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MEMORANDUM

To: Mr. Pascal Rettig, Chairman
Amesbury Planning Board

Cc: Mr. Nipun Jain, Director of Planning
Community & Economic Development

From: Gerard J. Fortin, P.E.
Michael Leach
Stantec Consulting Services Inc.

Date: September 4, 2026

Applicant: Frank Cavallaro
Owner: Frank Cavallaro

RE: **Tax Map 59 Lot 47**
29 Lake Attitash Road Development
Second Stormwater Peer Review
Project No. 179451250

As requested, Stantec Consulting Services, Inc. (Stantec) has conducted a second review of the stormwater report and system submitted with the site plan and Special Permit Application relative to the proposed development located at 29 Lake Attitash Road and submitted on behalf of Frank Cavallaro(Applicant). The review was based primarily on updated plans and stormwater report provided by Millenium Engineering, Inc. (MEI). We note the following available materials have been obtained:

1. Site Plan in Amesbury, MA at 29 Lake Attitash Road Prepared for Frank Cavallaro sheets 1 and 2 of 2 dated Sept 29, 2025 and last revised on 8/10/26 prepared by Millennium Engineering, Inc.;
2. Stormwater Management Report for the proposed improvements at 29 Lake Attitash Road Amesbury MA prepared for Frank Cavallaro dated December 10, 2025 and last revised on August 10, 2026 prepared by Millennium Engineering, Inc.;
3. Copy of Pollution Prevention and Operation and Maintenance Plan for Site Plan at 29 Lake Attitash Road Amesbury MA dated December 10, 2025 prepared by Millennium Engineering, Inc.;
4. Copy of Long-Term Pollution Prevention and Operation and Maintenance Plan for Site Plan at 29 Lake Attitash Road Amesbury MA dated December 10, 2025 prepared by Millennium Engineering, Inc.;
5. Copy of letter to Mr. Pascal Rettig, Chairman, Amesbury Planning Board dated August 10, 2026 prepared by Millennium Engineering, Inc.

As noted previously, the Applicant proposes to construct a single family dwelling on an existing vacant residential lot located in the City's designated Water Resources Protection District (WRPD) as defined in Amesbury Bylaws under Section XIV. The Applicant's submission indicates the subject parcel is located within the Zone C portion of the WRPD and includes wetlands. The submitted plans indicate a proposed single family dwelling that is served by underground sewer and water services and overhead wires with connections from Lake Attitash Road. Other site improvements include a permeable driveway, permeable walkway and a stormwater rain garden basin with all work located within the 100-foot wetland buffer. The topographic information indicates the elevation change from north to south of approximately four feet (102 to 98).

Based upon the Applicant's submission noted above in response to the May 15, 2026 letter, we offer the following general comments in the format of retaining the original comment when needed, *noting the Applicant's response (italics)*, and providing our **subsequent comment (bold)** as needed:

General Comments:

1. The Applicant has provided a stormwater management report for the project. We note the following general concerns:
   A. The Applicant's design appears to indicate the proposed rain garden stormwater basin will be excavated into the existing ground with depths below the existing ground varying up to one foot to construct the bottom elevation of 99.75 for the proposed bioretention basin. The bioretention detail on sheet 2 indicates the depth below the basin bottom to install the manufactured bioretention treatment layers is another 28 inches (~2.3 feet) below the basin bottom or to elevation 97.4. The test pits provided indicate the seasonal high water table varies from 16-18 inches below the existing ground and we note this equates to elevation 99.0 to 99.16 as noted on sheet 2 of the plan set. The design plan indicate the existing elevations along the wetlands adjacent to the basin vary from 98 to 99.5 and implies the bottom of the proposed stormwater basin structure would be below the existing seasonal high water table and does not provide the minimum two foot of separation above the seasonal high water table required per Volume 2 Chapter 2: Structural BMP Specifications for the Massachusetts Stormwater Handbook. We recommend the Applicant review the BMP Specifications for the Massachusetts Stormwater Handbook and update the bioretention basin design as necessary, in compliance with the Massachusetts Stormwater Handbook.

