Wetlands and Storm Water Section **Storm Water Program** **Office of Water Quality** **Indiana Department of Environmental Management**	**Authority:** *This inspection was conducted pursuant to Indiana Code (IC) 13-14-2-2 and is consistent with the requirements of IC 13-14-5.*
Municipal Separate Storm Sewer System (MS4) Minimum Control Measure Audit: • Construction Site Run-off • Post-Construction Run-off	**Date of Audit:** **Report Issued:** **Audit Conducted By:** **Report Prepared By:**

This audit report is a cumulative overview of the MS4 program for the construction site run-off and post-construction run-off minimum control measures. The report provides general background information, observations, recommendations, and requirements. The purpose of the audit is to identify program areas where an MS4 can improve program implementation, but to also identify deficiencies and/or violations that will require the MS4 to respond or address within specified timelines.

Section A: MS4 Program Information

MS4 Entity:

County:

MS4 Permit Number:

Permit Start and Expiration:

MS4 Operator:

MS4 Coordinator/Representative:

Audit Participants:

Construction Certification Date:
Post-Construction Certification Date:

Projects Regulated by MS4:

☐ All new projects are regulated upon the effective date of the construction site ordinance. The MS4 did not assume responsibility for projects that were active prior to passage of the local ordinance. These projects remain under the regulatory authority of IDEM.

☐ All new and active projects within the MS4 area, including those where construction was initiated prior to the effective date of the construction site ordinance.

☑ The MS4 is a non-traditional MS4 (University, Prison, College, etc.) and does not regulate projects within the MS4. All projects that occur within the MS4 are considered to be owned and operated by the MS4. The MS4 is responsible to obtain a permit in accordance with 327 IAC 15-5 and manage the construction site.

MS4 Boundaries for Program Administration of the Construction Minimum Control Measure:

☐ County MS4: ☐ Urbanized Areas Only ☐ Entire County, Excluding Incorporated Areas
Clarification:

☐ Municipality, City, Town: ☐ Urbanized Areas Only ☑ Other
Clarification:

Outreach to the Regulated Community (Construction Site and Post-construction Run-off):

Section B: Overall Program Assessment - Construction Site Run-off

(S = Satisfactory, M = Marginal, U = Unsatisfactory, NE = Not Evaluated, NA = Not Applicable)

S M U NE NA
(B1) ☐ ☐ ☐ ☐ ☐ The construction site ordinance meets the intent of 327 IAC 15-5.
Comment:
Recommendations:
Requirements:

S M U NE NA
(B2) ☐ ☐ ☐ ☐ ☐ Requirements and standards have been developed and/or adopted for the implementation of measures associated with erosion, sedimentation, and other waste on construction sites.

S M U NE NA
(C2) ☐ ☐ ☐ ☐ ☐ Requirements and standards have been developed and/or adopted for the implementation of measures associated with post-construction site run-off.

Comment:
Recommendations: yes Guidelines
Requirements:

S M U NE NA
(C3) ☐ ☐ ☐ ☐ ☐ The MS4 directs physical growth away from sensitive areas and towards those that will not compromise water quality. The MS4 manages the selection of measures in wellhead protection areas, discharges to other sensitive resource areas, and where applicable sinkholes.

Comment: We do comment on plans
Recommendations: NO We do Not issue permits
Requirements:

S M U NE NA
(C4) ☐ ☐ ☐ ☐ ☐ New retail gasoline outlets and refueling areas that replace their existing fuel tank systems are required by ordinance or other means to design and install appropriate measures to reduce lead, copper, zinc and polyaromatic hydrocarbons in storm water run-off from the facility.

Comment:
Recommendations: (As Needed) Casey's has it
Requirements:

S M U NE NA
(C5) ☐ ☐ ☐ ☐ ☐ Post-construction plans submitted for regulated projects are reviewed in accordance with the local MS4 ordinance.

Comment:
Recommendations: As Needed yes
Requirements:

S M U NE NA
(C6) ☐ ☐ ☐ ☐ ☐ The MS4 requires the development and implementation of written operational and maintenance plans for all planned structural post-construction storm water management measures to ensure long-term functionality.

Comment:
Recommendations: yes
Requirements:

S M U NE NA
(C7) ☐ ☐ ☐ ☐ ☐ The post-construction site run-off inspection program has established procedures for implementation, including a mechanism to enforce failure to maintain a post-construction measure.

Comment:
Recommendations: Pg 5
Requirements:

S M U NE NA
(C8) ☐ ☐ ☐ ☐ ☐ MS4 personnel responsible for plan review, inspection, and enforcement of the post-construction program attend annual training.

Comment:
Recommendations: yes AT Annual MS4
Requirements:

S M U NE NA
(C9) ☐ ☐ ☐ ☐ ☐ The post-construction site run-off program is reviewed at least once every five (5) years.

Comment:
Recommendations: yes New products
Requirements:

(C10) **Overall performance in administering the post-construction site run-off minimum control measure.**

Comment:

Recommendations:

Requirements: The MS4 should apply the same standards and/or requirements for post-construction to those projects they own and/or operate as they require for those projects they regulate.

Section D: Audit Summary

Action Items:

- **Recommendations:**
  (1)
- **Required Actions:**
  (1)

Attachments:

Action by IDEM: Failure to address and/or respond to deficiencies and/or violations may result in further action by IDEM including, but not limited to a compliance meeting and/or a non-compliance letter. As warranted, IDEM will perform follow-up inspections for projects owned and operated by the MS4 as they are permitted and will periodically revisit sites regulated by the MS4.

Section E: Audit Information

Report Provided to:

- Insert primary recipient

Report distributed: ☐ **Email** ☐ **Mail** ☐ **Via Certified Mail:**

Questions and the submittal of documents in response to this report should be directed to: , Storm Water Specialist Phone: Email:	Randy Braun, CPESC, CPMSM Section Chief Storm Water and Wetlands Program 100 North Senate Avenue IGCN, Room 1255 Indianapolis, Indiana 46204 Phone: 317-234-3980 Email: rbraun@idem.IN.gov

Comment:
Recommendations:
Requirements:

S	M	U	NE	NA	
(B3) ☐	☐	☐	☐	☐	Construction plans submitted for regulated projects are reviewed in accordance with the local MS4 ordinance.

Comment: yes
Recommendations:
Requirements: Send to Engr for Storm/Water/Sewer

S	M	U	NE	NA	
(B4) ☐	☐	☐	☐	☐	Construction projects are managed through a tracking system that includes name, address/location, duration, indication of compliance actions, and status (active NOI or equivalent and termination).

Comment: Not yet
Recommendations:
Requirements: I can count on one Hand.

S	M	U	NE	NA	
(B5) ☐	☐	☐	☐	☐	The construction site run-off inspection program has established procedures and written policy for program implementation; including sites that are a priority for inspection.

Comment:
Recommendations: use inspection forms
Requirements: w/ follow up

S	M	U	NE	NA	
(B6) ☐	☐	☐	☐	☐	Policy and procedures are implemented to enforce the construction site run-off program.

The MS4 utilizes ☑ Fines ☑ Stop work orders ☑ Penalties ☐ Permit suspension

Comment:
Recommendations: Only threaten (one) once → With Hold Water Service
Requirements:

S	M	U	NE	NA	
(B7) ☐	☐	☐	☐	☐	MS4 personnel responsible for plan review, inspection, and enforcement of construction activities attend annual training.

Comment: yes
Recommendations:
Requirements: Not sure on Engrs me yes

S	M	U	NE	NA	
(B8) ☐	☐	☐	☐	☐	The construction site run-off program is reviewed at least once every five (5) years.

Comment:
Recommendations:
Requirements: IF I SEE A New product then yes

(B9) Overall performance in administering the construction site run-off minimum control measure.
Comment:
Recommendations:
Requirements:

Section C: Overall Program Assessment - Post-construction Site Run-off

(S = Satisfactory, M = Marginal, U = Unsatisfactory, NE = Not Evaluated, NA = Not Applicable)

S	M	U	NE	NA	
(C1) ☐	☐	☐	☐	☐	The post-construction ordinance addresses local resource issues and meets the intent of 327 IAC15-5.

