TechLink Research Summary #3306

Filtrexx®, Compost, Low Impact Development, and Design Considerations for Storm Water Management

What is LID?

Low Impact Development (LID) is a comprehensive land planning and engineering design approach with the goal of maintaining and enhancing the pre-development hydrologic regime of post-development, urban and developing watersheds. LID is a storm water management design approach that seeks to provide on-site management using a variety of distributed landscape features and engineering devices that, 1) reduce stormwater runoff, 2) slow down runoff, 3) enhance infiltration, 4) filter runoff pollutants, and 5) capture stormwater. LID uses a hybrid of engineering - technical design to meet specific runoff management targets (peak flow, volume, water quality), and architectural - functional design for aesthetics and increased value and design principles (LID Center Inc, 2005).

Low Impact Development recognizes that impervious surfaces in a watershed or site relative to natural systems, 1) generate runoff more quickly, 2) generate greater runoff volume, and 3) carry more pollutants in runoff to receiving water bodies. For example, in a natural watershed, average runoff is 10% of the total precipitation volume; with 10-20% impervious surface area it increases to 20%; 35-50% impervious surface area increases to 30% runoff; 75% + impervious surface increases to 55% runoff (Tourbier and Westmacott, 1981). Watersheds with greater than 10% impervious surface area have been directly correlated to impaired stream water quality, and watersheds with greater than 25% impervious surface have been correlated to long term stream water quality impairment. As an example, an average single family home site in high density residential subdivision has a 25 to 60% impervious surface area.

Who uses LID?

LID can be used to address a wide range of wet weather flow issues, including Combined Sewer Overflows (CSOs), National Pollutant Discharge Elimination System (NPDES) Stormwater Phase II permits, Total Maximum Daily Load (TMDL) permits, Nonpoint Source Program goals, and other Water Quality Standards (LID Center Inc, 2005). Local permitting agencies can use LID as a model in revising local zoning and subdivision regulations in favor of more cost-effective, ecologically sound development practices. Developers can achieve greater project success and cost savings through the intelligent use of LID, and designers can apply these techniques for innovative, educational, and more aesthetically pleasing sites (LID Center Inc, 2005).

LID Design Objectives

By focusing on prevention and reduction of storm water runoff rather than control and treatment, LID manages runoff at the source, as it is being generated and before it reaches large concentrated flows. The hydrological goal of LID design is to mimic natural systems to achieve natural (or predevelopment) levels of: landscape surface water storage, infiltration, filtration, runoff velocity, interception, evapotransporation, and thermal control. Principle LID design objectives include - storm water quantity management under all conditions (volume, peak runoff rate, frequency, duration); water quality control under all conditions (pollution prevention); aesthetics; safety; and low cost (design, construction, maintenance). To achieve these objectives, the key LID design strategies are to - minimize land disturbance, maximize roughness along water flow paths (Manning's n value) to maintain or reduce flow velocity, maximize infiltration rate, maximize retention, disperse runoff flow - maintain sheet flow/discourage concentrated flows, filter water above and below ground, minimize slope angles, disconnect impervious surfaces, and connect pervious and natural surfaces.

LID Integrated Management Practices

LID Integrated Manangement Practices (IMPs) are designed to reduce the hydrograph, or maintain predevelopment and/or natural hydrograph conditions, and to reduce pollutant loads in storm water. LID Integrated Management Practices include bioretention cells, rain gardens, vegetated filter strips, filtration cells, bioretention swales, grassed swales, dry wells, level spreaders, infiltration trenches, engineered soils, soil amendments, green roofs, permeable pavement, rain barrels, and cisterns. Specifications are written using AASHTO and or ASTM criteria wherever possible. Standards, specifications, and design drawings for bioretention cells, bioretention swales, permeable pavement blocks, and soil amendments can be found at www.lowimpactdevelopment.org/resources.htm. An interactive, web-based LID IMP design tool can be accessed at www.lid-stormwater.net/intro/background.htm. Other design resources include *Low Impact Development Design Strategies - An Integrated Design Approach* at www.epa.gov and the USEPA LID Homepage at www.epa.gov/nps/lid.