      It is the professional opinion of MEI that this project is not subject to the requirements of the Massachusetts Stormwater Handbook. Nevertheless, MEI has designed the rain garden to meet the applicable BMP specifications to the maximum extent practicable. Although the soil media extends below the seasonal high groundwater table, the bottom of the rain garden (top of the soil media) remains above the seasonal high groundwater elevation. Providing the recommended two-foot separation from groundwater is infeasible due to the site's high groundwater conditions without raising the site, which would result in additional site disturbance. However, MEI believes the rain garden will function as intended during drier periods by providing groundwater recharge and reducing total suspended solids (TSS).

      In addition, the basin has been designed to provide storage for the 100-year storm event. As a result, during wetter periods when infiltration and recharge may be reduced, the basin will still provide adequate detention storage to attenuate stormwater runoff. A capped 4-inch underdrain has been provided at the bottom of the basin as a contingency measure should the rain garden be unable to infiltrate stormwater within an acceptable timeframe during prolonged wet conditions.

      A copy of the MassDEP Structural BMP's Volume 2/Chapter 2; pages 23-33 (rain garden design criteria) taken from the Massachusetts Stormwater Handbook is attached and provided for review, consideration, and information. The requirements of the Massachusetts Stormwater Handbook are not specifically stated in the Amesbury Bylaws but under XIV.I.B.7 the bylaws call for *"…a system of stormwater management and artificial recharge of precipitation is developed which is designed to prevent untreated discharges to wetland resource areas and surface water; preserve hydrologic conditions that closely resemble*

pre-development conditions; reduce or prevent flooding by managing peak discharges and volumes of runoff; minimize erosion and sedimentation; not result in significant degradation of ground water; reduce suspended solids and other pollutants to improve water quality and provide increased protection of sensitive natural resources. These standards may be met using the following or similar best management practices: (1) For lots occupied, or proposed to be occupied, by single or two family residences recharge shall be attained through site design that incorporates natural drainage patterns and vegetation in order to maintain predevelopment stormwater patterns and water quality to the greatest extent possible. Stormwater runoff from rooftops, driveways and other impervious surfaces shall be routed through grassed water quality swales, as sheet flow over lawn areas or to constructed stormwater wetlands, sand filters, organic filters, and/or similar systems capable of removing nitrogen and phosphorus from stormwater."

The DEP rain garden design is a based upon separation from the seasonal high water table to properly treat runoff as described under the DESIGN section on page 26. As presented, the Applicant's design would appear to inhibit/prevent complete treatment of runoff when the seasonal water table is within the filter media or within 2 feet below the media. It is our understanding the Applicant has not presented design information relative to raising the site as has been noted in the response letter for review and consideration by the Board.

B. **Comment addressed with revised submission**.
C. **Comment addressed with revised submission**

D. The typical guidance for projects in the WRPD is to demonstrate compliance with Massachusetts Stormwater Management Standards. We note the following:
   1. **Comment addressed with revised submission.**
   2. Standard 2 – Peak Rate Attenuation: As noted above, the Applicant's analysis and calculations do not address all the existing watershed flows or the proposed impacts to all abutters and compliance with this standard has yet to be demonstrated. Please update the analysis to demonstrate compliance is achieved with no increase in runoff under the post development conditions to each abutter including the roadway.

      As mentioned previously, MEI has expanded the Watershed areas to include upgrade stormwater runoff from abutting lots. No increase in runoff is achieved.

      The Applicant has updated and expanded the analysis to include the upstream contributing area, but has not identified all abutter impacts as previously requested. Please update the report to provide a summary table which clearly identifies the impacts to each abutter (pre and post development) and the roadway to demonstrate that no increase in runoff is achieved.

