

Bioretention Areas & Rain Gardens



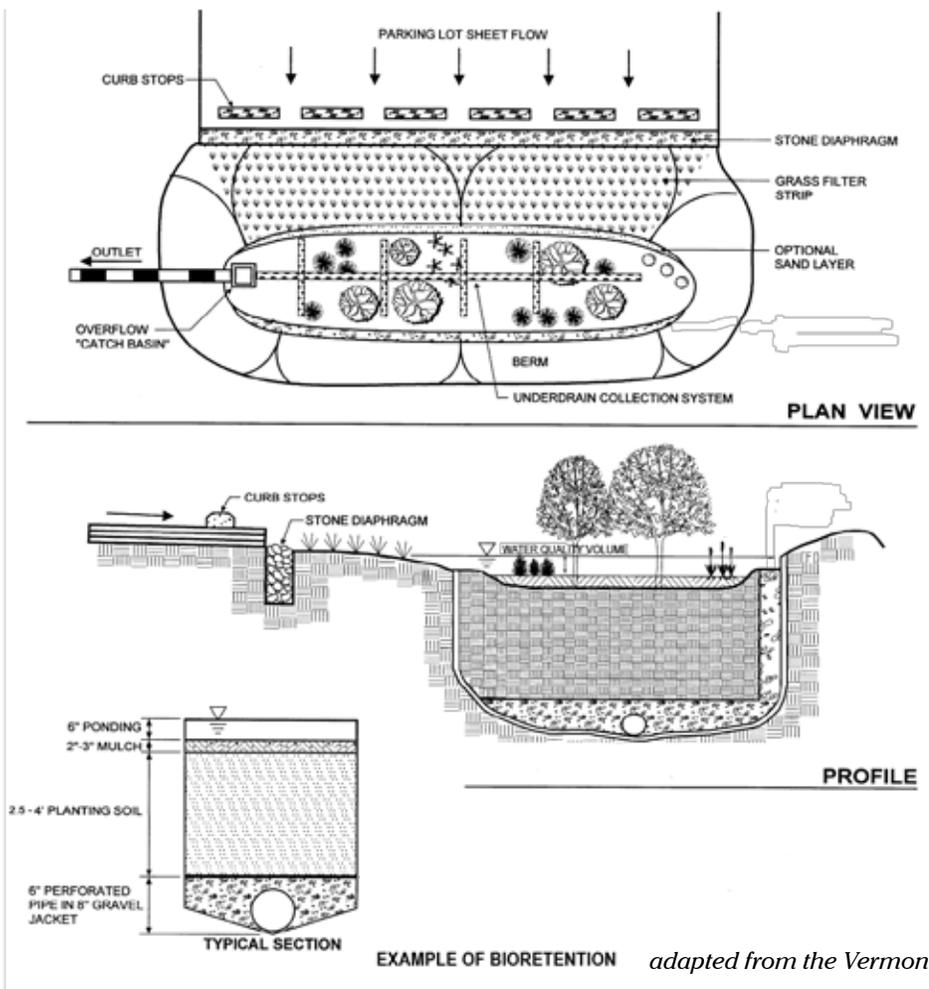
Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Stormwater runoff is directed into the cell via piped or sheet flow. The runoff percolates through the soil media that acts as a filter. There are two types of bioretention cells: those that are designed solely as an organic filter filtering bioretention areas and those configured to recharge groundwater in addition to acting as a filter exfiltrating bioretention areas. A filtering bioretention area includes an impermeable liner and underdrain that intercepts the runoff before it reaches the water table so that it may be conveyed to a discharge outlet, other best management practices, or the municipal storm drain system. An exfiltrating bioretention area has an underdrain that is designed to enhance exfiltration of runoff into the groundwater.

