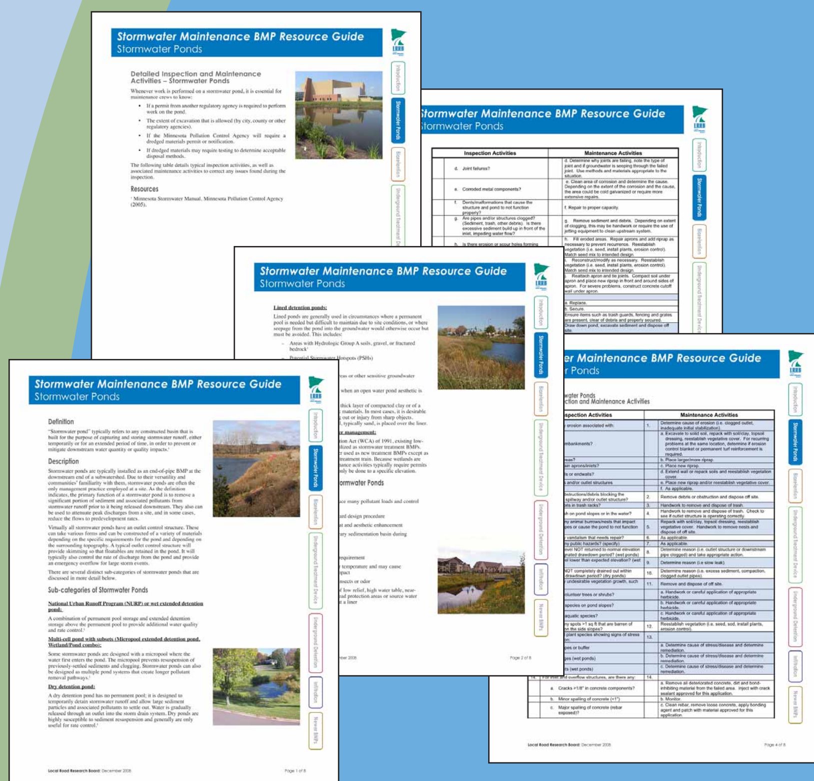
RESEARCH

2009RIC12

Stormwater Maintenance BMP Resource Guide



LRRB
LOCAL ROAD RESEARCH BOARD

Take the steps... Research...Knowledge...Innovative Solutions!

Transportation Research

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
MN/RC – 2009RIC12		

4. Title and Subtitle	5. Report Date
Stormwater Maintenance BMP Resource Guide	January 2009
	6.
7. Author(s) Michael Marti, Joni Giese, Lisa Goddard	8. Performing Organization Report No.
9. Performing Organization Name and Address SRF Consulting Group, Inc. One Carlson Parkway North, Suite 150 Minneapolis, MN 55477-4443	10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. 90351, RIC Task 12
12. Sponsoring Organization Name and Address Minnesota Department of Transportation Research Services Section 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes

http://www.lrrb.org/PDF/2009RIC12.pdf

16. Abstract (Limit: 200 words)

The use of stormwater treatment strategies, often referred to as Best Management Practices (BMPs), has increased significantly due to new stormwater regulations. These regulations also require governmental units to develop a systematic approach for the documentation of BMP inspection and maintenance as BMPs require on-going inspection and maintenance to ensure that they are achieving their desired treatment goals.

The resource guide was created to supplement the MN Stormwater Manual in regards to local government inspection and maintenance activities associated with various BMP categories. It can be used as a tool by city staff and policy makers for evaluating various BMPs to install based on anticipated long-term maintenance requirements.

This reference guide focuses primarily on BMPs that have been heavily used in Minnesota (Stormwater Ponds, Bioretention Basins, Underground Treatment Devices, Underground Detention, Infiltration) and concludes with a brief section covering BMPs that are newer to Minnesota and have been less commonly used to date (Sand/Media Filtration, Pervious Pavements, Tree Pits and Stormwater Planters). This section provides a description of the BMPs, a list of some Minnesota applications of the BMPs and resource documents for further exploration

17. Document Analysis/Descriptors		18.Availability Statement
stormwater maintenance stormwater inspection stormwater BMP stormwater regulations stormwater ponds bioretention basins underground treatment devices	underground detention infiltration sand filtration media filtration pervious pavement porous pavement stormwater planters	No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	44	

The Minnesota LRRB has developed a Stormwater Maintenance Best Management Practices (BMP) Resource Guide that is designed to provide technical staff, policy and decision makers with guidance on inspection and maintenance activities for various categories of BMPs. This reference guide focuses primarily on the following BMPs that have been heavily used in Minnesota:

a. Stormwater Ponds
b. Bioretention Facilities
c. Underground Treatment Devices
d. Underground Detention/Retention
e. Infiltration

At the time of printing, this report is a synthesis of the Technical Assistance Panel (TAP) consensus of the most useful information for application in Minnesota.

The inspection and maintenance checklists provided in this report can be downloaded from the LRRB website (www.lrrb.org Search: stormwater maintenance) in electronic Excel spreadsheet format, so that agencies can edit them for their specific situation.

Acknowledgements

The authors would like to thank the following individuals and organizations for their contributions to this document:

Technical Advisory Panel

Mark Maloney, City of Shoreview (Chair)
Doug Carter, Bolton and Menk
Dave Filipiak, SRF Consulting Group, Inc.
Kristine Giga, City of Roseville
Tim Gross, Three Rivers Park District
Mike Hanson, Mower County
Paul Kauppi, City of Woodbury
Jim Kosluchar, City of Fridley
Bruce Loney, City of Shakopee
Bob Moberg, City of Plymouth
Joe Pelwa, Hakanson-Anderson
Alan Rindels, Mn/DOT
Dave Robley, Douglas County
Joel Schilling, Schilling Consultants
Jesse Struve, City of Edina
Bruce Westby, City of Monticello

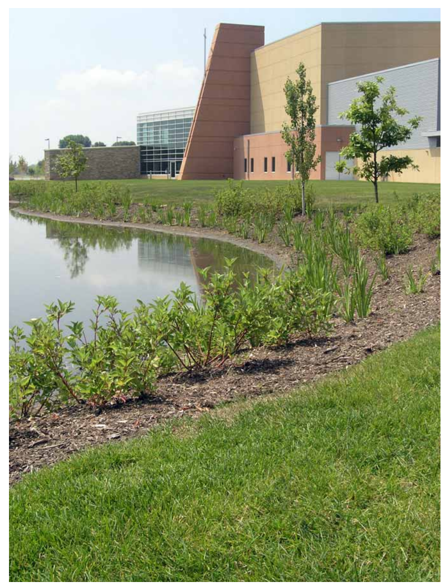
Stormwater Maintenance BMP Resource Guide
Introduction

The use of stormwater treatment strategies, often referred to as Best Management Practices (BMPs), has increased significantly due to new stormwater regulations. These regulations also require governmental units to develop a systematic approach for the documentation of BMP inspection and maintenance as BMPs require on-going inspection and maintenance to ensure that they are achieving their desired treatment goals.

A resource guide that addresses local government inspection and maintenance activities for various categories of BMP devices does not currently exist, and as a result, cities participating on the Local Road Research Board (LRRB) requested that this reference guide be created to supplement the Minnesota Stormwater Manual in regards to maintenance. The cities also requested that the reference guide function as a tool to help them decide which BMP category to select based on siting and long-term maintenance requirements.

This reference guide focuses primarily on BMPs that have been heavily used in Minnesota, such as stormwater ponds, bioretention basins, and underground treatment devices. The reference guide concludes with brief sections covering BMPs that are newer to Minnesota and have been less commonly used to date. In these instances, the reference guide provides a description of the BMPs, some Minnesota applications of the BMPs, and resources for further exploration.

History and Regulatory Requirements



The federal Clean Water Act of 1977 (CWA) provided a mandate for states to begin to address both point source and nonpoint source discharges of pollutants into the nation's surface waters. 'The statute employs a variety of regulatory and nonregulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff.' (www.epa.gov/watertrain/cwa/) In the early years, implementation of the CWA focused on controlling point source pollution (waste water treatment plans, etc.) with the issuance of National Pollution Discharge Elimination System (NPDES) permits. Starting in the late 1980s, efforts to regulate stormwater runoff, or nonpoint source pollution, increased significantly through the issuance of NPDES general permits. In Minnesota, the Minnesota Pollution Control Agency (MPCA) administers the various regulatory programs of the CWA.

Minnesota, through the 1982 Metropolitan Water Management Program (Minnesota Statutes, Section 103B.201, et seq.), the 1990 Comprehensive Local Water Management Program (M.S., Section 103B.311 et seq.) and Watershed Law (M.S. Chapter 103D) requires planning and implementation strategies for the control of water quantity and quality. On a regional level, specifically the metropolitan area, watershed management organizations have incorporated planning and regulations through watershed plans and implemented specific projects to protect waters in their respective jurisdiction. On a local level, cities and counties are charged with implementing strategies to meet the various federal and state regulatory requirements to control nonpoint source pollution.

Inspection and Maintenance Considerations

It is common knowledge that changing the oil in our cars at a regular interval is important for the car to operate at peak efficiency and achieve its expected lifespan. Stormwater BMPs are similar in that they operate at their greatest efficiency when properly maintained. In most applications, stormwater BMPs are designed to provide a specific pollutant removal efficiency given a fully functioning system. Most are designed with the laws of physics in mind, using a specific volume and/or surface area to settle or remove particles of sediment for a specific contributing subwatershed. The available volume decreases over time as it fills with debris and sediment, and as such, the BMP's efficiency also decreases to the point of being non-functioning if not maintained. Depending on the type of BMP and the methodology used to design it, the BMP may become "full" after just one year or after several years. Sometimes a "full" BMP may appear as if it is working, when in reality it is not functioning as designed. Therefore, regular inspection and maintenance is required to ensure that adequate volume is provided and that the outlet is not plugged and liable to cause flooding upstream.

As infiltration requirements are enacted, the BMPs selected will require higher levels of care to maintain their functionality. BMPs such as bioretention basins rely on soil permeability as well as biological processes and infiltration to provide treatment, especially of nutrients. In these instances, it is important that the plant communities are healthy for the system to function as predicted and achieve the desired life cycle.

To comply with the MPCA's requirements for Municipal Separate Storm Sewer Systems (MS4) permits, all BMPs must be inspected at least once every 5 years with a goal of 20 percent of an agency's BMPs being inspected annually. However, city and county engineers and maintenance crews understand that certain stormwater treatment facilities in their system may require more frequent inspections and/or maintenance than others. In order to effectively maintain stormwater facilities, cities and counties may want to specify a storm event that triggers inspection activities for these select locations. For example, an inspection event may be characterized as a rainfall of one inch over a 30 minute period which qualifies as a two-year event in some sections of the state.

It is not always possible to tell visually whether a BMP is functioning properly.

BMPs that are In-place and Heavily used in Minnesota

This reference guide focuses primarily on the following BMPs that have been heavily used in Minnesota:

a. Stormwater Ponds
b. Bioretention Facilities
c. Underground Treatment Devices
d. Underground Detention
e. Infiltration

Information provided for each major category of BMP includes:

– Definition of the BMP
– Description of the BMP treatment function
– Descriptions for distinct BMP sub-categories
– Benefits/Limitations of the technique
– Detailed inspection and maintenance activities
– Example inspection report forms
– Resources

Introduction
Stormwater Ponds
Bioretention
Underground Treatment Device
Underground Detention
Infiltration
Newer BMPs

Definition

"Stormwater pond" typically refers to any constructed basin that is built for the purpose of capturing and storing stormwater runoff, either temporarily or for an extended period of time, in order to prevent or mitigate downstream water quantity or quality impacts.[1]

Description

Stormwater ponds are typically installed as an end-of-pipe BMP at the downstream end of a subwatershed. Due to their versatility and communities' familiarity with them, stormwater ponds are often the only management practice employed at a site. As the definition indicates, the primary function of a stormwater pond is to remove a significant portion of sediment and associated pollutants from stormwater runoff prior to it being released downstream. They also can be used to attenuate peak discharges from a site, and in some cases, reduce the flows to predevelopment rates.

Virtually all stormwater ponds have an outlet control structure. These can take various forms and can be constructed of a variety of materials depending on the specific requirements for the pond and depending on the surrounding topography. A typical outlet control structure will provide skimming so that floatables are retained in the pond. It will typically also control the rate of discharge from the pond and provide an emergency overflow for large storm events.

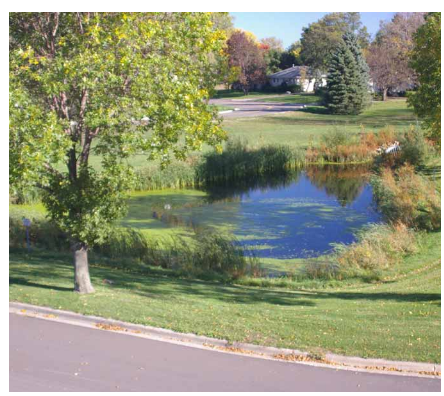
There are several distinct sub-categories of stormwater ponds that are discussed in more detail below.

