A Program
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North Carolina Cooperative Extension

NC STATE UNIVERSITY
Bio&Ag ENGINEERING

NC COOPERATIVE EXTENSION

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Manual by Wendi Hartup

Common Rain Garden Questions Answered

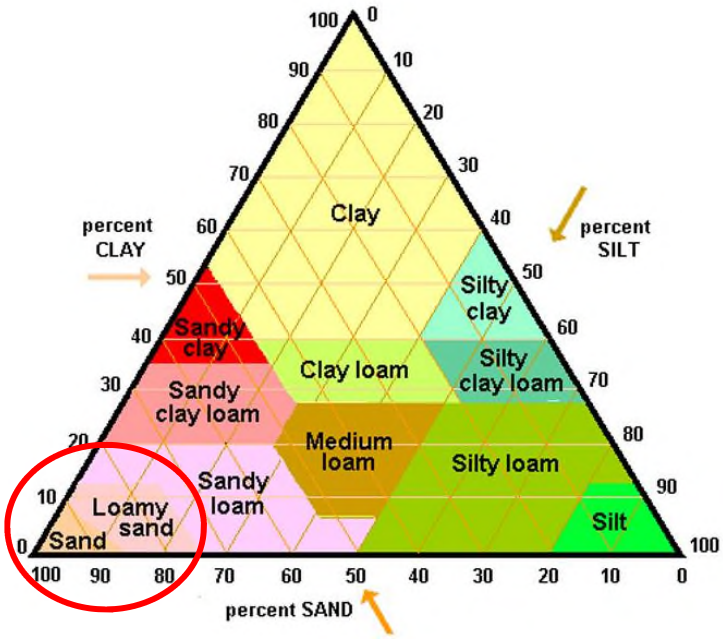
What is a rain garden? A garden shaped into a bowl-like depression in the ground to capture rainfall runoff from your rooftop and driveway and allow water to filter into the ground. The plants, mulch and soil in a rain garden combine natural processes to filter pollutants from runoff and break down in the soil over time.

Why do we need rain gardens? Many of our forests and other vegetated areas are developed into impervious surfaces like parking lots, roads and buildings. As plants are replaced with hard, compacted surfaces, the rainwater is unable to disperse energy and gradually soak into the ground. Instead this stormwater races across pavement picking up pollutants and sediment as it moves along curbs and ditches to storm drains; which empty directly into local waterbodies.

What are the benefits of rain gardens?

- Easy to design, install and maintain
- Come in all shapes and color schemes
- Provide aesthetic appeal while blending into landscape
- Provide habitat for wildlife, butterflies and beneficial insects
- Absorb nutrients and some heavy metals
- Enhance infiltration, stabilize soil and minimize runoff to storm drains

What type of soil conditions are needed for a rain garden? Rain gardens are essentially a water infiltration device. Ideally the soil conditions for rain gardens should have high percentages of sand with some loam and/or clay content to support plant growth and encourage infiltration (see red circle in diagram below).



Soil Texture Diagram

Rather than trying to change your soil conditions, consider working with how your soil drains and picking plants appropriate for that soil type.

Will this work without plants or just grass? Yes, just aerating the soil reduces soil compaction but do be sure to cover with some type of mulch. It will also work with just grass but you will need to mow it at 4 inches or at the highest setting. Using plants helps the rainwater to travel more efficiently through the soil to recharge groundwater. Native perennial root systems can extend 2 feet or more if the conditions are right! Turf root systems usually only grow 4-6 inches deep.

What types of plants are suitable for a rain garden?

- Tolerate periods of saturated soil, yet also thrive under dry conditions
- Most natives
- Sustainable and low maintenance

What types of plants are NOT suitable for a rain garden?

- Trees (growth changes sun conditions and alters spacing available for other plants)
- Heavy feeders (ex. Crape Myrtle)
- Plants that do not like "wet feet" (ex. Asian Azalea cultivars)
- Plants susceptible to root rot (ex. Flowering Dogwood)
- Plants with aggressive root systems (ex. Willows)

Does a rain garden form a pond? No. Rain gardens are designed to allow a typical one-inch rainfall to soak into the ground within three days (Note: a wetland garden would allow water to pool longer than 3 days).