Comment:
Recommendations: yes
Requirements:

Post Construction Site Storm Water Management Best Management Practices (BMP) - (MCM 5)

Guide book and List Developed for and Approved by Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

Category / Purpose	BMP #	BMP Name	Str. / Non-Str.
Storage			
Gathers runoff to control storm water volume and settle out pollutants	S-1	(Dry) Detention Ponds	S
	S-2	(Wet) Retention Ponds	S
Infiltration			
Facilitates runoff percolation through the soil to reduce storm water quantity and pollutant mobilization	I-1	Infiltration Basins	S
	I-2	Infiltration Trenches	S
Vegetative / Filtering			
Enhances pollutant removal, improves site hydrology, and can increase aesthetic appeal	VF-1	Grass Swales / Open Vegetated Channels	S
	VF-2	Filter Strips	S
	VF-3	Bioretention / Landscape areas	S
	VF-4	Storm Water Wetlands	S
Site / Development Design			
Sound planning (better site design) and low impact development practices promotes improved water quality in various ways	SD-1	Cluster Design / Maintain Open Space	N
	SD-2	Buffer Zones	N
	SD-3	Minimize Imperviousness	N
	SD-4	Grass Shoulders & Swales vs. Curb & Gutters	N
	SD-5	Directed Growth / Zoning	N

* The guidebook will generally contain the following information for each of the Structural BMP's

  * Application or Selection Criteria
  * Performance Standards and Specifications
  * Inspection (Operation) and Maintenance

* Maintenance needs are to be coordinated with the landowner or site operator who is responsible for maintaining the practice.

Structural BMP Expected Pollutant Removal Efficiency

BMP #	BMP Name	Typical Pollutant Removal (%)				
		Susp. Solids	Nitrogen	Phosphorus	Pathogens	Metals
S-1	(Dry) Detention Ponds	30-65	15-45	15-45	< 30	15-45
S-2	(Wet) Retention Ponds	50-80	30-65	30-65	< 30	50-80
I-1	Infiltration Basins	50-80	50-80	50-80	65-100	50-80
I-2	Infiltration Trenches	50-80	50-80	15-45	65-100	50-80
VF-1	Grass Swales / Open Vegetated Channels	30-65	15-45	15-45	< 30	15-45
VF-2	Filter Strips	50-80	50-80	50-80	< 30	30-65
VF-3	Bioretention / Landscape areas					
VF-4	Storm Water Wetlands	50-80	< 30	15-45	< 30	50-80

Post Construction Site Storm Water Management Best Management Practices (BMP) - (MCM 5)

Guide book and List Developed for and Approved by Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

This BMP guidebook has been developed with the intent to assist Developers, Contractors, and/or Site Operators of areas undergoing new development or redevelopment with proposed land disturbing activities greater than 1 acre within the Valparaiso Lakes Area Conservancy District (VLACD) designated Municipal Separate Storm Sewer System (MS4) area comply with NPDES general permit requirements under 327 IAC 15-13 (Rule 13) Minimum Control Measure 5, with its purpose to reduce pollutants in post construction storm water runoff and discharges. The guidebook is also intended to assist the VLACD with post construction storm water management BMP plan reviews, inspections, and maintenance.

This guidebook is intended to provide guidance to the application, design standards, and maintenance requirements of the construction site storm water runoff BMP's included herein. Reference is hereby made to the ***Indiana Storm Water Quality Manual***, developed by the DNR, Division of Soil Conservation for further post construction site storm water management BMP design standards and specifications.

The VLACD will periodically review the contents of this guidebook in order to maintain and keep information current. The VLACD will also periodically review new or other BMP's for inclusion into the guidebook. A copy of the latest revision of this guidebook will be made available at the following address:

Valparaiso Lakes Area Conservancy District
1805 Burlington Beach Road
Valparaiso, IN 46383

Graphics source: USEPA and USDA-IL.NCRS

Guidebook development: R.W. Armstrong & Associates, Inc.
8300 Broadway, Suite E-1
Merrillville, IN, 46410

SECTION 1 - STORAGE

S-1 through S-2

Guidebook and list developed for and approved by
Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

Prepared by: R.W. Armstrong & Associates, Inc.

(DRY) DETENTION PONDS S - 1

A dry extended detention pond is designed to temporarily detain runoff during storm events

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose:

Dry detention / extended detention ponds are basins whose outlets have been designed to detain the storm water runoff from a water quality design storm for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. They can also be used to provide flood control by including additional flood detention storage.

Application or Selection Criteria:

- Dry extended detention ponds are among the most widely applicable storm water management practices. Although they have limited applicability in highly urbanized settings, they have few other restrictions.
- Ultra-urban areas are densely developed urban areas in which little previous surface is present. It is difficult to use dry extended detention ponds in the ultra-urban environment because of the land area each pond consumes.
- Dry detention ponds can be used in areas where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in storm water, but they need significant separation from ground water if they will be used for this purpose.
- Dry extended detention ponds are very useful storm water retrofits, put into place after development has occurred to improve water quality, protect downstream channels, reduce flooding, or meet other specific objectives.
- Although dry extended detention ponds can be applied rather broadly designers need to ensure that they are feasible at the site in question.
- Dry extended detention ponds should be used on sites with a minimum drainage area of 5-10 acres.

- Dry extended detention basins can be used on sites with slopes up to about 15 percent.

- There is no minimum slope requirement, but there does need to be enough elevation drop from the pond inlet to the pond outlet to ensure that flow can move through the system.

- Extended detention basins can be used with almost all soils and geology, with minor design adjustments for regions of rapidly percolating soils such as sand. In these areas, extended detention ponds should be designed with an impermeable liner to prevent ground water contamination.

- Except for the case of high pollutant runoff, the only consideration regarding ground water is that the base of the extended detention facility should not intersect the ground water table.

- Dry extended detention ponds have only moderate pollutant removal when compared to other structural storm water practices, and they are ineffective at removing soluble pollutants.

- Dry extended detention ponds may become a nuisance due to mosquito breeding.

- Although wet ponds can increase property values, dry ponds can actually detract from the value of a home.

- Dry extended detention ponds are the least expensive storm water management practice, on the basis of cost per unit area treated.

Performance Standards or Specifications:

- Specific designs may vary considerable, depending on site constraints or preferences of the designer or community. Some features, however, should be incorporated into most dry extended detention pond designs. These design features can be divided into five basic categories: pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

<u>Pretreatment</u>

- Pretreatment incorporates design features that help to settle out course sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In ponds, pretreatment is achieved with a sediment forebay, which is a small pool (typically about 10 percent of the volume of water to be treated for pollutant removal).

<u>Treatment</u>

- Treatment design features help enhance the ability of a storm water management practice to remove pollutants. Designing dry ponds with a high length-to-width ratio (at least 1.5:1) and incorporating other design features to maximize the flow path effectively increases the detention time in the system by eliminating the potential of flow to short-circuit the pond. Designing ponds with relatively flat slopes can also help to lengthen the effective flow path. Finally, the pond should be sized to detain the volume of runoff to be treated for between 12 and 48 hours.

Conveyance

- The outfall of pond systems should always be stabilized to prevent scour. To convey low flows through the system, designers should provide a pilot channel. A pilot channel is a surface channel that should be used to convey low flows through the pond. In addition, an emergency spillway should be provided to safely convey large flood events. To help mitigate warming at the outlet channel, designers should provide shade around the channel at the pond outlet.

Maintenance Reduction

- In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to ease the maintenance burden of each practice. In dry extended detention ponds, a "micropool" at the outlet can prevent resuspension of sediment and outlet clogging. A good design includes maintenance access to the forebay and micropool.

- Another design feature that can reduce maintenance needs is a non-clogging outlet. Typical examples include a reverse-slope pipe or a weir outlet with a trash rack. A reverse slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and determines the water elevation of the micropool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris.

Landscaping

- Designers should maintain a vegetated buffer around the pond and should select plants within the extended detention zone (i.e., the portion of the pond up to the elevation where the storm water is detained) that can withstand both wet and dry periods. The side slopes of dry ponds should be relatively flat to reduce safety risks.

▪ Dry detention ponds are similar in design to extended detention ponds, except that they do not incorporate features to improve water quality. In particular, these practices do not detain storm water from small-flow events. Therefore, detention ponds provide almost no pollutant removal. However, dry ponds can help meet flood control, and sometimes channel protection, objectives in a watershed.

▪ If a pond is used to treat runoff or is used for snow storage, landscaping should incorporate salt-tolerant species. Sediment might need to be removed from the forebay more frequently than in warmer climates to account for sediment deposited as a result of road sanding.

▪ One objective of storm water management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Dry extended detention basins can easily be designed for flood control, and this is actually the primary purpose of most extended detention ponds.

- Dry extended detention basins provide moderate pollutant removal, provided that the design features described in this section are incorporated. Although they can be effective at removing some pollutants through settling, they are less effective at removing soluble pollutants because of the absence of a permanent pool. Typical removal rates, as reported by Schueler (1997), are as follows:

    - Total suspended solids: 61%
    - Total phosphorus: 19%
    - Total nitrogen: 31%
    - Nitrate nitrogen: 9%
    - Metals: 26%-54%

- There is considerable variability in the effectiveness of ponds, and it is believed that properly designing and maintaining ponds may help to improve their performance.