Ability to meet specific standards

Standard	Description
2 - Peak Flow	N/A
3 - Recharge	An exfiltrating bioretention area provides groundwater recharge.
4 - TSS Removal	90% TSS removal credit with adequate pretreatment
5 - Higher Pollutant Loading	Can be used for certain land uses with higher potential pollutant loads if lined and sealed until adequate pretreatment is provided. Adequate pretreatment must include 44% TSS removal prior to infiltration. For land uses that have the potential to generate runoff with high concentrations of oil and grease such as high intensity use parking lots and gas stations, adequate pretreatment may also include an oil grit separator, sand filter or equivalent. In lieu of an oil grit separator or sand filter, a filtering bioretention area also may be used as a pretreatment device for infiltration practices exfiltrating runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.
6 - Discharges near or to Critical Areas	Good option for discharges near cold-water fisheries. Should not be used near bathing beaches and shellfish growing areas.
7 - Redevelopment	Suitable with appropriate pretreatment

Pollutant Removal Efficiencies

- Total Suspended Solids (TSS) 90% with vegetated filter strip or equivalent
- Total Nitrogen 30% to 50% if soil media at least 30 inches
- Total Phosphorus 30% to 90%
- Metals (copper, lead, zinc, cadmium) 40% to 90%
- Pathogens (coliform, e coli) Insufficient data



Special Features:

- Can be lined and sealed to prevent recharge where appropriate
- Adequate pretreatment is essential
- Not recommended in areas with steep slope
- Depth of soil media depends on type of vegetation that is proposed
- Soil media must be 30 inches deep to achieve removal of nitrogen

Advantages/Benefits:

- Can be designed to provide groundwater recharge and preserves the natural water balance of the site
- Can be designed to prevent recharge where appropriate
- Supplies shade, absorbs noise, and provides windbreaks
- Can remove other pollutants besides TSS including phosphorus, nitrogen and metals
- Can be used as a stormwater retrofit by modifying existing landscape or if a parking lot is being resurfaced
- Can be used on small lots with space constraints
- Small rain gardens are mosquito death traps
- Little or no hazard for amphibians or other small animals

Disadvantages/Limitations:

- Requires careful landscaping and maintenance
- Not suitable for large drainage areas

Maintenance

Activity	Frequency
Inspect and remove trash	Monthly
Mow	2 to 12 times per year
Mulch	Annually
Fertilize	Annually
Remove dead vegetation	Annually
Prune	Annually

Bioretention Areas & Rain Gardens

Not all bioretention cells are designed to exfiltrate. Only the infiltration requirements are applicable to bioretention cells intended to exfiltrate.

Applicability

Bioretention areas can provide excellent pollutant removal for the “first flush” of stormwater runoff. Properly designed and maintained cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as “rain gardens” and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper direction.

Bioretention systems can be applied to a wide range of commercial, residential, and industrial developments in many geologic conditions; they work well on small sites and on large sites divided into multiple small drainage areas. Bioretention systems are often well suited for ultra-urban settings where little pervious area exists. Although they require significant space (approximately 5% to 7% of the area that drains to them), they can be integrated into parking lots, parking lot islands, median strips, and traffic islands. Sites can be retrofitted with bioretention areas by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites, they are commonly used for rooftop and driveway runoff.

Effectiveness

Bioretention areas remove pollutants through filtration, microbe activity, and uptake by plants; contact with soil and roots provides water quality treatment better than conventional infiltration structures. Studies indicate that bioretention areas can remove from 80% to 90% of TSS. If properly designed and installed, bioretention areas remove phosphorus, nitrogen, metals, organics, and bacteria to varying degrees.

Bioretention areas help reduce stress in watersheds that experience severe low flows due to excessive impervious cover. Low-tech, decentralized bioretention areas are also less costly to design, install, and maintain than conventional stormwater technologies that treat runoff at the end of the pipe.

Decentralized bioretention cells can also reduce the size of storm drain pipes, a major component of stormwater treatment costs. Bioretention areas enhance the landscape in a variety of ways: they improve the appearance of developed sites, provide windbreaks, absorb noise, provide wildlife habitat, and reduce the urban heat island effect.

Planning Considerations

Filtering bioretention areas are designed with an impermeable liner and underdrain so that the stormwater may be transported to additional BMPs for treatment and/or discharge. Exfiltrating bioretention areas are designed so that following treatment by the bioretention area the stormwater may recharge the groundwater.