Will there be standing water? Yes, after a rain there will be water in your garden. It may even look flooded. THIS IS OKAY! There may be 6"-9" of standing water for up to three days. This ponding will allow for the stormwater to slowly infiltrate into the ground.

Are they a breeding ground for mosquitoes? Not if they are draining properly. Most mosquitoes need about a week to complete their entire lifecycle. Mosquitoes are more likely to lay eggs in bird baths, storm drains, corrugated pipe attached to downspouts and lawns than in a sunny rain garden. Also rain gardens attract dragonflies, which eat mosquitoes!

Will I have to water the rain garden? After planting, yes! First season, yes! In droughts, yes! In rain, no!

Is a rain garden expensive? It doesn't have to be. The main cost will be purchasing the plants (often these are already in the landscape or swap plants with your neighbor) and mulch.

Sandy Ridge Community Center Rain Garden

Apex, NC Town Hall Rain Garden

Quick Steps to Building a Rain Garden

Step 1: Locate the Rain Garden

Observe your yard during a rainfall event. Determine where water begins flowing and where it is going. Rain gardens should ideally be located between the source of runoff (roofs and driveways) and the runoff destination (drains, streams, low spots, etc.). Be sure to consider the following:

- **IMPORTANT: Do not place rain garden uphill of homes, septic systems or wellheads!**
- Locate at least 10' away and downslope of the house foundation, if crawlspace or basement (if home is on a slab locate downslope of foundation).
- Locate 25' away and downslope of a septic system drain field.
- Locate 10' away and downslope of a well head.
- Avoid underground utility lines BEFORE you dig (Call 1-800-632-4949 or 811 in NC).
- The best location for the garden will be in partial to full sun (at least 4 hrs of sunlight).

Step 2: Determine Drainage of Soils

Rain gardens work best when constructed in well-drained soils, but they can also be installed on sites with less permeable soils with more clay content. Determining how the soil drains will help determine the type of plants most likely to succeed in the rain garden.

Pick a few places and dig a one-ft-deep hole for the preliminary infiltration test; then fill with water a few times. Time how long it takes for the test pit to drain. If satisfied with drainage time, dig 2-3 more one-ft-deep holes in that area to get an average drain time. CAUTION: In floodplain areas or East of I-95, dig two-ft-deep holes where high water tables are probable (highest in winter). The table below summarizes what type of practice to use based on drain time.

Drain Time	Appropriate Rain Garden Type
< 12 hours	Quick Draining Rain Garden
12 - 72 hours	Standard Rain Garden
> 3 days	Wetland Garden

Signs of an impermeable, compacted and/or wetland soil.

- The site ponds water or remains saturated for over four days after a storm event.
- Water poured in the dug hole is still there after four days, provided it hasn't rained.
- The soil shows signs of being a wetland soil within a foot of the surface. A wetland soil is often gray with ribbons or areas of brown color. It can also smell like rotten eggs.

Conduct drainage test at least twice at each hole! Also a good time to collect soil for testing to determine proper lime application.

Step 3: Size the Rain Garden

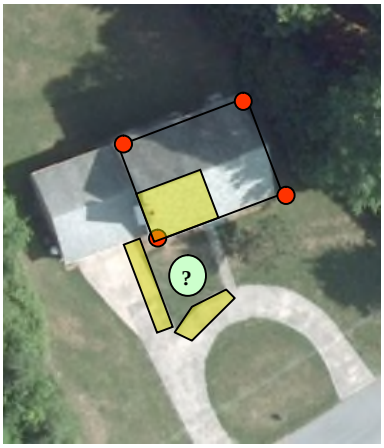
Determine which impermeable surfaces (roof top and driveway) will be treated with the rain garden. Measure the length and width of these surfaces and multiply together to get the surface area in square feet. This will be your watershed size.

The size of the rain garden should be at least 10% of the impervious surface draining to the rain garden. Rain gardens should be designed to pond 10 inches of rainwater on top of the mulch. Rain gardens that are 10% of the watershed and have a 10" ponding depth should capture the majority of one-inch storms.

