IOWA STORMWATER MANAGEMENT MANUAL

5.04 SEDIMENT FOREBAYS

IOWA | Department of Natural Resources

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Refer to the glossary for words in **bold black text.**
Some items of emphasis are in **bold blue text.**

5.04-1 LAYOUT AND DESIGN

A. SUMMARY

A sediment forebay may be used for **pretreatment** where concentrated flows enter various types of stormwater quality **Best Management Practices** (BMPs). The purpose of a forebay is to create a space where flow velocities are reduced, allowing heavier suspended sediments to settle from the incoming stormwater runoff before it is delivered to the water quality treatment area of the BMP. This concentrates sediment deposition into a confined area which should be accessible for the equipment used to remove the collected sediment. The way the forebay is designed and constructed will depend on what type of stormwater BMP is being protected by the forebay.

DESIGN PROCESS OVERVIEW

1. Complete Site Evaluation and Planning
2. Develop Site Into Watershed Subareas and Identify Locations for BMPs
3. Locate Pretreatment Practices
4. Develop Maintenance Plan
5. Integrate into Stormwater Plan

MAINTENANCE REQUIREMENTS

1. Designate Responsible Parties for Maintenance
2. Complete Construction Sequencing
3. Remove Accumulated Sediment and Debris Frequently from Pretreatment Area
4. Perform Regularly Occurring Maintenance

Wet forebay upstream of Vintage Lake within the Prairie Trail development in Ankeny, IA.

NOTE

See ISWMM Section 3.01 for more information about the USC.

B. APPLICATIONS

Sediment forebays are designed exclusively as pretreatment practices. While they improve water quality through reduction of heavier suspended pollutants, they are not intended to be used as a stand-alone water quality practice. They also will not significantly reduce runoff rates to the levels necessary to address the other elements within the Iowa Stormwater Management Manual's (ISWMM) **Unified Sizing Criteria** (USC).

A sediment forebay is typically the best option for pretreatment at most dry and wet detention basins, infiltration basins and constructed stormwater wetlands. The forebay is designed to capture and trap the sediments within a confined area at concentrated inflow points to stormwater water quality and detention BMPs. Removal of sediment from a forebay is less costly than having to dredge or remove sediment from an entire basin, pond or wetland. Reducing sediment inflow to ponds and wetlands will also improve their water quality by reducing the amount of phosphorus and other pollutants that tend to bind with sediment particles.

Smaller versions of forebays may be integrated near the entry points to stormwater planter boxes, bioretention cells and bioswales. In these locations, forebays can extend the infiltration capacity of these BMPs by preventing heavier sediment loads from clogging the surface or burying installed plant materials with sediment.

The collected sediment and debris will be more confined to locations with accessible paths for maintenance equipment. The forebay should be visible from the access routes to make it easier to evaluate when the forebay needs to be maintained.

Wet forebay during site construction. West Des Moines, IA.

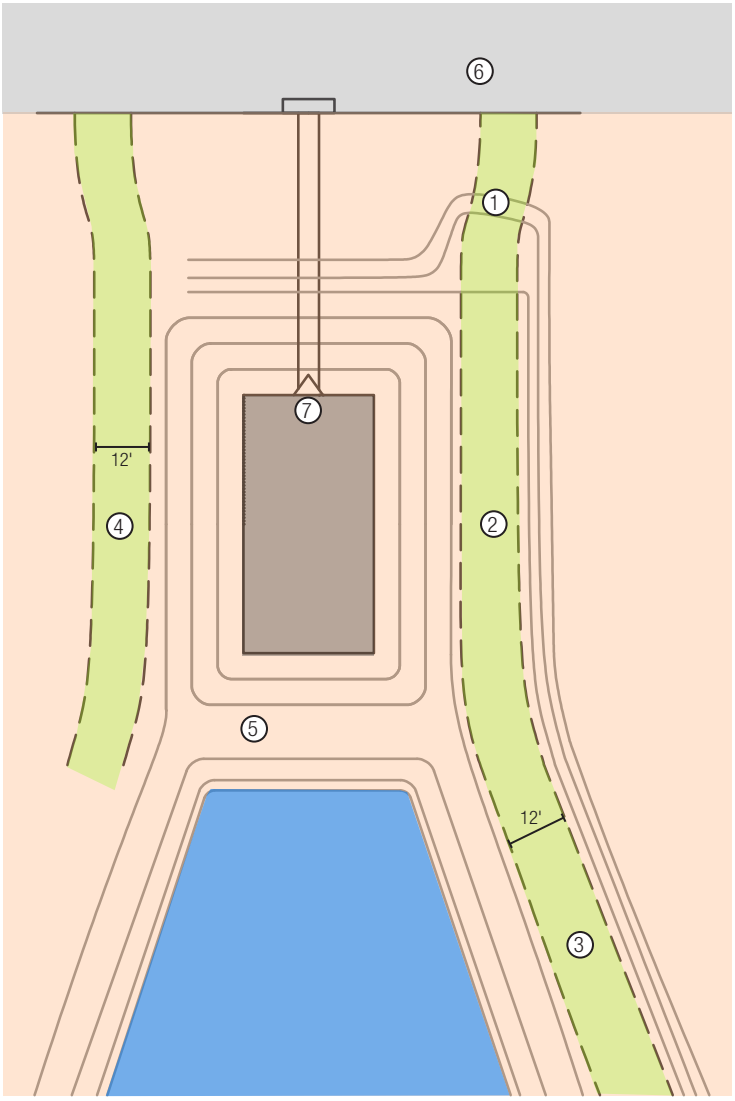
C. DESIGN ELEMENTS AND CRITERIA

ACCESS

There needs to be a clear path with legal right of access to allow the party responsible for maintenance to reach the forebay. ESSENTIAL

For larger forebays, the path needs to be designed to accommodate any required maintenance equipment. Access to smaller forebays near planter boxes and bioretention cells may not need a separate path, if access can be gained directly from adjacent drives, parking stalls or streets.

Access Path Illustration



1 - Access Route to Adjacent Road or Driveway
2 - Position Access Path Adjacent to Forebay
3 - Potential Connection to Maintenance Path Around Pond, Wetland or Basin
4 - A Second Access Path May Be Necessary to Remove Material from Larger Forebays
5 - In Some Cases, an Access Route Could Extend Across an Earth Embankment or Articulated Block Spillway
6 - Adjacent Roadway or Drive for Access
7 - Inflow Point to Forebay

NOTE

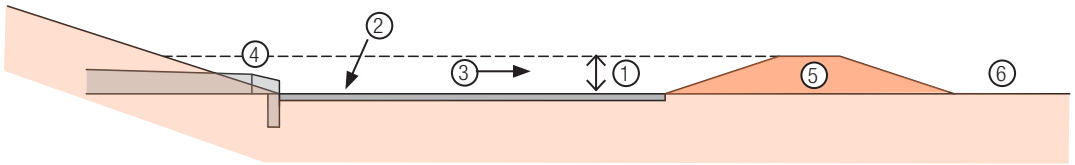
See Part 5.04-4 of this Section for more information about the design requirements for the access path.

CONDITION AND DEPTH

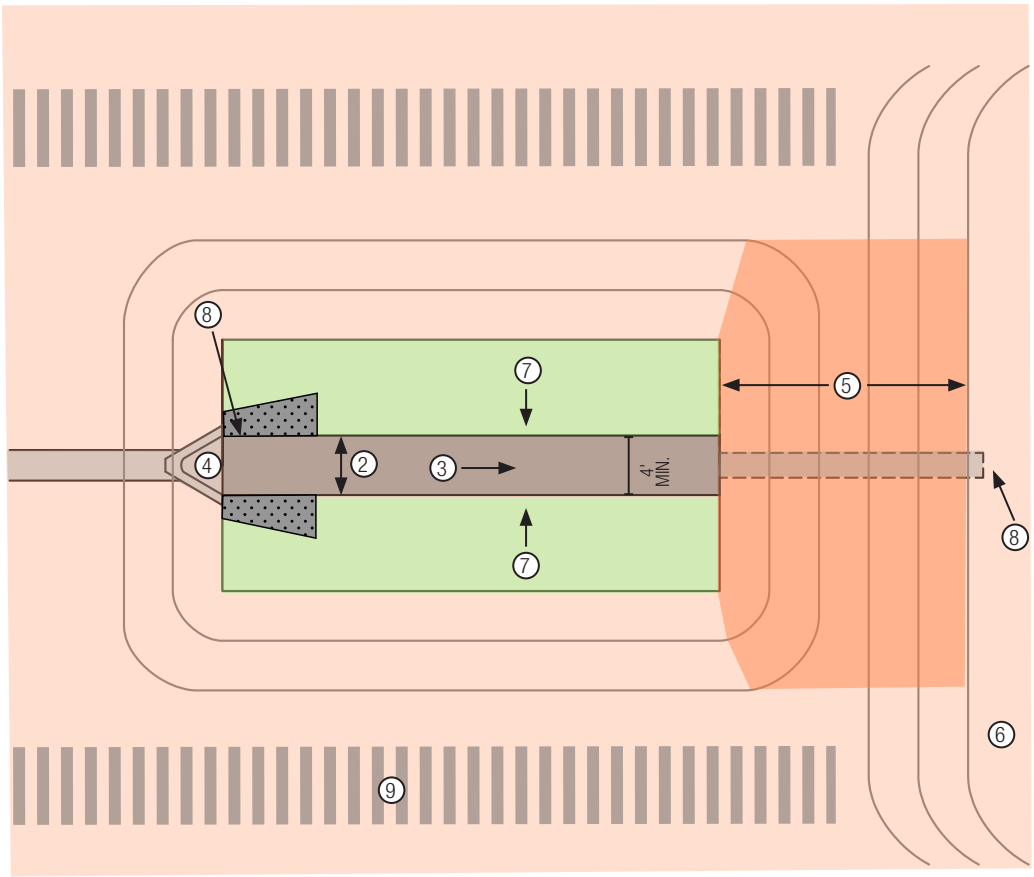
Guidelines for forebay depth vary based on the type of stormwater BMP the forebay is protecting.

- **For dry and extended dry detention basins and infiltration based BMPs, the forebay should be designed to only temporarily hold water after a rainfall event.** The shape and depth of the forebay should be used to extend residence time of runoff within the forebay, maximizing the potential for settlement.
  - The depth of the "dry" forebay should be as needed to provide the projected pretreatment volume. TARGET
  - A depth of less than four (4) feet is recommended for ease of maintenance. IDEAL
  - A flume constructed from concrete, articulated concrete block mats or vegetated concrete block mats is a recommended feature that could run from the inlet point of the forebay to the outlet. This feature could be used as the main sediment collection point and make the sediment easier to remove with less disturbance to vegetated areas. If used, the flume should have a slope of at least 0.5% toward the forebay outlet (or 1% if the flume is shorter than 50 feet in length). The vegetated area within the forebay should drain toward the flume or outlet point with a minimum grade of 1.5%. IDEAL
  - If a flume is not provided, the bottom of the dry forebay should drain toward the outlet point with a minimum grade of 1%. TARGET
- **For wet ponds and stormwater wetlands, the forebay should be designed to maintain a permanent pool of water.**
  - The permanent pool of the forebay should be sized to provide the projected pretreatment volume. TARGET
  - The depth of the wet forebay measured from its permanent pool elevation to its deepest point should be between two (2) and four (4) feet in depth. IDEAL The bottom of the forebay should be fairly level. It may be designed with no slope. TARGET
  - A concrete bottom constructed from concrete or articulated concrete block mats would make it easier to remove collected sediment from the forebay. IDEAL
  - If a concrete bottom is not used, a depth marker could be included. This would help maintenance personnel understand when they have reached the position of the original bottom of the forebay, so they know when to stop excavation. TARGET
  - If the outlet of the pond or wetland allows for water surface elevation to be lowered for maintenance, consider including methods to allow the water level of the forebay to be drawn down as well. IDEAL
    - This could be accomplished by using a pipe with a gate valve or water level control structure to allow the forebay water elevation to drop with the larger body of water.
    - If the separation between the forebay and the larger body of water is constructed from revetment materials. Water may move freely through the void spaces between stones. That would allow the water level to drop without the need for a separate pipe and control structure.