Both types of bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads. However, exfiltrating bioretention areas may be used to treat runoff from land uses with higher potential pollutant loads, only if pretreatment has been provided to achieve TSS removal of at least 44%. If the land use has the potential to generate runoff with high concentrations of oil and grease, other types of pretreatment, i.e., a deep sump catch basin and oil grit separator or a sand filter, is required prior to discharge of runoff to an exfiltrating bioretention area. A filtering bioretention area may also be used as a pretreatment device for an exfiltrating bioretention area or other infiltration practice that exfiltrates runoff from land uses with a potential to generate runoff with high concentrations of oil and grease.

To receive 90% TSS removal credit, adequate pretreatment must be provided. If the flow is piped to the bioretention area a deep sump catch catch basin and sediment forebay should be used to provide pretreatment. For sheet flow, there are a number or pretreatment options. These options include:

- A vegetated filter strip, grass channel or water quality swale designed in accordance with the specifications set forth in Chapter 2.
- A grass and gravel combination. This should consist of at least 8 inches of gravel followed by 3 to 5 feet of sod. (source: North Carolina Stormwater Manual, 2007, http://h2o.enr.state.nc.us/su/documents/Ch12-Bioretention_001.pdf)
- Pea diaphragm combined with a vegetated filter strip specially designed to provide pretreatment for a bioretention area as set forth in the following table. (source: Georgia Stormwater Manual and Claytor and Schuler 1996)

Dimensions for Filter Strip Designed Specially to Provide Pretreatment for Bioretention Area

Parameter	Impervious Area				Pervious Areas (lawns, etc.)			
Maximum inflow approach length (feet)	35		75		75		100	
Filter strip slope (max=6%)	<2%	>2%	<2%	>2%	<2%	>2%	<2%	>2%
Filter strip minimum length (feet)	10	15	20	25	10	12	15	18

Bioretention areas must not be located on slopes greater than 20%. When the bioretention area is designed to exfiltrate, the design must ensure vertical separation of at least 2 feet from the seasonal high groundwater table to the bottom of the bioretention cell.

For residential rain gardens, pick a low spot on the property, and route water from a downspout or sump pump into it. It is best to choose a location with full sun, but if that is not possible, make sure it gets at least a half-day of sunlight.

Do not excavate an extensive rain garden under large trees. Digging up shallow feeder roots can weaken or kill a tree. If the tree is not a species that prefers moisture, the additional groundwater could damage it. Size the bioretention area using the methodology set forth in Volume 3.

Design

Size the bioretention area to be 5% to 7% of the area draining to it. Determine the infiltrative capacity of the underlying native soil by performing a soil evaluation in accordance with Volume 3. Do not use a standard septic system (i.e., Title 5) percolation test to determine soil permeability.

The depth of the soil media must be between 2 and 4 feet. This range reflects the fact that most of the pollutant removal occurs within the first 2 feet of soil and that excavations deeper than 4 feet become expensive. The depth selected should accommodate the vegetation. If the minimum depth is used, only shallow rooted plants and grasses may be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater discharges, the bioretention area should have a soil media with a depth of at least 30 inches, because nitrogen removal takes place 30 inches below the ground surface. If trees and shrubs are to be planted, the soil media should be at least 3 feet.

Size the cells (based on void space and ponding area) at a minimum to capture and treat the required water quality volume (the first 0.5 inch or 1 inch

of runoff) if intended to be used for water quality treatment (Stormwater Standard No. 4), the required recharge volume if used for recharge (Stormwater Standard No. 3), or the larger of the two volumes if used to achieve compliance with both Stormwater Standards 3 and 4.

Cover the bottom of the excavation with coarse gravel, over pea gravel, over sand. Earlier designs used filter fabric as a bottom blanket, but more recent experiences show that filter fabric is prone to clogging. Consequently, do not use fabric filters or sand curtains. Use the Engineered Soil Mix below.

