Low Impact Development/Green Infrastructure

Introduction

On undeveloped land, most precipitation filters through the soil recharging groundwater and providing base flow to nearby streams, ponds, wetlands, rivers, and lakes.

Land development adds impervious surfaces such as cement, asphalt, and roofing. The natural cycle is disturbed, and the amount of precipitation that is infiltrated decreases, while the runoff portion increases. This changes both water quantity and quality, with increased flood risk, pollutant loading, waterway scour and sedimentation. Low impact development (LID) and green infrastructure have emerged as techniques that can reduce the negative effects of traditional drainage-based land development.

Low impact development (LID) is a holistic planning, design and construction process that seeks to reduce runoff volume by infiltrating and absorbing small, frequent storms close to where runoff is generated. Green Infrastructure is a new term that is often used interchangeably with LID. In fact, Green Infrastructure appears to be eclipsing LID and includes a broader goal of using natural systems and functions to reduce runoff and manage stormwater.


Fire lane


Bioswale

Green infrastructure also includes a concept of scale, whereas LID is typically associated with small, decentralized Best Management Practices (BMPs). For example, green infrastructure on a large scale may be a constructed wetland that offers multiple stormwater, environmental and social benefits. On a small scale, green infrastructure may include a bioswale or a permeable paver system to reduce runoff and provide a site amenity.

Regardless of the term used or project scale, mimicking predevelopment hydrology to meet water quality and channel protection goals using natural system functions (infiltration, absorption and evapo-transpiration) is the common objective.

Implications of Not Addressing the Issue

The impacts of traditional approaches to stormwater management are present in almost every community. Scoured, downcut and destabilized waterways are among the most visible results of added impervious area and drainage-based land development.

Furthermore, the strategy of collecting runoff in storm sewer systems and conveying it to the nearest stream or river as quickly as possible only serves to create an “express route” for nonpoint source pollutants that can impair nearby water resources. For example, excess nutrients, such as nitrogen and phosphorus lead to algae blooms and a condition known as eutrophication, which damages aquatic ecosystems. Metals and other toxic chemicals in polluted runoff negatively impact aquatic life and human health. Finally, polluted runoff can introduce bacteria, viruses and other pathogens into local water bodies.

Without the application of innovative approaches, communities will continue to finance storm drainage infrastructure as well as capital improvement projects to address waterway stabilization and water quality needs brought on by traditional, drainage-based development. These approaches will increase financial pressures on local governments, continue to degrade water quality and negatively impact the natural functions of riparian corridors.

Goals for Low Impact Development/Green Infrastructure

There are many techniques communities can use to promote the adoption of LID or Green Infrastructure approaches to land use and stormwater management. The choices made regarding these techniques are often a reflection of the individual community’s needs and priorities.

The goal of LID and Green Infrastructure is to reduce the negative impacts of increased imperviousness on waterways, riparian areas and overall water quality with the ultimate goal of having developed land function similar to undeveloped land.

Communities can advance this goal by:

- Removing regulatory obstacles to LID/Green Infrastructure design
- Providing incentives to encourage developments to use LID/Green Infrastructure design
- Providing opportunities for LID techniques in the public right of way
- Providing regulatory guidance on LID/Green Infrastructure design
- Requiring that land development design mimic pre-development hydrology
- Requiring that redevelopment incorporate LID/green infrastructure approaches to restore pre-development hydrology to the maximum extent practicable
- Addressing offsite costs of drainage-based design

The best protection of our water quality, riparian corridors and waterways is the thoughtful use of land that promotes healthy watersheds. The following code chart presents many options, from modest to aggressive, that may be used as a path to low impact development and/or green infrastructure.

