Bioretention For Infiltration
(1004)

Wisconsin Department of Natural Resources
Technical Standard

I. Definition

A bioretention device is an *infiltration device*[1] consisting of an excavated area that is back-filled with an engineered soil, covered with a mulch layer and planted with a diversity of woody and herbaceous vegetation. Storm water directed to the device percolates through the mulch and engineered soil, where it is treated by a variety of physical, chemical and biological processes before infiltrating into the *native soil*.

II. Purpose

A bioretention device may be applied individually or as part of a system of stormwater management practices to support one or more of the following purposes:

- Enhance storm water *infiltration*
- Reduce discharge of storm water pollutants to surface and ground waters
- Decrease runoff peak flow rates and volumes
- Preserve base flow in streams
- Reduce temperature impacts of storm water runoff

III. Conditions Where Practice Applies

Bioretention devices are suitable for small drainage areas where increased urban storm water pollutant loadings, thermal impacts, runoff volumes and peak flow discharges are a concern and the area is suitable for infiltration. Bioretention devices are best suited to providing on-site stormwater management opportunities adjacent to *source areas* such as landscaped areas, rooftops, parking lots and streets.

Bioretention devices are not suitable for controlling construction site erosion. These devices will not treat chlorides, and will be damaged by heavy loading of salt-based deicers.

IV. Federal, State and Local Laws

Users of this standard shall be aware of applicable federal, state and local laws, rules, regulations or permit requirements governing bioretention devices. This standard does not contain the text of federal, state or local laws.

V. Criteria

A. Site Criteria

1. A site selected for construction of a bioretention device shall be evaluated in accordance with the WDNR Technical Standard 1002, "Site Evaluation for Stormwater Infiltration" and shall meet the site requirements of that standard.

2. The following site criteria shall also be met:

   a. Private Onsite Wastewater Treatment System (POWTS) – The bioretention device shall be located a minimum of 50 feet from any POWTS and shall not be *hydraulically connected* to the POWTS dispersal cell or cause negative impacts such as cross contamination.

   b. Foundations – The bioretention device shall not be hydraulically connected to building or pavement foundations or cause negative impacts to structures.

   c. Slopes – Sloped areas immediately adjacent to the bioretention device shall be less than 20% but greater than 0.5% for pavement and greater than 1% for vegetated areas to ensure positive flow towards the device.

   d. Maximum Drainage Area – The area draining to the bioretention device shall not exceed 2 acres. The drainage area shall not contain significant sources of soil erosion.

[1] Words in the standard that are shown in italics are described in Section X Definitions. The words are italicized the first time they are used in the text.

B. Design – The bioretention device shall be sized using an *approved model*. (See Consideration L in Section VI).

1. Configuration - Bioretention components include *pretreatment,* flow regulation, ponding area, planting bed vegetation and surface mulch layer, engineered soil planting bed, storage layer, *underdrain,* sand/native soil interface layer and observation well (See Figure 1).

2. *Target Stay-on Depth* – The target stay-on depth shall be determined using an approved model. (See Consideration M in Section VI.)

3. Flow Regulation

   a. Inflow – The flow at the inlet to the bioretention device shall be controlled to prevent erosion and achieve uniform distribution across the surface of the soil planting bed.

   b. Overflow – The overflow system shall meet the following requirements:

      (1) A weir or standpipe shall be used to regulate the maximum ponding depth. The invert of the overflow structure shall be at the elevation of the maximum ponding depth of the bioretention device. This component shall meet the ponding requirements of Section V.B.4.

      (2) Water discharged from the overflow shall be conveyed to a stable outlet leading to a suitable conveyance such as a swale, storm drain or surface water.

      (3) Overflow control structures, such as *curtain drains,* that bypass the soil planting bed and discharge directly to ground water are allowed only if the sole source of stormwater runoff is from rooftops without significant contamination from industrial activity.

   c. Underdrain – The underdrain shall meet the requirements of Section V.B.8.

4. Ponding Area

   a. Maximum *Design Ponding Depth* – The design ponding depth shall not exceed 12 inches. In the event that ponding is greater than 12 inches, and less than 18 inches, an overflow weir with a variable stage discharge can be included.

   b. Drawdown Time - In designing the bioretention device, the design ponding depth divided by the *Design Drawdown Rate* (in inches / hour) shall not exceed 24 hours.

   c. Side slopes – The side slopes of the berm that forms the ponding area shall be 2H:1V or flatter.

5. Planting Bed Vegetation and Surface Mulch Layer

   a. Vegetation Plan – A vegetation plan and planting specification shall be prepared. The following apply:

      (1) The plan shall identify planting zones based on anticipated depth of water level fluctuations and duration of inundation.

