# APPENDICES

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**APPENDIX C – SEDIMENT CONTROL BEST MANAGEMENT PRACTICES**

# APPENDIX A

# SITE DEVELOPMENT INFORMATION FORM

# APPENDIX A – SITE DEVELOPMENT INFORMATION FORM

## APPENDIX A – SITE DEVELOPMENT INFORMATION FORM

Project Name: ______________________________ Location: ______________________________

Project Number: ______________________________________________________________

City/Local Agency: __________________________ Dates of Site Visits: _______________________

Property Street Address: ______________________________________________________

Legal Descriptions: __________________________________________________________

**A. CITY DEPARTMENT CONTACTS:**

1. Planning Department: ___________________________ Web Site ___________________________
   Person to Contact: _________________ Telephone #: ________ Email: ______________________

2. Public Works Department: _______________________ Web Site ___________________________
   Person to Contact: _________________ Telephone #: ________ Email: ______________________

3. Engineering Department: ________________________ Web Site ___________________________
   Person to Contact: _________________ Telephone #: ________ Email: ______________________

4. Water Department: _________________ Public: (YES) (NO) Web Site: _____________________
   Person to Contact: _________________ Telephone #: __ Email: ____________________________

5. Sewage Department: _______________ Public: (YES) (NO) Web Site: _____________________
   Person to Contact: _________________ Telephone #: __ Email: ____________________________

6. Storm Sewer Department: ___________ Public: (YES) (NO) Web Site: _____________________
   Person to Contact: _________________ Telephone #: __ Email: ____________________________

7. Fire Department: __________________ Public: (YES) (NO) Web Site: _____________________
   Person to Contact: _________________ Telephone #: __ Email: ____________________________

8. Other Departments (Could be either City or State EPA, DNR, Historical, Drainage Districts, Energy, etc.)
   Department: _____________________________________________________________________
   Person to Contact: _________________ Telephone #: __ Email: ____________________________
   Department: _____________________________________________________________________
   Person to Contact: _________________ Telephone #: __ Email: ____________________________

## APPENDIX A – SITE DEVELOPMENT INFORMATION FORM

Department:______________________________________________________________________

Person to Contact: ______________Telephone #:________Email: ____________________________

Department:______________________________________________________________________

Person to Contact: ______________Telephone #:________Email: ____________________________

### B. CITY FEES:

Zoning Fee:______________Platting Fee:________Building Permit Fees:______________________

Other Fees:________________________________________________________________________

### C. BUILDING CODES AND OTHER DESIGN CRITERIA:

1. General Building Code:__________________________ Web Site: ________________________

   Person to Contact: _________________Telephone #:________Email: ______________________

2. Plumbing Code:________________________________Web Site: __________________________

   Person to Contact: _________________Telephone #:________Email: ______________________

3, Mechanical HVAC Code:_________________________Web Site: __________________________

   Person to Contact: _________________Telephone #:________Email: ______________________

3. Electrical Code:_________________________________Web Site: __________________________

   Person to Contact: ___________Telephone #:______________Email: ______________________

4. Other Codes: (e.g., Energy, LEED, etc.)_____________Web Sites: _________________________

   Person to Contact: _________________Telephone #:________Email: ______________________

5. How are waivers for any code handled? _____________________________________________

   Are there Fees for Waivers Required? (Yes) (No) How Much?_____________________________

6. Zoning: Current Zoning of Site:____________________________________________________

7. Will variance be required? (Yes) (No)

   If so what is procedure?____________________________________________________________

   What is the Schedule for submittal of zoning change (Certain Date to submit): _______________

   How long does the process take? _____________________________________________________

8. Does the parcel of land need to be platted? (Yes)(No)

   When do plats need to be submitted to start the process? ________________________________

How long does the process take for approval?____________________________________________

9. Is Land in any Flood Zones? (Yes) (N0) Are flood maps available? (Yes) (No) Where?________
   Person to Contact: ___________Telephone #:_____________Email: _____________________
   Web Site:__________________________________________________________________________

10. Is Land in any known Brownfield Area? (Yes) (N0) Are flood maps available? (Yes) (No)
    Where?_______________________________________________________________________
    Person to Contact: ___________Telephone #:_____________Email: _____________________
    Web Site:_______________________________________________________________________

11. Is Land in any known Seismic Zone Area? (Yes) (N0) Are zone maps available? (Yes) (No)
    Where? ________________________________________________________________________
    Person to Contact: ___________Telephone #:_____________Email: _____________________
    Web Site:_______________________________________________________________________

12. Is Land in <u>any</u> known Wetland Area? (Yes) (N0) Are wetland maps available? (Yes) (No)
    Where?________________________________________________________________________
    Person to Contact: ___________Telephone #:_____________Email: _____________________
    Web Site:_______________________________________________________________________

13. Is there any easements known across the Land? (Yes) (No) Who would know what the
    easements are for?_____________________________________________________________
    Person to Contact: ___________Telephone #:_____________Email: _____________________

Web Site:____________________________________________________________________________

***(NOTE: If any of the above is checked as a YES, in the additional notes area below add the procedure and/or requirements to address the approval process needed for the project.)***

**ADDITIONAL NOTES***:*

______________________________________________________________________________

______________________________________________________________________________

**ADDITIONAL NOTES*:***

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**ADDITIONAL NOTES*:***

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**ADDITIONAL NOTES*:***

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**ADDITIONAL NOTES*:***

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## D. ACCESS TO SITE

**1.** Is the site accessible from a City Owned Street? (Yes) (No) If no, who owns the adjacent street? (State) (Private)

Person to Contact: __________________Telephone #:________Email: ______________________

If City Street, is there a curb cut permit required? (Yes) (No)

Is there a fee required? (Yes) (No) What does the permit cost:_____________________________

**ADDITIONAL NOTES*:***

______________________________________________________________________

______________________________________________________________________

## E. GENERAL SITE UTILITIES & SERVICES

1. Gas Company:_______________________ Web Site: _________________
   Person to Contact: ________Telephone #:__________Email: _______________

2. Water Company if not City:________________ Web Site: _________________
   Person to Contact: ________Telephone #:______Email: __________________

3. Sewer Company if not City:________________Web Site: _________________
   Person to Contact: ________Telephone #:__________Email: _______________

4. Electric Company if not City:_______________ Web Site: _________________
   Person to Contact: ________Telephone #:__________Email: _______________

5. Phone Company:______________________Web Site: _________________
   Person to Contact: ________Telephone #:__________Email: _______________

6. Internet System:_______________________ Web Site: _________________
   Person to Contact: ________Telephone #:______Email: __________________

7. Trash Services:_______________________ Web Site: _________________
   Person to Contact: ________Telephone #:______Email: __________________

**ADDITIONAL NOTES*:***

______________________________________________________________________

______________________________________________________________________

## F. SPECIFIC UTILITY DESCRIPTION

**1. Gas**: Available at the site? (Yes)( No) Main size: _______ Pressure in Main: ___________

Un-interruptible? (Yes) ( No)

Volume available (CFM or MBH)_____________

Typical Pressure after Meter______________

Location of line from Site: (If adjacent where in relation to centerline or property line in feet):

______________________________________________________________________

If not adjacent where is the Line? _____________________________________________

______________________________________________________________________

Who pays for extension: (Owner) (Gas Company) _______________________________

If Gas Company, what is cost of service:__________________________________________

If not adjacent who constructs the extension: (Owner) (Gas Company)

How long does this take:_______________________________________________

Meter requirements: Type of Meter (Mfg): ______________________Size:________ _________

Is Meter supplied by Gas Company? (YES) (NO) If yes, what is cost for Meter: ______________

Approved Material for pipe on-site and off-site: _______________________________________

Is an easement required for the gas line service? (Yes) (No) If yes who do we contact?

Department _____________________________________________________________

Name:___________________________Telephone #:-_____ ____________________________

**ADDITIONAL NOTES:**

______________________________________________________________________

______________________________________________________________________

2. **Water:** Available at the Site: (Yes) (No) Main size: _________Pressure in Main: ____________

How does the Owner request water service?_________ _________________________________

If pressure in not available, how do we request a fire flow for the Site?______________________

______________________________________________________________________

Location of line from Site: (If adjacent, where in relation to centerline or property line in feet):

______________________________________________________________________

If not adjacent where is the Line? _____________________________________________

______________________________________________________________________

What is acceptable piping material? Size: 2” or Smaller (COPPER) (PVC)

(Other:__________________________)

Size:____or Greater (PVC) (DI) (CI) (Other:)___________________________________________

Who pays for extension: (Owner) (Water Co.)

If Water Co., is cost charge to Owner (Yes) (No)

If not adjacent who constructs the extension:______________________________________________

How long does this take:________________________________________________________

If by Owner, is there a special construction permit required for construction: (Yes) (No)

Who issues:____________________________________________________________

What is cost to Owner for line extension?__________________________________________

Approved Material for pipe on-site and off-site: _________________________________________

Service Tap: Who make tap? (Water Co.) (Owner)

Are taps required for both domestic & fire: (Yes) (No)

Can the domestic & irrigation line be tied to fire line after the meter? ______________________

Domestic: (Yes) (No) Irrigation: (Yes) (No)

Meter requirements: Type of Meter(Mfg): ____________________________Size:____________

Is Meter supplied by Water Company (YES) (NO) If yes, what is cost for Meter: _____________

What is meter pit constructed of:___________________________________________________

Who places meter pit: (Water Co.) (Owner)

Where is meter pit typically located: _______________________________________________

Backflow Prevention (BF): Who is standard Backflow Mfg?______________________________

Is BF required ? Fire Line, (Yes) (No), Domestic Line, (Yes) (No), Irrigation Line (Yes) (No)

Picture (Yes) (No)

Fire Hydrants (FH): What is standard FH Manufacturer?_________________________________

Model #: _____________________________________________________________________

Size of nozzles on the FH: One ____inch Pumper Connection. Two ____inch Hose Connections. Thread:__________________________________________________________

Fire Hydrant Maximum Spacing:__________________________________________________

Are there seasonal restrictions on use? _____________________________________________

**ADDITIONAL NOTES:**

________________________________________________________________________

________________________________________________________________________

Is an easement required for the water line service? (Yes) (No) If yes who do we contact?

Department. ____________________________________________________________

Name:________________________Telephone #:- _____________________________

**ADDITIONAL NOTES:**

________________________________________________________________

________________________________________________________________

3. **Sewer:** Available at the Site: (Yes) (No) Main size: ___Type of Main: Gravity:_____Force:_____

Type of System: (Sewer System) (Combined Storm & Sewer)
If combined, is there special criteria? (Yes) (No)

How does the Owner request sewer service? _______________________________________

______________________________________________________________________

Location of line from Site: (If adjacent where in relation to centerline or property line in feet)

______________________________________________________________________

If not adjacent where is the Line:_____________________________________________

Who pays for extension: (Owner) (Sewer Co.) ____________________________________

If Sewer Co., is cost charge to Owner (Yes) (No)

If not adjacent who constructs the extension: ____________________________________

How long does this take?____________________________________________________

Manhole Spacing Criteria: _________________________Std Diameter: ______feet _______

Steps Required: (Yes) (No)

If by Owner, is there a special construction permit required for construction: (Yes) (No)

Who issues: ______________________________________________________________

What is cost to Owner for line extension?________________________________________

Approved Material for pipe on-site and off-site: ___________________________________

Service Tap: Who make tap? (Sewer Co.) (Owner)
Can sewer tap go into existing manhole if nearby? (Yes) (No)

Can cleanouts be used on 8” or smaller sewer lines on the Site in lieu of manholes?
(Yes) (No)

Manhole requirements: Construction Material__________________________Size:____________

Rims: Is rim stamped SEWER (Yes) (No)

Standard Manufacturer:______________________ Vented: (Yes) (No)

Lift Stations: Does agency have a special manufacturer? (Yes) (No)

If Required who Maintains?_______________________________________________________

Is an easement required for the sewer line? (Yes) (No) If yes who do we contact?

Department: ____________________________________________________________________

Name:___________________________Telephone #:- _________________________________

**ADDITIONAL NOTES:**

_______________________________________________________________________________

_______________________________________________________________________________

4. **Storm Sewer**: Available at the Site: (Yes) (No) Pipe size: ___________________________

Type of Main: Gravity:__________________________Force:__________________

Type of System: (Sewer System) (Combined Storm & Sewer)

If combined, is there special criteria? (Yes) (No)

How does the Owner request storm sewer service?__________________________________

_______________________________________________________________________________

Location of line from Site: (If adjacent where in relation to centerline or property line in feet):

_______________________________________________________________________________

If not adjacent where is the Line?_________________________________________________

Who pays for extension: (Owner) (Drainage Dist.)

If Drainage Dist., is cost charge to Owner (Yes) (No)

If not adjacent who constructs the extension: (Drainage Dist.) (Owner)

How long does this take:______________________________________________________________

What is the Design year Storm Event:_____________________ ____________________________

Is this based on 1-hour storm, 24 hour Storm, Other_____________________________________?

Is quantity reduction required? (Yes) (No) ____________________________________________

Is storm water treatment required?  (Yes) (No)

If yes, what level of treatment is required?  ___________________________________________

Manhole/Inlet Spacing Criteria: ________________________Std Diameter: ______feet

Steps Required: (Yes) (No)

If by Owner, is there a special construction permit required for construction: (Yes) (No)

Who issues:______________________________________________________________________

What is cost to Owner for line extension?______________________________________________

Can sewer tap go into existing manhole if nearby?  (Yes) (No)

Who makes connection into system? (Drainage Dist.) (Owner)   ___________________________

Are there Standard Inlet Plans? (Yes) (No)

Can cleanouts be used on 12" or smaller storm sewer lines on the Site in lieu of manholes?
(Yes) (No)

Manhole requirements: Construction Material___________________________

Standard_________________________________________________________Size:______________

Rims: Is rim stamped STORM SEWER (Yes) (No)
Standard Manufacturer:_____________________________________________________________

Lift Stations, if required: Does agency have a special manufacturer (Mfg)? (Yes) (No)

Is an easement required for the storm sewer service? (Yes) (No) If yes who do we contact?

Department:_________ _____________________________________________________________

Name:_____________________________Telephone #:- __________________________________

**ADDITIONAL NOTES:**

________________________________________________________________________

________________________________________________________________________

**5. Electricity:** Available at the Site: (Yes) (No)

Main voltage: 120/208 Single Phase, 120/208 3 Phase, 120/240 Single

Phase, 120/480 3 Phase, 277/480 3 Phase, 5 KV Single Phase, 15 KV 3 Phase, (Other _______)

How does the Owner request power service (PS)?________________________________________

Form Web Site:____________________________________________________________

Location of power source from Site: (If adjacent where in relation to centerline or property line in feet):______________________________________________________________

If not adjacent where is the Line:________________________________________________

If not adjacent, what is the cost to extend line to site?_____________________________

Transformer (T): Who supplies T? (Power Co.) (Owner)

Who installs Primary Side? (Power Co.) (Owner)

Who connects from Meter (M) to T? (Power Co.) (Owner)

Is there a standard power drop drawing? (Yes) (No)

Meter (M): Type of M: Pole attached (Yes) (No) Pedestal Mount (Yes) (No) (Other: __________)

Who Supplies M Socket/MFG? (Power Co.) (Owner)(________)

Who supplies the M? (Power Co.) (Owner)

Who Installs Conduits from M to T? (Power Co.) (Owner) Size: ______

Material: (PVC) (RIDGED)(OTHER________)

Who installs in Conductors from M to T? (Power Co.) (Owner) Size: ______Material: __________

Who installs Conductors from T to PS? (Power Co.) (Owner) Size: ______Material: __________
What is the cost of the electrical service?_____________________________________________

Is an easement required for the electrical service? (Yes) (No) If yes who do we contact?

Department.______________________________________________________________

Name:__________________________________Telephone #:- ___________________________

**ADDITIONAL NOTES:**

______________________________________________________________________

______________________________________________________________________

6. **Telephone**: Available at the Site: (Yes) (No) ___________________Where?_______________

   How does the Owner request telephone service (TS)? _______________________________

   ______________________________________________________________________

   Location of telephone source from Site: (If adjacent where in relation to centerline or property line in feet): _____________________________________________________

   ______________________________________________________________________

   If not adjacent where is the Line: . __________________________________________________

   If not adjacent, who extends the Line: (Telephone Co.) (Owner)

   What is the cost to extend line?_______________ _____________________________________

   What is the cost for a normal Telephone Service? _____________________________________

   Is an easement required for the telephone service? (Yes) (No) If yes who do we contact?

   Department: _________________________________________________________________

   Name:____________________________Telephone #:- __________________________________

**ADDITIONAL NOTES:**

______________________________________________________________________

______________________________________________________________________

7. **Internet Service:** Available at the Site: (Yes) (No)

   How does the Owner request Internet/Cable Television (ITS)? ____________________________

   ______________________________________________________________________

   Location of ITS source from Site: (If adjacent where in relation to centerline or property line in feet):________________________________________________________________

   If not adjacent where is the Line: ____________________________________________________

   If not adjacent, what is the cost to extend line to site?____________________________________

   What is the cost for a normal Internet and Cable Television Service? _______________________

Is an easement required for the internet service? (Yes) (No) If yes who do we contact?

Department: ____________________________________________

Name:____________________________Telephone #:- ________________________

**ADDITIONAL NOTES:**

_______________________________________________________________

_______________________________________________________________

**G. Storm Water Management Plan :** Who is review agency for Stormwater?

_______________________________________________________________

How does the Design Engineer Obtain information on the Stormwater Criteria? ______________

______________________________________________Web Site: __________________________

What is design storm that needs to be considered for quality and quantity requirements: ________

_______________________________________________________________

Are the design requirements different between the local jurisdiction and the Federal/State requirements? (Yes) (No)

Which one dictates? ____________________________________________

Time frame for review: ____________________________________________

Are there separate Grading Permit requirements for the Local jurisdiction? (Yes) (No)

Are stormceptor type BMP's allowed?________________________________________

Do you require infiltration? (Yes) (No)

Are there infiltration testing requirements (Yes) (No)

What is required TSS removal? ____________________________________________

Any Groundwater Recharge required or allowed? (Yes) (No)

Do we need special soils investigation for development of the SWPPP? ____________________

**ADDITIONAL NOTES:**

_______________________________________________________________

_______________________________________________________________

**H. Storm Water Pollution Prevention Plan (SWPPP):**
Who is review agency for SWPPP? ______________________________

How does the Design Engineer Obtain information on the SWPPP Criteria? ______________

______________________________________________________________

Web Site: ______________________________________________________

What type of SWPPPs are required? Preconstruction: (Yes) (No) Construction: (Yes) (No)
Post Const: Yes) (No)

Do you have approved BMPs that the designer can consider? (Yes) (No). ______________
Do you allow infiltration? (Yes) (No)

Do we need special soils investigation for development of the SWPPP? ______________

**ADDITIONAL NOTES:**

______________________________________________________________

______________________________________________________________

**I. STREET AND HIGHWAY**

**1. State Highway Department:** Location: ______________________________

______________________________ Web Site: ______________

**2. City Standard Specifications**: Location: ______________________________

______________________________ Web Site: ______________

**3. Street & Highway Work**: Are improvements planned in the near future? (Yes) (No)

When? ______________________________________________________

Where? ______________________________________________________

What is Planned? ______________________________________________

Are there drawings and specifications for the planned improvements? (Yes) (No) ____________

Is present road system at capacity? (Yes) (No) Is a traffic study available for area? (Yes) (No)

Is the document available for the design engineer to use? (Yes) (No) ______________
Is a new study required? (Yes) (No)

Will acel/decel lanes be required? (Yes) (No)
Will intersection signalization be required? (Yes) (No)

What type of curbs are in area? Curb: (Vertical) (Roll-over) (Other:________________________)

What type of pavement is used in the area? (Asphalt) (Concrete)
(City/State Standard Mix________________)

Who will pay for the improvements on the public right-of-ways?_____________________________

**ADDITIONAL NOTES:**

______________________________________________________________________

______________________________________________________________________

**J. FIRE DEPARTMENT INFORMATION**

**1. Closest Fire Station: Location:** ____________________________________________

____________________________________________Web Site: ___________________

**2. Fire Department: Pumper capabilities:** __________GPM
Turning Radius of Truck (Size):_________________________

Weight of Truck: _______________________Does the truck have outriggers? (Yes) (No) ______

**ADDITIONAL NOTES:**

______________________________________________________________________

______________________________________________________________________

**K. LANDSCAPING & GENERAL INFORMATION**

1. List of Plants and Grasses: Does City/State have approved list of Plants & Grasses? (Yes) (No) ____________________________________________Web Site: ___________________

2. Climate in area: What is summer temperature?_________________________________

   What is winter temperature?_______________________________________________

   Frost Depth? ____________________________________________________________

   If snow events occur, how much snow is typical per storm?_______________________

   What is total for year?_____________________________________________________

**3.** Rainfall information: What is summer precipitation? __________________________

   What is winter precipitation? ______________________________________________

4. Do we need a permit to plant or seed in Public Right-of-way? (Yes) (No)

Department _______________________________________________ ____________

Name:________________________Telephone #:- ______________________________

**ADDITIONAL NOTES:**

______________________________________________________________________

______________________________________________________________________

**L. CONSTRUCTION RESTRAINTS**

1. Construction Lay down Areas: On the site? (Yes) (No) If no, is there land adjacent? (Yes) (No)
2. Private or Public Owned land? (Private) (Public) What is on the land? ____________________
3. Off-Site: Would the City/State allow part of the street to be used for lay-down? (Yes) (No)

   Where? _______________________________________ _____________________
   What type of permit is required?_________________________________________

ADDITIONAL NOTES:

______________________________________________________________

______________________________________________________________

**M. OTHER INFORMATION PERTINENT TO SITE**

1. Air Quality (Intake or Exhaust): Agency Name:____________Web Site:________________

   Person to Contact: _______________Telephone #:_______Email: __________________
2. Cemetery or Public Lands Adjacent? (YES) (No) Which Direction? ____________________

   Person to Contact: _______________Telephone #:_______Email: __________________
3. Endangered Species: Is there potential for any endangered species on site? (Yes) (No)
   (Type:_________________________________________)
   Agency Name:___________________________________Web Site:________________

   Person to Contact: _______________Telephone #:_______Email: __________________
4. Adjacent Property types: Is there potential for any endangered species on site? (Yes) (No)
   (Type:_________________________________________)

   Agency Name:___________________________________Web Site:________________

Person to Contact: _______________Telephone #:________Email: ______________________

5. Sound Considerations. Is there a sound ordinance/code for this area? (Yes) (No)__________

   If yes, fill in the following:

   Agency Name:______________________________________Web Site:____________________

   Person to Contact: _______________Telephone #:________Email: ______________________

6. Tree Preservation. Is there a tree preservation ordinance/code for this area? (Yes) (No)_____
   If yes, fill in the following:

   Agency Name:______________________________________Web Site:____________________

   Person to Contact: _______________Telephone #:________Email: ______________________

***(NOTE: If any of the above is checked as a YES, in the additional notes area below add the procedure and/or requirements to address the approval process needed for the project.)***

**ADDITIONAL NOTES*:***

_____________________________________________________________________________

_____________________________________________________________________________

**ADDITIONAL NOTES*:***

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**ADDITIONAL NOTES*:***

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**ADDITIONAL NOTES*:***

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# APPENDIX B

# BEST MANAGEMENT PRACTICES

## GREEN ROOFS

Designers will need to work closely with building design professionals to identify applicable criteria, codes, and accepted standards of practice for the design of green roofs. There are generally two classes of green roofs: a) extensive; and b) intensive.

- Extensive green roofs generally have only a few inches of growth media and are relatively lightweight in structure. They are designed to be low-maintenance and are not designed for public access. Vegetation is typically limited to various species of sedums or other similar arid plants.

- Intensive green roofs are designed to be used by the public or building inhabitants as a park or relaxation area. Intensive green roofs typically require more growth media, greater than six inches in depth, adding a significant additional weight loading to the building. This requires greater capital and maintenance investments than extensive green roofs.

Green roofs can be constructed layer by layer, or can be purchased as a system. Several vendors offer modular trays containing the green roof components. Green roofs provide several benefits over conventional roofing, including:

- Reduction of stormwater runoff from buildings through absorption, storage and evapotranspiration. This reduces overall peak flow discharge to a storm sewer system and can result in less in-stream scouring, lower water temperatures and better water quality;
- Reduction of urban heat island effects with increased building thermal insulation and energy efficiency;
- Increased roof durability and lifespan.

### DESIGN CONSIDERATIONS

- Green roofs can add significant weight load to a building. A structural engineer should be consulted to ensure the building can support the added weight at maximum water capacity or fully saturated conditions.
- On high pitched roofs, incorporate special design features, such as structural anti-shear protection, to prevent slumping and ensure plant survival.

### MAINTENANCE REQUIREMENTS

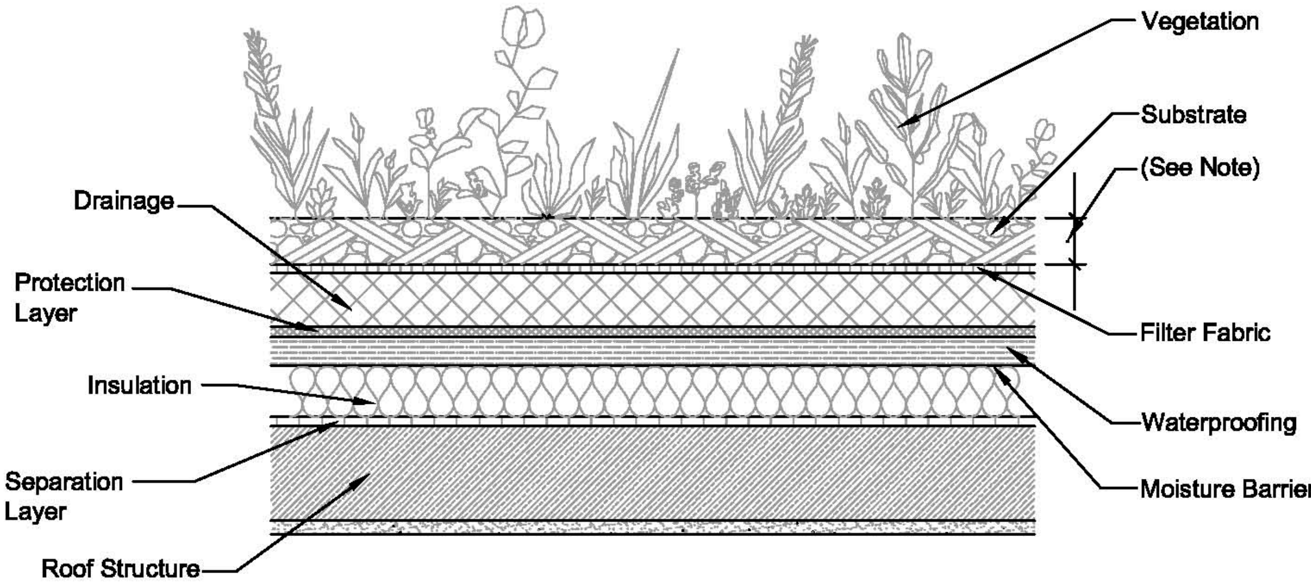
- Immediately after construction, inspect green roofs regularly until the vegetation has established. Water as needed to establish vegetation.
- After vegetation has established, inspect and fertilize extensive green roofs at least annually. Replace dead vegetation as needed.
- Weed green roofs as needed.
- Water extensive green roofs as needed during exceptionally dry periods.
- Maintain intensive green roofs as any other landscaped area. This will involve mulching, weeding, irrigation and the replacement of dead vegetation.

