Fort Wayne Green Infrastructure Series

Rain Gardens 101
Presented by Steve Barker
Rain Garden Design Outline

- Rain garden basics
- Determining rain garden size
- Example of sizing and evaluation
Why Do We Use Rain Gardens?

- Recharge local and regional aquifers
- Protects from flooding and drainage problems
- Protecting our streams and lakes from pollutants
- Provides valuable habitat for birds/butterflies etc.
Impacts of Conventional Development

- Increased runoff volume
- Decreased evapotranspiration and groundwater recharge
- Increased frequency of runoff events
- Faster conveyance of water
- Erosion and stream channel changes
- Decreased baseflow
- Impacted aquatic life
- Pollutants and temperature impacts
What is a Rain Garden?

• What is not a rain garden!
Types of Rain Gardens

Infiltration – recharge groundwater

Infiltration-filtration – partial recharge, filter and send downstream

• 3rd type – filtration – No groundwater interaction
• Type depends on site conditions and goals
• Regulatory or ordinance-driven objectives
Rain Gardens vs. Bioretention

- Size does matter?
Rain Garden Treatment Zones

Figure 7.5
Schematic of a small residential rain garden
Lean on the Green or the Bio in Bioretention

Evapotranspiration
Water evaporates from plant

Interception
Leaves and stem intercept up to 1/3” of rain

Erosion Control
Plants provide effective erosion control

Filtration
Plants filter nutrients from runoff

Infiltration
Root zone filters and transfers water to underlying material
Rain Garden Design…
Where to begin?

• Google search for RG or bioretention results in many hits

• State stormwater management manuals

• Variety of “light” publications geared toward homeowners
Rain Garden Location

- Rainwater runoff v. nearest waterway or storm drain
- Building foundations
- Call before you dig
- Don’t excavate under large trees.
Matters of Opinion – Design Criteria

- Size of event to capture
- Size and sizing of rain garden
- Ponding or drawdown time
- Depth of basin
Common Themes – Design Criteria

- Captured storm event – Most frequent size events
- Size – 3 - 20% of watershed
- Sizing – Regional method for Q
- Ponding – Plant survivability
- Depth of basin – Less than 18”
First Flush Principle

24-Hour Precipitation Totals at Hite Creek Wastewater Treatment Plant, Jefferson County, Kentucky

Rainfall (inches)

Month

2003
2004
2005
2006
2007

13.5%
86.5%
0.75
Common Themes – Design Criteria

• Captured storm event – Most frequent size events

• Size – 3 to 20% of watershed

• Sizing – Regional method for Q

• Ponding – Plant survivability

• Depth of basin – Less than 18”
Rain Garden Components

- Pretreatment
- Flow inlet
- Ponding area (basin)
- Plant material
- Mulch
- Planting soil
- Positive overflow
Rain Garden Design Steps

• Site Reconnaissance/feasibility

• Desktop analysis
  • Watershed area
  • Soils mapping

• Sizing
  • Defining/re-defining WQ goals
  • Modeling of some sort – back of envelope vs. hydrologic model

• Verification of sizing and drawdown

• Plant selection

• Putting it all together - pricing
Is A Rain Garden A Feasible Option?

- Existing soils/hydrology
- Land uses
- Cost
Site Reconnaissance - Feasibility

• What types of land uses are draining to the basin?

• Are there underground utilities?

• Where does the water go? Where can it go?

• What happens to backed up water?

• What are the existing site conditions? Soils? Drainage?
Desktop Analysis

- Determine watershed size
  - Topo maps
  - GIS
  - Google Maps or other online mapping tools
- Determine percentages of land uses in watershed
- Look up soils information
  - Hydrologic group – next step
  - Hydraulic conductivity – in a few more steps
Desktop Analysis - Soils

- Web Soil Survey –
  http://websoilsurvey.nrcs.usda.gov/app/

- Hydrologic group

- Saturated hydraulic conductivity (Ksat)

- Get info in report/table form
Rain Garden Sizing

- **1st Run** - % of watershed area (3 – 20%)
  - Back calculate, if watershed area is known
  - Doesn’t factor in land use and soils
  - Increase for more impervious surface in watershed

- **2nd Run** – Estimate runoff depth and volume to estimate amount of storage required
  - Hand calculations
  - Computer software – Win TR-55, RECARGA, SWMM
1.5 acre watershed within mixed land use with 75% park, 20% light residential (small lots <1/8 acre), 5% Impervious surface.