Example Dry Forebay Cross-Section View

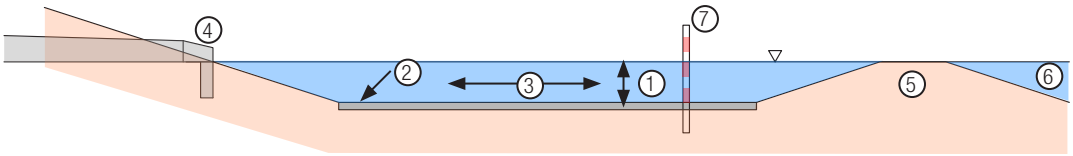


Example Dry Forebay Plan View

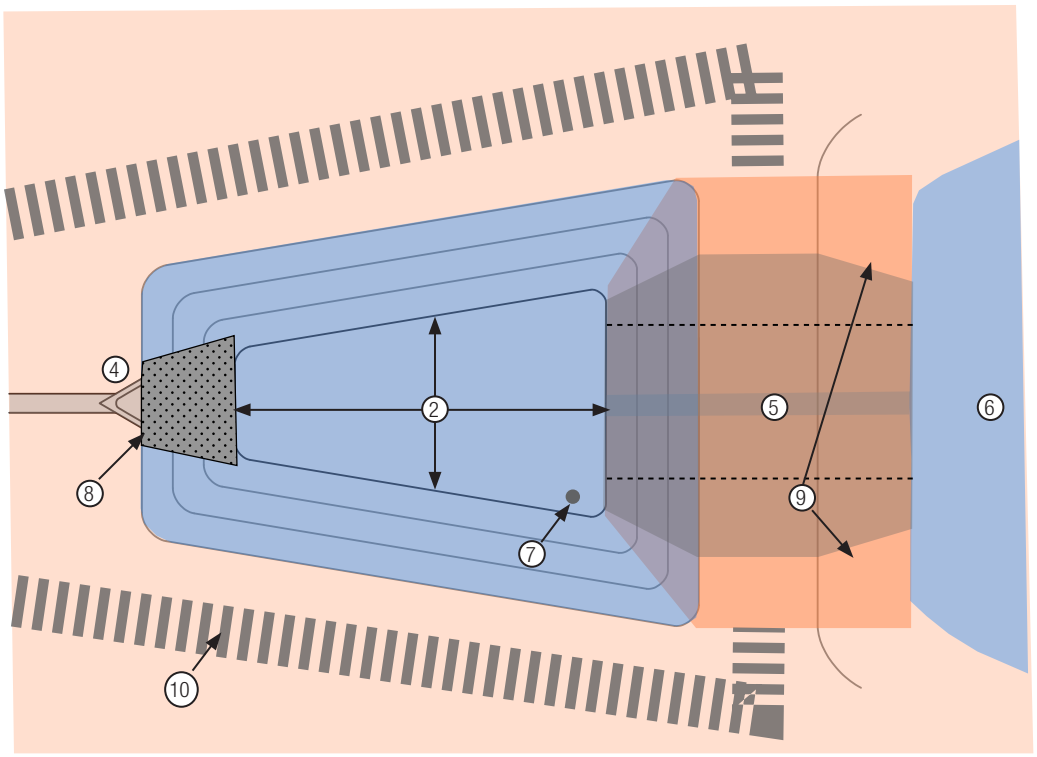


1 - Forebay Depth
2 - Flume
3 - Slope to Outlet
4 - Entry to Forebay
5 - Physical Separation from Downstream BMP
6 - Downstream BMP
7 - Slope Vegetated Area Toward Flume
8 - Scour Protection at Entry to Forebay and Outlet to Basin
9 - Maintenance Access Path

Example Wet Forebay Cross-Section View



Example Wet Forebay Plan View



1 - Forebay Depth	6 - Downstream BMP
2 - Concrete Bottom (option)	7 - Depth Marker (option)
3 - Level Bottom	8 - Scour Protection at Entry to Forebay
4 - Entry to Forebay	9 - Scour Protection at Spillway Over Physical Separation
5 - Physical Separation From Downstream BMP	10 - Maintenance Path

STORAGE

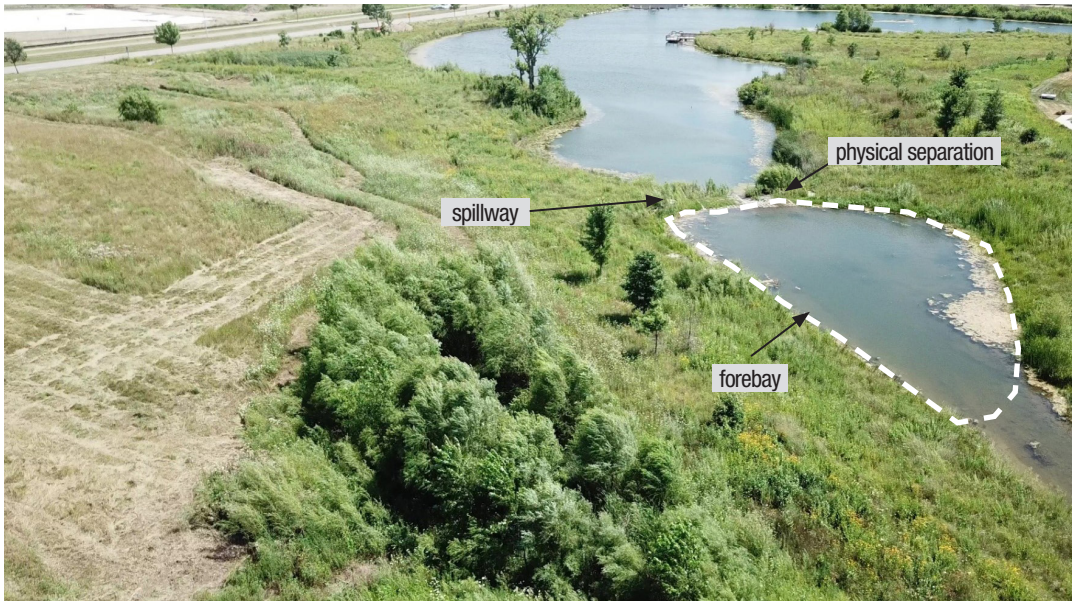
For dry and wet forebays located upstream of stormwater dry and wet basins and stormwater wetlands, the forebay should be sized to provide the following pretreatment volumes:

- Provide storage within the forebay for at least 10% of the calculated **water quality volume** that is not treated by upstream water quality BMPs. TARGET
- For wet forebays, the calculated pretreatment storage should be provided in the permanent pool volume expected to be sustained within the forebay. TARGET

SHAPE

The forebay should be shaped to maximize the length of flow through the forebay. This will increase residence time of runoff within the forebay and improve sediment deposition. The path of flow through the forebay should be greater than the maximum width of the forebay and additional length of flow would be preferred. TARGET

When designing the shape of the forebay, think about the reach of equipment expected to be used for maintenance. The forebay should be shaped so that the sediment can be effectively removed from the access path. IDEAL



Wet forebay upstream of Vintage Lake within the Prairie Trail development. Ankeny, IA.

NOTE

See Part 5.04-2.D of this Section for more information about the special cases for forebays for smaller water quality BMPs.

SCOUR PROTECTION AT INLET POINT

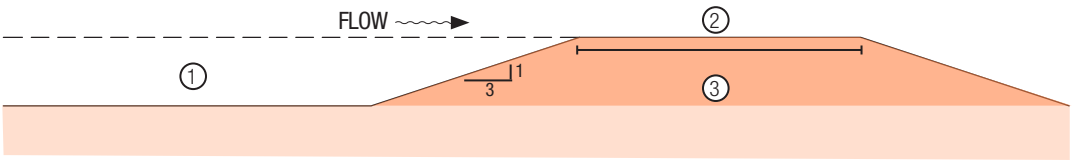
Where a storm pipe or channel outlets into the forebay, adequate scour protection needs to be provided. Revetment stone materials, transition mats, vegetated concrete mats or articulated concrete mats are all options to reduce the potential for scour in the area where flow will expand and erosion is at its highest potential. Refer to Iowa SUDAS Design Manual Sections 7E-10 (Rip Rap), 7E-21 (Flow Transition Mats), 7E-27 (Rock Chutes and Flumes) for more information about the design of scour protection.

PHYSICAL SEPARATION

The sediment forebay should be physically separated from the downstream BMP. This can be accomplished by several methods, including but not limited to building a berm or short dam out of earthen or revetment stone materials.

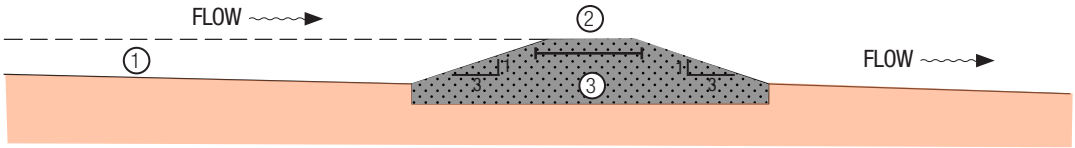
- If earth materials are used, the top width of the dam should be sufficient to avoid being washed out when over-topped. TARGET
- If revetment materials are used, the materials should be rated similar to "A Freeze" quality as defined in Iowa DOT Standard Specification Section 4130 (as referenced by Iowa SUDAS Section 9040). TARGET Class D revetment materials as defined in IDOT and SUDAS specifications are not recommended. ADVISORY

Physical Separations - Earth Berm Option



1 - Forebay
2 - Crest
3 - Earth Berm

Physical Separations - Revetment Berm Option



1 - Forebay
2 - Crest
3 - Revetment Berm

SIDE SLOPES

The slopes around the forebay both below and above the water surface (as applicable) should not be steeper than three (3) horizontal to one (1) vertical (3:1). ESSENTIAL

Slopes above the water surface may need to be flatter to comply with recommendations for access path design or to meet side slope guidelines described in other ISWMM sections for each specific BMP.

OUTLET TO BMP

Alternatives for forebay outlets will vary depending on the physical separation used between the forebay and BMP and the condition and depth of the forebay itself.