   3. Standard 2: The post development calculation for subcatchment P1B does not properly provide the CN value of 98 for the driveway and sidewalk area noted to be "pervious pavers". The analysis does not provide any calculations relative to these being "pervious" and infiltrating. In addition, the amount of impervious area

appears to be more than indicated in the calculations. Please review and revise the calculations accordingly and update the analysis to demonstrate compliance is achieved with no increase in runoff under the post development conditions.

The CN value of 50 is a conservative number typically used for permeable pavers. MEI has adjusted the HydroCAD to use a CN value of 74 which would be equivalent to a more conservative "grass good" value.

Please review and update the permeable paver area to be representative of the proposed conditions for subcatchment P1B. In addition, please revised the post development calculations for subcatchment P1A to properly include all the existing pavement and (off-site) roof areas consistent with predevelopment subcatchment 1S calculations to clearly demonstrate compliance is achieved with no increase in runoff under the post development conditions.

4. Standard 2: The post development pond routing analysis for pond 7P implies storage is available below the outlet, but the analysis does not include any infiltration as noted in the report description for groundwater recharge and to empty the pond. Please revise the analysis to include recharge or revise to eliminate storage below the outlet since volume below the outlet would not be available when the pond is full or under frozen conditions. Please review and revise the calculations accordingly and update the analysis to demonstrate compliance is achieved with no increase in runoff under the post development conditions.

The drainage report has been revised to account for infiltration within the proposed rain garden. As discussed previously, the bottom of the rain garden does not maintain the required 2-foot separation from the seasonal high groundwater table. As a result, infiltration rates may be reduced during periods of elevated groundwater.

To provide operational flexibility, a capped 4-inch underdrain outlet is proposed near the bottom of the rain garden. Under normal conditions, the outlet will remain capped to maximize infiltration. If monitoring indicates that the basin is draining more slowly due to elevated groundwater conditions, the cap can be removed to facilitate dewatering and restore the rain garden's storage capacity. To re-iterate, MEI believes that this project is not subject to the MA stormwater handbook

Please update the report to include calculations for the time to drain and demonstrate the rain garden will properly drain within 72 hours for each storm event without a 4" drain pipe. In addition, we recommend the 4" drain be removed, since there is no provision to ensure the drain will remain plugged and allow runoff treatment to properly occur within the rain garden consistent with the design intent and bylaws.

5. Standard 2: The post development pond routing analysis for pond 7P implies a rectangular weir is proposed with a height to 4.50 feet, but the spot elevations note the proposed pond embankment is only 0.1 feet below (101.15 Weir vs .101.25 top

of bank) and is not representative of the design presented. With an earthen embankment proposed at the outlet location, it is not likely that a rectangular outlet can be constructed. Please review and revise the analysis accordingly.

The rain garden has been revised by lowering the overflow weir elevation to 101.00 feet, while maintaining the surrounding top-of-berm elevation at 101.25 feet. This creates a 3-inch depressed overflow which can be constructed.

Please update the pond 7P calculations to properly indicate the width of the weir and the changes to the weir width above 3 inches.

6. **Comment addressed with revised submission.**
7. Standard 4 – Water Quality: The report includes a TSS removal worksheet, but the calculation does not appear to be properly completed consistent with the Structural BMP Specifications for the Massachusetts Stormwater Handbook. The specifications note that 90% TSS removal requires pretreatment. Please review and revise and clarify any pretreatment devices if applicable

The stormwater report has been revised.

The site has been designed to direct runoff over vegetated lawn areas and into the proposed rain garden in accordance with Section XIV 1(7)(1) of the Water Resource Protection District Bylaw.

As discussed previously, this project is not required to comply with the design specifications of the Massachusetts Stormwater Handbook. Nevertheless, the site has been designed to meet those standards to the maximum extent practicable while accounting for the site's constraints

Please revise the water quality calculations to include all of the proposed impervious area of the development and clarify the project design would provide appropriate water quality consistent with the Massachusetts Stormwater Handbook.