      (2) Rootstock and plugs shall be used in establishing trees, shrubs and herbaceous perennials. Seed shall not be used to establish vegetation.

      (3) If the bioretention device receives runoff from non-residential source areas or streets, the plant density at maturity must be low enough to accommodate long-term maintenance or replenishment of the surface mulch layer. A planting density of one foot on center is required unless the type of plants selected would justify a larger space between the plants. As stated in Consideration R in Section VI, shrubs and trees would be planted with more than one foot between them.

      (4) Plants shall be native to the area and capable of withstanding the environmental conditions of the bioretention device such as insect and disease infestations, drought, water level fluctuations and regional temperature variations. Vegetation shall be salt tolerant when the bioretention device is

likely to receive runoff containing salt-based deicers.

(5) Turf grass shall not be used to vegetate the bioretention device, although it may be used in the pretreatment area. Invasive plants and noxious weeds shall not be used.

(6) Woody vegetation shall not be specified at inflow locations. Trees and vegetation shall not block flow paths, create traffic or safety issues, or obstruct utilities.

(7) The planting plan shall cover plant placement, planting sequence, planting time of year, fertilizing, watering and protection from other stresses such as animals, wind and sun to maximize plant growth and survival.

(8) If the engineered soil will be left to settle prior to planting, the surface shall be mulched.

b. Surface Mulch Layer – Shredded hardwood mulch or chips, aged a minimum of 12 months, or a Class II erosion control mat (blanket) shall be placed on the surface of the bioretention area. The shredded hardwood mulch or chips shall be 2 to 3 inches in depth and the mat shall be overlapped, and anchored with hardwood stakes (6 inches or longer to hold the mat to the media). The use of an erosion control mat (fastened as above) shall also be placed over the hardwood mulch to prevent the mulch from floating, at least until dense vegetation is established. The mulch shall be free of foreign material, including other plant material.

6. Engineered Soil Planting Bed

a. Surface Area – The surface area shall be determined using an approved model. (See Consideration M.)

b. Surface Slope – The surface slope of the device shall not exceed 1%.

c. Engineered Soil Depth – After settling, there shall be sufficient soil to support the rooting depth of the vegetation. If the storage layer (V.B.7.) uses gravel, a lens of pea gravel not to exceed 4 inches shall separate the engineered soil from the storage layer. The soil layer (including the pea gravel lens) shall be at least 2 feet deep. A depth of 18 inches will also be allowed for sites with more restrictive elevation requirements.

d. Engineered Soil Composition– The soil shall be engineered to the following specifications:

(1) The planting mixture shall consist of a mixture of 70 to 85% sand and 15 to 30% compost. The percentages are based on volume. Special attention should be given to plant selection when the percentage of sand exceeds 75%.

Note: This mixture meets the equivalent level of protection as determined by DNR.

(2) The sand shall meet one of the following gradation requirements:

- USDA Coarse Sand (.02 - .04 inches)
- ASTM C33 (Fine Aggregate Concrete Sand)
- Wisconsin Standards and Specifications for Highway and Structure Construction, Section 501.2.5.3.4. (Fine Aggregate Concrete Sand) 2005 edition, or an equivalent as approved by the administering authority.

The preferred sand component consists of mostly SiO_2, but sand consisting of dolomite or calcium carbonate may also be used. Manufactured sand or stone dust is not allowed. The sand shall be washed and drained to remove clay and silt particles prior to mixing.

(3) The compost component shall meet the requirements of Wisconsin Department of Natural Resources Specification S100, Compost.

(4) The engineered soil mix shall be free of rocks, stumps, roots, brush or other material over 1 inch in diameter. No other materials shall be mixed with the planting soil that may be harmful to plant

growth or prove a hindrance to planting or maintenance.

(5) The engineered soil mix shall have a pH between 5.5 and 8.0.

(6) The engineered soil mix shall have adequate nutrient content to meet plant growth requirements.

7. Storage layer – A sand or gravel storage layer situated beneath the underdrain will facilitate groundwater recharge because water in this storage area can not exit via the underdrain. It can only exit the bioretention device by infiltration into the native soil. The following requirements shall be met in designing the storage layer.

   a. The storage layer is required when the design infiltration rate of the native soil is less than 3.6 inches/hour, as determined using DNR Technical Standard 1002, "Site Evaluation for Stormwater Infiltration."

   b. The design thickness of the storage layer shall be that which results in a *total device drain time* of 72 hours, but shall not exceed 48 inches. In calculating the total device drain time, assume that event runoff has ended and the bioretention device is *fully saturated* prior to the initiation of drawdown. (Refer to Section VI.V for guidance in determining the storage layer thickness.)

   c. Gravel Specifications – The gravel shall meet the coarse aggregate #2 and other specifications of Wisconsin Standards and Specifications for Highway and Structure Construction, Section 501.2.5, 2003 edition, or an equivalent as approved by the administering authority. Gravel shall be double-washed.