Sustainable Community Development Code Framework

LOW IMPACT DEVELOPMENT/GREEN INFRASTRUCTURE

Key Statistics:

- Impervious area in the U.S. nearly covers an area the size of Ohio.[1]
- Undeveloped land naturally absorbs small, frequent storms – for example, this is about the first inch of precipitation in the Denver Front Range.[2]
- Undeveloped land in metro Denver, for example, has less than one runoff event a year; after development; there are 20-30 runoff events.[3]
- The National Flood Insurance Program (NFIP) is in debt approximately $20 billion to the U.S. Treasury.[4]
- In the St. Louis, Missouri area, more than $2.2 billion of new development has occurred on land that was underwater during the 1993 flood.[5]
- A 1,000 square foot rooftop will contribute almost 350 gallons of runoff from only one inch of rain.[6]
- Because of impervious surfaces, a typical city block generates over five times more runoff than a woodland area of the same size.[7]
- Narrower streets can result in a five to 20% overall reduction in impervious area for a typical residential subdivision.[8]
- Cluster development can reduce imperviousness by 10 percent to 50 percent compared to conventional subdivision layouts, reducing the rate and volume of runoff and the quantity of pollutants.[9]
- Clean Water Services (an Oregon public utility) determined that car habitat (roads, parking lots, driveways) is 54% of the impervious area in suburban land development.[10]
- Roads and driveways often comprise the greatest amount of impervious area in new development (Pennsylvania) - as much as 70% of the total impervious area.[11]
- Boulder, Colorado's municipal trees intercept 6 million cubic feet of stormwater annually, or 1,271 gallons per tree on average. The total value of this benefit to the city is $532,311, or $14.99 per tree.[12]

RMLUI
Rocky Mountain Land Use Institute

		ACHIEVEMENT LEVELS (NOTE: HIGHER LEVELS GENERALLY INCORPORATE ACTIONS OF LOWER LEVELS)				
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
 Flush curb	**Remove Obstacles**	▪ Reduce minimum off-street parking standards • Permit shared parking • Reduce minimum off-street parking if public transportation is available • Allow single-sided parking on street • Allow overnight parking in driveways and on-street in developments that use shared driveways and rear-loaded garages ▪ Permit or encourage flush curbs or wheel stops and sumped landscape islands in parking lots	▪ Provide the same review timeframe for LID design as drainage-based design ▪ Provide credit towards open space dedication and set-aside requirements for protection of sensitive natural areas and wildlife habitat ▪ Allow pervious materials for sidewalks in accordance with Americans with Disabilities Act requirements ▪ Establish street templates based on actual access needs of emergency equipment	▪ Provide engineering templates for infiltration and absorption techniques when techniques are combined, such as grass buffers, bioswales, and permeable pavement systems ▪ Provide LID site development templates for residential, commercial and industrial development ▪ Base fees, charges and standards upon the true cost of drainage-based land development to the community	▪ National Association of Home Builders, *Municipal Guide to LID.* Available online. Retrieved December 2, 2010. ▪ AWARE Colorado, an initiative of the League of Women Voters of Colorado Education Fund, provides information to community leaders statewide about the impacts of land use on water quality, and suggests strategies to protect rivers, lakes and streams. Available online. Retrieved December 2, 2010. ▪ Colorado Association of Stormwater and Floodplain Managers, Available online. Retrieved December 2, 2010.	▪ Guidelines that could be adopted into local code: *Urban Drainage Criteria Manual Volume 3 – Four Step Process: BMP Planning for New Development and Redevelopment, section 1.2*: Available online. Retrieved December 2, 2010. ▪ City of Snohomish, WA, County Code, Low Impact Development, Section 30.63C.010, (go to page 550.) Available online. Retrieved December 2, 2010.

[1] Elvidge,C.D.,C. Milesi,J.B.Dietz,B. Tuttle,P.C.Sutton, R. Nemani and J.E. Vogelmann (2004), U.S. Constructed Area Approaches the Size of Ohio, EOS,Vol. 85, No. 24, 15 June 2004.
[2] Full Spectrum Detention 2005-01-01 Concept Paper, James Wulliman and Ben Urbonas, 2005. http://udfcd.org/downloads/pdf/tech_papers/Full%20Spectrum%20Detention%202005-01-01%20Concept%20Paper.pdf
[3] Urban Watershed Research Institute – Low Impact Development training class October, 2006, Ben Urbonas.
[4] Association of State Floodplain Managers - National Flood Programs and Policies in Review, 2007 http://www.floods.org/Publications/NFPPR_2007.asp
[5] http://www.wetlands-initiative.org/FloodDamageSummary.html
[6] Protecting Our Waters: Subdivision Design, http://clean-water.uwex.edu/plan/subdivision.htm
[7] EPA **841-F-03-003**. Protecting Water Quality from Urban Runoff.
[8] Better Site Design Fact Sheet: Narrower Residential Streets
[9] Site Planning for Urban Stream Protection: Chapter 4 - Stream Protection Clusters
[10] http://www.oeconline.org/rivers/stormwater/impacts
[11] Pg 11: http://www.dep.state.pa.us/dep/subject/advcoun/Stormwater/Manual_DraftJan05/Section08-jan-rev.pdf
[12] City Of Boulder, Colorado Municipal Tree Resource Analysis