8. Standard 4: The removal of the nitrogen and phosphorus in the report should be reviewed and revised, if necessary, based upon the final design of the proposed stormwater system per Section XIV.I.7(a)(1).

As mentioned in the report, the rain garden is capable of 30-50% nitrogen removal and 30-90% phosphorus removal. This has remained unchanged.

Under DESIGN on page 26 of the attached Structural BMP for the rain garden, it notes"… *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."* **Since the Applicant's design indicates the rain garden media is within the seasonal high water and does not provide a proper design including a two-foot separation from the seasonal high water table to allow appropriate treatment above the water table,**

please provide supporting information to demonstrate the nitrogen and phosphorus removal information presented in the revised report is valid/representative for inclusion in the Planning Board project file.

9. Standard 4: The report does not include a Long Term Pollution Prevention and Operations and Maintenance Plan document for maintenance of the post construction BMP's. We recommend the Applicant prepare a Long Term Pollution Prevention and Operations and Maintenance Plan document and recommend the document be a separate complete document as typically requested by the Board. This document may become part of the special permit conditions under this application per Section XIV.I.B.7(a)(2)of the bylaws.

   MEI has included a long term pollution prevention plan and O&M document in the latest submittal for review.

   The Applicant has provided Long-Term Pollution Prevention and Operation and Maintenance Plan document with this submission. We recommend the Applicant update the document to include a description for maintenance of the grass areas and the swale, and maintenance of the pervious pavers since these items are part of the site stormwater design. Please remove the 4" pipe reference from the rain garden description. We recommend an inspection checklist and separate plan be provided with the (separate) document that labels each item for proper maintenance to complete the document.

   Amesbury is an MS4 community, and we recommend copies of the stormwater inspection checklist be provided to the City on an annual basis. This should be noted in the updated document submission.

10. **Comment addressed with revised submission.**
11. **Comment addressed with revised submission.**
12. **Comment addressed with revised submission**.
13. **Comment addressed with revised submission**.
14. Standard 8 – Construction Period Controls: The report does not include a document or information relative to the proposed construction. We note sheet 2 includes a silt soxx detail. We recommend the Applicant update the plans to include discussion about construction sequence, construction management, good housekeeping practices during construction and minimizing exposure during construction consistent with this standard.

    No response required.

    The Applicant has provided a separate "Pollution Prevention and Operation and Maintenance Plan" document with this submission that appears to address this comment. However, the document calls for a stabilized construction entrance that does not appear to be shown or a detail provided with this submission. In addition, the document includes a construction sequence and calls out items such as a covered dumpster, and portable toilet that do not appear to be shown on the project

plan. It appears that a separate construction phase plan may be appropriate that indicates the above noted items. Please update the construction phase document accordingly in a subsequent submission as acceptable to the Board.

15. Standard 9 – Operation and Maintenance Plan: We would anticipate this standard would be part of the information provided under Standard 4 above.

An operation and maintenance document has been provided in this submittal.

Please revise the operation and maintenance document to include maintenance of the lawns areas and swale, and maintenance of the pervious pavers since these BMP items are part of the site design and stormwater analysis. In addition, we recommend the document be updated/clarified to include:

- **Name of the stormwater management system owners;**
- **Party responsible for operation and maintenance;**
- **Schedule for implementation of routine and non-routine maintenance tasks;**
- **Plan showing the location of all stormwater BMPs to be maintained;**
- **Operation and Maintenance Log Form (checklist) that includes each BMP to be inspected and the date of inspection.**

Amesbury is an MS4 community, and we recommend copies of the stormwater inspection checklist be provided to the City on an annual basis. This should be noted in the document. Please update the document accordingly in a subsequent submission as acceptable to the Board.

16. **Comment addressed with revised submission**.