(Length of surface x Width of surface) x .10 = total rain garden area sq. ft.

EXAMPLE: A portion of a 60' by 60' house (4 downspouts total) and 500 sq ft of driveway runs off to the rain garden location. The rain garden will capture 1 inch of rainfall, what size should the rain garden be?

$$\text{Roof area} = \frac{60 \text{ x } 60}{4} = 900\text{ft}^2$$



Roof area plus driveway: 900 + 500 = 1400 sq ft

Divide square footage by 10: 1400/10 = 140 sq ft

A 11'X12' or 14'X10' garden design would be sufficient.

The size of your rain garden can also depend on the space available and your budget. If you don't have enough space, you can build multiple rain gardens or build a smaller one and plan for it to overflow more often.

Step 4: Construct the Rain Garden

Consider how rainwater gets to your rain garden. Will the water sheet flow across the landscape from the downspout? Will the water be piped underground to daylight into the rain garden?

Lay out the boundary of the garden to keep a shape. You can use a rope, spray paint or even flags to outline your shape. Keep in mind how you determined the infiltration time period in Step 2.

NOTE: Always determine where utility lines are located BEFORE you start to dig. CALL 811!

Helpful Tools

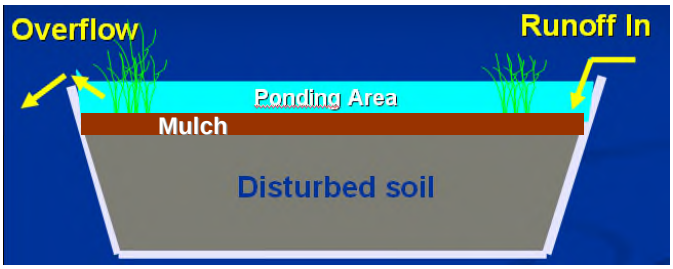
- **Auger**
- **Tape Measure**
- **Shovels and/or Backhoe**
- **Rakes**
- **Pitchforks**
- **Trowels**
- **Tamper**
- **Wheelbarrow**
- **Line Level and/or Ruler**
- **Stakes and String**
- **Tarp**
- **Extra Labor**

- If present, remove and save sod for berm and weir
- Remove any topsoil and set aside.
- Dig to account for 10" ponding depth.
- Dig to account for 3" of mulch.
- Rough up 4"-6" of the bottom so it is not compacted and mix in topsoil you removed earlier. This will not only improve drainage but help plants survive. This is a good time to apply lime if you took a soil test.

NOTE: Contact your County's Cooperative Extension office for soil sampling boxes or visit http://www.ncagr.gov/agronomi/sthome.htm/

Forming the Berm and Overflow Weir

Your rain garden is designed to capture the first inch of rainfall. Rainfalls larger than 1" will cause the rain garden to overflow. Rain gardens should have distinct entrances and exits to prevent erosion.



<u>Rain Garden Entrance</u>

Establish a 1'-2' grass strip, rock border or combination along the upper edge of the rain garden to slow down the runoff water as it enters the rain garden. If piping downspouts to rain garden, make sure the pipe opens up into the rain garden and is not buried.

Rain Garden Exit

You will have lots of soil available from digging. Place extra soil on the downhill side of the rain garden to create a berm, an earthen dam or barrier that holds water inside. Most rain gardens have berms about 3" - 6" tall. Compact the soil slightly with your feet or shovel as you build the berm. Cover with turf grass sod, mulch, plants, or rocks.

You will need to design a weir or nature will do that for you. A weir is an area of the berm that allows water to gently pass over it. Typically weirs are a one-foot wide section of the berm and several inches lower than the rest of the berm. To properly size the weir, use the amount of impervious surface area (see table below). Weirs can be covered with turf grass sod or rocks; additionally they can be made of wood. Make sure the weir is level and lower than the rest of the berm.

