2.9 Bioretention

Description

Bioretention is a shallow depression over an excavation that is backfilled with an engineered media (soil) and vegetated. It is among the most effective and versatile stormwater management practices. The gradual percolation of ponded runoff through a vegetated media supplies many different runoff treatment mechanisms including sedimentation, filtration, sorption, biodegradation, nutrient assimilation, transformation, and thermal mitigation. An anaerobic zone or potential sorptive amendments added to the media may enhance the removal of nutrients. Once through the media, captured stormwater can infiltrate into the surrounding subsoil which reduces the volume of runoff, attenuates discharge rates, and recharges groundwater. Where soil infiltration rates are low, an underdrain below the media can be installed to discharge excess runoff to a storm sewer or a downstream channel. This chapter applies bioretention on a small-scale at the individual development level.

Credits

Table 2.9.1 Credits for Bioretention Meeting the Criteria in this Chapter

Objective	Credit	
Runoff Reduction Volume (RRv)	Practices that infiltrate the Water Quality Volume (WQv)	100% of the WQv.
	Practices with an underdrain above a 15-inch internal water storage	75% of the WQv in HSG B soil. 50% of the WQv in HSG C soil. 25% of the WQv in HSG D soil.
	Lined practices	None.

Planning and Feasibility

Bioretention is best suited to receive surface flow directly from roadways, parking areas, or other pavements. where it can be incorporated within adjacent landscaped areas such as parking lot islands, cul-de-sacs, and right-of-way. Smaller, distributed bioretention practices are preferable to a large, centralized practice. Small bioretention practices put treatment as close to the source of runoff as possible. This reduces the stormwater and pollutant loads on each installation resulting in a higher functioning practice with less maintenance and failure risk. When coupled with a central flood-control basin, upstream bioretention practices create an effective treatment train.

The impervious area draining to a single bioretention practice should be five acres or less. Bioretention is often impractical where expansive impervious area produces erosive runoff flow velocities in deeply buried, large-diameter storm sewers. Furthermore, large drainage areas yield a bioretention size that can be unwieldy from a maintenance perspective.

Bioretention filters ponded stormwater as it percolates downward through the media. Do not design bioretention as a bioswale or surface conveyance under this chapter. Surface flow can bypass treatment in the media and/or erode the practice.

Do not plan bioretention where an excessive sediment load is expected. Sediment fills the pore space of the engineered media at its surface which in excess can form an impermeable crust that leads to frequent maintenance and a greater risk of practice failure.

Locate bioretention practices away from areas where foot traffic may compact the media and damage vegetation.

Plan bioretention with caution in known karst regions where infiltrating stormwater could promote the formation of sinkholes. Conduct a thorough geotechnical survey in karst regions. Lined bioretention is recommended in karst areas.

Evaluating Soil Infiltration Potential

Bioretention performs best when constructed in well-drained soil that allows stormwater to readily infiltrate, but an underdrain can be installed to accommodate infiltration into moderately to poorly drained soils. The drainage properties of the in-situ subsoil must be assessed to select a suitable outlet design. The Web Soil Survey may help with the initial planning and feasibility assessment. Consider the characteristics and limitations of the soil map unit (soil series) as well as its possible inclusions, evaluating the soil profile data at the planned depth of the practice.

The Web Soil Survey gives approximate value ranges that are not meant for engineering applications (USDA-NRCS). An on-site soil evaluation will supply accurate data for use in the final design. An on-site soil assessment may also reveal limitations not shown in the Web Soil Survey (for example man-made alterations). This is especially true in urban areas where land alterations are common but farming practices can also alter soil properties. Refer to the design criteria and Chapter 2.17 for specific infiltration test guidance.

In-line versus Offline Placement

Bioretention may be positioned in-line or offline with the flow of runoff. An in-line practice ponds the WQv and then discharges excess flow through an internal overflow outlet such as a drop inlet riser. Large storms must be routed through in-line bioretention without causing damage to the practice. This is the most common bioretention configuration.

An offline practice fills the WQv and then is bypassed by excess runoff, minimizing the potential for erosion and damage during high flows. However, the inlet must be precisely designed and constructed to ensure that the proper volume of runoff enters and fills the practice before bypass occurs. Numerous off-line bioretention installations have shown how poor design or poor construction may cause the intended treatment volume to bypass the practice.