### DESIGN REFERENCES

- EPA (2006a)

## GREEN ROOFS

**PROFILE**




NOTE: Substrate thickness varies depending on intensive or extensive use.

## STORMWATER PONDS

The following are examples of Stormwater Ponds:

- Micropool Extended Detention Pond
- Wet Pond
- Wet Extended Detention Pond
- Multiple Pond System
- Pocket Pond

General Requirements Applicable to All Stormwater Ponds:

- Design must include a hydrologic budget to show sufficient water available to maintain permanent pool depth
- A qualified professional must develop a planting plan
- Inlet and outlet should be located as far apart as possible
- Provide a manually controlled drain, if elevations allow, to dewater pond over 24-hour period
- Provide energy dissipation at inlet and outlet for scour prevention
- Provide small trash racks for outlets ≤ 6 inches in diameter or weirs ≤ 6 inches wide
- Additional requirements as listed in Design Criteria for each illustrated BMP

## MICROPOOL EXTENDED DETENTION POND

An extended detention pond with a micropool temporarily stores and releases the Water Quality Volume (WQV) over an extended drawdown time. The micropool is typically provided near the outlet, to enhance pollutant removal and to help prevent re-suspension of captured sediments. Except for the micropool, the basin is designed to be dry between storms, once the WQV has been discharged. The basin provides pollutant removal by settling of sediments and associated pollutants.

### DESIGN CONSIDERATIONS

- Use may be limited by depth to groundwater or bedrock
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- May have a greater risk of sediment re-suspension than do wet ponds, wet extended detention ponds or stormwater wetlands
- May not remove soluble pollutants as effectively as wet ponds, extended detention wet ponds or stormwater wetlands

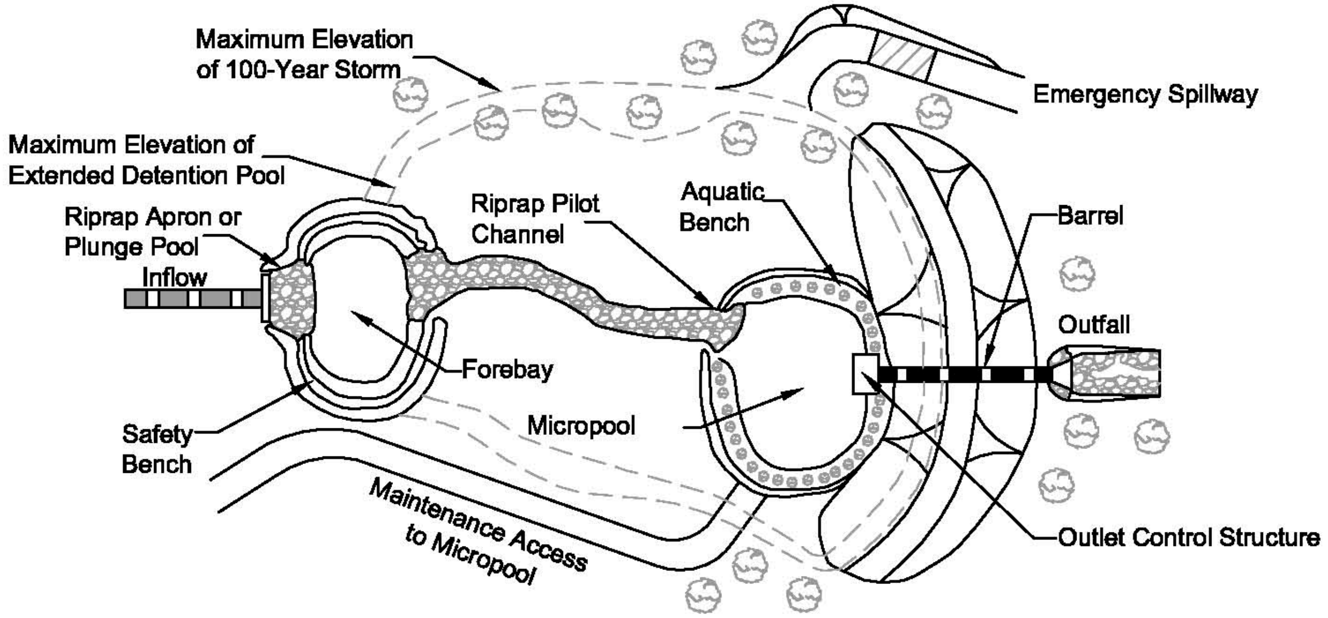
### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from fill embankments
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

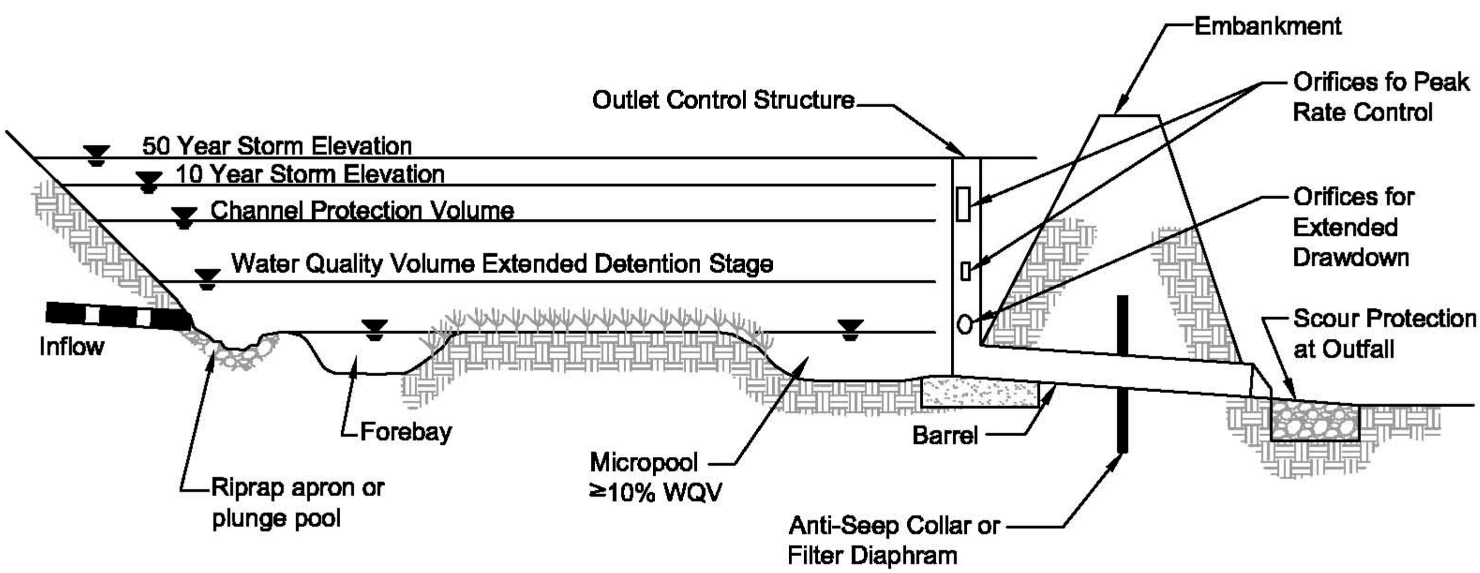
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Micropool + Extended Detention Volume | ≥ WQV |
| Permanent Pool Depth | Average depth of 3 to 6 feet; no greater than 8 feet |
| Extended Detention Drawdown | 24-hour minimum<br>Size extended detention volume outlet to discharge at maximum flow rate as follows:<br>$Q_{max} \leq 2 * Q_{avg}$; $Q_{avg}$ = EDV/24 hours |
| Length to Width Ratio | 3:1 minimum |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Micropool Volume | Approximately 10% of WQV |
| Micropool Area | Approximately 5% of surface area of WQV pool |

## MICROPOOL EXTENDED DETENTION POND

**PLAN VIEW**




**PROFILE**



## WET POND

Wet ponds are designed to maintain a permanent pool of water throughout the year. The pool, located below the outlet invert, allows for pollutant removal through settling and biological uptake or decomposition.

Wet ponds, if properly sized and maintained, can achieve high rates of removal for a number of urban pollutants, including sediment and its associated pollutants: trace metals, hydrocarbons, BOD, nutrients and pesticides. They also provide some treatment of dissolved nutrients through biological processes within the pond.

Where the temperature of receiving waters is a concern, the addition of an underdrained gravel trench in the bench area around the permanent pool allows for slow, extended release of stormwater, which minimizes the risk of the outlet structure clogging and provides effective cooling to avoid thermal impacts to receiving waters.

### DESIGN CONSIDERATIONS

- Use may be limited by depth to groundwater
- Use may be limited by depth to bedrock
- Use may be limited by soils permeability or groundwater levels, or require special design measures to control exfiltration of retained water or inflow of groundwater
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- Safety issues must be addressed relative to establishing a permanent pool

### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from fill embankments
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

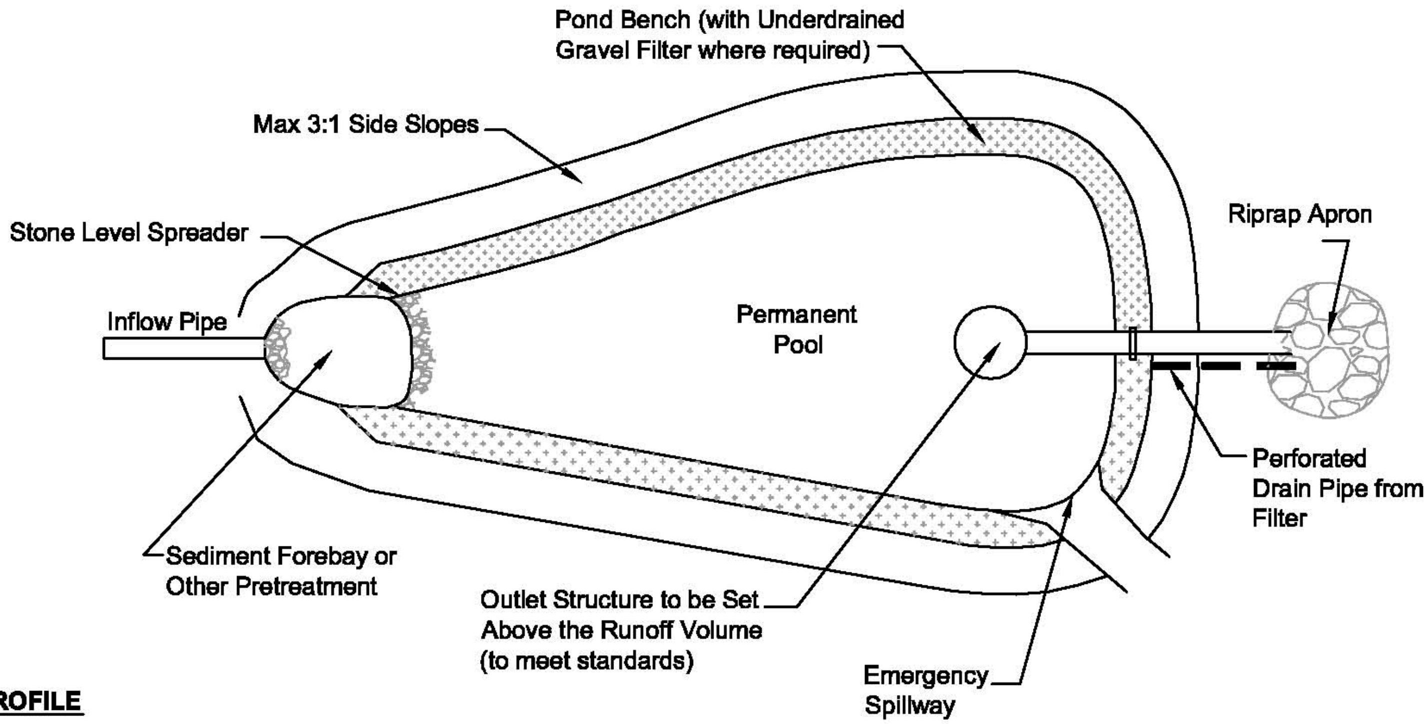
### DESIGN REFERENCES

- EPA (1999f)

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Permanent Pool Volume | 2-4 times the WQV, recommended for enhancing pollutant removal effectiveness |
| Permanent Pool Depth | Average depth of 3 to 6 feet; no greater than 8 feet |
| Length to Width Ratio | 3:1 minimum |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Recommended Drainage Area | At least 10 acres unless groundwater conditions will sustain permanent pool |
| Safety Bench | Recommended, > 10 feet width |

## WET POND

**PLAN VIEW**

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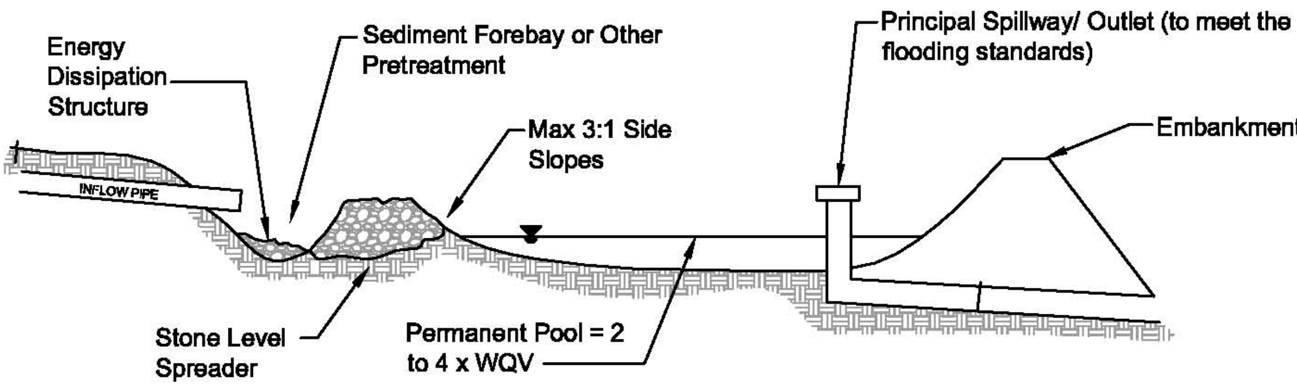


## WET EXTENDED DETENTION PONDS

Wet extended detention ponds combine the features of wet ponds and extended detention ponds. The combined permanent pool and extended detention volume can be used to treat the Water Quality Volume and meet Channel Protection requirements.

### DESIGN CONSIDERATIONS

- Use may be limited by depth to bedrock
- Use may be limited by soils permeability or groundwater levels, or require special design measures to control exfiltration of retained water or inflow of groundwater
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- Safety issues must be addressed relative to establishing a permanent pool

### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from fill embankments
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

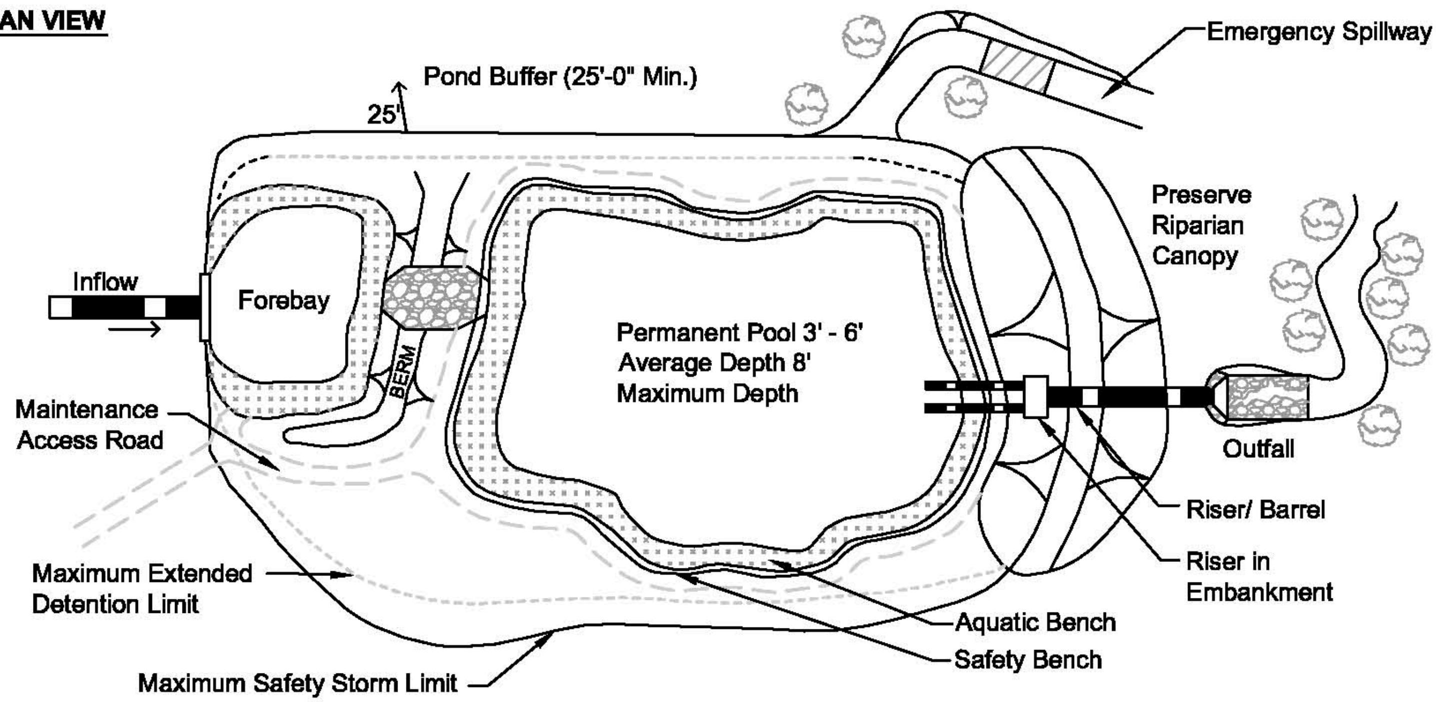
### DESIGN REFERENCES

- EPA (1999f)

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Combined Volume, Permanent Pool and Extended Detention | ≥ WQV |
| Permanent Pool Depth | ≥ 50% of WQV |
| Length to Width Ratio | 3:1 minimum |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Recommended Drainage Area | At least 10 acres unless groundwater conditions will sustain permanent pool |
| Safety Bench | Recommended, > 10 feet width |

## WET EXTENDED DETENTION PONDS

**PLAN VIEW**

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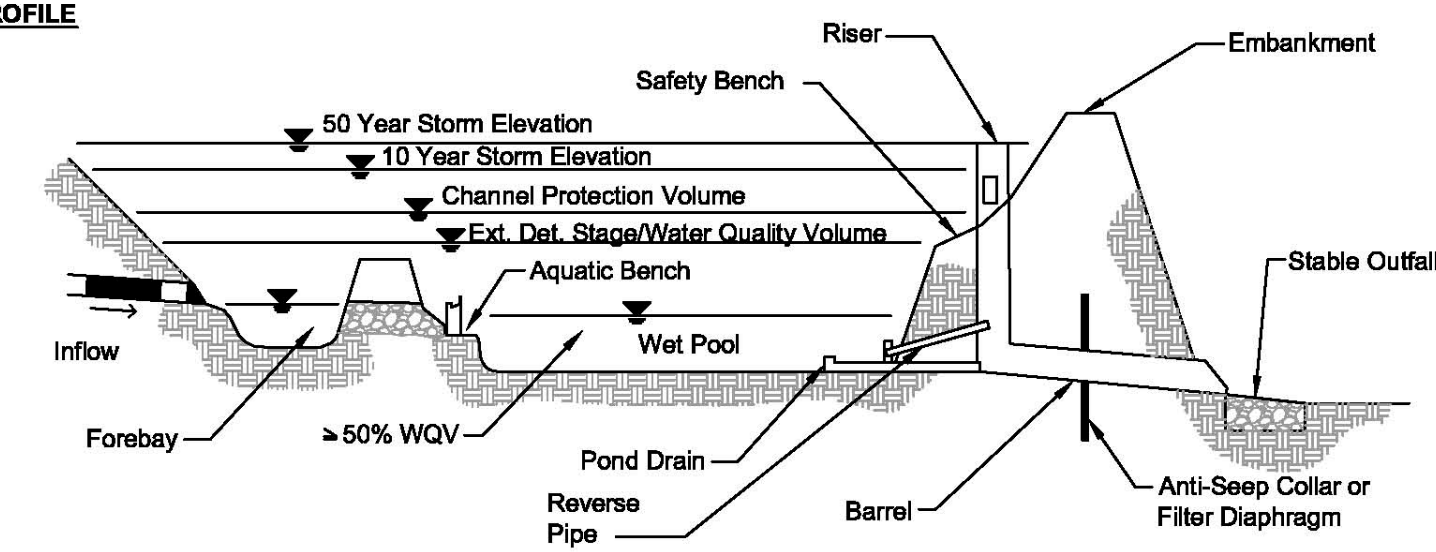


## MULTIPLE POND SYSTEM

The multiple pond system is similar to the wet pond, except that the total treatment volume is distributed over two or more pond “cells,” rather than a single pond. This type of design can be useful for adapting the component ponds to fit a particular site layout, provide for a more aesthetic design, or address changes in elevation on a sloping site.

### DESIGN CONSIDERATIONS

- Use may be limited by depth to bedrock
- Use may be limited by soils permeability or groundwater levels, or require special design measures to control exfiltration of retained water or inflow of groundwater
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- Safety issues must be addressed relative to establishing a permanent pool

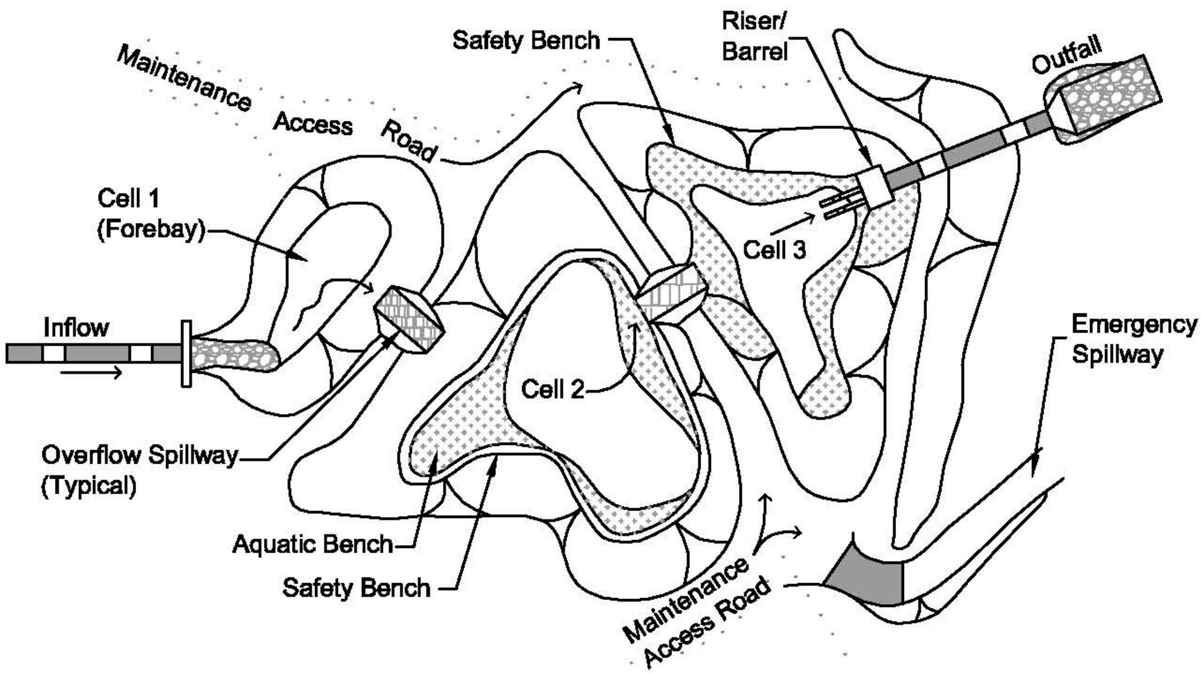
### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from fill embankments
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Permanent Pool Volume | Combined volume of pond cells 2 and 3 ≥ WQV |
| Permanent Pool Depth | Average depth of 3 to 6 feet; no greater than 8 feet |
| Length to Width Ratio | 3:1 minimum, applicable to each pond cell |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Recommended Drainage Area | At least 10 acres unless groundwater conditions will sustain permanent pool |
| Safety Bench | Recommended, > 10 feet width |

## MULTIPLE POND SYSTEM

**PLAN VIEW**

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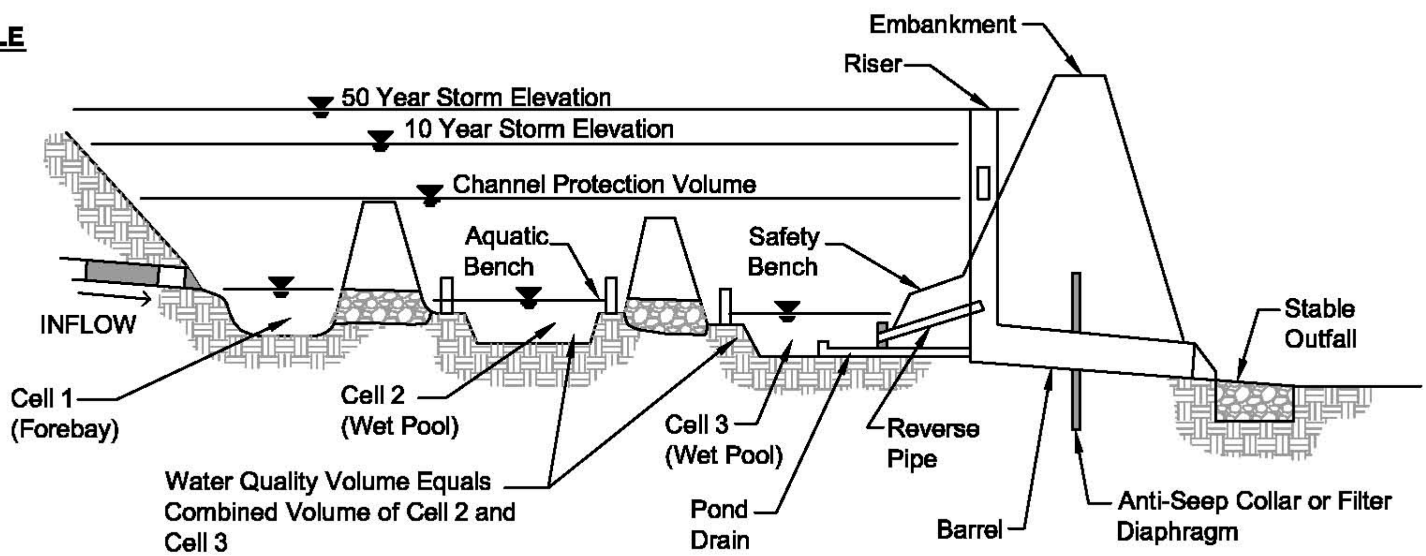


## POCKET POND

The pocket pond is a wet pond or wet extended detention pond designed to serve a small contributing area. While similar to other wet ponds and wet extended detention ponds in design, the water budget for this pond will likely depend on the presence of groundwater, because the smaller contributing watershed would not sustain a permanent pool. This manual considers a "wet swale" type of water quality swale to be a "pocket pond."

