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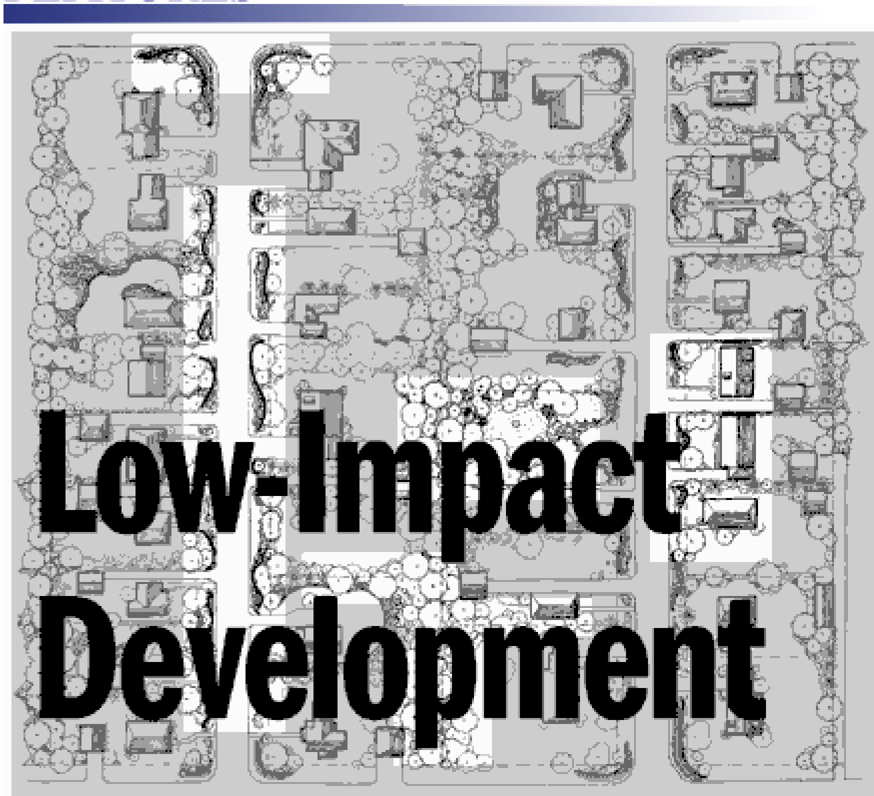
FEATURES



Lot-level approaches to stormwater management are gaining ground.

By Mary Catherine Hager

There's an enthusiastic and growing movement in the United States toward managing stormwater through low-impact development (LID) approaches. But what exactly is low-impact development, and how does it compare to conventional stormwater management? Is LID a passing trend or a philosophy to be taken seriously? Of course, LID proponents support the latter, describing the relatively new approach in ecological and hydrological terms. Says Larry Coffman, associate director of Programs and Planning, Environmental Resources in Prince George's County, MD, and a national expert on low-impact development, "LID is the culmination of all our thinking about how to modify the nature of development so as to maintain natural ecological function." In traditional stormwater management, water is typically moved off a site as quickly as possible to a centralized facility, such as a pond or a local tributary. LID, however, treats rainfall on-site by attempting to integrate control into site and building design in order to maintain hydrological function. Coffman recognizes the gap between the traditional mindset of stormwater management and the LID philosophy. "With LID, we view rainwater as a resource as opposed to a toxic waste product. We begin to see it as a vital part of maintaining the ecosystem." Essentially, LID attempts to model nature and match predevelopment hydrology through infiltrating, storing, filtering, evaporating, and detaining runoff.

Neil Weinstein shares Coffman's passion for LID applications. As executive director of the Low Impact Development Center in Beltsville, MD, a nonprofit organization that promotes sustainable development, Weinstein strives to make LID technology widely available. He describes LID as a "distributed source-control approach designed to treat and manage runoff at the source." In contrast to conventional stormwater management, says Weinstein, LID is based on developing controls and strategies for targeted resources or regulatory objectives, not just on modifying flood-control approaches.