Inspection (Operation) and Maintenance:

- In addition to incorporating features into the pond design to minimize maintenance, some regular maintenance and inspection practices are needed as follows:

Activity	Schedule
Note erosion of pond banks or bottom.	Semiannual inspection
Inspect for damage to the embankment.	Annual inspection
Monitor for sediment accumulation in the facility and forebay.	
Examine to ensure that inlet and outlet devices are free of debris and operational.	
Repair undercut or eroded areas.	As needed or required
Mow side slopes.	
Manage pesticide and nutrients.	
Remove litter and debris.	
Seed or sod to restore dead or damaged ground cover.	Annual maintenance (as needed)
Remove sediment from the forebay.	5- to 7-year maintenance
Monitor sediment accumulations, and remove sediment when the pond volume has been reduced by 25 percent.	20 to 30 year maintenance

(WET) RETENTION PONDS S - 2

The primary functions of a wet pond are to detain storm water and facilitate pollutant removal through settling and biological uptake

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose:

Wet retention ponds are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Ponds treat incoming storm water runoff by settling and algal uptake. The primary removal mechanism is settling as storm water runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond.

Application or Selection Criteria:

- Wet ponds are among the most cost-effective and widely used storm water practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain storm water runoff in order to provide settling.
- Wet ponds have limited applicability in highly urbanized settings and in arid climates, they have few other restrictions.
- Ultra-urban areas are densely developed urban areas in which little pervious surface exits. It is difficult to use wet ponds in the ultra-urban environment because of the land area each pond consumes.
- Wet ponds can accept runoff from areas of high pollutant concentration, but need significant separation from the ground water if they will be used for this purpose.
- Wet retention pond designers need to ensure that this management practice is feasible at the site in question.
- Wet ponds need sufficient drainage area to maintain the permanent pool, which is typically about 25 acres.
- Wet ponds can be used on sites with an upstream slope up to about 15 percent. Although there is no minimum slope requirement, there does need to be enough

elevation drop from the pond inlet to the pond outlet to ensure that water can flow through the system.

- Wet ponds can be used in almost all soils and geology.
- Unless they receive high pollutant concentration runoff, ponds can often intersect the ground water table. However, some research suggests that pollutant removal is reduced when ground water contributes substantially to the pool volume.
- If improperly located, wet pond construction may cause loss of wetlands or forest.
- Although wet ponds consume a small amount of space relative to their drainage areas, they are often inappropriate in dense urban areas because each pond is generally quite large.
- Wet ponds may pose safety hazards.
- Wet ponds are relatively inexpensive storm water practices. The construction costs associated with these facilities range considerably.

Performance Standards or Specifications:

- Specific designs may vary considerably, depending on site constraints or preference of the designer or community. There are some features, however, that should be incorporated into most wet pond designs. These design features can be divided into five basic categories: Pretreatment, treatment, conveyance, maintenance reduction, and landscaping.

<u>Pretreatment</u>

- Pretreatment incorporates design features that help to settle out course sediment particles. By removing these particles from runoff before they reach the large permanent pool, the maintenance burden of the pond is reduced. In ponds, pretreatment is achieved with a sediment forebay. A sediment forebay is small pool (typically about 10 percent of the volume of the permanent pool). Coarse particles remain trapped in the forebay, and maintenance is performed on this smaller pool, eliminating the need to dredge the entire pond.

<u>Treatment</u>

- Treatment design features help enhance the ability of a storm water management practice to remove pollutants. The purpose of most wet pond treatment features is to increase the amount of time that storm water remains in the pond.
- One technique of increasing the pollutant removal of a pond is to increase the volume of the permanent pool. Typically, ponds are sized to be equal to the water quality volume (i.e., the volume of water treated for pollutant removal). Designers may consider using a larger volume to meet specific watershed objectives, such as phosphorous removal in a lake system. Regardless of the pool size, designers need to conduct a water balance analysis to ensure that sufficient inflow is available to maintain the permanent pool.
- Other design features do not increase the volume of a pond, but can increase the amount of time storm water remains in the practice and eliminate short-

circuiting. Ponds should always be designed with a length-to-width ratio of at least 1.5:1. In addition, the design should incorporate features to lengthen the flow path through the pond, such as underwater berms designed to create a longer route through the pond. Combining these two measures helps ensure that the entire pond volume is used to treat storm water. Another feature that can improve treatment is to use multiple ponds in series as part of a "treatment train" approach to pollutant removal. This redundant treatment can also help slow the rate of flow through the system.

<u>Conveyance</u>

- The outfall of pond systems should always be stabilized to prevent scour. In addition, an emergency spillway should be provided to safely convey large flood events, To help mitigate warming at the outlet channel, designers should provide shade around the channel at the pond outlet.

<u>Maintenance Reduction</u>

- In addition to regular maintenance activities needed to maintain the function of storm water practices, some design features can be incorporated to ease the maintenance burden of each practice. In wet ponds, maintenance reduction, include techniques to reduce the amount of maintenance needed, as well as techniques to make regular maintenance activities easier.

- One potential maintenance concern in wet ponds is clogging of the outlet. Ponds should be designed with a non-clogging oulet such as a reverse-slope pipe, or a weir outlet with a trash rack. A reverse-slope pipe draws from below the permanent pool extending in a reverse angle up to the riser and establishes the water elevation of the permanent pool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris. Another general rule is that no orifice should be less than 3 inches in diameter. (Smaller orifices are more susceptible to clogging).

- Design features are also incorporated to ease maintenance of both the forebay and the main pool of ponds. Ponds should be designed with a maintenance access to the forebay to ease this relatively routine (5-7 year) maintenance activity. In addition, ponds should generally have a pond drain to draw down the pond for the more infrequent dredging of the main cell of the pond.

<u>Landscaping</u>

- Landscaping of wet ponds can make them an asset to a community and can also enhance the pollutant removal of the practice. A vegetated buffer should be preserved around the pond to protect the banks from erosion and provide some pollutant removal before runoff enters the pond by overland flow. In addition, ponds should incorporate an aquatic bench (i.e., a shallow shelf with wetland plants) around the edge of the pond. This feature may provide some pollutant uptake, and it also helps to stabilize the soil at the edge of the pond and enhance habitat and aesthetic value.

▪ There are several variations of the wet pond design. Some of these design alternatives are intended to make the practice adaptable to various sites and to account for regional constraints and opportunities.

▪ The wet extended detention pond combines the treatment concepts of the dry extended detention pond and the wet pond. In this design, the water quality volume is split between the permanent pool and detention storage provided above the permanent pool. During storm events, water is detained above the permanent pool and released over 12 to 48 hours. This design has similar pollutant removal to a traditional wet pond and consumes less space. Wet extended detention ponds should be designed to maintain at least half the treatment volume of the permanent pool. In addition, designers need to carefully select vegetation to be planted in the extended detention zone to ensure that the selected vegetation can withstand both wet and dry periods.

- In this design alternative, a pond drains a smaller area than a traditional wet pond, and the permanent pool is maintained by intercepting the ground water. While this design achieves less pollutant removal than a traditional wet pond, it may be an acceptable alternative on sites where space is at a premium, or in a retrofit situation.

- Some designers have used wet ponds to act as a water source, usually for irrigation. In this case, the water balance should account for the water that will be taken from the pond.

- One option to deal with high pollutant loads and runoff volumes during the spring snowmelt is the use of a seasonally operated pond to capture snowmelt during the winter, and retain the permanent pool during warmer seasons.

- Designers should consider planting the pond with salt-tolerant vegetation if the facility receives road runoff. In order to counteract the effects of freezing on inlet and outlet structures, the use of inlet and outlet structures that are resistant to frost, included weirs and larger diameter pipes, may be useful. Designing structures on-line, with a continuous flow of water through the pond, will also help prevent freezing of these structures.

- One objective of storm water management practices can be to reduce the flood hazard associated with large storm events by reducing the peak flow associated with these storms. Wet ponds can easily be designed for flood control by providing flood storage above the level of the permanent pool.

- Wet ponds cannot provide ground water recharge. Infiltration is impeded by the accumulation of debris on the bottom of the pond.

- Wet ponds are among the most effective storm water management practices at removing storm water pollutants. A wide range of research is available to estimate the effectiveness of wet ponds. Typical removal rates, as reported by Schueler (1997a) are:

    - Total Suspended Solids: 67%
    - Total Phosphorous: 48%
    - Total Nitrogen: 31%
    - Nitrate Nitrogen: 24%
    - Metals: 24-73%
    - Bacteria: 65%

- There is considerable variable in the effectiveness of ponds, and it is believed that properly designing and maintaining ponds may help to improve their performance.