### DESIGN CONSIDERATIONS

- Use may be limited by depth to bedrock
- Use may be limited by soils permeability or groundwater levels, or require special design measures to control exfiltration of retained water or inflow of groundwater
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- Safety issues must be addressed relative to establishing a permanent pool

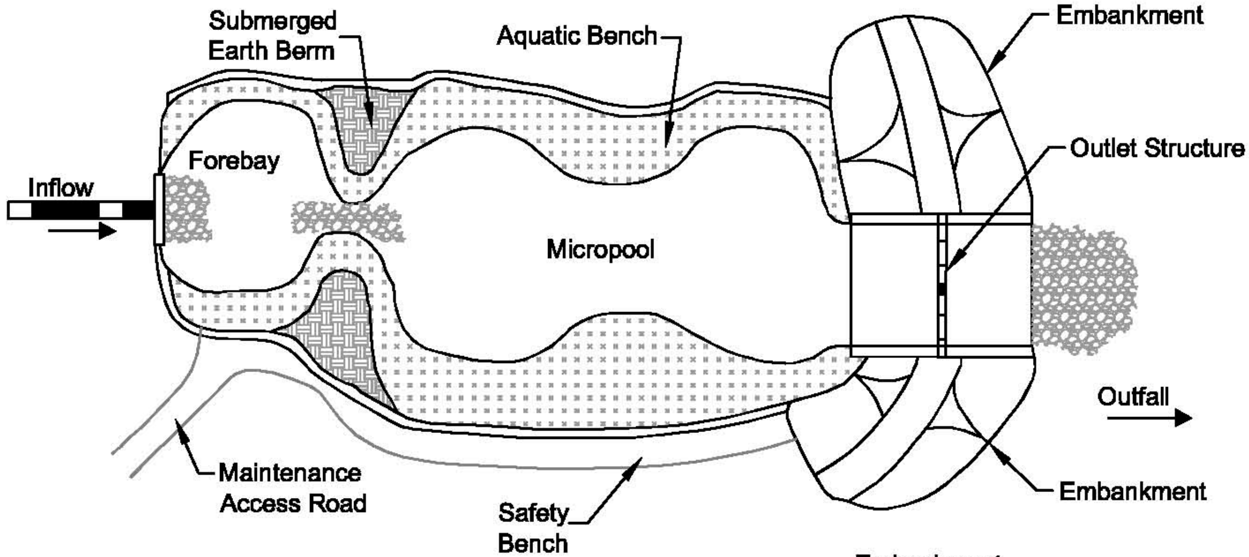
### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from fill embankments
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Combined Volume, Permanent Pool and Extended Detention | ≥ WQV |
| Permanent Pool Volume | ≥ 50% of WQV |
| Permanent Pool Depth | Average depth of 3 to 6 feet; no greater than 8 feet |
| Length to Width Ratio | 3:1 minimum |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Groundwater Depth | Groundwater conditions shall be presented to support maintenance of a micropool |
| Safety Bench | Recommended, > 10 feet width |

## POCKET POND

**PLAN VIEW**

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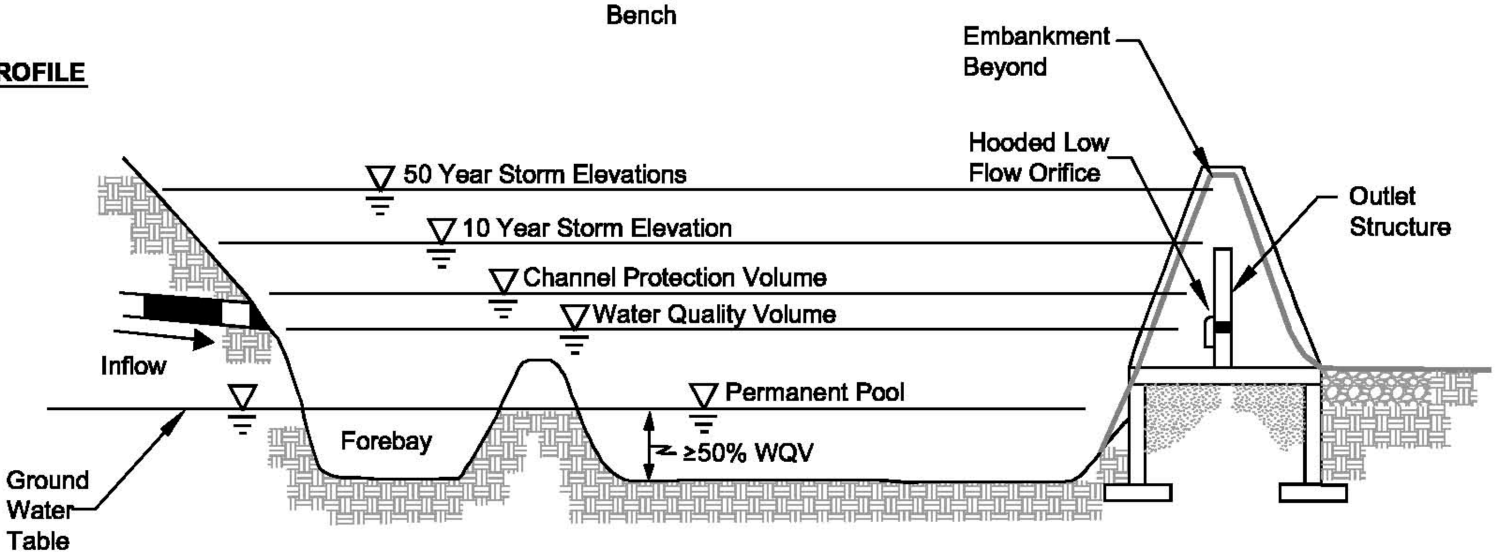


## EXTENDED DURATION DETENTION PONDS

Dry extended duration detention ponds otherwise known as dry ponds, extended detention basins, detention ponds, extended detention ponds are basins whose outlets have been designed to detain the stormwater runoff from a water quality design storm for some minimum time, usually 72 hours, to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool. They can also be used to provide flood control by including additional flood detention storage.

## STORMWATER WETLANDS

The following are examples of Stormwater Wetlands:

- Shallow wetlands (including "pocket wetlands")
- Extended detention wetlands
- Pond/wetland systems
- Gravel wetlands

The shallow, extended detention, and pond/wetland systems have a number of similarities, with the basic differences being the relative proportions of open water relative to marsh, and extended detention volume relative to permanent pool. The marsh areas typically include zones with the following depth ranges:

- Deepwater Greater than 18 inch depth, up to the design maximum depth
- Low Marsh 6 inch to 18 inch depth below normal pool
- High Marsh Up to 6 inches depth below normal pool
- Semi-wet Areas above normal pool that are periodically inundated and expected to support wetland vegetation

General Requirements Applicable to Stormwater Wetlands are as follows:

- The wetland perimeter must be curvilinear;
- Design must include a hydrologic budget to show sufficient water available to maintain permanent pool depth;
- A qualified professional must develop a planting plan;
- Inlet and outlet should be located as far apart as possible;
- Provide a manually controlled drain, if elevations allow, to dewater ponds (if included in the design) over 24-hour period;
- Provide energy dissipation at inlet and outlet for scour prevention;
- Provide small trash racks for outlets ≤ 6 inches in diameter or weirs ≤ 6 inches wide;
- Additional requirements as listed in Design Criteria for each illustrated BMP.

| **Recommended Design Criteria for Stormwater Wetlands Designs** | | | | |
|---|---|---|---|---|
| **Design Criteria** | **Shallow Wetland** | **Pond/Wetland** | **ED Wetland** | **Pocket Wetland** |
| Wetland/Watershed Area Ratio | ≥ 2.0% | ≥ 1.0% | ≥ 1.0% | ≥ 1.0% |
| Minimum Drainage Area (acres) | ≥ 25 | ≥ 25 | ≥ 25 | ≥ 25 |
| Length to Width Ratio (minimum) | ≥ 3:1 | ≥ 3:1 | ≥ 3:1 | ≥ 3:1 |
| Extended Detention | No | Option | Yes | Option |
| Percent Allocation of Treatment Volume (pool/marsh/ED) | 30/70/0 | 70/30/0 | ≥ 20/≥ 30/≥ 50/ | 20/80/0 |
| Percent Allocation of Surface Area to Wetland Type | Refer to next Table | | | |
| Cleanout Frequency (years) | 2 to 5 | 10 | 2 to 5 | 10 |
| Outlet Configuration | Reverse-slope pipe or hooded broad crest weir | Reverse-slope pipe or hooded broad crest weir | Reverse-slope pipe or hooded broad crest weir | Hooded broad crest weir |
| Source: Adapted from Schueler (1992) | | | | |

| Recommended Design Criteria for Stormwater Wetlands Designs | | | | |
|---|---|---|---|---|
| **Target Allocations** | **Shallow Wetland** | **Pond/Wetland** | **ED Wetland** | **Pocket Wetland** |
| **% of Surface Area** | | | | |
| Forebay | 5 | 0 | 5 | 5 |
| Micropool | 5 | 5 | 5 | 5 |
| Deepwater | 5 | 40 | 0 | 0 |
| Lo Marsh | 40 | 20 | 40 | 45 |
| Hi Marsh | 40 | 25 | 40 | 40 |
| Semi-wet | 5 | 5 | 10 | 5 |
| **% of Treatment Volume** | | | | |
| Forebay | 10 | 0 | 10 | 10 |
| Micropool | 10 | 10 | 10 | 10 |
| Deepwater | 10 | 60 | -- | 0 |
| Lo Marsh | 45 | 20 | 20 | 55 |
| Hi Marsh | 25 | 10 | 10 | 25 |
| Semi-wet | 0 | 0 | 50 | 0 |
| | | | | |
| Definition of terms:<br>Deepwater - Greater than 18 inch depth, up to the design maximum depth<br>Low Marsh - 6 inch to 8 inch depth below normal pool<br>High Marsh – Up to 6 inches depth below normal pool<br>Semi-wet - Areas above normal pool that area periodically inundated and expected to support<br>. wetland vegetation | | | | |
| Source: Adapted from EPA (1999d) | | | | |

## SHALLOW WETLANDS

Shallow wetlands for stormwater treatment consist of pools ranging from 6” (150 mm) to 18” (450 mm) in depth under normal conditions, with some areas of deepwater pools. They may be configured with a variety of low marsh and high marsh “cells” with sinuous channels to distribute flows to maximize retention time and contact area. Shallow wetland systems are designed with wetland vegetation suitable for these varying depths. The entire Water Quality Volume is provided within the deepwater, low marsh, and high marsh zones.

### DESIGN CONSIDERATIONS

- Requires sufficient contributing area and/or groundwater elevation to maintain permanent pool
- Use may be limited by depth to bedrock
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- May develop mono-culture of invasive plant species over time

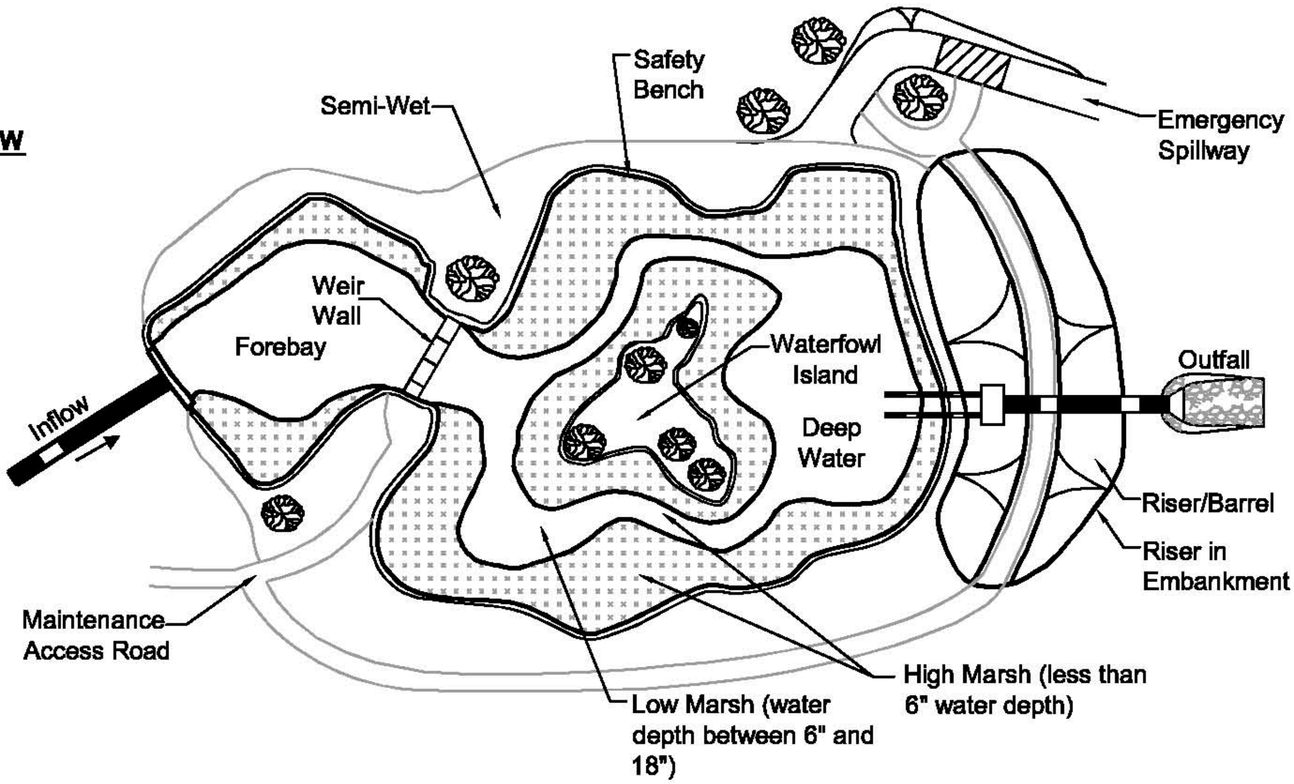
### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from embankments
- Removal of invasive species from semi-wet, marsh, and deepwater areas
- Monitoring and replanting, as warranted, of wetland vegetation
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Permanent Pool Volume | ≥ WQV (combined deep water, low marsh, high marsh) |
| Permanent Pool Depth | ≤ 8 feet |
| Length to Width Ratio | 3:1 minimum, applicable to each pond cell |
| Maximum Temporary Pool Depth | ≤ 4 feet above permanent pool |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Marsh/Deepwater Ratios | See Tables in Stormwater Wetlands section |

## SHALLOW WETLANDS

**PLAN VIEW**

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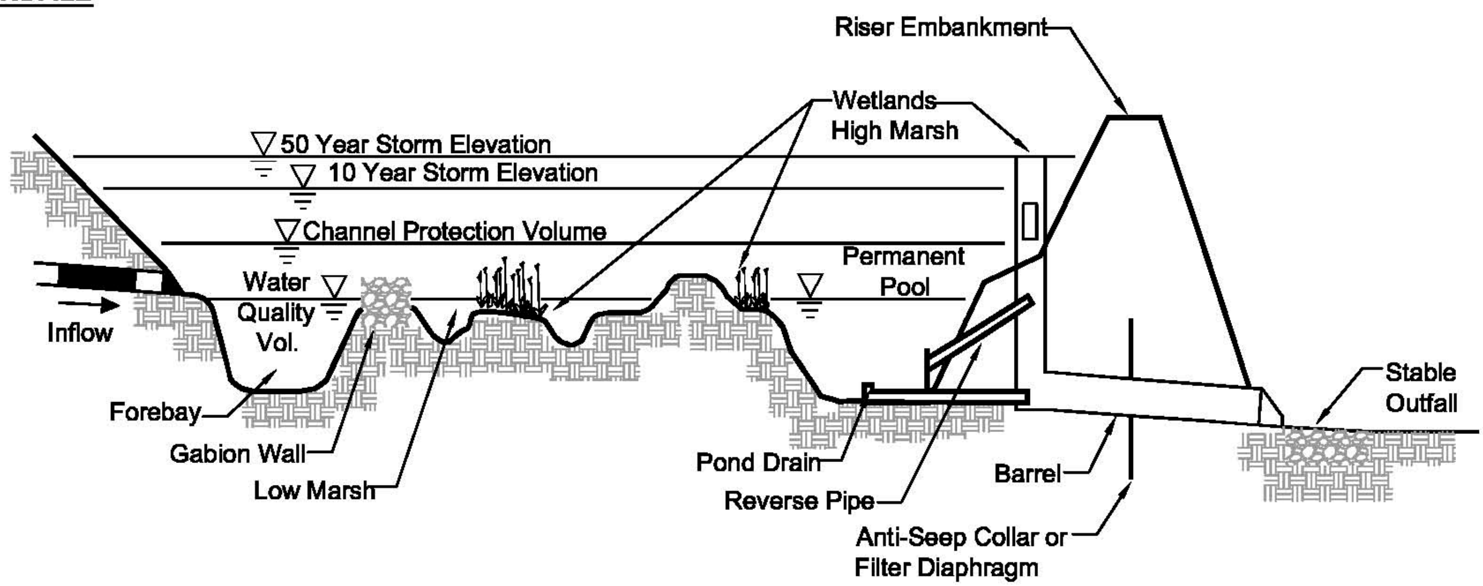


## EXTENDED DETENTION STORMWATER WETLANDS

Extended detention stormwater wetlands typically require less space than shallow wetlands systems, because part of the Water Quality Volume (WQV) is stored above the level of the permanent pool. Deepwater areas tend to be less extensive and semi-wet areas more extensive than those provided for shallow wetlands. Wetland plants that tolerate both intermittent flooding and dry periods must be selected for the area above the permanent marsh.

### DESIGN CONSIDERATIONS

- Requires sufficient contributing area and/or groundwater elevation to maintain permanent pool
- Use may be limited by depth to bedrock
- May increase water temperature, which may affect use in watersheds of cold water fisheries; because of the smaller area of permanent marsh, this effect may be more moderate than for a shallow wetland or pond/wetland system
- May develop mono-culture of invasive plant species over time

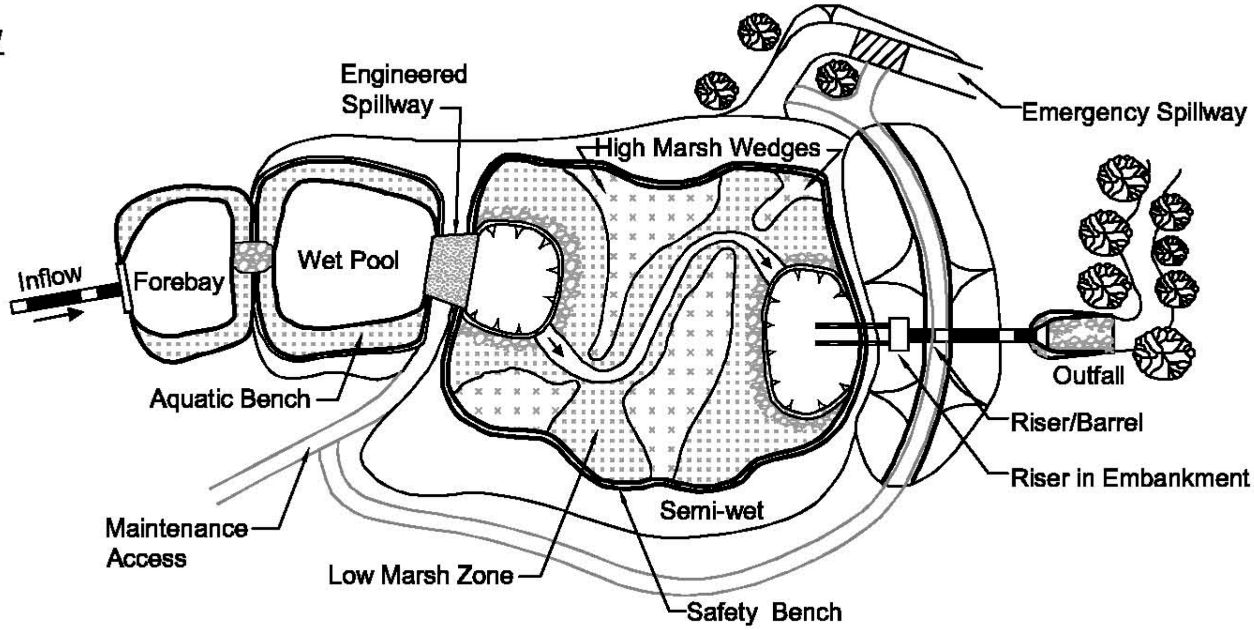
### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from embankments
- Removal of invasive species from semi-wet, marsh, and deepwater areas
- Monitoring and replanting, as warranted, of wetland vegetation
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Permanent Pool + Extended Detention Volume | ≥ WQV (combined deep water, low marsh, high marsh, and extended detention volume) |
| Extended Detention Volume | ≤ 50% of WQV |
| Extended Detention Drawdown | 24-hour minimum |
| Permanent Pool Depth | ≤ 8 feet |
| Length to Width Ratio | 3:1 minimum, applicable to each pond cell |
| Maximum Temporary Pool Depth | ≤ 4 feet above permanent pool |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Marsh/Deepwater Ratios | See Tables in Stormwater Wetlands section |

## EXTENDED DETENTION STORMWATER WETLANDS

**PLAN VIEW**

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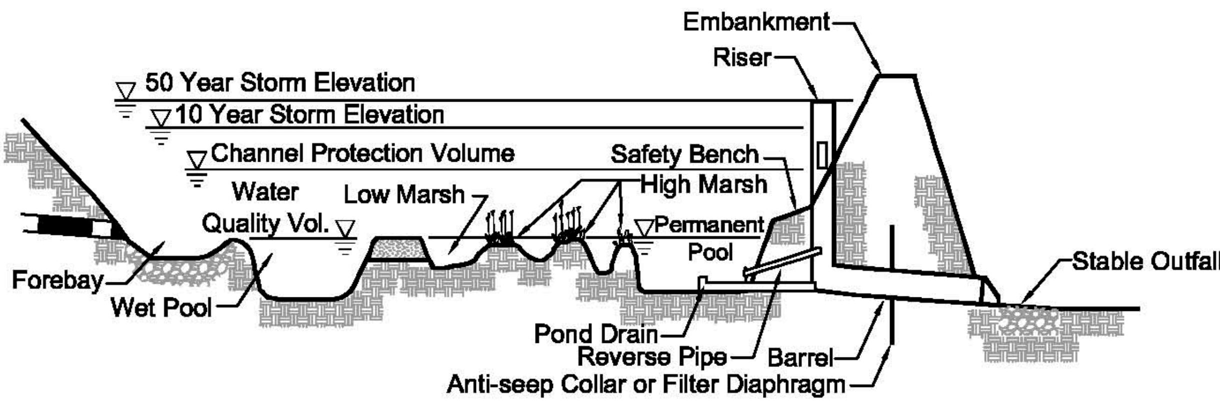


## POND/WETLAND SYSTEM

The wetlands/pond system for stormwater treatment consists of a series of cells using at least one wet pond in combination with shallow marsh wetlands. The first cell typically comprises the wet pond, which provides initial treatment primarily by settling of particles. The wet pond can also reduce the velocity of runoff entering the system. The shallow marsh provides subsequent additional treatment of the runoff, particularly for soluble pollutants through vegetative uptake and the biological activity associated with the wetland vegetation community. With the deeper pool of the wet pond, these systems can typically require less space than the shallow marsh system.

### DESIGN CONSIDERATIONS

- Requires sufficient contributing area and/or groundwater elevation to maintain permanent pool
- Use may be limited by depth to bedrock
- May increase water temperature, which may affect use in watersheds of cold water fisheries
- May develop mono-culture of invasive plant species over time

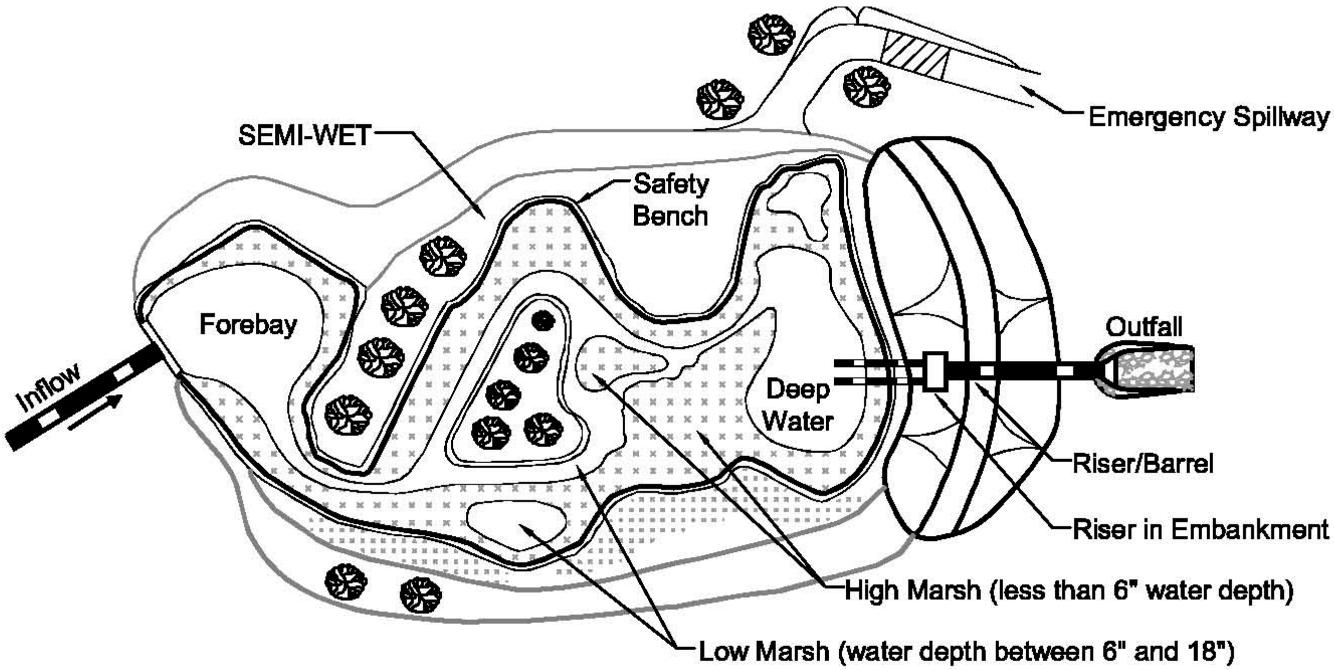
### MAINTENANCE REQUIREMENTS

- Periodic mowing of embankments
- Removal of woody vegetation from embankments
- Removal of invasive species from semi-wet, marsh, and deepwater areas
- Monitoring and replanting, as warranted, of wetland vegetation
- Removal of debris from outlet structures
- Removal of accumulated sediment
- Inspection and repair of embankments, inlet and outlet structures, and appurtenances

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Permanent Pool Volume | ≥ WQV (combined wet pond, micropool (deepwater), low marsh, and high marsh) |
| Extended Detention Volume | ≤ 50% of WQV |
| Permanent Pool Depth | ≤ 8 feet |
| Length to Width Ratio | 3:1 minimum, applicable to each pond cell |
| Maximum Temporary Pool Depth | ≤ 4 feet above permanent pool |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |
| Marsh/Deepwater Ratios | See Tables in Stormwater Wetlands section |

## POND/WETLAND SYSTEM

**PLAN-VIEW**

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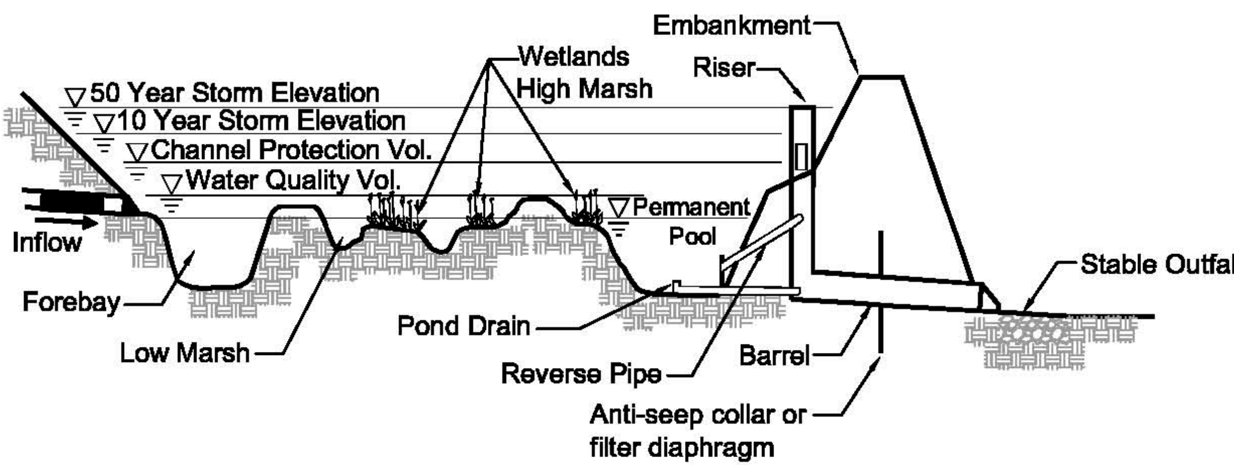


# GRAVEL WETLANDS

The gravel wetland system consists of one or more flow-through constructed wetland cells, preceded by a forebay. The cells are filled with a gravel media, supporting an organic substrate that is planted with wetland vegetation. During low-flow storm events, the system is designed to promote subsurface horizontal flow through the gravel media, allowing contact with the root zone of the wetland vegetation. The gravel and planting media support a community of soil microorganisms. Water quality treatment occurs through microbial, chemical, and physical processes within this media. Treatment may also be enhanced by vegetative uptake.