Weinstein illustrates the need for the LID approach through an example of stormwater management difficulties in the suburban Maryland and Washington, DC, area. "In this region we're having problems [with] groundwater recharge because conventional end-of-pipe technology has conveyed water off-site and therefore significantly altered the hydrologic cycle." Weinstein believes the LID approach provides the path to maintaining watershed integrity and hydrologic function.

LID takes a lot-level approach to stormwater management, treating rainwater where it falls by creating conditions that allow the water to infiltrate back into the ground. The integrated management practices applied to accomplish LID span a diverse range, including but not limited to:

- **conservation and minimization** through narrower residential streets, reductions in impervious sidewalk area, additions of porous pavement or replacement of existing pavement with pervious structures, and creation of concave medians and landscaped traffic-calming features;
- **conveyance** through grassed channels and bioretention channels, and disconnection of impervious areas to redirect runoff to vegetated areas;
- **storage** to reduce peak discharge via pedestal sidewalks, rainwater capture and use (rain barrels), green roofs, and yard, curb, or subsurface storage;
- **infiltration** through trenches and basins, and exfiltration devices; and
- **landscaping** measures such as bioretention cells, rain gardens, slope reduction, planter boxes, native ground cover, and green alleys.

Kevin Mercer, executive director of RiverSides Stewardship Alliance in Toronto, ON, an organization dedicated to prevention of nonpoint-source pollution, feels particularly strongly about the role of urban forests in LID. Trees intercept and slow down the flow of water, help infiltrate large quantities of water, and contribute to water cycling through evapotranspiration.

Rain Gardens, Rain Barrels, and SmartStorm

PHOTO: JOAN IVERSON NASSAUER

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Rain gardens, such as this one in Maplewood, detain or infiltrate rainwater in small depressions constructed on individual lots.

Coffman and Prince George's County have played key roles in the development of LID in the US. But Coffman explains that its roots arose in the early 1980s from other nations, including Germany, France, and Japan, where cities were interested in applying distributed, integrated management techniques to reducing stormwater quantity to alleviate problems with combined sewer overflow (CSO). Hydrology manuals in those countries developed the concepts in models even earlier than that, specifying the causes of hydrology changes in urban areas. Coffman believes that LID technology could have taken off long ago. "The philosophy and science have always been there, but no one's really explored them before."

Coffman's own experience with LID began in the late 1980s and early 1990s through his involvement with bioretention technology. Problems with oil grid separators led him to explore filtering water through "the green space that is available at an industrial commercial site." By about 1988, Coffman had begun to work with forestry experts and landscape architects to develop a plant-soil microbe filter modeled after a terrestrial forest complex. Such filters had been operating effectively in the wastewater-water field for decades. During 1990-93, Coffman developed natural bioretention, the process of capturing pollutants in bacterial and plant biomass. One of the engineers on the bioretention project noted that the effort was going to alter runoff on the project site. Intrigued, Coffman proceeded to see how much the nature of runoff could be changed by storing water on the site. "We can control it all," he discovered, "and we don't need a lot of space." Coffman then progressed from changing flow to pursuing ways of restoring ecological function.

Also in the early 1990s, landscape architects began incorporating environmentally sensitive design into stormwater control efforts. Joan Iverson Nassauer, professor of landscape architecture at the University of Michigan, has pursued research and design opportunities dealing with "urban ecosystem management." Nassauer's projects, typically collaborative efforts with municipal civil engineers and water management personnel, implement retrofit solutions to improve stormwater control. She has actively employed rain gardens, or "rainwater gardens," as additions to existing properties. Rain gardens detain or infiltrate rainwater in small depressions that are constructed near where the rain falls. They are designed to collect and soak up rainwater and capture pollutants and to drain or detain standing water efficiently. They are generally planted with native species that are wet- and dry-tolerant and often add to the biodiversity of an urban area.

In 1995, Nassauer and colleagues launched a demonstration rain garden project across two blocks of a residential street in Maplewood, MN, a suburb of Minneapolis–St. Paul. Residents volunteered to have small rain gardens constructed on appropriate locations of their property and participated in their design. Because the street was experiencing periodic flooding, it had previously been slated for repaving and the installation of curb and gutter stormwater sewers.