Inspection (Operation) and Maintenance:

- In addition to incorporating features into the pond design to minimize maintenance, some regular maintenance and inspection practices are needed as follows:

Activity	Schedule
If wetland components are included, inspect for invasive vegetation.	Semi-annual inspection
Inspect for damage.	Annual inspection
Note signs of hydrocarbon build-up, and deal with appropriately.	
Monitor for sediment accumulation in the facility and forebay.	
Examine to ensure that inlet and outlet devices are free of debris and operational.	
Repair undercut or eroded areas.	As needed maintenance
Clean and remove debris from inlet and outlet structures.	Monthly maintenance
Mow side slopes.	
Manage and harvest wetland plants.	Annual maintenance (if needed)
Remove sediment from the forebay.	5- to 7-year maintenance
Monitor sediment accumulations, and remove sediment when the pool volume has become reduced significantly or the pond becomes eutrophic.	20-to 50 year maintenance

SECTION 2 - INFILTRATION

I-1 through I-2

Guidebook and list developed for and approved by
Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

Prepared by: R.W. Armstrong & Associates, Inc.

INFILTRATION BASINS

I - 1

Infiltration basins are designed to collect storm water from impervious areas and provide pollutant removal benefits through detention and filtration

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose:

An infiltration basin is a shallow improvement which is designed to infiltrate storm water into the ground water, provide pollutant removal and can also help recharge the ground water.

Application or Selection Criteria:

- Infiltration basins have select applications. Their use is often sharply restricted by concerns over ground water contamination, soils, and clogging at the site.
- Infiltration basins should never receive runoff from an area where land use or activities generate highly contaminated runoff, unless the storm water has already been treated by another practice. This caution is due to potential ground water contamination.
- Infiltration basins should be used to treat small sites (less than 5 acres).
- It is often difficult to find areas where soils are appropriate for infiltration in an already urban or suburban environment.
- Infiltration basins are best applied to small sites, yet need a flat, relatively continuous area. It is often difficult to finds sites with this type of area available.
- Infiltration basins are an excellent option for cold water streams because they encourage infiltration of storm water and maintain dry weather flow. Because storm water travels underground to the stream, it has little opportunity to increase in temperature.
- In most cold climates, infiltration basins can be a feasible practice, but there are some challenges to its use. First, the practice may become inoperable during some portions of the year when the surface of the basin becomes frozen. Other design

features also may be incorporated to deal with the challenges of cold climates. Such as the volume of runoff associated with the spring snowmelt event. The capacity of the infiltration basin might be increased to account for snowmelt volume.

- The basin may be disconnected during the winter to ensure that chlorides do not enter the ground water in areas where this is a problem, or if the basin is used to treat roadside runoff. Designers may also want to reconsider application of infiltration practices on parking lots or roads where deicing is used, unless it is confirmed that the practice will not cause elevated chloride levels in the ground water. If the basin is used for snow storage, or to treat roadside or parking lot runoff, the basin bottom should be planted with salt-tolerant vegetation.

- Infiltration basins are not generally aesthetic practices, particularly if they clog. If they clog, the soils become saturated, and the practice can be a source of mosquitoes.

- Maintenance of infiltration practices can be burdensome, and they have a relatively high rate of failure.

Performance Standards or Specifications:

- Infiltration practices need to be located extremely carefully. In particular, designers need to ensure that the soils on the site are appropriate for infiltration, and that designs minimize the potential for ground water contamination and long term maintenance problems.

- The bottom of infiltration basins needs to be completely flat to allow infiltration throughout the entire basin bottom.

- Soils must be significantly permeable to ensure that the practice can infiltrate quickly enough to reduce the potential for clogging, and soils that infiltrate too rapidly may not provide sufficient treatment, creating the potential for ground water contamination. The infiltration rate should range between 0.5 and 3 inches per hour. In addition, the soils should have no greater that 20 percent clay content, and less than 40 percent silt/clay content.

- Designers always need to provide significant separation distance (2 to 5 feet) from the bottom of the infiltration basin and the seasonally high ground water table, to reduce the risk of contamination. Infiltration practices should also be adequately separated from drinking water wells.

- In order to ensure that pretreatment mechanisms are effective, designers should incorporate "multiple pretreatment," using practices such as grassed swales, sediment basins, and vegetated filter strips in series that provide settling of large particles before runoff reaches the infiltration basin.

- For infiltration practices, designers need to stabilize upland soils to ensure that the basin does not become clogged with sediment. In addition, the facility needs to be sized so that the volume of water to be treated infiltrates through the bottom in a given amount of time. Because infiltration basins are designed in this matter, infiltration basins designed on less permeable soils should be significantly larger than those designed on more permeable soils.

- Designers need to be particularly careful in ensuring that channels leading to an infiltration practice are designed to minimize erosion. In general, infiltration basins should be designed to treat only small storms (i.e., only for water quality). Thus, these practices should be designed "off-line,' using a flow separator to divert only small flows to the practice.

- In infiltration basins, designers need to provide access to the basin for regular maintenance activities. Where possible, a means to drain the basin, such as an underdrain, should be provided in case the bottom becomes clogged. This feature allows the basin to be drained and accessed for maintenance in the event that the water has ponded in the basin bottom or the soil is saturated.

- In infiltration basins, the most important purpose of vegetation is to reduce the tendency of the practice to clog. Upland drainage needs to be properly stabilized with a thick layer of vegetation, particularly immediately following construction.

- Infiltration basins can provide ground water recharge and pollutant removal.

- Infiltration basins recharge the ground water because runoff is treated for water quality by filtering through the soil and discharging the ground water.

- The average pollutant removal, assuming the infiltration basin is sized to treat the runoff from a 1-inch storm, is:

  - TSS 75%
  - Phosphorous 60-70%
  - Nitrogen 55-60%
  - Metals 85-90%
  - Bacteria 90%

- These removal efficiencies assume that the infiltration basin is well designed and maintained. Schueler (1987).

Inspection (Operation) and Maintenance:

- Typical maintenance activities for infiltration basins:

Activity	Schedule
Inspect facility for signs of wetness or damage to structures	Semi-annual inspection
Note eroded areas	
If dead or dying grass on the bottom is observed, check to ensure that water percolates 2-3 days following storms	
Note signs of petroleum hydrocarbon contamination and handle properly	Semi annual
Mow and remove litter and debris	Standard maintenance (as needed)
Stabilize of eroded banks	
Repair undercut and eroded areas at inflow and outflow structures	
Disc or otherwise aerate bottom	Annual maintenance
Dethatch basin bottom	
Scrape bottom and remove sediment. Restore original cross-section and infiltration rate	5-year maintenance
Seed or sod to restore ground cover	

INFILTRATION TRENCHES

I - 2

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose:

An infiltration trench is a rock-filled trench with no outlet that receives storm water runoff. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matix. The primary pollutant removal mechanism of this practice is filtering through the soil.

Application or Selection Criteria:

- Infiltration trenches have select applications. While they can be applied in most regions of the country, their use is sharply restricted by concerns due to common site factors, such as potential ground water contamination, soils, and clogging.
- Infiltration trenches should not receive runoff from areas where land use or activities generate highly contaminated runoff, unless the storm water has already been treated by another storm water management practice, because of potential ground water contamination.
- In most cold climates, infiltration trench volume may need to be increased in order to treat snowmelt. In addition, if the practice is used to treat roadside runoff, it may be desirable to divert flow around the trench in the winter to prevent infiltration of chlorides from road salting, where this is a problem. Finally, a minimum setback from roads is needed to ensure that the practice does not cause frost heaving.
- Infiltration trenches provide no visual enhancements. Their application is limited due to concerns over ground water contamination and other soils requirements. Maintenance can be burdensome, and infiltration practices have a relatively high rate of failure.

Performance Standards or Specifications:

- Infiltration trench designers need to ensure that the soils on site are appropriate for infiltration and that designs minimize the potential for ground water contamination and long-term maintenance.

- Infiltration trenches generally can be applied to relatively small sites (less than 5 acres).

- Infiltration trenches should be placed on flat ground, but the slopes of the site draining to the practice can be as steep as 15 percent.

- Soils must be significantly permeable to ensure that the storm water can infiltrate quickly enough to reduce the potential for clogging. In addition, soils that infiltrate too rapidly may not provide sufficient treatment, creating the potential for ground water contamination. The infiltration rate should range between 0.5 and 3 inches per hour. In addition, the soils should have no greater than 20-percent clay content, and less than 40-percent silt/clay content.

- Designers always need to provide significant separation (2 to 5 feet) from the bottom of the infiltration trench and the seasonally high ground water table, to reduce the risk of contamination. In addition, infiltration practices should be adequately separated from drinking water wells.

- To ensure that pretreatment mechanisms are effective, designers should incorporate "multiple pretreatment," using practices such as grassed swales, vegetated filter strips or detention, that provide settling of large practices before runoff reaches the trench.

