwater runoff before it enters the stream. They also cost less to install than curbs, storm drain inlets, and piping systems. For more information, see Grassed Swales fact sheet and Stormwater Technology: Vegetated Swales [PDF - 81 KB - 7 pp].

Conservation Development

Like LID, Conservation Development tries to mitigate the effects of urbanization, but it places additional emphasis on protecting aquatic habitat and other natural resources. Conservation Development subdivisions are characterized by compact clustered lots surrounding a common open space. Conservation Development's goal is to disturb as little land area as possible while simultaneously allowing for the maximum number of residences permitted under zoning laws.

Prior to new construction, conservation developers evaluate natural topography, natural drainage patterns, soils and vegetation. They deploy stormwater best management practices to help prevent flooding and protect natural hydrology. By maintaining natural hydrological processes, Conservation Development creates conditions that slow, absorb, and filter stormwater runoff onsite.

Because future development threatens valuable natural features, Conservation Development provides specific provisions for long-term and permanent resource protection. Conservation easements, transfer of development rights, and other "in perpetuity" mechanisms ensure that protective measures are more than just temporary. For more information, go to NOAA Alternatives for Coastal Development EXIT Disclaimer website.

Better Site Design

The goals of Better Site Design are to reduce impervious cover, preserve natural lands, and capture stormwater onsite. To meet these goals, designers employ a variety of methods. To reduce impervious cover, they narrow streets and sidewalks, minimize cul-de-sacs, tighten parking spaces, and reduce the size of driveways and housing lots.

To reduce stormwater runoff, designers preserve natural lands, using them as buffer zones along streams, wetlands and steep slopes. They employ landscaping techniques that flatten slopes and preserve native vegetation and clusters of trees. They create bioretention areas - open channels, filter strips and vegetated swales - to increase stormwater infiltration, helping to protect steams, lakes, and wetlands. For more information, see the Center for Watershed Protection's Better Site Design EXIT Disclaimer website.

Development Districts

Development districts are areas zoned specifically for the purpose of permitting property development. Development districts concentrate intense, mixed-use development in an area typically five-acres and larger. Although a development district's percentage of imperviousness may exceed those of surrounding areas, such focused, compact development creates a smaller "footprint" than traditional development patterns.

A well-designed development district can contribute to a number of water quality benefits. Compact development lends itself to more environmentally friendly transportation options, like biking or walking, and shorter and less frequent automobile trips. A development district that redevelops an urban area reuses existing infrastructure, which can reduce the demand for new construction elsewhere in a watershed. Many development districts incorporate tree-lined streets, rain gardens, green roofs and other best management practices into their designs, helping manage stormwater onsite. For more information, see Development Districts fact sheet.

Smart Growth

Smart Growth is a set of development strategies that seek to balance economic growth, urban renewal, and conservation. In newly developing areas, Smart Growth advocates compact, town-centered communities composed of open green space, businesses, and affordable housing, interconnected by pedestrian walkways and bicycle lanes. Smart Growth's emphasis on walkable communities and alternative forms of transportation can help alleviate the environmental consequences of automobile use. Smart Growth also advocates the revitalization of inner cities and older suburbs. Reusing existing infrastructure often costs less than new construction, and it helps slow the spread of large-scale impervious surfaces.

Ten core principles guide Smart Growth:

- Mix land use.
- 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 toward existing communities.
- Provide a variety of transportation choices.
- Make development decisions predictable, fair and cost effective.
- Encourage community and stakeholder collaboration in development decisions.

While not explicitly mentioned as a guiding principal, stormwater management nevertheless benefits from Smart Growth policies. Compact, high-density development reduces the spread of impervious surfaces on a watershed scale. This helps reduce overall stormwater runoff. Infill and redevelopment that reuses existing infrastructure can be cheaper than greenfield development, which requires expensive new infrastructure. The `Fix it First' management philosophy advocates repairing and upgrading existing, frequently crumbling infrastructure before spending on new infrastructure.

All of these development strategies can contribute to reducing sprawl and slow the rapid spread of impervious surfaces. All of the site design frameworks discussed in this fact sheet can be coupled with the Smart Growth approach so that small-scale reductions in run-off aren't offset by watershed-scale increases in run-off.

Holistic Planning

The damaging effects of stormwater runoff can be mitigated if urban planners use development designs that reduce the "footprint" of impervious structures. Traditional stormwater approaches, with their emphasis on collection, conveyance, storage and discharge, cannot adequately address the environmental problems caused by sprawling urbanization. Furthermore, with rapid development occurring beyond the fringe of metropolitan regions, urban stormwater is jeopardizing hard fought gains in U.S. water quality.