2. The Applicant's site plan indicates flow arrows at the driveway to direct runoff to the rain garden, but does not provide spot elevations to clarify and demonstrate the grading design intent for proper construction. Please include spot elevations in the updated grading design to clarify the proper grading intent and for proper construction. Please provide documentation from the DPW that the updated driveway is acceptable for the Planning Board's project file.

MEI has revised the site plan to include spot elevations directing runoff from the driveway into the rain garden

The revised grading design indicates a proposed berm across the driveway entrance at elevation 102 varying up to nearly one foot in height at the northerly end that does not seem practical to construct with pavers. Please review and provide an appropriate design. In addition, please provide documentation from the DPW that the updated driveway (pavers constructed within the City's right-of-way) is acceptable for the Planning Board's project file.

3. **Comment addressed with revised submission.**

4. The proposed bioretention detail on sheet 2 indicates the proposed filter media does not meet the specifications noted for the BMP in the Massachusetts Stormwater Handbook. In addition,

we recommend the detail be expanded to clarify the width of the proposed embankment and detail of the proposed outlet weir for proper construction. The Applicant should review and revise the bioretention detail accordingly.

As previously noted, the project is exempt from meeting all requirements outlined in the Massachusetts Stormwater Handbook. However, MEI believes the proposed rain garden will function as intended under typical, drier conditions. To address potential periods of elevated groundwater and slower infiltration rates, a contingency underdrain component has been incorporated into the design to provide additional drainage capacity when needed.

The proposed bioretention detail on sheet 2 indicates the proposed filter media does not meet the specifications noted for the BMP in the Massachusetts Stormwater Handbook (copy attached), specifically the amount of compost which provides nutrients for the planting and treatment to stormwater. The revised basin now includes a new and separate pipe outlet to be provided for the basin that is not recommended, since there is no provision to ensure the drain will remain plugged and allow water treatment to occur in the rain garden consistent with the design intent and bylaws. The stormwater analysis does not address this new 4" outlet relative to impacts to abutters. In addition, we recommend the detail be expanded to clarify the width of the proposed embankment and detail of the proposed outlet weir for proper construction. The Applicant should review and revise the bioretention detail accordingly.

5. The design indicates overhead utility services from the roadway which does not comply with section XI.C.8.m requiring underground utilities from existing roadway utilities. Please update the design accordingly for compliance and provide a utility trench detail in the revised plan set submission.
   Comment <u>not</u> addressed with revised submission.

6. The project proposes clearing on the site, but the plans do not identify all trees larger than 8" per XI.C.5.b of the Zoning Bylaws. We note portions of the existing tree canopy along the property lines are shown to remain undisturbed. The trees to remain should also be noted on the site plan.

   There are several trees greater than 8 inches in diameter identified on the plan. MEI is currently in the process of confirming that all trees greater than 8 inches in diameter within the limit of work have been identified. If additional trees are identified, MEI will submit a revised plan accordingly.

   Please label all trees greater than 8" in a revised submission.

7. The plan set does not include a driveway sight distance plan and profile that demonstrates the minimum sight distance of 300 feet is provided. We recommend the plan set be revised accordingly.
   Comment <u>not</u> addressed with revised submission.

Other information for Planning Board Consideration under a Special Permit:

1. Special Permit under Section XIV of the Bylaws:
   A. The submission appears to indicate a proposed impervious area of approximately 1,440 SF including the improvements in Lake Attitash Road which is estimated to be less than 15 percent of the subject lot area (10,919 SF x 0.15 = 1,638 SF) per Section XIV.I.7(a).
   B. **Comment addressed with revised submission.**

2. The Applicant has submitted an NOI application to the Conservation Commission and DEP for this project that is currently under consideration by the Commission and DEP.

Summary:

We recommend the Applicant arrange a meeting with the Community and Economic Department before addressing the issues noted above. After the meeting, we recommend the Applicant address the comments and issues noted above and resubmit revised drawings and supporting information. We recommend the Applicant provide a summary response letter with the revised stormwater report, drawings, and supporting information addressing each comment noted above.

