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Overview

- What is a rain garden?
- Why have a rain garden?
- How do rain gardens work?
- What are the soil characteristics of planting mixture design?
- How do I design a rain garden?
- Where should I locate my rain garden?
- What maintenance does a rain garden need?
What is a Rain Garden?
Rain Garden or Bioretention Cell

- Plants
- Mulch
- Underdrain (optional)
- Additional Storage (optional)
- In-situ soils
- Buffer
- Ponding
- Planting Mix
- Buffer

Rain Gardens

Lathrup Village, MI
Courtesy of Lillian Dean
Bioretention Cells

Why have a Rain Garden?
Hydrologic Cycle

Pollutants in Urban Runoff

- Sediment
- Nutrients (phosphorus and nitrogen)
- Heavy Metals
- Pesticides/herbicides
- Bacteria/pathogens
- Hydrocarbons (oils/gasoline/grease)
Rain Gardens - Benefits

- Key feature for LID/conservation design
- Focus on water quality volume - know as first flush (first ½” to 1” of rainfall) & represents 90% of all rainfall events
- Filter and removal mechanism - remove sediments (85%), nutrients (50% - 80%), metals (95%), and hydrocarbons (80%)
- Stormwater master plan => rain gardens can have tremendous impact on a watershed

Rain Gardens - Benefits

- Improved natural habitat & biodiversity
- Less drug depended turf grass to mow (reduces carbon emission - global warming)
- Landscaping improves property values
- Joy of gardening
How do Rain Gardens work?

- Rain Gardens capture and filter stormwater
- Numerous physical and biological processes including evapotranspiration, adsorption, filtration, plant uptake, microbial activity, decomposition, and volatilization
- Planting mix comprised of sand, topsoil, and compost - topped with mulch
How do Rain Gardens work?

- **Mulch**
  - Filter pollutants & microorganism degrade hydrocarbons
  - Protects planting mix from eroding and holds moisture in during dry season
- **Planting Mix**
  - Absorbs and degrades pollutants
  - Clay specifically good at absorbing hydrocarbons and heavy metals
  - Sand improves drainage
  - Compost provides nutrients and increases retention

How much sand, topsoil, or compost should I use?
Rain Garden Mix Designs

- Numerous recommended mix designs have been published (17 states & 2 others)
- For new community developments mix designs might be specified by municipality
- Example Mix Designs:
  - 50% sand, 30% topsoil, 20% compost
  - 20% sand & 60% compost (SOCWA)
  - NRCS Soil Triangle (Loamy Sand to Sandy Loam)

Balance sand & compost based on your specific site and native soils.
How do I design a Rain Garden?

Observation or Quantitative
Rain Garden Infiltration

- Infiltration of native soils is key for performance
- Need native soil information for proper design
  - HSG maps (soil type A (1 to 3 in/hr); B (0.5 in/hr); C (0.2 in/hr); D (< 0.1 in/hr)
- Home test
  - 18” hole – fill with water; drain, refill and record
  - Infiltration rate \( i \) = rate fall/time = inches/hour
  - If original fill takes more than 48 hours = clay
  - Key is infiltration at “bottom” of the rain garden

Rain Garden Infiltration

- Improve infiltration by tilling or ripping
- \( i > 0.5 \) in/hr then basic rain garden design
- \( i < 0.5 \) in/hr => underdrain or overflow
- Above seasonal water table
Rain Garden Sizing

- Total area flowing into a rain garden should be less than 1 ac total and ½ acre impervious
- Minimum rain garden dimensions are commonly 10 ft by 20 ft
  - any size will work as a landscaping feature
- Recommended planting mix depth is 2.5 ft (1 ft to 4 ft)
- Ponding depth is typically 6” to 18”
- Recommend 24 to 48 hours to drain (< 72 hours)

Rain Garden Sizing Techniques

- Homeowner How-to Manuals available from U of Wisc. Ext., VA Dept of Forestry, & SOCWA (handout)
- Numerical Design Techniques
  - Run-off Method
  - Simplified Darcy’s Law
Rain Garden Design
Run-off Method

- Developed in the Mid-Atlantic
- Assumptions
  - 1” of rainfall will be capture
  - 2.5 ft and 4ft of planting depth with 50/30/20 mix
  - 6” ponding with 48 hour drainage time
  - Doesn’t consider native soils

\[
SA = 0.07 \times (C_{\text{imp}} \times DA_{\text{imp}} + C_{\text{green}} \times DA_{\text{green}})
\]

- \(SA\) = surface area of filter bed (rain garden) (ft\(^2\))
- \(C_{\text{imp}}\) = runoff coefficient of impervious surfaces = 0.9
- \(C_{\text{green}}\) = runoff coefficient of green areas = 0.25
- \(DA\) = drainage area (ft\(^2\))

Rain Garden Design
Simplified Darcy’s Law

- Simplified by Dr. Carpenter
- Assumptions
  - 1” of rainfall will be capture (90% of all rain events)
  - Excess rainfall should be bypassed
  - Well maintained rain garden with mix of compost/sand
  - 48 hour drainage time
  - Includes infiltration rate of native soils
Rain Garden Design
Simplified Darcy’s Law

\[ SA = \frac{0.04 \times c \times DA \times \text{depth}}{(i \times (\text{depth} + \text{ponding}))} \]