Engineered Soil Mix for Bioretention Systems Designed to Exfiltrate

- The soil mix for bioretention areas should be a mixture of sand compost and soil.
 - 40 % sand,
 - 20-30% topsoil, and
 - 30-40% compost.
 - The soil mix must be uniform, free of stones, stumps, roots or similar objects larger than 2 inches. Clay content should not exceed 5%.
 - Soil pH should generally be between 5.5-6.5, a range that is optimal for microbial activity and adsorption of nitrogen, phosphorus, and other pollutants.
 - Use soils with 1.5% to 3% organic content and maximum 500-ppm soluble salts.
 - The sand component should be gravelly sand that meets ASTM D 422.
- | Sieve Size | Percent Passing |
|--------------|-----------------|
| 2-inch | 100 |
| ¾-inch | 70-100 |
| ¼-inch | 50-80 |
| U.S. No. 40 | 15-40 |
| U.S. No. 200 | 0-3 |
- The topsoil component shall be a sandy loam, loamy sand or loam texture.
 - The compost component must be processed from yard waste in accordance with MassDEP Guidelines (see <http://www.mass.gov/dep/recycle/reduce/leafguid.doc>). The compost shall not contain biosolids.

On-site soil mixing or placement is not allowed if soil is saturated or subject to water within 48 hours. Cover and store soil to prevent wetting or saturation.

Test soil for fertility and micro-nutrients and, only if necessary, amend mixture to create optimum conditions for plant establishment and early growth.

Grade the area to allow a ponding depth of 6 to 8 inches; depending on site conditions, more or less ponding may be appropriate.

Cover the soil with 2 to 3 inches of fine-shredded hardwood mulch.

The planting plan shall include a mix of herbaceous perennials, shrubs, and (if conditions permit) understory trees that can tolerate intermittent ponding, occasional saline conditions due to road salt, and extended dry periods. A list of plants that are suitable for bioretention areas can be found at the end of this section. To avoid a monoculture, it is a good practice to include one tree or shrub per 50 square feet of bioretention area, and at least 3 species each of herbaceous perennials and shrubs. Invasive and exotic species are prohibited. The planting plan should also meet any applicable local landscaping requirements.

All exfiltrating bioretention areas must be designed to drain within 72 hours. However, rain gardens are typically designed to drain water within a day and are thus unlikely to breed mosquitoes.

Bioretention cells, including rain gardens, require pretreatment, such as a vegetated filter strip. A stone or pea gravel diaphragm or, even better, a concrete level spreader upstream of a filter strip will enhance sheet flow and sediment removal.

Bioretention cells can be dosed with sheet flow, a surface inlet, or pipe flow. When using a surface inlet, first direct the flow to a sediment forebay. Alternatively, piped flow may be introduced to the bioretention system via an underdrain.

For bioretention cells dosed via sheet flow or surface inlets, include a ponding area to allow water to pond and be stored temporarily while stormwater is exfiltrating through the cell. Where bioretention areas

are adjacent to parking areas, allow three inches of freeboard above the ponding depth to prevent flooding.

Most bioretention cells have an overflow drain that allows ponded water above the selected ponding depth to be dosed to an underdrain. If the bioretention system is designed to exfiltrate, the underdrain is not connected to an outlet, but instead terminates in the bioretention cell. If the bioretention area is not designed to exfiltrate, the underdrain is connected to an outlet for discharge or conveyance to additional best management practices.

Construction

During construction, avoid excessively compacting soils around the bioretention areas and accumulating silt around the drain field. To minimize sediment loading in the treatment area, direct runoff to the bioretention area only from areas that are stabilized; always divert construction runoff elsewhere.

To avoid compaction of the parent material, work from the edge of the area proposed as the location of an exfiltrating bioretention cell. Never direct runoff to the cell until the cell and the contributing drainage areas are fully stabilized.

Place planting soils in 1-foot to 2-foot lifts and compact them with minimal pressure until the desired elevation is reached. Some engineers suggest flooding the cell between each lift placement in lieu of compaction.