New land and stormwater management strategies take a more holistic approach. Communities employing conservation development techniques have found that natural features like undeveloped landscapes, vegetation, and buffer zones effectively reduce and filter stormwater flows. There are also other benefits like recreation, wildlife habitat, and increased property values.

Case studies of green design practices have shown substantial decreases in stormwater runoff in pre-existing communities refitted with bioretention basins, permeable pavements, vegetated roof covers, and grass swales.

For example, a study of runoff and pollutant loading conducted in the parking lot of The Florida Aquarium in Tampa revealed an 80 percent decline in runoff volumes when the parking lot was retrofitted with pervious pavement and grass swales. Amounts of copper, manganese, lead, and other metals found in runoff also dropped steeply. For more information, go to Infiltration Opportunities in Parking Lot Designs Reduce Runoff and Pollution [PDF - 701 KB - 10 pp] EXIT Disclaimer.

Similarly, a study of vegetated roofs in Philadelphia, PA found that an older building retrofitted with a green roof absorbed all but 15 inches of a total 44 inches of rainfall that fell during the nine-month test period. Twenty-five years of German research on green roofs support this finding. For more information, go to Vegetated Roof Cover [PDF - 150 KB - 3 pp].

LID integrates ecological considerations into each phase of urban development, from design to construction to post-construction. Pilot programs conducted in the U.S. and around the world show that LID saves money by reducing construction costs for curbing, paving materials, drainage pipes and land clearing. Techniques that manage runoff onsite, such as swales and rain gardens, deliver tangible improvements in water quality and ground water recharge. LID practices also improve air quality, reduce the heat island effect, and enhance community appearance.

Green Design concepts used individually can yield measurable improvements in stormwater runoff management. Used in combination, they can help local governments address significant sources of stormwater pollution, particularly in older urban and suburban areas.

Because Green Design practices like LID blend multiple technologies, they are more versatile than the more limited drain-and-discharge methods of traditional stormwater management. LID can effectively address sources of water pollution in new and existing developments, in brownfields and greenfields, in warm climates and cold, and wet and dry climates. In urban areas, green roofs used in combination with rain gardens, permeable pavement, bio-retention cells and rain barrels produce results far greater than a single technology used alone.

Sound engineering principals form the basis of Green Design practices. Years of experience derived from stormwater management, sanitary engineering, agriculture, and other disciplines, demonstrate soil's ability to effectively absorb and digest many waterborne pollutants. By capturing stormwater onsite, Green Design techniques not only reduce pollutants and runoff volume, but they do so cost-effectively.

Resources

Austin City Connection - Smart Growth Initiative. [http://www.ci.austin.tx.us/smartgrowth/ EXIT Disclaimer].

Coffman, Larry S - Low Impact Development: Smart Technology for Clean Development. [http://www.wsud.org/downloads/Info%20Exchange%20&%20Lit/Larry%20Coffman%20Low%20Impact%20Development.pdf [PDF - 191 KB - 11 pp] EXIT Disclaimer]

EPA - "Environmental Benefits of Smart Growth." [http://www.epa.gov/smartgrowth/topics/eb.htm] Accessed 8-15-06

EPA - "Low Impact Development: A literature Review." [http://www.epa.gov/owow/nps/lid/lid.pdf [PDF - 566 KB - 41 pp]].

EPA - "Protecting Water Resources with Smart Growth." [http://www.epa.gov/dced/pdf/waterresources_with_sg.pdf [PDF - 1.39 MB - 120 pp]].

EPA - "Why Smart Growth: A primer." Accessed 9-20-06 [http://www.epa.gov/smartgrowth/pdf/WhySmartGrowth_bk.pdf [PDF - 869 KB - 44 pp]].

Low Impact Development Center - Introduction to Low Impact Development. [http://www.lid-stormwater.net/intro/background.htm#1 EXIT Disclaimer] Accessed 8-15-06.

Michigan Environmental Council - "Smart Growth Techniques for NPDES Phase II Stormwater Management Compliance in Michigan." [http://www.mecprotects.org/techniques.pdf [PDF - 217 KB - 18 pp] EXIT Disclaimer].

National Resources Defense Council - "Low Impact Development." [http://www.nrdc.org/water/pollution/storm/chap12.asp EXIT Disclaimer].

Northeastern Illinois Planning Commission, Environment and Natural Resources Group - Conservation Development in Practice. [http://www. nipc.org/environment/sustainable/conservationdesign/Conservation%20Development%20in%20Practice/ EXIT Disclaimer].

Click here to comment on this fact sheet