Slopes and Low Impact Development

Designing and Siting LID Practices on Slopes

LID Barrier Busters Fact Sheet Series

Low impact development (LID) practices, also referred to as green infrastructure, include a variety of practices that are used to mimic or preserve natural drainage processes to manage stormwater. Most LID practices are designed to retain stormwater and infiltrate the water into the ground to reduce runoff, water pollution and downstream flooding.

Ideally, slopes prone to destabilization due to clearing, grading and development should be protected. However, this does not always happen in practice. In instances where development occurs on slopes, LID practices can be used when the proper precautions are followed. Note that LID practices should not be a substitute for slope protection.

> *FAQ*
>
> Are LID practices inappropriate for sloped areas?
>
> ***Barrier Busted!***
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> With proper analysis and design, LID practices can be used on slopes.
>
> EPA's LID Barrier Busters fact sheet series... helping to overcome misperceptions that can block adoption of LID in your community

Building LID practices on or near slopes presents a risk of soil erosion and landslides; risk increases when slopes are saturated with water. Because many LID practices encourage infiltration of water into the soil, planners must consider these risks when designing LID projects for areas dominated by hills and valleys.

Despite these potential risks, LID practices can be used successfully on sloped landscapes where site conditions are favorable, the correct practice is selected and the design incorporates elements to prevent slope failure and blow-out of the LID practice.

PA DEP

The rock check dams placed along this sloped, grassy swale help slow stormwater flow.

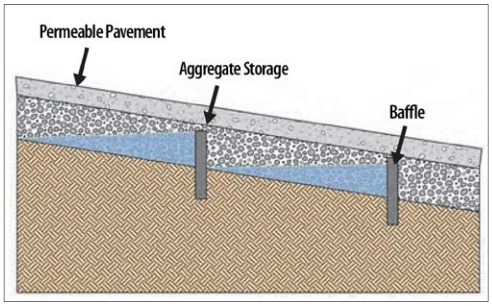
Design Features for Building LID on Slopes

Many LID practices can be implemented with design features such as vegetative plantings, diversion berms, structural walls, check dams and baffles. These features help slow down, retain and infiltrate water on slopes.

- Slopes can be stabilized by planting trees and other vegetation that hold soil in place and absorb water.
- Diversion berms can be constructed across slopes to reduce runoff velocity and erosive flows and to promote infiltration and plant growth by retaining water in depressions.
- Terraces and weep gardens can be designed with structural walls on the downslope face that will discharge excess runoff when the system is saturated.
- Check dams can be incorporated on slopes to manage the flow volume, encourage retention and infiltration, and reduce erosion.
- Baffles can be constructed beneath permeable pavement to increase storage and promote infiltration.

PA DEP

Adding structural walls to this terraced treatment train allowed it to be built in a sloped area.



Portland Cement Association

Permeable pavement designed for a slope includes baffles that encourage water infiltration.

Case Studies

110th Street Cascade, Seattle, Washington

Seattle Public Utilities installed 12 cascading bioretention cells in 2002 alongside a sloped (6 percent grade) residential road to manage the runoff from a 2-acre drainage area. The objectives of the project were to reduce the volume of stormwater, encourage infiltration, slow the flow rate, and to trap sediment and pollutants. The design used concrete walls, vegetation, soils and rocks to slow down, infiltrate and filter the stormwater. The following results were determined from monitoring the influent and effluent between 2003 and 2006.

Cascading (terraced) bioretention cells in Seattle are separated by notched concrete weirs.

Results

- The system absorbed 186 of the 235 precipitation events recorded (79 percent); no runoff or pollution was generated for these events.
- In dry antecedent conditions, storms with rainfall depths of up to 1 inch were completely infiltrated.
- For all stormwater runoff events, at least 48 percent (and as much as 74 percent) of the incoming water was retained through infiltration or evaporation.

Estimated Mass Loading Pollutant Removal Rates*

Total suspended solids	87%
Total nitrogen	63%
Total phosphorous	67%
Total copper and total zinc	80%
Total lead	86%
Motor oil	92%

* These are conservative estimates that only account for the pollutants that entered at the monitored inlet.

Source: Horner, R.R., and C. Chapman. 2007. **NW 110th Street Natural Drainage System Performance Monitoring**. Civil and Environmental Engineering, University of Washington, Seattle, WA.

Permeable Pavement Road, Auckland, New Zealand

In 2006 a 2,100-square-foot permeable pavement test site was constructed on an active roadway with a slope that varied between 6 and 7.4 percent and was underlain by clay soils. The contributing drainage area consisted of 4,250 square feet of pavement, sidewalk and grass. The project team conducted flow monitoring for 2 years to assess how effectively the project reduced stormwater runoff volume and peak flow rate when compared to a nearby conventional asphalt road which was monitored over the same time period.

This monitoring site in Auckland, New Zealand, tested the effectiveness of permeable pavement on slopes.

Results

- For the 81 observed storm events, stormwater volumes and peak flow rates measured from the permeable pavement underdrain were less than the discharge from the conventional asphalt site. Additionally, the measured flows from the permeable pavement were comparable to or below modeled predevelopment conditions.
- The permeable pavement was able to slow the flow of stormwater so that it more closely resembled the flow characteristics from a natural area, reducing peak flows and stretching out the time when peak flows occur after a storm, both of which serve to reduce flooding.
- The permeable pavement was able to effectively handle stormwater from frequent storms and large storms, even on slopes underlain with clay soils. Although not as well-draining as other soil types, the clay soils in this project area provided effective capacity for stormwater retention and infiltration (see also **Soil Constraints and Low Impact Development**).

Source: Fassman, E.A., and S. Blackbourn. 2010. **Urban runoff mitigation by a permeable pavement system over impermeable soils.** *Journal of Hydrologic Engineering* 15:475–485.

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