Outlet to BMPs - Option A: Dry Forebay - Earth Embankment with Riser Pipe

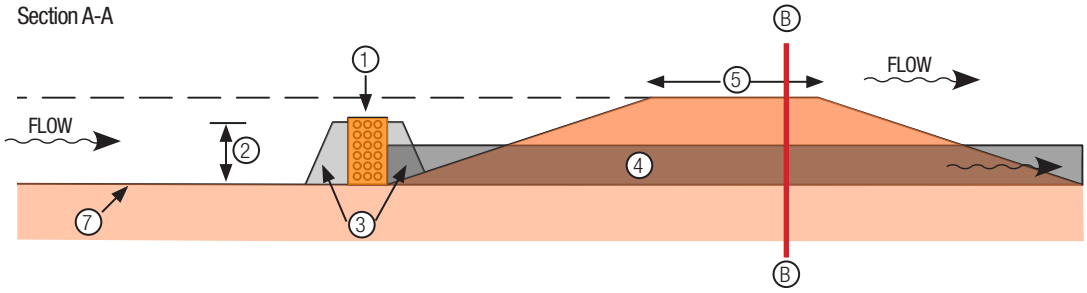
1. A perforated riser pipe constructed of PVC, HDPE or CMP materials could be used as the primary inlet structure.
   - The number and size of the pipe openings may vary based on project design, but any individual opening should not be greater than 1/2" in diameter. The riser should not be wrapped with engineering fabric (except when used as an additional temporary sediment protection during construction). IDEAL
   - The top of the riser pipe should be left open, set above the depth needed to provide the target pretreatment storage volume. TARGET
   - The pipe should be surrounded with 1" clean aggregate materials (IDOT Gradation 3) to reduce the potential for clogging the perforated riser openings and to improve sediment capture. TARGET
   - The riser should be connected to a pipe that extends through the earth embankment. The pipe and the open top of the riser structure should be sized so the peak flow from at least the Water Quality event (WQv – 1.25", 24-hour rainfall) can pass through the pipe without over-topping the auxiliary spillway of the forebay. TARGET
   - The earth embankment should include an auxiliary spillway with sufficient width so that the peak flow of storms up to the 10-year, 24-hour storm event can pass through with velocity at the crest of the spillway of less than five (5) foot per second (fps). TARGET
     - The level crest width of the auxiliary spillway should be set at least 12 inches below the crest elevation of the remainder of the earth embankment, or as needed to contain the 10-year storm events within the spillway. TARGET
     - The designer should consider the expected velocities, slope and elevation drop on the downhill side of the forebay embankment and provide adequate scour protection, using Turf Reinforcement Mats (TRMs), vegetated concrete mats or articulated concrete block mats. ESSENTIAL
       - The scour protection should extend up the side slopes of the auxiliary spillway to the crest of the embankment on each side and cover at least five (5) feet of the embankment crest on each side to reduce the potential for erosion along the edges of the protected area. IDEAL
       - The protection should begin at least one (1) foot below the crest of the auxiliary spillway on the uphill side of the forebay embankment and extend at least five (5) feet beyond the toe of slope on the downhill side. IDEAL
       - The values above are recommended minimum levels of protection, which will often need to be exceeded based on specific site conditions. The designer should evaluate the specific needs of their site to determine the type and extent of scour protection. IDEAL

NOTE

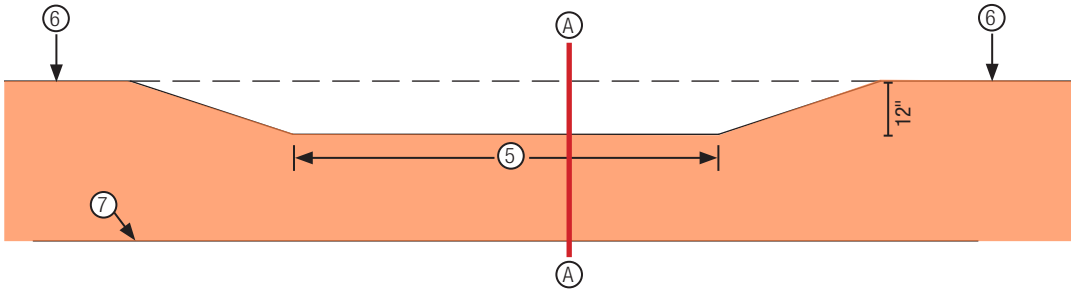
The calculated pretreatment storage should be provided below the top opening of the riser pipe if outlet Option A is used.

Outlet to BMPs - Option A: Dry Forebay - Earth Embankment

Section A-A



Section B-B



1 - Perforated Riser	6 - Crest of Rest of Earth Embankment
2 - Set Open Top of Riser Above Depth to Store Pretreatment Volume	7 - Bottom of Forebay
3 - 1" Clean Aggregate	A - Section Line
4 - Outflow Pipe	B - Section Line
5 - Auxiliary Spillway Crest	

Outlet to BMPs - Option B: Dry Forebay - Earth Embankment with Skimmer Device

A skimmer device could be used as the primary inlet structure. A skimmer device can rise and fall with the water elevation within the forebay and draws water from the surface, which typically contains less suspended sediment.

- The skimmer should be connected to a pipe that extends through the earth embankment. The skimmer should be sized so the peak flow from the Water Quality event can pass through the skimmer and outlet pipe. Larger storm events would allow water levels in the forebay to rise until it could spill over an auxiliary spillway or other pipe outlet to the downstream BMP. TARGET
- Other guidelines for the design and protection of the auxiliary spillway of the forebay as listed in Option A on the previous page would also apply to this type of outlet configuration.

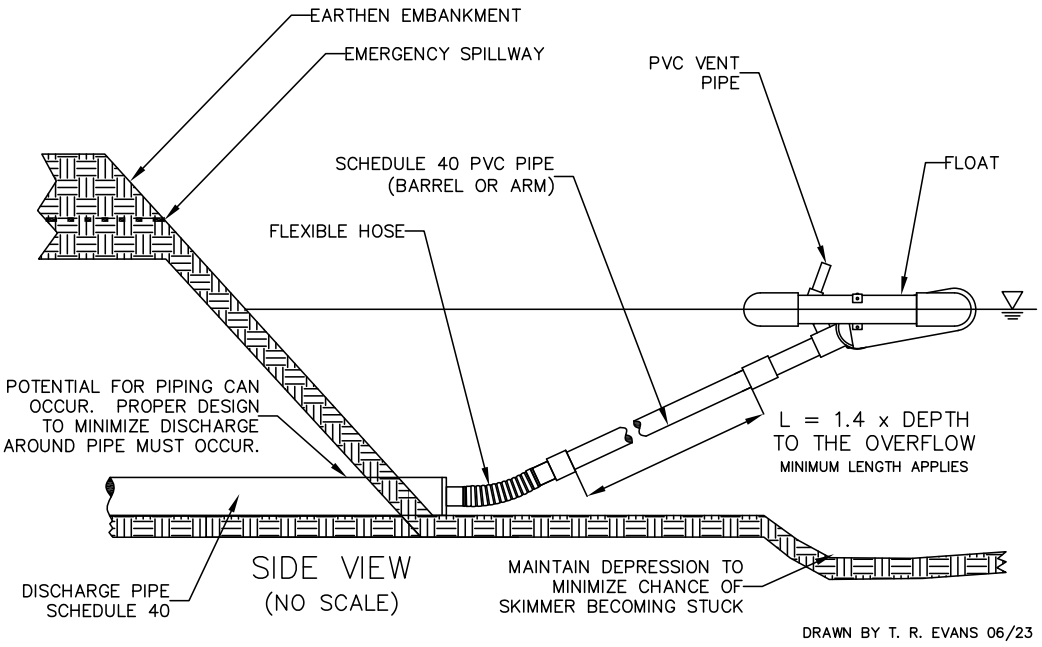


Diagram of a skimmer device. (Source: Faircloth Skimmer website)

NOTE

For Option B, the pretreatment storage should be provided below the elevation of the auxiliary spillway.

NOTE

For Option C, the pretreatment storage should be provided below the elevation of the auxiliary spillway.

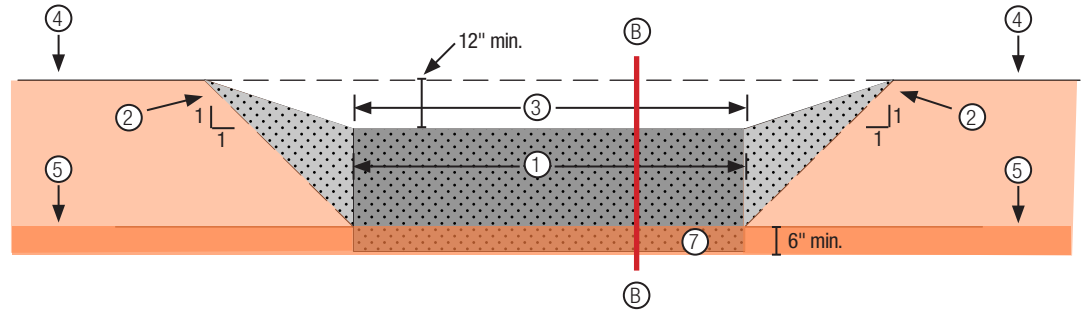
Outlet to BMPs - Option C: Dry Forebay - Earth Embankment with Stone Weeper

A section of the earth embankment can be constructed as a stone weeper.

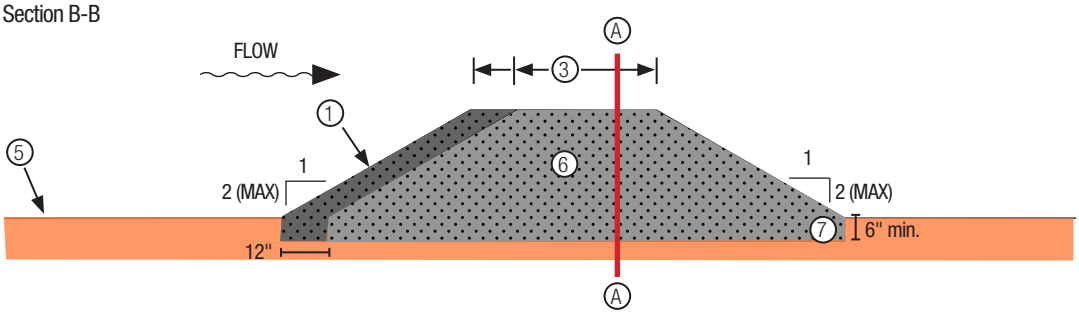
- A stone weeper is essentially a check dam constructed of open graded stone materials (less than 5% fine particles).
- The front of the check dam is constructed with smaller diameter stone materials (1" clean aggregate / IDOT Gradation 3) to restrict flow through larger diameter erosion stone or Class E revetment materials used to construct the remainder of the stone weeper.
- Above the weeper, the earth embankment should be shaped to include an auxiliary spillway. The guidelines for the design and protection of the auxiliary spillway as listed in Option A above would also apply to in this application. TARGET
- The stone weeper should be designed to allow the peak flow from the WQv event to pass through the smaller diameter stone filter material on the face of the weeper, without over-topping the auxiliary spillway. TARGET
- The stone materials should be keyed into the soil below and to the sides of the weeper by at least 6 inches. IDEAL