LOW IMPACT DEVELOPMENT/GREEN INFRASTRUCTURE

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 Permeable paver parking lot   Green Roof  Street bioswale Photo: Seattle Public Utilities	**Remove Obstacles**	▪ Place stormwater design review early in the development review process ▪ Enable joint department review of development plans ▪ Allow alternative street designs that reduce imperviousness but maintain emergency access ▪ Allow alternative cul-de-sac designs that reduce imperviousness but maintain emergency access and full access for pedestrians and cyclists ▪ Prohibit private covenants that prevent the use of LID and/or water conservation landscaping ▪ Allow narrower sidewalks or sidewalks on one side of the street as appropriate ▪ Provide predictability and transparency about which lands are more suitable for development and which are a priority for preservation (see Section on Sensitive Natural Lands) ▪ Allow LID/Green Infrastructure facilities to count towards local open space set-aside requirements ▪ Acknowledge trees as part of community infrastructure and develop a coordinated design for locating public utilities to provide enough space for mature tree canopy and root development (see Structural Soil guidelines under References) ▪ Adopt streamlined permitting procedures for brownfield redevelopment plan review ▪ Tailor standards for landscaping, buffering, parking, and open space areas to avoid imposing suburban parking requirements in high-density infill areas	▪ Reduce the size of conventional stormwater infrastructure requirements relative to the use and benefits of LID/Green Infrastructure ▪ Encourage property owners to adopt site-based LID/green infrastructure practices, such as rain gardens, rain barrels and other rainwater harvesting practices* ▪ Allow LID/green infrastructure techniques off-site for infill and redevelopment areas	▪ Except in critical aquifer recharge areas, allow porous/permeable pavement options for right-of-way and emergency access: fire lanes, shoulders and alley ▪ Update development, building, and plumbing codes to allow reuse of stormwater for non-potable purposes	▪ ECONorthwest. *The Economics of Low Impact Development: A Literature Review,* Available online. Retrieved December 2, 2010. ▪ U.S. Environmental Protection Agency, *Reducing Stormwater Costs Through LID Strategies and Practices.* Available Online. Retrieved December 2, 2010. ▪ University of Nevada, *Nonpoint Education for Municipal Officials (NEMO)*. Available online. Retrieved December 2, 2010. ▪ University of Arizona. *NEMO. Available online.* Retrieved December 2, 2010. ▪ City of Seattle, WA *Street Edge Alternatives (SEA Streets) project*: Available online. Retrieved December 2, 2010. ▪ Puget Sound Partnership. *Puget Sound Regulatory Assistance Project*: Available online. Retrieved December 2, 2010. ▪ National Association of Home Builders. *Builders Guide to LID*: Available online. Retrieved December 2, 2010. ▪ U.S. Environmental Protection Agency. *Fact Sheets & Reports, Design/Guidance Manuals*. Available online. Retrieved December 2, 2010. ▪ Cornell University. *Cornell Structural Soil for Urban Trees*. Available online. Retrieved December 2, 2010. ▪ Urban Drainage and Flood Control District. *Peak Flow Control for Full Spectrum of Design Storms, detention concept paper.* Available online. Retrieved February 10, 2010. ▪ Stormwater Center. *Better Site Design Fact Sheet: Narrower* Residential Streets. Available online. Retrieved February 10, 2010.	▪ United States Environmental Protection Agency, *Model Ordinances to Protect Local Resources,* Available online. Retrieved December 2, 2010.