- Upland soils of infiltration trenches need to be stabilized to ensure that the trench does not become clogged with sediment, and the trench should be sized so that the volume to be treated can infiltrate out of the trench bottom in 24 hours.

- Designers need to be particularly careful in ensuring that channels leading to an infiltration practice are designed to minimize erosion. Infiltration trenches should be designed to treat only small storms, (i.e., only for water quality). Thus, these practices should be designed "off-line," using a structure to divert only small flows to the practice. The sides of an infiltration trench should be lined with a geotextile fabric to prevent flow from causing rills along the edge of the practice.

- Infiltration trenches should have an access path for maintenance activities. An observation well (i.e., a perforated PVC pipe that leads to the bottom of the trench) can enable inspectors to monitor the drawdown rate. Where possible, trenches should have a means to drain the practice if it becomes clogged, such as an under drain. A perforated pipe system in a gravel bed, installed on the bottom of filtering practices to collect and remove filtered runoff.

- Infiltration trenches can provide ground water recharge and pollutant control.

- Infiltration trenches recharge the ground water because runoff is treated for water quality by filtering through the soil and discharging to ground water.

- The average pollutant removal, assuming the infiltration trench is sized to treat the runoff from a 1-inch storm, is:

    - TSS 75%
    - Phosphorous 60-70%
    - Nitrogen 55-60%
    - Metals 85-90%
    - Bacteria 90%

- These removal efficiencies assume that the infiltration trench is well designed and maintained. Schueler (1987).

Inspection (Operation) and Maintenance:

- Typical maintenance activities for infiltration trenches:

Activity	Schedule
Check observation wells following 3 days of dry weather. Failure to percolate within this time period indicates clogging.	Semi-annual inspection
Inspect pretreatment devices and diversion structures for sediment build-up and structural damage.	
Remove sediment and oil/grease from pretreatment devices and overflow structures.	Standard maintenance
If bypass capacity is available, it may be possible to regain the infiltration rate in the short term by using measures such as providing an extended dry period.	5-year maintenance
Partial or total rehabilitation of the trench should be conducted to maintain storage capacity within 2/3 of the design treatment volume and 72-hour exfiltration rate limit.	Upon failure
Trench walls should be excavated to expose clean soil.	

Post Construction Site Storm Water Management Best Management Practices (BMP) - (MCM 5)

Guide book and List Developed for and Approved by Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

This BMP guidebook has been developed with the intent to assist Developers, Contractors, and/or Site Operators of areas undergoing new development or redevelopment with proposed land disturbing activities greater than 1 acre within the Valparaiso Lakes Area Conservancy District (VLACD) designated Municipal Separate Storm Sewer System (MS4) area comply with NPDES general permit requirements under 327 IAC 15-13 (Rule 13) Minimum Control Measure 5, with its purpose to reduce pollutants in post construction storm water runoff and discharges. The guidebook is also intended to assist the VLACD with post construction storm water management BMP plan reviews, inspections, and maintenance.

This guidebook is intended to provide guidance to the application, design standards, and maintenance requirements of the construction site storm water runoff BMP's included herein. Reference is hereby made to the ***Indiana Storm Water Quality Manual***, developed by the DNR, Division of Soil Conservation for further post construction site storm water management BMP design standards and specifications.

The VLACD will periodically review the contents of this guidebook in order to maintain and keep information current. The VLACD will also periodically review new or other BMP's for inclusion into the guidebook. A copy of the latest revision of this guidebook will be made available at the following address:

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Post Construction Site Storm Water Management Best Management Practices (BMP) - (MCM 5)

Guide book and List Developed for and Approved by Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

Structural BMP Expected Pollutant Removal Efficiency

BMP #	BMP Name	Typical Pollutant Removal (%)				
		Susp. Solids	Nitrogen	Phosphorus	Pathogens	Metals
S-1	(Dry) Detention Ponds	30-65	15-45	15-45	< 30	15-45
S-2	(Wet) Retention Ponds	50-80	30-65	30-65	< 30	50-80
I-1	Infiltration Basins	50-80	50-80	50-80	65-100	50-80
I-2	Infiltration Trenches	50-80	50-80	15-45	65-100	50-80
VF-1	Grass Swales / Open Vegetated Channels	30-65	15-45	15-45	< 30	15-45
VF-2	Filter Strips	50-80	50-80	50-80	< 30	30-65
VF-3	Bioretention / Landscape areas					
VF-4	Storm Water Wetlands	50-80	< 30	15-45	< 30	50-80

SECTION 3 - VEGETATIVE / FILTERING

VF-1 through VF-4

Guidebook and list developed for and approved by
Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

Prepared by: R.W. Armstrong & Associates, Inc.

GRASS SWALES / OPEN VEGETATED CHANNELS VF - 1

Grassed swales can be used along roadsides and parking lots to collect and treat storm water runoff

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose: A series of vegetated, open channel management practices designed specifically to treat and attenuate storm water runoff through filtering by the vegetation in the channel, filtering through a subsoil matix, and/or infiltration into the underlying soils.

Application or Selection Criteria:

- Swales are very well suited for treating highway or residential road runoff because they are linear practices.
- Grassed swales are generally not well suited to ultra-urban areas because they require a relatively large area of pervious surfaces.
- Areas where land use or activities generate highly contaminated runoff, should not be directed toward grassed channels. These practices either infiltrate storm water or intersect the ground water.
- One retrofit opportunity using grassed swales modifies existing drainage ditches. Ditches have traditionally been designed only to convey storm water away from roads. In some cases it may be possible to incorporate features to enhance pollutant removal or infiltration such as check dams.
- Designers need to ensure that this management practice is feasible at the site in question because some site conditions (i.e., steep slopes, highly impermeable soils) might restrict the effectiveness of grassed channels.
- In cold or snowy climates, swales may serve a dual purpose by acting as both a snow storage/treatment and a storm water management practice. This dual purpose is particularly relevant when swales are used to treat road runoff. If used

for this purpose, swales should incorporate salt-tolerant vegetation, such as creeping bentgrass.

- Grassed swales cannot treat a very large drainage area.
- Wet swales may become a nuisance due to mosquito breeding.
- If designed with inadequate slope grassed channels will have very little pollutant removal.
- A thick vegetative cover is needed for these practices to function properly.

Performance Standards or Specifications:

- Grassed swales should generally treat small drainage areas of less than 5 acres.
- Grassed swales should be used on sites with relatively flat slopes of less than 5 percent slope; 1 to 2 percent slope is recommended. Runoff velocities within the channel become too high on steeper slopes. This can cause erosion and does not allow for infiltration or filtering in the swale.
- In the dry swale and grassed channel options, designers should separate the bottom of the swale from the ground water by at least 2 ft to prevent a moist swale bottom, or contamination of the ground water. IN the wet swale option, treatment is enhanced by a wet pool in the practice, which is maintained by intersecting the ground water.
- Swales should generally have a trapezoidal or parabolic cross section with relatively flat side slopes (flatter than 3:1). Designing the channel with flat side slopes maximizes the wetted perimeter. Increasing the wetted perimeter slows runoff velocities and provides more contact with vegetation to encourage filtering and infiltration. The flat bottom should be between 2-8 ft wide. The minimum width ensures a minimum filtering surface for water quality treatment, and the maximum width prevents braiding, the formation of small channels within the swale bottom.
- A small forebay should be used at the front of the swale to trap incoming sediments, A pea gravel diaphragm, a small trench filled with river run gravel, should be used as pretreatment for runoff entering the sides of the swale.
- Design grassed swales with a flat longitudinal slope (generally between 1 percent and 2 percent) and a dense vegetative cover in the channel. The flat slope helps to reduce the velocity of flow in the channel. The dense vegetation also helps reduce velocities, protect the channel from erosion, and act as a filter to treat storm water runoff. During construction, it is important to stabilize the channel before the turf has been established, either with a temporary grass cover or with the use of natural or synthetic erosion control products.
- In addition to treating runoff for water quality, grassed swales need to convey larger storms safely. Typical designs allow the runoff from the 2-year storm to flow through the swale without causing erosion. Swales should also have the capacity to pass a 10-year storm and safely.
- Grassed swales can be used to meet ground water recharge and pollutant removal goals.