Outlet to BMPs - Option C: Dry Forebay - Earth Embankment with Stone Weeper

Section A-A



Section B-B



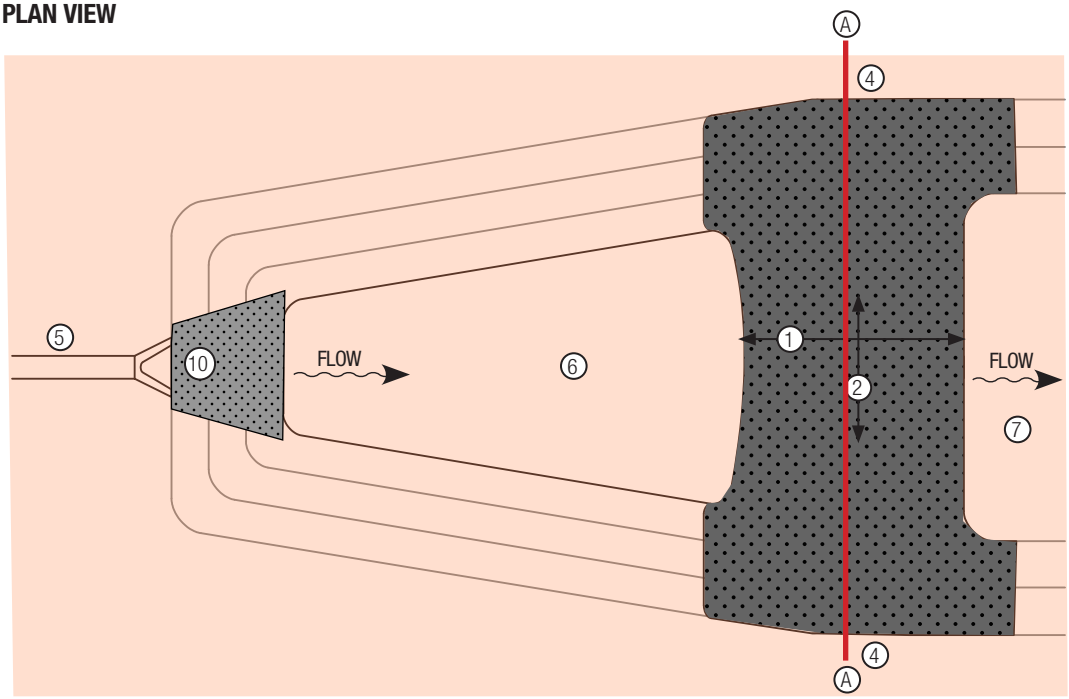
1 - 1" Clean Stone	6 - Larger Stone = Class "E" Revetment or Erosion Stone, Etc.
2 - May Slope Edges of Stone Materials	7 - Key Stone Materials at Least 6" Into Soil
3 - Auxiliary Spillway Crest	
4 - Crest of Rest of Earth Embankment	A - Section Line
5 - Bottom of Forebay	B - Section Line

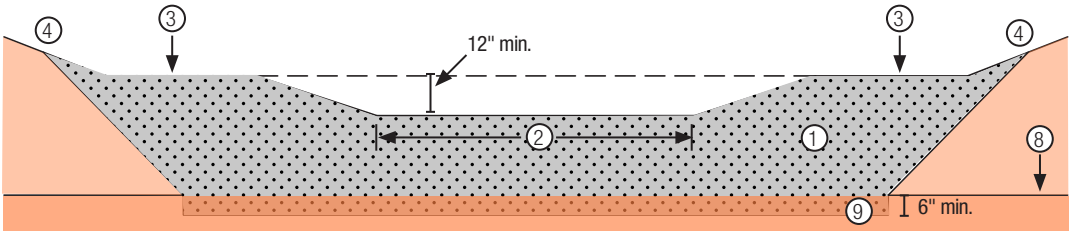
Outlet to BMPs - Option D: Dry Forebay with Stone Embankment

In this configuration, the entire embankment is constructed as a stone weeper, as described in Option C above.

- A portion of the stone weeper should be constructed as an auxiliary spillway, meeting the guidelines as listed in Option A. TARGET

Outlet to BMPs - Option D: Dry Forebay with Stone Embankment
PLAN VIEW





1 - Stone Weeper - Similar to Cross-Section B-B shown on the Previous Page	6 - Forebay
2 - Auxiliary Spillway Crest	7 - Downstream BMP
3 - Crest of Rest of Stone Embankment	8 - Bottom of Forebay
4 - Extend Edges of Stone Material Up Side Slope	9 - Key Stone Materials at Least 6" Into Soil
5 - Inflow to Forebay	10 - Scour Protection at Inflow Points to Forebay
	A - Section Line

NOTE

For Option D, the pretreatment storage should be provided below the elevation of the auxiliary spillway.

Wet Forebay with Earth Embankment

Options A, B and C for Dry Forebays can also be utilized for forebays that will retain a permanent pool of water.

Outlet to BMPs - Option E: Wet Forebay - Earth Embankment

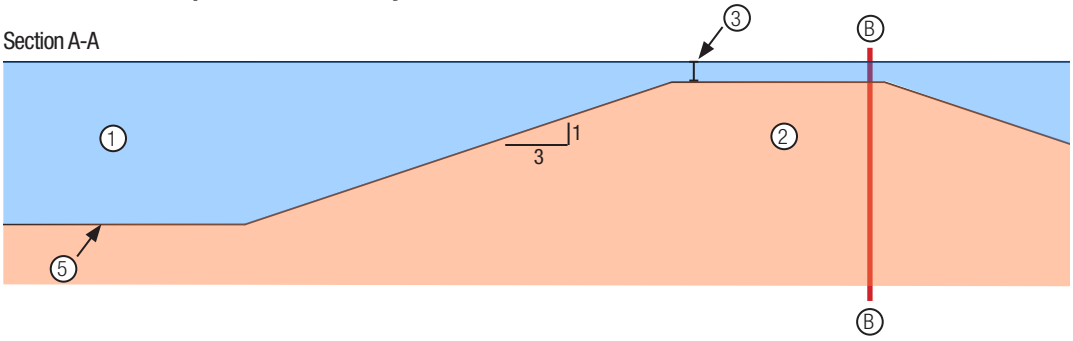
Wet forebays can also be constructed so that the overflow spillway from the forebay is the primary way that flow is passed out of the forebay.

- In this configuration, the crest of the overflow spillway should be set between zero (0) and six (6) inches below the permanent pool elevation expected to be sustained within the forebay. IDEAL
- The spillway should have sufficient width so that the peak flow of storms up to the 10-year, 24-hour storm event can pass through with velocity at the crest of the spillway of less than five (5) foot per second (fps). TARGET
- The level crest width of the auxiliary spillway should be set at least 12 inches below the crest elevation of the remainder of the earth embankment, or as needed to contain the 10-year storm events within the spillway. TARGET
- The designer should consider the expected velocities, slope and elevation drop on the downhill side of the forebay embankment and provide adequate scour protection, using revetment stone materials, vegetated concrete mats or articulated concrete block mats. ESSENTIAL

NOTE

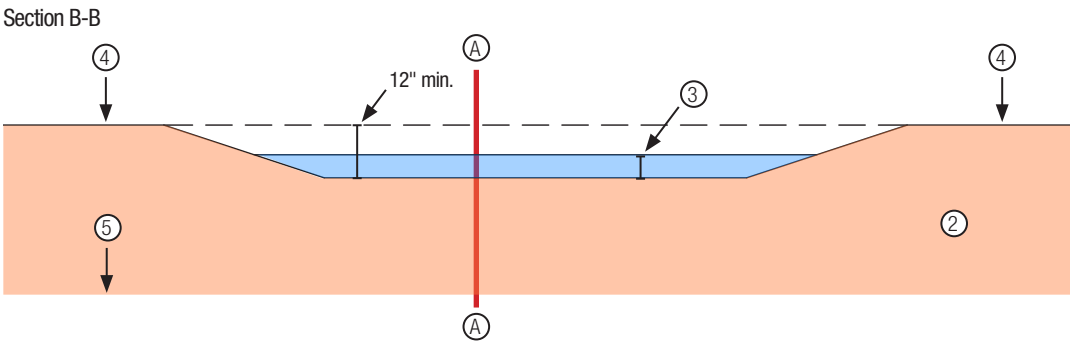
See site example on page 27.

Outlet to BMPs - Option E: Wet Forebay with Earth Embankment



Wet Forebay with Rock Embankment

In this configuration, the entire embankment is constructed as a stone weeper, as described for Dry Forebay with Stone Embankment (Option D).



1 - Wet Forebay	4 - Crest of Rest of Embankment
2 - Revetment or Earth Berm	5 - Bottom of Forebay
3 - Forebay Spillway Crest Set 0-6" Below Permanent Pool of Forebay	A - Section Line
	B - Section Line

D. SPECIAL CASE ADAPTATIONS

FOREBAYS ELEVATED ABOVE DOWNSTREAM BMPS

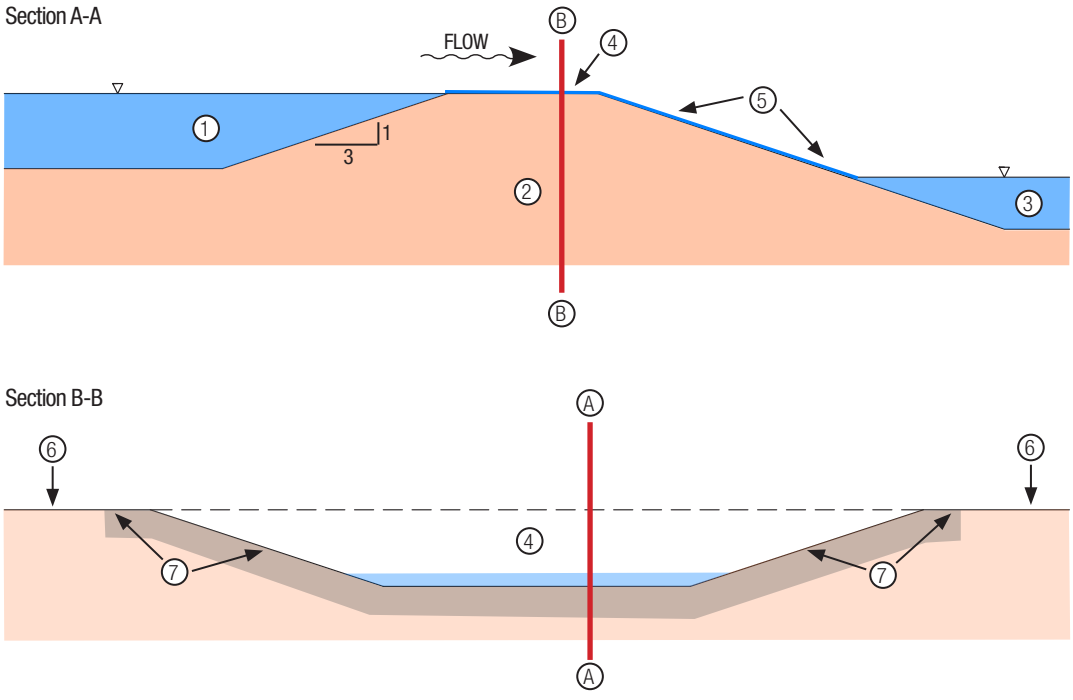
In some cases, forebays may be placed in a location where they are elevated above the downstream BMP. In those cases, more consideration needs to be focused on the manner of overflow from the forebay and the potential for surface erosion in the area between the forebay and BMP. In such cases, the auxiliary or overflow spillway should be designed to accommodate at least the peak flow rate expected by the 10-year, 24-hour storm event. ESSENTIAL

A preferred approach would be to size the spillway to convey the peak flow rate during a 100-year, 24-hour storm event without over-topping the remainder of the forebay embankment. IDEAL

If runoff is expected to overtop portions of the embankment outside of the spillway during the 100-year storm event, the expected flow velocities across the crest of the embankment and on the downhill slope should be checked to evaluate the potential for surface erosion. ESSENTIAL

- In some cases, the embankment may need to be protected by TRMs, revetment stone materials, vegetated concrete mats or articulated concrete block mats.