Sub-categories of Stormwater Ponds

National Urban Runoff Program (NURP) or wet extended detention pond:

A combination of permanent pool storage and extended detention storage above the permanent pool to provide additional water quality and rate control.[1]

Multi-cell pond with subsets (Micropool extended detention pond, Wetland/Pond combo):



Some stormwater ponds are designed with a micropool where the water first enters the pond. The micropool prevents resuspension of previously-settled sediments and clogging. Stormwater ponds can also be designed as multiple pond systems that create longer pollutant removal pathways.[1]

Dry detention pond:

A dry detention pond has no permanent pool; it is designed to temporarily detain stormwater runoff and allow large sediment particles and associated pollutants to settle out. Water is gradually released through an outlet into the storm drain system. Dry ponds are highly susceptible to sediment resuspension and generally are only useful for rate control.[1]

Lined detention ponds:

Lined ponds are generally used in circumstances where a permanent pool is needed but difficult to maintain due to site conditions, or where seepage from the pond into the groundwater would otherwise occur but must be avoided. This includes:

- Areas with Hydrologic Group A soils, gravel, or fractured bedrock[1]
- Potential Stormwater Hotspots (PSHs)
- Karst terrain[1]
- Wellhead Protection Areas or other sensitive groundwater recharge areas

Lined ponds also may be used when an open water pond aesthetic is desired.

Liners can be constructed of a thick layer of compacted clay or of a variety of proprietary synthetic materials. In most cases, it is desirable to protect the liner from drying out or injury from sharp objects. Sometimes a covering material, typically sand, is placed over the liner.

Wetlands used for stormwater management:

Prior to the Wetland Conservation Act (WCA) of 1991, existing low-quality wetlands were often utilized as stormwater treatment BMPs. Existing wetlands are no longer used as new treatment BMPs except as a final device in a stormwater treatment train. Because wetlands are regulated waterbodies, maintenance activities typically require permits and removal of sediment can only be done to a specific elevation.

Benefits/Limitations of Stormwater Ponds

Benefits[1]

- Able to effectively reduce many pollutant loads and control runoff flow rates
- Relatively straightforward design procedure
- Potential wildlife habitat and aesthetic enhancement
- May be used as temporary sedimentation basin during construction

Limitations[1]

- Relatively large space requirement
- Tends to increase water temperature and may cause downstream thermal impact
- Potential for nuisance insects or odor
- Problematic for areas of low relief, high water table, near-surface bedrock, wellhead protection areas or source water protection areas without a liner

Detailed Inspection and Maintenance Activities – Stormwater Ponds

Whenever work is performed on a stormwater pond, it is essential for maintenance crews to know:

- If a permit from another regulatory agency is required to perform work on the pond.
- The extent of excavation that is allowed (by city, county or other regulatory agencies).
- If the Minnesota Pollution Control Agency will require a dredged materials permit or notification.
- If dredged materials may require testing to determine acceptable disposal methods.

The following table details typical inspection activities, as well as associated maintenance activities to correct any issues found during the inspection.

Resources

[1] Minnesota Stormwater Manual, Minnesota Pollution Control Agency (2005).

Table 1: Stormwater Ponds
Detailed Inspection and Maintenance Activities

Inspection Activities		Maintenance Activities	
1.	Is there any erosion associated with:	1.	Determine cause of erosion (i.e. clogged outlet, inadequate initial stabilization).
	a. Slopes/embankments?		a. Excavate to solid soil, repack with soil/clay, topsoil dressing, reestablish vegetative cover. For recurring problems at the same location, determine if erosion control blanket or permanent turf reinforcement is required.
	b. Riprap areas?		b. Place larger/more riprap.
	c. Storm drain aprons/inlets?		c. Place new riprap.
	d. Headwalls or endwalls?		d. Extend wall or repack soils and reestablish vegetation cover.
	e. Spillways and/or outlet structures		e. Place new riprap and/or reestablish vegetative cover.
	f. Other?		f. As applicable.
2.	Are there obstructions/debris blocking the emergency spillway and/or outlet structure?	2.	Remove debris or obstruction and dispose off site.
3.	Is there debris in trash racks?	3.	Handwork to remove and dispose of trash.
4.	Is there trash on pond slopes or in the water?	4.	Handwork to remove and dispose of trash. Check to see if outlet structure is operating correctly.
5.	Are there any animal burrows/nests that impact pond fill slopes or cause the pond to not function properly?	5.	Repack with soil/clay, topsoil dressing, reestablish vegetative cover. Handwork to remove nests and dispose of off site.
6.	Is there any vandalism that needs repair?	6.	As applicable.
7.	Are there any public hazards? (specify)	7.	As applicable.
8.	Has water level NOT returned to normal elevation within designated drawdown period? (wet ponds)	8.	Determine reason (i.e. outlet structure or downstream pipe clogged) and take appropriate action.
9.	Is water level lower than expected elevation? (wet pond)	9.	Determine reason (i.e slow leak).
10.	Has water NOT completely drained out within designated drawdown period? (dry ponds)	10.	Determine reason (i.e. excess sediment, compaction, clogged outlet pipes).
11.	Is there any undesirable vegetation growth, such as:	11.	Remove and dispose of off site.
	a. Young, volunteer trees or shrubs?		a. Handwork or careful application of appropriate herbicide.
	b. Invasive species on pond slopes?		b. Handwork or careful application of appropriate herbicide.
	c. Invasive aquatic species?		c. Handwork or careful application of appropriate herbicide.
12.	Are there any spots >1 sq ft that are barren of vegetation on the side slopes?	12.	Reestablish vegetation (i.e. seed, sod, install plants, erosion control).
13.	Are desired plant species showing signs of stress or disease on:	13.	
	a. Pond slopes or buffer		a. Determine cause of stress/disease and determine remediation.
	b. Pond edges (wet ponds)		b. Determine cause of stress/disease and determine remediation.
	c. Emergents (wet ponds)		c. Determine cause of stress/disease and determine remediation.
14.	For inlet and overflow structures, are there any:	14.	
	a. Cracks >1/8" in concrete components?		a. Remove all deteriorated concrete, dirt and bond-inhibiting material from the failed area. Inject with crack sealant approved for this application.
	b. Minor spalling of concrete (<1")		b. Monitor.
	c. Major spalling of concrete (rebar exposed)?		c. Clean rebar, remove loose concrete, apply bonding agent and patch with material approved for this application.

	Inspection Activities		Maintenance Activities
	d. Joint failures?		d. Determine why joints are failing, note the type of joint and if groundwater is seeping through the failed joint. Use methods and materials appropriate to the situation.
	e. Corroded metal components?		e. Clean area of corrosion and determine the cause. Depending on the extent of the corrosion and the cause, the area could be cold galvanized or require more extensive repairs.
	f. Dents/malformations that cause the structure and pond to not function properly?		f. Repair to proper capacity.
	g. Are pipes and/or structures clogged? (Sediment, trash, other debris). Is there excessive sediment build up in front of the inlet, impeding water flow?		g. Remove sediment and debris. Depending on extent of clogging, this may be handwork or require the use of jetting equipment to clean upstream system.
	h. Is there erosion or scour holes forming around inlets?		h. Fill eroded areas. Repair aprons and add riprap as necessary to prevent recurrence. Reestablish vegetation (i.e. seed, install plants, erosion control). Match seed mix to intended design.
	i. Is structure misaligned? Has it settled?		i. Reconstruct/modify as necessary. Reestablish vegetation (i.e. seed, install plants, erosion control). Match seed mix to intended design.
	j. Are aprons failing (disconnected or becoming disconnected from pipe)?		j. Reattach apron and tie joints. Compact soil under apron and place new riprap in front and around sides of apron. For severe problems, construct concrete cutoff wall under apron.
15.	If there is a pond drain valve, is it:	15.	
	a. NOT operational?		a. Replace.
	b. NOT properly secured?		b. Secure.
16.	Are safety features present and functional?	16.	Ensure items such as trash guards, fencing and grates are present, clear of debris and properly secured.
17.	Measure pond depth to determine if sediment is significantly reducing pond storage.	17.	Draw down pond, excavate sediment and dispose off site.
18.	Are sediment forebays or ponds >50% full of sediment?	18.	Remove sediment with backhoe and dispose off site.
19.	Is there excessive sediment buildup (impeding water movement)?	19.	Remove and dispose of sediment off site.
	a. Near storm drain aprons?		a. Hand remove from apron. Outside of apron, remove sediment with backhoe.
	b. Other locations?		b. Remove sediment with backhoe.
20.	Will sediment accumulations negatively impact plant health?	20.	Draw down pond, excavate sediment and dispose off site.
21.	Are there any irregularities that indicate upstream problems?	21.	Discuss with engineer to determine probable cause. Follow up investigation.
22.	Are there signs of illicit discharges?	22.	Determine potential source(s) of discharge. Notify your supervisor.
23.	Are there any obstructions to getting maintenance equipment down to the pond?	23.	Stabilize slopes and drive path, clear vegetation or other work as appropriate.
24.	Are there any encroachments into stormwater treatment area or access areas?	24.	Notify your manager.

Stormwater Pond - Inspection and Maintenance Checklist

This inspection report shall be used for all wet ponds and dry ponds.

Storm Pond Name/Number:____

Pond Location: ____

Rainfall Data Source: *(Owner to fill in a consistent rainfall data source)*

Time (in hours) since last rainfall_________ Rainfall Quantity (in inches) ____________

Plants	Inspection Date #1:	Maintenance Date #1
	Inspector Name #1:	Crew Leader Name #1:
All other Items	Inspection Date #2:	Maintenance Date #2:
	Inspector Name #2	Crew Leader Name #2

Inspection Frequency	**Inspection Items:**		**√ if "yes"**	**Inspection Comment**	**√ if Maintenance is Complete**	**Follow up Comments**
	A.	**Is a permit required to perform maintenance on this pond?**				
	B.	**Will sediment removal require a MPCA permit or notification?**				
	1.	Is there any erosion associated with:				
		a. Slopes/embankments?				
		b. Riprap areas?				
		c. Storm drain aprons/inlets?				
		d. Headwalls or endwalls?				
		e. Spillways and/or outlet structures?				
		f. Other?				
	2.	Are there obstructions/debris blocking the emergency spillway and/or outlet structure?				
	3.	Is there debris in trash racks?				
	4.	Is there trash on pond slopes or in the water?				
	5.	Are there any animal burrows/nests that cause the pond to not function properly?				
	6.	Is there any vandalism that needs repair?				
	7.	Are there any public hazards? (specify)				
	8.	Has water level NOT returned to normal elevation within designated drawdown period? (wet pond)				
	9.	Is water level lower than expected elevation? (wet pond)				
	10.	Has water NOT completely drained out within designated drawdown period? (dry pond)				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Inspection Frequency	Inspection Items:	√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	11. Is there any undesirable vegetation growth, such as				
	a. Young, volunteer trees or shrubs?				
	b. Invasive species on pond slopes?				
	c. Invasive aquatic species?				
	12. Are there any spots >1 sq ft that are barren of vegetation?				
	13. Are desired plant species showiing signs of stress or disease on:				
	a. Pond slopes or buffer				
	b. Pond edges (wet ponds)				
	c. Emergents (wet ponds)				
	14. For inlet and overflow structures, are there any:				
	a. Cracks >1/8" in concrete coomponents?				
	b. Minor spalling of concrete (<1")?				
	c. Major spalling of concrete (rebar exposed)?				
	d. Joint failures?				
	e. Corroded metal components?				
	f. Dents/malformations that cause the structure and pond to not function properly?				
	g. Are pipes and/or structures clogged? (Sediment, trash, other debris). Is there excessive sediment build up in front of the inlet, impeding water flow?				
	h. Is there erosion or scour holes forming around inlets?				
	i. Is structure misaligned? Has it settled?				
	j. Are aprons failing (disconnected or becoming disconnected from pipe)?				
	15. If there is a pond drain valve, is it:				
	a. NOT operational?				
	b. NOT properly secured?				
	16. Are safety features present and functional?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Inspection Frequency	Inspection Items:		√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	17.	Measure pond depth to determine if sediment is significantly reducing pond storage.				
	18.	Are sediment forebays or ponds >50% full of sediment?				
	19.	Is there excessive sediment buildup (impeding water movement)?				
		a. Near storm drain aprons?				
		b. Other locations?				
	20.	Will sediment accumulations negatively impact plant health?				
	21.	Are there any irregularities that indicate upstream problems?				
	22.	Are there signs of illicit discharges?				
	23.	Are there any obstructions to getting maintenance equipment down to the pond?				
	24.	Are there any encroachments into stormwater treatment or access areas?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the City Engineer)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Definition