Table 1: Site Characteristics and LID Design Strategies

	Minimize Disturbance	Maximize Roughness	Maximize Infiltration	Maximize Retention	Filter Runoff	Minimize Slopes
Runoff Peak Flow Rate	↓	↓	↓	↓		↓
Runoff Volume	↓	↓	↓	↓	↓	↓
Time of Concentration	↑	↑	↑	↑		↑
Infiltration Rate	↑	↑	↑	↑	↑	
Pollutant Loading	↓	↓	↓	↓	↓	

Recreated from Low Impact Development Design Strategies - An Integrated Design Approach (Prince George's County, MD, 1999)

HOW DOES FILTREXX AND COMPOST FIT INTO LID & STORM WATER DESIGN?

Design Tools, Prediction Models, Equations, Values, and Coefficients

USDA NRCS TR55/TR20, Rational Method, US Army Corp of Engineers HEC-1, USEPA Storm Water Management Model, and the US EPA Hydrologic Simulation Program - FORTRAN are storm water prediction models commonly used for land development and watersheds designed for various aspects of storm water discharge, water quantity and quality relationships, rainfall-runoff relationships, hydrologic-hydraulic characteristics, pollutant wash-off and transport, sediment yield, runoff flow rates, runoff volume, and potential affects on stream and river flows (Prince George's County, MD, 1999).

Hydrologic abstractions (initial), runoff coefficients, runoff curve numbers, peak runoff rates, runoff volumes, and unit hydrographs for compost blankets have been developed and can be used in selected storm water/runoff prediction models.

Ia = hydrologic abstraction (initial) - is the amount of precipitation absorbed by a landscape before initiation of runoff (influenced by antecedent soil moisture, vegetation density/cover, soil/surface roughness, soil type [organic content, bulk density, aggregation]). It is a storage volume capacity, and is correlated to infiltration rate, which consequently declines over the storm duration as the landscape reaches saturation. Runoff volume can also be correlated to abstraction, since the greater the initial abstraction the lower the runoff volume.

In a study conducted by the University of Georgia, initial abstractions for compost blankets, relative to bare soil, at the time of installation, on average were 51% greater and after one year were 65% greater (Faucette et al, 2005). Based on three 1 hr/50 yr (3.1 in/hr for 1 hr) storm events, initial abstractions averaged 2.5 in (78%) and were as high as 3.2 in (96%), and runoff commencement was delayed by an average of 20 min and as much as 1 hour. In a follow up study, using two designed 1 hr/100 yr return (4 in/hr for 1 hr) storms, compost blankets held an average of 80% of the 132 gallons of rainfall applied, increased the time to runoff initiation by a factor of 6, and reduced runoff volume (Vr) by 60%.

In a similar study, Iowa State University reported that a 2 in compost blanket on a 3:1 slope, under simulated rainfall of 1 hr/100 yr return (4 in/hr for 1 hr), delayed runoff commencement by 50 min relative to a 6 inch topsoil blanket and a disk-tilled soil (Persyn et al, 2004).

Research conducted at Texas A&M, for the TX Commission of Environmental Quality, using 2 in compost blankets on a 3:1 slope of clayey soil, under a simulated rainfall of 3.6 in/hr for 1 hr (25 yr return), found that prior to vegetation establishment the compost blankets reduced runoff volume by 35% relative to soils receiving commercial fertilizer, prior to vegetation establishment (Mukhtar et al, 2004).

Tc = time of concentration - is the time it takes for a raindrop to travel from its point of surface contact to a predetermined or designated outflow

Q = the peak runoff flow rate. A high Tc and a low Q are preferred, and generally lead to greater infiltration, lower erosivity, and lower sediment and pollutant loads.

In the same study conducted by the University of Georgia, over one year, peak runoff rates for soils treated with compost blankets were reduced by 36% relative to bare soil and 27% relative to hydroseeded soil. In the same follow up study compost blankets without vegetation reduced peak runoff rates by 34% and with vegetation by 51%.

In the same Iowa State University study compost erosion control blankets reduced runoff rate by 79% relative to bare disked-tilled soil and 71% relative to a 6 in topsoil blanket.