To accommodate higher flows, the system is designed to permit inundation of the wetland surface, and the system would function similar to other constructed wetland systems. Overflow from the wetland is provided by an outlet structure designed for this “extended detention” condition. Following such an event, remaining water on the surface of the wetland would infiltrate into the gravel media, and flow horizontally through the media as in the low flow condition.

The outlet of the wetland system is designed to keep the media submerged, to provide the hydrology to support the wetland plant community. The gravel media consists of either crushed rock or processed gravel. An organic soil layer is placed on top of this material, and the wetland plants are rooted in the media where they can directly take up pollutants.

The system can be designed to integrate some stormwater storage, and also to provide infiltration. With these features, the practice would not only remove pollutants, but also contribute to the attenuation of peak rates through temporary storage and reduction in runoff volume through infiltration and evapotranspiration. This BMP is particularly suited to areas with limited available space.

## DESIGN CONSIDERATIONS

- The BMP requires sufficient contributing area to maintain saturated conditions and support vegetation.
- Unless used to treat runoff from high load areas, gravel wetlands may intersect the groundwater table.
- The bottom of each treatment cell should be lined with an impermeable liner if located on hydrologic group A and B soils.
- Pretreatment measures are essential to prevent clogging of the gravel media and the pipe manifold system.

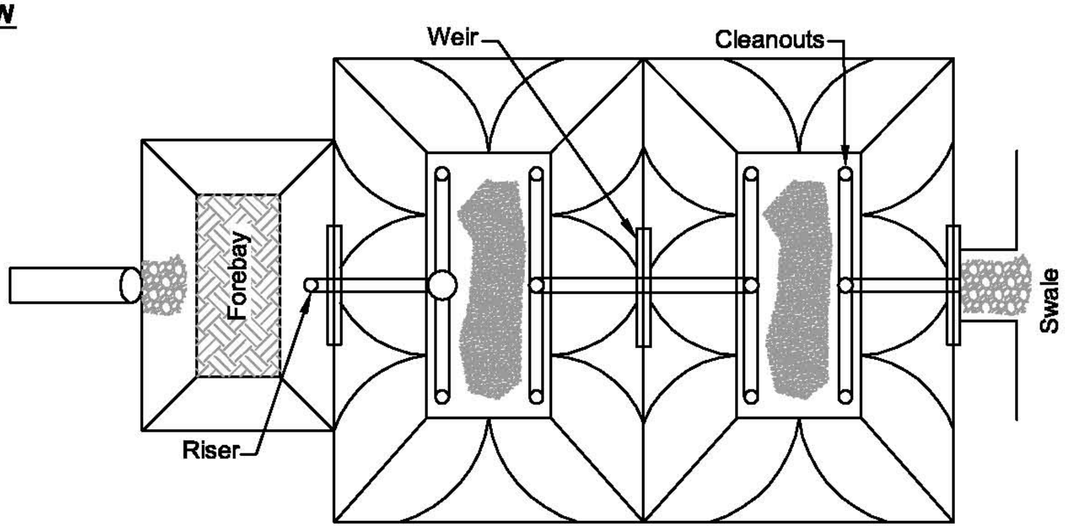
## MAINTENANCE REQUIREMENTS

- Monitoring and replanting, as warranted, of wetland vegetation
- Removal of debris from inlet and outlet structures
- Inspection and removal of sediment accumulation in the gravel bed
- Depending on sediment accumulation, bed may require periodic replacement and replanting
- Inspection and repair of containment structure (if applicable), inlet and outlet structures, and appurtenances

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Sediment Forebay | 10% of WQV; see criteria for Sediment Forebay |
| Maximum Side Slopes | 3:1 |
| Permanent Pool Volume + Extended Detention Volume | At a minimum; 10% of the WQV in the sediment forebay and 45% of the WQV in each treatment cell |
| Extended Detention Volume | ≤ 50% of WQV |
| Extended Detention Drawdown | 24 to 48 hours |
| Length to Width Ratio | 3:1 minimum, applicable to each pond cell |
| Maximum Temporary Pool Depth | ≤ 4 feet above permanent pool |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping and at least one foot of freeboard shall be provided |
| Embankment Design | See criteria for Detention Basin |

## GRAVEL WETLANDS

**PLAN VIEW**

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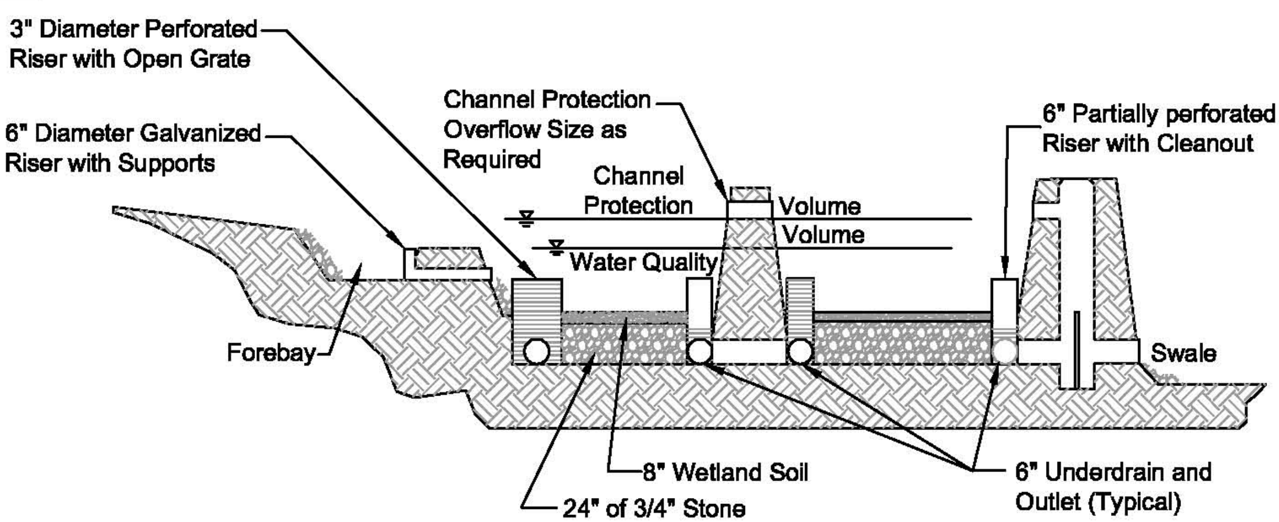


## INFILTRATION PRACTICES

The following are examples of Infiltration Practices:

- Infiltration trenches
- Drip edges
- Infiltration basins
- Dry wells

Note that "permeable pavements," discussed under "Filtering Practices," may also be designed to provide for infiltration.

General Requirements Applicable to Infiltration Practices

- Infiltration is prohibited as follows:
  - Into groundwater protection areas where the stormwater is from a high-load area
  - Into areas where contaminants occur in groundwater above ambient standards
  - Into areas where contaminants occur in soil above site-specific standards
  - Into areas where the soils have infiltration rates < 0.5 inches per hour
  - Into areas where the infiltration rate is too rapid to provide treatment, unless treatment is either not necessary or has already been provided. Note, however, soils may be amended to reduce infiltration rate.
  - Into areas with slopes > 15%, unless calculations show that seepage will not cause slope instability.
  - From areas with soil contaminants above site-specific standards
  - From areas with underground and aboveground storage tanks
- Pretreatment must be provided if the infiltration BMP will receive stormwater other than roof runoff.
- Design infiltration rates
- BMPs used to meet stormwater treatment or groundwater recharge objectives should be sized without depending on infiltration that occurs during the design event (static sizing method). However, BMPs used for channel protection or peak flow control may be sized accounting for infiltration during the design event (dynamic sizing method).

## INFILTRATION TRENCH

An infiltration trench is a stone-filled excavation used to temporarily store runoff and allow it to infiltrate into surrounding, natural soil. Typically, runoff enters the trench as overland flow after pretreatment through a filter strip or vegetated buffer. An infiltration trench is suitable for treating runoff from small drainage areas (less than 10 acres). Installations around the perimeter of parking lots, and along roads are most common. Infiltration trenches can also be incorporated along the center of a vegetated swale to increase its infiltration ability.

An infiltration drip edge is constructed similar to an infiltration trench, except that a drip edge intercepts only roof runoff, and does not require pretreatment.

### DESIGN CONSIDERATIONS

- Pretreatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent infiltration BMPs.
  - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
  - After the basin is excavated to the final design elevation, the floor should be deeply tilled with a rotary tiller or disc harrow to restore infiltration rates, followed by a pass with a leveling drag.
  - Do not place infiltration systems into service until the contributing areas have been fully stabilized.
- For any fill required for system construction, use clean, washed, well-sorted aggregate for infiltration media; the porosity of material provided for construction should be verified against the porosity specified by design.
- Drip edges are not recommended adjacent to buildings with foundation drains, as the intercepted runoff may adversely affect performance of the foundation drainage system. Also, if there is a foundation sub-drain beneath the drip edge trench, the sub-drain will likely prevent infiltration from occurring, by intercepting the flow and conveying it to discharge along with other foundation drainage.
- For more guidance on installing monitoring wells, see: Sprecher, S.W. 2008. Installing monitoring wells in soils (Version 1.0). National Soil Survey Center, NRCS, USDA, Lincoln, NE.

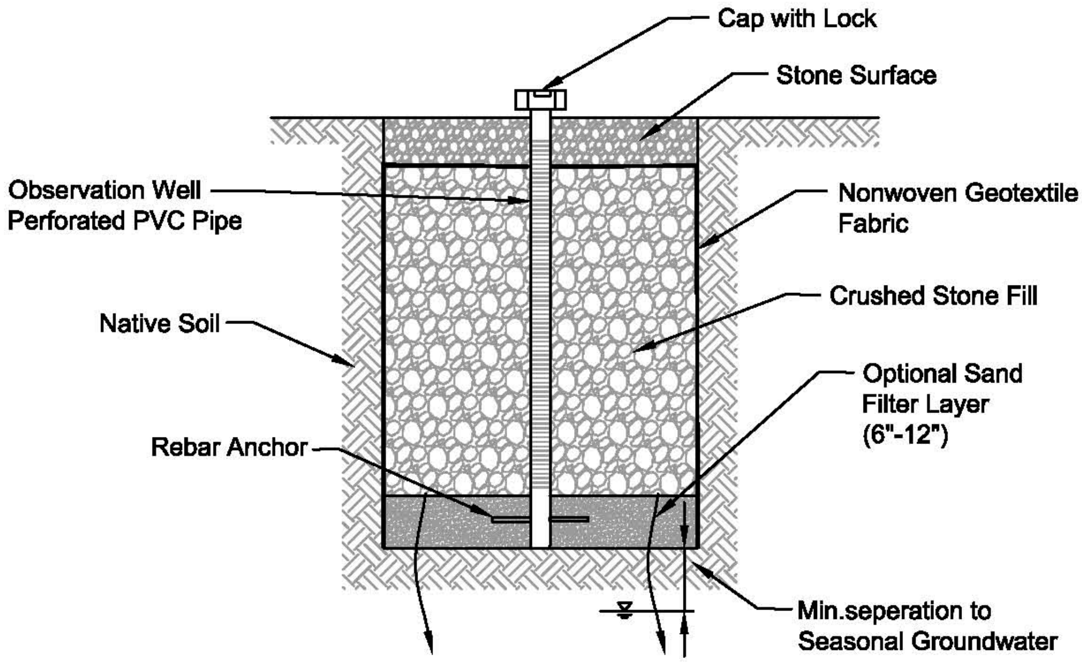
### MAINTENANCE REQUIREMENTS

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5" (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pretreatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- If an infiltration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

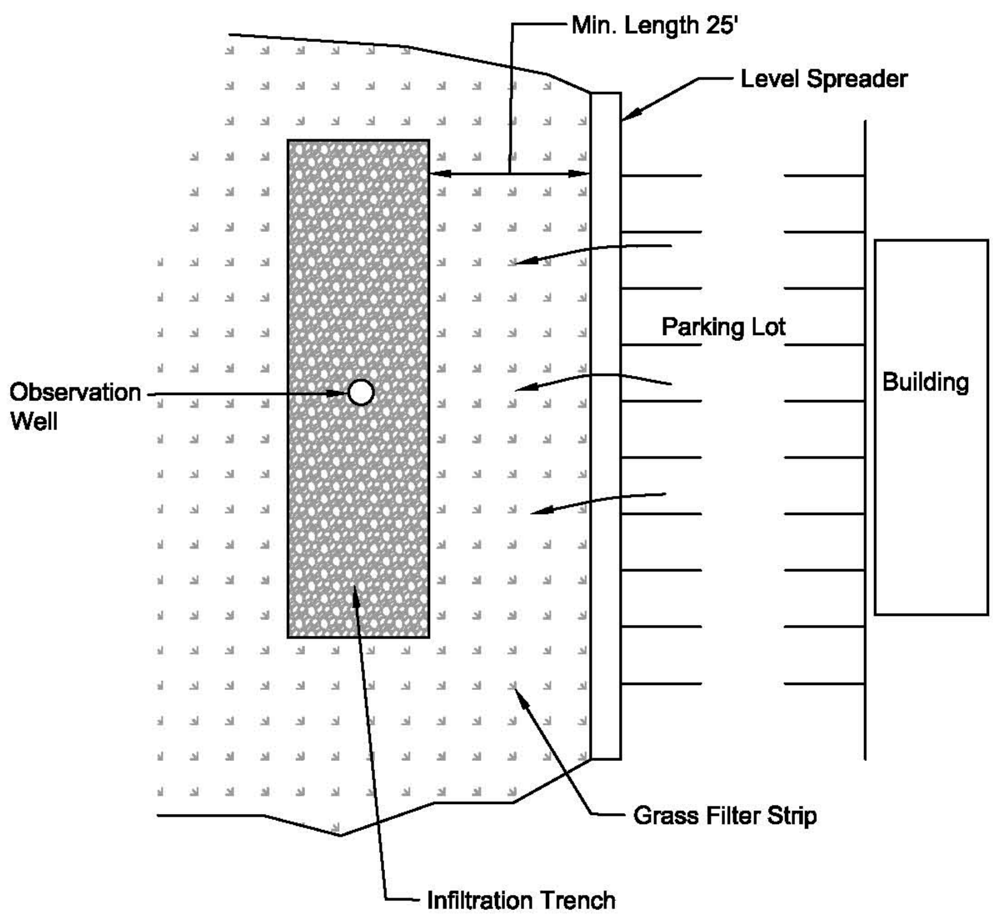
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Pretreatment | Required (See Pre-treatment section in this manual) |
| BMP Volume | ≥ the larger of WQV or GRV, depending on purpose of BMP excluding sediment forebay capacity, if present, and exclude infiltration occurring during the design event |
| Minimum trench depth | 4 feet |
| Maximum trench depth | 10 feet |
| Design Infiltration Rate | Obtain from infiltration tests |
| Drain Time | < 72 hours for complete drainage of the water quality volume |
| Depth to Bedrock and Seasonal High Water Table Elevation | ≥ 3 feet from bottom of BMP, except:<br>≥ 4 feet if within groundwater or water supply intake protection area<br>≥ 1 foot if runoff has been treated prior to entering BMP |
| Overflow Discharge Capacity | 10-year, 24-hour storm |
| Infiltration Media Material | Clean, washed, uniform (well-sorted) aggregate<br>Diameter 1.5 to 3 inches<br>Porosity = 40% |

## INFILTRATION TRENCH

**SECTION**




**PLAN VIEW**



## IN-GROUND INFILTRATION BASIN

Infiltration basins are impoundments designed to temporarily store runoff, allowing all or a portion of the water to infiltrate into the ground. An infiltration basin is designed to completely drain between storm events. An infiltration basin is specifically designed to retain and infiltrate the entire Water Quality Volume. Some infiltration basins may infiltrate additional volumes during larger storm events, but many will be designed to release stormwater exceeding the water quality volume from the larger storms. In a properly sited and designed infiltration basin, water quality treatment is provided by runoff pollutants binding to soil particles beneath the basin as water percolates into the subsurface. Biological and chemical processes occurring in the soil also contribute to the breakdown of pollutants. Infiltrated water is used by plants to support growth or it is recharged to the underlying groundwater.

As with all impoundment BMPs, surface infiltration basins should be designed with an outlet structure to pass peak flows during a range of storm events, as well as with an emergency spillway to pass peak flows around the embankment during extreme storm events that exceed the combined infiltration capacity and outlet structure capacity of the facility.

### DESIGN CONSIDERATIONS

- Pretreatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent infiltration BMPs.
  - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
  - After the basin is excavated to the final design elevation, the floor should be deeply tilled with a rotary tiller or disc harrow to restore infiltration rates, followed by a pass with a leveling drag.
  - Vegetation should be established immediately.
  - Do not place infiltration systems into service until the contributing areas have been fully stabilized.

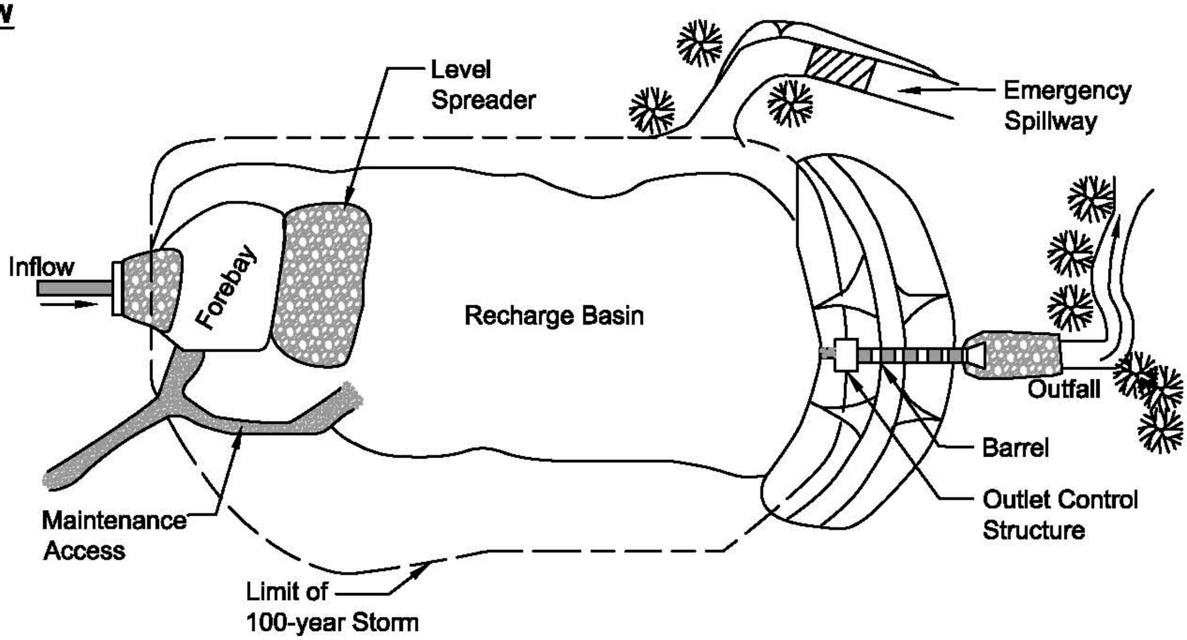
### MAINTENANCE REQUIREMENTS

- Removal of debris from inlet and outlet structures
- Removal of accumulated sediment
- Inspection and repair of outlet structures and appurtenances
- Inspection of infiltration components at least twice annually, and following any rainfall event exceeding 2.5” (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Inspection of pretreatment measures at least twice annually, and removal of accumulated sediment as warranted by inspection, but no less than once annually.
- Periodic mowing of embankments
- Removal of woody vegetation from embankments
- Inspection and repair of embankments and spillways
- If an infiltration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

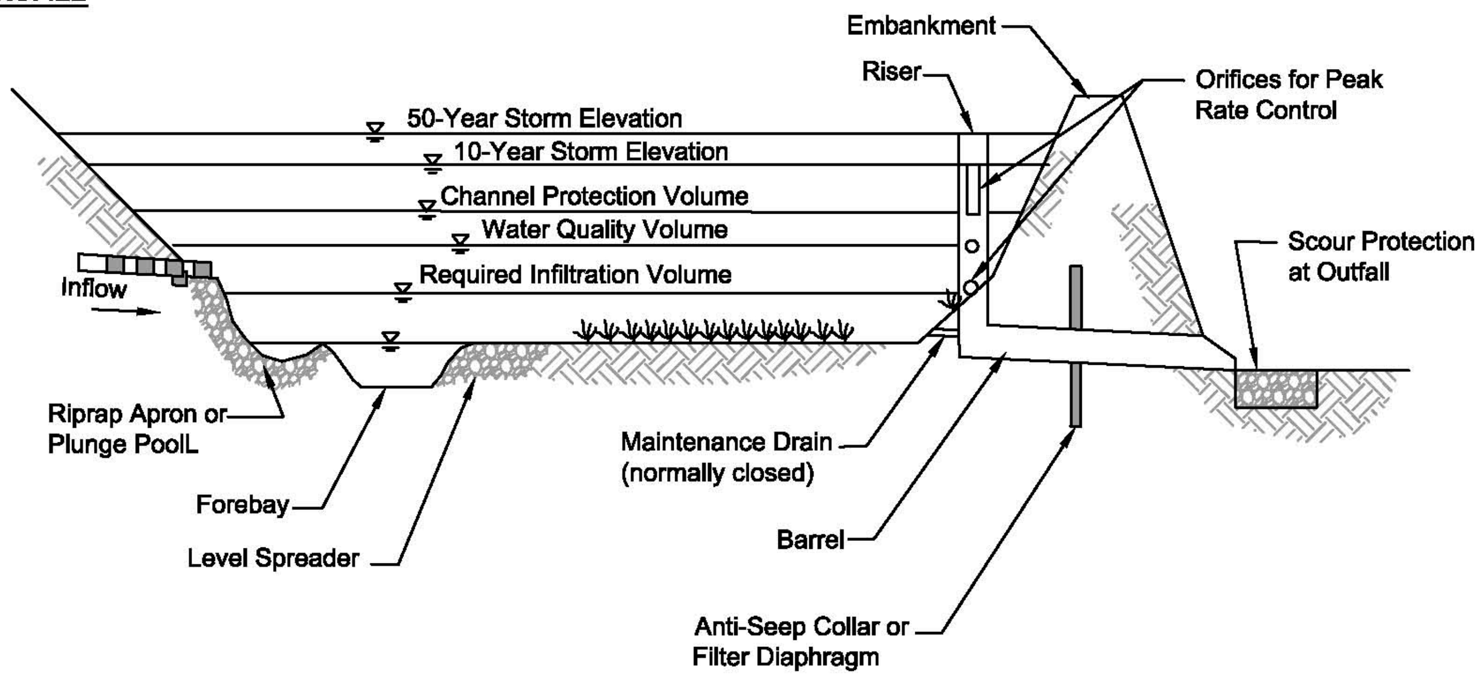
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Pretreatment | Required (See Pre-treatment section in this manual) |
| BMP Volume | ≥ the larger of WQV or GRV, depending on purpose of BMP excluding sediment forebay capacity, if present, and exclude infiltration occurring during the design event |
| Layout | The pond perimeter shall be curvilinear |
| Minimum side slopes | 3:1 |
| Maximum side slopes | 20:1 |
| Slope of Basin Floor | 0% (flat) |
| Design Infiltration Rate | Obtain from infiltration tests |
| Depth to Bedrock and Seasonal High Water Table Elevation | ≥ 3 feet from bottom of BMP, except:<br>≥ 4 feet if within groundwater or water supply intake protection area<br>≥ 1 foot if runoff has been treated prior to entering BMP |
| Basin Floor Preparation | 6” layer of coarse sand or 3/8” pea gravel;<br>Grass turf that can be inundated for 72+ hours; or<br>Coarse organic material such as erosion control mix or composted mulch that is tilled into the soil soaked, and allowed to dry. |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping |

## IN-GROUND INFILTRATION BASIN

**PLAN VIEW**




**PROFILE**



## UNDERGROUND (SUBSURFACE) INFILTRATION BASIN

Infiltration basins are structures designed to temporarily store runoff, allowing all or a portion of the water to infiltrate into the ground. The structure is designed to completely drain between storm events. An underground infiltration basin is specifically designed to retain and infiltrate the entire Water Quality Volume. Some infiltration basins may infiltrate additional volumes during larger storm events, but many will be designed to release stormwater exceeding the water quality volume from the larger storms. In a properly sited and designed infiltration basin, water quality treatment is provided by runoff pollutants binding to soil particles beneath the basin as water percolates into the subsurface. Biological and chemical processes occurring in the soil also contribute to the breakdown of pollutants. Infiltrated water is recharged to the underlying groundwater.

Subsurface infiltration basins may comprise a subsurface manifold system with associated crushed stone storage bed, or specially-designed chambers (with or without perforations) bedded in or above crushed stone.