Elevated Forebays



1 - Forebay Elevated Above Downstream BMP
2 - Earth Embankment
3 - Downstream BMP
4 - Forebay Spillway Crest (Convey at Least 10-Year Peak Flow within Spillway
5 - Design Scour Protection on Downslope Side of Embankment
6 - Crest of Rest of Embankment
7 - Extend Scour Protection Up Sides of Spillway and Edges of Embankment Crest as Needed to Prevent Erosion
A - Section Line
B - Section Line

FOREBAYS FOR SMALLER INFILTRATION BASED BMPS

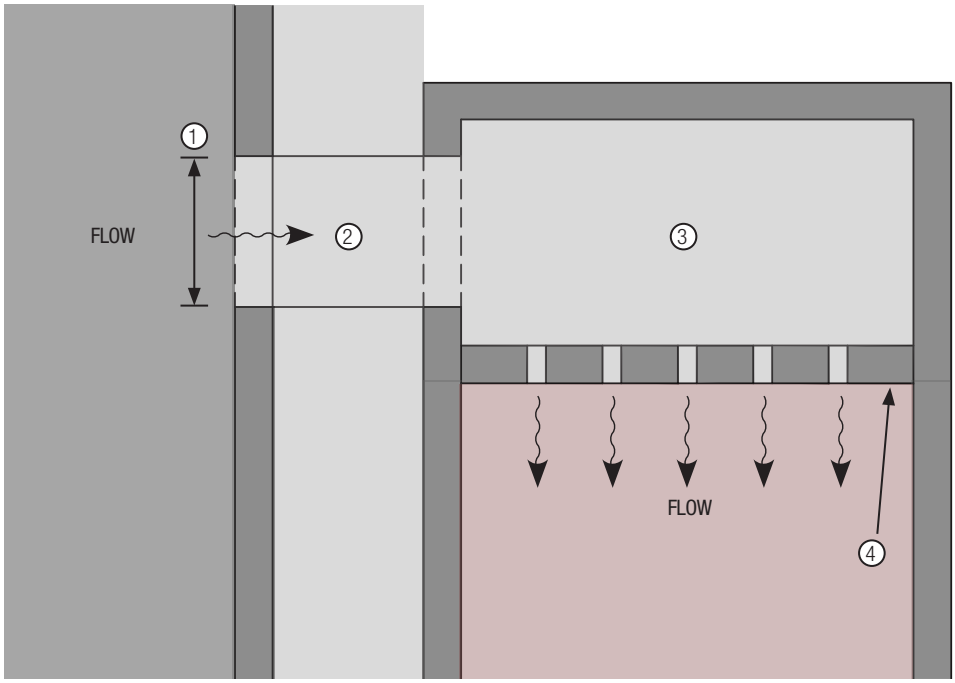
Smaller "micro-forebays" are sometimes included at curb cuts and other concentrated inflow points to smaller infiltration based BMPs, such as bioretention cells or stormwater planter boxes. They may also be appropriate in other smaller scale retrofit projects. In any of those cases, the micro-forebay is typically created by creating a small, depressed area at the entry point with a bottom stabilized with a concrete slab, metal surface or paver blocks. ESSENTIAL

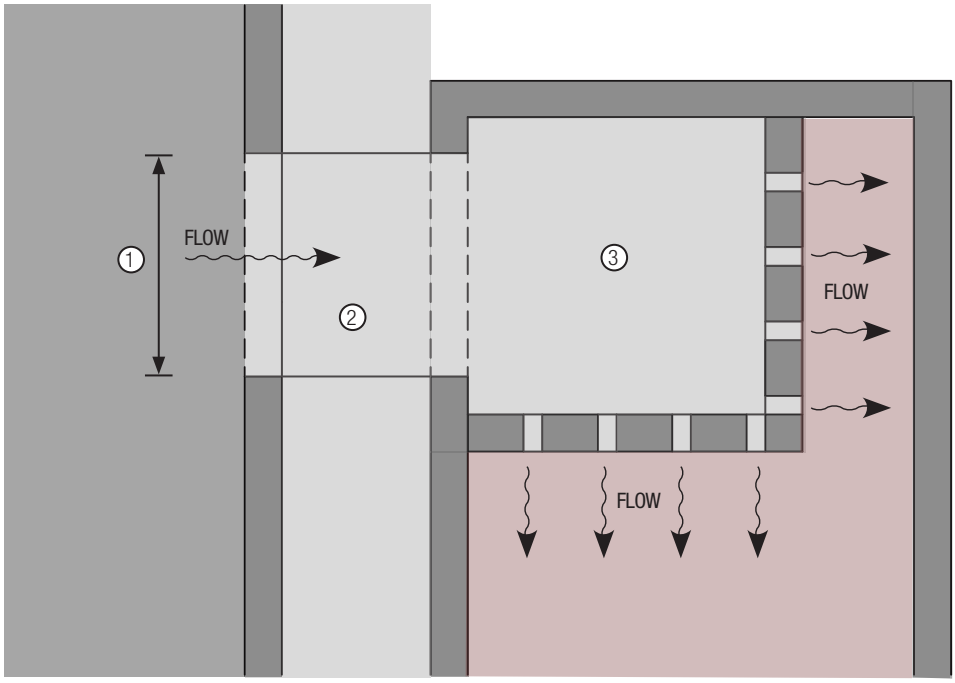
- Flow out of the forebay into the BMP may be restricted using open graded stone materials, paver blocks or edgers constructed from concrete, metal or composite materials. TARGET
- The edger would have smaller openings that allow flow to drain out of the micro-forebay and into the BMP. The top of the edger would be designed to ensure that the entirely of the peak flow from the design storm event (typically the WQv event) can enter the practice. TARGET

Since these micro-forebays are typically limited in surface area and depth, the recommended pretreatment storage volumes is reduced to 2.5% of the WQv expected to be treated by the BMP. TARGET Additional pretreatment storage is advisable, providing more of the WQv when possible. IDEAL

- Since this volume is less than what is recommended for other types of forebays, sediment and debris will need to be removed more frequently to protect the function of the downstream BMP. ESSENTIAL
- For this reason, inlet sump structures or other pretreatment methods may provide greater protection of downstream BMPs.

Micro-Forebay





1 - Curb Opening	3 - Stabilized Forebay Area
2 - Stabilized Water Entry Into Planter Box	4 - Edger with Small Openings

5.04-2 SIZING CALCULATIONS

A. CALCULATION PROCEDURE

1. **Determine the watershed area that the sediment forebay is providing pretreatment for.** Assess the parameters of that area, including total area, **impervious** cover, soil type and level of **soil quality restoration** (or existing soil quality).

2. **Calculate the Water Quality volume (WQv) parameters.**

    a. Determine the Water Quality volume to be treated and the peak rate of flow during the WQv event.
    b. Calculate the pretreatment volume recommended based on the type of forebay being constructed.

3. **Estimate the size, length and depth of the forebay. Design the final forebay size and volume on that basis.**

4. **Determine if the forebay will be wet or dry and the type of physical separation from the downstream BMP to be used.**

5. **Select the desired type of outlet from the forebay. Design the related features, including (as applicable):**

    a. Riser pipe
    b. Outlet pipe
    c. Stone weeper
    d. Auxiliary and overflow spillways
    e. Elevation and width of the embankment materials

6. **Design scour protection at the inlet point into the forebay.**

7. **Design scour protection at the outlet points of the forebay,** including (as applicable):

    a. Pipe outlets
    b. Spillway slope and toe
    c. Embankment slope and toe

B. DESIGN EXAMPLES

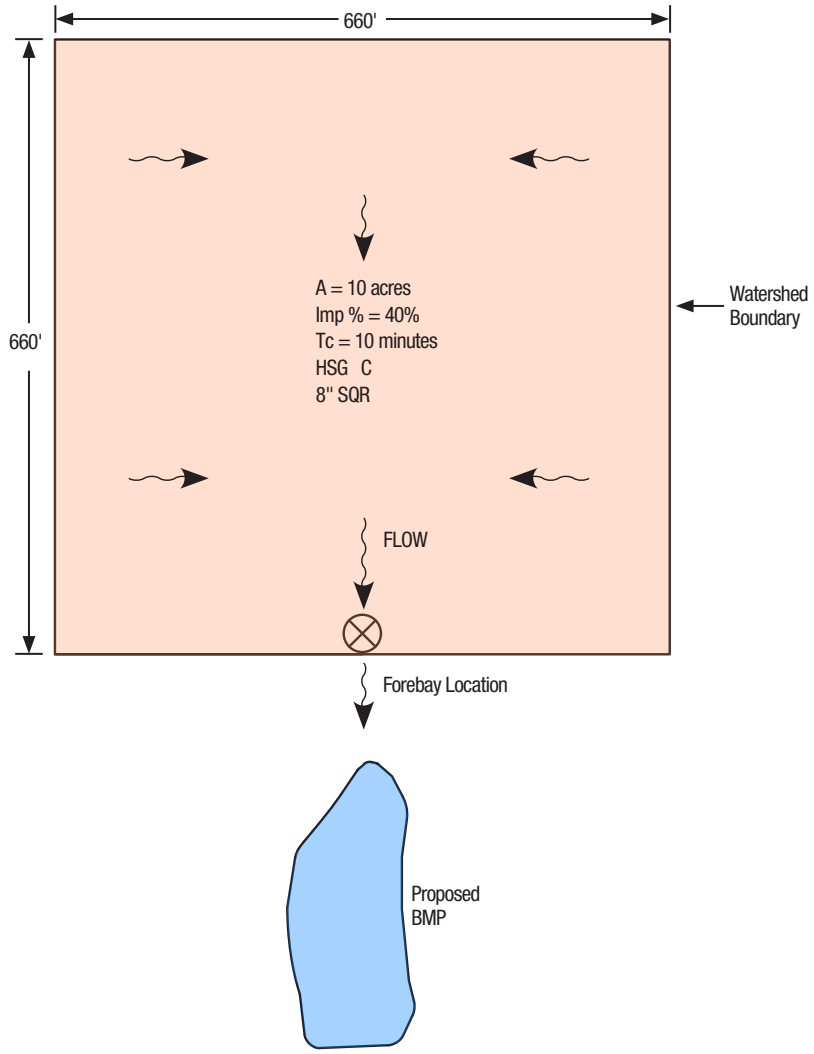
For this example, it is given that part of a residential development will drain to a storm sewer system which will outlet to a sediment forebay for pretreatment upstream of a stormwater quality and quantity BMP.

Example of Step 1: **Determine the watershed area that the forebay is expected to provide pretreatment for.** Assess the parameters of that area, including total area, impervious cover, **time of concentration**, soil type and level of soil quality restoration (or existing soil quality).

For this example, it is given that the watershed to the inlet has the following parameters:

- Area = 10 acres
- Impervious surfaces = 4.00 acres (40%)
- Time of concentration (Tc) = 10 minutes
    - (given for this example, but should be calculated in practice)
- Soils:
    - **Hydrologic Soil Group** (HSG) C
    - Method of Soil Quality Restoration: Stripping and respread of 8” topsoil with 5% organic matter
- **Curve Number** for larger storm events = 84
    - 40% impervious (CN=98), 60% open spaces, w/ 8” SQR (CN=74)

Watershed Area Example



Example of Step 2: **Calculate the Water Quality volume (WQv) parameters.** Determine the Water Quality volume to be treated and the peak rate of flow during the WQv event.