- One study of available performance data estimates the removal rate for grassed channels as (Schueler, 1997) :

    - Total Suspended Solids: 81%
    - Total Phosphorous: 29%
    - Nitrate Nitrogen: 38%
    - Metals: 14% to 55%
    - Bacteria: -50%

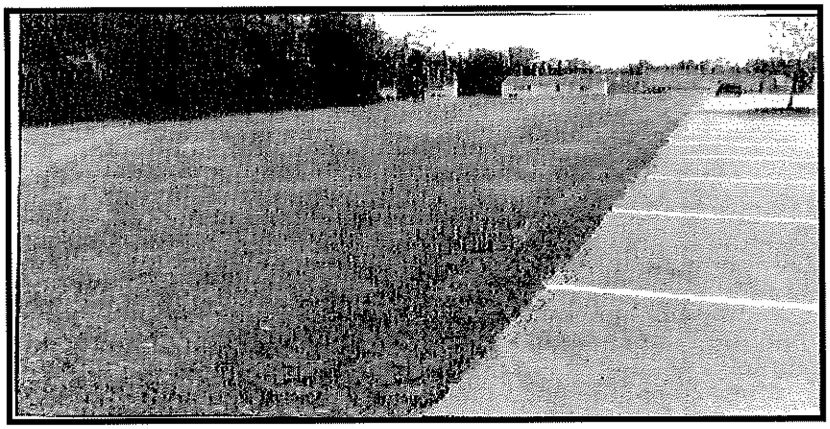
Inspection (Operation) and Maintenance:

- Typical maintenance activities for Grass Swales:

Activity	Schedule
Inspect pea gravel diaphragm for clogging and correct the problem.	Annual (semi-annual the first year).
Inspect grass along side slopes for erosion and formation or rills or gullies and correct.	
Remove trash and debris accumulated in the inflow forebay.	
Inspect and correct erosion problems in the sand/soil bed of dry swales.	
Based on inspection, plant an alternative grass species if the original grass cover has not been successfully established.	
Replant wetland species (for wet swale) if not sufficiently established.	
Rototill or cultivate the surface of the sand/soil bed of dry swales if the swales does not draw down within 48 hours.	As needed (infrequent)
Remove sediment build-up within the bottom of the swale once it has accumulated to 25 percent of the original design volume.	
Mow grass to maintain a height of 3-4 inches.	As needed (frequent seasonally)

FILTER STRIPS

VF - 2



BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose:

Filter strips are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils.

Application or Selection Criteria:

- Filter strips are best suited to treating runoff from roads and highways, roof downspouts, very small parking lots, and previous surfaces.
- Filter strips should not receive runoff from areas where land use or activities generate highly contaminated runoff, because the practice encourages infiltration.
- Filter strips are generally a poor retrofit option because they consume a relatively large amount of space and cannot treat large drainage areas.
- Filter strips should not be used on soils with a high clay content, because they require some infiltration for proper treatment. Very poor soils that cannot sustain a grass cover crop are also a limiting factor.
- In cold climates, filter strips provide a convenient area for snow storage and treatment. If used for this purpose, vegetation in the filter strip should be salt tolerant, (e.g., creeping bentgrass).
- The practice has not been shown to achieve high pollutant removal.
- Filter strips require a large amount of space, typically equal to the impervious area they treat, making them often infeasible in urban environments where land prices are high.
- If improperly designed, filter strips can become a mosquito breeding ground.
- Proper design requires a great deal of finesse, and slight problems in the design, such as improper grading, can render the practice ineffective in terms of pollutant removal.

Performance Standards or Specifications:

- When flow concentrates, it moves too rapidly to be effectively treated by a grassed filter strip. As a general rule, flow concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces. Using this rule, a filter strip can treat one acre of impervious surface per 580-foot length.

- Filter strips should be designed on slopes between 2 and 6 percent. Greater slopes than this would encourage the formation of concentrated flow. Except in the case of very sandy or gravelly soil, runoff would pond on the surface on slopes flatter than 2 percent, creating potential mosquito breeding habitat.

- Filter strips should be separated from the ground water by between 2 and 4 ft to prevent contamination and to ensure that the filter strip does not remain wet between storms.

- The following design features are critical to ensure that the filter strip provides some minimum amount of water quality treatment.

    - A pea gravel diaphragm should be used at the top of the slope acting as a pretreatment device and a level spreader.

    - The filter strip should be designed with a pervious berm of sand and gravel at the top of the slope. This feature provides an area for shallow ponding at the bottom of the filter strip. Runoff ponds behind the berm and gradually flows through outlet pipes in the berm. The volume ponded behind the berm should be equal to the water quality volume. The water quality volume is the amount of runoff that will be treated for pollutant removal in the practice. Typical water quality volumes are the runoff from a 1-inch storm or 1/2-inch of runoff over the entire drainage area to the practice.

    - The filter strip should be at least 25 feet long to provide water quality treatment.

    - Designers should choose a grass that can withstand relatively high velocity flows and both wet and dry periods.

    - Both the top and toe of the slope should be as flat as possible to encourage sheet flow and prevent erosion.

Inspection (Operation) and Maintenance:

Typical maintenance activities for filter strips:

Activity	Schedule
Inspect pea gravel diaphragm for clogging and remove built up sediment.	Annual inspection (semi-annual the first year)

Inspect vegetation for rills and gullies and correct. Seed or sod bare areas.	
Inspect to ensure that grass has established. If not, replace with an alternate species.	
Mow grass to maintain a 3-4 inch height	Regular (frequent)
Remove sediment build-up within the bottom when it has accumulated to 25% of the original capacity.	Regular (infrequent)

BIORETENTION / LANDSCAPE AREAS VF - 3

Bioretention areas can be used in parking areas to collect and treat storm water (Source: University of Maryland, 2000)

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose: Bioretention areas are landscaping features designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems to provide onsite treatment of storm water runoff.

Application or Selection Criteria:

- Bioretention systems are generally applied to small sites and in a highly urbanized setting.
- Bioretetion facilities are ideally suited to many ultra-urban areas, such as parking lots. While they consume a fairly large amount of space (approximately 5 percent of the area that drains to them), they can be fit into existing parking lot islands or other landscaping areas.
- Bioretention areas can be used to treat areas where land use or activities generate highly contaminated runoff as long as an impermeable liner is used at the bottom of the filter bed.
- Bioretention can be used as a storm water retrofit, by modifying existing landscaping areas, or if a parking lot is being resurfaced. In highly urbanized areas, this is one of the few retrofit options that can be employed.
- Bioretention can be applied on many sites, with its primary restriction being the need to apply the practice on small sites.

- In cold climates, bioretention areas can be used as snow storage areas. If used for this purpose, or is used to treat runoff from a parking lot where salt is used as a deicer, the bioretention area should be planted with salt-tolerant, nonwoody plant species.

- Bioretention areas cannot be used to treat a large drainage area, limiting their usefulness for some sites.

- Although the practice does not consume a large amount of space, incorporating bioretention into a parking lot design may reduce the number of parking spaces available.

- The construction cost of bioretention areas is relatively high compared with many other management practices.

Performance Standards or Specifications:

- Bioretention areas should usually be used on small sites 5 acres or less. When used to treat larger areas, they tend to clog. In addition, it is difficult to convey flow from a large area to a bioretention area.

- Bioretention areas are best applied to relatively shallow slopes (usually about 5 percent). However, sufficient slope is needed at the site to ensure that water that enters the bioretention area can be connected with the storm drain system.

- Bioretention areas can be applied in almost any soils or topography, since runoff percolates through a man-made soil bed and is returned to the storm water system.

- Bioretention should be separated somewhat from the ground water to ensure that the ground water table never intersects with the bed of the bioretention facility. This design consideration prevents possible ground water contamination.

- Pretreatment should be incorporated with bioretention design. Incorporating pretreatment helps to reduce the maintenance burden of bioretention and reduces the likelihood that the soil bed will clog over time.

- The bioretention system should be sized between 5 and 10 percent of the impervious area draining to it.

- The practice should be designed with a soil bed that is sand/soil matix, with a mulch layer above the soil bed.

- The bioretention area should be designed to pond a small amount of water (6-9 inches) above the filter bed.

- Storm water should be conveyed to and from practices safety and to minimize erosion potential. Ideally, some storm water treatment can be achieved during conveyance to and from the practice.

- Bioretention practices are designed with an underdrain system to collect filtered runoff at the bottom of the filter bed and direct it to the storm drain system. An underdrain is a perforated pipe system in a gravel bed, installed on the bottom of the filter bed. Designers should provide an overflow structure to convey flow from storms that are not treated by the bioretention facility to the storm drain.

- Designers should ensure that the bioretention area is easily accessible for maintenance.
- Landscaping is critical to the function and aesthetic value of bioretention areas. It is preferable to plant the area with native vegetation, or plants that provide habitat value, where possible. Another important design feature is to select species that can withstand the hydrologic regime they will experience. At the bottom of the bioretetion facility, plants that tolerate both wet and dry conditions are preferable. At the edges, which will remain primarily dry, upland species will be the most resilient. Finally, it is best to select a combination of trees, shrubs, and herbaceous materials.
- Bioretetion areas can provide only pollutant removal.
- Assuming that bioretention systems behave similarly to swales, their removal rates are relatively high.
- There is considerable variability in the effectiveness of bioretention areas, and it is believed that properly designing and maintaining theses areas may help to improve their performance.