### DESIGN CONSIDERATION

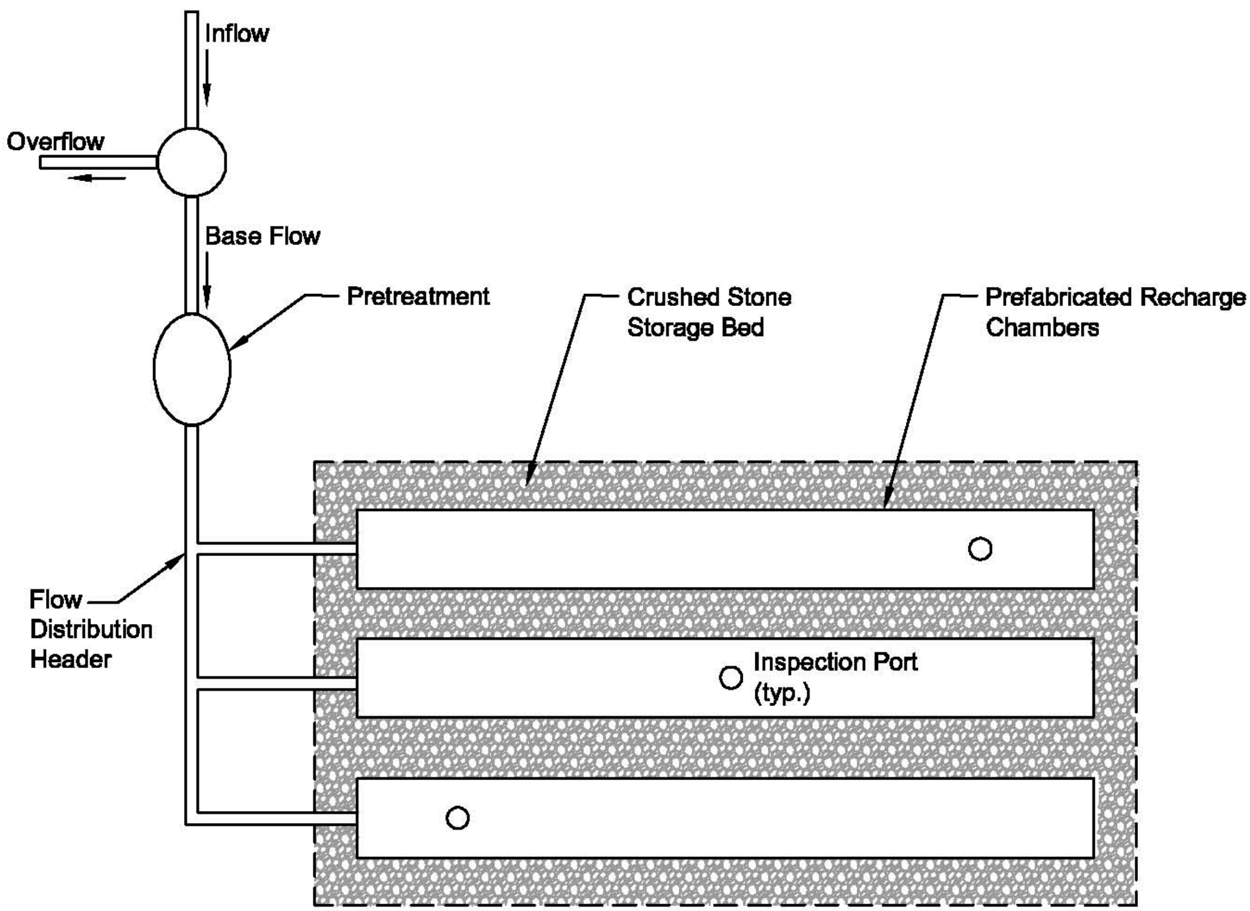
- Pretreatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent infiltration BMPs.
  - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
  - Do not place infiltration systems into service until the contributing areas have been fully stabilized

### MAINTENANCE REQUIREMENTS

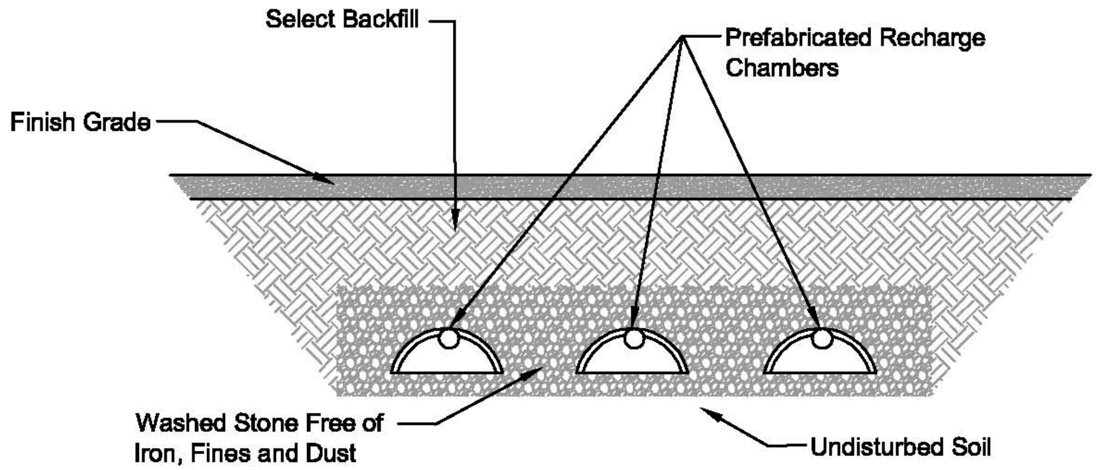
- Removal of debris from inlet and outlet structures
- Removal of accumulated sediment
- Inspection and repair of outlet structures and appurtenances
- Inspection of infiltration components at least twice annually, and following any rainfall event exceeding 2.5” (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Inspection of pretreatment measures at least twice annually, and removal of accumulated sediment as warranted by inspection, but no less than once annually.
- If an infiltration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Pretreatment | Required (See Pre-treatment section in this manual) |
| BMP Volume | ≥ the larger of WQV or GRV, depending on purpose of BMP excluding sediment forebay capacity, if present, and exclude infiltration occurring during the design event |
| Layout | The pond perimeter shall be curvilinear |
| Minimum side slopes | 3:1 |
| Maximum side slopes | 20:1 |
| Slope of Basin Floor | 0% (flat) |
| Design Infiltration Rate | Obtain from infiltration tests |
| Drain Time | < 72 hours for complete drainage of the water quality volume |
| Depth to Bedrock and Seasonal High Water Table Elevation | ≥ 3 feet from bottom of BMP, except:<br>≥ 4 feet if within groundwater or water supply intake protection area<br>≥ 1 foot if runoff has been treated prior to entering BMP |
| Basin Floor Preparation | 6” layer of coarse sand or 3/8” pea gravel;<br>Grass turf that can be inundated for 72+ hours; or<br>Coarse organic material such as erosion control mix or composted mulch that is tilled into the soil soaked, and allowed to dry. |
| Design Discharge Capacity | 50-year, 24-hour storm without overtopping |

**PLAN VIEW**




**PROFILE**



# DRY-WELL AND LEACHING BASIN

**Dry wells** are essentially small subsurface leaching basins. It consists of a small pit filled with stone, or a small structure surrounded by stone, used to temporarily store and infiltrate runoff from a very limited contributing area. Runoff enters the structure through an inflow pipe, inlet grate, or through surface infiltration. The runoff is stored in the structure and/or void spaces in the stone fill. Properly sited and designed dry wells provide treatment of runoff as pollutants become bound to the soils under and adjacent to the well, as the water percolates into the ground. The infiltrated stormwater contributes to recharge of the groundwater table.

Dry wells are well-suited to receive roof runoff via building gutter and downspout systems. When used for roof drainage, pretreatment of runoff is not typically required.

**Leaching basins** are dry wells used in well drained soils for the discharge of roadway or parking area runoff. In this case, pretreatment is required prior to discharge to the leaching basin. A typical arrangement is to use a deep sump, hooded catch basin in combination with a leaching basin.

Dry wells, leaching basins, and similar devices should meet the design criteria applicable to subsurface infiltration basins.

## DESIGN CONSIDERATIONS

- Pretreatment is essential to the long-term function of infiltration systems.
- Preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
    - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent infiltration BMPs.
    - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.
    - Do not place infiltration systems into service until the contributing areas have been fully stabilized.

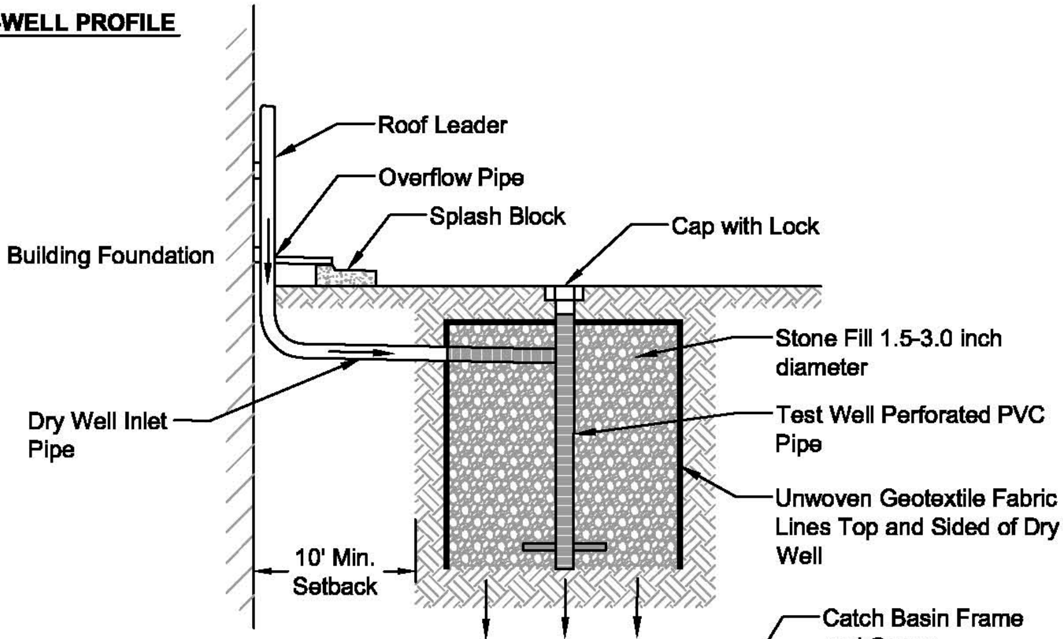
## MAINTENANCE REQUIREMENTS

- Removal of debris from inlet and outlet structures
- Removal of accumulated sediment
- Inspection and repair of outlet structures and appurtenances
- Inspection of infiltration components at least twice annually, and following any rainfall event exceeding 2.5” (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- If an infiltration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore infiltration function, including but not limited to removal of accumulated sediments or reconstruction of the infiltration trench.

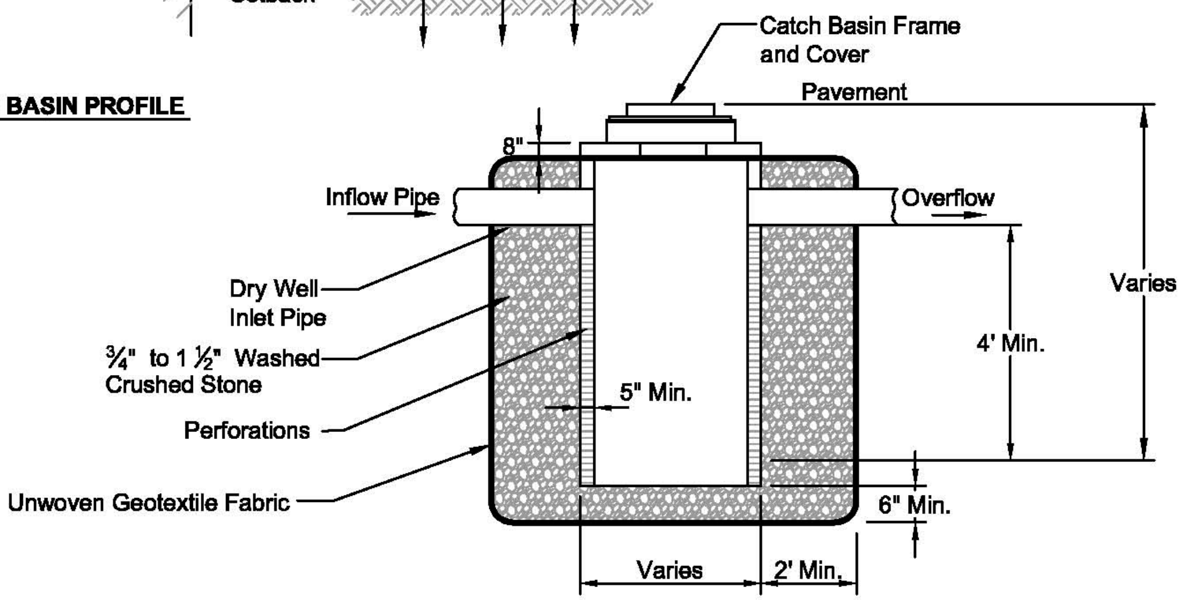
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Pretreatment | Required (See Pre-treatment section in this manual) |
| BMP Volume | ≥ the larger of WQV or GRV, depending on purpose of BMP excluding sediment forebay capacity, if present, and exclude infiltration occurring during the design event |
| Design Infiltration Rate | Obtain from infiltration tests |
| Drain Time | < 72 hours for complete drainage of the water quality volume |
| Depth to Bedrock and Seasonal High Water Table Elevation | ≥ 3 feet from bottom of BMP, except:<br>≥ 4 feet if within groundwater or water supply intake protection area<br>≥ 1 foot if runoff has been treated prior to entering BMP |

## DRY WELL & LEACHING BASIN

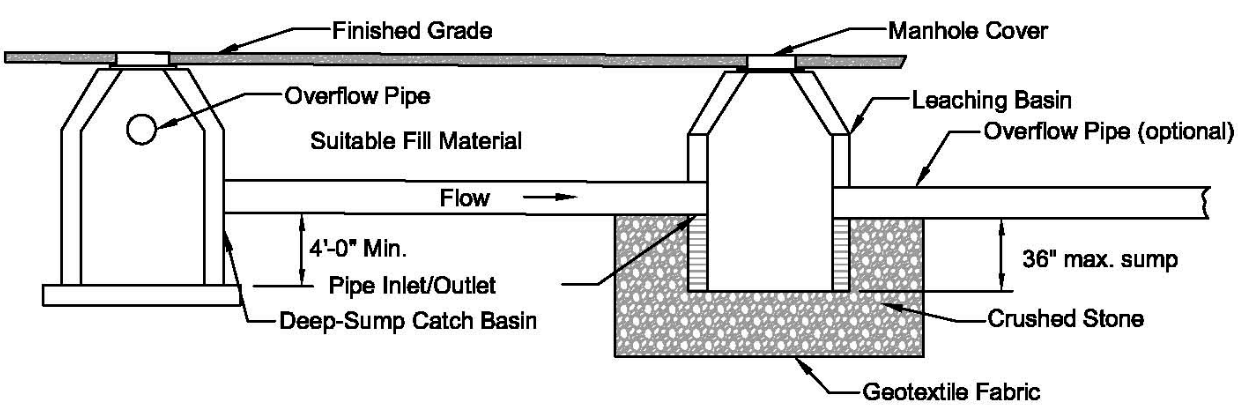
**DRY-WELL PROFILE**




**LEACHING BASIN PROFILE**




**LEACHING BASIN FOR ROADWAY**



## FILTERING PRACTICES

The following are examples of filtering practices:

- Surface sand filters
- Underground sand filters
- Bioretention systems
- Tree box filters
- Pervious asphalt and pervious concrete (permeable pavement)

General Requirements Applicable to Filtering Practices:

- Filtering practices are prohibited as follows, unless an impermeable liner is provided:
  - Into areas groundwater protection areas where stormwater is from a high-load area
  - Into areas where contaminants occur in groundwater above ambient standards
  - Into areas where contaminants occur in soil above site-specific standards
  - Into areas with slopes > 15%, unless calculations show that seepage will not cause slope instability
  - From areas with soil contaminants above site-specific standards
  - From areas with underground or aboveground storage tanks
- Pretreatment is required if BMP will receive stormwater other than roof runoff (except permeable pavements do not require pretreatment of runoff from their surfaces)
- Underdrain system is required if underlying native soil or fill soil has an infiltration rate < 0.5" (12 mm) per hour
- Where infiltration applies, the design infiltration rates must be determined
- Provide recommended clearances to seasonal high water table, to maintain adequate drainage, prevent structural damage to the filter, and minimize the potential for interaction with groundwater.

## SURFACE SAND FILTER

The surface sand filter is typically designed as an off-line device, so that storms exceeding the water quality volume are diverted from the BMP. Thus, the system usually includes a flow splitter, used to divert the first flush of runoff into a pretreatment device, such as a sedimentation chamber (wet or dry) where coarse sediments settle out of the water. Pretreated runoff then enters the sand filter, saturating the filter bed and filling temporary storage volume provided above the bed. As the water filters down through the sand bed, pollutants are strained from the water or adsorbed to the filter media. The top surface of the sand filter is exposed to the elements, but is kept free of vegetation.

If the filter is designed for infiltration, the treated water is allowed to percolate into the underlying native soil. Alternatively, the filter can be designed with a perforated underdrain system to collect treated water at the bottom of the sand filter and direct it to a suitable outlet. If necessary, the underdrained sand filter can be designed with a liner to isolate it from adjacent soil material and prevent discharge of treated water to the groundwater table.

### DESIGN CONSIDERATIONS

- Sand and other media filters may be advantageous for specialized applications where specific target pollutants must be addressed.
- Sand and other media filters may be advantageous for sites with limited space.
- Pretreatment is essential to the long-term function of surface sand filtration systems.
- Do not place filtration systems into service until the contributing areas have been fully stabilized.
- Where ultimate discharge from the filter is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent filtration/infiltration BMPs.
  - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.

### MAINTENANCE REQUIREMENTS

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5” (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pretreatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- Trash and debris should be removed at each inspection.
- Manufactured filter media should be replaced periodically per manufacturer’s specifications
- At least once annually, system should be inspected for drawdown time. If a filtration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore filtration function, including but not limited to removal of accumulated sediments or reconstruction of the filter.

### DESIGN REFERENCES

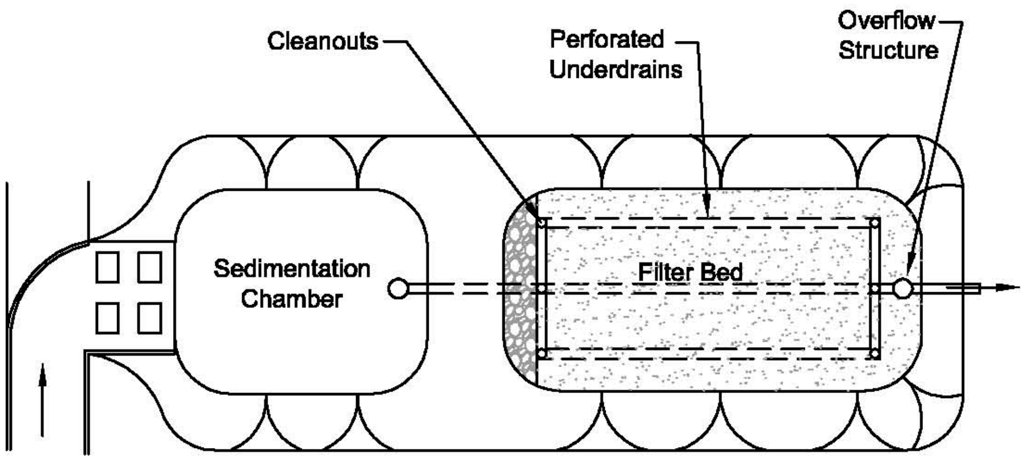
- EPA (1999c)

| Table – Filter Mixtures | | | |
|---|---|---|---|
| **Component Material** | **Percent of Mixture by Volume** | **Gradation of Material** | |
| | | **Sieve No.** | **Percent by Weight Passing Standard Sieve** |
| **Filter Media Option A** | | | |
| ASTM C-33 concrete sand | 50 to 55 | | |
| Loamy sand topsoil, with fines as indicated | 20 to 30 | 200 | 15 to 25 |
| Moderately fine shredded bark or wood fiber mulch, with fines as indicated | 20 to 30 | 200 | < 5 |
| **Filter Media Option B** | | | |
| Moderately fine shredded bark or wood fiber mulch, with fines as indicated | 20 to 30 | 200 | < 5 |
| | | 60 | 15 to 40 |
| | | 200 | 8 to 15 |

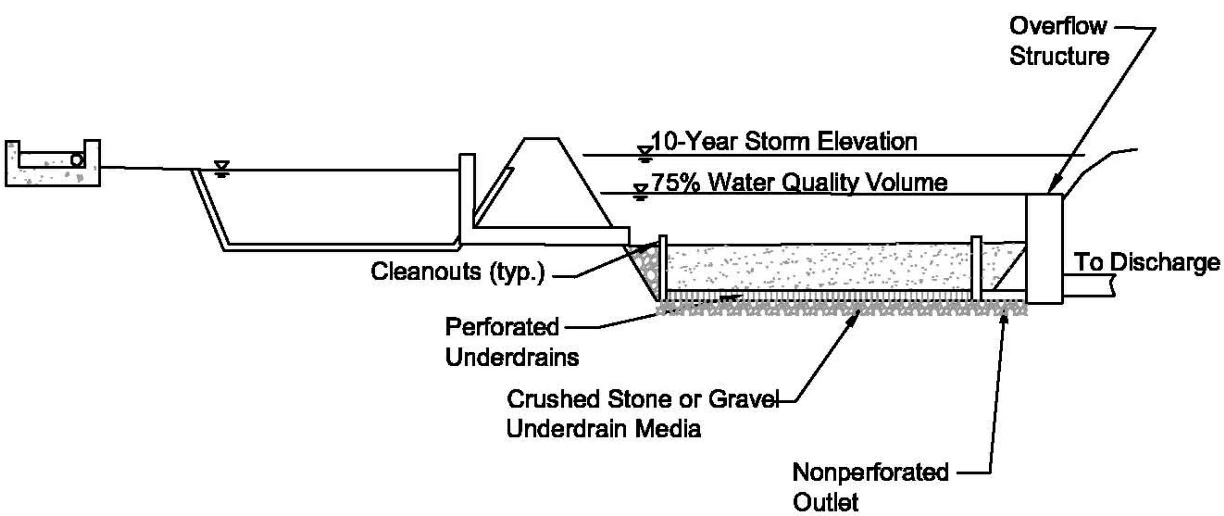
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Filter Volume | ≥ 75% WQV (including storage area above filter, filter media voids, and pre-treatment area) |
| Watershed | < 10 acres of contributing drainage area |
| Depth of Filter Media | 18 to 24 inches |
| Filter Media | See Table above – Filter shall not be covered with grass |
| Filter Appurtenances | Must have access grate |
| Drain Time | < 72 hours for complete drainage |
| Underdrain (where required) | ≥ 6-inch diameter perforated PVC or HDPE set in ¾ to 2-inch diameter stone or gravel free of fines and organic material |
| Depth to Bedrock and Seasonal High Water Table (SHWT) Elevation | If not providing an impermeable liner:<br>≥ 1 foot below the bottom of the filter course material.<br><br>If within groundwater or water supply intake protection area the practice shall also have:<br>• 1 foot of separation from the bottom of the practice to the SHWT or<br>• 1 foot of separation from the bottom of the filter course material and twice the depth of the filter course material recommended. |
| Overflow Discharge Capacity | 10-year, 24-hour storm |

## SURFACE SAND FILTER

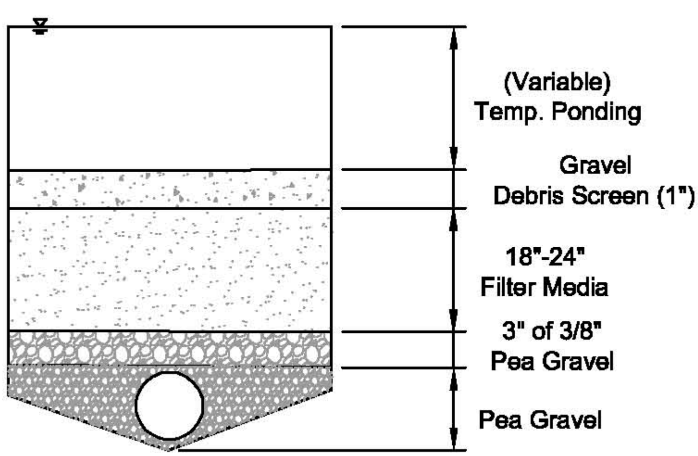
**PLAN VIEW**




**PROFILE**




**SECTION**



## UNDERGROUND SAND FILTER

The underground sand filter operates in a similar fashion to the surface sand filter, except that the system is enclosed in a below-grade structure. The structure may consist of a multi-chambered vault that accommodates pretreatment, as well as the filtration component of the system. The structure is made accessible through manholes or grate openings.

A typical structure incorporating pretreatment will consist of a three-chambered vault, with the first chamber comprising a sedimentation chamber, the second chamber consisting of the filter, and the final chamber serving as the outlet control for the system. The first chamber provides pretreatment by settling coarse sediments and by trapping floating materials such as trash and oil. The pretreated water then enters the sand filter. A permeable layer of gravel may be installed on top of the filter to help prevent clogging of the filter media. A perforated underdrain at the bottom of the filter directs treated water towards an outlet. Similar to the surface sand filter, the subsurface filter should be designed as an off-line device, with capacity to treat the Water Quality Volume, with larger storm events diverted from the device.

Typical subsurface filter systems are fully enclosed in structures. However, some systems may be designed with an open bottom in contact with native soils, allowing for infiltration to occur. In these systems, the “hybrid” BMP needs to be designed to meet the requirements of Subsurface Infiltration Systems, in addition to the requirements for the filter system.

### DESIGN CONSIDERATIONS

- Sand and other media filters may be advantageous for specialized applications where specific target pollutants must be addressed.
- Sand and other media filters may be advantageous for sites with limited space.
- Pretreatment is essential to the long-term function of surface sand filtration systems.
- Do not place filtration systems into service until the contributing areas have been fully stabilized.
- Where ultimate discharge from the filter is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to permanent filtration/infiltration BMPs.
  - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.

### MAINTENANCE REQUIREMENTS

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5” (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pretreatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- Trash and debris should be removed at each inspection.
- Manufactured filter media should be replaced periodically per manufacturer’s specifications.
- At least once annually, system should be inspected for drawdown time. If a filtration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required

to restore filtration function, including but not limited to removal of accumulated sediments or reconstruction of the filter.