Weir Sizing Table

Impervious Surface Area (ft^2)	Overflow Weir Length (ft)
2000 or less	1.0
3000	1.5
4000	2.0
5000	2.5

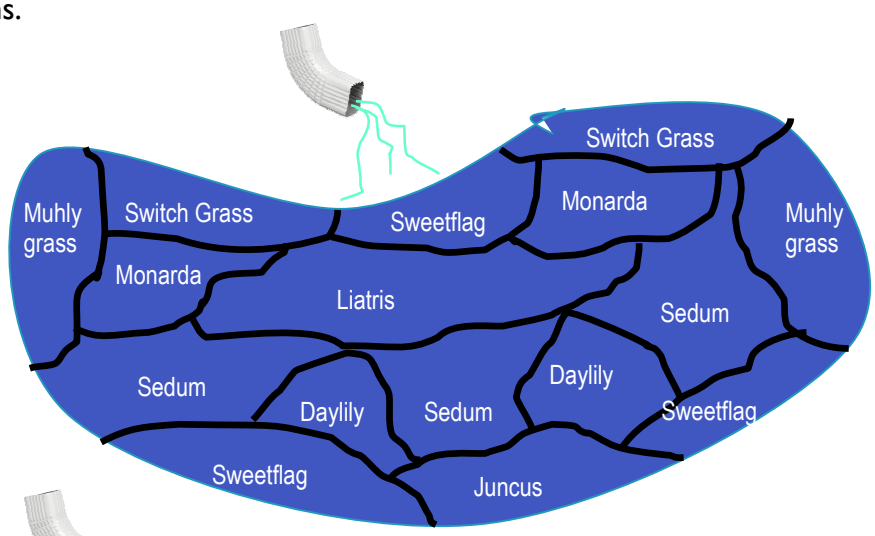

Guilford Cooperative Extension Rain Garden


Dixie Classic Fairgrounds Rain Garden

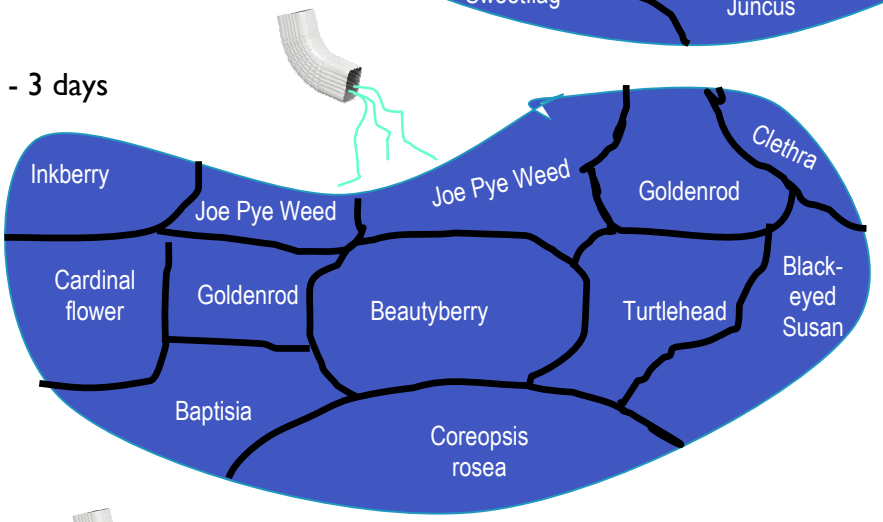
Adding Plants

Pick your plants based on how your soil drains so you are working with nature instead of against it. Below are example rain garden plans.