Inspection (Operation) and Maintenance:

- Bioretention requires frequent landscaping maintenance, including measures to ensure that the area is functioning properly, as well as maintenance of the landscaping on the practice. In many cases, bioretention areas initially require intense maintenance, but less maintenance is needed over time. In many cases, maintenance tasks can be completed by a landscaping contractor, who may already be hired at the site.

Activity	Schedule
Remulch void areas	As needed
Treat diseased trees and shrubs	
Mow turf areas	
Water plants daily for 2 weeks	At project completion
Inspect soil and repair eroded areas	Monthly
Remove litter and debris	
Remove and replace dead and diseased vegetation	Twice per year
Add mulch	Once per year
Replace tree stakes and wires	

STORM WATER WETLANDS VF - 4

A storm water wetland detains storm water, removes pollutants, and provides habitat and aesthetic benefits (Source: The Bioengineering Group, Inc., no date)

BMP Type

Temporary / **Permanent**

Structural / Non-Structural

Purpose: Storm water wetlands are structural practices similar to wet ponds that incorporate wetland plants into the design. As storm water runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake within the practice.

Application or Selection Criteria:

- Wetlands are among the most effective storm water practices in terms of pollutant removal and they also offer aesthetic value.
- It is difficult to use wet ponds in the ultra-urban environment because of the land area each wetland consumes.
- Wetlands can be used in almost all soils and geology.
- Cold climates present many challenges to designers of wetlands. During the spring snowmelt, large volume of water runs off in a short time, carrying a relatively high pollutant load. In addition, cold winter temperatures may cause freezing of the permanent pool or freezing at inlets and outlets. Finally, high salt concentrations in runoff resulting from road salting, as well as sediment loads from road sanding, may impact wetland vegetation.
- Some features of storm water wetlands that may make the design challenging include the following:
  - Each wetland consumes a relatively large amount of space, making it an impractical option on many sites.
  - Improperly designed wetlands can become a breeding area for mosquitoes.
  - Wetlands require careful design and planning to ensure that wetland plants are sustained after the practice is in place.

- It is possible that storm water wetlands may release nutrients during the non-growing season.

- Designers need to ensure that wetlands do not negatively impact natural wetlands or forest during the design phase.

- Wetlands consume a large amount of land. This characteristic may limit their use in areas where land values are high.

Performance Standards or Specifications:

- Wetlands need sufficient drainage area to maintain the permanent pool. In humid regions, this is typically about 25 acres, but a greater area may be needed in regions with less rainfall.

- Wetlands can be used on sites with an upstream slope of up to about 15 percent. The local slope should be relatively shallow, however. While there is no minimum slope requirement, there does need to be enough elevation drop from the inlet to the outlet to ensure that hydraulic conveyance by gravity is feasible (generally about 3 to 5 feet).

- Unless they receive hot spot runoff, wetlands can often intersect the ground water table.

- In wetlands, pretreatment is achieved with sediment forebay. A sediment forebay is a small pool (typically about 10 percent of the volume of the permanent pool). Course particles remain trapped in the forebay, and maintenance is performed on this smaller pool, eliminating the need to dredge the entire pond.

- The surface area of wetlands should be at least 1 percent of the drainage area to the practice.

- Wetlands should have a length-to-width ratio of at least 1.5:1. Making the wetland longer than it is wide helps prevent "short circuiting" of the practice.

- Effective wetland design should have zones of both very shallow (<6 inches) and moderately shallow (<18 inches) wetlands incorporated, using underwater earth berms to create the zones. This design will provide a longer flow path through the wetland to encourage settling, and it provides two depth zones to encourage plant diversity.

- The outfall of pond systems should always be stabilized to prevent scour. In addition, an emergency spillway should be provided to safely convey large flood events. To help mitigate warming at the outlet channel, designers should provide shade around the channel at the pond outlet.

- Wetlands should be designed with a nonclogging outlet such as a reverse slope pipe or a weir outlet with a trash rack.

- Another general rule is that no orifice should be less than 3 inches in diameter.

- Another feature that can help reduce the potential for clogging of the outlet is to incorporate a small pool, or "micropool" at the outlet.

- Wetlands should be designed with a maintenance access to the forebay to ease this relatively routine (5 to 7 year) maintenance activity. In addition, the permanent pool should have a pond drain to draw down the pond for the more infrequent dredging of the main cell of the wetland.

- To ensure the establishment and survival of wetland plants, a landscaping plan should provide detailed information about the plants selected, when they will be planted, and a strategy for maintaining them. The plan should detail wetland plants, as well as vegetation to be established adjacent to the wetland.

- A variety of techniques can be used to establish wetland plants. The most effective techniques are the use of nursery stock as dormant rhizomes, live potted plants, and bare rootstock. A "wetland mulch," soil from a natural wetland or a designed "wetland mix," can be used to supplement wetland plantings or alone to establish wetland vegetation. Wetland mulch carries with it the seed bank fro the original wetland, and can help to enhance diversity in the wetland. The least expensive option to establish wetlands is to allow the wetland to colonize itself. One disadvantage to this last technique is that invasive species such as cattails or Phragmites may dominate the wetland.

- When developing a plan for wetland planting, care needs to be taken to ensure that plants are established in the proper depth and within the planting season. This season varies regionally, and is generally between 2 and 3 months long in the spring to early summer. Plant lists are available for various regions of the United States through wetland nurseries, extension services, and conservation districts.

- "On-line" designs allowing flow to move continuously can help prevent outlets from freezing.

- Wetlands should be designed with multiple cells, with a berm or weir separating each cell. This modification will help to retain storage for treatment above the ice layer during the winter season.

- Outlets that are resistant to freezing should be used. Some examples include weirs or pipes with large diameters.

- When wetlends drain highway runoff, or parking lots, salt-tolerant vegetation, such as pickle weed or cord grass should be used. In addition, designers should consider using a large forebay to capture the sediment from road sanding.

- Wetlands can provide flood control, channel protection, and pollutant removal.

- Wetlands are among the most effective storm water management practices at removing storm water pollutants. Wetlands have high pollutant removal rates, and are more effective than any other practice at removing nitrate and bacteria.

Inspection (Operation) and Maintenance:

- Typical maintenance activities for Storm Water Wetlands:

Activity	Schedule
Replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.	One-time
Inspect for invasive vegetation and remove where possible.	Semi-annual inspection
Inspect for damage to the embankment and inlet/outlet structures. Repair as necessary.	Annual inspection
Note signs of hydrocarbon build-up, and deal with appropriately.	
Monitor for sediment accumulation in the facility and forebay.	
Examine to ensure that inlet nad outlet devices are free of debris and are operational.	
Repair undercut or eroded areas.	As needed maintenance
Clean and remove debris from inlet and outlet structures.	Frequent (3-4 times/year) maintenance
Mow side slopes.	
Supplement wetland plants if a significant portion have not established (at least 50% of the surface area)	Annual maintenance (if needed)
Harvest wetland plants that have been "choked out" by sediment build-up.	
Remove sediment from the forebay.	5- to 7-year maintenance
Monitor sediment accumulations, and remove sediment when the pool volume has become reduced significantly, plants are "choked" with sediment, or the wetland becomes eutropic.	20- to 50- year maintenance

SECTION 4 - SITE / DEVELOPMENT DESIGN

SD-1 through SD-5

Guidebook and list developed for and approved by
Valparaiso Lakes Area Conservancy District (VLACD) - January 2005

Prepared by: R.W. Armstrong & Associates, Inc.