The rain gardens effectively slowed and infiltrated stormwater runoff without additional concrete infrastructure. The City of Maplewood has considered the rain gardens enough of a success that is has incorporated or plans to incorporate nearly 250 more of them into other neighborhoods, both new and established, since the pilot effort.

Nassauer is pleased with the contribution of the rain gardens to recharging groundwater, maintaining natural hydrology, and absorbing and detaining pollutants carried in the stormwater. "The project was in the pothole topography of central Minnesota," she explains, "and the stormwater would've gone from this little neighborhood directly into a lake. I'm glad we were able to infiltrate and detain that water instead."

Cliff Aichinger, city engineer for Maplewood, was involved with the original project and has taken part in the annual reviews of the gardens' performance ever since. "The soils in much of the city are very permeable and support the rain garden approach without holding water for more than a day or two. Some areas infiltrate in a matter of hours. The areas where the rain gardens are located are used to having some standing water following rain events. The concept would be much more difficult to sell in areas that are used to having stormwater disappear immediately." He notes that the 1950s-era neighborhood where the first gardens were constructed was essentially rural in design with no concrete gutters or storm sewers. "When the streets need upgrading or reconstruction, it is easy to sell the rain gardens to residents rather than expensive curb, gutter, and storm sewer assessments."

Rain gardens have also been incorporated into both residential and commercial properties in several of Coffman's many LID projects. Somerset, a new residential community in Prince George's County, includes a rain garden on each of the nearly 200 lots. The neighborhood is also designed with grassy open drainage swales on the sides of the roads—made wider to allow for pedestrian traffic—but no curbs, gutters, sidewalks, or conventional BMP ponds. Coffman has worked closely with Somerset's developers to design and implement the LID features.

Another major LID component common in residential development is the rain barrel, designed to retain stormwater that washes off rooftops. Unlike in rain gardens, water retained in a rain barrel can be reused for watering lawns, gardens, or trees. RiverSides Stewardship Alliance recommends that every house have at least two rain barrels, with a minimum storage capacity of 1 m^3 (1,000 lit.). "Overall we're looking at capturing, at a minimum, the five-year storm, as much of what comes off a roof as possible." Mercer explains that rain barrels serve multiple purposes, one being to attenuate first flush off the roof, a "triple whammy" of high volume, thermal load, and contaminants. Each rain barrel installation is coupled with a soak-away pit or dry well that consists of granular material covered with a grate that infiltrates rain barrel overflow into the groundwater table. Each installation not only prevents storm flow and provides water efficiency but also acts to recharge captured rainfall into the soil.

PHOTOS: RIVERSIDES STEWARDS ALLIANCE

Rain barrels retain stormwater that washes off rooftops.

Mercer considers the RiverSides rain barrel to be "intelligently designed." "This is a cost-effective engineer-built solution that is vectorproof and childproof and large enough [at] 565 liters, or 150 gallons." Its unique feature is a bypass valve that filters out grit and other contaminants and serves as a bypass, routing overflow to a soak-away pit or a rain garden. Mercer calls the RiverSides rain barrel a "perfect solution" for residential properties trying to maintain the capacity of their lots to reinfiltrate stormwater.

PHOTO: RIVERSIDES STEWARDSHIP ALLIANCE

Front yard rain barrel

Rain barrels are an integral part of such major municipal water-quality programs as the City of Ottawa's WaterLinks surface-water-quality protection program, which distributed 500 of them, and the City of Toronto's successful Downspout Disconnection Program. Mercer believes the rain barrels are an effective lot-level method for clean-water protection and personal action, which he views as "the heart of low-impact development, stormwater capture and reuse, and the reduction of combined sewer overflows."

