WSB & Associates, Inc.

Municipal Guide to

Storm Water Management Techniques

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This Municipal Guide to Storm Water Management Techniques has been developed to assist the City Council and City Staff in reviewing a number of storm water management and treatment techniques. These techniques include methods that are typically used in the Metro area and compares them to other techniques that may be new to a community.

The recent focus in the field of storm water management has been on improving water quality and meeting impaired waters and non-degradation requirements. A focus on water quality is very important, but must also be balanced by flood storage, rate control, and long term maintenance costs to be part of a responsible storm water management program.

The purpose of this Guide is to assist local city government officials in determining which types of storm water management techniques, or Best Management Practices (BMPs), would be beneficial to their individual communities. The information is presented in a non-technical manner and is intended to provide a brief overview of a BMP with a summary of benefits and potential drawbacks.

While this Guide contains general information, more detailed information can be provided to the City if needed. The effectiveness and performance of each BMP will vary based on specific application, location, land use, soils, and design.

WSB & Associates would be happy to review this information with you and provide any additional information you may need. If you would like more information or have questions, please feel free to call:

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Wet Pond (NURP Pond)

Definition: Ponding area that maintains an area of open water to capture and store a certain volume of runoff to provide water quality treatment.

Purpose: Provide storm water treatment by storing water until sediment and nutrients are removed by gravity, absorption, or plant uptake. The pond also provides storage of flood waters above the normal outlet to protect adjacent and downstream properties.

Construction Methods: Excavation of upland areas dedicated for drainage purposes.

Maintenance Activities: Remove accumulated sediment every 10-20 years.

Benefits

- Removes 70-90% total suspend solids
- Removes 40-60% total phosphorus
- Provides flood protection to adjacent property
- Potential to provide volume reduction with infiltration design elements
- Provides rate control of storm water runoff
- Prevents/reduces downstream flooding
- Provides pollutant removal with minimal annual maintenance effort

Potential Drawbacks

- Reduces developable area
- Safety concerns
- Algae blooms may occur
- Improperly designed ponds may have limited vegetation and cause shoreline erosion

Other Considerations: Ponds should be designed with a shallow bench to allow for maintenance and safety

Performance of BMP
Key: ● Excellent ◗ Fair ○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Wet Ponds (NURP Ponds)	●	◗	●	◗	○	High	Low	Low

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Infiltration Basin

Definition: A depressional area that collects and infiltrates storm water runoff into the soil.

Purpose: Reduce storm water runoff volume and discharge rates.

Construction Methods: Infiltration area is graded; soil is scarified and loosened to avoid compaction; may include rock or sand trenches or soil amendments to aid in infiltration.

Maintenance Activities: Maintenance is required to remove sediment, debris and excessive vegetation to keep the basin functioning as designed.

Benefits

- Can remove up to 100% total suspended solids
- Can remove up to 100% of total phosphorus
- Provides groundwater recharge
- Reduces the volume of runoff discharged off site
- Provides rate control
- Reduces/prevents downstream flooding
- Assists in meeting NPDES Nondegradation volume requirements

Potential Drawbacks

- Land uses need to be evaluated to limit risk of pollutant transfer to groundwater
- Requires frequent maintenance to remove vegetation and debris
- Infiltration not available when ground is frozen
- Reduces developable area

Other Considerations: Works best in sandy soils; use caution if implementing in wellhead protection area. Pretreatment should be provided prior to discharge to an infiltration basin; vegetation should be carefully selected to avoid unsightly basins.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Infiltration Basin	●	●	●	●	●	High	Low	Medium

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Photo from the City of Maplewood

Rain Garden

Definition: Depressional landscaped area created on a site-by-site basis that encourages infiltration of storm water runoff.

Purpose: Provide water quality treatment and volume reduction through plant uptake and infiltration.

Construction Methods: Areas are excavated and may be filled with sand and organic material. Native or garden variety plants are installed to provide a visually appealing, landscaped runoff retention and infiltration area.

Maintenance Activities: Annual removal of sediment and vegetation maintenance, at minimum.

Benefits

- Provides some water quality treatment
- Provides rate control for very small storm events
- Provides groundwater recharge
- Reduces some runoff volume
- Maintained gardens can be attractive
- Can work in older residential areas where no treatment is provided