All land uses in are Soil Hydrologic Group C

Method 1 – Rule of Thumb

1,961 sqft (3%); 5,228 sqft (8%); 7,841 sqft (12%)
Sizing Example

- Weighted CN
  - 0.75 * 74 (Park-well developed) = 55.5
  - 0.05 * 90 (Residential) = 4.5
  - 0.20 * 98 (Impervious) = 19.6
  - Weighted CN = 80

- S = (1000/CN) - 10 = 2.5

- Runoff depth = \((P - 0.2*S)^2/(P + 0.8*S)\)
  = \((1 - 0.2*2.5)^2/(1 + 0.8*2.5)\) = 0.08 in.

- Runoff volume = 0.08 * (1/12) * 1.5 * 43,560
  453 cft of stormwater from 1-in event
Basin Design

Source: Prince George’s County Bioretention Manual with modifications by Cahill Associates, 2004
Basin Infiltration

- Soil infiltration rate – Need 1 – 6 in/hr (kSat)
- Existing soils
- Amended soils – 60-70% sand; 30-40% compost

Table 3.2 Soil Texture Effects on Bioretention Facility Design

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Sat. Hydraulic Conductivity (in/hr)¹</th>
<th>Typical Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>3.60</td>
<td>Basic Bioretention</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>1.63</td>
<td>Basic Bioretention</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>0.50</td>
<td>Basic Bioretention</td>
</tr>
<tr>
<td>Loam</td>
<td>0.24</td>
<td>Underdrain Recommended²</td>
</tr>
<tr>
<td>Silt Loam</td>
<td>0.13</td>
<td>Underdrain Required</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>0.11</td>
<td>Underdrain Required</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>0.03</td>
<td>Not Recommended for Infiltration³</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>0.19</td>
<td>Underdrain Required</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>0.04</td>
<td>Not Recommended for Infiltration³</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>0.07</td>
<td>Not Recommended for Infiltration³</td>
</tr>
<tr>
<td>Clay</td>
<td>0.07</td>
<td>Not Recommended for Infiltration³</td>
</tr>
</tbody>
</table>

2. Underdrain system recommended but may be capped initially; see section 3.6 for details.
3. Generally not feasible to meet infiltration goals; however, may be used for water-quality treatment if designed with an underdrain.
Amended Soils

• Use when existing soils do not provide enough infiltration

• Custom mixed by vendor or on-site

• Minimum of root zone depth (1.5 ft to 4 ft)
Filtration Rain Gardens – Underdrain

- Storage layer (below root layer) has limited infiltration
- Basin filters stormwater and dampens stormwater pulse
- Estimate infiltration rate using Darcy’s Law
- Estimate size or number of underdrains (2 step process)
Darcy’s Law

- \( q = \frac{k \Delta H}{L} \)
  Where \( k \) = hydraulic conductivity, \( \Delta H \) = change in head (height of water), \( L \) = depth of soil layer to underdrain

- Example – 9 in. deep basin with a 3 ft soil layer with a Ksat of 0.15 in/hr. Total basin area is 750 sqft.

- \( q = 0.15 \times (9 \times \frac{1}{12} + 3) / 3 = 0.19 \) in/hr per unit area

- Total flow (\( Q \)) = \( q \times \) basin area (convert to cubic ft/sec)

- \( Q = 0.19 \times (750 \times \frac{1}{12}) \times (1/3600) = 0.003 \)

- Outflow needs to be 10X inflow = 0.003 \times 10 = 0.03 \text{ cfs}
Calculating Outflow and Underdrains

- Total flow (Q) = q*basin area (convert to cubic ft/sec)
  
  \[ Q = 0.19 \times (750 \times 1/12) \times (1/3600) = 0.003 \]

- Outflow needs to be 10X inflow = 0.003 * 10 = 0.03 cfs

- Underdrain Size and No. = \( 16 \times ((Q \times n)/s^{0.5})^{3/8} \)
  
  Where Q = outflow, s = pipe slope, n = Manning’s coefficient

- Example – \( N \times D = 16 \times ((0.03 \times 0.014)/0.005^{0.5})^{3/8} \)
  \( N \times D = 2.3 \) inches – 1 single-walled 4-inch pipe would drain rain garden
Plant Selection

- Selection is driven by salinity, soils, basin size, aesthetics, maintenance

- In general, species that can be inundated for a short period and have extended dry periods is critical.