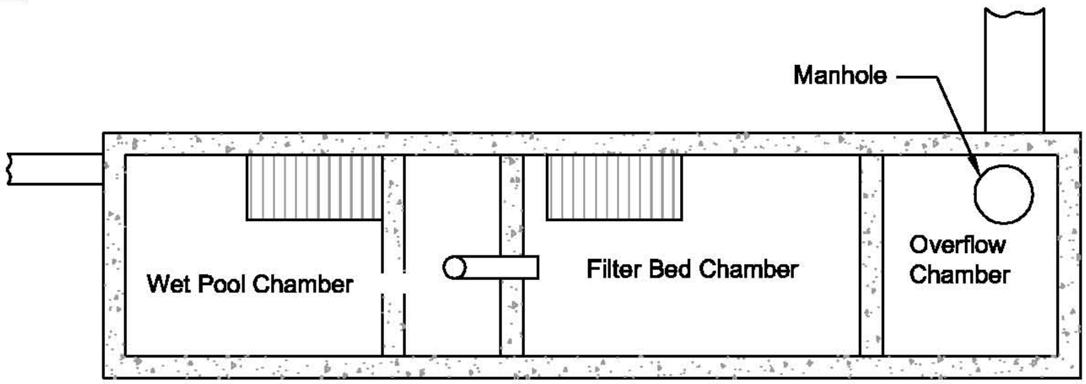
**DESIGN REFERENCES**

- EPA (1999c)

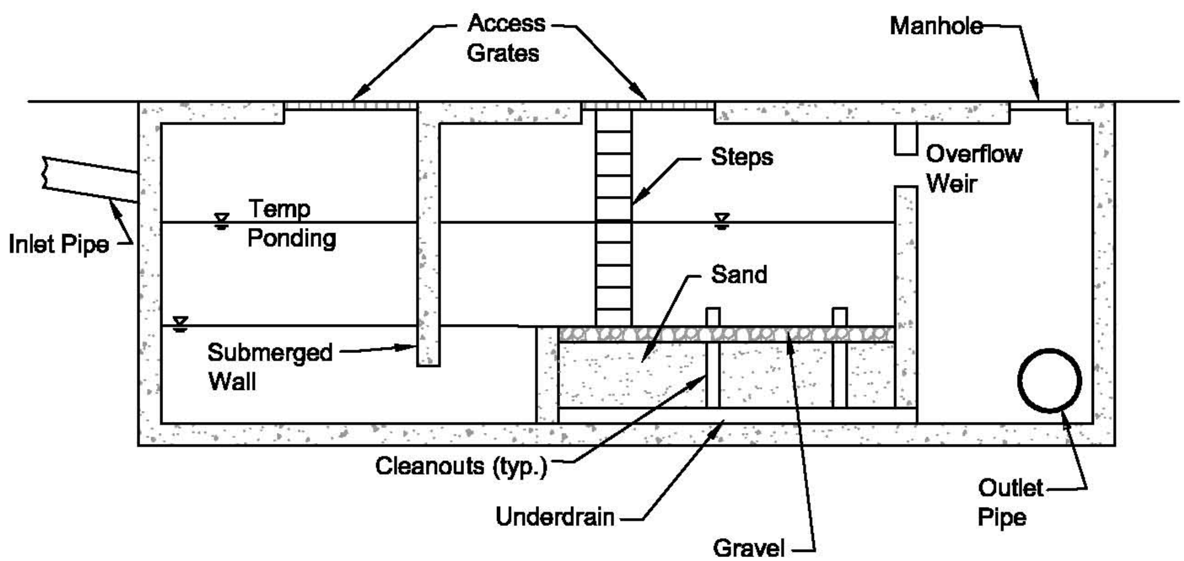
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Filter Volume | ≥ 75% WQV (including storage area above filter, filter media voids, and pre-treatment area) |
| Watershed | < 10 acres of contributing drainage area |
| Depth of Filter Media | 18 to 24 inches |
| Filter Media | See Table above – Filter shall not be covered with grass |
| Filter Appurtenances | Must have access grate |
| Drain Time | < 72 hours for complete drainage |
| Underdrain (where required) | ≥ 6-inch diameter perforated PVC or HDPE set in ¾ to 2-inch diameter stone or gravel free of fines and organic material |
| Depth to Bedrock and Seasonal High Water Table (SHWT) Elevation | If not providing an impermeable liner:<br>≥ 1 foot below the bottom of the filter course material.<br><br>If within groundwater or water supply intake protection area the practice shall also have:<br>• 1 foot of separation from the bottom of the practice to the SHWT or<br>• 1 foot of separation from the bottom of the filter course material and twice the depth of the filter course material recommended. |
| Overflow Discharge Capacity | 10-year, 24-hour storm |

## UNDERGROUND SAND FILTER

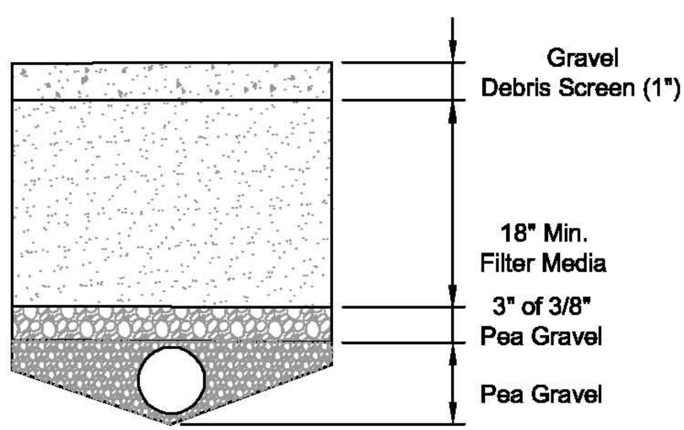
**PLAN VIEW**




**PROFILE**




**SECTION**



## BIORETENTION SYSTEM

A bioretention system (sometimes referred to as a "rain garden") is a type of filtration BMP designed to collect and filter moderate amounts of stormwater runoff using conditioned planting soil beds, gravel beds and vegetation within shallow depressions. The bioretention system may be designed with an underdrain, to collect treated water and convey it to discharge, or it may be designed to infiltrate the treated water directly to the subsoil. Bioretention cells are capable of reducing sediment, nutrients, oil and grease, and trace metals. Bioretention systems should be sited in close proximity to the origin of the stormwater runoff to be treated.

The major difference between bioretention systems and other filtration systems is the use of vegetation. A typical surface sand filter is designed to be maintained with no vegetation, whereas a bioretention cell is planted with a variety of shrubs and perennials whose roots assist with pollutant uptake. The use of vegetation allows these systems to blend in with other landscaping features.

### DESIGN CONSIDERATIONS

- Bioretention areas should be located close to the source of runoff.
- Bioretention areas are particularly adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.
- Bioretention areas can also be used to meet recharge objectives, where allowed by land use and receiving water characteristics.
- Do not place bioretention systems into service until the BMP has been planted and its contributing areas have been fully stabilized.
- Where ultimate discharge from the bioretention area is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to the bioretention area during any stage of construction.
  - Do not traffic exposed soil surface with construction equipment. If feasible, perform excavations with equipment positioned outside the limits of the infiltration components of the system.

### MAINTENANCE REQUIREMENTS

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5 " (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Pretreatment measures should be inspected at least twice annually, and cleaned of accumulated sediment as warranted by inspection, but no less than once annually.
- Trash and debris should be removed at each inspection.
- Manufactured filter media should be replaced periodically per manufacturer's specifications.
- At least once annually, system should be inspected for drawdown time. If a filtration system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the facility to determine measures required to restore filtration function, including but not limited to removal of accumulated sediments or reconstruction of the filter.

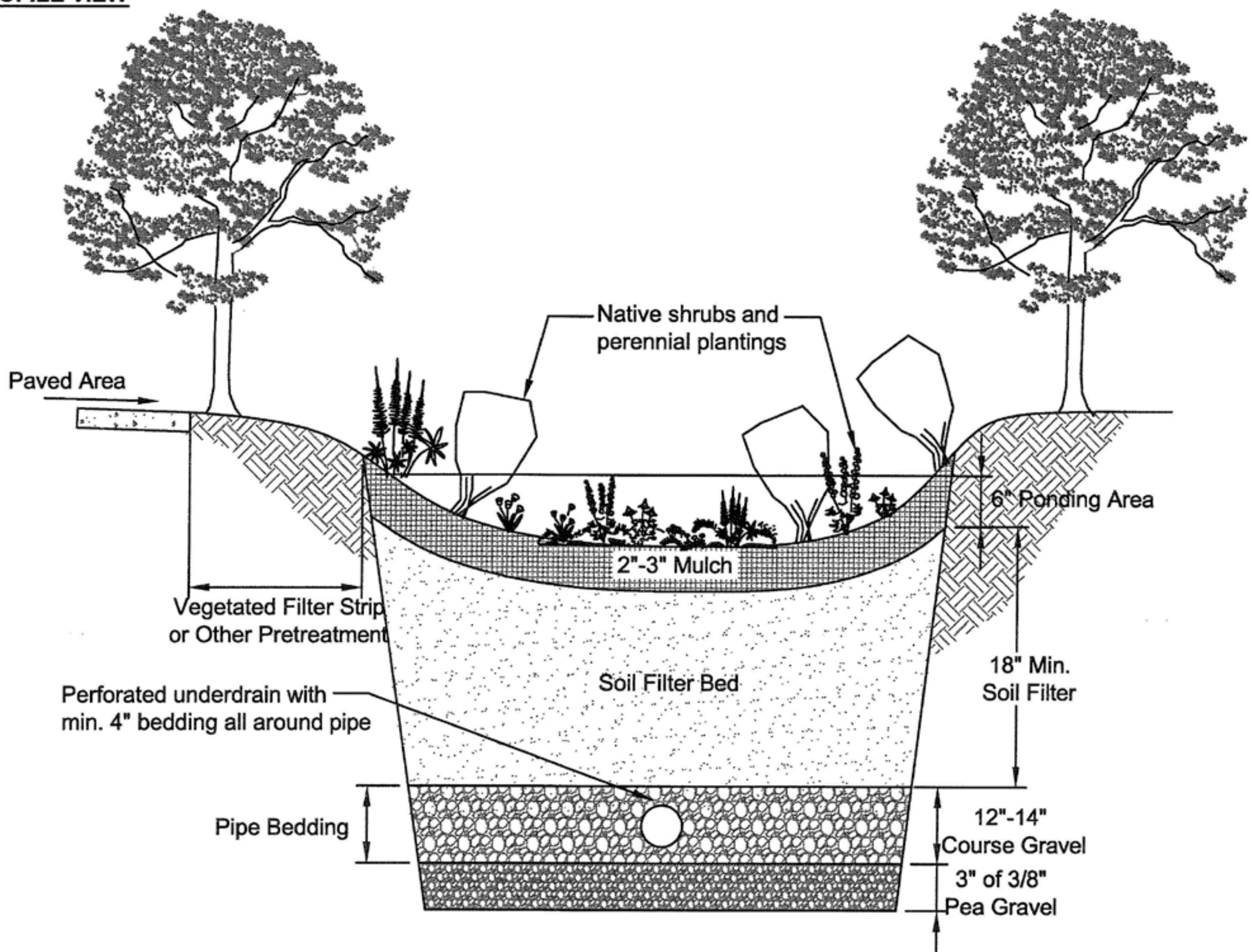
- Vegetation should be inspected at least annually, and maintained in healthy condition, including pruning, removal and replacement of dead or diseased vegetation, and removal of invasive species.

| Bioretention Filter Media | | | |
|---|---|---|---|
| **Component Material** | **Percent of Mixture by Volume** | **Gradation of Material** | |
| | | **Sieve No.** | **Percent by Weight Passing Standard Sieve** |
| **Filter Media Option A** | | | |
| ASTM C-33 concrete sand | 50 to 55 | | |
| Loamy sand topsoil, with fines as indicated | 20 to 30 | 200 | 15 to 25 |
| Moderately fine shredded bark or wood fiber mulch, with fines as indicated | 20 to 30 | 200 | < 5 |
| **Filter Media Option B** | | | |
| Moderately fine shredded bark or wood fiber mulch, with fines as indicated | 20 to 30 | 200 | < 5 |
| Loamy coarse sand | 70 to 80 | 10 | 85 to 100 |
| | | 20 | 70 to 100 |
| | | 60 | 15 to 40 |
| | | 200 | 8 to 15 |

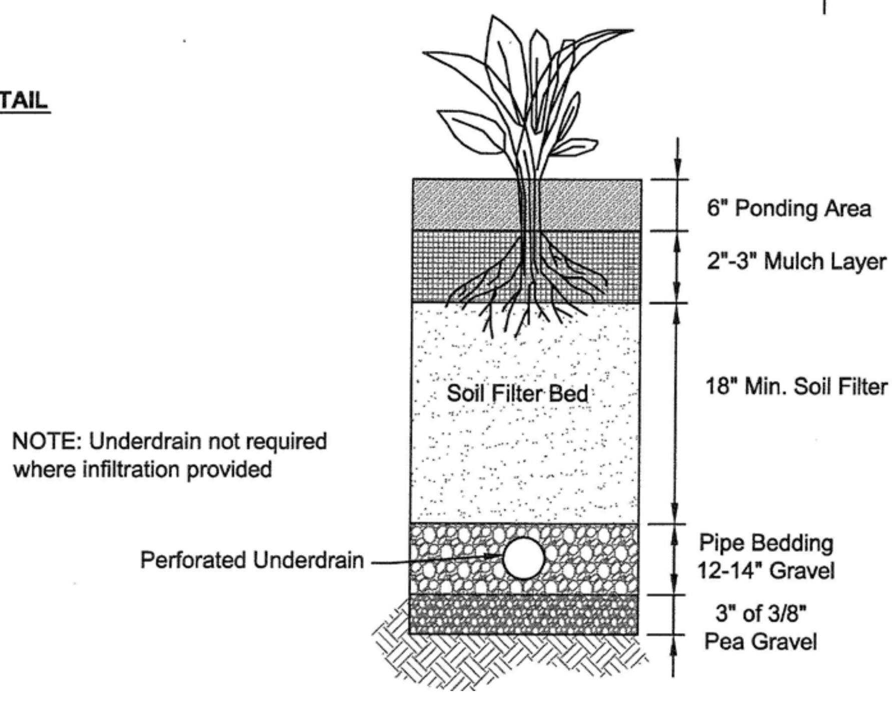
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Filter Volume | ≥ 75% WQV (including storage area above filter, filter media voids, and pre-treatment area) |
| Watershed | < 10 acres of contributing drainage area |
| Depth of Filter Media | ≥ 24 inches |
| Filter Media | See Table above – Filter shall not be covered with grass |
| Filter Appurtenances | Must have access grate |
| Drain Time | < 72 hours for complete drainage |
| Underdrain (where required) | ≥ 6-inch diameter perforated PVC or HDPE set in ¾ to 2-inch diameter stone or gravel free of fines and organic material |
| Depth to Bedrock and Seasonal High Water Table (SHWT) Elevation | If not providing an impermeable liner:<br>≥ 1 foot below the bottom of the filter course material.<br><br>If within groundwater or water supply intake protection area the practice shall also have:<br>• 1 foot of separation from the bottom of the practice to the SHWT or<br>• 1 foot of separation from the bottom of the filter course material and twice the depth of the filter course material recommended. |
| Overflow Discharge Capacity | 10-year, 24-hour storm |

## BIORETENTION SYSTEM

**PROFILE VIEW**




**SECTION DETAIL**



## TREE BOX FILTER

The Tree Box Filter is essentially a small bioretention system, combining the function of a curb-side drainage inlet with the water quality treatment functions of a vegetated soil media. It consists of an open bottom or closed bottom concrete box or barrel filled with a porous soil media. An underdrain system, consisting of a perforated pipe bedded in crushed gravel, is provided beneath the soil media. A tree is planted in the soil media. Stormwater is directed from surrounding impervious surfaces through the top of the soil media.

If the device has an open bottom, the stormwater percolates through the media into the underlying ground. If the filtered stormwater exceeds the infiltration capacity of the underlying natural soil, the excess will be intercepted by the underdrain, where it may be directed to a storm drain, other device, or surface water discharge.

Where a closed bottom box filter is used, such as where necessary to protect groundwater resources, the filter is isolated from the underlying soil. In this case, all of the stormwater that passes through the soil media filter will be intercepted by the underdrain and conveyed to a suitable outlet.

### DESIGN CONSIDERATIONS

- Tree box filters should be carefully integrated into the design of parking areas and streets, to provide a sufficient number of units in suitable locations for capturing the required Water Quality Volume. Generally, these systems are sized and spaced similarly to catch basin inlets.
- Tree box filters are particularly adaptable to integration with site landscaping, and offer an aesthetically attractive opportunity to provide highly effective stormwater treatment.
- Do not use tree box filters to treat runoff from high-load areas
- Tree box filters can be used to meet recharge objectives, where underlying soils are suitable and where allowed by land use and receiving water characteristics.
- Do not place tree box filters into service until the BMP has been planted and its contributing areas have been fully stabilized.
- Where ultimate discharge from the tree box filter is by infiltration into the subsoil, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) to the tree box filter during any stage of construction.
  - Do not put traffic or compact exposed soil surface within the area of the filter with construction equipment. Perform excavation for the construction of this BMP with equipment positioned outside the limits of the system.

### MAINTENANCE REQUIREMENTS

- Systems should be inspected at least twice annually, and following any rainfall event exceeding 2.5” (60 mm) in a 24 hour period, with maintenance or rehabilitation conducted as warranted by such inspection.
- Trash and debris should be removed at each inspection
- If inspection indicates that the system does not drain within 72-hours following a rainfall event, then a qualified professional should assess the condition of the tree box filter to determine measures required to restore filtration function or infiltration function (as applicable), including but not limited to removal of accumulated sediments or reconstruction of the filter media.

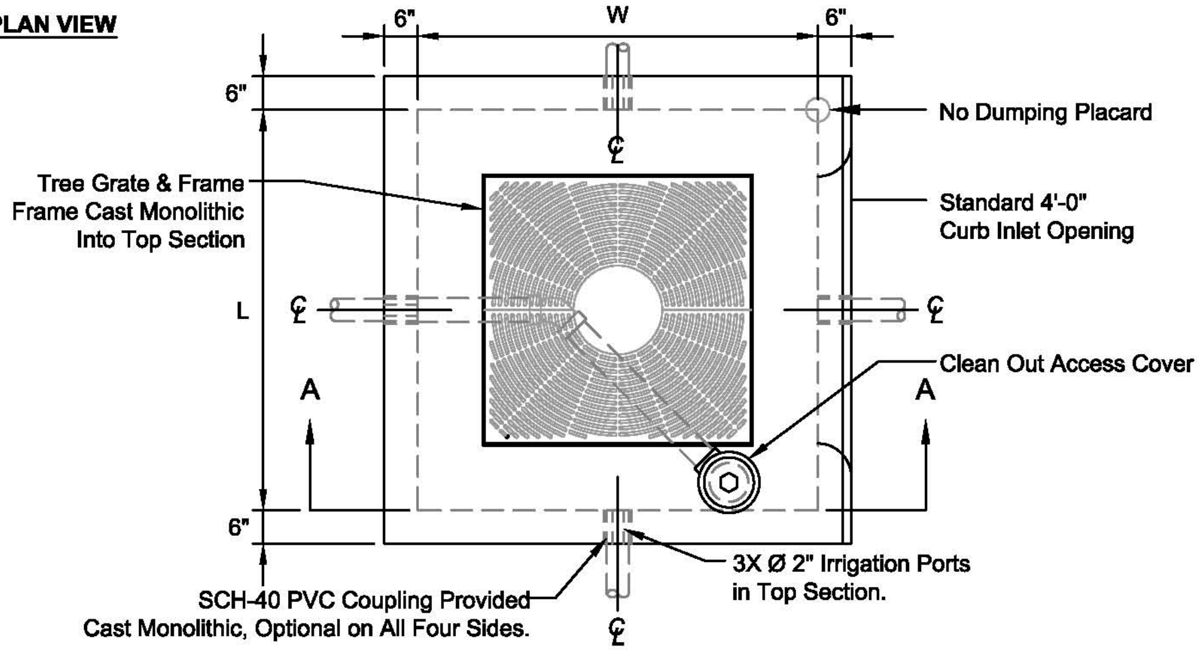
- The tree should be inspected at least annually, and maintained in healthy condition, including pruning. A dead or diseased tree, or a tree in stressed condition because of the constricted root space in the filter, should be removed and replaced. Filter media should be replaced when the tree is replaced.

| Table– Tree Box Filter Media | | |
|---|---|---|
| **Component Material** | **Percent of Mixture by Volume** | **Required Material Characteristics** |
| Sand | 80 | ASTM C-33 concrete sand |
| Organic material, composted bark mulch recommended | 20 | <5% passing #200 sieve |
| General requirements applicable to the mixture | 1. Soil Mix should be uniform, free of stones, stumps, roots, or similar materials larger than 2 inches.<br>2. Soil pH should be between 5.5 and 6.5 | |

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Pretreatment | Pretreatment not required. However, tree box filters shall not be used for high-load areas. |
| Tree Box Filter Volume | ≥ WQV (including storage area above filter and filter media voids) |
| Depth of Filter Media | 36 inches, minimum |
| Filter Media | See Table above – Filter shall not be covered with grass |
| Filter Appurtenances | Must have access grate |
| Drain Time | < 72 hours for complete drainage |
| Underdrain (where required) | ≥ 6-inch diameter perforated PVC or HDPE set in ¾ to 2-inch diameter stone or gravel free of fines and organic material |
| Depth to Bedrock and Seasonal High Water Table (SHWT) Elevation | If not providing an impermeable liner:<br>≥ 1 foot below the bottom of the filter course material.<br><br>If within groundwater or water supply intake protection area the practice shall also have:<br>• 1 foot of separation from the bottom of the practice to the SHWT or<br>• 1 foot of separation from the bottom of the filter course material and twice the depth of the filter course material recommended. |
| Overflow Discharge Capacity | 10-year, 24-hour storm |
| Planting Design | Vegetation selected for these systems shall consist of native, drought-tolerant and salt-tolerant species. Plants with aggressive root growth may clog the sub-drain, and therefore may not be suitable for this type of system. |

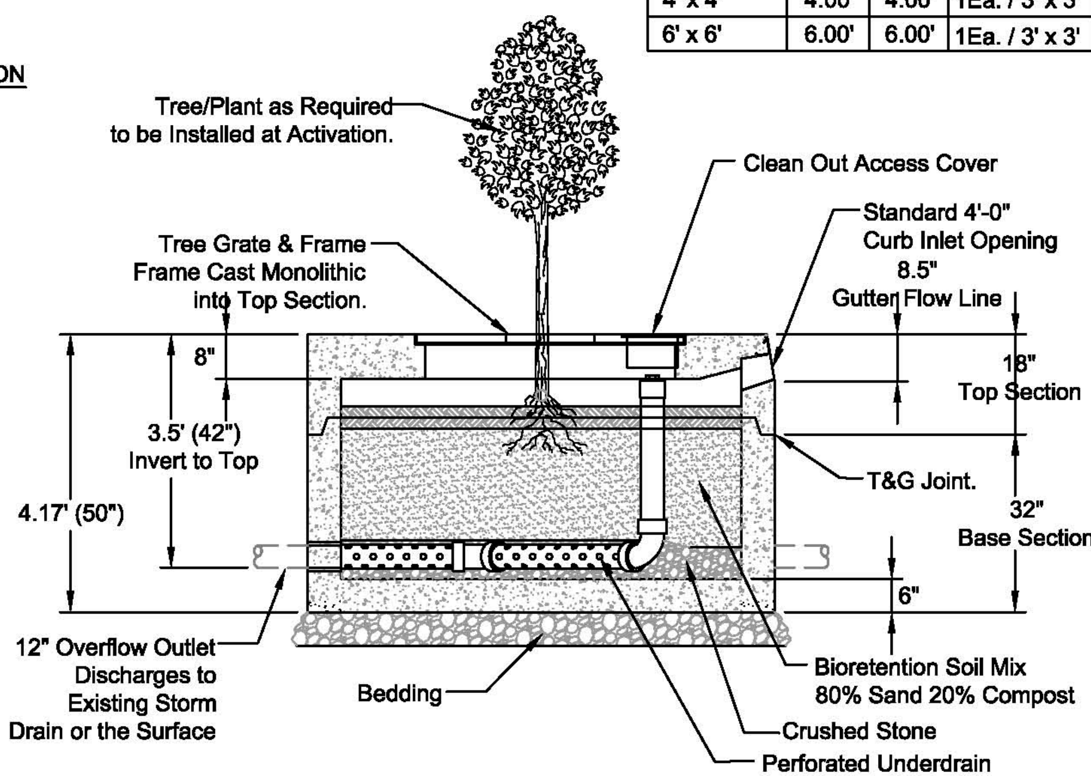
## TREE BOX FILTER

**PLAN VIEW**




| TABULATION | | | | |
|---|---|---|---|---|
| Size / Designation | L (Feet) | W (Feet) | Tree Grate Quantity / Size | Outlet Pipe PVC SCH-40 |
| 4' x 4' | 4.00' | 4.00' | 1Ea. / 3' x 3' | Ø4.00" |
| 6' x 6' | 6.00' | 6.00' | 1Ea. / 3' x 3' | Ø4.00" |

**SECTION**



# PERMEABLE PAVEMENT

Permeable pavement consists of a porous surface, base, and sub-base materials which allow penetration of runoff through the surface into underlying soils. The surface materials for permeable pavement can consist of paving blocks or grids, pervious asphalt, or pervious concrete. These materials are installed on a base which serves as a filter course between the pavement surface and the underlying sub-base material. The sub-base material typically comprises a layer of crushed stone that not only supports the overlying pavement structure, but also serves as a reservoir to store runoff that penetrates the pavement surface until it can percolate into the ground.

Although traffic loading capacities vary, permeable pavement alternatives are generally appropriate for low traffic areas (e.g. sidewalks, parking lots, overflow parking). Pavement type and thickness are selected based on anticipated load (light, moderate, heavy) and maintenance requirements. Careful maintenance is essential for long term use and effectiveness.

Frequently, permeable pavements filter only the runoff generated on the pavement surface itself. However, runoff from other areas can be directed to permeable pavement if properly designed. Runoff generated from adjacent areas of the site may require pretreatment prior to discharge to the pavement surface, to prevent clogging of the pavement structure and (where the pavement is used to infiltrate as well as filter the runoff) the underlying soils.

Porous asphalt is very similar to conventional asphalt except that it is mixed without particles smaller than coarse sand (less than 600 μm or No. 30 sieve). Without these smaller size particles, water is able to pass through the surface and into a crushed stone storage area. The lack of fine particles in the asphalt, however, limits the loading capacity of the asphalt relative to conventional asphalt. Because of this limitation, pervious asphalt should not be used in high-traffic areas. An advantage to the use of porous asphalt is the reduced need for stormwater conveyance systems and other additional BMPs.

Pervious concrete uses carefully controlled amounts of water and cementitious materials to create a thick coating around aggregate particles, but retaining significant void space in the placement of the mixture. A pervious concrete mixture contains little or no sand, creating this void content. The installed surface will typically have between 15% and 25% voids in the hardened concrete, capable of passing water at extremely high flow rates through the surface. The low mortar content and high porosity reduce the strength of this surface compared to conventional concrete mixtures, which limits the use of the surface to low load-bearing areas, as is the case for porous asphalt. The pervious concrete surface is placed over an aggregate filter and storage layer, similar in characteristics to porous asphalt.

## DESIGN CONSIDERATIONS

- Permeable pavements are generally applicable to low-traffic access ways, overflow or low-use parking areas, pedestrian access ways, bikepaths, and patios. Because of the reduced strength of pavement associated with permeable pavement surfaces such as porous asphalt and concrete, these surfaces are not typically appropriate for high traffic or heavy vehicle loads.
- Particular care must be taken during construction to assure preparation of subgrade, placement of aggregates, and installation of pavements meets design specifications.
- On sloping pervious pavement surfaces, impermeable trench berms should be considered within the filter and reservoir courses to minimizing flow laterally within the

pavement courses. The berm should be sized to a depth necessary to retain the stormwater for sufficient time to infiltrate.