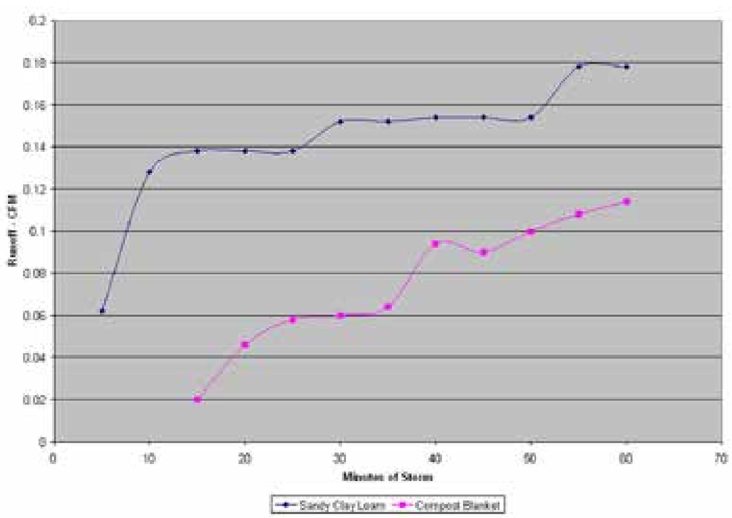
Research performed by the University of Texas-Austin, for the Federal Highway Administration and the US DOT, found that 3 in compost blankets applied to a clay soil on a 3:1 slope reduced peak runoff rates 10 fold under a 3.45 in/hr simulated rainstorm for a 3 hr duration (Kirchhoff et al, 2003).

CN = runoff curve number - is the number assigned to a watershed or surface area based on its tendency to shed water (1-99). Compost Blankets = 43. See Determining Runoff Curve Numbers for Compost Erosion Control Blankets.

C = runoff coefficient, in the Rational Formula (see below), is the ratio of runoff to rainfall. For example, C = 1, or 100% of the rainfall volume in a designated area or watershed becomes runoff. Impervious services (e.g. asphalt, concrete, roof) have a runoff coefficient of 0.95, undisturbed forests have a runoff coefficient of 0.15, lawns are 0.1 to 0.35 (depending on soil type and slope), pasture is 0.1 to 0.3, graded and unvegetated soil are 0.3 (sandy) to 0.6 (clay), gravel is 0.5, downtown areas are 0.95, neighborhoods are 0.7, single family homes are 0.5, and apartment areas have a C of 0.7 (Georgia Stormwater Management Manual, 2001). Compost blankets have a runoff coefficient of 0.05 to 0.35 (depending on soil type underneath).

Rational Formula
Where: $Q = C \times i \times A$

Q = peak runoff rate (cubic feet/sec)
C = runoff coefficient
i = rainfall intensity (in/hr)
A = area of watershed/drainage area (acres)



Unit Hydrographs

A hydrograph allows you to visually compare runoff rate of soil/vegetation complexes and/or management practices, over the duration (time) of a storm. Above is a single event hydrograph for a compost blanket and a sandy clay loam without vegetation. This is based on a constant 4 in/hr storm for a 1 hour duration (1 hr 50 yr return for this site), on a 10% slope. Generally, the slower the runoff rate and the longer the elapsed time to peak flow conditions, the more effective the storm water management practice.

LID Practices and their Benefits using Filtrexx and Compost

Runoff Filtration Practices - vegetated filter strips, bioretention ponds
Benefit: high pollutant removal efficiency (FilterSoxxTM - phosphorus, metals, suspended solids, turbidity, total solids); reduction in discharge volume of runoff to reduce pollutant loads to receiving waters (compost blankets, Filtrexx® Filtration system).

Soil Amendments (compost is listed) - used specifically to improve water retention and infiltration, increase soil aeration, reduce soil erodibility, reduce soil compaction, increase slope stabilization, and enhance vegetation establishment.
Benefit: reduced storm water conveyance and management costs; reduced area required for capture ponds; smaller ponds = less capital and maintenance cost; smaller footprint = more land for other use (e.g. development, income generation, green space, recreation, habitat conservation). Reduced storm water volume discharge = lower storm water utility fees paid to municipality. Less pollutant loading = benefit to water quality and TMDL list water bodies, and lower treatment costs.

Green Roof (compost as growing media) - used to increase hydrologic abstraction, reduce peak runoff rates, buffer temperature.
Benefit: reduced storm water discharge, lower storm water utilities, and energy savings.

Conclusions

Chemical adsorption of nutrient and metal pollutants by compost + runoff reduction from high hydrologic abstraction and water absorption of compost + removal efficiency due to settling in designed detention or filtration area = compost is ideal for bioretention ponds, rain gardens, sediment detention ponds, and storm water treatment and management ponds. For more information on design considerations and criteria using Filtrexx products and practices consult the Filtrexx® Design Manual.

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