Bioretention is a stormwater treatment practice that utilizes the chemical, biological, and physical properties of plants, microbes, and soils for capturing/reducing stormwater runoff and removing pollutants from runoff. This process is often incorporated into many different types of filtration and infiltration stormwater treatment practices.[1]

Bioretention facilities can be broken into the following sub-categories:

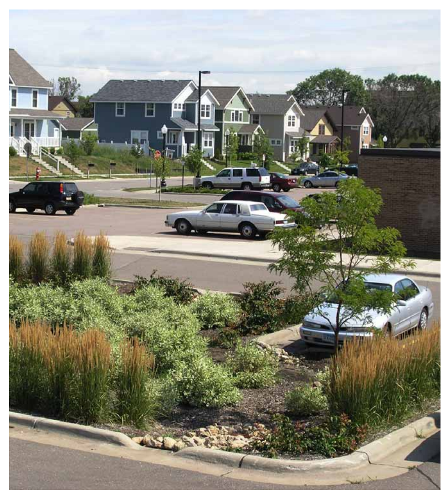
- Rain gardens
- Infiltration basins
- Filtration basins
- Bioswales
- Filter strips (pre-treatment)

Description

Bioretention facilities are shallow, landscaped depressions that capture rainwater runoff where it is then filtered through a prepared soil medium. Once the soil pore space capacity of the medium is exceeded, stormwater begins to pool at the surface of the planting soil. Pollutants are removed by a number of processes including adsorption, filtration, volatilization, ion exchange, and decomposition. Filtered runoff can either be allowed to infiltrate into the surrounding soil (functioning as an infiltration basin or rain garden), or collected by an under-drain system and discharged to the storm sewer system or directly to receiving waters (functioning like a surface sand filter), or a combination of the two. Runoff from larger storms is generally designed to bypass the area or flow through the basin and discharge directly to the storm drain system.[1]

A properly designed and maintained bioretention facility will exhibit the following characteristics:

- Will not have standing water in the bioretention facility 48 hours after a rain event, in compliance with the MPCA's Construction General Permit.[1]
- Will have healthy vegetation appropriate to the function of the basin and surrounding environment and be free of noxious weeds.



Bioretention facilities benefit from pre-treatment to prevent clogging by the sediment carried in the stormwater runoff. Pre-treatment devices are intended to trap the largest volume of sediment and be more easily maintained. Pre-treatment can consist of vegetated or rock filter strips, sediment forebays, sump manholes, or proprietary underground treatment devices.

Healthy vegetation in the bottom of a bioretention basin increases infiltration effectiveness. Plants can lose 30% of their root structures annually, which produces macropores. Macropores in an infiltration practice can increase the infiltration rate of the basin or trench so that more stormwater runoff is infiltrated. Additionally, vegetation can reduce overland flow velocities and can therefore reduce erosion and resuspension of captured solids.[2] Vegetation also breaks down petroleum based pollutants and uptakes excess nutrients in the stormater runoff. Typically, the basins are planted with a mix of native deep-rooted perennials, shrubs, and trees that are adapted to growing in periodically wet conditions.

A preponderance of wetland plants can be an indication that the facility is not draining properly.

If the native soils are not conducive to infiltration, an "engineered" mixture comprised of sand and compost, is used to promote rapid infiltration and good plant growth. Underdrains may be added to account for poor or non infiltrating underlying soils, stormwater hotspots, lining due to groundwater or bedrock proximity, or in cases where clean stormwater is being harvested for reuse. Cleanouts and inspection/observation wells are frequently part of the underdrain system. Overflow structures provide a controlled outlet for stormwater volumes above the design volume.

Bioretention areas should not be used as dedicated snow disposal areas so that soil compaction is minimized and should be protected from excessive snow storage where sand and salt is applied to protect the vegetation. If used to treat parking lot runoff, the bioretention area should be planted with appropriate salt tolerant plant species.[1]

Sub-categories of Technique

Rain Gardens

Rain gardens are small-scale, vegetated depressions used to promote infiltration and treatment from the first flush of runoff from a parcel or small catchment area. Runoff enters the gardens via sheet flow. Rain gardens can be planned and integrated into both new and existing developments. A rain garden combines shrubs, grasses, and flowering perennials in depressions (about 6 to 18 inches deep) that allow water to pool for only a short time after a rain. Water is retained in the ponding area until it either infiltrates or evaporates.[3]

Infiltration Basins

An infiltration basin is a constructed impoundment that captures, temporarily stores, and infiltrates the design volume within an acceptable time period. Infiltration basins contain a flat, densely vegetated floor situated over naturally permeable soils.[2] Infiltration basins function similarly to rain gardens but can generally treat larger areas than rain gardens. In many cases, the vegetation in an infiltration basin has a less manicured appearance than in a rain garden and may therefore require less frequent maintenance.

This type of facility is suitable for areas where high recharge of groundwater is possible and would be beneficial. Because there is no under-drain, the in-situ soils need to have a high infiltration rate to accommodate the inflow levels. This facility type is suitable for areas and land uses that are expected to generate nutrient runoff (i.e.; residential and business campuses) that can be infiltrated and captured by the facility. Fresh mulch rather than aged shredded bark mulch can be used to enhance denitrification processes.[1]

Filtration Basins

A filtration basin may look very similar to an infiltration basin from the surface, in that it is a vegetated impoundment that captures and temporarily stores stormwater runoff. It differs in that the stormwater is prevented from entering the groundwater system through the use of an impermeable liner and underdrains.

This type of facility is recommended for areas that are known as potential stormwater "hot-spots" (gas stations, transfer sites, and transportation depots), for sites in wellhead protection areas, that have karst topography, or have close proximity to groundwater or bedrock.

An important feature of this type of facility is the liner designed to reduce or eliminate the possibility of groundwater contamination. The facility provides a level of treatment strictly through filtration processes that occur when the runoff moves through the soil material to the underdrain discharge point. In the event of an accidental spill, the underdrain can be blocked and the objectionable materials siphoned through the observation well and safely contained.[1]

Depending on design goals and site characteristics, a combination of infiltration/filtration basins components may be used in one project. Factors such as groundwater sensitivity to pollution, existing soil contamination, infiltration characteristics of the underlying soil, and the desire to either harvest or infiltrate the treated stormwater runoff will impact the final approach used.

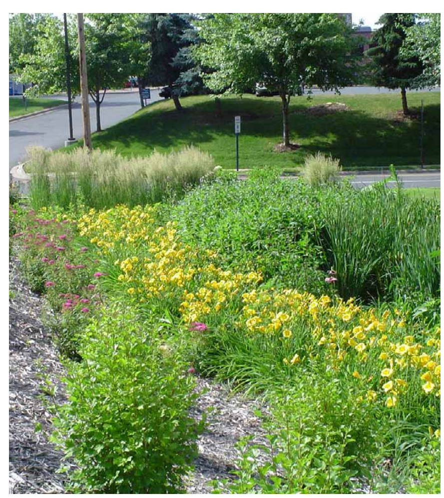
Bioswales

Bioswales are modified vegetated swales that use bioretention media beneath the swale to improve water quality, reduce the runoff volume, and peak runoff rate. These systems perform some of the same functions as traditional grassed swales or ditches by serving as a conveyance structure with minor treatment of runoff through filtering and infiltrating. However, like other types of bioretention facilities, bioswales encourage infiltration or filtration in order to retain runoff volume and use a variety of physical, chemical, and biological processes to reduce runoff pollutant loadings. Infiltration may be enhanced by placing material below the channel bottom, such as gravel, other permeable material, or perforated underdrains. Native and other appropriate plants may be used in the channel as an alternative to grass.[4]

Depending upon the geometry of land available, a bioswale may have a meandering or almost straight channel alignment. A common application is around parking lots, to collect and treat runoff from the paved surfaces. Swale checks may be added for bioswales with relatively steep longitudinal slopes to slow the stormwater flow and encourage infiltration.

Filter Strips (Pre-treatment)

Filter strips rely on the use of vegetation to slow runoff velocities, promote sheet flow, and filter out sediment and other pollutants from urban stormwater. Filter strips differ from grassed swales in that swales are concave, channelized, vegetated conveyance systems, whereas filter strips provide treatment by sheet flow over level-to-gently sloped surfaces.[5]



To be effective, filter strips require the presence of sheet flow across the entire strip. Once flow concentrates to form a channel, it effectively short-circuits the filter strip. The filter strip is typically an on-line practice, so it must be designed to withstand the full range of storm events without eroding. Filter strips can be as simple as a strip of turf between a roadway and a stormwater pond or a small area of riprap. Filter strips typically do not provide adequate pollutant removal benefits to act as a stand-alone BMP.[1] Filter strips cannot treat high-velocity flows. Therefore, they have generally been recommended for use in small drainage areas with a low percentage of impervious surfaces.[5]

Filter strips can differ from natural buffers in that strips are often designed and constructed specifically for limited or nominal pollutant removal. Natural features may be incorporated into the treatment system; a filter strip can be an enhanced natural buffer where the pollutant-removal capability of the natural buffer is improved through engineering and maintenance activities, such as land grading, the installation of a level spreader, or the enhancement of vegetation.[5]

Another type of filter strip used as a pre-treatment device is a rock infiltration or filtration trench, which consists of a shallow, excavated trench, backfilled with a coarse stone aggregate. The trench allows for the temporary storage of runoff in the void space of the material, while sediments and debris carried by the runoff are trapped within the pore spaces of the aggregate. Discharge of this stored runoff occurs through infiltration into the adjacent prepared soil medium or naturally permeable soil. Trenches are commonly used for drainage areas less than five acres in size.

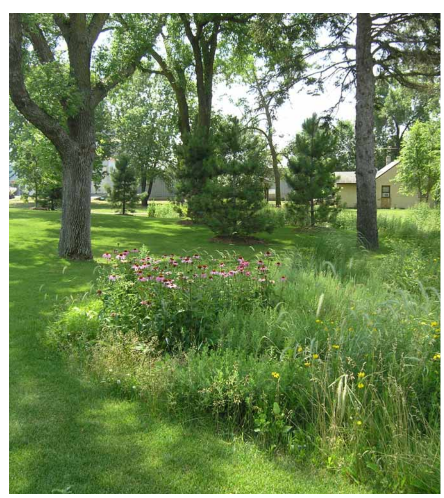
Benefits/Limitations of Bioretention Facilities

Benefits[1]

- Can be very effective for removing fine sediment, trace metals, nutrients, bacteria, and organics.
- Provides many additional environmental (habitat, improves air quality, urban micro-climates), social (creates a unique sense of place), and economic benefits (reduces development and maintenance cost, greater lot yield, increases property values).
- Well suited for high impervious areas.
- Reduces runoff volume.
- Flexible design, affording many opportunities for creativity.
- Less thermal impacts to surface waters than typical wet detention pond.

Limitations[1]

- Susceptible to clogging by sediment; therefore maintenance and pre-treatment is necessary to maintain effectiveness.
- May not be effective for large drainage areas (use multiple structures, closer to source of runoff).
- Soil medium prone to erosion (use energy reduction measures for incoming stormwater).



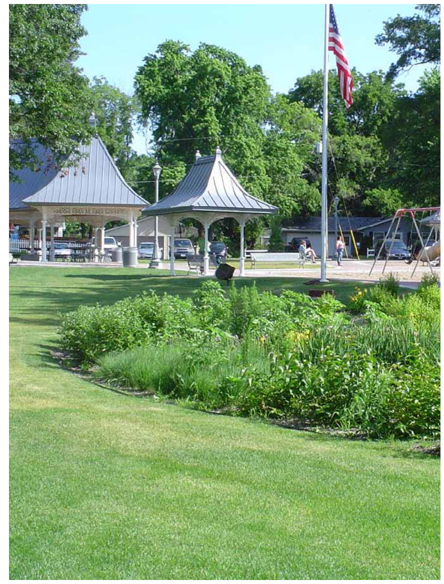
Detailed Inspection and Maintenance Activities: Bioretention Facilities[1,2,6]

Bioretention facilities may have an initial growing period of approximately 3-5 years that may require more frequent inspection up front while the plants establish themselves. Inspection activities, maintenance, and warranties should be written into the construction contract. This resource guide focuses solely on activities required once the basins have become fully established. Table 1 provides a useful list of maintenance activities.

All maintenance activities need to be undertaken in a manner that does not lead to soil compaction. Such compaction will reduce vertical water flow rates and could cause potential damage to an underlying drain tile system.[6]

Bioretention Facilities: Less Frequent Maintenance Activities

Similar to other landscaped areas, bioretention basins typically require that certain maintenance activities take place on a regular, but less frequent basis to maintain the health of the plant communities. As noted above, a healthy plant community can improve the infiltration rate of the soil medium. Table 2 describes these activities.