      Note: Inadequate washing of aggregate may lead to clogging at the native soil interface.

   d. Sand Specifications – A layer of sand may be used in lieu of gravel to form the storage layer. The sand shall meet the specification set forth section V.B.6.d.(2).

8. Underdrain – A perforated underdrain pipe is required unless there is no suitable pipe outlet or the risk of infiltration failure at the native soil interface is minimal. The risk of infiltration failure is assumed to be minimal if the design infiltration rate of the native soil is determined to be at least 3.6 inches/hour, as determined using DNR Technical Standard 1002, "Site Evaluation for Stormwater Infiltration."

   a. Pipe Location - The underdrain pipe shall be placed at the top of the gravel or sand storage layer.

   b. Size and Material – The pipe shall have a minimum diameter of 6 inches and be made of flexible pipe or other material approved by the administering authority. The pipe shall be capable of withstanding expected traffic loads over portions of the pipe extending beyond the soil planting bed.

   c. Orifice Diameter – The underdrain orifice shall be restricted as necessary so that the *design infiltration rate* plus the *underdrain flow rate* equals the design draw down rate. The restriction shall be achieved by using an adjustable restrictor plate or valve. The restriction device shall be accessible for adjustment.

   d. Perforations – The total opening area of all perforation holes combined shall be sufficient to allow the underdrain pipe to discharge at full capacity, as would occur if there were no orifice restriction. The amount of perforation shall be increased to provide a margin of safety but shall not be so great as to compromise structural integrity of the pipe material.

   e. Pipe Protection – The underdrain pipe shall be protected from clogging by use of filter fabric or a filter sock. If the storage layer is sand, a filter sock shall be used. A cover of pea gravel may also be used.

      (1) Pea Gravel – If used, the pea gravel layer shall be at least 4 inches thick. Pea gravel shall be washed. Pea gravel shall be large enough to prevent its falling through the perforations of the under-drain pipe.

      (2) Filter Fabric – Filter fabric shall cover the underdrain pipe and shall not extend laterally from either side of the pipe more than two feet. The fabric shall meet the specifications of Wisconsin Standards and Specifications for

Highway and Structure Construction, Section 645.2.4, Schedule Test B, 2003 edition, or an equivalent approved by the administering authority.

(3) Filter Sock - The openings in the fabric shall be small enough to prevent sand particles from entering the underdrain pipe. The flow rate of the fabric shall be capable of passing water at a rate equal to or greater than the flow rate capacity of the total combined perforations in the underdrain pipe. In addition, the fabric shall meet the other requirements of Wisconsin Standards and Specifications for Highway and Structure Construction, Section 612.2.8(1-3), 2003 edition, or an equivalent approved by the administering authority.

f. Clean-out Port – The underdrain pipe shall have a vertical, connecting standpipe to serve as a clean-out port for the underdrain pipe. The pipe shall be rigid, non-perforated PVC pipe, a minimum of 6 inches in diameter and covered with a watertight cap that is flush with the ground elevation of the device.

g. Outlet – The underdrain pipe shall discharge to an existing drainage system. Examples of drainage systems include swales, storm sewers, subsurface dispersal fields and surface waters.

(1) A check valve shall be installed when backflow is possible.

(2) Access for maintenance of the check-valve shall be provided.

9. Sand/Native Soil Interface Layer

a. The interface layer is required when the design infiltration rate of the native soil is less than 3.6 inches/hour, as determined using DNR Technical Standard 1002, "Site Evaluation for Stormwater Infiltration."

b. Three inches of sand shall be placed below the gravel or sand storage layer, and vertically mixed with the native soil interface to a depth of 2-4 inches.

c. Sand shall meet the specifications set forth in section V.B.6.d.(2).

10. Design Infiltration Rate – The design infiltration rate of the native soil shall not exceed the rate identified in accordance with WDNR Technical Standard 1002 "Site Evaluation for Stormwater Infiltration".