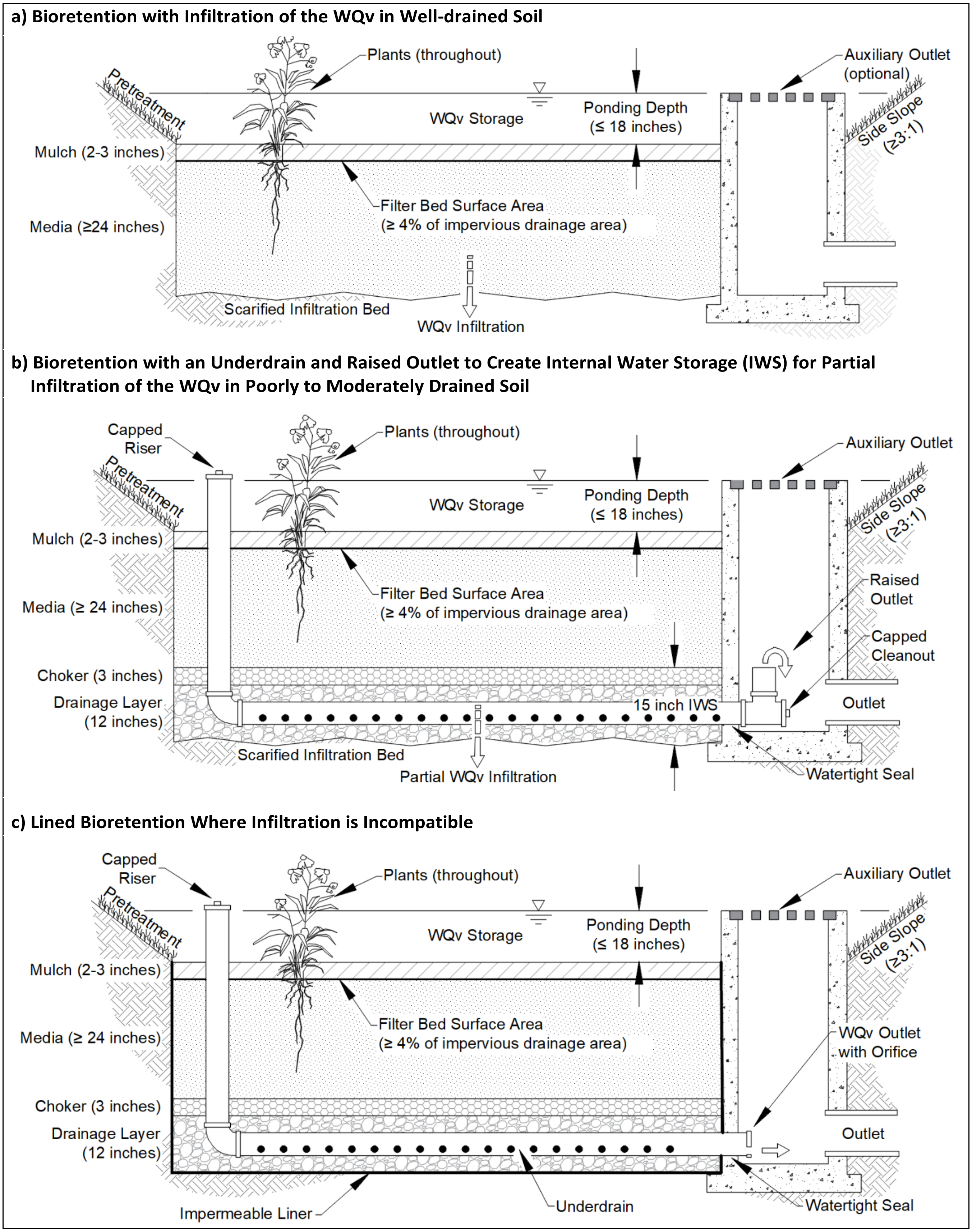

Figure 2.9.1 Schematic Sections of Bioretention (not to scale)

Design Criteria

Water Quality Volume Storage and Drawdown

All bioretention practices shall be designed to capture and store the water quality volume (WQv) in a shallow basin above the mulch surface as Figure 2.9.1 illustrates. See Chapter 2.18 for instructions on calculating the WQv of the area draining to the practice.

The target and maximum drawdown time for the ponded WQv is 24 hours. The ponded WQv plus the upper 24 inches of media should drain within 48 hours. These timeframes ensure readiness for subsequent storm events, prevent nuisance conditions, and maintain adequate oxygen levels for plants and soil biota. The bioretention media specification in this chapter can be assumed to produce the target drawdown time. Where infiltration of the full WQv is planned, the field saturated hydraulic conductivity (K_{fs}) of the in-situ soil will control the drawdown time.

Pretreatment and Inlet

Carefully plan how runoff will enter bioretention. Design the inlet to do the following.