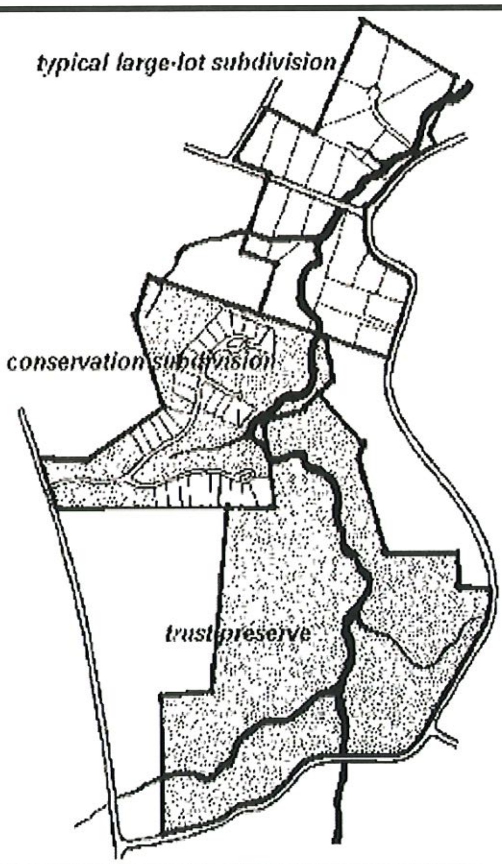
CLUSTER DESIGN / MAINTAIN OPEN SPACE SD - 1

BUFFER ZONES SD - 2

MINIMIZE IMPERVIOUSNESS SD - 3

GRASS SHOULDERS & SWALES VS. CURBS & GUTTERS SD - 4

DIRECTED GROWTH / ZONING SD - 5

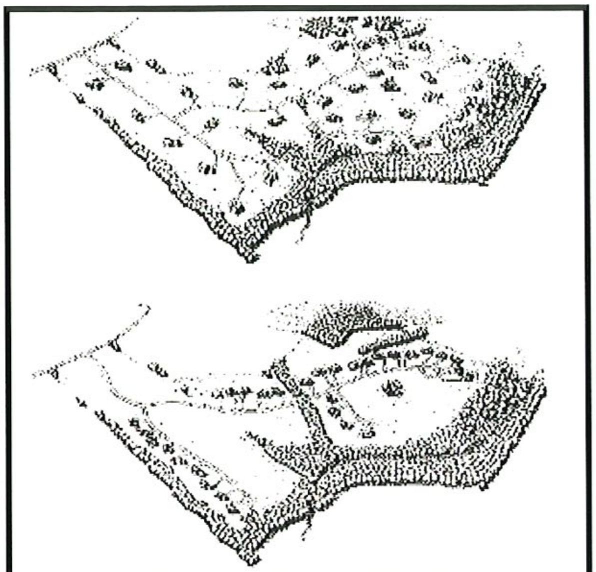


Property boundaries differ widely between traditional large-lot zoning, which maximizes the acreage of individual properties, and conservation zoning, which maximizes the amount of shared open space (Source: Arendt, 1996)

BMP Type

Temporary / **Permanent**

Structural / **Non-Structural**



A site developed using open space design principles (bottom) maintains more undeveloped common space than the conventional development plan (top) (Source: Arendt, 1996)

A porous pavement parking lot (Source: Invisible Structures, no date)

Purpose:

Better site design practices focus on subdivision codes, zoning ordinances, and sound planning for low impact development, which promotes improved storm water management and improved water quality in various ways.

Principles or Objectives:

Cluster Design / Maintain Open Space

- A better site design technique that concentrates dwelling units in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site.
- The minimum lot sizes, setbacks and frontage distances for the residential zone are relaxed in order to create the open space at the site.
- Open space designs have many benefits in comparison to the conventional subdivisions that they replace: they can reduce impervious cover, storm water pollutants, construction costs, grading, and the loss of natural areas.
- The greatest storm water and pollutant reduction benefits typically occur when open space design is applied to residential zones that have larger lots (less than two dwelling units per acre). In these types of large lot zones, a great deal of natural or community open space can be created by shrinking lot sizes.
- Along with reduced imperviousness, open space designs provide a host of other environmental benefits lacking in most conventional designs. These developments reduce potential pressure to encroach on resource and buffer areas because

enough open space is usually reserved to accommodate resource protection areas. As less land is cleared during the construction process, the potential for soil erosion is also greatly diminished. Perhaps most importantly, open space design reserves 25 to 50 percent of the development site in green space that would not otherwise be protected, preserving a greater range of landscapes and habitat "islands" that can support considerable diversity in mammals, songbirds, and other wildlife.

Buffer Zones

- The primary function of a aquatic buffers is to physically protect and separate a stream, lake, or wetland from future disturbance or encroachment.

- If properly designed, a buffer can provide storm water management and act as a right-of-way during floods, sustaining the integrity of stream ecosystems and habitats.

- The three types of buffers are water pollution hazard setbacks, vegetated buffers, and engineered buffers. Water pollution hazard setbacks are areas that separate a potential pollution hazard from a waterway. By providing setbacks from these areas in the form of a buffer, the potential for pollution can be reduced. Vegetated buffers are any number of natural areas that exist to divide land uses or provide landscape relief. Engineered buffers are areas specifically designed to treat storm water before it enters into a stream, lake, or wetland.

- Buffers can be applied to new development by establishing specific preservation areas and sustaining management through easements or community associations. For existing developed areas, an easement may be needed from adjoining landowners. A local ordinance can help set specific criteria for buffers to achieve storm water management goals.

- For optimal storm water treatment, the buffer should be composed of three lateral zones: a storm water depression area that leads to a grass filter strip that in turn leads to a forested buffer. The storm water depression is designed to capture and store storm water during smaller storm events and bypass larger stormflows directly into a channel. The captured runoff within the storm water depression can than be spread across a grass filter designed for sheetflow conditions for the water quality storm. The grass filter then discharges into a wider forest buffer designed to have zero discharge of surface runoff to the stream.

- An effective buffer management plan should include establishment, management, and distinctions of allowable and unallowable uses in the buffer zones. Buffer boundaries should be well defined and visible before, during and after construction. Without clear signs or markers defining the buffer, boundaries become invisible to local governments, contractors, and residents. Buffers designed to capture storm water runoff from urban areas will require more maintenance if the first zone is designated as a bioretention or other engineered depression area.

Minimize Imperviousness

- These principles focus on those codes, ordinances, and standards that determine the size, shape, and construction of parking lots, roadways, and driveways in the suburban landscape.

    1. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance and service vehicle access. These widths should be based on traffic volume.

2. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.

3. Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.

4. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.

5. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction.

6. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas.
7. Relax side yard setbacks and allow narrower frontage to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.

8. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.

Grass Shoulders & Swales vs. Curbs & Gutters

- This better site design practice involves promoting the use of grass swales as an alternative to curbs and gutters.

- Curbs and gutters are designed to quickly convey runoff from the street to the storm drain and, ultimately, to the local receiving water. Consequently, curbs and gutters provide little or no removal of storm water pollutants.

- Curbs often act as a pollutant trap where deposited pollutants are stored until they are washed out in the next storm.

- The use of engineered swales in place of curbs and gutters should be encouraged in low-and medium-density residential zones where soils, slope and housing density permit. However, eliminating curbs and gutters is generally not feasible for streets with high traffic volume or extensive on-street parking demand.

- <u>Contributing drainage area</u> - Most individual swales cannot accept runoff from more than 5 acres of contributing drainage area, and typically serve 1-2 acres each.

- <u>Slope</u> - Swales generally require a minimum slope of 1 percent and a maximum slope of 5 percent.

- <u>Soils</u> - The effectiveness of swales is greatest when the underlying soils are permeable (hydrologic soil groups A and B). The swale may need more engineering if soils are less permeable.

- Water Table - Swales should be avoided if the seasonally high water table is within 2 feet of the proposed bottom of the swale.

- Development Density - The use of swales is often difficult when development density becomes more intense that four dwelling units per acre, simply because the number of driveway culverts increases to the point where the swales essentially becomes a broken-pipe system. Typically, grass swales are designed with a capacity to handle the peak flow rate from a 10-year storm, and fall below erosive velocities for a 2-year storm.

- The potential for pavement failure at the road/grass interface can be alleviated by "hardening" the interface with grass pavers or geo-synthetics placed beneath the grass. Other options include placing a low-rising concrete strip along the pavement edge.

- Maintenance requirements for grass channels are generally comparable to those of curb and gutter systems. The major requirements involve turf mowing, debris removal, and periodic inspections.

- Grass channels are not designed to retain water for any appreciable period of time, and the potential for snakes and other vermin can be minimized by frequent mowing.

- The major maintenance requirement for grass swales involves mowing during the growing season, a task usually performed by homeowners. In addition, sediment deposits may need to be removed from the bottom of the swale every ten years or so, and the swale may need to be tilled and re-seeded periodically. Occasionally, erosion of swale side slopes may need to be stabilized. The overall maintenance burden of grass swales is low in relation to the other storm water practices, and is usually within the competence of the individual homeowner.

Directed Growth / Zoning

- Zoning can serve numerous functions and can help mitigate storm water runoff problems by facilitating better site designs. By correctly applying the right zoning technique, development can be targeted into specific areas, limiting development in other areas and providing protection for the most important land conservation areas.

- There are numerous types of zoning techniques for better site design, including:

  - Watershed-Based Zoning
  - Overlay Zoning
  - Impervious Overlay Zoning
  - Floating Zones
  - Incentive Zoning
  - Performance Zoning
  - Urban Growth Boundaries
  - Large lot Zoning
  - Infill / Community Redevelopment
  - Transfer of Development Rights (TDRs)
  - Limited Infrastructure Extensions