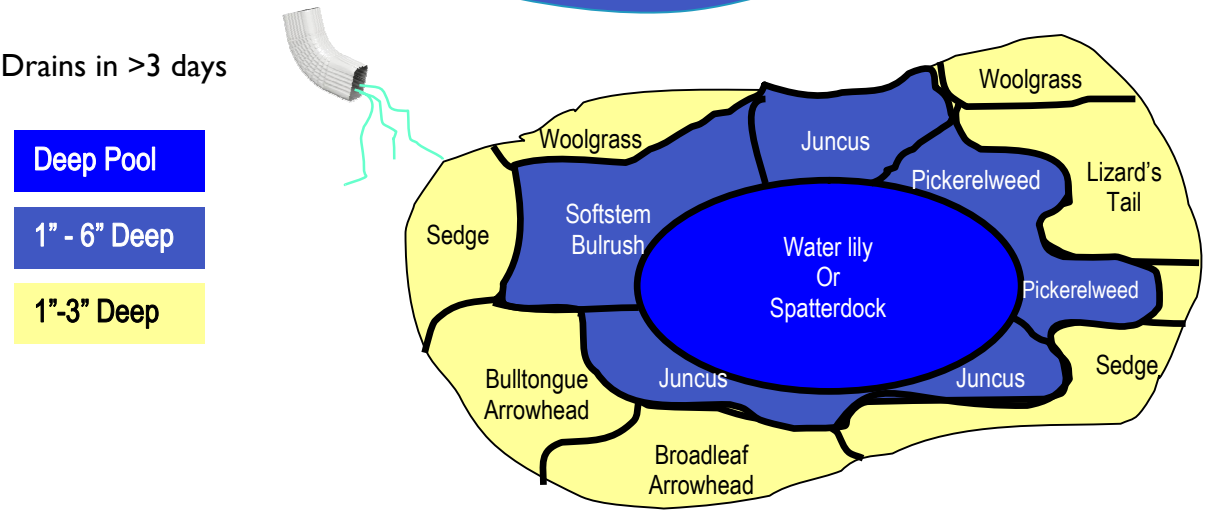
Drains in <12 hrs



Drains in 12 hrs - 3 days



Drains in >3 days



- ♻ Add 3" double or triple shredded hardwood mulch.
- ♻ Direct the downspout to the rain garden.

Step 5: Water and Weed the Rain Garden

Make sure to water every 7-10 days without adequate rainfall (1" per week) until plants become established; usually takes the first year. Once established, plants should be watered in long periods of drought.

Fertilizers are typically not necessary.

Refresh mulch annually. Loosen existing mulch and add only if needed up to 3 inches of mulch. Best times to mulch are after 1st frost in fall or after last frost in spring, otherwise the plants could be insulated too soon. Un-mulched surfaces may develop into a hardpan, a condition in which the soil surface becomes cemented together, forming a hard, impervious layer. Make sure mulch is only 3-4 inches; too much mulch will reduce ponding and function of rain garden.

Weed regularly during plant establishment, as newly planted species may have a tough time competing with weeds. Once plants become established, less weeding will be required.

Pruning may be needed to let some of the other plants grow. In the winter, leave dormant plants standing and deadheads for bird food. Cut back in the spring.

Keep your garden healthy and clean. Rain gardens should be periodically cleared of dead vegetation and any debris that may collect. Replanting may be necessary over time. If a plant is not doing so well in one location of the garden, it may have to be moved to a wetter or dryer area.

Your garden may need a bit more maintenance than a lawn in the beginning, but in the long run it will be easier to care for and provide many added benefits!

Rain Garden Maintenance Tasks and Schedule

TASK	SCHEDULE
Prevent Soil Erosion	Keep watch on out parcels and parking lot use
Trash removal	Weekly
Pruning	Annual
Mulch renewal	After 1st frost in fall or last frost in spring
Mulch removal	Every 3 years
Weeding and Plant replacement	As needed
Remove sediment	As needed or during mulch renewal
Perimeter Mowing	As needed, keep clippings out of rain garden

RESOURCES

Documents and websites consulted in the development of this document include:

Hunt, Bill. "How to Build Your Own Backyard Rain Garden." N.C. Cooperative Extension. http://www.bae.ncsu.edu/topic/raingarden/Entire_handout.doc

NC State
- http://www.bae.ncsu.edu/topic/raingarden/
- http://www.bae.ncsu.edu/stormwater
- http://plants.ces.ncsu.edu/

National Wetland Plant List. US Army Corps of Engineers. http://rsgisias.crrel.usace.army.mil/NWPL/

The Oregon Rain Garden Guide: A Step by Step Guide to Landscaping for Clean Water and Healthy Streams. Oregon State University. http://seagrant.oregonstate.edu/sgpubs/onlinepubs/h10001.pdf