1) Create an area for preliminary capture and periodic removal of sediment and trash, particularly from parking areas which tend to produce a higher load of eroded coarse material. Capturing excess sediment prior to the filter media reduces the potential for crusting and eases the maintenance burden.
2) Dissipate the energy of incoming flow to minimize scouring of the mulch and media.
3) Distribute stormwater over the surface area to use all of the media filter and water all plants.

Wherever possible, direct runoff into bioretention as sheet flow off gently sloped pavement. A gravel verge (a shallow, stone-filled trench) at the edge of pavement or a three- to five-foot-wide grass filter strip (often as the basin side-slopes) can easily achieve the objectives listed above when runoff enters bioretention as sheet flow. A flush curb or walkway with raised wheel stops will preserve sheet flow from adjacent parking stalls.

Concentrated inflow to bioretention may be through swales, curb openings, or small-diameter underground pipes, all of which are shallow entrances with manageable flow velocities. A grass swale provides excellent pretreatment while conveying flow to bioretention. Where the inlet will be a small-diameter pipe entrance or a curb cut, use a shallow sump (forebay), rock pad, or manufactured device to capture sediment and dissipate energy. Ensure that accumulated sediment can be easily removed from the pretreatment with a shovel or vac-truck. Do not allow stormwater to bypass the media treatment area by flowing directly from a forebay sump to the underdrain.

Curb cuts should be a minimum of 24 inches wide. Configure curb cuts to accept gutter flow without abrupt changes in the direction of flow. For example, a grated drop inlet across the gutter may better intercept gutter flow than a curb opening parallel to flow. Note curbing that defines the perimeter of bioretention may compel contractors to raise the media elevations to resemble typical parking lot islands, inadvertently diminishing WQv storage capacity.

Positive surface drainage from impervious area into bioretention is critical. Specify inlet elevations in the construction plans. Filter strips and verges should be two to three inches lower than the flush curb or adjacent pavement to prevent the gradual buildup of sediment and vegetation from damming flow back onto the pavement. Similarly, the lip of curb cuts should be slightly lower than the adjacent pavement with chutes at a positive grade.

Ponding Depth

The ponding depth of the WQv in the storage basin above the bioretention media surface shall be less than or equal to 18 inches. A WQv ponding depth of 12 inches or less optimizes the filter media and infiltration bed area.

The depth of ponding is controlled by the height of the internal overflow structure of an online practice or the inlet elevation of an offline practice. Additional detention storage with a proper outlet may be included above the WQv to satisfy local peak discharge requirements.

Consider safety, vegetation health, media compaction, and side slope stability when planning the total ponding depth.

Media Filter Bed Area and Geometry

The surface area of bioretention media forms a horizontal filter bed that shall be equal to or greater than four percent of the impervious drainage area to prevent overloading it.

The filter bed surface should be level and shaped to ensure that stormwater spreads over the entire media surface. Non-uniform perimeters fit into the contours of the landscape may be more aesthetically pleasing.

Side Slopes

The maximum side slope of the basin above the filter bed is 3:1 to prevent erosion. Side slopes should be grassed unless their mowing will be impractical. Walls and rockeries may be installed where necessary to ensure stability, but incoming surface flow may not plunge erosively onto the filter bed.

Bioretention Media (Engineered Soil)

Bioretention media is an engineered soil designed to mimic the hydrologic soil properties of natural loamy sand. It forms a well-drained rooting environment that supports plants and a microbial community so that both plant- and soil-based mechanisms treat runoff as it slowly percolates through the media. The media layer shall be a minimum of two feet thick to develop sufficient contact time for these treatment processes to occur.

All bioretention media shall be certified by a qualified laboratory (1 test per 100 cubic yards of media) to meet the properties listed in Table 2.9.2. All media shall be free of contaminates including any metals, treated wood, plastic, petroleum, glass, concrete, brick, or inert materials not intended specifically as a soil supplement. It shall not contain stumps, branches, large stones, clay clumps, or materials that may adversely affect the planned properties. To the extent possible, bioretention media shall be free of obnoxious weed seeds, pathogens, or other undesirable organisms. Obtaining bioretention media from a reputable earth materials supplier experienced in mixing bioretention media from select sand, topsoil, and compost materials to develop these properties is highly recommended.