Maintenance

Premature failure of bioretention areas is a significant issue caused by lack of regular maintenance.

Ensuring long-term maintenance involves sustained public education and deed restrictions or covenants for privately owned cells. Bioretention areas require careful attention while plants are being established

Bioretention Maintenance Schedule		
<i>Activity</i>	<i>Time of Year</i>	<i>Frequency</i>
Inspect & remove trash	Year round	Monthly
Mulch	Spring	Annually
Remove dead vegetation	Fall or Spring	Annually
Replace dead vegetation	Spring	Annually
Prune	Spring or Fall	Annually
Replace entire media & all vegetation	Late Spring/early Summer	As needed*

* Paying careful attention to pretreatment and operation & maintenance can extend the life of the soil media

and seasonal landscaping maintenance thereafter.

In many cases, a landscaping contractor working elsewhere on the site can complete maintenance tasks. Inspect pretreatment devices and bioretention cells regularly for sediment build-up, structural damage, and standing water.

Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove litter and debris monthly. Treat diseased vegetation as needed. Remove and replace dead vegetation twice per year (spring and fall).

Proper selection of plant species and support during establishment of vegetation should minimize—if not eliminate—the need for fertilizers and pesticides. Remove invasive species as needed to prevent these species from spreading into the bioretention area. Replace mulch every two years, in the early spring. Upon failure, excavate bioretention area, scarify bottom and sides, replace filter fabric and soil, replant, and mulch. A summary of maintenance activities can be found on the previous page.

Because the soil medium filters contaminants from runoff, the cation exchange capacity of the soil media will eventually be exhausted. When the cation exchange capacity of the soil media decreases, change the soil media to prevent contaminants from migrating to the groundwater, or from being discharged via an underdrain outlet. Using small shrubs and plants instead of larger trees will make it easier to replace the media with clean material when needed.

Plant maintenance is critical. Concentrated salts in roadway runoff may kill plants, necessitating removal of dead vegetation each spring and replanting. The operation and maintenance plan must include measures to make sure the plants are maintained. This is particularly true in residential subdivisions, where the operation and maintenance plan may assign each homeowner the legal responsibility to maintain a bioretention cell or rain garden on his or her property. Including the requirement in the property deed for new subdivisions may alert residential property owners to their legal responsibilities regarding the bioretention cells constructed on their lot.

Cold Climate Considerations

Never store snow in bioretention areas. The Operation and Maintenance plan must specify where on-site snow will be stored. All snow dumps must

comply with MassDEP's guidance. When bioretention areas are located along roads, care must be taken during plowing operations to prevent snow from being plowed into the bioretention areas. If snow is plowed into the cells, runoff may bypass the cell and drain into downgradient wetlands without first receiving the required water quality treatment, and without recharging the groundwater.

References

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University of North Carolina, www.bae.ncsu.edu/topic/bioretention
www.bae.ncsu.edu/stormwater/PublicationFiles/DesigningRainGardens2001.pdf

Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species:	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
	Indicator Status	Habitat	Ponding (days)	Salt	Oil/Grease	Metals	Insects/Disease	Exposure	Form	Height	Root System	Native	Wildlife	
<i>Agrostis alba</i> redtop	FAC	Mesic-Xeric	1-2	H	-	H	H	Shade	Grass	2-3'	Fibrous Shallow	Yes	High	-
<i>Andropogon gerardii</i> bluejoint	FAC	Dry Mesic-Mesic	1-2	-	-	-	-	Sun	Grass	2-3'	Fibrous Shallow	Yes	High	-
<i>Andropogon virginicus</i> broomsedge	-	Wet meadow	1-2	L	-	-	-	Full sun	Grass	1-3'		Yes	High	Tolerant of fluctuating water levels and drought.
<i>Carex vulpinoidea</i> fox sedge	OBL	Freshwater marsh	2-4	L	-	-	-	Sun to partial sun	Grass	2-3.5'	Rhizome	Yes	High	-
<i>Chelone glabra</i>														
<i>Deschampsia caespitosa</i> tufted hairgrass	FACW	Mesic to wet Mesic	2-4	H	-	H	H	Sun	Grass	2-3'	Fibrous Shallow	Yes	High	May become Invasive.
<i>Glyceria striata</i> fowl mannagrass, nerved mannagrass	OBL	Freshwater marsh, seeps	1-2	L	-	-	-	Partial shade to full shade	Grass	2-4'	Rhizome	Yes	High	-
<i>Hedera helix</i> English Ivy	FACU	Mesic	1-2	-	-	-	H	Sun	Evergreen ground cover	-	Fibrous Shallow	No	Low	-
<i>Hibiscus palustris</i>														
<i>Iris kaempferi</i>														