Resources

[1] Minnesota Stormwater Manual, Minnesota Pollution Control Agency (2005).

[2] Assessment of Stormwater Best Management Practices, University of Minnesota (2007).

[3] Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates, Metropolitan Council (2001).

[4] Fairfax County – LID BMP Fact Sheet – Bioswales February 28, 2005 (www.lowimpactdevelopment.org/ffxcty/1-4_bioswale_draft.doc)

[5] Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota, MPCA (2000).

[6] King County Drainage Maintenance Standards For Commercial and Multifamily Drainage Facilities: Definitions, Defects & Maintenance Necessary to Bring to Standard, King County Department of Natural Resources and Parks Water and Land Resources Division, Washington (September 2005).

Table 1
Bioretention Facilities: Detailed Inspection and Maintenance Activities

Inspection Activities		Maintenance Activities	
1.	Vegetated Filter Strips: Are there any problems with	1.	
	a. Weeds or volunteer woody vegetation?		a. Mow, prune and weed as needed to maintain appearance and functionality.
	b. Sedimentation?		b. Remove sediment with rake and/or broom as needed to maintain positive drainage and healthy vegetation.
	c. Erosion or gullies?		c. Fill in/repair erosion and gullies with topsoil; re-seed or re-sod, as necessary. Replace mulch where appropriate. Protect newly seeded areas from erosion with an erosion control blanket or mulch.
2.	Rock filter trenches: Are there any problems with	2.	
	a. Crust or layer of fine sediment on the surface of the trench?		a. Remove rock from trench; wash or obtain new rock and reinstall.
	b. Visible sediment around the rock after using a shovel to remove upper few inches?		b. Remove rock from trench; wash or obtain new rock and reinstall.
3.	Is water channelized prior to entering the filter strips/trenches?	3.	Search upstream to determine cause of channelization. Make necessary modifications or repairs.
4.	Do the trees and shrubs on the side slopes and within basins show signs of disease?	4.	Prune to maintain appearance. Remove any dead or severely diseased vegetation.
5.	Is there erosion or gullying of the side slopes?	5.	Search upstream to determine cause and make necessary modifications/repairs. Minor erosion areas can be reseeded, matching the seed mix of the intended design. Gully erosion should be filled, reseeded and covered with an erosion control blanket.
6.	Are there any spots >1 sq ft that are barren of vegetation on the side slopes or within the basin?	6.	Reestablish vegetation (i.e. seed, sod, install plants, erosion control). Match seed mix to intended design. For bare spots or dead vegetation in the bottom of the basin, check that water percolates within 48 hours following significant rain events. For grassed bioswales, determine why grass growth is poor and correct that condition. Replant with plugs of grass from the upper slope: plant in the swale bottom at 8-inch intervals, or re-seed into loosened, fertile soil. Do not use sod to reestablish grass.
7.	Is there any undesirable vegetation growth, such as:	7.	Remove and dispose of off site.
	a. Young, volunteer trees or shrubs?		a. Handwork or careful application of appropriate herbicide.
	b. Invasive species on pond slopes?		b. Handwork or careful application of appropriate herbicide.
	c. Weeds in mulched areas?		c. Handwork or careful application of appropriate herbicide.
	d. Invasive aquatic species?		d. Handwork or careful application of appropriate herbicide.
	e. For bioswales, is the height of the vegetation great enough to impede flow?		e. Mow vegetation or eradicate nuisance vegetation such that flow is not impeded. Mow grass to a height of between 4 and 9 inches. If grass has died, replant/reestablish grass. Do not use sod to reestablish grass.
8.	Is there trash or debris within the basin or on the side slopes?	8.	Remove as needed and dispose off site.
9.	Does sediment depth measure more than 2” in depth over 25% or more of the basin? **Bioretention areas should be inspected for sand build-up on the surface following the spring thaw.**	9.	Draw down water if needed. Remove sediment from basins in a manner that will not compact the soil. Replace vegetation using seed or plugs to match intended design **This may also be a sign that the pre-treatment devices are at capacity or not functioning properly.**
10.	Is there standing water in the basin more than 48 hours after a rainfall event due to sediment crust on top of the bioretention soil?	10.	Draw down water if needed. Remove sediment from basins using a skidsteer (bobcat) with low pressure tires or tracks. Replace vegetation using seed or plugs to match original design.
11.	Do plant species in the bottom of the basin appear to be transitioning to wetland types?	11.	This is an indication that basin is not draining properly. Basin should be investigated to determine if surface is clogged with silt and/or clay or if underdrain system is not functioning.
12.	Is there indication of erosion or channelization in the bottom of the basin? **Inspect in the spring or fall when vegetation is low.**	12.	Minor erosion areas can be re-vegetated, matching the seed mix of the intended design. Gully erosion should be filled, re-vegetated and covered with an erosion control blanket. **This may be an indication that the velocity of the incoming water is too great and that additional energy dissipation may be required.**

Inspection Activities		Maintenance Activities	
13.	Is sediment visible in cleanouts and inspection/observation manholes? Does sediment depth appear to restrict flow? Does clogging appear to contribute to standing water problems in the bioretention basin?	13.	Jet out pipes in the underdrain system.
14.	For inlet and overflow structures, are there any	14.	
	a. Concrete cracks >1/8" in concrete structures?		a. Remove all deteriorated concrete, dirt and bond-inhibiting material from the failed area. Inject with crack sealant approved for this application.
	b. Minor spalling of concrete (<1")?		b. Monitor.
	c. Major spalling of concrete (rebar exposed)?		c. Clean rebar, remove loose concrete, apply bonding agent and patch with material approved for this application.
	d. Joint failures?		d. Determine why joints are failing and note the type of joint and if groundwater is seeping through the failed joint. Use methods and materials appropriate to the situation.
	e. Areas of metal corrosion?		e. Clean area of corrosion and determine the cause. Depending on the extent of the corrosion and the cause, the area could be cold galvanized or require more extensive repairs.
	f. Dents/malformations that cause the structure and basin to not function properly?		f. Repair to proper capacity.
	g. Are pipes and/or structures clogged? (Sediment, trash, other debris) Is there excessive sediment build up in front of the inlet, impeding water flow?		g. Remove sediment and debris and dispose off site. Depending on extent of clogging, this may be handwork or require the use of jetting equipment to clean upstream system.
	h. Is there erosion or scour holes forming around inlets?		h. Fill eroded areas. Repair aprons and add riprap as necessary to prevent recurrence. Reestablish vegetation (i.e. seed, install plants, erosion control). Match seed mix to intended design.
	i. Is structure misaligned? Has it settled?		i. Reconstruct/modify as necessary. Reestablish vegetation (i.e. seed, install plants, erosion control). Match seed mix to intended design.
	j. Are aprons failing (disconnected or becoming disconnected from pipe)?		j. Reattach apron and tie joints. Compact soil under apron and place new riprap in front and around sides of apron. For severe problems, construct concrete cutoff wall under apron.
15.	Is maintenance access route NOT in operational condition?	15.	Stabilize slopes and drive path and/or clear vegetation as needed.
16.	Are there any encroachments into stormwater treatment area or access route?	16.	Notify your manager.
17.	Are there signs of illicit discharges?	17.	Determine potential source(s) of discharge. Notify your supervisor.
18.	If stormater treatment facility also includes the following elements, see appropriate resource guide section for specific inspection requirements and maintenance activities.		
	a. Sediment forebays		a. See Stormwater Ponds Section.
	b. Underground treatment devices		b. See Underground Treatment Device Section.

Table 2
Bioretention Facilities: Less Frequent Maintenance Activities

Maintenance Activity		Frequency	
1.	As conditions warrant, perform a controlled burn to eliminate unwanted species and reinvigorate desirable plant communities.	1.	Every 2 to 3 years.
2.	Replace mulch over the entire area.	2.	Every 2 to 3 years.
3.	Replace pea gravel diaphragm or filter fabric around underdrain, if warranted.	3.	Upon failure.
4.	Test planting soils for pH.	4.	When plants exhibit signs of stress.
5.	Disc or otherwise aerate bottom of basin. Depending on type of vegetation, de-thatch basin bottom.	5.	Every 2 to 3 years.

Bioretention Facility - Inspection and Maintenance Checklist

This inspection report shall be used for all bioretention facilities.

Bioretention Facility Name/Number:____ Rainfall Data Source: *(Owner to fill in a consistent raindfall data source)*

Bioretention Facility Location:____ Time (in hours) since last rainfall_________ Rainfall Quantity (in inches) ____________

Plants	Inspection Date #1:	Maintenance Date #1
	Inspector Name #1:	Crew Leader Name #1:
All other Items	Inspection Date #2:	Maintenance Date #2:
	Inspector Name #2	Crew Leader Name #2

Inspection Frequency		**Inspection Items:**	**√ if "yes"**	**Inspection Comment**	**√ if Maintenance is Complete**	**Follow up Comments**
	1.	Vegetated Filter Strips: Are there any problems with:				
		a. Weeds or volunteer woody vegetation?				
		b. Sedimentation?				
		c. Erosion or gullies?				
	2.	Rock Filter trenches: Are there any problems with:				
		a. Crust or layer of fine sediment on the surface of the trench?				
		b. Visible sediment around the rock after using a shovel to remove upper few inches?				
	3.	Is water channelized prior to entering the filter strips/trenches?				
	4.	Do the trees and shrubs on the side slopes and within basins show signs of disease?				
	5.	Is there erosion or gullying of the side slopes?				
	6.	Are there any spots >1 sq ft that are barren of vegetation on the side slopes or within the basin?				
	7.	Is there undesirable vegetation growth, such as:				
		a. Young, volunteer trees or shrubs?				
		b. Invasive species on pond slopes?				
		c. Weeds in mulched areas?				
		d. Invasive aquatic species?				
		e. For bioswales, is the height of the vegetation great enough to impede flow?				
	8.	Is there trash or debris within the basin or on the side slopes?				
	9.	Does sediment depth measure more than 2" in depth over 25% or more of the basin? **Bioretention areas should be inspected for sand build-up on the surface following the spring thaw.**				
	10.	Is there standing water in the basin more than 48 hours after a rainfall event due to sediment crust on top of the bioretention soil?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

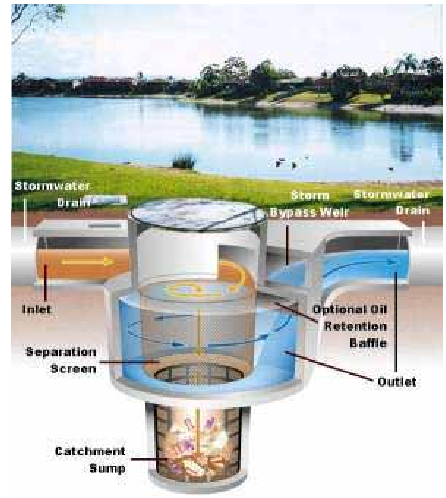
Inspection Frequency	Inspection Items:	√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	11. Do plant species in the bottom of the basin appear to be transitioning to wetland types?				
	12. Is there indication of erosion or channelization in the bottom of the basin? **Inspect in the spring or fall when vegetation is low.**				
	13. Is sediment visible in cleanouts and inspection/observation manholes? Does sediment depth appear to restrict flow? Does clogging appear to contribute to standing water problems in the bioretention basin?				
	14. For inlet and overflow structures, are there any:				
	a. Cracks >1/8" in concrete components?				
	b. Minor spalling of concrete (<1)?				
	c. Major spalling of concrete (rebar exposed)?				
	d. Joint failures?				
	e. Corroded metal components?				
	f. Dents/malformations that cause the structure and basin to not function properly?				
	g. Are pipes and/or structures clogged? (Sediment, trash, other debris). Is there excessive sediment build up in front of the inlet, impeding water flow?				
	h. Is there erosion or scour holes forming around inlets?				
	i. Is structure misaligned? Has it settled?				
	j. Are aprons failing (disconnected or becoming disconnected from pipe)?				
	15. Is maintenance access route NOT in operational condition?				
	16. Are there any encroachments into stormwater treatment area or access route?				
	17. Are there signs of illicit discharges?				
	Less Frequent Maintenance Activities	**√ if "yes"**	**Inspection Comment**	**√ if Maintenance is Complete**	**Follow up Comments**
	1. Is it time to perform controlled burn to eliminate unwanted species and reinvigorate desirable plant communities?				
	2. Is it time to replace mulch over the entire area?				
	3. Is it time to replace pea gravel diaphragm or filter fabric around underdrain?				
	4. Is it time to test planting soils for pH? **If the pH is out of range, make appropriate soil amendments.**				
	5. Is it time to improve soil surface permeability and vegetation health through aeration or de-thatching basin bottom?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Stormwater Maintenance BMP Resource Guide
Underground Treatment Devices

Definition

Underground treatment devices are designed and engineered to decrease the flow velocity, provide temporary storage of stormwater runoff, or both, to allow suspended solids to settle out and be retained by the stormwater BMP.[1]



Source: Contech Construction Products, Inc.