Table 2.9.2 Bioretention Media Specifications

USDA Soil Texture Classification	Loamy sand.
Clay Content	The mineral fraction of the media shall be no greater than 10 percent clay per USDA classification (< 0.002 mm) by weight.
Sand Content	The mineral fraction of the media shall be no less than 80 percent and no more than 90 percent medium to coarse sand per USDA classification (0.25 to 1.0 mm) by weight.
Organic Matter Content	1.5 to 5 percent by dry weight as determined by percent loss on ignition (ASTM-D2974).
pH	5.5 to 8.0
Phosphorus	Not to exceed 40 mg/kg as determined by the Mehlich-3 test.
Soluble Salts	500 ppm maximum (soil/water 1:2).

Bioretention media should have a long-range saturated hydraulic conductivity (K_{sat}) of one to five inches per hour. The K_{sat} of media as supplied may initially be slightly higher as it is expected to diminish as the practice ages. ASTM F1815-06 is the recommended method to test the K_{sat} of bioretention media. Note this chapter does not apply to manufactured biofiltration systems with a high design flow rate ($K_{sat} \geq 10$ in/hr) media.

Blending Raw Materials for Bioretention Media

Bioretention media should be a homogeneous blend by volume of 70 to 90 percent sand, 5 to 20 percent topsoil, and 0 to 10 percent wood-based compost. The composition of each raw material will influence the exact proportions needed to achieve the overall media characteristics given in Table 2.9.2. Use the guidelines below to select raw materials for blending into bioretention media.

- Sand should consist of clean natural or manufactured sand meeting the fine aggregate specification of ASTM C-33 (Standard Specification for Concrete Aggregates). It must be free of any harmful substances. Fine sands (passing a No. 40 sieve) present a greater risk of clogging and should be no more than 30 percent of the media sand content. Rock dust is not an alternative to sand.
- Topsoil should be natural loam or silt loam topsoil (A-horizon). These soil textures have the right proportion of silts and clays to produce the desired loamy sand media. Too high of a clay content will reduce the media infiltration rate, potentially to the point of failure. Topsoil also contributes stable organic matter which is necessary for healthy vegetation and treatment processes such as cation exchange and microbial metabolism. Test at least one or two samples per donor site to evaluate how its composition will influence the overall recipe. Topsoil must be free of dense subsoil and contaminants.
- Soil organic matter may be supplemented with the addition of compost derived from arborist chip, tree trimmings, agricultural plant waste, leaves, pine bark fines, or another low-phosphorus feedstock. In addition to supplying nutrients, organic matter increases the media water holding capacity and is a carbon source for treatment mechanisms including biological degradation and metal sorption. However, nutrients supplied in excess of plant needs can leach from bioretention media which is counterproductive to stormwater treatment. **Compost derived from grass clippings, post-consumer waste, animal manure, biosolids, and similar materials with a relatively high phosphorus content must be avoided.** Keep in mind that nutrients in potting soil accompanying container plants should initially support the plant after which there will be an incoming nutrient load in stormwater runoff over the life of the practice.

  All compost used shall meet the U.S. Composting Council's Seal of Testing Assurance Program and originate from an Ohio EPA Class IV (yard and agricultural plant-based materials) composting facility. Compost must be well-aged and free of objectionable odors and content. It must not contain shredded lumber which may be contaminated with chromated copper arsenate, paint, nails, and other deleterious materials.

Stratified Media Profile Alternative

Ament (2021), CSC (2022), Iowa (2020), Maine (2017), and others reference conditions where a higher organic content media layered over a sandier media may be a better alternative to the conventional homogeneous media design. One such case is bioretention planted with short grass or trees, both of which have shallow roots. Concentrating organic matter near the media surface will better supply nutrients and water-holding capacity to a shallow root system. A six to 12-inch top layer in the upper range of organic matter content placed above a layer of 85 percent sand and 15 percent wood chips is suggested. A stratified media may be used to capture nutrients. A media layer with compost to support plant growth placed over sand mixed with sorptive amendments is suggested to reduce phosphorus leaching. Similarly, an aerobic media layer placed over a zone of anaerobic media may improve nitrogen removal. Both are discussed later in this chapter.

Subsoil Infiltration and Internal Water Storage

The infiltration of stormwater into the subsoil that bioretention is excavated into reduces runoff volumes, recharges groundwater, and further treats water soaking through the native soil matrix. Given time and storage, some infiltration can occur even on poorly drained soils. Because of these benefits, plan to exfiltrate at least some of the WQv unless adverse conditions call for an impermeable liner. How much of the WQv and the bioretention design depend on the properties of the in-situ subsoil.

A. Where in-situ subsoil can infiltrate the entire WQv within 48 hours, exfiltration may be the sole outlet for the WQv. These are usually loamy sand and sandy loam textures with a Kfs ≥ 0.50 inches per hour that are typically placed in Hydrologic Soil Group (HSG) A but may include HSG B soils. Figure 2.9.1.a illustrates this configuration.