- “Mesic” species
Design in the Formal Landscape

Basic landscape principles apply.
- Staggered bloom times
- Taller species in the back
- Accent vantage points
- Use species that behave themselves within the mix
- Establish an edge to clarify planting zones
- Address maintenance and weed control

Promote natural landscape buy-in through education.
Use nesting boxes to benefit wildlife.
Native Plants: Their Role in the Landscape & Ecosystem

- Adaptable
- Resistant to disease
- Drought and pest tolerant
- Support wildlife habitat
- Provide food / shelter
- Promote ecosystem health
- Promote ecosystem resilience
- Improve soil / water / air quality
- Reduce maintenance costs
Native Plant Selection

- Must be customized to hydrologic regime
- Plants and seed mixes differ with Ecological BMPs
- Plugs **should** accompany seed mixes to ensure success
Top Species for a Rain Garden

A successful rain garden should have wet species in the lowest sections and upland species around the rim.
Black-eyed Susan
Swamp Milkweed
Cardinal Flower
Swamp
Bergamot
Blazing Star
Black-eyed Susan
Fox Sedge
Remaining Rain Garden Components

- **Pretreatment** – Drainage swales, grassed filters, stone diaphragms – Reduce amount sediment

- **Flow inlet** – Channelized inflow from pipe or swale needs protection to dissipate energy – stone or blanket

- **Mulch** – Composted or shredded hardwood mulch. Min. of 2 in (3-4 in, preferred).

- **Positive overflow** – Ability to control overflow – emergency outlet, drain above basin
Rain Gardens Applied
Residential Section
Commercial Section
Strip Mall Parking Lot
Practically Easy Landscape Maintenance
A Care Manual for Natural Drainage Systems

A Care Manual for Natural Drainage Systems

What's in this Manual?
This manual includes helpful tips for major landscape maintenance tasks needed to establish and nurture Natural Drainage System plantings, or to maintain any residential yard, such as...

Watering
Answers questions about how much and how often plants need to be watered.

Weeding
Answers questions about which plants are weeds and how to minimize weeding.

Mulching
Answers questions about why mulch is good, how to mulch and with what materials.

Other Gardening Tasks
Other maintenance tasks include brush removal, lawn care, fall leaves, pruning, fertilizing and pest/disease control.

Landscape Maintenance
Calendar & Guide Card
Summarizes tasks and tips, and illustrates common weeds likely to sprout. Take the laminated version, located in the back pocket of this guide, outside with you while gardening or post it in your home garden shed.

Plant Identification
Illustrates a typical planting cross section, and provides photos and descriptions of plants installed for the Natural Drainage System in your neighborhood.

Resources
Bibliography, web sites, contact numbers.

Year 1: Watering Schedule for Summer (June – August)

<table>
<thead>
<tr>
<th>Type of Plant</th>
<th>Amount of Water</th>
<th>Frequency for Year 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree</td>
<td>5 – 10 gallons</td>
<td>Once a Week</td>
</tr>
<tr>
<td>Shrub</td>
<td>3 – 6 gallons</td>
<td>Once a Week</td>
</tr>
<tr>
<td>Ground Cover</td>
<td>1 – 2 gallons</td>
<td>Once or Twice a Week</td>
</tr>
<tr>
<td>Perennial/Annual</td>
<td>1/2 gallons</td>
<td>Twice a Week</td>
</tr>
<tr>
<td>Grass Lawn†</td>
<td>1 inch</td>
<td>Per Week</td>
</tr>
</tbody>
</table>

*Option: Stop watering lawn. Mowing is reduced while grass is dormant.

Some common weeds:

*Birdweed  *Butterfly Bush  *Canada Thistle  *Cats ear

*English Ivy  *Groundsel  *Horse Robert  *Scotch Broom
Maximizing Open Space

[Diagram showing a water management system with various components like ponds, filters, and pipes, indicating a multi-step process for water collection and distribution.]

[Image of a natural outdoor setting with a paved path and wildflowers, illustrating the application of open space management techniques.]
Conclusions

• Rain gardens/bioretention used to improve water quality, stormwater volume and velocity

• Designed to capture a minimum of 0.75 in – 1 inch rain event – Pass larger events

• Inputs needed to estimate rain garden size
  • Watershed size and characteristics (land use, soils)
  • Stormwater run-off volume
  • Basin characteristics (depth, root zone, storage layer, underdrain)
  • Plant characteristics
  • Basin protection for inflow and overflow

• Can use simple to complicated methods to estimate and re-check basin size and characteristics

• Design effort = what’s at stake i.e. large site, high profile, public perception, regulatory or ordinances, and operation and maintenance