A dramatic use of rain barrels is underway in a demonstration project in the Boston, MA, area where, as in many urban areas, reduced groundwater recharge and growing demands for potable water have combined to stress the local watershed. The Charles River Watershed Association (CRWA), led by executive director Robert Zimmerman, is employing its own SmartStorm Rainwater Recovery System to capture rooftop runoff and store water for irrigation and nonpotable uses. In the summer of 2002, 30-40 residents in the Bellingham community were offered the SmartStorm system without cost, a value of $2,000 - $3,000 per home. Each homeowner received two rain barrels, installed partially buried near roof drains, capable of storing the equivalent of 100% of the runoff from a 2-in. rainstorm off a 2,000-ft.^{2} roof. Any small amount of overflow from the tanks' dry wells is directed away from homes. Proponents of the SmartStorm system believe it benefits the environment through increased groundwater recharge, decreased runoff volume and peak flows, decreased flooding potential, reduced demand for potable water used for irrigation, and improved stormwater quality. Homeowners benefit because the onsite storage reduces dependency on municipal water and supplies water for nonpotable uses, even during town watering bans. The CRWA expects to place the SmartStorm system on the market by this spring.

Comparing Costs

Stormwater managers and engineers wary of high installation and maintenance costs question the affordability of LID practices. But results of completed LID projects indicate that the higher initial landscaping costs of LID might be offset by reductions in the infrastructure and site preparation work associated with conventional approaches. Estimates from pilot projects and case studies suggest that LID projects can be completed at a cost reduction of 25-30% over conventional projects—in decreased site development, stormwater fees, and residential site maintenance. The Somerset rain gardens enjoyed even greater savings, with an estimated implementation cost of $100,000 compared to a cost of $400,000 for the BMP ponds originally planned on the site, not including curbs, sidewalks, and gutters. Though not as dramatic a cost difference, the retrofitted Maplewood rain gardens saved that city about 10% of the cost of completing a conventional stormwater upgrade. LID practitioners in new developments promote its initial cost savings as an incentive for developers, saying it allows them more flexibility and the opportunity to add other features to the property or even develop space that might otherwise be dedicated to a stormwater pond.

But beyond construction estimates, even LID proponents recognize the difficulty of directly comparing its maintenance costs against those of conventional stormwater management practices. Coffman explains that some LID site designs cost nothing, such as maintaining existing sandy soils for their drainage potential. "The biggest factor we've found is disconnection of runoff. Let all the impervious surfaces drain into some grassy area or conservation area. If you can disconnect and distribute your drainage, it reduces your runoff volumes by 30, 40, or 50%, [and] it doesn't cost anything." Although Coffman estimates that projects designed to minimize infrastructure enjoy substantial cost reductions, he acknowledges that other LID practices do indeed add costs. "When you start adding integrated management practices - like amended soils and bioretention and even open drainage systems - you add costs back in." Still, Coffman estimates the overall costs of establishing LID practices to be generally equal to or less than those of conventional stormwater management.

Weinstein believes that costs of traditional and LID stormwater management are very difficult to compare because the "marginal costs" have not been effectively addressed for either approach. Many LID projects are still in pilot stages, and therefore their maintenance costs have not been fully assessed. Weinstein asserts that this information is also lacking for conventional stormwater management. "What's happening now [with] the first generation of stormwater facilities—from the '80s or, in Florida, the late '70s—[engineers] are starting to see what it actually costs to retrofit them and repair the environmental damage that some of these have done." He elaborates that "lost land costs and long-term community costs, such as replacing an entire pipe system after 50 or 60 years of leaking pipes," have very rarely been estimated for conventional management. Coffman believes that reducing the concrete infrastructure of a stormwater management project directly decreases its overall maintenance costs.

Both Coffman and Weinstein predict that LID techniques will become less expensive over time as growing numbers of competing LID practitioners drive down prices and the technology becomes standard. "We're hoping that as we develop this technology, we'll come up with a simple suite of techniques," says Coffman. He gives as examples rain gardens, open drainage systems, amended soils, or roof gardens "four or five techniques that we can [become] more efficient in using, which will drive the cost down."

Maintenance Issues

PHOTOS: LOW IMPACT DEVELOPMENT CENTER

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A frequent criticism of the LID approach is the maintenance responsibility that falls on individual property owners when such features as rain gardens or rain barrels are installed on their lots. Nassauer agrees that this is an issue to be taken seriously. "Local governments that ultimately need to be responsible for stormwater management must be utterly clear about what the maintenance plans are for these systems and what entity is responsible." In Nassauer's Maplewood rain garden project, the demonstration gardens were designed to be maintained by the city through a single annual cutting. The city found that arrangement impractical for subsequent projects, so those residents currently accepting rain gardens are responsible for their maintenance. Individual property owners are offered a range of garden plans, including some considered virtually maintenance-free.