Rain Gardens: A How-to Manual for Homeowners. University of Wisconsin-Extension. http://clean-water.uwex.edu/pubs/pdf/home.rgmanual.pdf

Rain Gardens: A Rain Garden Manual for South Carolina. Clemson University. http://www.clemson.edu/public/carolinaclear/cc_toolbox/index.html

Ruth, Cliff. Plants for Constructed Wetlands and Rain Gardens. http://www.ces.ncsu.edu/copubs/env/water/018/RaingardenPlantsBrochure.pdf

NATIVE PLANT SUPPLIERS

Many seed companies available online.
North Carolina Native Plant Society, http://www.ncwildflower.org/natives/sources.htm

FOR FURTHER ASSISTANCE, CONTACT YOUR LOCAL COOPERATIVE EXTENSION OFFICE

North Carolina, http://www.ces.ncsu.edu/
Nationally, http://www.csrees.usda.gov/Extension/index.html

Links to other internet locations may or may not have been provided in this article because they contain related information that may be of interest to the reader. The North Carolina Cooperative Extension does not necessarily endorse the views expressed or the facts presented on those sites. Further, N.C. Cooperative Extension does not endorse any commercial products that may be advertised or available on those sites.

Revised April 2018

Table 1: Planting Plan Recommendations

Planting Plan Topic	Recommendation
Plant community	Should be diverse plant to avoid susceptibility to insects, drought, and/or disease.
Sod media for sod	Sod must *not* be installed that has been grown in soil that has an impermeable layer, such as **clay**.
Standards for plant materials	Plant material should conform to the current edition of American Standards for Nursery Stock.
Upon delivery of plants, check:	Normal, well-developed branches and vigorous root systems, and be free from physical defects, plant diseases, and insect pests, tagged for identification, not root-bound.
Container size	In most cases, herbaceous plants installed in bioretention cells are grown in containers holding 3.6 to 6.8 cubic inches of media (for example, and not limited to, 72, 50 and IP 110). Other container sizes or bare root stock may be appropriate for some species and conditions. No container size is specified for trees and shrubs.
Optimal planting time	Fall and winter planting are best (will vary for western Piedmont and mountains). Spring is acceptable but will require more summer watering than fall planting. Summer planting drastically increases plant mortality and requires regular watering immediately following installation.
How the plants should be planted	For best survival, trees should be planted with the top of the root ball partially out of the media. For trees and shrubs, the top of the root ball should be 1-3" above the media. If large trees are to be planted in deep fill media, care should be taken to ensure that they would be stable and not fall over.
Local jurisdiction codes	Local jurisdictions often have specific guidelines for the types and location of trees and other landscape plants planted along public streets or rights-of-way. Additionally, local landscape ordinances must be followed. Contact local authorities when making plant selections for your project.

Plants used in low impact development SCMs should be suitable for their purpose: Select non-aggressive plants adapted to the region. Native species (USDA NRCS PLANTS Database) are preferred. However, well-known non-aggressive, non-seeding introduced species and/or horticultural selections of native species may be appropriate for high visibility bioretention cells to enhance public appeal. Do not use invasive species (Southeast Exotic Plant Pest Council), noxious weeds (NCDA&CS Noxious Weed List) or plants known to be weeds (Global Compendium of Weeds).

Plants suitable for North Carolina bioretention cells are listed in Tables 2 through 4. Additional plant species that are not shown in the table may also be suitable.

Table 2: Trees for Bioretention Cells

Latin Name	Common Name	Comments
Aesculus pavia *Aesculus sylvatica*	Red buckeye Painted buckeye	
Amelanchier arborea *Amelanchier canadensis*	Serviceberry	Height: 25-50 ft 
Asimina triloba	Pawpaw	
Betula nigra	River birch	Entire state (ht: 50-75ft) 
Carpinus caroliniana	Ironwood	
Cercis canadensis	Eastern redbud	
Chionanthus virginicus	Fringe tree	
Ilex opaca	American holly	
Liriodendron tulipifera	Tulip poplar	
Nyssa sylvatica *Nyssa biflora*	*Blackgum* *Swamp tupelo*	
Oxydendrum arboreum	Sourwood	
Platanus occidentalis	American sycamore	
Quercus bicolor *Quercus laurifolia* *Quercus lyrata* *Quercus michauxii* *Quercus nigra* *Quercus phellos* *Quercus shumardii*	Swamp white oak Laurel oak Overcup oak Swamp chestnut oak Water oak Willow oak Shumard oak	
Taxodium distichum	Bald cypress	Piedmont to Coast; low drought resistance; not salt tolerant. Height: 25-50 ft 
Magnolia virginiana	Sweet bay magnolia	