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 Shared driveway  Street bioswale  Permeable pavers and bioswale	**Create Incentives**	Provide incentives such as eliminating or reducing stormwater drainage fees, providing density credits, expediting case processing/approval time if the development/redevelopment incorporates one or more of the following: ▪ LID and green infrastructure techniques ▪ Shared parking ▪ Transit-oriented developments or mixed-use ▪ Narrow or shared driveways ▪ Cluster development ▪ Phased construction ▪ Plans for reduced soil disturbance and/or compaction ▪ Retaining or amending topsoil ▪ Surface swales and ditches instead of storm sewer ▪ Retaining existing trees on site ▪ Rear-loaded garages	▪ Sponsor pilot demonstration projects ▪ Subsidize maintenance of LID/Green Infrastructure BMPs on private property to ensure functionality ▪ Identify LEED point potential outside of structures (stormwater volume reduction, water quality, urban heat island) and provide incentives for including LEED points in the site design ▪ Grant additional open space credit for off-site LID/green Infrastructure that is improved/designed for public recreational purposes and social value ▪ Provide incentives, such as increased Floor Area Ratios, for green roofs that reflect environmental, economic and social benefits ▪ Create formal program offering incentives to property owners who use pervious pavement elements ▪ Reduce stormwater management facility requirements for developments employing comprehensive rainwater harvesting	▪ Provide cost sharing for property owners to retrofit with runoff reduction techniques	▪ Mecklenburg County. *Watershed - Urban Cost Share Program.* Available online. Retrieved December 2, 2010. ▪ A Citizen's Guide to Stormwater Management in Maryland. Available online. Retrieved December 2, 2010. ▪ US Green Building Council. *LEED for Neighborhood Development.* Available online. Retrieved December 2, 2010.	▪ City of Sammamish, WA, *Proposed LID Municipal Code Amendments.* Available online. Retrieved December 2, 2010.

