Use of Green Roofs to Meet New Development Runoff Requirements

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Nov. 8, 2007

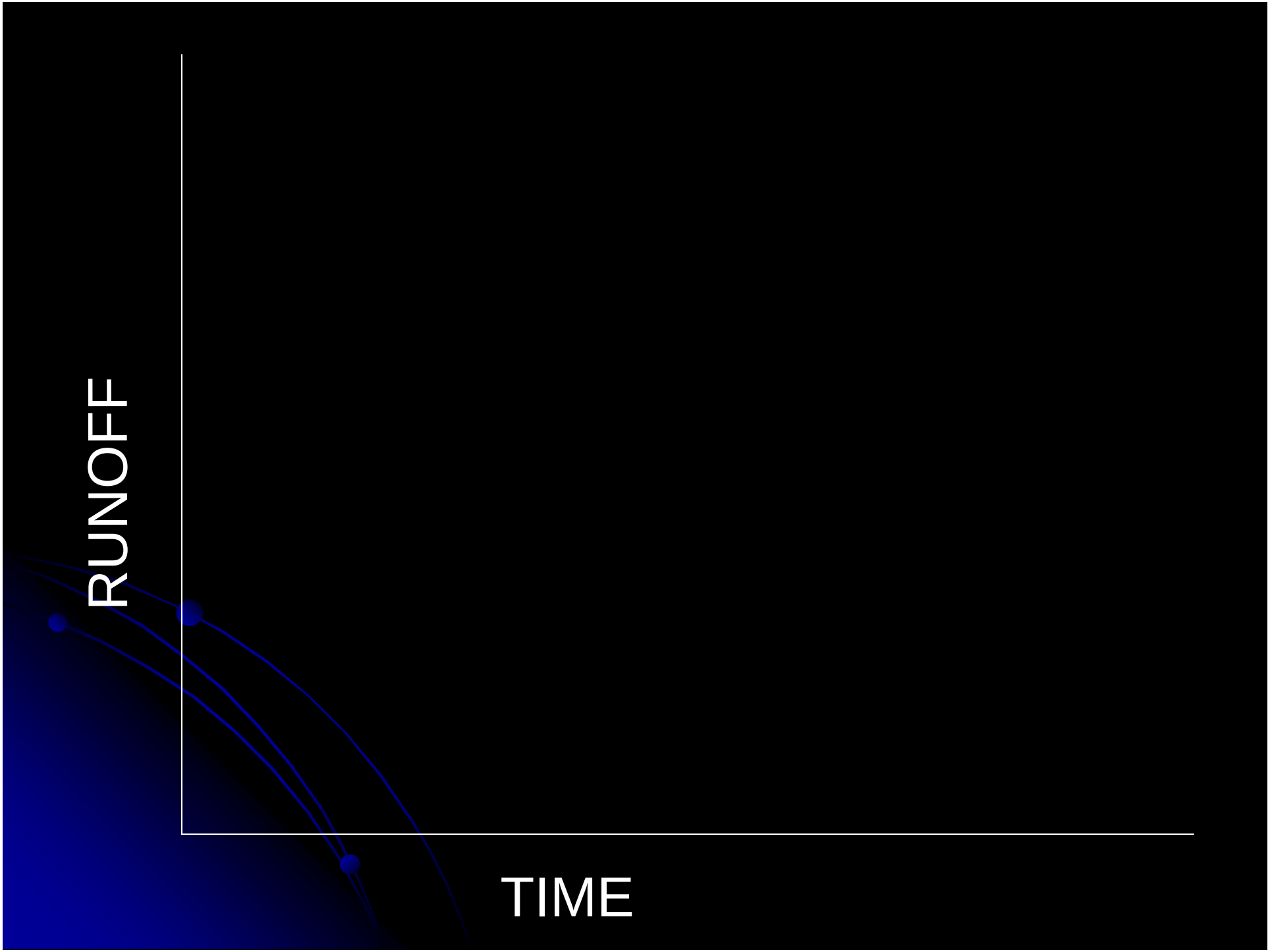
Why green roof?

- Absorption of precipitation
- Increased insulation
- Reduced urban heat island effect
- Pollutant removal
- Improved urban habitat
- Aesthetics

A green roof is a stormwater BMP

- Regulated by both state and municipal regulations
- For the purpose of reducing the rate and quantity of stormwater runoff
- Regulations exist to ensure that designated uses in the water body can be maintained

In Denver, all runoff drains to the South Platte River


RUNOFF
TIME

Denver's MS4 permit requirements

1. Commercial/ Residential Management Program
2. Illicit Discharges Management Program
3. Industrial Facilities Management Program
4. ***Construction Sites Program***
5. Municipal Facility Runoff Control Program

New development planning procedures

… The permittee (Denver) shall continue to implement planning procedures and enforce controls to reduce the discharge of pollutants after construction is complete from new development and significant redevelopment

… All *significant development or re-development shall be required to submit a plan that includes Best Management Practices as part of the development proposal

(*significant = 1/2 acre)

Denver BMP requirements

- Reduce site imperviousness as practicable
- Provide for the Water Quality Capture Volume (WQCV)
- One or more of six types of water quality basins, each draining slowly to provide for long-term settling of sediment particles, may be selected

Reducing site imperviousness

- A recommendation, not a requirement.
- BMPs for which there are criteria include grass buffers, grass swales, porous pavement
- Other BMPs include tree conservation, vegetated roofs, infiltration trenches

Calculating effective imperviousness

- **Calculating Effective Imperviousness.** The first step in estimating the magnitude of runoff from a site is to first estimate the site's imperviousness. The total imperviousness of a site is the weighted average of individual areas of like imperviousness. For instance, according to Table 3-1 of Volume 1 of the USDCM, paved streets (and parking lots) have an imperviousness of 100-percent, drives and walks have an imperviousness of 96-percent, roofs have an imperviousness of 90-percent, and lawn areas have an imperviousness of 0-percent. The total imperviousness of a site can be determined taking an area-weighted average of the imperviousness of the street, walk, roof, and lawn areas.