- Where infiltration is provided by the design, the preservation of infiltration function of underlying soils requires careful consideration during construction. To prevent degradation of infiltration function:
  - Do not discharge sediment-laden waters from construction activities (runoff, water from excavations) into areas designated for permeable pavement.
  - Do not allow stormwater from other areas of the site to flow onto the completed permeable pavement until those areas have been fully stabilized

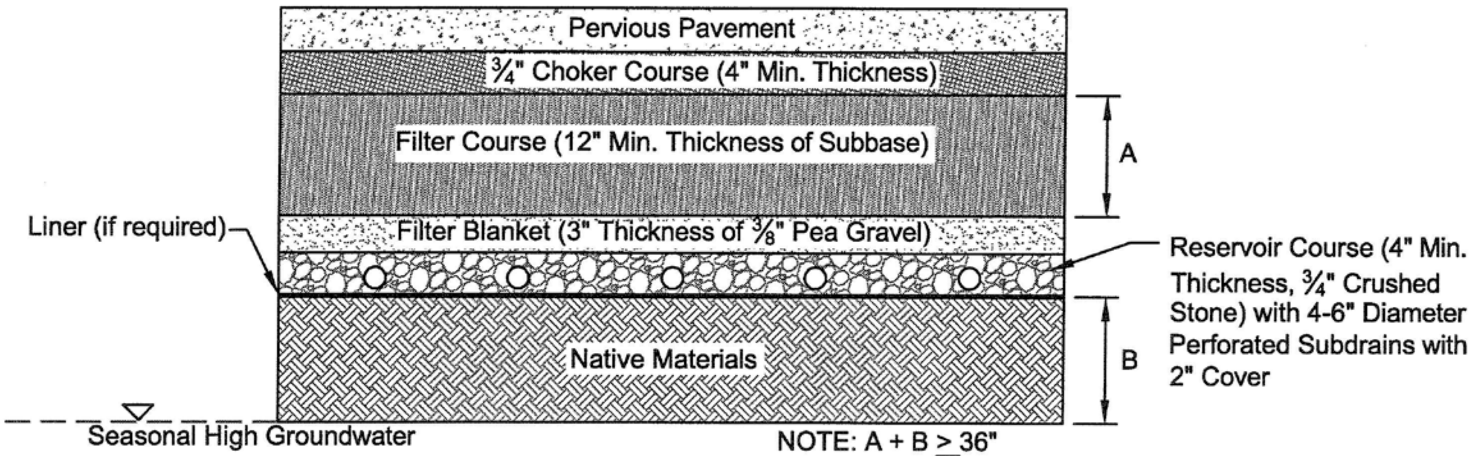
**MAINTENANCE REQUIREMENTS**

- Provision of signs is recommended, to indicate locations of permeable pavements and the applicability of special maintenance measures.
- No winter sanding of permeable pavements is permitted.
- Minimize application of salt for ice control.
- Never reseal or repave with impermeable materials.
- Inspect annually for pavement deterioration or spalling.
- Monitor periodically to ensure that the pavement surface drains effectively after storms
- For porous asphalt and concrete, clean periodically (2-4 times per year) using a vacuum sweeper. Power washing may be required prior to vacuum sweeping, to dislodge trapped particles.
- For interlocking paving stones, periodically add joint material to replace lost material
- For seeded grid systems, periodic reseeding of grass pavers to fill in bare spots
- Major clogging may necessitate replacement of pavement surface, and possibly filter course and sub-base course.

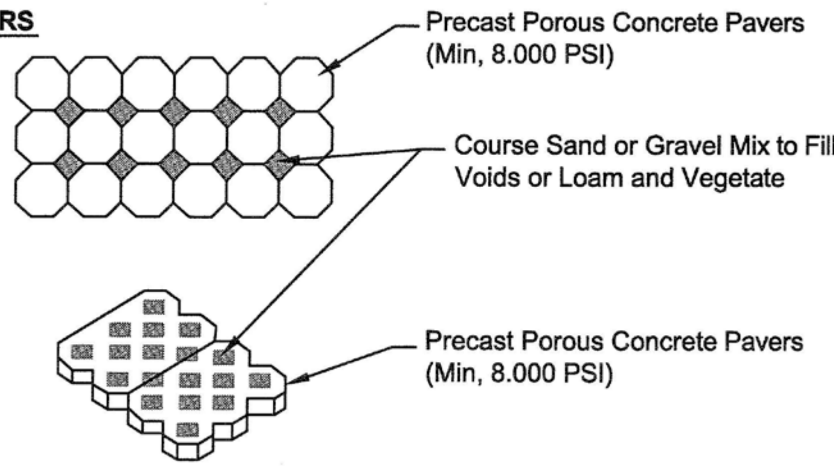
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Porous asphalt design | Industry standards |
| Porous concrete design | American Concrete Institute (2006) |
| Porous concrete installation | Contractor certified by the National Ready Mix Concrete Association (NRMCA) through the NRMCA Pervious Concrete Contractor Certification program |
| Pervious interlocking paver design | Interlocking Concrete Pavement Institute (2002) |
| Filter Course Material | See Filter material in this manual |
| Filter Course Thickness | > 12 inches for any section which receives only direct rainfall to its surface; or<br>> (12 inches * Total contributing area)/area of the surface |
| Total Section Thickness | 65% of the frost depth<br>Typically, the frost depth in most jurisdictions is 48 inches. Therefore, total section thickness (top of pervious pavement to the native ground) shall be at least 32”. Verify the frost depth on a project by project basis. |
| Aggregate Storage Volume (Reservoir Course, Filter Blanket, Filter Course, Choker Course) | ≥ Larger of WQV or Recharge Volume, as applicable for purpose of BMP. |
| Underdrain (where required) | ≥ 6-inch diameter perforated PVC or HDPE set in ¾ to 2-inch diameter stone or gravel free of fines and organic material |
| Depth to Bedrock and Seasonal High Water Table (SHWT) Elevation | If not providing an impermeable liner:<br>≥ 1 foot below the bottom of the filter course material.<br><br>If within groundwater or water supply intake protection area the practice shall also have:<br>• 1 foot of separation from the bottom of the practice to the SHWT or<br>• 1 foot of separation from the bottom of the filter course material and twice the depth of the filter course material recommended. |
| Overflow Discharge Capacity | 10-year, 24-hour storm |
| Overflow outlet | Provide overflow from aggregate storage layer |
| Observation Well(s) | Necessary to monitor conditions in reservoir course |

## PERMEABLE PAVEMENT

### PERMEABLE PAVEMENT SECTION

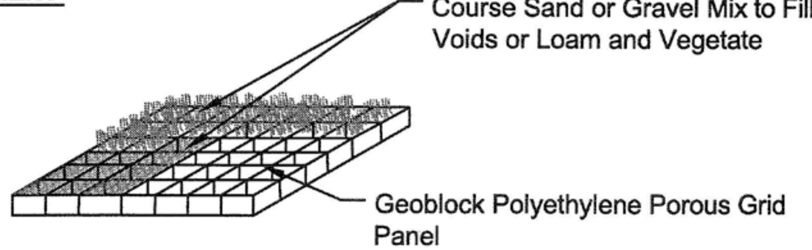



### PERMEABLE CONCRETE PAVERS




NOTE: Prepare Subsurface Reservoir to Match Below

### GEOBLOCK POROUS PAVEMENT




NOTE: Prepare Subsurface Reservoir to Match Below

## TREATMENT SWALES

Treatment swales differ from practices such as underdrained swales (for example, “dry swales” and “bioretention swales”), which are essentially filtration practices, and “wet swales,” which are similar in function to pocket ponds.

General Requirements Applicable to Treatment Swales:

- Swales are prohibited in areas of RSA 482-A jurisdiction unless a wetlands permit has been issued
- Swales are prohibited in groundwater protection areas receiving stormwater from a high-load area unless an impermeable liner is provided
- Swale shape should be trapezoidal or parabolic
- Swale must have ≥ 85% vegetated growth prior to receiving runoff
- Bottom of swale must be above seasonal high water table

### DESIGN CONSIDERATIONS

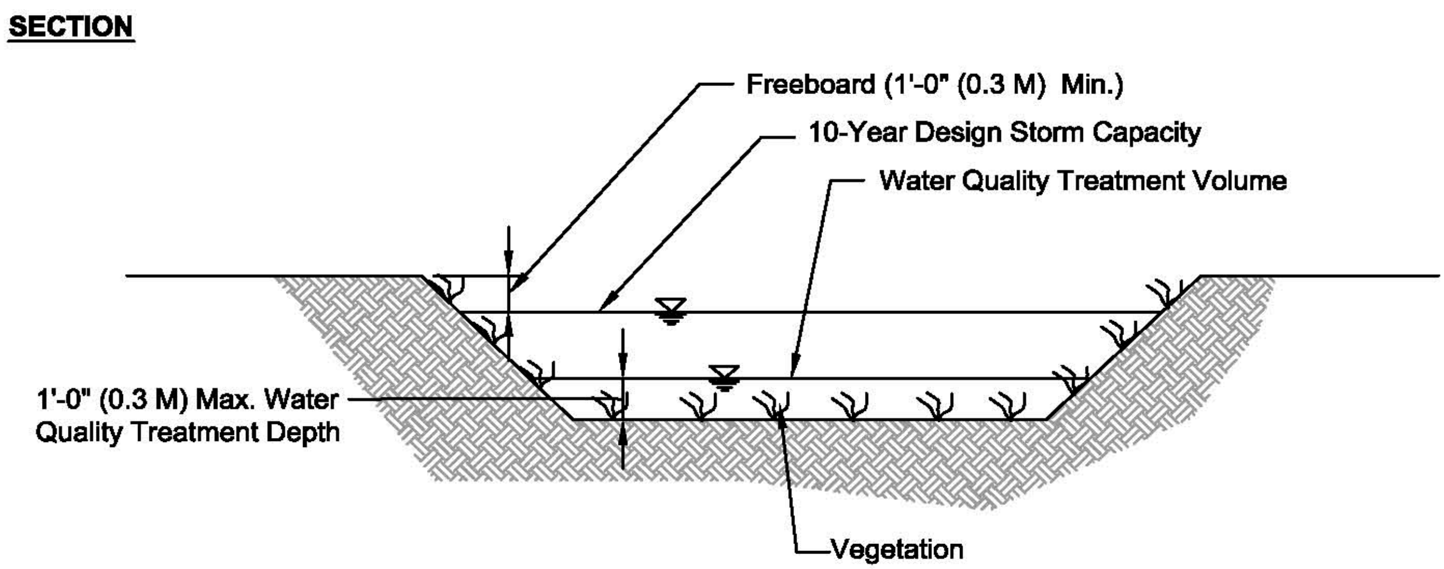
- Flow-Through Swales must be designed so that the flow travels the full length to receive adequate treatment. For this reason, flow must be directed to the inlet end of the swale, rather than the swale collecting water continuously along its length.
- All channels should be designed for capacity and stability. A channel is designed for capacity when it can carry the maximum specified design flow within the design depth of the channel (allowing for recommended freeboard). A channel is designed for stability when the channel lining (vegetation, riprap, or other material) will not be eroded under maximum design flow velocities. Analyses of these conditions must account for both the type of lining and its condition (for example, capacity analysis for a grassed channel must consider the resistance of the maximum height of grass, while the stability analysis must consider the grass under its shortest, mowed condition).
- Vegetation should be selected based on site soils conditions, planned mowing requirements (height, frequency), and design flow velocities.
- The roughness coefficient, n, varies with the type of vegetative cover and flow depth. At very shallow depths, where the vegetation height is equal to or greater than the flow depth, the n value should be approximately 0.15. This value is appropriate for flow depths up to 4 inches typically. For higher flow rates and flow depths, the n value decreases to a minimum of 0.03 for grass channels at a depth of approximately 12 inches. The n value must be adjusted for varying flow depths between 4” and 12”.

### MAINTENANCE REQUIREMENTS

- Inspect annually for erosion, sediment accumulation, vegetation loss, and presence of invasive species.
- Perform periodic mowing; frequency depends on location and type of grass. Do not cut shorter than Water Quality Flow depth (maximum 4” (100 mm))
- Remove debris and accumulated sediment, based on inspection.
- Repair eroded areas, remove invasive species and dead vegetation, and reseed with applicable grass mix as warranted by inspection.

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Minimum Length | ≥ 100 feet (not including portions in a roadside ditch) |
| Bottom Width | 4 to 8 feet (widths up to 16 feet are allowable with dividing berm/structure such that neither channel width exceeds 8 feet) |
| Longitudinal Slope | 0.5% to 2% without check dams<br>2% to 5% with check dams |
| Maximum Side Slopes | 3:1 |
| Flow Depth | 4 inches maximum at the WQF |
| Hydraulic Residence Time | > 10 minutes during the WQF |
| Design Discharge Capacity | 10-year, 24-hour storm without overtopping |

## TREATMENT SWALES




## PRE-TREATMENT PRACTICES - SEDIMENT FOREBAY

A sediment forebay is an impoundment, basin, or other storage structure designed to dissipate the energy of incoming runoff and allow for initial settling of coarse sediments. Forebays are used for pretreatment of runoff prior to discharge into the primary water quality treatment BMP.

In some cases, forebays may be constructed as separate structures but often, they are integrated into the design of larger stormwater management structures.

General Requirements Applicable to All Sediment Forebays:
- Provide a fixed vertical sediment marker to measure depth of accumulated sediment.
- Re-stabilize all disturbed areas upon completion of maintenance in accordance with approved plans.

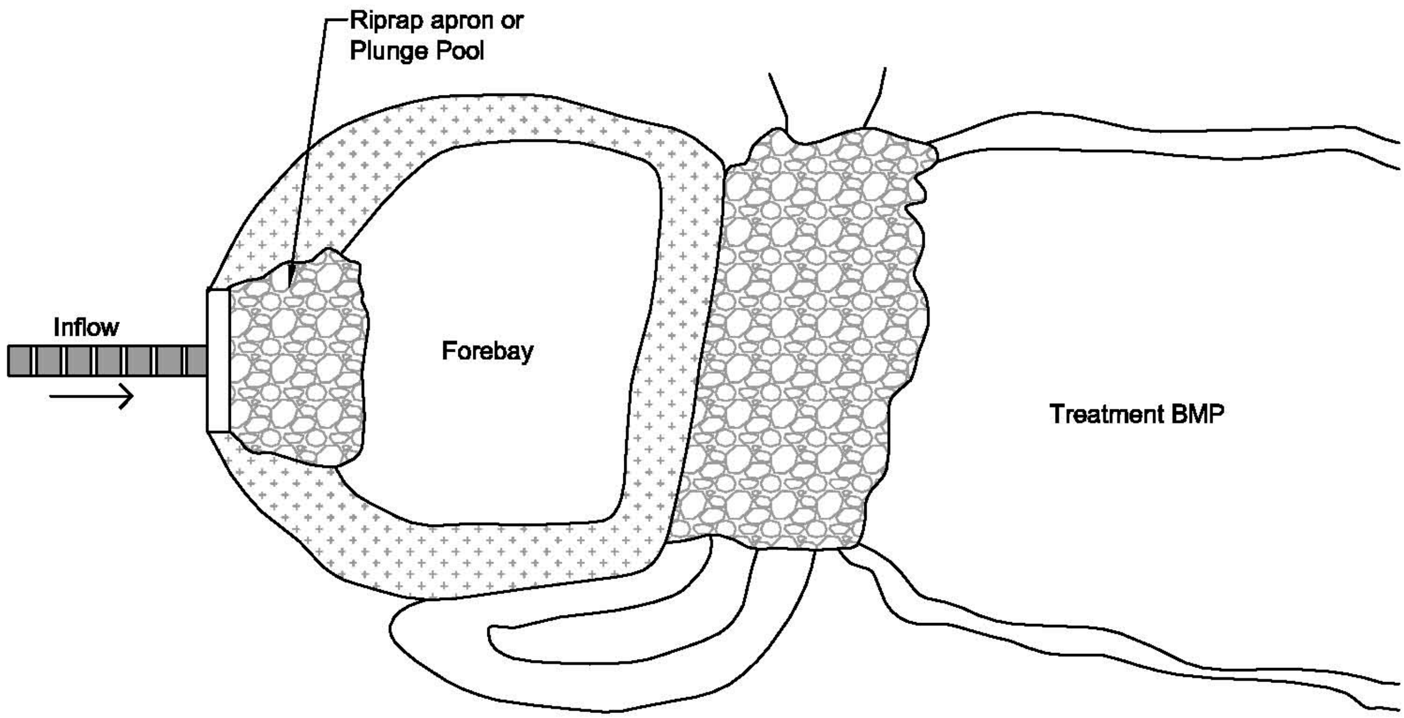
**DESIGN CONSIDERATIONS**
- Maintenance access must be provided;
- Embankment design must be engineered to meet applicable safety standards (see description of Detention Basins);
- Exposed earth slopes and bottom of basin should be stabilized using seed mixes appropriate for soils, mowing practices, and exposure to inundation;
- Exit velocities from the forebay should be non-erosive;
- As an alternative to an earthen basin, an underground structure may serve as a forebay. However, use of fully enclosed structures must consider accessibility for inspection and cleaning.

**MAINTENANCE REQUIREMENTS**
- Forebays help reduce the sediment load to downstream BMPs, and will therefore require more frequent cleaning.
- Inspect at least annually;
- Conduct periodic mowing of embankments (generally two times per year) to control growth of woody vegetation on embankments;
- Remove debris from outlet structures at least once annually;
- Remove and dispose of accumulated sediment based on inspection;
- Install and maintain a staff gage or other measuring device, to indicate depth of sediment accumulation and level at which clean-out is required.

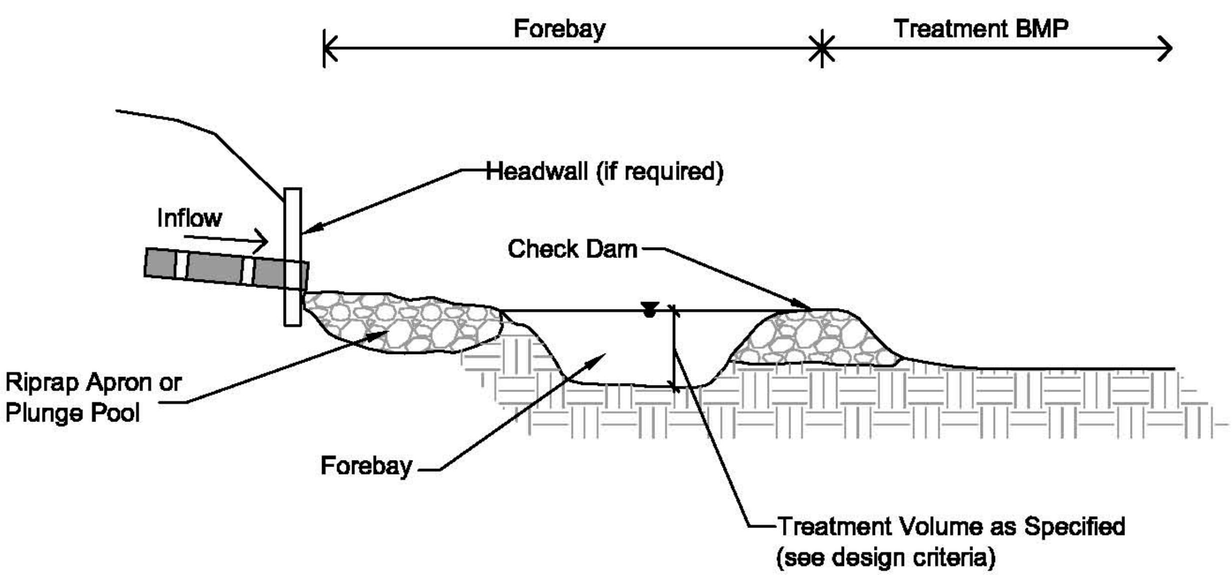
| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Forebay Volume | 10% of the WQV, at a minimum. See specific Treatment Practice for appropriate size. |
| Minimum Depth | 2 feet |
| Maximum Depth | 6 feet |
| Maximum Side Slopes | 3:1 |

## SEDIMENT FOREBAY

**PLAN VIEW**




**PROFILE**



## PRE-TREATMENT PRACTICES- VEGETATED FILTER STRIPS

Vegetated Filter Strips are gradually sloped areas of land with natural or established vegetation allowed to grow with minimal to no maintenance. They are designed to receive runoff as sheet flow. The vegetation slows runoff and allows water to infiltrate as sediments settle. A level spreader may be necessary to convert runoff to sheet flow as it enters the filter strip. Vegetation may consist of meadow, forest, or a combination.

General Requirements Applicable to Vegetative Filter Strips:

- Vegetative cover type should be forest, meadow, or combination forest/meadow

### DESIGN CONSIDERATIONS

- Effectiveness of filter strip is dependent on shallow diffuse flow. Care is required to select or prepare the site, so that flow enters the filter strip as sheet flow and does not re-concentrate after entering the filter strip.
- The filter strip should be continuous for its entire length (flow path), not interrupted by other site features.

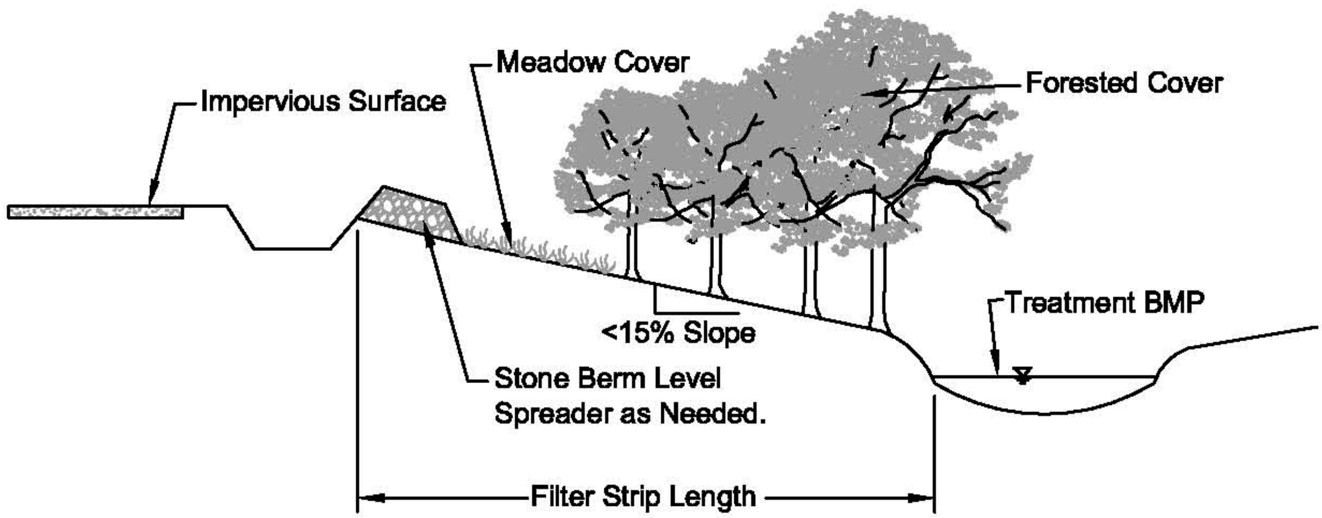
### MAINTENANCE REQUIREMENTS

- Inspect filter strip at least annually for signs of erosion, sediment buildup, or vegetation loss.
- Along the upper edge of the filter strip, the deposition of sediment may form a “berm” that obstructs flow into the filter area or concentrates flow. The filter strip and level spreader (if applicable) should be inspected at least annually to detect this condition, and accumulated sediment removed to restore sheet flow into the filter area.
- If a meadow, provide periodic mowing as needed to maintain a healthy stand of herbaceous vegetation.
- If a forested filter strip, maintain in an undisturbed condition, unless erosion occurs.
- If erosion of either forested area or meadow occurs, eroded areas should be repaired and replanted with vegetation similar to the remaining buffer. Corrective action should include eliminating the source of the erosion problem, and may require retrofit with a level spreader.
- Remove debris and accumulated sediment, based on inspection.

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Maximum Length of Overland Flow to the Filter Strip | 75 feet |
| Maximum Longitudinal Slope | 15% measured along flow path |
| Minimum Filter Strip Length | 25 feet measured along flow path |
| Filter Strip Width | Equal to width of the area draining to the strip |

## VEGETATED FILTER STRIPS

**PROFILE**



# PRE-TREATMENT SWALES

Pre-treatment swales are shallow, vegetated, earthen channels designed to convey flows, while capturing a limited amount of sediment and associated pollutants. A pre-treatment swale differs from a Treatment Swale in that the grass swale is not designed for a specified hydraulic residence time, but only for a minimum length. Therefore, pre-treatment swales do not necessarily provide sufficient time for the removal of pollutants other than those associated with larger sediment particles, and may only be used for pretreatment.

The Treatment Swale is described in this manual under Best Management Practices, and provides enhanced pollutant removal through filtration through vegetation, infiltration into underlying soils and physical settling.

General Requirements Applicable to pre-treatment swales:

- Swales are prohibited in groundwater protection areas receiving stormwater from a high-load area unless an impermeable liner is provided
- Swale shape should be trapezoidal or parabolic
- Bottom of swale should not be within the seasonal high water table.
- Swale should be vegetated.

## DESIGN CONSIDERATIONS

- Pre-treatment swales must be designed so that the flow travels the full length to receive adequate pretreatment. For this reason, flow must be directed to the inlet end of the swale, rather than the swale collecting water continuously along its length.
- Vegetation should be selected based on site soil conditions, anticipated mowing requirements (height, frequency), and design flow velocities.
- All channels should be designed for capacity and stability. A channel is designed for capacity when it can carry the maximum specified design flow within the design depth of the channel (allowing for recommended freeboard). A channel is designed for stability when the channel lining (e.g., vegetation) will not be eroded under maximum design flow velocities. Analyses of these conditions must account for both the type of lining and its condition (for example, capacity analysis for a grassed channel must consider the resistance of the maximum height of grass, while the stability analysis must consider the grass under its shortest, mowed condition).

## MAINTENANCE REQUIREMENTS

- Inspect annually for erosion, sediment accumulation, vegetation loss, and presence of invasive species.
- Perform periodic mowing; frequency depends on location and type of grass. Do not cut shorter than Water Quality Flow depth (minimum 4” (100 mm))
- Remove debris and accumulated sediment, based on inspection
- Repair eroded areas, remove invasive species and dead vegetation, and reseed with applicable grass mix as warranted by inspection.

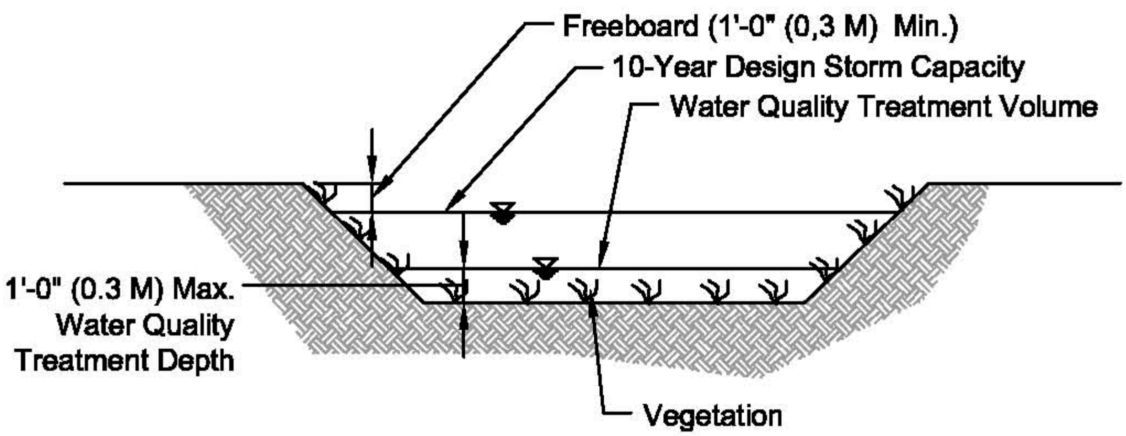
## DESIGN REFERENCES

- EPA (1999e)

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Minimum Length | ≥ 50 feet (not including portions in a roadside ditch) |
| Bottom Width | 4 to 8 feet |
| Longitudinal Slope | 0.5% to 2% without check dams<br>2% to 5% with check dams |
| Maximum Side Slopes | 3:1 |
| Flow Depth | 4 inches maximum at the WQF |
| Design Discharge Capacity | 10-year, 24-hour storm without overtopping |

## PRE-TREATMENT SWALES

**SECTION**



## PRE-TREATMENT PRACTICES- FLOW THROUGH DEVICES

The following are flow-through devices as BMP's for pre-treatment of stormwater runoff before entering a treatment practice.