11. Observation Wells – If there is no underdrain, one or more observation wells shall be installed to monitor drainage from the device. There shall be a minimum of one well per 1,000 square feet of *effective infiltration area*. The wells shall be:

a. Located at the center of each section being monitored.

b. A minimum 6 inch diameter slotted PVC pipe, anchored vertically to a footplate at the bottom of the bioretention device. The top of the pipe shall be high enough to prevent the entry of water ponded within the infiltration device.

c. Have a secured aboveground cap.

12. **Construction Sequencing and Oversight** – A person trained and experienced in the construction, operation and maintenance of infiltration devices shall be responsible for construction of the device. The following apply:

1. Construction Site Stabilization – Construction site runoff from disturbed areas shall not be allowed to enter the bioretention device. Runoff from pervious areas shall be diverted from the device until the pervious areas have undergone *final stabilization.*

2. Suitable Weather – Construction shall be suspended during periods of rainfall or snowmelt. Construction shall remain suspended if ponded water is present or if residual soil moisture contributes significantly to the potential for soil smearing, clumping or other forms of compaction.

3. Compaction Avoidance – Compaction and smearing of the soils beneath the floor and side slopes of the bioretention area, and compaction of the soils used for backfill in the soil planting bed, shall be minimized. During site development, the area dedicated to the bioretention device shall be cordoned off to prevent access by *heavy equipment*. Acceptable equipment for constructing the

bioretention device includes excavation hoes, light equipment with turf type tires, marsh equipment or wide-track loaders.

4. Compaction Remediation – If compaction occurs at the base of the bioretention device, the soil shall be refractured to a depth of at least 12 inches. If smearing occurs, the smeared areas of the interface shall be corrected by raking or roto-tilling.

5. Placement and Settling of Engineered Soil – The following apply:

   a. Prior to placement in the bioretention device, the engineered soil shall be pre-mixed and the moisture content shall be low enough to prevent clumping and compaction during placement.

   b. The engineered soil shall be placed in multiple lifts, each approximately 12 inches in depth.

   c. Steps may be taken to induce mild settling of the engineered soil bed as needed to prepare a stable planting medium and to stabilize the ponding depth. Vibrating plate-style compactors shall not be used to induce settling.

6. Planting – The entire soil planting bed shall be mulched prior to planting vegetation to help prevent compaction of the planting soil during the planting process. Mulch shall be pushed aside for the placement of each plant.

VI. Considerations

A. This infiltration device is especially suitable where other benefits are desired such as shade, windbreak, noise absorption, reduction in reflected light, microhabitat for plants and wildlife and improved aesthetics.

B. Place the infiltration device in a site that is visible to encourage routine up-keep and maintenance. Choose a site that provides ample room for maintenance access to all parts of the device. Consider traffic visibility and other safety issues when siting the infiltration device.

C. The bioretention device may be constructed as a filtration and recovery system followed by discharge to a storm sewer or surface outlet.

D. This infiltration device is not suitable for treating chlorides. Chloride use on source areas tributary to the bioretention device can be reduced or eliminated by minimizing the amount of compound used, using alternative de-icers or using clean sand. Aggressive sweeping in these areas, along with pretreatment sumps and filter strips, will reduce the impact of the sand on the bioretention device.

E. A maximum drainage area is established to protect the device and reduce risk of failure. Potential problems such as erosion at the inflow points, disruption of the mulch layer, premature clogging of the device and inputs of chlorides and sodium will be reduced. Additionally, numerous smaller bioretention devices are expected to have better long term performance when compared to one large device. For large impervious areas, such as parking lots, dividing the drainage area up into smaller portions (0.5 – 1 acre) is recommended. If the total drainage area to a treatment device must be larger than 2 acres, an alternative practice should be selected.

F. Longevity of the engineered soil is decreased by clogging, reduced cation exchange capacity and accumulation of sodium. Clogging problems can be reduced by limiting the input of sediment. Cation exchange capacity can be rejuvenated by the replacement of the engineered soil. Sodium accumulation can be countered by adding gypsum to the soil and/or by allowing about 1" of clean water to percolate through the planting bed 3 to 4 times in the spring

G. Erosion at the inlet to the bioretention device can be reduced by using a sump inlet or gravel bed. Level spreading can be enhanced by the use of a level spreader or by using multiple pipe inlets.

H. Pretreatment - Pretreatment will extend the life of the bioretention device, particularly when runoff is from parking lots and streets. Alternatives include grass channels, grass filter strips, sumps or forebays. Sumps and forebays should be sized to trap coarse sand (.02 - .04 inches). Table 3 provides sizing guidelines for pretreatment grass channels. Table 4 provides guidelines for sizing filter strips. Pretreatment is not considered part of the effective infiltration area for purposes of section NR 151.12(5)(c) or NR 151.24(5)(a), Wis. Adm. Code.