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FAC Facultative - Equally likely to occur in wetlands and non-wetlands.
FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
OBL Obligate Wetland - Occur almost always in wetlands

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<i>Lobelia siphilitica</i>															
<i>Lotus Corniculatus</i> birdsfoot-trefoil	FAC	Mesic-Xeric	1-2	H	L	H	H	Sun	Grass	2-3'	Fibrous Shallow	Yes	High	Member of the legume family.	
<i>Onoclea sensibilis</i> sensitive fern, beedfern	FACW							Shade		1-3.5'			H		
<i>Pachysandra terminalis</i> Japanese pachysandra	FACU	Mesic	1-2	-	-	-	M	Shade	Evergreen ground cover	-	Fibrous Shallow	No	Low	-	
<i>Panicum virgatum</i> switch grass	FAC to FACU	Mesic	2-4	H	-	-	H	Sun or Shade	Grass	4-5'	Fibrous Shallow	Yes	High	Can spread fast and reach height of 6'	
<i>Vinca major</i> large periwinkle	FACU	Mesic	1-2	-	-	-	H	Shade	Evergreen ground cover	-	Fibrous Shallow	No	Low	Sensitive to soil compaction and pH changes.	
<i>Vinca minor</i> common periwinkle	FACU	Mesic	1-2	-	-	-	H	Shade	Evergreen ground cover	-	Fibrous Shallow	No	Low	-	
Indian grass															
Little bluestem															
Deer tongue															
Green coneflower															

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	Indicator Status	Habitat	Ponding (days)	Salt	Oil/Grease	Metals	Insectal/Disease	Exposure	Form	Height	Root System	Native	Wildlife	
<i>Aronia arbutifolia</i> (<i>Pyrus arbutifolia</i>) red chokeberry	FACW	Mesic	1-2	H	-	H	M	Sun to partial sun	Deciduous shrub	6-12'	-	Yes	High	Good bank stabilizer. Tolerates drought.
<i>Clethra alnifolia</i> sweet pepperbush	FAC	Mesic to wet Mesic	2-4	H	-	-	H	Sun to partial sun	Ovoid shrub	6-12'	Shallow	Yes	Med	Coastal plain species.
<i>Cornus stolonifera</i> (<i>Cornus sericea</i>) red osier dogwood	FACW	Mesic-Hydric	2-4	H	H	H	M	Sun or shade	Arching, spreading shrub	8-10'	Shallow	Yes	High	Needs more consistent moisture levels.
<i>Cornus amomum</i> silky dogwood	FAC	Mesic	1-2	L	-	-	M	Sun to partial sun	Broad-leaved	6-12'	-	Yes	High	Good bank stabilizer
<i>Euonymus europaeus</i> spindle-tree	FAC	Mesic	1-2	M	M	M	M	Sun to partial sun	Upright dense oval shrub	10-12'	Shallow	No	No	-
<i>Hammamelis virginiana</i> witch hazel	FAC	Mesic	2-4	M	M	M	M	Sun or shade	Vase-like compact shrub	4-6'	Shallow	Yes	Low	-
<i>Hypericum densiflorum</i> common St. John's wort	FAC	Mesic	2-4	H	M	M	H	Sun	Ovoid shrub	3-6'	Shallow	Yes	Med	-
<i>Ilex glabra</i> inkberry	FACW	Mesic to wet Mesic	2-4	H	H	-	H	Sun to partial sun	Upright dense shrub	6-12'	Shallow	Yes	High	Coastal plain species.
<i>Ilex verticillata</i> winterberry	FACW	Mesic to wet Mesic	2-4	L	M	-	H	Sun to partial sun	Spreading shrub	6-12'	Shallow	Yes	High	-