   A professional soil scientist or other qualified professional shall conduct field tests at the expected bottom depth and exact location of the bioretention following the methods described in Chapter 2.17 to measure a design Kfs. The designer shall use the design Kfs to size the infiltration bed area to exfiltrate the entire WQv within 48 hours.

B. Subsoils with a Kfs less than 0.50 inches per hour offer an opportunity to infiltrate a sizable portion of the WQv. Internal water storage (IWS) beneath an underdrain creates a subsurface storage volume which extends time for infiltration to occur at a rate compatible with moderately to poorly drained soils without prolonged surface ponding or compromising readiness for the next rainfall. As illustrated in Figure 2.9.1.b, create a 15-inch deep IWS within the drainage and choker stone layers by placing a raised outlet on an underdrain. An IWS may also be created within a 15-inch aggregate-filled sump beneath the underdrain without a raised inlet. After filtering through the media, runoff volume that exceeds the IWS capacity will discharge through the underdrain.

   A 15-inch IWS is predicted to exfiltrate an annual runoff volume which can be credited as RRv (represented as a percentage of the WQv in Table 2.91). Field soil infiltration tests are not needed to apply these simple RRv credits, however soil borings must confirm the mapped soil texture is present. Map units having a Bt or Bx horizon in the NRCS official series description must be sampled for the absence of an impermeable fragipan. Alternative credits may be approved by Ohio EPA when validated through acceptable modeling (U.S. EPA's Stormwater Management Model 5 or similar) and field soil infiltration rate test data.

The designer must evaluate the potential adverse impacts of infiltrating stormwater runoff (for example, the potential for groundwater contamination, slope failure, and flooding or structural damage to below-grade foundations, basements, and other infrastructure) as well as site conditions which may be unfavorable to infiltration (for example, a high water table, karst, shallow bedrock, or anticipated high pollutant loads). Use an impervious liner as illustrated in Figure 2.9.1.c. to address these issues. Install the underdrain without a raised outlet but fitted with a control orifice to meet the targeted 24-hour WQv drawdown time. These designs are often referred to as "biofiltration".

The Subsoil Infiltration Bed

The excavation walls and floor become the infiltration bed, a non-traditional but critical constructed feature of bioretention that should be specified in the construction plans and specifications. The process of construction itself must not degrade the subsoil infiltration rate. For example, excavator buckets smear and seal off clayey soil, especially when they are wet. To preserve the design soil infiltration rate and the RRv credit, require:

1. excavation take place only in dry soil conditions,
2. excavation take place from the perimeter or use protective mats if equipment must be operated within the bioretention excavation to minimize soil compaction,
3. the builder rakes the soil surface a few inches deep with the teeth of the excavator bucket during the final excavation pass or a similar method; and
4. any unavoidable soil smearing or surficial compaction be remediated by tilling, scarifying, and/or fracturing the soil surface once it has dried.

If efforts to prevent compaction and smearing cannot be included in the plans, conduct infiltration tests after excavation to confirm the design Kfs.

The bioretention bottom should be as level as possible to allow runoff to uniformly infiltrate into the subsoil.

Choker Layer

A choker layer composed of three inches of washed pea gravel approximately three-eighths inch in grain size (AASHTO No. 8) keeps the media from migrating into the drainage layer. Do not use filter fabrics to separate the media from the drainage layer below. Fabric blinding presents a considerable risk of failure that will not be easy to fix.

Drainage Layer

Place a layer of AASHTO No. 57 or 67 washed stone below a choker layer to serve as a free-draining media as well as protective cover and bedding for the underdrain pipes. The drainage layer is typically 12 inches thick with a minimum of three inches above and below a six-inch diameter underdrain pipe but may be increased to accommodate larger pipe or create more internal water storage volume.

Table 2.9.3 Recommended Porosity Values for Storage Volume Calculations

Engineered Bioretention Media	0.20
Sand	0.30
Stone	0.40

Underdrain and Outlet

The underdrain shall discharge to a suitable, stable outlet with free, positive drainage. Specify a six-inch diameter or larger perforated thick-wall plastic pipe or equivalent capable of withstanding the expected load and stresses from pressurized back-flushing, root removal equipment, or other maintenance activity. Place the underdrain level or on a positive slope with holes or slots oriented downward. Do not wrap the underdrain in filter fabric or sock which poses a risk of irreparable clogging.