I. When possible, the dimensions of the planting bed should have a minimum width of 10 feet, a minimum length of 15 feet and a width to length ratio of about 2:1.

J. If no vegetated pretreatment area is provided, snow may be piled upgradient of the bioretention device, preferably upgradient of the pretreatment forebay or sump. If a vegetated pretreatment area, such as a filter strip, is provided, it may be used for snow storage but heavy machinery should not be driven onto or across the vegetated area.

K. In the event that an area greater than 2 acres drains to a bioretention device, consideration should be given to adding a pre-treatment system and / or splitting up the drainage area such that two or more bioretention devices are used to avoid overwhelming the bioretention device treatment capacity Another method would be to provide a bypass of the bioretention device for high flows.

Table 3. Pretreatment Grass Channel Guidance
The grass channel length should be at least 20 feet long. A level spreader should be used between the grass channel and the bioretention device. The channel shape should have: • A parabolic or a trapezoidal cross-section with a bottom width of 2 to 8 feet. • Channel side slopes that are 3 horizontal:1 vertical or flatter. • Flow velocities under 1 fps for the 1-year, 24-hour design storm. • Flow depth 4 inches or less for the 1-year, 24-hour design storm.

Table 4. Pretreatment Filter Strip Sizing Guidance

Parameter	Stormwater Runoff Inflow Approach From Impervious Parking Lots				Stormwater Runoff Inflow Approach From Lawns/Landscaped Areas				Notes
Maximum inflow approach length (feet)	35		75		75		150		
Filter strip slope	≤2%	>2%	≤2%	>2%	≤2%	>2%	≤2%	>2%	Maximum Slope = 6%
Filter strip Minimum length	10'	15'	20'	25'	10'	12'	15'	18'	

Example: To pretreat runoff that flows 75 feet across a parking lot before reaching the bioretention device, the filter strip should be 20 feet long if the filter strip slope is <2% and 25 feet long if the filter strip slope is over 2%.

L. Regulatory Sizing "Caps" – If a bioretention device designed in accordance with this standard exceeds the maximum required effective infiltration area established in s. NR 151.12(5)(c), the designer may reduce the effective infiltration area in the final design. Such a reduction is not required, however, and sizing based on an approved model will achieve optimal infiltration and device longevity. If the size of the device is reduced as provided for in NR 151.12(5)(c), then the design should consider maximizing the pond depth and gravel storage thickness to compensate for the decrease in the effective infiltration area.

M. The DNR has created a technical note that may be used to size bioretention devices. The "Technical Note for Sizing Infiltration Basins and Bioretention Devices To Meet State Of Wisconsin Stormwater Infiltration Performance Standards" contains an approved method to determine the target stay-on depth and presents an approved infiltration model (RECARGA) that can be used to determine the effective infiltration area requirements. Other models may be used if approved. The Technical Note can be accessed at: http://dnr.wi.gov/org/water/wm/nps/stormwater/techstds.htm#Post

N. If possible, settling of the planting bed should be accomplished naturally by allowing the filled bed to sit for several months. This will require over-filling the planting area so that after settling the proper ponding depth is achieved. Watering each lift of the planting bed to induce settling is not recommended unless water can be gently applied and the watered lift is allowed sufficient time (at least 24 hours) to thoroughly drain prior to adding the subsequent lift and at least 48 hours prior to adding mulch.

O. The sidewalls of the planting bed and sand/gravel storage area may be sloped as needed to assure a stable configuration.

P. To reduce lateral flow of water from the bioretention device towards pavement foundations, a geotextile fabric may be placed along the side-walls of the device.

Q. The optimal design pond depth for overall system function is 6-9 inches.

R. Plants can be selected to simulate a variety of plant communities. Forest and forest fringe communities should contain a mix of trees and shrubs. Trees should be planted 11-19 feet apart, shrubs 4-7 feet apart and shrub-tree mixes about 7 feet apart. Ornamental communities should contain a mix of shrubs and perennial herbaceous plants. The foliage canopy of ornamental communities should completely cover the soil planting bed at the end of two growing seasons. Meadows and meadow gardens that employ a mixture of grasses and wildflowers may also be planted.

S. Use plant materials from a certified nursery that offers a plant warranty. Select plants that can thrive with minimum maintenance in the environment of the bioretention device and that have added wildlife value as food or cover. Section IX includes two references for plant selection (Shaw and Schmidt, 2003; Bannerman and Considine, 2003). It is recommended that experienced individuals be consulted to assist with vegetation selection and establishment.