Table 3: Shrubs for Bioretention Cells

Latin Name	Common Name	Comments
Alnus serrulata	Tag alder	
Aronia arbutifolia *Aronia melanocarpa,*	Red chokeberry Black chokeberry	
Callicarpa americana	American beautyberry	
Ceanothus americanus	New Jersey tea	
Cephalanthus occidentalis	Button bush	
Clethra alnifolia	Summersweet Clethra	Piedmont-Coastal Plain; flood and salt tolerance
Cornus amomum	Silky dogwood	
Cyrilla racemiflora	Swamp Cyrilla (ti-ti)	Entire state; medium drought tolerance, some salt tolerance
Diospyros virginiana	Persimmon	
Eubotrys racemosus	Coastal fetterbush	
Halesia carolina	Carolina silverbell	
Hamamelis virginiana	Witchhazel	
Hydrangea quercifolia	Oakleaf hydrangea	
Hypericum densiflorum	Dense Hypericum	Entire state; flood & salt tolerant
Hypericum prolificum	Shrubby St. Johnswort	Entire state; flood & salt tolerant
Ilex decidua	Possum haw	
Ilex glabra	Inkberry	
Ilex verticillata	Winterberry	
Ilex vomitoria	Yaupon Holly	High drought tolerance

Itea virginica	Virginia Sweetspire	
Lindera benzoin	Northern Spicebush	
Leucothoe fontanesiana *Leucothoe axillaris*	Highland doghobble Coastal doghobble	
Lyonia lucida	Fetterbush	
Rhododendron viscosum *Rhododendron atlanticum*	Swamp Azalea Dwarf Azalea	Entire state; medium drought tolerance 
Physocarpus opulifolius	Ninebark	
Rosa palustris	Swamp rose	
Salix caroliniana *Salix sericea*	Carolina willow Silky willow	
Sambucus canadensis	American black elderberry	
Spiraea tomentosa	Steeplebush	Entire state; drought tolerant; pink flowers 
Styrax americanus	American snowbell	
Symphoricarpos orbiculatus	Coralberry	
Vaccinium arboreum *Vaccinium corymbosum* *Vaccinium fuscatum*	Farkleberry Highbush blueberry Black highbush blueberry	
Viburnum dentatum *Viburnum prunifolium* *Viburnum nudum*	Arrowwood Viburnum Blackhaw Viburnum Possumhaw Viburnum	Entire state; flood tolerant & drought tolerant; salt resistant 
Xanthorhiza simplicissima	Yellowroot	

Table 4: Herbaceous Plants for Bioretention Cells

Latin Name	Common Name	Comments
Acorus americanus	Sweet flag	
Amsonia tabernaemontana	Eastern blue Star	Entire state; drought resistant; pale blue flowers 

Andropogon glomeratus	Bushy bluestem	
Asclepias incarnata	Swamp milkweed	
Baptisia alba *Baptisia australis*	White wild indigo Blue indigo	Coast. White flowers. 
Canna flaccida	Yellow canna	
Carex amphibola *Carex cherokeensis* *Carex comosa* *Carex crinita* *Carex grayi* *Carex lupulina* *Carex lurida* *Carex muskingumensis* *Carex radiata* *Carex rosea* *Carex squarrosa* *Carex stricta* *Carex vulpinoidea* *Carex glaucescens* *Carex intumescens*	Creek Sedge Cherokee Sedge Longhair Sedge Fringed Sedge Gray's Sedge Hop Sedge Lurid Sedge Palm Sedge Eastern Star sedge Rosy Sedge Narrow-Leaved Cattail Sedge Tussock Sedge Fox Sedge Waxy sedge Bladder sedge	
Chasmanthium latifolium *Chasmanthium laxum*	River Oats Slender Woodoats	Entire state; medium drought tolerance 
Chelone glabra	White turtlehead	
Cladium jamaicense	Saw grass	
Coreopsis lanceolata *Coreopsis tinctoria*	Tickseed	
Dulichium arundinaceum	Three-way sedge	
Echinacea purpurea	Purple coneflower	
Eleocharis quadrangulata	Square-stem spikerush	
Elymus canadensis *Elymus hystrix* *Elymus virginicus*	Wildrye	
Eupatorium perfoliatum	Boneset	Entire state 
Eutrochium dubium (syn. *Eupatorium dubium*) *Eutrochium fistulosum* (syn *Eupatorium fistulosum*)	Coastal Joe Pye Weed Joe Pye Weed	