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 Porous landscape detention  Private road with detention under pavers  Street bioretention	**Enact Standards**	▪ Require runoff reduction techniques for new development and redevelopment ▪ Require and enforce riparian buffer strips that adequately protect riparian functions and values ▪ Integrate LEED requirements with stormwater benefits in the building and land development code ▪ Integrate National Association of Home Builders' Model Green Home Building Guidelines in land development code ▪ Evaluate actual parking needs for residential and commercial development and revise parking standards accordingly ▪ Prohibit roof downspouts from discharging to impervious surfaces such as driveways ▪ Require porous or pervious materials be used in areas of parking lots that will be used for snow storage ▪ Enact tree ordinances that protect existing trees and require new trees to be planted in such a way as to develop and maintain healthy tree cover ▪ Require operations and maintenance plan for LID and other stormwater structures for new and redevelopment ▪ Require developers to meet a specified percentage of their stormwater requirements with LID/green infrastructure practices ▪ Require any public trees removed or damaged during construction be replaced on- or off-site with an equivalent amount of tree caliper (e.g., remove a 24-diameter tree/replace with 6 four-inch diameter trees)	▪ Integrate LID and "No Adverse Impact" recommendations from Association of State Floodplain Managers into the local development code ▪ Require and enforce riparian buffer strips of at least 50 feet that adequately protect riparian functions and values ▪ Require redevelopment projects to increase porosity and permeability ▪ Require developers to conduct a natural resource inventory prior to site design ▪ Require that high quality topsoil be saved and replaced onsite or soil must be augmented with organic materials ▪ Prohibit excessive soil compaction by requiring laying mulch, chipped wood, or plywood sheets before construction equipment enters site ▪ Require parking lot landscaping that promotes infiltration, such as porous landscape detention, swales, and filter strips ▪ Require pervious parking for the spaces constructed beyond the average needs ▪ Require developers to meet at least 25% of their stormwater requirements with LID/green infrastructure practices ▪ Adopt regulations to protect steep slopes, hillsides, and other sensitive natural lands ▪ Adopt an impact fee that is used to purchase open space that assists in stormwater management	▪ Require that new development mimics pre-development hydrology ▪ Require and enforce riparian buffer strips of at least 100 feet that adequately protect riparian functions and values ▪ Require no net runoff volume increase when variances for extra parking are granted ▪ When technically feasible, require porous/permeable pavement options for right-of-way and emergency access: fire lanes, shoulders, alleys ▪ Establish maximum parking limitations instead of, or in addition to, minimum parking requirements ▪ Establish a system that allows/requires payment-in-lieu fees for off-site LID/green Infrastructure ▪ Require developers to meet at least 50% of their stormwater requirements with LID/green infrastructure practices	▪ Urban Drainage Flood Control District. *Urban Drainage Criteria Manual Volume 3 – Four Step Process: BMP Planning for New Development and Redevelopment, section 1.2*: Available online. Retrieved December 2, 2010. ▪ Association of State Floodplain Managers. Available online. Retrieved December 2, 2010. ▪ Stormwater Center. *Better Site Design Fact Sheet: Narrower* Residential Streets. Available online. Retrieved December 2, 2010. ▪ U.S. Environmental Protection Agency. *Residential LID Tools.* Available online. Retrieved December 2, 2010. ▪ Nonpoint Education. *Addressing Imperviousness in Plans, Site Design and Land Use Regulations.* Available online. Retrieved December 2, 2010. ▪ Center for Watershed Protection Site Planning Model Development Principles Available online. Retrieved December 2, 2010. ▪ Guidelines for Developing and Evaluating Tree Ordinances. Available online. Retrieved December 2, 2010.	▪ U.S. Army Corps of Engineers, *Site Design Checklist and LID Calculations Worksheet*, Available online. Retrieved December 2, 2010. ▪ Center for Watershed Protection, *Code and Ordinance Worksheet.* Available online. Retrieved December 2, 2010. ▪ National Association of Homebuilders, *Model Green Home Building Guidelines.* Available online. Retrieved December 2, 2010. ▪ National Association of Homebuilders, *Tree Preservation Ordinances* ,Available online. Retrieved December 2, 2010. ▪ Stormwater Center. *Model Ordinances for Aquatic Resource Protection*. Available online. Retrieved December 2, 2010. ▪ Urban Design Tools: Low Impact Development Available online. Retrieved December 2, 2010. ▪ Southeast Metro Stormwater Authority: *Criteria Manuals, Templates, and Sample Drawings.* Available online. Retrieved December 2, 2010. ▪ Douglas County. *Grading, Erosion and Sediment control Manual.* Available online. Retrieved December 2, 2010. ▪ City of Lacey, WA. *Zero Impact Development Ordinance.* Available online. Retrieved December 2, 2010. ▪ Resurces Defense Council. *Stormwater Strategies: Community Responses to Runoff Pollution: Chapter 12: Zero Impact Development Ordinance. Available online*.

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 Permeable pavers with high albedo		▪ Differentiate between greenfield, brownfield and infill development in local codes, ordinances, and policies ▪ Allow two-track driveways by technical street/subdivision specifications ▪ Require all road/street projects to allocate a minimum amount of the total project cost to LID/green infrastructure elements ▪ Adopt requirement that some percentage of parking lots, alleys, or roads in a development use pervious materials ▪ Require large developments to adopt transportation demand management techniques to lower vehicle use and parking demand	▪ Require long-term maintenance agreements that allow for public inspections of the management practices and also account for transfer of responsibility in leases and/or deed transfers ▪ Conduct regular inspections, prioritizing properties that pose the highest risk to water quality ▪ Develop a plan approval and post-construction verification process to ensure that stormwater standards are being met, including enforceable procedures for bringing noncompliant projects into compliance			

Strategic Success Factors

Supportive planning policy and programs support and compliment regulations and are listed here as strategic success factors.

- Local government creates formal program offering incentives (e.g., cost sharing, reduction in street widths/parking requirements, assistance with maintenance) to property owners who utilize pervious pavement element
- Support or partner with land trusts to acquire critical natural areas
- Adopts funding mechanisms for remediation and redevelopment of brownfield sites.
- Establish a dedicated source of funding for open space acquisition and management

*Rainwater harvesting techniques that impede the flow of gravity and capture water for use at some later time (including pumping or bucket dipping) are currently prohibited in Colorado without a water right. Low impact development techniques that mimic predevelopment hydrology though infiltration, absorption (landscaping) or by not producing runoff in the first place (porous and permeable pavements), are legal.