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<i>Ilex virginica</i> tassel-white, Virginia sweetspire	OBL	Mesic	1-2	M	-	-	M	Sun or shade	Broad-leaved, deciduous shrub	6-12'	-	Yes	Low	-
<i>Juniperus communis</i> "compressa" common juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Mounded shrub	3-6'	Deep taproot	No	High	Evergreen
<i>Juniperus horizontalis</i> "Bar Harbor" creeping juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Matted shrub	0-3'	Deep taproot	No	High	Evergreen
<i>Lindera benzoin</i> spicebush	FACW	Mesic to wet Mesic	2-4	H	-	-	H	Sun	Upright shrub	6-12'	Deep	Yes	High	-
<i>Myrica pennsylvanica</i> bayberry	FAC	Mesic	2-4	H	M	M	H	Sun to partial sun	Rounded, compact shrub	6-8'	Shallow	Yes	High	Coastal plain species.
<i>Physocarpus opulifolius</i> ninebark	FAC	Dry Mesic to wet Mesic	2-4	M	-	-	H	Sun	Upright shrub	6-12'	Shallow	Yes	Med	May be difficult to locate.
<i>Viburnum cassinoides</i> northern wild raisin	FACW	Mesic	2-4	H	H	H	H	Sun to partial sun	Rounded, compacted shrub	6-8'	Shallow	Yes	High	-
<i>Viburnum dentatum</i> arrow-wood	FAC	Mesic to wet	2-4	H	H	H	H	Sun to partial sun	Upright, multi-stemmed shrub	8-10'	Shallow	Yes	High	-
<i>Viburnum lentago</i> nannyberry	FAC	Mesic	2-4	H	H	H	H	Sun to partial sun	Upright, multi-stemmed shrub	8-10'	Shallow	Yes	High	-

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<i>Acer rubrum</i> red maple	FAC	Mesic-Hydric	4-6	H	H	H	H	Partial sun	Single to multi-stem tree	50-70	Shallow	Yes	High	-	
<i>Amelanchier canadensis</i> shadbush	FAC	Mesic	2-4	H	M	-	H	Partial sun	Single to multi-stem tree	35-50	Shallow	Yes	High	Not recommended for full sun.	
<i>Betula nigra</i> river birch	FACW	Mesic-Hydric	4-6	-	M	M	H	Partial sun	Single to multi-stem tree	50-75	Shallow	Yes	High	Not susceptible to bronze birch borer.	
<i>Betula populifolia</i> gray birch	FAC	Xeric-Hydric	4-6	H	H	M	H	Partial sun	Single to multi-stem tree	35-50	Shallow to deep	No	High	Native to New England area.	
<i>Fraxinus americana</i> white ash	FAC	Mesic	2-4	M	H	H	H	Sun	Large tree	50-80	Deep	Yes	Low	-	
<i>Fraxinus Pennsylvanica</i> green ash	FACW	Mesic	4-6	M	H	H	H	Partial sun	Large tree	40-65	Shallow to deep	Yes	Low	-	
<i>Ginkgo biloba</i> Maidenhair tree	FAC	Mesic	2-4	H	H	H	H	Sun	Large tree	50-80	Shallow to deep	No	Low	Avoid female species-offensive odor from fruit.	
<i>Gleditsia triacanthos</i> honeylocust	FAC	Mesic	2-4	H	M	-	M	Sun	Small copied large tree	50-75	Shallow to deep variable taproot	Yes	Low	Select thornless variety.	
<i>Juniperus virginiana</i> eastern red cedar	FACU	Mesic-Xeric	2-4	H	H	-	H	Sun	Dense single stem tree	50-75	Taproot	Yes	Very high	Evergreen	
<i>Liquidambar styraciflua</i> sweet gum	FAC	Mesic	4-6	H	H	H	M	Sun	Large tree	50-70	Deep taproot	Yes	High	Edge and perimeter fruit is a maintenance problem.	
<i>Nyssa sylvatica</i> black gum	FACW	Mesic-Hydric	4-6	H	H	H	H	Sun	Large tree	40-70	Shallow to deep taproot	Yes	High	-	