Description

Underground treatment devices can take a variety of forms and use a variety of technologies or methods to provide stormwater quality treatment. There are many names applied to these devices: oil/grit separator, grit chamber, sump manhole/catch basin, wet vault, hydrodynamic separator, water quality inlet, and proprietary stormwater treatment device, to name a few.

Generally, underground treatment devices act as oil and grit separators using the physical principles of sedimentation for the grit and phase separation for the oil. Baffles are frequently included to trap trash, oil, grease, and other floatables. However, they are most effective on coarse sediments and have reduced effectiveness at removing pollutants such as nutrients or metals. As pollutants are not actually removed by the devices until they are cleaned out, resuspension of the trapped sediments can be a problem in some units without an aggressive maintenance program or flow restrictions. Except in the case of wet vaults, there is minimal attenuation of flow since the devices are not designed with significant detention storage.[2]

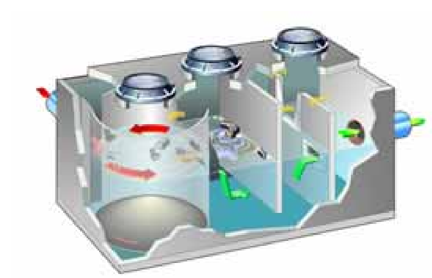
Many of the available proprietary sediment removal devices are intended to be installed below the frost-line and, therefore, operate as designed under all weather conditions. Many of the underground treatment devices are typically designed to provide optimal removal efficiency for smaller, more frequent storms with minimal removal in larger, less common storms.[3] Therefore, these are typically used as pre-treatment in combination with other BMPs, but can operate as a stand-alone practice where lower levels of protection are needed.[4]

Underground treatment devices can be used in-line with smaller storm sewer networks. However, when used on larger storm trunk lines, a diversion structure is typically used on the trunk line to regulate the amount of stormwater being sent through the device. Flows over the capacity of the unit are allowed to bypass. The flow rate is typically controlled via the use of a weir, which may be located in an upstream, adjacent structure.

Sub-categories of Technique

Proprietary Treatment Devices

There are many companies that have proprietary designs for improving the effectiveness of underground treatment devices. They often enhance the rate of sediment settling through the circular motion of stormwater within the chamber. The devices also capture oil, grease, and other floatables, most often through the use of baffles or screens. Hydrodynamic devices are typically designed to provide optimal removal efficiency for smaller, more frequent storms with minimal removal in larger, less common storms. To maintain removal efficiency, the devices require regular removal of accumulated sediment and floatables.[3]



Source: Contech Construction Products, Inc.

These devices are proprietary and typically are designed for each application by the manufacturer.[3] Some components will only be available from the manufacturer. Furthermore, each type of proprietary device may have different maintenance procedures. The manufacturer should supply an operation and maintenance manual as part of their design.

Source: Stormceptor

Sump Catch Basins

Catch basins are chambers installed in a storm sewer network, which allow surface runoff to enter the network. Many catch basins are designed with the bottom two feet or more below the lowest pipe invert elevation. This low area is called a "sump" and is intended to retain sediment. Sump catch basins are likely to be one of the most common BMPs in an agency's system. By trapping coarse sediment, the catch basin prevents solids from clogging the storm sewer or being washed into receiving waters. However, the sumps must be cleaned out periodically to maintain their sediment-trapping ability because they are easily scoured out during high flow events.[5] For this reason, many agencies are phasing out the use of sump catch basins.

Wet Vaults

A wet vault is an underground structure designed to provide temporary or permanent storage for stormwater runoff from a specified storm event. Wet vaults have a permanent pool of water, which dissipates energy and improves the settling of particulate stormwater pollutants. Wet vaults are typically on-line, end-of-pipe BMPs. Treatment mechanisms are similar to surface ponds, except that biological pollutant removal mechanisms do not occur in wet vaults since they are not exposed to sunlight.[2]

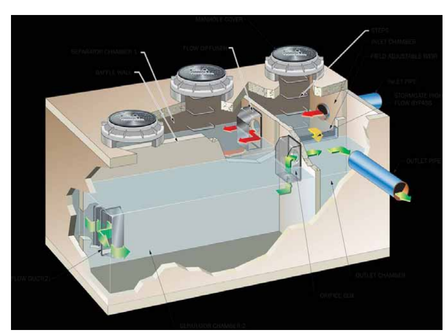
The wet vault may have a valve at or near the bottom of the structure that can provide a gravity outlet to drain the structure completely for maintenance. Many maintenance activities will require Occupational Safety and Health Administration (OSHA) confined space safety procedures to be used, as accumulated sediment and stagnant conditions may cause noxious gases to form and accumulate in the vault, especially if regular maintenance is neglected.[2]

These types of facilities may require more frequent inspection to minimize noxious gases and complaints from adjacent property owners regarding odors.

Benefits/Limitations of Underground Treatment Devices

Benefits[3]

- Units are underground and do not consume much land area, which allows the land to be used for other purposes (parking lots, etc.).
- They can often be easily incorporated into fully developed sites and for retrofit of existing systems.
- They can be used for pre-treatment prior to other BMP practices.
- Suitable for cold climates if installed below frostline.
- Provides an easily accessed structure for maintenance.
- Standardized designs allow for relatively easy installation.[2]



Source: Sustura

Limitations[3]

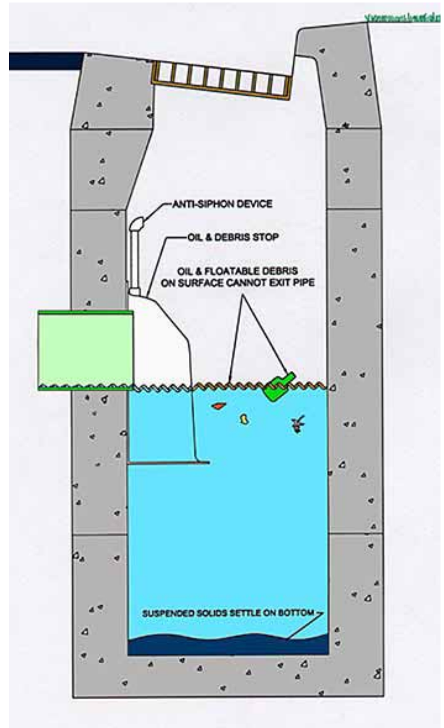
- Each type of unit has specific design constraints and limitations for use.
- Treatment may be reduced if frequent maintenance is not conducted.
- May not meet local standards when used alone.
- Generally good for solids and litter, but much less effective for common soluable pollutants.
- These types of facilities require OSHA confined space entry procedures.[2]

Detailed Inspection and Maintenance Activities – Underground Treatment Devices[1,2,3]

Because there is the potential for regulated materials to be removed from these devices during cleaning, the owner should check with the MPCA for current disposal guidance.

In the case of proprietary devices, there may be specific inspection and maintenance measures called for by the manufacturer beyond what is detailed in Table 1. As part of the visual inspection, the date of the last cleaning should be noted.

Note that some inspection and maintenance procedures detailed below will need to meet OSHA confined space entry requirements. Entrances to confined space areas must be clearly marked. This may be accomplished by hanging a removable sign in the access riser just under the access lid.[2]



Source: Best Management Products, Inc.

Resources

[1] Assessment of Stormwater Best Management Practices, University of Minnesota (2007).

[2] Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates, Metropolitan Council (2001).

[3] Minnesota Stormwater Manual, Minnesota Pollution Control Agency (2005).

[4] St. Paul water quality manual (flashcards)

[5] Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota, MPCA (2000).

Table 1
Underground Treatment Devices: Detailed Inspection and Maintenance Activities

Inspection Activities		Maintenance Activities	
1.	Are inlet pipes clogged? If so, with what? (Sediment, trash, other debris?) Is there excessive sediment build up in the pipe, impeding water flow?	1.	Remove sediment and debris and dispose off site. Depending on extent of clogging, this may be handwork or require the use of jetting equipment to clean upstream system.
2.	Is there a significant amount of water entering the device more than 72 hours after runoff event has finished?	2.	Determine reason (clogged pipes, leaking pipes or joints, lawn irrigation, etc). If manhole appears to be leaking, ensure that all joints between barrels are sealed and that there is no leaking around pipes or castings.
3.	Is the unit not functioning properly even though sediment is below the recommended cleaning level? If so, are there obstructions that could be hindering performance?	3.	Remove any obstructions, sediment or debris to ensure proper operation of the device. Depending on the amount and type of material, this may be handwork.
4.	Is the outlet clogged? If so, with what? (Sediment, trash, other debris?)	4.	Remove any obstructions, sediment or debris to ensure proper operation of the device. Depending on the amount and type of material, this may be handwork or jetting.
5.	For flow splitters/diversion structures upstream of the treatment device:	5.	
	a. Is there sediment, trash or debris collecting in front of or behind the diversion weir?		a. Remove any obstructions, sediment or debris to ensure proper operation of the device. Depending on the amount and type of material, this may be handwork.
	b. Does the weir appear to be functioning properly?		b. Determine reason (leakage around the weir, cracking, improper construction, etc.). Fill any gaps or cracks with grout or sealant approved for this type of application. If necessary, verify the spill elevation and discuss with appropriate personnel.
	c. Are connections between the diversion structure and the treatment chamber plugged, askew or misaligned?		c. Determine reason. If plugged, remove sediment and debris by hand or as specified by manufacturer. If misaligned or askew, contact appropriate personnel.
6.	Has the level of sediment in the storage chamber reached the specified level for requiring maintenance?	6.	For proprietary devices: Follow manufacturer's operations and maintenance guidelines for procedures to remove the trapped sediment, oils, and trash. For sump catch basins: Use a vactor truck to pump out the water and sediment. This may require handwork to remove packed sediment. For wet vaults: Remove floating oil using a spill kit; use vactor truck to pump out sediment. Once maintenance is completed, ensure that the gravity-flow valve is in the closed position.
7.	For concrete structures, are there any	7.	
	a. Cracks >1/8"?		a. Remove all deteriorated concrete, dirt and bond-inhibiting material from the failed area. Inject with crack sealant approved for this application.
	b. Minor spalling (<1")?		b. Monitor.
	c. Major spalling (rebar exposed)?		c. Clean rebar, remove loose concrete, apply bonding agent and patch with material approved for this application.
	d. Joint failures?		d. Determine why joints are failing and note the type of joint and if groundwater is seeping through the failed joint. Use methods and materials appropriate to the situation.

Inspection Activities		Maintenance Activities	
8.	For components within the structures, are there any	8.	
	a. Areas of corrosion?		a. Clean area of corrosion and determine the cause. Depending on the extent of the corrosion and the cause, the area could be cold galvanized or require more extensive repairs.
	b. Dents/malformations that cause the structure to not function properly?		b. Repair to proper capacity.
	c. Do proprietary components (such as screens, filters, baffles, etc.) show signs of damage that cause the structure to not function properly?		c. Notify your supervisor to contact the manufacturer to discuss repair methods or replacement parts.
9.	Are there any obstructions to getting maintenance equipment to the BMP?	9.	Stabilize slopes and drive path, clear vegetation or other work as appropriate.
10.	Are there any encroachments into stormwater treatment area or access areas?	10.	Notify your manager.
11.	Are there signs of illicit discharges?	11.	Determine potential source(s) of discharge. Notify your supervisor

Underground Treatment Devices - Inspection and Maintenance Checklist

This inspection report shall be used for all underground treatment devices.

Device Name/Number:____

Device Location: ____

Rainfall Data Source: *(Owner to fill in a consistent rainfall data source)*

Time (in hours) since last rainfall_________ Rainfall Quantity (in inches) ____________

Device Information	Manufacturer: Model Number:

Activity Log	Inspection Date #1: Inspector Name #1:	Maintenance Date #1: Crew Leader Name #1:

Inspection Frequency	Inspection Items:	√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	1. Are inlet pipes clogged? If so, with what? (Sediment, trash, other debris?) Is there excessive sediment build up in the pipe, impeding water flow?		n/a	n/a	
	2. Is there a significant amount of water entering the device more than 72 hours after runoff event has finished?				
	3. Is the unit not functioning properly even though sediment is below the recommended cleaning level? If so, are there obstructions that could be hindering performance?				
	4. Is the outlet clogged? If so, with what? (Sediment, trash, other debris?)				
	5. For flow splitters/diversion structures upstream of the treatment device:				
	a. Is there sediment, trash or debris collecting in front of or behind the diversion weir?				
	b. Does the weir appear to be functioning properly?				
	c. Are connections between the diversion structure and the treatment chamber plugged, askew or misaligned?				
	6. Has the level of sediment in the storage chamber reached the specified level for requiring maintenance?				
	7. For concrete structures, are there any				
	a. Cracks in concrete components >1/8"?				
	b. Minor spalling of concrete (<1")?				
	c. Major spalling of concrete (rebar exposed)?				
	d. Joint failures?				
	8. For components within the structures, are there any				
	a. Areas of corrosion?				
	b. Dents/malformations that cause the structure to not function properly?				
	c. Do proprietary components (such as screens, filters, baffles, etc.) show signs of damage that cause the structure to not function properly?				
	9. Are there any obstructions to getting maintenance equipment to the BMP?				
	10. Are there any encroachments into stormwater treatment area or access areas?				
	11. Are there signs of illicit discharges?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Definition

Underground detention devices are used to store stormwater runoff temporarily. As such, they are primarily used for rate control.