- \( SA \) = surface area of rain garden (\( ft^2 \))
- \( DA \) = drainage area (\( ft \))
- \( \text{depth} \) = planting bed depth (\( ft \))
- \( i \) = infiltration rate (\( ft / day \))
- \( c \) = runoff coefficient (between 0.1 and 0.9)
- \( \text{ponding} \) = average ponding depth (\( ft \))

Runoff coefficient spectrum

<table>
<thead>
<tr>
<th>Native</th>
<th>Lawn</th>
<th>Patio</th>
<th>Roof/Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
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</tbody>
</table>

Bioretention Cell Design Example
Rain Garden Design Solution Sheet
Run-off Method

\( D_A = 7500 \text{ sq ft total with 2000 sq ft roof & 5500 sq ft backyard} \)
\( C_{imp} = 0.9 \)
\( C_{green} = 0.25 \)

Solution:

\[ S_A = 0.07 \times (C_{imp} \times D_A_{imp} + C_{green} \times D_A_{green}) \]
\[ S_A = 0.07 \times (0.9 \times 2000 + 0.25 \times 5500) = 222.25 \text{ ft}^2 \]

Dimensions of Rain Garden = 20 feet by 11 feet

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Rain Garden Design Solution Sheet
Darcy’s Law

\( D_A = 7500 \text{ sq ft total with 2000 sq ft roof & 5500 sq ft backyard} \)
\( c = 0.4 \)
\( depth = 2.5 \text{ ft} \)
\( ponding = 0.3 \text{ ft} \)
\( i = 1 \text{ ft/day (sandy soils)} \)

\[ S_A = 0.04 \times c \times D_A \times \text{depth} \times \frac{\text{ponding}}{(i) \times (\text{depth} + \text{ponding})} \]
\[ S_A = \text{surface area of rain garden (ft}^2) \]
\( D_A = \text{drainage area (ft)} \)
\( depth = \text{planting bed depth (ft)} \)
\( i = \text{infiltration rate (ft/day)} \)
\( c = \text{runoff coefficient} \)
\( ponding = \text{average ponding depth (ft)} \)

Solution:

\[ S_A = 0.04 \times 0.4 \times 7500 \times 2.5 \]
\[ \frac{1}{1 \times (2.5 + 0.3)} = 100 \text{ sq ft} \]

Dimensions of Rain Garden = 12 feet by 8 feet
# Rain Garden Sizing Comparison

- 1000 sq ft of roof (all impervious)
- 2.5 ft of planting depth & 0.5 ft ponding
- Sand (1.0 ft/day) & Clay (0.2 ft/day)

<table>
<thead>
<tr>
<th></th>
<th>Simplified Darcy’s</th>
<th>Run-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>30 sq ft</td>
<td>63 sq ft</td>
</tr>
<tr>
<td>Clay</td>
<td>150 sq ft</td>
<td>63 sq ft</td>
</tr>
</tbody>
</table>

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### Where should I locate my Rain Garden?
Rain Garden Design
Location & Landscaping

- Observe natural flow paths
- Direct water from down spouts and pavement into the garden
- Create berms with overflows
- Not within 10 ft of building foundation
- Avoid underground utilities!
- Avoid disturbing mature trees & drip zones
- Avoid areas of standing water

- Limit erosive velocities enter garden
- Site slopes (min 10H:1V – max 3H:1V)
- Buffer zones to limit fines and reduce velocities (rock, grass, etc.)
- Multiple smaller gardens might be more effective than one larger garden especially in clay soils
- Proper landscaping and plant choice is essential
- 2” to 3” of aged hardwood mulch (max!)
What maintenance does a rain garden need?

Rain Garden Maintenance

- Regular Maintenance
  - Weeding, watering
  - Cutting, pruning, and removing
  - Replace and replant
  - V-notch edge
  - 2” to 3” of aged hardwood mulch (as needed)
Field Infiltration Measurements

<table>
<thead>
<tr>
<th>Municipal Rain Gardens (7)</th>
<th>Private Rain Gardens (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.7</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>1.9</td>
</tr>
<tr>
<td>High</td>
<td>4.1</td>
</tr>
<tr>
<td>Low</td>
<td>0*</td>
</tr>
</tbody>
</table>

*below detectable limit; ^underdrain present

References & Resources

- Lawrence Tech University Stormwater Page
  http://www.ltu.edu/stormwater.html
- SOCWA Healthy Lawns and Gardens -
  http://www.socwa.org/lawn_and_garden.htm
- Rain Gardens of West Michigan -
  http://www.raingardens.org/Index.php
- Virginia Department of Forestry – Rain Gardens Technical Guide
  http://www.dof.virginia.gov
- Minnesota Stormwater Manual-
- Low Impact Development Manual for Michigan
  http://www.semco.org/lowimpactdevelopmentreference.aspx
- Center for Watershed Protection
  http://www.cwp.org
Questions?

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