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- M Medium Tolerance
- L Low Tolerance
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- FAC Facultative - Equally likely to occur in non-wetlands and wetlands.
- FACW Facultative Wetland - Usually occur in wetlands, however, occasionally found in non-wetlands.
- OBL Obligate Wetland - Almost always occur in wetlands.

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Plant Species Suitable for Use in Bioretention - Herbaceous Species

Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
	Indicator Status	Habitat	Ponding (days)	Salt	Oil/Grease	Metals	Insects/Disease	Exposure	Form	Height	Root System	Native	Wildlife	
<i>Platanus acerifolia</i> London plane-tree	FACW	Mesic	2-4	H	-	-	M	Sun	Large tree	70-80'	Shallow	No	Low	Tree roots can heave sidewalks.
<i>Platanus occidentalis</i> sycamore	FACW	Mesic-Hydric	4-6	M	M	M	M	Sun	Large tree	70-80'	Shallow	Yes	Med	Edge and perimeter; fruit is a maintenance problem; tree is also prone to windthrow.
<i>Populus deltoides</i> eastern cottonwood	FAC	Xeric-Mesic	4-6	H	H	H	L	Sun	Large tree with spreading branches	75-100'	Shallow	Yes	High	Short lived.
<i>Quercus bicolor</i> Swamp white oak	FACW	Mesic to wet Mesic	4-6	H	-	H	H	Sun to partial sun	Large tree	75-100'	Shallow	Yes	High	One of the faster growing oaks.
<i>Quercus coccinea</i> scarlet oak	FAC	Mesic	1-2	H	M	M	M	Sun	Large tree	50-75'	Shallow to deep	Yes	High	-
<i>Quercus macrocarpa</i> bur oak	FAC	Mesic to wet Mesic	2-4	H	H	H	M	Sun	Large spreading tree	75-100'	Taproot	No	High	Native to Midwest.
<i>Quercus palustris</i> pin oak	FACW	Mesic-Hydric	4-6	H	H	H	M	Sun	Large tree	60-80'	Shallow to deep taproot	Yes	High	-
<i>Quercus phellos</i> willow oak	FACW	Mesic to wet Mesic	4-6	H	-	-	H	Sun	Large tree	55-75'	Shallow	Yes	High	Fast growing oak.
<i>Quercus rubra</i> red oak	FAC	Mesic	2-4	M	H	M	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	Yes	High	-
<i>Quercus shumardii</i> Shumard's red oak	FAC	Mesic	2-4	H	H	H	M	Sun to partial sun	Large spreading tree	60-80'	Deep taproot	No	High	Native to Southeast.

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Species	Moisture Regime		Tolerance						Morphology			General Characteristics		Comments
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Scientific Name Common Name <i>Sophora japonica</i> Japanese pagoda tree	FAC	Mesic	1-2	M	M	-	M	Sun	Shade tree	40-70'	Shallow	No	Low	Fruit stains sidewalk.
<i>Taxodium distichum</i> bald cypress	FACW	Mesic-Hydric	4-6	-	-	M	H	Sun to partial sun	Typically single stem tree	75-100'	Shallow	Yes	Low	Not well documented for planting in urban areas.
<i>Thuja occidentalis</i> arborvitae	FACW	Mesic to wet/Mesic	2-4	M	M	M	H	Sun to partial sun	Dense single stem tree	50-75'	Shallow	No	Low	Evergreen
<i>Zeakova serrata</i> Japanese zelkova	FACU	Mesic	1-2	M	M	-	H	Sun	Dense shade tree	60-70'	Shallow	No	Low	Branches can split easily in storms.

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