Source: Ford Motor Company

Description

Storm sewer systems convey surface stormwater to subsurface vaults or systems of large-diameter interconnected storage pipes or chambers. Stored water is then released directly through an outlet pipe back into various downstream conveyance systems or water bodies at rates designed to reduce peak water flows during storms to better mimic pre-development conditions. In some cases, stored water can be allowed to infiltrate to recharge groundwater (if soil types are suitable and the groundwater table is located sufficiently below the water storage units).[1] Generally, they are used in place of dry ponds or wet ponds in developed areas because they do not consume land surface area, which can then be used for other purposes. Underground detention devices that have infiltration components will be covered in the infiltration section of this document.

Underground stormwater storage provides varying degrees of stormwater quality benefits, but can be a successful segment to a development's overall stormwater management plan when coupled in-line with other stormwater BMPs. The addition of pre-treatment features at the system's inlet can facilitate improvements to water quality by removing floatables, skimming of oils and grease, and trap some level of sediments through deposition.[1]

Subsurface storage systems are constructed from vaults, arches, or large diameter, rigid pipes with capped ends and can be made of concrete, plastic, steel, or aluminum. A number of prefabricated, modular systems are also commercially available. Storage structures, inlet and outlet pipes, and maintenance access manholes are fitted and attached in a predetermined excavated area, and then the entire area is backfilled to surrounding landscape surface height with gravel or other pervious material and subsequently surfaced.[1] Integrated into the downstream end of the system, control structures or smaller pipes regulate the rate at which runoff is discharged from the system.

Benefits/Limitations of Underground Detention

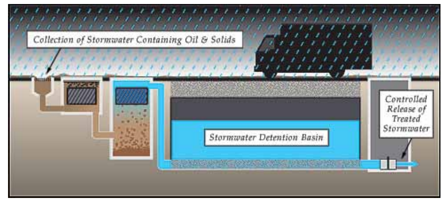
Benefits[1,2]

- Reduces peak stormwater runoff flow rate.
- Provides extended storage and slow, measured release of collected stormwater runoff.
- Good option for high density or urban areas with limited available space, unusual shapes or where land is expensive.
- Prefabricated modular systems can be relatively quick to install.
- Durability and long life (50 years plus for most systems).


Source: Capital Region Watershed District

Limitations[1, 2]

- Provides varying degrees of water quality improvement. To achieve water quality improvement additional stormwater BMPs must be incorporated in-line with storage system.
- Special equipment (and access) is often required to perform routine maintenance.
- There is the potential for noxious gases to form in the system.
- Confined space protocols may be required during inspections and maintenance.



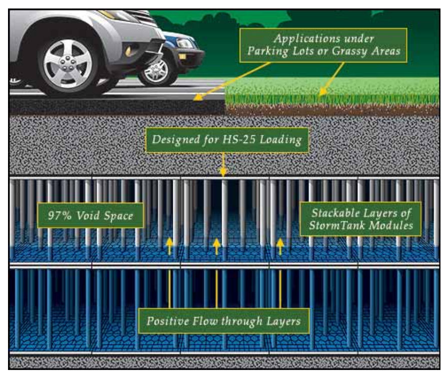
Source: Brentwood Industries

Detailed Inspection and Maintenance Activities – Underground Detention[4]

Because there is the potential for regulated materials to be removed from these devices during cleaning, the owner should check with the MPCA for current disposal guidance.

Because suspended solids may settle out, this sediment may accumulate and eventually fill the system or may be scoured out in later storm events. Whenever possible during maintenance activities, sediment removal should be by mechanical means other than flushing to prevent sediment from being transported to downstream water bodies. If flushing is the only cleaning option, special care should be taken to trap and remove sediment before it moves downstream.[2, 3]

Note that some inspection and maintenance procedures detailed below will need to meet OSHA confined space entry requirements. Entrances to confined space areas must be clearly marked. This may be accomplished by hanging a removable sign in the access riser just under the access lid.[3]



Source: Brentwood Industries

Resources

[1] Site Design Toolkit, Lake Superior/Duluth Streams (duluthstreams.org)

[2] Stormwater Technology Fact Sheet: On-Site Underground Retention/ Detention, US EPA (September 2001).

[3] Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates, Metropolitan Council (2001).

Table 1
Underground Detention: Detailed Inspection and Maintenance Activities

	Inspection Activities		Maintenance Activities
1.	Are inlet pipes clogged? If so, with what? (Sediment, trash, other debris?) Is there excessive sediment build up in the pipe, impeding water flow?	1.	Remove sediment and debris and dispose off site. Depending on extent of clogging, this may be handwork or require the use of jetting equipment to clean upstream system.
2.	Is the unit not functioning properly even though sediment is below the recommended cleaning level? If so, are there obstructions that could be hindering performance?	2.	Remove any obstructions, sediment or debris to ensure proper operation of the device. Depending on the type of system, the amount and type of material, this may be handwork.
3.	Is the outlet clogged? If so, with what? (Sediment, trash, other debris?)	3.	Remove any obstructions, sediment or debris to ensure proper operation of the device. Depending on the amount and type of material, this may be handwork or jetting.
4.	Is sediment accumulating in detention device?	4.	Follow manufacturer's operations and maintenance guidelines for procedures to remove the trapped sediment. This may involve the use of a vacuum truck or jetting equipment. Special care should be taken to trap and remove sediment before it moves downstream.
5.	For concrete access manholes or pipe networks, are there any:	5.	
	a. Cracks >1/8"?		a. Remove all deteriorated concrete, dirt and bond-inhibiting material from the failed area. Inject with crack sealant approved for this application.
	b. Minor spalling (<1")?		b. Monitor.
	c. Major spalling (rebar exposed)?		c. Clean rebar, remove loose concrete, apply bonding agent and patch with material approved for this application.
	d. Joint failures?		d. Determine why joints are failing and note the type of joint and if groundwater is seeping through the failed joint. Use methods and materials appropriate to the situation.
6.	For metal access manholes or pipe networks, are there any:	6.	
	a. Areas of corrosion?		a. Clean area of corrosion and determine the cause. Depending on the extent of the corrosion and the cause, the area could be cold galvanized or require more extensive repairs.
	b. Dents/malformations that cause the structure or detention area to not function properly?		b. Repair to proper capacity.
7.	Are there indications that the system has pressurized during storm events?	7.	Note observations and contact appropriate personnel.
8.	Are there any problems with:	8.	
	a. Obstructions for getting maintenance equipment to the BMP?		a. Stabilize slopes and drive path, clear vegetation or other work as appropriate.
	b. Access to all chambers? If so, what is impeding access?		b. Clear obstacles.
9.	Are there any encroachments into stormwater treatment area or access areas?	9.	Notify your manager.

Underground Detention - Inspection and Maintenance Checklist

This inspection report shall be used for all underground detention facilities.

Device Name/Number:____

Device Location: ____

Rainfall Data Source: *(Owner to fill in a consistent raindfall data source)*

Time (in hours) since last rainfall_________ Rainfall Quantity (in inches) ____________

Device Information	Manufacturer:
	Model Number:

Activity Log	Inspection Date #1:	Maintenance Date #1:
	Inspector Name #1:	Crew Leader Name #1:

Inspection Frequency	**Inspection Items:**	**√ if "yes"**	**Inspection Comment**	**√ if Maintenance is Complete**	**Follow up Comments**
	1. Are inlet pipes clogged? If so, with what? (Sediment, trash, other debris?) Is there excessive sediment build up in the pipe, impeding water flow?				
	2. Is the unit not functioning properly even though sediment is below the recommended cleaning level? If so, are there obstructions that could be hindering performance?				
	3. Is the outlet clogged? If so, with what? (Sediment, trash, other debris?)				
	4. Is sediment accumulating in detention device?				
	5. For concrete access manholes or pipe networks, are there any:				
	a. Cracks >1/8"?				
	b. Minor spalling (<1")?				
	c. Major spalling (rebar exposed)?				
	d. Joint failures?				
	6. For metal access manholes or pipe networks, are there any:				
	a. Areas of corrosion?				
	b. Dents/malformations that cause the structure or detention area to not function properly?				
	7. Are there indications that the system has pressurized during storm events?				
	8. Are there any problems with:				
	a. Obstructions for getting maintenance equipment to the BMP?				
	b. Access to all chambers? If so, what is impeding access?				
	9. Are there any encroachments into stormwater treatment area or access areas?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Definition

Stormwater infiltration practices capture and temporarily store stormwater before allowing it to infiltrate into the soil. Design variants include: infiltration basins, infiltration trenches, dry wells, and underground infiltration systems. As the stormwater penetrates the underlying soil, chemical, biological, and physical processes remove pollutants and delay or reduce peak stormwater flows.[1]

This section deals with structural practices relying on infiltration processes that are distinguishable from bioretention practices in that the former do not rely on vegetation to aid in the treatment. See the Bioretention Section for discussion of those practices where vegetation is integral to the treatment process.

Infiltration Trench - Source: Minnesota Stormwater Manual

Description

In general terms, infiltration systems can be described as natural or constructed depressions located in permeable soils that capture, store, and infiltrate stormwater runoff. These depressions can be located at the surface of the ground (e.g. infiltration basin) or they can be designed as underground facilities (e.g. structural chamber or excavated pit filled with aggregate such as an infiltration trench). Typically, infiltration systems are designed with one or more pre-treatment facilities. They can be designed as on-line or off-line facilities, which for the latter situation, the pre-treated water quality volume is diverted to the infiltration practice. As part of a stormwater management system, the practice may be used to achieve one or more of the following objectives:[1]

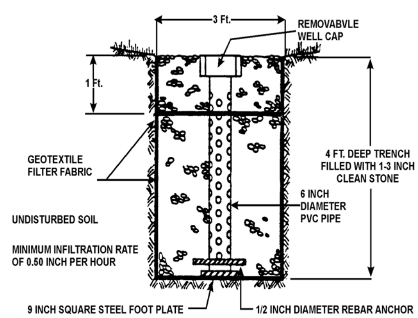
- Reduce stormwater pollutants
- Increase groundwater recharge
- Decrease peak flow rates and stormwater runoff volumes
- Preserve base flow in streams
- Reduce thermal impacts of runoff

Infiltration practices are applicable to sites with naturally permeable soils and a suitable distance to the seasonally high groundwater table, bedrock, or other impermeable layer. If a particular practice has on-going drainage problems, they may be due to inappropriate site selection given the physical circumstances. A suitable course of action should be discussed with appropriate personnel knowledgeable in design of this type of system.

Sub-categories of Technique

Infiltration Basin or Trench

An infiltration basin is an impoundment that captures, temporarily stores, and infiltrates the design volume of water. Infiltration basins are typically used for drainage areas of five to 50 acres with land slopes that are less than 20 percent. Typical depths range from two to 12 feet, including bounce in the basin.[1] It should be noted that the basin might not have an outlet except for the emergency overflow.



Infiltration Trench - Source: Southeastern Wisconsin Regional Planning Commission, 1991

An infiltration trench is a narrow excavated trench, typically three to 12 feet deep, that is backfilled with a coarse stone aggregate allowing for the temporary storage of runoff in the void space of the material. Discharge of this stored runoff occurs through infiltration into the surrounding naturally permeable soil. Trenches are commonly used for drainage areas less than five acres in size.[1]

Dry Wells

A dry well, or soak-away pit, is a smaller variation of an infiltration trench. It is a subsurface storage facility (a structural chamber or an excavated pit backfilled with a coarse stone aggregate) that receives and temporarily stores stormwater runoff. Discharge of this stored runoff occurs through infiltration into the surrounding naturally permeable soil. Due to their size, dry wells are typically designed to handle stormwater runoff from smaller drainage areas, less than one acre in size (e.g. roof tops), that generate relatively clean runoff.[1]

Underground Infiltration System

Several underground infiltration systems, including prefabricated pipes, vaults, and modular structures, have been developed as alternatives to infiltration basins and trenches for space-limited sites and stormwater retrofit applications. The system may have perforations or an open bottom that allows stormwater to have direct contact with the underlying soil. These systems are similar to infiltration basins and trenches in that they are designed to capture, temporarily store, and infiltrate the design volume of stormwater over several days. Underground infiltration systems are generally applicable to small development sites (typically less than 10 acres) and should be installed in areas that are easily accessible to routine and non-routine maintenance. These systems should not be located in areas or below structures that cannot be excavated in the event that the system needs to be replaced.[1]

Underground Storage & Infiltration - Source: Minnesota Stormwater Manual

Benefits/Limitations of Infiltration

Benefits[1]

- Reduces peak stormwater runoff flow rate.
- Increases groundwater recharge.
- Improves surface water quality.
- Provides thermal benefits to cold water fisheries.