Attachment: MassDEP Structural BMP's Volume 2/Chapter 2; pages 23-33

GJF/ml

Bioretention Areas & Rain Gardens

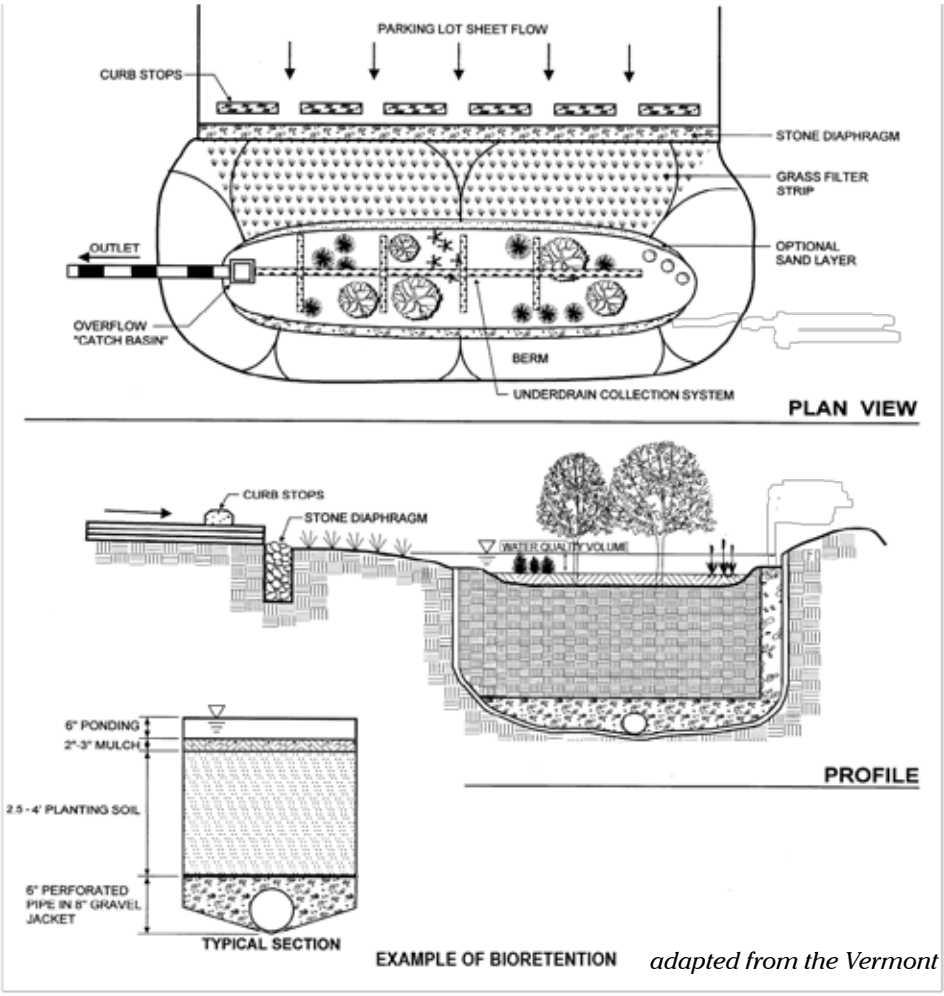
Description: Bioretention is a technique that uses soils, plants, and microbes to treat stormwater before it is infiltrated and/or discharged. Bioretention cells (also called rain gardens in residential applications) are shallow depressions filled with sandy soil topped with a thick layer of mulch and 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



EXAMPLE OF BIORETENTION *adapted from the Vermont Stormwater Manual*

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 my be used. If there is a Total Maximum Daily Load that requires nitrogen to be removed from the stormwater dischrges, 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.
  - o 40 % sand,
  - o 20-30% topsoil, and
  - o 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 exfiltrationg 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

Activity	*Time of Year*	*Frequency*
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.