Water Quality volume calculations:

Runoff coefficient (Rv) = 0.05 + 0.009 (I) I = impervious cover (%) **Equation 5.04-2-1**

Rv = 0.05 + 0.009 (40) = 0.410

Water Quality volume (WQv) = Rv x P **Equation 5.04-2-2**

P = WQv precipitation (1.25 inches)

WQv = Rv x P = 0.410 x 1.25 inches = 0.513 watershed-inches

= 0.513 watershed-inches x 10 acres x 43,560 (square feet / acre) / 12 (inches / foot)

= 18,604 CF (cubic feet)

Water Quality volume adjusted Curve Number (CN):

$$CN = \frac{1000}{[10 + 5P + 10Q_a] - 10(Q_a{}^2 + 1.25Q_aP)^{\frac{1}{2}}}$$ **Equation 5.04-2-3**

(From ISWMM Small Storm Hydrology Section)

P = rainfall (1.25 inches)

Qa = Water Quality volume (watershed-inches) = 0.513 watershed-inches

Solving the equation above, CN = 90

Calculate Water Quality volume peak flow rate

Software running the NRCS TR-55 method to compute peak flows may be used. For this example, Hydraflow Hydrographs was used with the following parameters:

Area = 10 acres

CN (adjusted) = 90

Tc = 10 minutes

Time interval = 1 minute

Results:

Peak flow = 7.9 cfs (cubic feet per second)

Volume = 17,927 CF

This value is similar to the 18,604 CF solved previously

The 18,604 cubic feet value is the value to use for design of water quality BMPs, but making sure these values are similar is a good double check that the adjusted CN is correct.

Example of Step 3: **Design the sediment collection area, as applicable.**

Example 3A: **If a dry forebay is to be used:**

Calculate 10% of the WQv:

18,604 cubic feet x 10% = 1,861 CF

Estimate the area required.

- For this example, the designer is choosing to use a target forebay storage depth of 3 feet and is trying to make the forebay twice as long as it is wide.
  - Footprint of "middle contour" of the forebay (3 feet / 2 = 1.5 feet above bottom of forebay).
- Pretreatment volume (CF) / Depth (feet) = Target footprint area (SF)
  - = 1,861 CF / 3 feet = 620.3 SF
- Preliminary dimensions of forebay: Area = width (w) x length (2w) = $2w^2$
  - $w = (\text{Area (SF)} / 2)^{1/2}$
  - $w = (620.3 \text{ SF} / 2)^{1/2}$
  - w = 17.6 feet (rounded up to 18 feet)
  - Area = 18 feet x (18 feet x 2) = 648 SF (18' x 36' for middle contour)

Using 4 (horizontal) : 1 (vertical) side slopes:

- Bottom area = 0 SF (sloped to outlet point)
- 1 foot above bottom = 14 x 32' = 448 SF
  - (width = 18' – 2 x (4 x 0.5') = 14', length = 36' – 2 x (4 x 0.5') = 32'
- 1.5 feet above bottom = 18' x 36' = 648 SF
- 2 feet above bottom = 22' x 40' = 880 SF
  - (width = 18' + 2 x (4 x 0.5') = 22', length = 36' + 2 x (4 x 0.5') = 40'
- 3 feet above bottom = 30' x 48' = 1,440 SF
  - (width = 18' + 2 x (4 x 1.5') = 30', length = 36' + 2 x (4 x 1.5') = 48'

Table 5.04-2-1: Preliminary Design of Dry Forebay

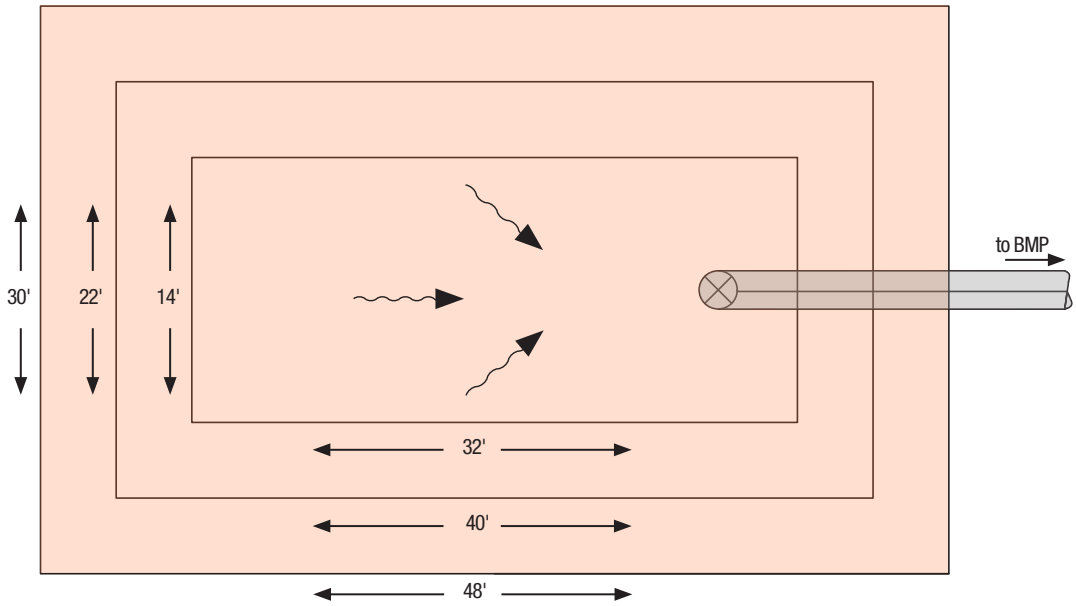
Elevation (feet)	Area (SF)	Incremental Storage (CF)	Cumulative Storage (CF)
0	0	0	0
1	448	224	224
2	880	664	888
3	1,440	1,160	2,048

A final design of the forebay shape and volume would then be prepared using this preliminary design as a guide.

NOTE

Rectangular shape in illustration is used for preliminary sizing. Shape of the final design may vary. More natural shapes are encouraged.

Dry Forebay Example - Preliminary Volume Schematic



Example 3B: **If a wet forebay is to be used:**

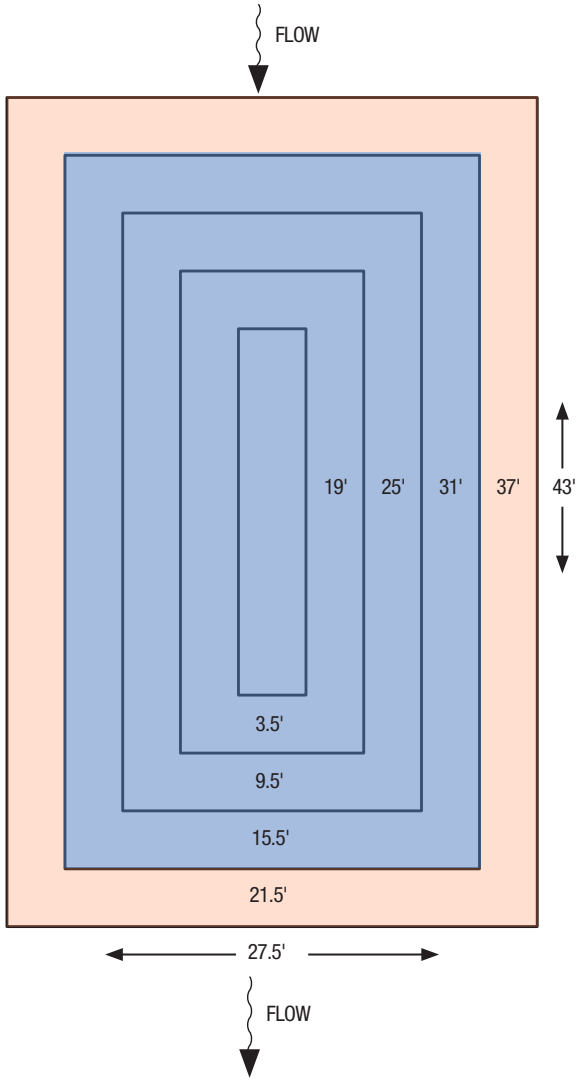
- Calculate 10% of the WQv:
  - 18,604 cubic feet x 10% = 1,861 CF
  - Estimate the area required.
    - » For this example, the designer is choosing to use a target forebay storage depth of 4 feet and is trying to make the forebay twice as long as it is wide.
    - » Footprint of "middle contour" of the forebay (4 feet / 2 = 2 feet above bottom of forebay).
    - » Pretreatment volume (CF) / Depth (feet) = Target footprint area (SF)
      - = 1,861 CF / 4 feet = 465.3 SF
    - » Preliminary dimensions of forebay: Area = width (w) x length (2w) = $2w^2$
      - $w = (\text{Area (SF)} / 2)^{1/2}$
      - $w = (466 \text{ SF} / 2)^{1/2}$
      - w = 15.3 feet (use 15.5 feet)
      - Area = 15.5 feet x (15.5 feet x 2) = 480.5 SF
- Using 3 (horizontal) : 1 (vertical) side slopes:
  - Bottom area = 3.5' x 19' = 66.5 SF (flat bottom)
  - 1 foot above bottom = 9.5' x 25' = 237.5 SF
  - 2 feet above bottom = 15.5' x 31' = 480.5 SF
  - 3 feet above bottom = 21.5' x 37' = 795.5 SF
  - 4 feet above bottom = 27.5' x 43' = 1,182.5 SF

Table 5.04-2-2: Preliminary Design of Wet Forebay

Elevation (feet)	Area (SF)	Incremental Storage (CF)	Cumulative Storage (CF)
0	66.5	0	0
1	237.5	152	152
2	480.5	359	511
3	795.5	638	1,149
4	1,182.5	989	2,138

A final design of the forebay shape and volume would then be prepared using this preliminary design as a guide.

Wet Forebay Preliminary Volume - Schematic



NOTE

Rectangular shape in illustration is used for preliminary sizing. Shape of the final design may vary. More natural shapes are encouraged.