Limitations[1, 2]

- Effectiveness is sensitive to construction and maintenance practices.
- Tendency to lose effectiveness over time due to clogging if not properly constructed or maintained.
- Not recommended for areas with steep slopes, karst topography, adjacent to buildings, or near potential stormwater hotspots.
- Special equipment (and access) is often required to perform routine maintenance for underground infiltration systems.
- Surface infiltration systems may require landscaping capable of handling periods of inundation and drought.
- Typically need to be paired with a pre-treatment device.

Detailed Inspection and Maintenance Activities – Infiltration[3]

These facilities have a high probability of failure, given the nature of their construction. Therefore, attention should be provided to make sure they are functioning properly immediately following construction. Furthermore, various studies performed in the 1990s have shown that infiltration practices have a relatively short life span. The majority of the practices were not operating as designed and had either partially or completely failed within the first five years of operation. For infiltration basins without built-in pre-treatment systems, failure can happen even more quickly. The most commonly cited reason for failure of infiltration structures is clogging due to sediment and organic debris but other common reasons include:[3]

- Compaction of in-situ soil
- Improper maintenance of appropriate surface vegetation
- Poor site selection
- Lack of pre-treatment structures

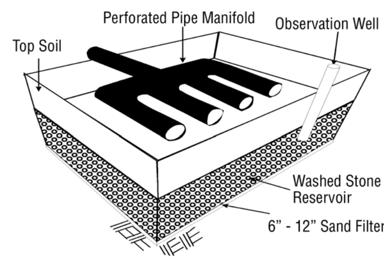
Because of these factors, diligent construction inspection and post-construction inspection and maintenance are required.

For underground infiltration systems, sediment removal should be by mechanical means other than flushing to prevent sediment from being transported deeper into the system or, depending on the outlet design to downstream water bodies.[4,6] If flushing is the only cleaning option and depending on the design of the overflow structure, special care may be needed to trap and remove sediment before it moves downstream.[4]

Note that some inspection and maintenance procedures detailed below will need to meet OSHA confined space entry requirements. Entrances to confined space areas must be clearly marked. This may be accomplished by hanging a removable sign in the access riser just under the access lid.[4]

All maintenance activities need to be undertaken in a manner that does not lead to soil compaction, because such compaction will reduce vertical water flow rates.

Table 1 provides a list of inspection and corresponding maintenance activities specific to infiltration basins. Other types of infiltration BMPs, such as drywells, infiltration trenches, and underground infiltration systems, are covered in Table 2.



Typical Infiltration Drainfield Schematic[5]

Resources

[1] Minnesota Stormwater Manual, Minnesota Pollution Control Agency (2005).

[2] Stormwater Technology Fact Sheet: On-Site Underground Retention/Detention, US EPA (September 2001).

[3] Assessment of Stormwater Best Management Practices, University of Minnesota (2007).

[4] Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates, Metropolitan Council (2001).

[5] Metropolitan Washington Council of Governments, 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*.

[6] ChamberMaxx™ Inspection and Maintenance Guide, CONTECH Construction Products, Inc. (2008).

Table 1
Infiltration Basins: Detailed Inspection and Maintenance Activities

Inspection Activities		Maintenance Activities	
1.	Do the trees and shrubs on the side slopes and within basins show signs of disease?	1.	Prune to maintain appearance. Remove any dead or severely diseased vegetation.
2.	Is there erosion or gullying of the side slopes?	2.	Search upstream to determine cause and make necessary modifications/repairs. Minor erosion areas can be reseeded, matching the seed mix of the intended design. Gully erosion should be filled, reseeded and covered with an erosion control blanket.
3.	Are there any spots >1 sq ft that are barren of vegetation on the side slopes or within the basin?	3.	Reestablish vegetation (i.e. seed, sod, install plants, erosion control). Match seed mix to intended design. For bare spots or dead vegetation in the bottom of the basin, check that water percolates within a time frame appropriate for that basin/device following significant rain events.
4.	Young, volunteer trees or shrubs?	4.	Handwork or careful application of appropriate herbicide. Remove vegetation and dispose of off site.
5.	Invasive species on pond slopes?	5.	Handwork or careful application of appropriate herbicide. Remove vegetation and dispose of off site.
6.	Weeds in mulched areas?	6.	Handwork or careful application of appropriate herbicide. Remove vegetation and dispose of off site.
7.	Is there trash or debris within the basin or on the side slopes?	7.	Remove as needed.
8.	Is there standing water in the basin for longer than is appropriate for that basin/device after a rainfall event due to sediment crust on top of the bioretention soil?	8.	Draw down water if needed. Remove sediment from basins such that compaction of infiltration soil is minimized. Replace vegetation using seed or plugs to match intended design.
9.	Do plant species in the bottom of the basin appear to be transitioning to wetland types?	9.	This is an indication that basin is not draining properly. Basin should be investigated to determine if surface is clogged with silt and/or clay or if underdrain system is not functioning.
10.	Is there indication of erosion or channelization in the bottom of the basin? **Inspect in the spring or fall when vegetation is low.**	10.	Minor erosion areas can be re-vegetated, matching the seed mix of the intended design. Gully erosion should be filled, re-vegetated and covered with an erosion control blanket. **This may be an indication that the velocity of the incoming water is too great and that additional energy dissipation may be required.**
11.	For inlet and overflow structures, are there any	11.	
	a. Cracks >1/8" in concrete components?		a. Remove all deteriorated concrete, dirt and bond-inhibiting material from the failed area. Inject with crack sealant approved for this application.
	b. Minor spalling of concrete (<1")?		b. Monitor.
	c. Major spalling of concrete (rebar exposed)?		c. Clean rebar, remove loose concrete, apply bonding agent and patch with material approved for this application.
	d. Joint failures?		d. Determine why joints are failing and note the type of joint and if groundwater is seeping through the failed joint. Use methods and materials appropriate to the situation.
	e. Corroded metal components?		e. Clean area of corrosion and determine the cause. Depending on the extent of the corrosion and the cause, the area could be cold galvanized or require more extensive repairs.
	f. Dents/malformations that cause the structure and basin to not function properly?		f. Repair to match intended design.
	g. Are pipes and/or structures clogged? (Sediment, trash, other debris) Is there excessive sediment build up in front of the inlet, impeding water flow?		g. Remove sediment and debris. Depending on extent of clogging, this may be handwork or require the use of jetting equipment to clean upstream system.
	h. Is there erosion or scour holes forming around inlets?		h. Fill eroded areas. Repair aprons and add riprap as necessary to prevent recurrence. Reestablish vegetation (i.e. seed, install plants, erosion control). Match seed mix to intended design.
	i. Is structure misaligned? Has it settled?		i. Reconstruct/modify as necessary. Reestablish vegetation (i.e. seed, install plants, erosion control). Match seed mix to intended design.
	j. Are aprons failing (disconnected or becoming disconnected from pipe?		j. Reattach apron and tie joints. Compact soil under apron and place new riprap in front and around sides of apron. For severe problems, construct concrete cutoff wall under apron.
12.	Are there any obstructions to getting maintenance equipment to the BMP?	12.	Stabilize slopes and drive path, clear vegetation or other work as appropriate.
13.	Are there any encroachments into stormwater treatment area or access areas?	13.	Notify your manager.

Table 2
Infiltration Other: Detailed Inspection and Maintenance Activities

Inspection Activities		Maintenance Activities	
1.	For infiltration trenches or dry wells:	1.	
	a. Crust or layer of fine sediment on the surface of the trench?		a. Remove rock from trench; wash or obtain new rock and reinstall.
	b. Visible sediment around the rock after using a shovel to remove upper few inches?		b. Remove rock from trench; wash or obtain new rock and reinstall.
	c. Is there water in pore spaces around rock for longer than is appropriate for that basin/device after a rainfall?		c. Remove rock from trench; wash or obtain new rock and reinstall.
	d. Is there water standing inside observation well for soak-away pit or dry well for longer than is appropriate for that basin/device after a rainfall?		d. Remove rock and filter fabric from trench; wash or obtain new rock and reinstall; install new filter fabric and reinstall observation well.
	e. Are the covers on any observation wells in place and in good condition?		e. Replace as necessary.
2.	For underground infiltration systems.	2.	Follow manufacturer's guidelines for inspection and maintenance.
3.	Are there any obstructions to getting maintenance equipment to the BMP?	3.	Stabilize slopes and drive path, clear vegetation or other work as appropriate.
4.	Are there any encroachments into stormwater treatment area or access areas?	4.	Notify your manager.

Infiltration Basins - Inspection and Maintenance Checklist

This inspection report shall be used for all infiltration basins. Use the form titled "Other Infiltration BMPs" for infiltration trenches, dry wells, etc.

Basin Name/Number:____ Rainfall Data Source: *(Owner to fill in a consistent raindfall data source)*

Basin Location:____ Time (in hours) since last rainfall_________ Rainfall Quantity (in inches) ____________

Plants	Inspection Date #1:	Maintenance Date #1
	Inspector Name #1:	Crew Leader Name #1:
All other Items	Inspection Date #2:	Maintenance Date #2:
	Inspector Name #2	Crew Leader Name #2

Inspection Frequency	Inspection Items:	√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	1. Do the trees and shrubs on the side slopes and within basins show signs of disease?				
	2. Is there erosion or gullying of the side slopes?				
	3. Are there any spots >1 sq ft that are barren of vegetation on the side slopes or within the basin?				
	4. Young, volunteer trees or shrubs?				
	5. Invasive species on pond slopes?				
	6. Weeds in mulched areas?				
	7. Is there trash or debris within the basin or on the side slopes?				
	8. Is there standing water in the basin for longer than is appropriate for that basin/device after a rainfall event due to sediment crust on top of the bioretention soil?				
	9. Do plant species in the bottom of the basin appear to be transitioning to wetland types?				
	10. Is there indication of erosion or channelization in the bottom of the basin? Inspect in the spring or fall when vegetation is low.				
	11. For inlet and overflow structures, are there any				
	a. Cracks >1/8" in concrete components?				
	b. Minor spalling of concrete (<1")?				
	c. Major spalling of concrete (rebar exposed)?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the Owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Inspection Frequency	Inspection Items:	√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	d. Joint failures?				
	e. Corroded metal components?				
	f. Dents/malformations that cause the structure and basin to not function properly?				
	g. Are pipes and/or structures clogged? (Sediment, trash, other debris) Is there excessive sediment build up in front of the inlet, impeding water flow?				
	h. Is there erosion or scour holes forming around inlets?				
	i. Is structure misaligned? Has it settled?				
	j. Are aprons failing (disconnected or becoming disconnected from pipe?				
	12. Are there any obstructions to getting maintenance equipment to the BMP?				
	13. Are there any encroachments into stormwater treatment area or access areas?				

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the Owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Other Infiltration BMPs - Inspection and Maintenance Checklist

This inspection report shall be used for all infiltration BMPs other than infiltration basins. For those, use the form titled "Infiltration Basins".

Device Name/Number:____

Device Location:____

Rainfall Data Source: *(Owner to fill in a consistent raindfall data source)*

Time (in hours) since last rainfall_________

Rainfall Quantity (in inches) ____________

Device Information	Type or Manufacturer:
	Model Number (if applicable):

Activity Log	Inspection Date #1:	Maintenance Date #1:
	Inspector Name #1:	Crew Leader Name #1:

Inspection Frequency	Inspection Items:			√ if "yes"	Inspection Comment	√ if Maintenance is Complete	Follow up Comments
	1.	For infiltration trenches or dry wells:					
		a.	Crust or layer of fine sediment on the surface of the trench?				
		b.	Visible sediment around the rock after using a shovel to remove upper few inches?				
		c.	Is there water in pore spaces around rock for longer than is appropriate for that basin/device after a rainfall?				
		d.	Is there water standing inside observation well for soak-away pit or dry well for longer than is appropriate for that basin/device after a rainfall?				
		e.	Are the covers on any observation wells in place and in good condition?				
	2.	For underground infiltration systems, follow manufacturer's guidelines for inspection and maintenance.					
	3.	Are there any obstructions to getting maintenance equipment to the BMP?					
	4.	Are there any encroachments into stormwater treatment area or access areas?					