At least one run of underdrain should extend across the filter bed and end with a riser pipe for observation and cleanout. Extend a solid-wall, rigid riser pipe with a screw-type cap above the ponded water elevation. Consider adding cleanouts along excessively long underdrains, at bends, and in locations that will ease maintenance. Consider additional underdrain runs if the practice is large or has multiple lobes (for example, L-shaped or triangular), placing cleanouts at the end of each run.

As with all stormwater practices, the designer must evaluate and account for potential tailwater conditions in the receiving storm sewer or stream. Bioretention should be free draining and not subject to tailwater conditions where the underdrain outlet would be fully or partially submerged. Any scenario in which water from the larger drainage network (such as a detention basin; a receiving stream or lake; or a storm sewer) is backed into the bioretention cell by having a higher head at the outlet than is present in the bioretention practice should be avoided. From a practical standpoint, the engineer might use the following rules of thumb when checking for backflow into the bioretention practice from tailwater/surcharge in the drainage network.

- The bioretention practice should be designed such that the tailwater elevation does not exceed the elevation of the internal water storage zone for the one-year, 24-hour event.
- The bioretention practice should be designed such that the tailwater elevation does not enter the top 12 inches of planting media for the 10-year, 24-hour event.

All bioretention practices shall have a means of discharging runoff that exceeds the WQv in a safe, non-erosive manner. This is commonly a drop inlet riser set at the maximum ponding elevation of the WQv. An off-line practice must have a carefully designed inlet that bypasses the practice only after the ponding depth fills the WQv.

Landscape Plan

Vegetation is fundamental to bioretention. Plants evapotranspire runoff, take up pollutants, prevent media erosion, and maintain the Ksat of the media and soil. Supply a quantity of plants that will fill the media without the plants competing against each other. Plan an aerial coverage at plant maturity of 70 to 90 percent of the media surface. Dense vegetation also controls weeds, deters foot traffic, and often has better aesthetics.

Consult a landscape architect, horticulturalist, or plant expert familiar with bioretention to create a landscape plan appropriate to the predicted conditions and desired look of the practice. The plan may include perennial herbaceous plants, shrubs, sedges, rushes, grasses, and/or trees. Native, non-invasive species are strongly encouraged, but selection should focus on root propagation, survivability, maintainability, pollutant tolerance, and pollutant extraction. Plants with fibrous roots that will permeate the media are preferred over those with taproots or creeping root systems. Select plants that, in addition to tolerating the buildup of pollutants generated by stormwater (for example road deicers), can withstand widely varying soil moisture conditions as bioretention can be very dry for extended periods, punctuated with periods of temporary submergence. Note that moisture conditions can also vary by position within the practice itself. Choose plants that will fit the depth and surface area of media when fully grown. It may be necessary to increase the media depth and area to accommodate desired large plants, shrubs, and trees.

Post-construction stormwater management practices are usually placed into immediate service. To increase plant survival and accelerate maturation of the practice, use one-gallon potted plants and two-gallon potted shrubs. Plugs and seeds are less likely to survive, will need more watering, and may delay the readiness of the practice.

Trees may be planted if there is sufficient room for their roots and canopy at maturity with minimal risk of damaging infrastructure. There should be at least 36 inches of media over an underdrain to deter roots from blocking the drain. Select trees that will not produce excessive fruits, nuts, pods, or litter that can mat the media surface and clog outlets. Plan species with smaller leaves that decompose quicker after falling. Plant trees with a caliper size of at least one inch. Consider that trees may be more difficult to replace if they die prematurely.

“No-mow” grasses are a possibility where view obstruction or plant maintenance is a concern, or where a lawn-like look is desired. These grasses reach a height of six to twelve inches but may flop over to lower the height. They are mowed only once or twice per year which minimizes the risk of damage to the practice including compaction of the media. Although they blend in with, no-mow grasses should not be maintained as typical turf lawn. “Do not mow” signs may be necessary to direct maintenance personnel.

Turfgrass may be considered only when necessary. Their shallow roots and mowing frequency may limit bioretention’s effectiveness. Sod rather than seed turfgrasses to rapidly establish cover. To prevent clay in the sod’s root mass from sealing off the media, all sod must either be washed to remove all soil from its roots or be grown on loamy sand soil. Further, washed sod may root more quickly than standard sod.

Mulch

A hardwood mulch cover is a key part of bioretention serving several purposes. The mulch layer is an easy-to-replace pretreatment filter that protects the media from crusting over with sediment by collecting coarse sediment. Wood mulch also treats runoff by bonding heavy metals and serves as a growth medium for microorganisms that degrade organic pollutants. As a protective cover, it minimizes weed growth while keeping the underlying media from drying and eroding.