Gaillardia pulchella	Blanket Flower	
Helenium autumnale	Sneezeweed	
Helianthus angustifolius	Swamp sunflower	
Heliopsis helianthoides	False sunflower	
Heuchera americana	Coral bells	Entire state; many different cultivars 
Hibiscus coccineus *Hibiscus moscheutos*	Scarlet rose mallow Rose mallow	Not found in the mountains. 
Iris virginica	Southern blue flag	
Juncus coriaceus *Juncus effusus* *Juncus tenuis*	Leathery rush Soft rush Path rush	Entire state; medium drought 
Kosteletskya pentacaropos (syn. *Kosteletskya virginica*)	Marsh mallow	
Liatris spicata	Blazing star	
Lobelia cardinalis *Lobelia elongata*	Cardinal flower Blue lobelia	
Monarda fistulosa *Monarda didyma*	Bee Balm	
Panicum virgatum and cultivars	Switchgrass	Entire state, few mtns; drought resistant 
Pycnanthemum muticum *Pycnanthemum virginianum*	Mountain mint	Entire state 
Ratibida pinnata	Gray-headed coneflower	
Rudbeckia fulgida *Rudbeckia hirta*	Blackeyed susan	
Saururus cernuus	Lizard's tail	
Scirpus cyperinus	Wool Grass	
Solidago canadensis *Solidago rugosa*	Goldenrod	Entire state 

Solidago sempervirens		
Sorghastrum nutans	Indiangrass	Entire state; drought tolerant 
Silphium perfoliatum	Cup plant	
Symphyotrichum lateriflorum *Symphyotrichum laeve* *Symphyotrichum novae-angliae* *Symphyotrichum oblongifolium*	Calico aster Smooth aster New England aster Aromatic aster	
Verbena hastata	Blue vervain	
Vernonia noveboracensis	Ironweed	

Table 5: Turfgrass Specification for Bioretention Cells

In grassed bioretention cells, use perennial grasses such as hybrid Bermuda or centipede in the CP and Piedmont, use cool season turf grass such as fescue or bluegrass in the Mountains. Grass should never be seeded, use sod instead. When using sod, avoid sod that is grown in soil that has an impermeable layer (such as clay).

NOTE: There are native turf trials going on at NCSU and additional species may be recommended in the future.

BIORETENTION MDC 11: MULCH.
For bioretention cells with vegetation other than sod, triple shredded hardwood mulch shall be used for the portion of the cell that will be inundated. Mulch shall be uniformly placed two to four inches deep.

Triple-shredded hardwood mulch has been found less likely to wash away than other forms of mulch (such as pine). The mulch layer functions to reduce weeds; regulate soil temperatures and moisture; reduce soil compaction and prevent erosion; and prevent soil and fungi from splashing on the foliage. Mulch serves as a pretreatment layer by trapping the finer sediments that remain suspended after the primary pretreatment.

Applying more than four inches of mulch can cause plants to grow in the mulch and not the soil, which weakens them, particularly during drought. Mulch should be free of weed seeds, soil, roots, and other material that is not bole or branch wood or bark.

Mulch needs to be periodically renewed to maintain a two to four-inch depth. The ideal time to reapply mulch is in the late spring after the soil has warmed. Every few years, mulch should be removed and replaced.