Inspection Frequency Codes
E = Inspect on an Event Basis (as defined by the Owner)
1 = Inspect yearly
2 = Inspect every 2 years
3 = Inspect every 3 years
4 = Inspect every 4 years
5 = Inspect every 5 years

Introduction

This section covers stormwater BMPs that are newer to Minnesota and have not yet become commonly used. It is intended to provide a framework to evaluate these BMPs for future use. The BMPs chosen either have a few installations in the state or are being considered more frequently as part of stormwater management plans. Furthermore, these are BMPs that tend to be located in the public right-of-way and would be maintained by Public Works crews. The section ends with a few resources that may be useful for further exploration of each BMP.

Sand/Media Filtration

Definition

Filtration is the process by which suspended solids are removed from stormwater by passing the water through a bed of porous media. Filtration practices are structural stormwater controls that capture, temporarily store, and route stormwater runoff through a filter bed to improve water quality. The media can be made of sand, peat, grass, soil, or compost and should be assigned on a case-by-case basis. Filters can be off-line systems or designed as pre-treatment before discharging to other stormwater features.[1, 2] See the Bioretention Section when vegetation is used as the filter media.

Description

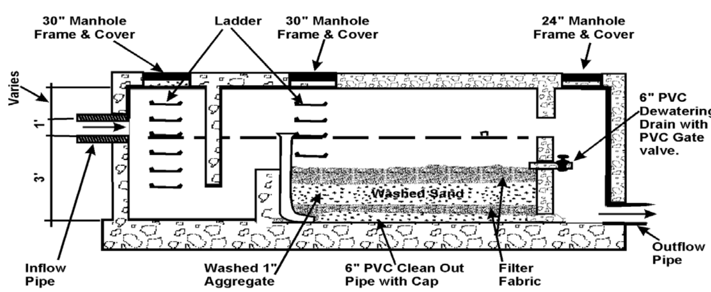
Filtering practices covered in this section are those using media filtration. Media filters can be located on the surface, underground, along the perimeter or an area, or in what is called a pocket design. Media filters operate similarly and provide comparable water quality capabilities as bioretention. Media filters can be designed with an underdrain, which makes them a good option for treating potential stormwater hotspots.[1]

The primary retention mechanism is sieving, where solids that are larger than the pore spaces in the sand or soil structure are captured and retained as the stormwater passes through the filter media. Solid deposition or attachment onto filter media or previously deposited solids is another possible solid retention mechanism in filters.[2] For regulatory purposes, filtration practices fall under the "Infiltration / Filtration" category described in Part III.C.2 of the MPCA General Construction Permit. If used in combination with other practices, credit for combined stormwater treatment can be given as described in Part III.C.4.[1]

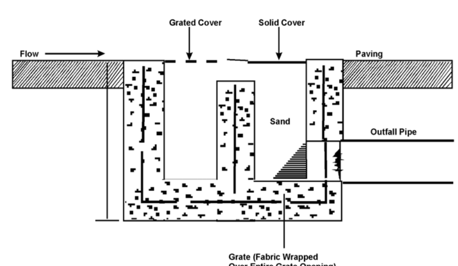
Sub-categories of Technique

- *Underground Sand Filters (following Delaware, or Washington DC methods)*

  The underground sand filter was adapted for sites where space is at a premium. In this design, the sand filter is placed in a three-chamber, underground vault accessible by manholes or grate openings. The vault can be either on-line or off-line in the storm drain system, but is most effective as an off-line BMP. The first chamber is used for pre-treatment and relies on a wet pool as well as temporary runoff storage. It is connected to the second sand filter chamber by an inverted elbow, which keeps the filter surface free from trash and oil. The filter bed is 18 inches in depth and may have a protective screen of gravel or permeable geotextile to limit clogging. During a storm, the water quality volume is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir. Filtered runoff is collected, using perforated underdrains that extend into the third "overflow" chamber.[1, 3]



Typical Washington D.C. Sand Filter Design[5]



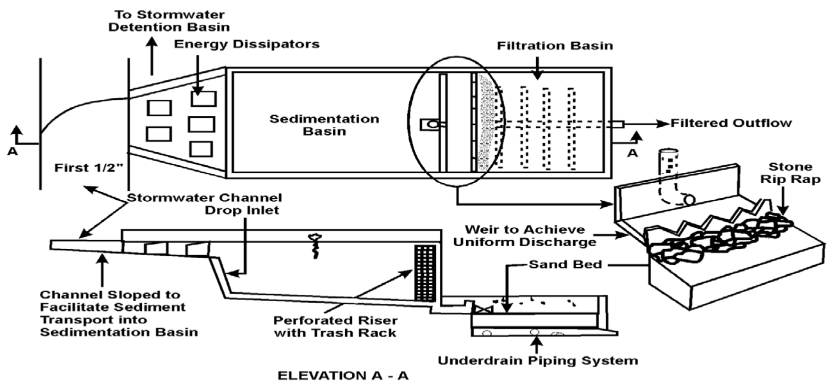
Typical Delaware Sand Filter Design[6]

- *Surface Sand Filters (following Austin methods)*

  Surface sand or soil filters (sometimes called "Austin sand filters") have a filter mechanism typically made up of a layer of filter media (18–24 inches). The filter media is separated from a gravel bed by a layer of geotextile fabric that prevents the filter media from washing through to the gravel bed. The gravel bed contains a perforated pipe collection system that captures filtered stormwater and delivers it either downstream for additional stormwater treatment or directly to receiving waters.[1]

  The Austin sand filtration system is more suited than underground sand filters for large drainage areas that have both impervious and pervious surfaces. This system is located at grade and is often used at transportation facilities, in large parking areas, and in commercial developments.[4]

  For discussion of rock filter trenches see the Bioretention Section.



Typical Austin Sand Filter Design[7]

- *Proprietary Devices Utilizing Cartridges or Other Media*

  Filtration devices, depending on the design, can treat stormwater to reduce nutrients, sediment, floatables, metals, oil, and/or organic compounds. Different filtration media are used depending on the type of pollutant to be removed. Filter media may be a screen, fabric, activated carbon, perlite, zeolite, or other materials. Often a combination of filter media can be used to target the specific pollutants of interest.[1]

  These devices differ from the structural stormwater filters described above in two aspects. First, these devices are proprietary and are designed to fit as an insert into the hydraulic infrastructure (e.g. a manhole or catch basin). Second, the media material may have unique characteristics which are different from the soil/sand media recommended for general stormwater filtration.[1]

  Filtration devices have been developed for use in locations such as underground chambers, catch basins, trench drains, and roof drains. The manufacturer specifications should indicate key design parameters such as size, allowable flow rate, allowable pollutant concentrations, and removal efficiency. A bypass should be part of the system to allow high flows to circumvent the filtration device.[1]

  Performance data are often provided by the manufacturer. Users should review this information to ensure it was provided by an independent source.[1] Suppliers of proprietary devices should be able to provide an operations and maintenance manual specific to their product.

Some Minnesota Applications

- *Underground Sand Filters (following Delaware, or Washington DC methods)*
  Mound Transit Station, City of Mound, MN (2007)
- *Surface Sand Filters, Rock Filter Trenches (following Austin methods)*
  TCF Bank Stadium, University of Minnesota (construction in 2009)
- *Proprietary Devices Utilizing Cartridges or Other Media*
  TCF Bank Stadium, University of Minnesota (2008)

Pervious Pavement (Asphalt, Concrete or Pavers)

Definition

Pervious pavements reduce the amount of runoff by allowing water to pass through load bearing surfaces that would otherwise be impervious. Water can either infiltrate into the ground, if soil permeability rates allow, or be conveyed to other BMPs or a storm water system by an underdrain.[1]

Pervious Concrete - Source: National Ready Mixed Concrete Association

Description

Pervious pavements can be subdivided into three general categories:[1]

1) Porous Pavements – porous surfaces that infiltrate water across the entire surface (i.e. porous asphalt and pervious concrete pavements);
2) Permeable Pavers – impermeable modular blocks or grids separated by spaces or joints that water drains through (i.e. block pavers, plastic grids, etc.);
3) Amended Soils - Fiber or artificial media added to soil to maintain soil structure and prevent compaction.

Permeable Pavers

Typically, pervious pavement systems have an open-graded aggregate base course. The depth of the base course is dependent on the runoff volume and must be of sufficient depth to prevent cracking of the asphalt or concrete during freeze/thaw cycles. Runoff is stored in the stone aggregate base course/ storage layer, if present, and allowed to infiltrate into the surrounding soil (functioning like an infiltration basin), or collected by an underdrain system and discharged to the storm sewer system or directly to receiving waters (functioning like a surface sand filter).[1]

Regular maintenance of pervious pavements is necessary to ensure long-term effectiveness. Regular vacuum sweeping of surface debris (litter, sediment, etc.) is recommended for pavement or pavers. If clogging occurs, the filtration media below the surface may need to be replaced. Manufacturers should be consulted for specific maintenance requirements.[1]

Some Minnesota Applications

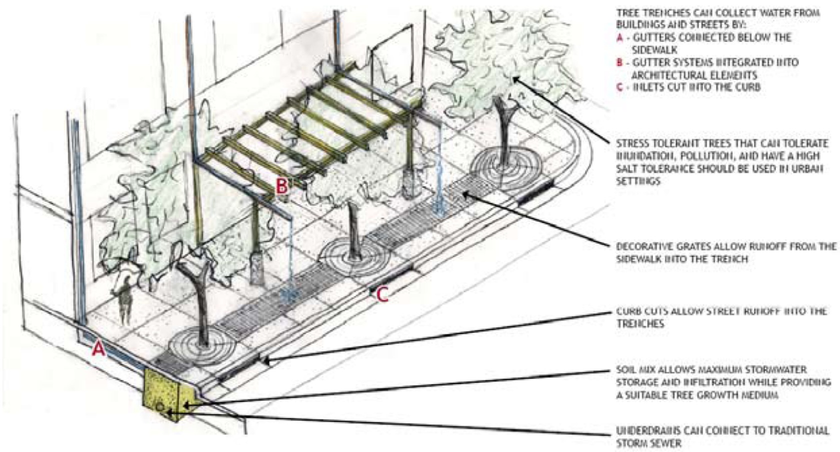
- Mound Transit Station, City of Mound, MN (2007)
- TCF Bank Stadium, University of Minnesota (construction in 2009)
- Edgewater Park, Minneapolis Park & Recreation Board (2006)
- University of Minnesota Landscape Arboretum, University of Minnesota (2002)
- District office parking lot, Ramsey-Washington Metro Watershed District (2005)
- Raspberry Island, City of Saint Paul, MN (2008)
- Various street applications, City of Minneapolis, MN (various)

Porous Asphalt

Tree Pits/Stormwater Planters

Definition

Tree pits and stormwater planters are types of bioretention BMPs, utilizing a system of plants and soil to treat stormwater runoff.



Tree Box Filter - Source: Minnehaha Creek Watershed District

Description

Simple "tree pits" are used for local drainage interception, in which a very shallow ponding area is provided in a "dished" mulch area around the tree or shrub. Typically, the mulched area extends to the drip line for the tree and is similar to conventional mulching practices, except that the mulch area is depressed at least two to three inches rather than mounded around the tree.[1] In urban streetscape settings, structural soil or proprietary systems may be necessary to allow the tree root system to fully develop.

A more complex version is the Tree Box Filter, which can be used in highly urbanized streetscapes. The system consists of a container filled with a soil mixture, a mulch layer, underdrain system and a shrub or tree. Stormwater runoff drains directly from impervious surfaces via curb openings or as overland flow where it infiltrates into a filter media. The runoff is cleaned by vegetation and soil, after which the treated water flows out of the system through an underdrain connected to a storm drainpipe/inlet or into the surrounding soil. Furthermore, the runoff collected in the tree boxes helps irrigate the trees or shrubs. Tree box filters can also be used to control runoff volumes/flows by adding storage volume beneath the filter box with an outlet control device.[1]

Stormwater planters are self-contained landscaping areas that capture and temporarily store a fraction of rooftop runoff and filter it through the soil media.[1]

Some Minnesota Applications

Marquette Avenue and Second Avenue South, City of Minneapolis, MN (anticipated 2009-2010)

Resources

[1] Minnesota Stormwater Manual, Minnesota Pollution Control Agency (2005).

[2] Assessment of Stormwater Best Management Practices, University of Minnesota (2007).

[3] Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates, Metropolitan Council (2001).

[4] Stormwater Technology Fact Sheet: Sand Filters, US EPA (September 1999).

[5] Troung, H., 1989. *The Sand Filter Water Quality Structure*. The District of Columbia.

[6] Shaver, E., 1991. *Sand Filter Design for Water Quality Treatment*. Delaware Department of Natural Resources and Environmental Control. Updated December, 1998.

[7] Schueler, T.R., 1992. *A Current Assessment of Urban Best Management Practices*. Metropolitan Washington Council of Governments.