- Water Quality Inlets
- Proprietary Flow-through Devices (such as Oil/Particle Separators and Hydrodynamic Separators)

**General Requirements Applicable to Flow-through Devices:**

- Design devices to manufacturer's recommendations based on the Water Quality Flow (WQF) to achieve required removal rate.
- Document that the devices remove a minimum of 80% Total Suspended Solids.
- The A/E shall verify with the local regulating authority during design to verify that flow-through devices are an acceptable method of treatment.
- The A/E shall also verify that there are at least three manufacturers of a particular device prior to using it in the design.

## PRE-TREATMENT PRACTICES- WATER QUALITY INLET

A water quality inlet is an underground storage structure with multiple chambers, designed to capture coarse sediments, floating debris, and some hydrocarbons from stormwater runoff. Such inlet devices are typically used for pretreatment of runoff prior to discharge to another treatment practice.

The devices use baffles with weirs or orifices to control flow and help capture sediment, and inverted baffles or hooded outlets to help capture floating materials. Depending on the design of the unit and the magnitude of peak flow events, the captured sediments may be subject to re-suspension and flushing from the device. Floating hydrocarbons captured in the unit can be removed for disposal during maintenance operations by skimming or by use of sorbent materials. Note, however, that hydrocarbons carried by stormwater frequently are dispersed in suspension or adsorbed to fine-grained sediment particles or organic materials, and may not necessarily be captured in the unit.

To limit potential for re-suspension of captured materials, the device is usually designed as an “off-line” unit sized for the Water Quality Flow. Larger storm events would then bypass the unit.

### DESIGN CONSIDERATIONS

- Recommended installation as an off-line device;
- Inspection and maintenance may require “confined space” safety procedures;
- Limited capacity for fine sediment removal, together with potential for re-suspension, result in limited overall pollutant removal capability. The device should only be used for pre-treatment.

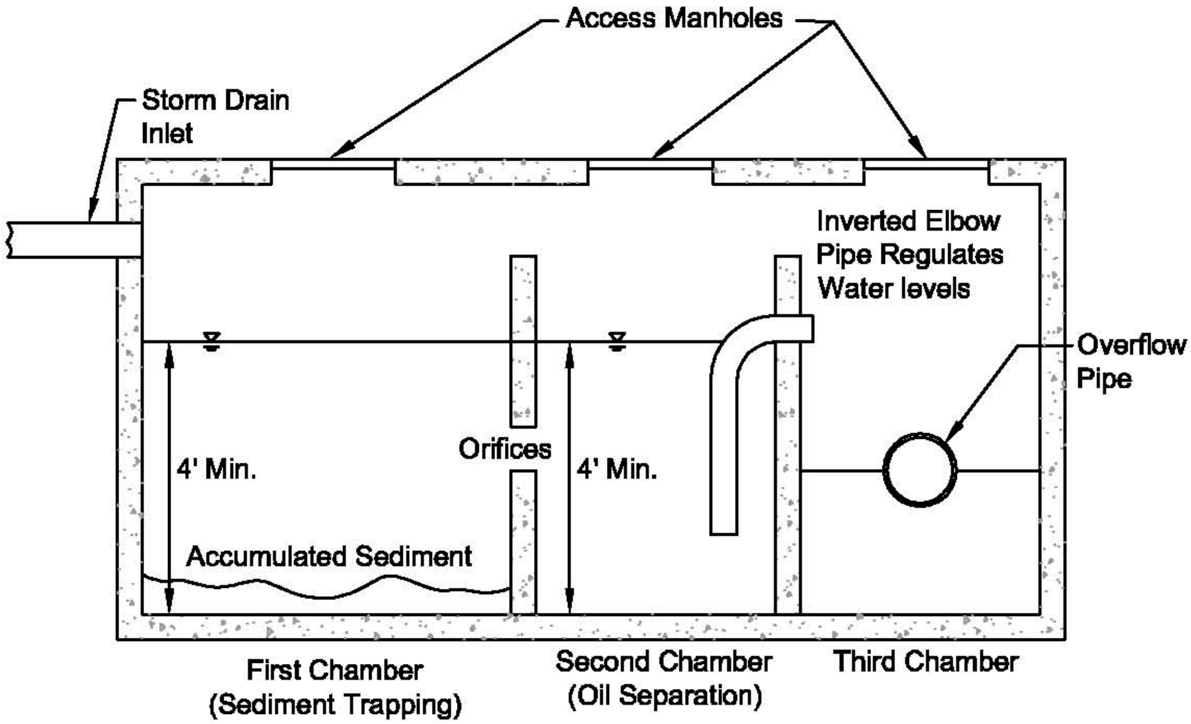
### MAINTENANCE REQUIREMENTS

- Inspect Water Quality Inlet quarterly. Remove and legally dispose of floating debris at each inspection.
- Remove sediment when inspection indicates depth is approaching half the depth to the lowest orifice or other outlet in the first chamber baffle. However, it is recommended that the unit be cleaned at least once per year;
- Remove floating hydrocarbons immediately whenever detected by • inspection;
- Dispose of sediments and other wastes in conformance with applicable local, state, and federal regulations.

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Required chamber arrangement | 3 chambers, each with separate manhole |
| Minimum Sump Depth | 4 feet |
| Combined Volume of 1st and 2nd Chamber | ≥ 400 cubic feet per acre of contributing impervious area |
| Maximum recommended contributing area | < 1 acre of impervious area |

## WATER QUALITY INLET

**PROFILE**



## PRE-TREATMENT PRACTICES- HYDRODYNAMIC SEPARATORS AND OIL/PARTICLE SEPARATORS

Several manufacturers offer a number of proprietary flow-through stormwater treatment devices. These devices are variously referred to as “oil/particle separators,” “oil/grit separator,” or “hydrodynamic separators.” Some of these devices use multiple chambers arranged horizontally or vertically to help trap and retain sediments and floating substances. Some use internal components to promote a swirling flow path to help enhance removal and retention of sediment.

These flow-through devices are normally sited close to the source of runoff, often receiving stormwater from relatively small areas that are mostly, if not entirely, impervious surface. They may only be used as pretreatment of stormwater prior to discharge to other treatment BMPs.

Because runoff is detained briefly in conventional separators, only moderate removal of coarse sediments, oil and grease can be expected. Soluble pollutants, fine-grained sediment, and pollutants attached to the sediment such as trace metals or nutrients will likely pass through the separator.

With their comparatively small size and underground installation, they can be conveniently located to facilitate access for inspection and maintenance. However, given their limited capacity they require frequent maintenance. Also, because they are enclosed underground structures, selection, design, and installation should consider whether maintenance activities will be subject to confined-space safety procedures.

### DESIGN CONSIDERATIONS

- Flow-through units must be installed as an off-line device;
- Inspection and maintenance may require “confined space” safety procedures;
- Limited capacity for removal of fine sediment and dissolved contaminants may result in limited overall pollutant removal capability. The devices may only be used for pre-treatment.

### MAINTENANCE REQUIREMENTS

- Inspect quarterly, or more frequently as recommended by manufacturer. Remove and legally dispose of floating debris at each inspection.
- Based on inspection, remove sediment when it reaches level specified by manufacturer. However, it is recommended that the unit be cleaned at least once per year, or more frequently as recommended by manufacturer;
- Remove floating hydrocarbons immediately whenever detected by inspection;
- Dispose of sediments and other wastes in conformance with applicable local, state, and federal regulations.

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Minimum Sump Depth | 4 feet |
| Maximum Drainage Area | 1 acre of impervious area |
| Minimum Permanent Pool Storage Volume | 400 cubic feet per acre of contributing impervious area |
| Maximum contributing impervious drainage area | ≤ 1 acre |
| Off-line configuration | Required |
| Manhole access | Each chamber must be accessible by separate manhole |

## PRE-TREATMENT PRACTICES- DEEP SUMP CATCH BASIN

A deep sump catch basin consists of a manhole-type structure with an inlet grate, an outlet pipe connected to the piped drainage system, and a sump with a depth several times the diameter of the outlet pipe. The inlet grate is located at the surface, and is sometimes combined with a vertical inlet integrated with a street or parking area curb. The sump's purpose is to capture coarse sediments and debris from the runoff intercepted by the structure. The outlet pipe can be fitted with a "hood" consisting of a cast metal or formed plastic fitting, designed to prevent floating materials from exiting the structure.

Deep sump catch basins used as pretreatment are most effective if sited "off-line" since flow-through basins are more susceptible to sediment re-suspension. The outlet hood provides benefits for trapping floating trash, as well as for short-term spill containment.

### DESIGN CONSIDERATIONS

- Deep sump catch basins used as pretreatment devices must be located "off-line."
- Hoods may be susceptible to displacement or damage from cleaning activities. This should be considered in the configuration of the tops of structures (e.g., use of eccentric cones or flat tops with the inlet off-set from alignment with the hood) to minimize risk of damage from cleaning equipment. However, the configuration should also permit access for repositioning or replacing the hood.

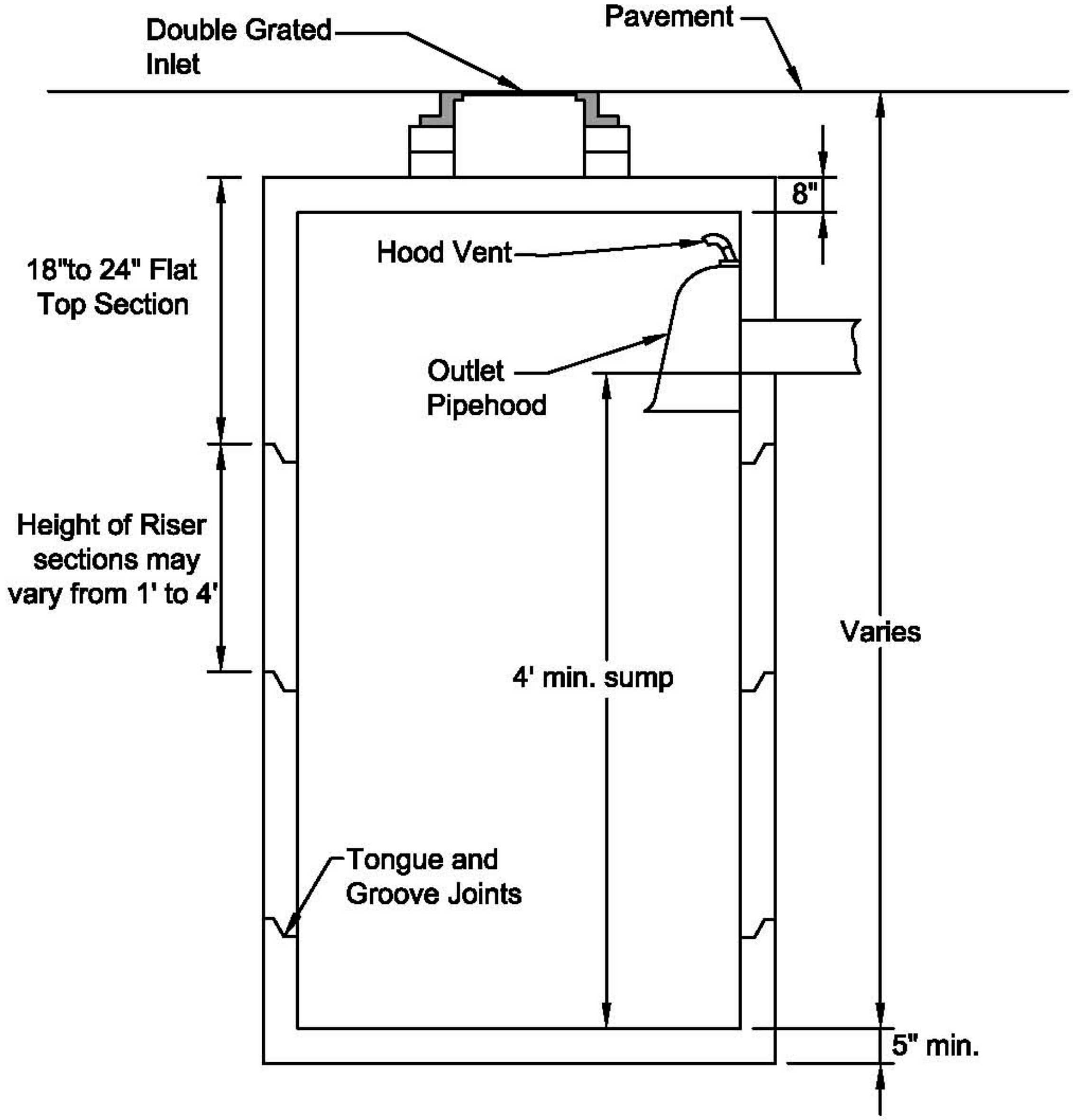
### MAINTENANCE REQUIREMENTS

- Catch basins may require frequent maintenance. Depending on location, this may require several cleanings of the sumps each year. At a minimum, it is recommended that catch basins be inspected at least twice annually, once following snow-melt and once following leaf-drop, and cleaned as indicated by inspection.
- Sediment should be removed when it approaches half the sump depth.
- If floating hydrocarbons are observed during an inspection, the material should be removed immediately by skimming, absorbent materials, or other method and disposed in conformance with applicable state and federal regulations.
- Cleaning may require Vacuum-truck instead of "clam-shell" to avoid damage to hood.
- Damaged hoods should be replaced when noted by inspection

| DESIGN CRITERIA | |
|---|---|
| **Design Parameter** | **Gradation of Material** |
| Maximum Drainage Area | ≤ 0.25 acres of impervious area |
| Off-line configuration (no storm drain inlet pipes to the device) | Required |
| Minimum Catch Basin Diameter | 4 feet |
| Depth from Outlet Invert to Sump Bottom | ≥ 4 times the diameter of the outlet pipe |
| Hooded Outlet | Required. Horizontal hood opening ≥ |

## DEEP SUMP CATCH BASIN

**PROFILE**



# APPENDIX C

# SEDIMENT CONTROL BEST MANAGEMENT PRACTICES

## SILT FENCE

Silt fences have a useful life of one season. They function primarily to slow and pond the water and allow soil particles to settle. Silt fences are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Their use is limited to areas where overland sheet flows are expected.

Silt fence is a sediment control practice, not an erosion control practice. It is intended to be used in conjunction with other practices that do prevent or control erosion. Improperly applied or installed silt fence will increase erosion.

Silt fences should not be used across streams, channels, swales, ditches or other drainage ways. Silt fences are not capable of effectively filtering the high rates and volumes of water associated with channelized flow. Silt fences should not be designed to impound sediment or water more than 18 inches high. Silt fences installed across a concentrated flow path are subject to undercutting, end cutting, and overtopping. This frequently not only results in the bypass of sediment laden-water, but also in the complete failure of the fence. Such failures typically release the sediment accumulated on the up gradient side of the fence, and severe erosion of the channel both upstream and downstream of the fence.

### DESIGN CONSIDERATIONS

- Silt fence barriers are used where:
  - Flow to the silt fence from a disturbed area occurs as overland sheet flow.
  - Sedimentation can pollute or degrade adjacent wetlands or watercourses.
  - Sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.
  - The contributing drainage area is less than 1/4 acre per 100 feet of barrier length, the maximum length of slope above the barrier is 100 feet, and the maximum gradient behind the barrier is 50%(2:1). If any of these conditions are exceeded, other measures may be necessary to control erosion and to intercept and treat the sediment load.
  - Sediment barriers should not be used in areas of concentrated flows. Under no circumstances should silt fences be constructed in streams or in swales where there is the possibility of a washout.
- Silt fences (synthetic filter) can be used for 60 days or longer depending on ultraviolet stability and manufacturer’s recommendations. However, silt fences generally have a useful life of one season, and should be periodically replaced on longer duration construction projects.
- Silt fencing generally is a better barrier than hay bale barriers.
- Potential causes of silt fence failure include:
  - Improper placement on the site;
  - Allowing excessive drainage area to the silt fence structure;
  - Inadequate trenching depth and improper backfill and compaction of the bottom of the silt fence fabric;
  - Improper attachment to posts;
  - Inadequate maintenance of the silt fence after installation;
  - Installing silt fence with a descending grade along the fence alignment, resulting in the diversion or concentration of runoff.
  - Placement of fence at mid-slope of a cut or fill embankment. Because a silt fence works by impounding water, it should be placed at the toe of such slopes, to allow for this function, and to avoid potential diversion or concentration of flows.

## STRAW AND HAY BALE BARRIER

Straw or hay bale barriers have a useful life of less than six months. They function primarily to slow and pond the water and allow soil particles to settle. They are not designed to withstand high heads of water, and therefore should be located where only shallow pools can form. Their use is limited to areas that only contribute sheet flow to the device.

Straw or hay bale barriers constitute a sediment control practice, not an erosion control practice. The must be used in conjunction with other practices that do prevent or control erosion. Improperly applied or installed sediment barriers will increase erosion.

Straw or hay bale barriers should generally not be used across streams, channels, swales, ditches or other drainage ways or areas with concentrated flows. Such barriers are not capable of effectively filtering the high rates and volumes of water associated with channelized flow. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than an acre, and provide for frequent monitoring of the barrier. Straw or hay bale barriers installed across a concentrated flow path are subject to undercutting, end cutting, and overtopping. This frequently not only results in the bypass of sediment laden-water, but also in the complete failure of the barrier. Such failures typically release the sediment accumulated on the up gradient side of the barrier, and severe erosion of the channel both upstream and downstream of the device.

### DESIGN CONSIDERATIONS

- Straw or hay bale barriers principally trap sediment by temporarily ponding water, allowing particles to settle. These barriers are not designed to withstand high heads of water; therefore they should be located where only shallow pools can form. Straw or hay bale barriers are used where:
  - Flow to the barrier from a disturbed area occurs as overland sheet flow.
  - Sedimentation can pollute or degrade adjacent wetlands or watercourses.
  - Sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.
  - The contributing drainage area is less than 1/4 acre per 100 feet of barrier length, the maximum length of slope above the barrier is 100 feet, and the maximum gradient behind the barrier is 50% (2:1). If any of these conditions are exceeded, other measures may be necessary to control erosion and to intercept and treat the sediment load.
  - Sediment barriers should not be used in areas of concentrated flows. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than one acre, and provide for frequent monitoring of the barrier. Under no circumstances should sediment barriers be constructed in live streams or in swales where there is the possibility of a washout.
- Straw or hay bales should only be used as a temporary barrier for no longer than 60 days.
- Potential causes of straw or hay bale barrier failure include:
  - Improper placement on the site;
  - Allowing excessive drainage area to the barrier;
  - Inadequate keying of the bales into the ground surface;
  - Inadequate maintenance after installation

## EROSION CONTROL MIX BERMS

The erosion control mix berms are installed across or at the toe of a slope, to intercept and retain small amounts of sediment from disturbed or unprotected areas.

Erosion control mix berms and socks sometimes offer a better solution than silt fence and other sediment control methods, because the organic material does not require any special trenching, construction, or removal, unlike straw bales, silt fence or coir rolls. This makes the technique very cost-effective.

The erosion control mix is organic, biodegradable, renewable, and can be left onsite. This is particularly important below embankments near streams, as re-entry to remove or maintain a synthetic barrier can cause additional disturbance. Silt fence has to be disposed of as a solid waste, and is often left abandoned on job sites.

Erosion control mix berms can be easily and quickly fixed, if they are disturbed in the course of construction activity.

### DESIGN CONSIDERATIONS

The berm is used where:

- Sedimentation can pollute or degrade adjacent wetland and/or watercourses.
- Sedimentation will reduce the capacity of storm drainage systems or adversely affect adjacent areas.
- The contributing drainage area is less than 1/4 acre per 100 feet of barrier length, the maximum length of slope above the barrier is 100 feet, and the maximum gradient behind the barrier is 5%. If the slope length is greater, other measures such as diversions may be necessary to reduce the slope length.
- Sediment barriers should not be used in areas of concentrated flows. Under no circumstances should erosion control mix barriers be constructed in live streams or in swales where there is the possibility of a washout.
- Sediment barriers are effective only if installed and maintained properly.
- Sediment barriers should be installed prior to any soil disturbance of the contributing drainage area above them.
- Frozen ground, outcrops of bedrock and very rooted forested areas are locations where berms of erosion control mix are most practical and effective.
- Other BMPs should be used at low points of concentrated runoff, below culvert outlet aprons, around catch basins and closed storm systems, and at the bottom of steep perimeter slopes.

## TEMPORARY CHECK DAMS

Check dams may also trap small amounts of sediment generated in the ditch itself. However, the check dam is not a sediment trapping practice and should not be used as such.

The practice is limited to use in small open channels that drain one acre or less. It should not be used in either perennially flowing streams or intermittent stream channels.

Check dams can be constructed of stone. In locations where stone is not available, timber check dams may be considered. Typical applications include temporary or permanent ditches or swales, which need protection during the establishment of grass linings.

Hay or straw bales should generally not be used as check dams, or in any location where there is concentrated flow. However, they may be used for check dams in applications where installation access or other conditions prevent the use of preferred materials such as stone; in such cases, installation must provide proper embedment of the straw or hay bale barrier, limit contributing drainage area to less than one acre, and provide for frequent monitoring of the barrier.

### DESIGN CONSIDERATIONS

- This practice is intended for use in areas of concentrated flow, but must not be used in stream channels (whether perennial or intermittent).
- The check dam may be left in place permanently to avoid unnecessary disturbance of the soil on removal, but only if the project design has accounted for their hydraulic performance and construction plans call for them to be retained.
- If it is necessary to remove a stone check dam from a grass-lined channel that will be mowed, care should be taken to ensure that all stones are removed. This includes stone that has washed downstream.

## TEMPORARY STORM DRAIN INLET PROTECTION

The purpose of storm drain inlet protection is to prevent sediment from entering a storm drainage system prior to permanent stabilization of the contributing disturbed area. Storm drains made operational before their drainage areas are stabilized can convey large amounts of sediment to storm sewer systems or natural drainage ways. In some cases, the storm drain itself may accumulate sufficient sediment to significantly reduce or eliminate its conveyance capacity. To avoid these problems, it is necessary to prevent sediment from entering the system at the inlets.

### DESIGN CONSIDERATIONS

- This practice applies primarily to enclosed drainage systems.
- This practice includes several types of inlet barriers, the use of which may depend on site conditions and the type of inlet. Other techniques for accomplishing the same purpose may be used, but they should be installed only after careful study of their effectiveness.
- This practice is effective in reducing coarse grain suspended particles from runoff. Silt and clay particles will bypass the inlet protection.
- The inlet protection practices are for drainage areas of less than one acre. Runoff from large disturbed areas should be routed through a sediment trap or sediment basin.
- The best way to prevent sediment from entering the storm sewer system is to stabilize the site as quickly as possible, preventing erosion and stopping sediment at its source.

## TEMPORARY CONSTRUCTION EXIT

### DESIGN CONSIDERATIONS

- Only construction traffic leaving the site is required to use the temporary stabilized exit. Consider providing a separate, unprotected, entrance for traffic entering the site. This will increase the longevity of the stabilized exit by eliminating heavy loads entering the site and reducing the total traffic over the device.
- Locate construction entrances and exits to limit sediment leaving the site and to provide for maximum utility by all construction vehicles. Avoid entrances that have steep grades and entrances at curves in public roads.
- The entrance should be maintained in a condition that will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand, and repair and/or maintenance of any measures used to trap sediment.

## SEDIMENT TRAP

### DESIGN CONSIDERATIONS

- A sediment trap should be installed as close as possible to the disturbed area or sediment source.
- Sediment traps should be used in drainage ways with small watersheds (contributing drainage area less than 5 acres). For larger contributing areas, engineered sediment basins should be used instead.
- Sediment traps should be installed where runoff from undisturbed areas can be excluded from the trap.
- Traps should be located to obtain maximum storage benefit from the terrain, as well as for ease of removal and disposal of accumulated sediment.

## TEMPORARY SEDIMENT BASIN

Sediment basins may be made by constructing a dam or embankment or by excavating a depression.

Sediment basins differ from sediment traps, in that basins are engineered impoundment structures, and may serve larger areas than sediment traps.

The sediment basin's is designed to:

- Detain stormwater volume and slowly release it to the downstream waterways;
- Trap sediment originating from construction site and prevent subsequent deposition in downstream drainage waterways;
- Provide storage of the trapped sediment and debris.

### DESIGN CONSIDERATIONS

- Sediment basins should only be used where the following conditions exist:
  - Failure of the dam will not result in loss of life; damage to homes, commercial or industrial buildings, main highways, or railroads; or interruption of the use or service of public utilities.
- It is possible to use a basin that is designed for eventual permanent use as a detention basin or water quality treatment facility for the final constructed project. However, this practice should not be undertaken unless specifically provided in the design of the project, and authorized by the design engineer. In some cases, the long-term operating integrity of a basin can be adversely affected by temporary use as a sediment basin (such as potential clogging of soils intended to provide future infiltration function).
- A sediment basin should be installed as close as possible to the disturbed area or sediment source.
- Sediment basins should be installed where runoff from undisturbed areas can be excluded from the structure.
- Sediment basins mostly trap coarse-grained sediments. Fine-grained sediments such as silts and clays will remain suspended in the water and will travel off-site unless the water is detained for an extended period of time, or unless other treatment measures (such as use of flocculants) are implemented to enhance settling of these materials.
- Sediment basins, like detention ponds, can result in warmer water temperatures than the natural condition. Care must be exercised to not locate discharges from sediment basins near to cold-water streams.
- Pond locations and construction activities may affect downstream water quality, wetlands and water-related wildlife habitats. These conditions must be considered in the design.
- Overall planning and design should be carefully considered to minimize the number of sediment basins required.

## CONSTRUCTION DEWATERING

Construction sites typically require construction dewatering operations. Excavations that do not "daylight" to existing grade trap either rainwater or groundwater, and cofferdams collect rain, ground or seepage water within the work area. This water needs to be removed before certain operations can be performed or to keep work conditions safe. Contractors typically use ditch pumps to dewater these enclosed areas. If care is not taken to select the point of discharge and provide adequate treatment, the pumped water may discharge to down gradient natural resources such as lakes, wetlands, or streams, with subsequent sedimentation of those water bodies.

Construction dewatering activities must be conducted to:

- Prevent the discharged water from eroding soil on the site.
- Remove sediment from the collected water.
- Preserve down gradient natural resources and property.
- Choose the best location for discharge in order to meet the above objectives.

### DESIGN CONSIDERATIONS

- The discharge areas should be chosen with careful consideration to the down gradient water resources and the existing landscape's ability to treat water flows from the dewatering process. Wooded buffers and flat to moderate slopes provide the best opportunity for filtration and absorption of such discharges.
- Care must be exercised to prevent contact of water from construction dewatering with oil, grease, other petroleum products, or toxic and hazardous materials. Contaminated runoff must be contained, treated, and discharged or removed in accordance with EPA requirements.
- All requirements of state law and permit requirements of local, state, and federal agencies must be met, including the Construction Dewatering General permit for projects that propose to discharge construction dewatering water to wetlands, intermittent streams, or other surface waters.
- The discharge should be stopped immediately if the receiving area shows any sign of instability or erosion.