PHOTOS: LOW IMPACT DEVELOPMENT CENTER

LID efforts are seen in parking lots and other commercial settings.

Weinstein points out that large, conventional stormwater facilities demand large-scale maintenance not easily managed by some smaller communities. The Low Impact Development Center is partnered with the Friends of the Rappahannock in a planning and demonstration project whose goal is to assist the rural Chesapeake Bay town of Warsaw, VA, in its efforts to effectively manage its natural resources in the face of the growth common to the region. The grant-funded project is assisting the town in applying LID techniques, from modifying stormwater ordinances to providing public education through project demonstration. Weinstein explains the appeal of the new approach to a small community: "They are quite behind it because they don't have the staff to maintain a lot of these centralized, big facilities. [They prefer] smaller structures that are easy to maintain yet still function."

Coffman emphasizes that the goal of LID is to replace traditional hard infrastructure of a conveyance-based facility with one that is "living, dynamic, and integrated into the way the site functions, with no infrastructure needed at all." His answer to criticism of such practices as rain gardens and rain barrels as structures doomed to fail when they are not maintained is that this perspective doesn't take into account the complexity and "multifunctionality" of the LID approach. Coffman lists many of the techniques integrated into rain gardens that don't involve maintenance. "In the initial layout of the subdivision, [architects, planners, and developers] did conservation, they did distribution and disconnection, [and] they saved infiltratable soils and amended soils to have more assimilative capacity. They reduced the amount of impervious surfaces, and more importantly they increased the amount of functional surfaces." Coffman elaborates that with the dozens of techniques available to implement LID, even a loss of 30-40% of installed rain gardens over time will be offset by the redundancy of the other techniques. "The beauty of LID is that it can't fail for lack of maintenance," he contends. "And you can overdesign. If you think that some of the systems are going to fail because of lack of maintenance, then you add more volume storage." Coffman and other LID practitioners believe that the function of these systems can increase over time, as soils mature and vegetation grows.

Practices that don't require input or participation by the property owner include recharge areas, drainage courses, buffer zones, infiltration swales, and open drainage systems. LID practitioners strive to design such ecologically sound practices that over time the systems are virtually self-sustaining. "Like a terrestrial forest complex," says Coffman, "we're trying to mimic the same ideas, the same natural processes, so there's ultimately less maintenance." Most important to the success of LID efforts are site designers knowledgeable in low-maintenance practices as well as in effectively reducing concrete infrastructure, reducing impervious area and disconnecting that which remains, and conserving open space.

Educating residents and accurately assessing their needs and attitudes goes hand in hand with property owners' participation in LID efforts and their willingness to provide that portion of maintenance. As a landscape architect heavily involved in academic research, Nassauer has devoted much effort to evaluating and predicting property owners' values and accommodating those in environmental designs. She sums up her underlying philosophy of merging landscape ecology and stormwater management: "If you design this green infrastructure, or low-impact development, so that people can recognize it from the beginning as something that they like and value, that makes all the difference." Nassauer cautions that underestimating the importance of such perceptions is a certain path to failure. "If we design and implement something that might be extraordinarily effective from the standpoint of stormwater management or the standpoint of ecology, but people don't get it or don't particularly like it in their neighborhood or their yard, it's just not going to be there in five or 10 years." But she hardly feels limited by this restriction. "You can just do so many innovative things with stormwater management within that framework, but I always start with what people like."

The redundancy of LID allowed for individual preferences in Nassauer's Maplewood project. Although rain gardens were not accepted and installed by all property owners in the targeted developments, the total area of rainwater gardens installed effectively handled rain and runoff. Coffman feels that property owners should take responsibility for environmental impacts associated with their lots, an attitude he believes is fostered by including more LID functions into lot design. But again, 100% compliance is not expected or required. "Seventy percent compliance is good enough, even less, because there are still so many techniques built into the system. With a multisystem approach, if one of the systems begins to falter, you still have all these other backup systems."