T. The rooting depth of plants and the depth of the soil planting bed should be matched to prevent plant roots from clogging holes in the underdrain.

U. A reasonable underdrain perforation safety factor is 2 to 4. The underdrain outlet may be fitted with an end wall and rodent shield if allowed by the local jurisdiction.

V. A 72-hour time limit is established in this standard for draining water from a fully saturated bioretention device. This limit is established to reduce the risk of declining infiltration caused by persistent saturation at the native soil interface.

The maximum allowable thickness of the storage layer will depend on how much time is available to drain water from that layer after time is taken to drain water from the ponding area and engineered soil. The water in the ponding area and the engineered soil exits the bioretention device via the underdrain and the native soil. The water in the storage layer exits only via the native soil. The following equations may be used to determine the allowable storage layer thickness:

$H_P = D_P/(K_u + K_n)$
$H_{ES} = (D_{ES} * P_{ES})/(K_u + K_n)$
$D = (72 \text{ hours} - (H_p + H_{ES})) * K_n$
$T_{SL} = D/P_{SL}$

Where:
H_P = Time to drain the ponding area (hours)
D_P = Depth of ponding area (inches)
K_u = Underdrain flow rate (inches/hour)
K_n = Native soil infiltration rate (inches/hour)
H_{ES} = Time to drain the engineered soil (hours)
D_{ES} = Depth of the engineered soil (inches)
P_{ES} = Porosity of engineered soil
D = Maximum depth of water in storage layer (inches)
T_{SL} = Thickness of storage layer (inches)
P_{SL} = Porosity of gravel storage layer

Using these equations, Table 5 shows sample storage layer thicknesses for a variety of conditions. Variables include pond depth, drawdown rate (underdrain flow rate (Ku) +design infiltration rate (Kn)) and design infiltration rate (Kn).

Table 5. Sample storage layer thicknesses (inches) that meet the 72-hour total device drain time								
		Kn (in/hr)						
Pond Depth	Ku+Kn	0.07	0.11	0.13	0.24	0.5	1.63	3.6
(in)	(in/hr)	*Storage Layer Thickness (inches)*						
6	0.24	*1*	*2*	*3*	*6*			
6	0.5	*9*	*14*	*16*	*29*	*48*		
6	1.63	*13*	*21*	*25*	*45*	*48*	*48*	
6	3.6	*14*	*23*	*27*	*48*	*48*	*48*	*48*
9	0.5	*7*	*12*	*14*	*25*	*48*		
9	1.63	*13*	*20*	*24*	*44*	*48*	*48*	
9	3.6	*14*	*22*	*26*	*48*	*48*	*48*	*48*
12	1.63	*12*	*20*	*23*	*43*	*48*	*48*	
12	3.6	*14*	*22*	*26*	*48*	*48*	*48*	*48*

The following assumptions are incorporated into Table 5:

- Maximum pond depth will drain in 24 hours or less,
- The maximum allowable storage layer thickness is 48 inches,
- The engineered soil depth is 36 inches,
- Engineered soil porosity is assumed to be 27%,
- Storage layer porosity is assumed to be 33%.

W. A municipal easement may be acquired to facilitate maintenance.

X. Once the design depth of the storage layer is determined, it can be reduced as long as the total storage volume is maintained. This will require making a corresponding increase in the surface area of the storage layer. This may be necessary at some sites to meet the required groundwater separation.

VII. Plans and Specifications

A. Plans and specifications shall be prepared for each specific field site in accordance with the criteria of this standard and shall describe the requirements for applying the infiltration device to achieve its intended use. Plans shall specify the materials, construction processes and sequence, location, size, and elevations of all components of the infiltration device to allow for certification of construction upon completion.

B. The plans shall include:

1. A vicinity map showing the drainage area, device location and flow paths to and from the device.
2. A plan view of the device showing the shape, dimensions, flow paths to and from the device, vegetation plan (including plant names and planting locations) and pretreatment components.
3. Longitudinal and cross-section views of the device

C. Specifications shall include the following:

1. A description of the contractor's responsibilities.
2. A requirement for the contractor to submit certifications prior to use for all materials that are to be incorporated into the project stating compliance with the standards.
3. Initial maintenance requirements.
4. Additional specifications relating to vegetation, including:
   a. Site preparation sufficient to establish and grow selected species.
   b. Planting dates, care, and handling of the plants to ensure that planted materials have an acceptable rate of survival, including weeding and watering responsibilities.
   c. Vegetation warranty period

VIII. Operation and Maintenance

A. An operation and maintenance plan shall be developed that is consistent with the purposes of this infiltration device, its intended life, safety requirements and the criteria for its design. The plan shall be developed for inspection, operation and maintenance of the device. The plan shall assign responsibility for activities and the qualifications of the personnel performing the work.