Benefits of reducing imperviousness

- Increased infiltration and decreased rate and volume of site runoff
- Decreased WQCV and, in turn decreased size of required WQCV facilities

Providing for the WQCV

- Runoff from 100-percent of the impervious surfaces must flow through one or more of the six WQCV BMPs
  - Porous pavement detention
  - Porous landscape detention
  - Extended detention basin
  - Sand filter extended detention basin
  - Constructed wetland basin
  - Retention pond
- Alternate equivalent designs may be considered

Treating WQCV

- WQCV is defined in Criteria Manual Vol. 3 as capture and treatment of the 80th percentile storm
- The primary pollutant removal mechanism consists of physical settling of suspended sediments and associated adsorbed pollutants. Secondary pollutant removal mechanisms include filtering, biological uptake, and adsorption.
- Detention times are specified in the Criteria Manual and depend on BMP performance

Porous pavement detention

Porous landscape detention

Sand filter extended detention basin

Retention pond

This isn't rocket science…

Alternate BMPs... green roof

Alternate BMPs… detention vault

Dry detention pond cost

- $C = 12.4V^{0.760}$
  - C = Construction, Design and Permitting Cost
    V = 10-year storm treatment volume (cubic feet)
  - $ 41,600 for a 1 acre-foot pond
  - $ 239,000 for a 10 acre-foot pond
  - $ 1,380,000 for a 100 acre-foot pond
- Land cost = 2-3% of contributing area
- Maintenance = 3-5% of construction cost

Source: Brown, W. and T. Schueler. 1997. The Economics of Stormwater BMPs in the Mid-Atlantic Region. Prepared for: Chesapeake Research Consortium. Edgewater, MD. Center for Watershed Protection. Ellicott City, MD.

Green roof cost (extensive)

- Design/specs. – 5-10% of total cost
- Project administration – 2.5-5% of total cost
- Re-roofing w/ water repellant membrane ($10-$15/s.f.)
- Green roof system ($5-$10/s.f.)
- Plants ($1-$2/s.f.)
- Installation ($3-$8/s.f.)
- Maintenance (1.25-$2/s.f.)
- Irrigation ($2-$4/s.f.)

Source: Design Guidelines for Green Roofs by Steven Peck and Monica Kuhn, B.E.S., B. Arch,O.A.A.

Green roof costs (intensive)

- Design/specs. – 5-10% of total cost
- Project administration – 2.5-5% of total cost
- Re-roofing w/ water repellant membrane ($10-$15/s.f.)
- Green roof system ($15-$30/s.f.)
- Plants ($5-$200/s.f.)
- Installation ($8-$18/s.f.)
- Maintenance ($1.25-$2/s.f.)

Source: Design Guidelines for Green Roofs by Steven Peck and Monica Kuhn, B.E.S., B. Arch,O.A.A.

EPA building costs (20,000 s.f. green roof)

- Green roof system including installation – $240,000 ($12.00/s.f. installed)
- 2 years maintenance contract – ensures 90% survival at end of 2 years -$15,540
- Irrigation installation - $54,745.00
- Watering - $7,500/yr. (est. based on $6.88/1,000gal and 55 gal/yr/s.f. required)
- Total cost = $310,285 ($15.50/s.f.) + $7,500/yr.

EPA building costs (detention vault for 14,000 s.f.)

- Detention vault system in the parking garage includes detention vault, sand filter and pump
- Installation ($150,000 including permits/fees/labor)
- Maintenance ($10,000 / yr.)
- Total cost = $150,000 ($10.70/s.f. + $10,000/yr. maintenance)

EPA building costs

- Projected cost for detention w/o green roof = 34,000s.f.(10.70) = $363,800
- 2 yr. cost difference for green roof is $96,485 (not including parking revenues lost and reduced heating costs)
  - Additional detention costs 363,800 – 150,000 = 213,800
  - Green roof costs - $310,285
  - Additional 2 yr. cost = 310,285 – 213,800

Life cycle cost analysis

- Typical roof replacement required every 10-20 years
- Typical green roof replacement required every 40 years
- Ultraviolet radiation and environmental conditions degrade roof membranes based on degree of exposure
- Heating and cooling costs reduced with added insulation

Life cycle cost analysis

- Land used for detention/retention facilities may not be used for parking or other structures
- Aesthetics can increase the potential lease price
- Reductions in stormwater (impervious surface) utility costs may be available
- Carbon credits may become available

Table 1: Green Roof & Conventional Roof Costs

	Green Roof Cost per S.F.	**Conventional Roof** Cost per S.F.	**Delta**
First Cost	$10 - $15	$3 - $9	
Mean	12.50 $/SF	6.00 $/SF	6.50 $/SF
Re-Roofing	$15 - $25	$5 - $20	
Membrane Replacement	0.00 $/SF	3.25 $/SF	-3.25 $/SF
Drainage	0.013 $/SF	0.021 $/SF	0.008 $/SF

Source: City of Portland Ecoroof Program: Bureau of Environmental Services estimates based on City of Portland demonstration projects, and information obtained from roof contractors.

First cost includes structural support

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www.epa.gov/region8/greenroof