Place a two- to three-inch-thick layer of coarsely shredded hardwood mulch over the media surface unless it will be grassed. Specifying the mulch be certified by the Mulch & Soil Council helps ensure the product has no chromated copper arsenate (treated lumber) or other contaminates. Do not use pine mulch or fine mulch which are more likely to scour and float, potentially blocking drainage. Decorative stone may be placed at locations wood mulch is prone to scour, near an inlet for example.

Horizontal Separation Distance

Plan adequate horizontal separation between an infiltrating practice and any water supply wells, septic systems, steep slopes, retaining walls, and building foundations or basements. Table 2.9.4 recommends minimum horizontal separation distances for unlined bioretention. Ensure a consolidated soil mass creates sufficient travel distance, increasing a setback distance where conditions merit. Alert structural designers to bioretention near new buildings so that any necessary precautions can be taken for basement, footing, and foundation designs. Ensure nearby curb and foundation drains, sanitary sewer, or utility conduits (including bedding) will not intercept infiltrating stormwater.

Table 2.9.4 Recommended Horizontal Separation from Infrastructure for Unlined Bioretention

Protected Feature	Minimum Setback Distance
Well	100 feet
Septic system (including perimeter drain)	50 feet
Steep slope or retaining wall	50 feet (or conduct slope stability analysis)
Building foundations or basements	25 feet (or 10 feet with an underdrain)

Follow setbacks from property line established by the local government. Ensure adequate sight distances and clear zones for roadway applications.

Consult the local jurisdiction or utility owner for horizontal and vertical separation requirements from buried utilities. Avoid placing bioretention over utilities which could be exhumed in the future.

Groundwater and Bedrock Separation

Separation from groundwater ensures bioretention media does not stay saturated and unable to function effectively. Evaluate the seasonal high water table (SHWT) elevation at the site recognizing that impervious cover and drainage system in urban areas may affect the mapped SHWT. The bottom of the excavated practice should be at least one foot above the predicted SHWT. Groundwater separation may also be achieved by installing a geomembrane or compacted clay liner or by installing perimeter drains that lower the local water table.

An impermeable liner separating bioretention from the in-situ soil is required where excessive non-sediment pollutant loads including spills of hazardous materials could be reasonably expected to occur.

RRv and groundwater recharge do not apply to lined bioretention.

Maintain a minimum of two feet of in-situ soil between the bioretention bottom and bedrock.

Protection from Construction Sediment

Sediment-laden runoff from construction activity shall not pass through a bioretention practice. Protection from construction sediment must be accounted for in the bioretention plans. A geotextile cover or a perimeter sediment barrier alone do adequately protect bioretention from construction sediment. The best option is to delay constructing bioretention until its drainage area is permanently stabilized or divert runoff to a separate temporary sediment basin. Where a bioretention area must be used to capture construction sediment, excavate the sediment trap or basin bottom at least 12 inches higher than the planned bioretention floor. After the drainage area is permanently stabilized, remove ponded water and accumulated sediment, allow the soil to dry, then excavate the bioretention to design elevation.

Optional Design Enhancements

Bioretention is an evolving stormwater management practice. Designers may consider novel designs or enhancements that are supported by rigorous academic research to improve function and performance.

Anaerobic Media Zone for Nitrogen Removal

Denitrification, which is the metabolic conversion of more harmful forms of nitrogen such as nitrate and ammonia into nitrogen gas, requires anaerobic soil that has a significant carbon source. A raised outlet that extends the IWS at least six inches up into the media as illustrated in Figure 2.9.2 creates an anaerobic media layer that promotes denitrification. Supplement the anaerobic media layer with extra wood chips, shredded bark, pine needles, or another low-nutrient carbon source to support denitrifying microbes. Leave at least 18 inches of unsaturated media above the IWS for healthy plant growth. This design modification is encouraged in watersheds with a Total Maximum Daily Load (TMDL) for nitrogen (nitrate or ammonium).