B. At a minimum, the plan shall address operation and maintenance of all vegetative and non-vegetative components identified in this standard.

C. At a minimum, the plan shall also include details on the following: frequency of inspections; inspecting for sediment buildup and clogging, erosion, trash and debris build-up and plant health; frequency of sediment removal; disposal locations for sediment; pH testing of the soil; frequency of soil, mulch, and plant replacement; inlet and outlet maintenance, and providing access to perform the operation and maintenance activities. The maintenance activities in the plan shall be consistent with Table 6.

Table 6. Typical Maintenance Activities for Bioretention Areas

ACTIVITY	FREQUENCY
Water Plants	As necessary during first growing season
Water as necessary during dry periods	As needed after first growing season
Re-mulch void areas	As needed
Treat diseased trees and shrubs	As needed
Inspect soil and repair eroded areas	Monthly
Remove liter and debris	Monthly
Add additional mulch	Once per year

D. Snow shall not be dumped directly onto the conditioned planting bed.

E. If the bioretention device receives runoff only from residential land uses other than streets, the mulch layer can be discontinued at maturity provided that a dense vegetation layer is formed.

IX. References

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Definitions

Approved Model (V.B.): A computer model with an infiltration component that has been approved by the applicable regulatory authorities.

Curtain Drain (V.B.3.b.(3)): An overflow system structures consisting of vertical columns of gravel or sand, called curtain drains, that allow the water quality volume to bypass the soil planting bed and discharge untreated to ground water.

Design Drawdown Rate (V.B.4.b.). The rate (inches/hour) at which water drains from the ponding area through a combination of infiltration into the native soil and loss through the underdrain.

Design Infiltration Rate (V.B.8.c.): The infiltration rate of the native soil selected as a basis to size an infiltration device.

Design Ponding Depth (V.B.4.a.) The distance (inches) between the top of the mulch layer and the invert of the overflow structure.

Effective Infiltration Area (V.B.11) The area of the infiltration system that is used to infiltrate runoff, not to include the area used for site access, berms or pretreatment. For bioretention, the effective infiltration area is considered to be the surface area of the bottom of the excavated hole, at the native soil interface.

Final Stabilization (V.C.1) A condition achieved on pervious areas when uniform perennial vegetative cover has been established with a density of at least 70%.

Fully Saturated(V.B.7.b) A bioretention device that has a saturated storage layer, a saturated engineered soil layer and water ponded to the invert of the overflow pipe in the ponding area.

Heavy Equipment (V.C.3): Equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires.

Hydraulically connected (V.A.2.a): Two entities are said to be hydraulically connected if a surface or subsurface conduit exists between the two such that water is transmitted from one entity to the other.

Infiltration (II): Entry and movement of precipitation or runoff into or through the soil. It includes water that may be subsequently evapotranspired. It does not include water discharged through underdrains or overflow devices.

Infiltration Device (I): A structure or mechanism engineered to facilitate the entry and movement of precipitation or runoff into or through the soil.

Native Soil (I): The undisturbed soil, situated below the bioretention device.

NR 151 (V.B.6.d.(1)): Chapter NR 151, Wisconsin Administrative Code (Runoff Management) that includes State of Wisconsin performance standards for infiltration.

Pretreatment (V.B.1): Preliminary reduction of pollutants from storm water prior to discharge of the storm water to the bioretention device.

Source Area (III): A component of urban land use including rooftops, sidewalks, driveways, parking lots, storage areas, streets and lawns from which urban runoff pollutants and volumes are generated during periods of snow melt and rainfall runoff.

Target Stay-on Depth (V.B.2): The amount of infiltration required on an average annual basis. It is the portion of the annual rainfall (inches) on the development site that must be infiltrated on an annual basis to meet the infiltration goal.

Total Device Drain Time (V.B.7.b): The time it takes water to drain from a fully saturated bioretention device. This includes the time it takes to drain water from the ponding area, the engineered soil and the storage layer. Water from the ponding area and engineered soil exit via a combination of the underdrain and native soil. Water from the storage layer exits only via the native soil.

Underdrain (V.B.1.): A perforated drain pipe situated below the engineered soil bed and above the gravel storage layer.

Underdrain Flow Rate (V.B.8.c.): The rate at which water is discharged from the underdrain, as determined by the orifice flow equation.