Nassauer's LID designs are incorporated primarily into retrofit areas, where the emphasis has to be on residents or business owners with existing expectations about their property and their property value. In contrast, LID incorporated into new development can be promoted by developers as an environmentally sensitive design, an added value to prospective buyers.

Nassauer's projects demonstrate that LID can be well suited to retrofit situations. Weinstein explains that the lot-level approach of LID enhances its retrofit potential over that of conventional stormwater management because established urban environments are often so lacking in space compared to new development. "LID allows you to look at very small-scale, discrete areas and look at fitting things in," he says, adding that retrofitting through LID technology affords increased opportunities for urban renewal, HUD projects, or rebuilding. Nassauer experiences the "creative challenges" demanded by urban retrofit projects subject to spatial constraints. She and her colleagues are currently involved in the demonstration portion of a particularly challenging retrofit project for the City of Chicago that deals with adding rain gardens to a neighborhood with three-and-a-half-story walkups separated by 5-10 ft.

Questions of Safety and Vector Control

Those unfamiliar with or wary of the LID approach question how it compares to conventional approaches in terms of safety and vector control. Conventional stormwater ponds are raising concerns in some parts of the nation for their potential to breed mosquitoes or present safety hazards. The son of basketball player Julius Erving died in 2000 when he drove his car into a residential stormwater pond; the event led to a lawsuit against the security firm guarding the area and the developer responsible for the pond. Engineers in Fairfax County, VA, have placed on hold plans for additional ponds and are exploring alternatives in response to residents' concerns regarding vector control and safety, particularly that of children living near the ponds.


PHOTO: LOW IMPACT DEVELOPMENT CENTER

Weinstein explains that the threat of mosquitoes in LID practices is minor because LID uses BMPs to temporarily store, filter, and infiltrate, so there is less potential for large volumes of stagnant water to form than in conventional BMPs. Although Weinstein is unaware of any study of the hazards of LID projects, he believes that the smaller scale of these approaches reduces hazards. Coffman agrees, asserting that there are more "financial, public health, and safety liabilities" associated with conventional stormwater management than with LID.

LID seems to be gaining popularity in several parts of the country. Coffman believes veterans of long-term stormwater management to be one of the groups most involved with LID. "In those areas where we've used the [conventional] technology for a long, long time, we're beginning to see the financial and public health liabilities [and] to search for new alternatives." Communities more likely to explore LID options are those with special resources to protect, such as the Great Lakes region, the Pacific Northwest, and the Chesapeake Bay. In the Northwest, the city of Portland has pursued many LID technologies as an integrated approach to CSO control, and LID tools have been applied to protection efforts in the Puget Sound, WA, region.

The federal government has also taken an active interest in LID, especially with the movement toward the greening of government. Weinstein's organization has developed an LID Design Resource Web site (http://www.lid-stormwater.net/) funded by the US Environmental Protection Agency and is working with the US Navy on a manual to offer official guidance with LID efforts on Department of Defense areas.

Although certain stormwater management projects are better suited to LID approaches than others are, LID proponents consider the philosophy applicable to all situations. Weinstein allows that there might be occasions where LID needs some backup from conventional technology, such as ponds in flood-control situations where large volumes of storage are required, but he asserts that LID efforts succeed on their own by controlling runoff pollutants and volume for the majority of storms.

The future of LID will certainly depend on the success of collaborative efforts among such diverse parties as landscape architects, civil engineers, developers, stormwater managers, and individual property and business owners. LID projects to date - including the Maplewood, Somerset, and Boston-area efforts described in this article - have indeed relied upon these types of cooperative arrangements.

Practitioners of LID realize the leap that municipalities facing the challenges of stormwater management must make to consider LID approaches over conventional ones. Coffman believes that in order for communities and individuals to be willing and able to implement LID technology, they must first understand nature's processes well enough to engineer sites that maintain those processes naturally rather than destroy them. "We really need to wake up and begin to look at this seriously," he urges, "and to understand that mitigation technologies designed to minimize development impacts aren't good enough to maintain the integrity of these receiving waters. We really need to get a lot smarter and come up with better technology that mimics natural processes, to save these ecosystems."

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