New Example: **Example of Sizing a Stone Weeper Outlet**

- Stone weepers are sized using the following formula

$$Q = \frac{h^{3/2}\ W}{\left(\frac{L}{D} + 2.5 + L^2\right)^{1/2}}$$

Equation 5.04-2-4

Q = Design flow through stone weeper (cubic feet per second, cfs)

H = Ponding height against stone weeper (feet)

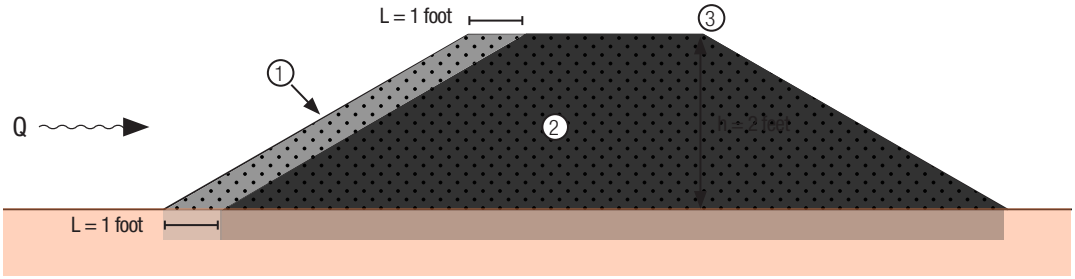
W = Total length of the dam (feet)

L = Horizontal flow path length (feet) through most restrictive flow layer

D = Average stone size diameter (feet)

Source: Dane County, Wisconsin Stormwater Manual

Stone Weeper Illustration



1 - 1" Clean Stone Layer
2 - Larger Stone Material
3 - Spillway

- Using the information from the previous example, where Q = 7.9 cfs (for the WQv event)
  - Assume the 1" clean stone material is the layer which limits flow, and it is installed as a 1 foot thick layer (length of flow)
    - » D = 1/12 feet
    - » h = 2 feet (given as the designer's selection for this example)
    - » L = 1 feet
    - » Need to solve for W…

Using a W = 11 feet:

$$Q = \frac{h^{3/2}\ W}{\left(\frac{L}{D} + 2.5 + L^2\right)^{1/2}}$$

$$Q = \frac{(2\ feet)^{3/2}\ (11\ feet)}{\left(\frac{1\ foot}{\frac{1}{12} feet} + 2.5 + (1\ feet)^2\right)^{1/2}}$$

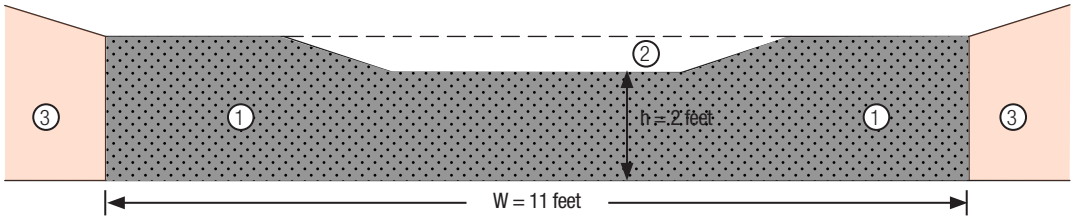
$$Q = \frac{(2\ feet)^{3/2}\ (11\ feet)}{(15.5)^{1/2}}$$

$$Q = \frac{(2.828)\ (11)}{3.937}$$

$$Q = 7.9\ cfs$$

For this example, a stone weeper with a width of 11 feet would be sufficient to pass the water quality event.

Stone Weeper Design Example



1 - Stone Weeper Cross-Section
2 - Spillway
3 - Adjacent Earth Material

5.04-3 CONSTRUCTION

A. POLLUTION PREVENTION

If the sediment forebay is part of a project whose total disturbed area exceeds one acre (including all parts of a common plan of development) a stormwater pollution prevention plan (SWPPP) is required by state and federal law to be prepared.

Prior to construction, coverage under the State of Iowa's NPDES General Permit No. 2 shall be obtained (or, if required, coverage through an individual permit).

The SWPPP document will meet state and local regulatory requirements and will detail the structural and non-structural pollution prevention best management practices (BMPs) that are to be employed at the site.

EXTERIOR PROTECTION

All perimeter and site exit controls should be installed prior to any land-disturbing activities. Such controls may include (but are not limited to) site construction exits, perimeter sediment controls, construction limit fencing, waste collection, sanitary facilities and concrete washout containment systems.

INTERIOR PROTECTION

As construction activities begin, internal controls will be added to prevent erosion and sediment loss from the site area.

Erosion controls (mulches, rolled erosion control products, turf reinforcement mats, etc.) prevent detachment of soil particles from the surface.

Sediment controls (wattles, filter socks, silt fences, sediment basins, etc.) capture sediments after they have become suspended in runoff.

For pollution prevention requirements for other stormwater best management practices associated with the project, refer to the relevant section of ISWMM for more pollution prevention information.

B. CONSTRUCTION SEQUENCING

Sediment forebays are typically designed to be constructed as part of a larger project. They typically will be created during rough site grading. The forebay should be installed to the length, width and depth as specified by the designer. The forebay control structure and/or spillway should be constructed early in the project, so that the forebay can be used to provide some protection of the downstream BMP during construction. In some cases, the forebay can be used as a dewatering location to bypass smaller storm flows around the downstream BMP during construction.

Seedbed preparation in the area surrounding the forebay should be performed prior to the installation of permanent seed materials. After seeding, install any specified RECPs or TRMs. If RECPs or TRMs need to be installed earlier during construction to reduce surface erosion, perform seedbed preparation and apply a temporary cover crop seed mix before installation. Permanent seeding application rates may need to be increased when seeding over RECPs and TRMs.

Sediment forebays are sized to capture sediment loadings from areas that are fully stabilized with permanent vegetation post-construction. During construction activities, sediment levels within incoming stormwater runoff will likely be elevated. This means sediment may need to be removed at various intervals during construction. Near the end of project construction, any accumulated sediment should be removed from the forebay so that it has nearly its full capacity available as the project reaches the post-construction phase. Some areas may need to be mulched or seeded several times during construction if areas near the forebay are disturbed as part of sediment removal activities.

Wet forebay separated by stone embankment from downstream pond. Vegetated concrete mat used for maintenance access and scour protection at sides of stone embankment. Clive, IA.

C. CONSTRUCTION OBSERVATION

A designated representative of the owner should observe construction operations on a frequent basis to confirm the following:

- Topsoil stripping, stockpiling and respread activities have been completed as specified.
- Rough grading generally conforms to plan elevations and test results have been provided that demonstrate that compaction requirements have been met.
- If the runoff is intended to be bypassed around the forebay during construction, make sure the bypass pipes or channels are constructed as designed.
- In some cases, the forebay may be used as a collection point to collect and pump water around a downstream pond or wetland during construction. If that approach is used, observe that the methods of pump diversion are in place and the pump system is operating properly.
- Storm sewer and pipe structures or adjacent paved surfaced leading to the forebay are installed to the dimension, location and elevations specified on the plans and proper installation techniques and trench compaction techniques have been followed.
- The forebay is installed to the dimension, location and elevations specified on the plans.
- The correct surface protection material is installed within the forebay (if specified).
- The forebay embankment and outlet (pipes and/or spillway) are installed to the dimension, location and elevations specified on the plans.
- Verify that the required methods of soil quality restoration surrounding the forebay are completed and that surface roughening and seedbed preparation are completed prior to seeding.
- Confirm that seed, plug and other landscape materials (trees, shrubs, etc.) delivered to the site are in accordance with the contract documents.
- Observe that the rate of temporary and permanent seed and mulch materials are in compliance with the contract documents, and that activities are completed within the specified seeding dates.
- Complete a walk-through with the designer and contractor to identify any items which are not in compliance with project requirements. Document issues in a punch list and confirm when all items are installed or repaired.
- As needed by the local jurisdiction, author a letter of acceptance noting either conformance with construction documents, or any allowed deviation thereof.
- Be present during vegetation establishment and maintenance operations to verify that required duties are completed and vegetation has been established as specified.

D. AS-BUILT REQUIREMENTS

During construction, records should be kept by the contractor (and site observer) that will allow record drawings of as-built improvements to be provided to the owner. To demonstrate that the project has complied with contract documents, these records should include, but not be limited to, the following:

- Spot elevations at the bottom of the forebay and crest elevations of the embankment and spillway.
  - In some cases, the designer may choose to specify that the forebay grading and capacity be verified by topographic survey after construction.
- The flowline elevations of any storm pipes or structures leading into or out of the forebay.

Wet forebay upstream of Gray's Station constructed stormwater wetland in Des Moines, IA.

5.04-4 MAINTENANCE

ACCESS PATH

The access path needs to provide access to the inlet and outlet points of the forebay and along at least one of its sides.

TARGET In some locations, it may be necessary to have access on multiple sides of the forebay to increase the area where sediment can be efficiently removed. The access route should be at least 12 feet wide with a cross slope of no more than 8% (5% preferred). The path could be as simple as a path that is kept clear of trees and brush or extensive as a path stabilized with a stone or paved surface.

For micro-forebays or other smaller forebays, sediment may need to be removed using shovels, smaller equipment or vacuum trucks. Make sure there is a clear path from sidewalks, adjacent drives or streets for the wheelbarrows, wagons, small equipment or trucks to be positioned close enough to the micro-forebays to complete the required maintenance.

ACTIVITIES

During the design process, the entity responsible for routine and long-term maintenance should be identified. ESSENTIAL
These tasks are necessary to maintain the function of the forebay. The capacity of the forebay to intercept suspended sediments and other debris will be reduced if these tasks are not completed. This could require additional or more frequent maintenance or repairs of downstream BMPs to maintain their function.

Table 5.04-4-1

Activity	Schedule
During Construction (as applicable)	
Diversion reconnection after construction (if used to bypass practices during construction).	After construction, if applicable.
Throughout construction, remove accumulated sediment within the forebay.	As needed, or at least when 50% of the sediment collection capacity if filled and at completion of major construction activities.
Post-Construction	
Look for signs of sediment accumulation and erosion damage. Check surface water entry points for signs of surface erosion.	At least annually AND after rain events of 1.25" or larger.
Inspect the sediment collection areas.	At least three times during the first year, and at least once annually after that, but more frequently as needed if sediment buildup is often observed.
Remove sediment from the collection area.	When 50% of the sediment collection capacity is filled. Typically, it would be expected that sediment may need to be removed from forebays at least once every three (3) to ten (10) years.
If a stone weeper is used as part of the forebay outlet, inspect the stone materials. If the smaller stone material is clogged with sediment, remove and replace those materials to re-establish that stone materials have open void spaces to accommodate flow.	Inspect materials at least annually. Replace materials as needed. May be coordinated sediment removal activities.
Clean and remove debris as necessary.	When observed.
Repair undercut or eroded areas within or around the forebay.	When observed.
Complete maintenance of the surrounding perennial vegetation.	Annually, as specified.

- Sediments excavated from forebays that do not receive runoff from designated **hotspots** are not currently considered toxic or hazardous material and can be safely disposed of by either land application or at a permitted landfill. However, guidance on the related to Per- and Polyfluoroalkyl Substances (PFAS), sometimes referred to as "forever chemicals" is evolving. This guidance may need to be addressed as more federal or state guidance on PFAS is created.
- Sediment testing may be required prior to sediment disposal when a hotspot land use is present.
- Sediment removed from forebays during construction should be disposed of according to an approved SWPPP.

5.04-5 SIGNAGE RECOMMENDATIONS

Signage for pretreatment areas is not required, as it is less commonly used than at stormwater quality BMPs. However, signage could be provided as an educational tool to detail the purpose and function of the sediment forebay to the general public. Signage can also be used to advise maintenance staff on maintenance requirements.

Illustration of an educational sign.