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Plant Species Suitable for Use in Bioretention - Herbaceous Species

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

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

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Aronia arbutifolia (Pyrus arbutifolia) red chokeberry	FACW	Mesic	1-2	H	_	H	M	Sun to partial sun	Deciduous shrub	6-12'	_	Yes	High	Good bank stabilizer. Tolerates drought.
Clethra alnifolia 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.
Cornus Stolonifera (Cornus sericea) 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.
Cornus amomum silky dogwood	FAC	Mesic	1-2	L	_	_	M	Sun to partial sun	Broad-leaved	6-12'	_	Yes	High	Good bank stabilizer
Euonymous europaeus spindle-tree	FAC	Mesic	1-2	M	M	M	M	Sun to partial sun	Upright dense oval shrub	10-12'	Shallow	No	No	_
Hamamelis virginiana witch hazel	FAC	Mesic	2-4	M	M	M	M	Sun or shade	Vase-like compact shrub	4-6'	Shallow	Yes	Low	_
Hypericum densiflorum common St. John's wort	FAC	Mesic	2-4	H	M	M	H	Sun	Ovoid shrub	3-6'	Shallow	Yes	Med	_
Ilex glabra 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.
Ilex verticillata 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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Itea virginica tassel-white, Virginia sweetspire	OBL	Mesic	1-2	M	–	–	M	Sun or shade	Broad-leaved, deciduous shrub	6-12'	–	Yes	Low	–
Juniperus communis "compressa" common juniper	FAC	Dry Mesic-Mesic	1-2	M	H	H	M-H	Sun	Mounded shrub	3-6'	Deep taproot	No	High	Evergreen
Juniperus horizontalis "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
Lindera benzoin spicebush	FACW	Mesic to wet Mesic	2-4	H	–	–	H	Sun	Upright shrub	6-12'	Deep	Yes	High	–
Myrica pennsylvanica bayberry	FAC	Mesic	2-4	H	M	M	H	Sun to partial sun	Rounded, compact shrub	6-8'	Shallow	Yes	High	Coastal plain species.
Physocarpus opulifolius ninebark	FAC	Dry Mesic to wet Mesic	2-4	M	–	–	H	Sun	Upright shrub	6-12'	Shallow	Yes	Med	May be difficult to locate.
Viburnum cassinoides northern wild raisin	FACW	Mesic	2-4	H	H	H	H	Sun to partial sun	Rounded, compacted shrub	6-8'	Shallow	Yes	High	–
Viburnum dentatum 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	–
Viburnum lentago nannyberry	FAC	Mesic	2-4	H	H	H	H	Sun to partial sun	Upright, mlti-stemmed shrub	8-10'	Shallow	Yes	High	–

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Acer rubrum red maple	FAC	Mesic-Hydric	4-6	H	H	H	H	Partial sun	Single to multi-stem tree	50-70'	Shallow	Yes	High	-
Amelanchier canadensis 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.
Betula nigra 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.
Betula populifolia 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.
Fraxinus americana white ash	FAC	Mesic	2-4	M	H	H	H	Sun	Large tree	50-80'	Deep	Yes	Low	-
Fraxinus Pennsylvanica green ash	FACW	Mesic	4-6	M	H	H	H	Partial sun	Large tree	40-65'	Shallow to deep	Yes	Low	-
Ginko biloba 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.
Gleditsia triacanthos honeylocust	FAC	Mesic	2-4	H	M	-	M	Sun	Small caopied large tree	50-75'	Shallow to deep variable taproot	Yes	Low	Select thornless variety.
Juniperus virginiana eastern red cedar	FACU	Mesic-Xeric	2-4	H	H	-	H	Sun	Dense single stem tree	50-75'	Taproot	Yes	Very high	Evergreen
Liquidambar styraciflua 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.
Nyssa sylvatica 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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