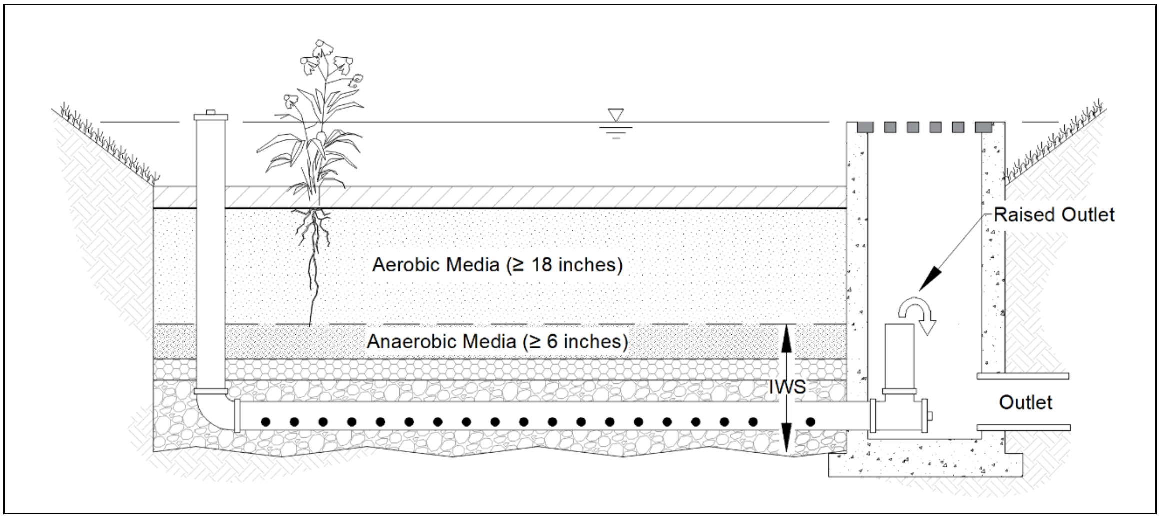

Figure 2.9.2 Schematic Profile of Bioretention with an Anaerobic Media Zone for Denitrification (see Figure 2.9.1 for remaining details) (not to scale)

Phosphorus Capturing Media Blends and Amendments

Research continues to explore media blends and amendments that may improve the capture of phosphorus compounds or other specific pollutants found in stormwater runoff. These amendments have included alum, aluminum hydroxide, biochar, calcium-water treatment residuals (spent lime), expanded shale, fly ash, gypsum, iron fillings, and others as well as in various combinations and arrangements.

Consult Ohio EPA for approval prior to proposing any amended bioretention media. Amendment materials may be subject to an Ohio EPA beneficial use permit. Amendments must be shown to have no adverse impact on the media's hydraulic conductivity (through clogging or preferential flow) or vegetative growth. The overall long-term treatment capability must also be fully understood including how changing saturation levels and the periodic influx of road salts may affect performance. Ensure alterations to the media's pH, CEC, and chemical properties will not result in incidental release of non-targeted pollutants.

Some amendments evaluated are produced as an uncontrolled waste product with properties that can be inconsistent between batches, sources, and regions. The sourced material must be analyzed for equivalency in particle size distribution, chemical composition, and any other key properties with the material used in research or pilot projects.

Construction Considerations

Bioretention's reliance on infiltration and non-traditional materials (plants, engineered media) increases its sensitivity to construction methods. It is also a novel practice to much of the construction industry. Consequently, detailed construction notes and specifications within the Stormwater Pollution Prevention Plan (SWP3) and the construction plans can be essential to bioretention functioning as intended.

Media

Instruct the builder to submit test documentation for the sourced bioretention media to inspecting entities well in advance of its planned construction and include it in the SWP3 available on-site.

Placing the media in eight- to 12-inch lifts and gently soaking each lift with clean water promotes consolidation. Plan to fill the media up to five percent higher than the finish grade to allow for settling.

Mulch and Vegetation

Biodegradable netting or light watering may minimize the floating of the mulch.

Ensure planting activity will not compact the bioretention media or that damage will be repaired afterward.

Note that plants may require watering over the first several months to aid establishment, especially during periods of dry weather. Identify who is responsible for watering and for how long after construction concludes.

Stake trees and tall shrubs subject to being thrown by the wind.

Maintenance Considerations

Bioretention must work long-term. Consider the ease of maintenance when designing bioretention to ensure a consistent level of treatment will occurs over its life. The SWP3 must be accompanied by a detailed operation and maintenance plan that outlines the maintenance activities necessary for sustained performance and their expected schedule.

Bioretention is a landscaped practice requiring regular attention (for example, pruning and replacement of plants; removal and replacement of mulch; and trash removal) for proper function and aesthetic appeal.

Ensure ample clearance for maintenance to routinely occur without disrupting normal site operations. A drainage easement may be necessary to allow access for inspections and maintenance.

Ensure that routine inspection and maintenance activity will not compact the bioretention media by placing inspection ports and the outlet structure near the perimeter.

Signage is recommended to ensure third-party landscaping services follow the operation and maintenance plan.

For residential applications, measures such as educational materials and deed restrictions are recommended to prevent a homeowner or a homeowner's association from altering a bioretention practice in a way that would diminish its effectiveness (for example by over-mulching).

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