5.04-6 GLOSSARY

Best Management Practice (BMP)	A feature designed to meet stormwater water quality or quantity management goals.
Curve Number	A parameter used in NRCS Technical Release 20 or 55 (TR-20 or TR-55) that is used to estimate the rate and volume of stormwater runoff that will be created from rainfall, based on the soil types and land uses at a given location. Values range from around 30 to 100, with higher values resulting in more runoff being predicted from the equations used by TR-20 and TR-55 methods. See the NRCS TR-55 Methodology section of ISWMM for more information.
Hotspot	Land uses or activities that have the potential to generate higher pollutant loads than typical urban land uses. Gas stations and some industrial sites are examples of hotspots.
Hydrologic Soil Group (HSG)	Categories shown on County Soils Maps that describe the runoff potential of common soil groups. HSG categories range from A to D, with HSG A soils generating the least amount of runoff from rainfall events and HSG D soils generating the most.
Impervious cover	Surfaces on the landscape that do not allow water to pass through, such as roofs and paved surfaces.
Pretreatment	Use of practices or features to capture the heaviest sediment particles, trash or debris out of stormwater flows before it can enter a downstream BMP.
Time of concentration	The length of time it takes stormwater runoff to pass from the farthest upstream point in a drainage area to the outlet after runoff from rainfall has started.
Soil Quality Restoration (SQR)	Creating a healthy soil profile through methods of respreading topsoil materials or using blends of compost and sand to improve soil properties. (See the Soil Quality Management and Restoration Section of ISWMM.)
Unified Sizing Criteria (USC)	The set of stormwater management quality and quantity goals recommended by ISWMM.
Water Quality Volume (WQv)	One of ISWMM's USC, defined as the runoff generated by a 1.25-inch rainfall event. Over 90% of all rainfall events in Iowa are at or less than this amount of rain.

5.04-7 RESOURCES

Fairloth Skimmer website. https://fairclothskimmer.com/

5.04-8 APPENDIX

KEY DESIGN PARAMETER CHECKLIST

There are important aspects of this manual to consider when jurisdictions seek to create stormwater ordinances or policies that reference or adopt this manual. The Iowa Department of Natural Resources (IDNR) is responsible for the creation and maintenance of this manual, working with a technical committee of local volunteers. However, regulation and enforcement of post-construction stormwater management is primarily left to local jurisdictions.

Therefore, the IDNR does not enforce as requirements, the sizing and design criteria set for this document. For this reason, the language used within this manual has purposefully been written as a guideline, rather than a standard. This means certain language that conveys something is required (i.e. shall, must, etc.) is generally avoided. This has the potential to leave "gray areas" as to what may be interpreted to be required and what is recommended or optional, if this manual is adopted and referenced by local jurisdictions as a standard.

Throughout this section, different design parameters or considerations have been grouped into key categories:

ESSENTIAL

An element of the design of a BMP seen as critical to its proper performance, operation or aesthetics. **These aspects should be most important for inclusion and compliance and should rarely be deviated from.**

TARGET

An element of the design of a BMP seen as important to its proper performance, operation or aesthetics. **These aspects should be included in designs, if at all possible.** However, there is more flexibility to allow deviations if it can be demonstrated that it is infeasible to meet the requirement at a given location, or if a certain requirement is in conflict with other requirements. **Designers should explain any reason for deviation from targets, for the consideration of the jurisdiction as part of their review.**

IDEAL

An element of the design of a BMP seen as the recommended approach for its proper performance, operation or aesthetics. Designers are encouraged to include these in designs as best practice. However, these items are seen as less critical as those noted as essentials or targets.

CAUTION

These are notes or design guidance to highlight items for the designers' careful consideration.

ADVISORY

These are practices, techniques or potential deviations from the design ethic that should be avoided in most circumstances.

ESSENTIAL

1. There needs to be a clear path with legal right of access to allow the party responsible for maintenance to reach the forebay. (page 3)
2. The slopes around the forebay both below and above the water surface (as applicable) should not be less than three (3) horizontal to one (1) vertical (3:1). (page 9)
3. The designer should consider the expected velocities, slope and elevation drop on the downhill side of the forebay embankment and provide adequate scour protection, using Turf Reinforcement Mats (TRMs), vegetated concrete mats or articulated concrete block mats. (pages 9 and 13)
4. In some cases, forebays may be placed in a location where they are elevated above the downstream BMP. In those cases, more consideration needs to be focused on the manner of overflow from the forebay and the potential for surface erosion in the area between the forebay and BMP. In such cases, the auxiliary or overflow spillway should be designed to accommodate at least the peak flow rate expected by the 10-year, 24-hour storm event. (page 14)
    a. If runoff is expected to overtop portions of the embankment outside of the spillway during the 100-year storm event, the expected flow velocities across the crest of the embankment and on the downhill slope should be checked to evaluate the potential for surface erosion. (page 15)
5. Smaller "micro-forebays" are sometimes included at curb cuts and other concentrated inflow points to smaller infiltration based BMPs, such as bioretention cells or stormwater planter boxes. They may also be appropriate in other smaller scale retrofit projects. In any of those cases, the micro-forebay is typically created by creating a small, depressed area at the entry point with a bottom stabilized with a concrete slab, metal surface or paver blocks. (page 15).
    a. Since the volume stored in micro-forebays is less than what is recommended for other types of forebays, sediment and debris will need to be removed more frequently to protect the function of the downstream BMP. (page 15)
6. During the design process, the entity responsible for routine and long-term maintenance should be identified. (page 31)

TARGET

1. The depth of the "dry" forebay should be as needed to provide the projected pretreatment volume. (page 4)
2. If a flume is not provided, the bottom of the dry forebay should drain toward the outlet point with a minimum grade of 1%. (page 4)
3. The permanent pool of the "wet" forebay should be sized to provide the projected pretreatment volume. (pages 4 and 7)
4. The bottom of the wet forebay should be fairly level. It may be designed with no slope. (page 4)
5. If a concrete bottom is not used, a depth marker could be included. This would help maintenance personnel understand when they have reached the position of the original bottom of the forebay, so they know when to stop excavation. (page 4)
6. Provide storage within the forebay for at least 10% of the calculated water quality volume that is not treated by upstream water quality BMPs. (page 7)
7. For wet forebays, the calculated pretreatment storage should be provided in the permanent pool volume expected to be sustained within the forebay. (page 7)
8. The forebay should be shaped to maximize the length of flow through the forebay. The path of flow through the forebay should be greater than the maximum width of the forebay and additional length of flow would be preferred. (page 7)
9. If earth materials are used for the physical separation between the forebay and BMP, the top width of the dam should be sufficient to avoid being washed out when over-topped. (page 8)
10. If revetment materials are used, the materials should be rated similar to "A Freeze" quality as defined in Iowa DOT Standard Specification Section 4130 (as referenced by Iowa SUDAS Section 9040).
11. The top of the perforated riser pipe should be left open, set above the depth needed to provide the target pretreatment storage volume. (page 9)
    a. The pipe should be surrounded with 1" clean aggregate materials (IDOT Gradation 3) to reduce the potential

for clogging the perforated riser openings and to improve sediment capture. (page 9)

b. The riser should be connected to a pipe that extends through the earth embankment. The pipe and the open top of the riser structure should be sized so the peak flow from at least the Water Quality event (WQv – 1.25", 24-hour rainfall) can pass through the pipe without over-topping the auxiliary spillway of the forebay. (page 9)

c. The level crest width of the auxiliary spillway should be set at least 12 inches below the crest elevation of the remainder of the earth embankment, or as needed to contain the 10-year storm events within the spillway. (page 9)

12. If a skimmer is used, it should be sized so the peak flow from the Water Quality event can pass through the skimmer and outlet pipe. (page 11)

13. When a stone weeper is used, the earth embankment above the weeper should be shaped to include an auxiliary spillway. The guidelines for the design and protection of the auxiliary spillway as listed in Option A would also apply to in this application. (pages 12 and 13)

    a. The stone weeper should be designed to allow the peak flow from the WQv event to pass through the smaller diameter stone filter material on the face of the weeper, without over-topping the auxiliary spillway. (page 11)

    b. A portion of the stone weeper should be constructed as an auxilliary spillway, meeting the guidelines as listed in Option A. (page 13)

14. For a wet forebay with an earth embankment, the spillway should have sufficient width so that the peak flow of storms up to the 10-year, 24-hour storm event can pass through with velocity at the crest of the spillway of less than five (5) foot per second (fps). (page 14).

    a. The level crest width of the auxiliary spillway should be set at least 12 inches below the crest elevation of the remainder of the earth embankment, or as needed to contain the 10-year storm events within the spillway. (page 14)

15. Flow out of micro-forebays into BMPs may be restricted using open graded stone materials, paver blocks or edgers constructed from concrete, metal or composite materials. (page 16)

    a. The edger would have smaller openings that allow flow to drain out of the micro-forebay and into the BMP. The top of the edger would be designed to ensure that the entirely of the peak flow from the design storm event (typically the WQv event) can enter the practice. (page 16)

    b. Since these micro-forebays are typically limited in surface area and depth, the recommended pretreatment storage volumes is reduced to 2.5% of the WQv expected to be treated by the BMP. (page 16)

16. The access path needs to provide access to the inlet and outlet points of the forebay and along at least one of its sides. In some locations, it may be necessary to have access on multiple sides of the forebay to increase the area where sediment can be efficiently removed. (page 30)

    a. The access route should be at least 12 feet wide with a cross slope of no more than 8% (5% preferred). (page 30)

    b. The path could be as simple as a path that is kept clear of trees and brush or extensive as a path stabilized with a stone or paved surface. (page 30)

IDEAL

1. A depth of less than four (4) is recommended for ease of maintenance.(page 4)

2. A flume constructed from concrete, articulated concrete block mats or vegetated concrete block mats is a recommended feature that could run from the inlet point of the forebay to the outlet. (page 4)

    a. If used, the flume should have a slope of at least 0.5% toward the forebay outlet (or 1% if the flume is shorter than 50 feet in length). (page 4)

    b. The vegetated area within the forebay should drain toward the flume or outlet point with a minimum grade of 1.5%. (page 4)

3. The depth of the wet forebay measured from its permanent pool elevation to its deepest point should be between two (2) and four (4) feet in depth. (page 4)

4. A concrete bottom constructed from concrete or articulated concrete block mats would make it easier to remove collected sediment from the forebay. (page 4)

5. If the outlet of the pond or wetland allows for water surface elevation to be lowered for maintenance, consider including methods to allow the water level of the forebay to be drawn down as well. (see options on page 4)

6. The forebay should be shaped so that the sediment can be effectively removed from the access path. (page 7)

7. The number and size of the pipe openings for a perforated riser may vary based on project design, but any individual opening should not be greater than 1/2" in diameter. The riser should not be wrapped with engineering fabric (except when used as an additional temporary sediment protection during construction). (page 9)
8. For overflow spillways, the scour protection should extend up the side slopes of the auxiliary spillway to the crest of the embankment on each side and cover at least five (5) feet of the embankment crest on each side to reduce the potential for erosion along the edges of the protected area. (page 9)
    a. The protection should begin at least one (1) foot below the crest of the auxiliary spillway on the uphill side of the forebay embankment and extend at least five (5) feet beyond the toe of slope on the downhill side. (page 9)
    b. The values listed on page 9 are recommended minimum levels of protection, which will often need to be exceeded based on specific site conditions. The designer should evaluate the specific needs of their site to determine the type and extent of scour protection. (page 9)
9. For stone weepers, the stone materials should be keyed into the soil below and to the sides of the weeper by at least 6 inches. (page 12)
10. For a wet forebay with an earth embankment, the crest of the overflow spillway should be set between zero (0) and six (6) inches below the permanent pool elevation expected to be sustained within the forebay. (page 14)
11. When forebays are elevated above downstream BMPs, a preferred approach would be to size the spillway to convey the peak flow rate during a 100-year, 24-hour storm event without over-topping the remainder of the forebay embankment. (page 15)

ADVISORY

1. Class D Revetment materials as defined in IDOT and SUDAS specifications are not recommended. (page 8)