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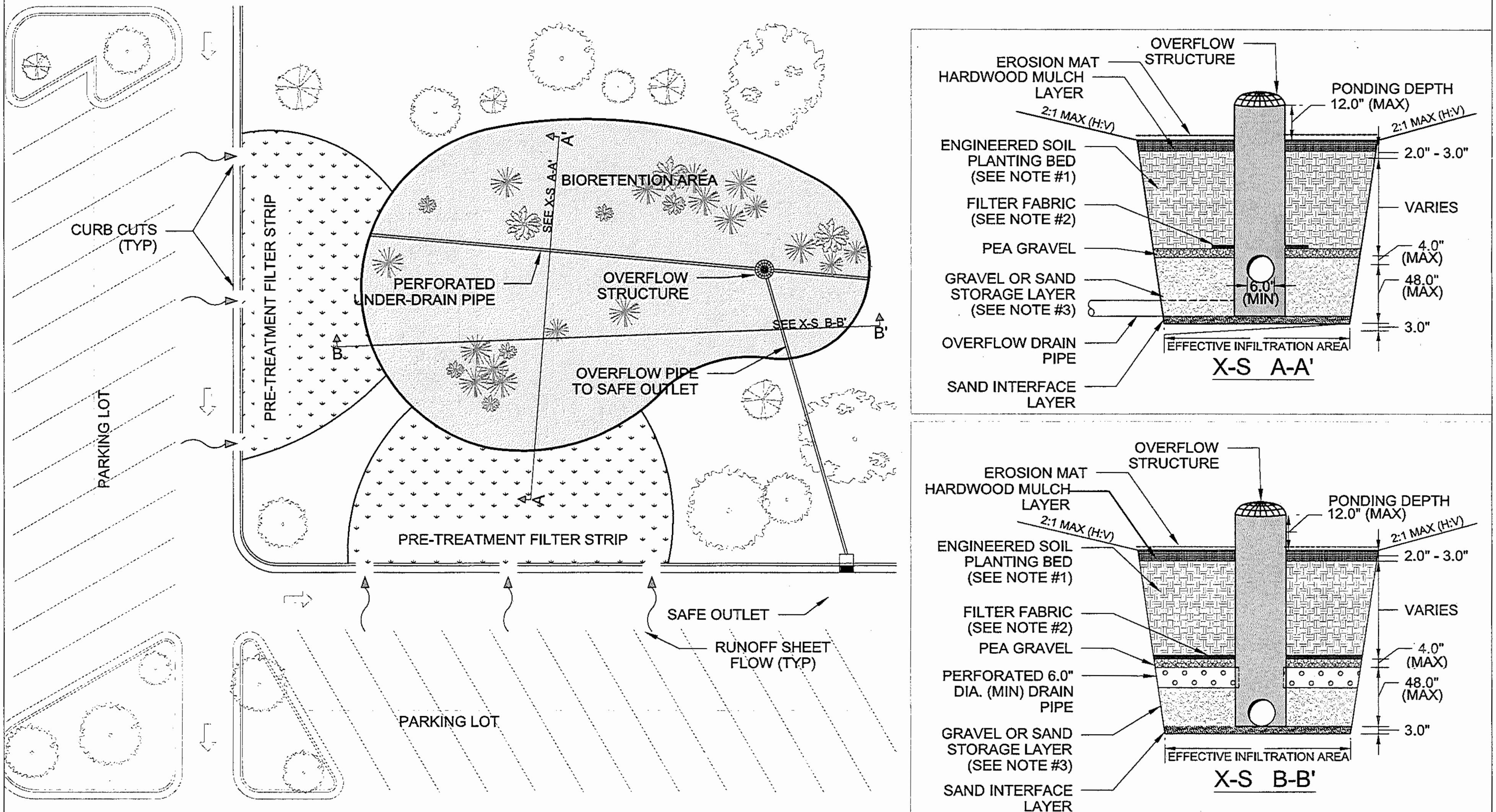
FIGURE 1. BIORETENTION DEVICE



PLAN VIEW

NOTES:

1. RECOMMENDED ENGINEERED SOIL PLANTING DEPTH IS 24.0". SHALLOWER PLANTING DEPTH IS ALLOWED WHEN SITE CONDITIONS ARE LIMITED. SOIL PLANTING DEPTH SHALL BE MINIMUM OF 18.0".
2. GEOTEXTILE FILTER FABRIC TO BE PLACED OVER PERFORATED UNDER-DRAIN.
3. GRAVEL / SAND STORAGE LAYER TO BE MAXIMUM OF 48.0" BELOW PERFORATED UNDER-DRAIN PIPE.

WISCONSIN DEPT. OF NATURAL RESOURCES

1062
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NOT TO SCALE