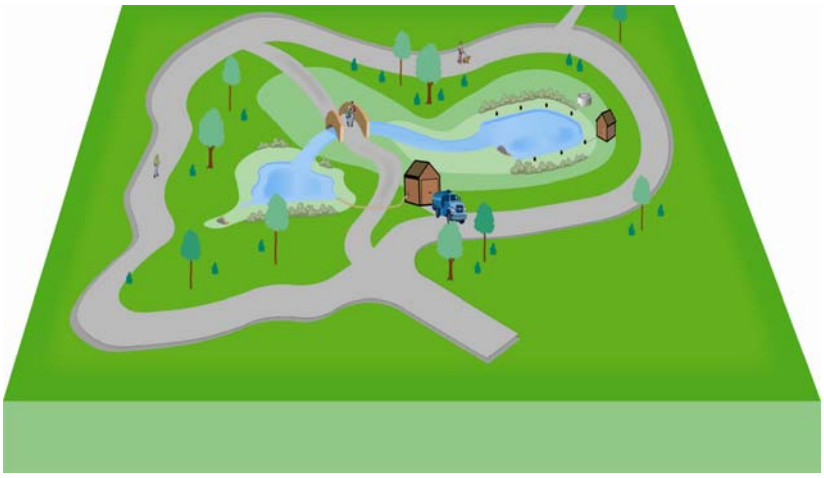
Potential Drawbacks

- Requires frequent debris removal and vegetation maintenance
- Not suitable for sites with high water table or poorly drained soils
- Limited historical data on long-term function and maintenance needs
- Does not provide flood protection or storm water storage for large storm events
- May not function during snow melt conditions

Other Considerations: This BMP may be a good option where residents are interested in gardening and maintaining these areas. Responsible party for long-term maintenance needs to be carefully considered.

Performance of BMP
Key: ● Excellent ◗ Fair ○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Rain Gardens	◗	◗	○	●	◗	Low	High	High



RESTORE Pond

Definition: A Regional, Enhanced Stormwater Treatment and Outdoor Recreation Environment. This is a multi-use, depressional area that receives storm water, infiltrates the runoff into the soil, and treats the runoff through a combination or detention and chemical treatment (Iron or Alum).

Purpose: Reduce downstream nutrients and storm water runoff volume.

Construction Methods: Chemical is injected or sprayed into the treated infiltration system; pumping tank and access route are provided; 2nd cell may include a pump to regularly treat water.

Maintenance Activities: Pump system should be regularly maintained; tank should be filled and treatment pond should be excavated to remove pollutants and flocculants.

Other Considerations: System can assist in meeting TMDL and nondegradation requirements.

Benefits

- Chemical floc can virtually eliminate all nutrients from the system to meet water quality standards
- Can guarantee treatment to a required standard
- Provides groundwater recharge, rate control, water quality treatment, and reduces the volume of runoff
- Infiltration bed is less susceptible to plugging and requires less maintenance
- Reduces/prevents downstream flooding
- Can be integrated into park, recreation area, or greenway system
- Infiltration may be available during frozen ground conditions

Potential Drawbacks

- Permitting of chemical system may be needed
- Regular maintenance and disposal of flocculent is needed
- Systems may require frequent maintenance
- Groundwater not protected from pollutant

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
RESTORE Pond	●	●	●	●	●	High	High	High

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Dry Pond

Definition: A depressional area that temporarily stores storm water runoff.

Purpose: Reduce risk of flooding by temporarily storing storm water runoff.

Construction Methods: The area is graded; outlet structure is constructed.

Maintenance Activities: Clean out of sediment and trash that is collected in the basin; outlet structure can be designed to catch trash in localized area.

Benefits

- Prevents/reduces downstream flooding potential
- Provides flood protection to adjacent properties
- Provides rate control of storm water runoff
- Can be designed for dual purposes such as park areas/parking lots/athletic fields

Potential Drawbacks

- May develop mud flats and look unattractive if vegetation is not properly selected or maintained
- Vegetation may have difficulty establishing due to frequent water fluctuations
- Provides limited treatment of runoff
- Sediment deposited in basin may be resuspended in large storm events
- Reduces developable area

Other Considerations: The length of time that an area will be inundated with water will determine the type of vegetation and uses that may occur within the dry pond area.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Dry Ponds	◗	◗	●	◗	○	High	Low	Low

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Photo from Lower Columbia River Partnership

Sand Filters

Definition: A depressional area that is generally dry between storm events and has been amended with sand, gravel, or other media to filter pollutants from storm water.

Purpose: Reduce pollutants and volume of storm water by filtering the water through sandy media.

Construction Methods: A depressional area is graded and amended with sand, gravel, or other media. Underdrains are generally used to collect and convey the filtered water away from the area.

Maintenance Activities: Removal of sediment and trash that is collected in the area; outlet structure can be designed to catch trash in localized area.

Benefits

- Removes sediment and nutrients from storm water runoff
- Can be designed to infiltrate storm water runoff
- Provides some reduction in storm water runoff rates

Potential Drawbacks

- Expensive to replace filter media
- Filtration media can clog if water is not pretreated for coarse sediments
- Requires frequent maintenance to insure proper performance

Other Considerations: Pretreatment to trap coarse sediments should be used prior to water being directed to the filter.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Sand Filters	●	◗	◗	◗	◗	High	High	High

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Photo from University of Minnesota Duluth

Underground Storage/ Infiltration System

Definition: Holding facility designed to retain and/or infiltrate storm water underground prior to discharge.

Purpose: Provides temporary storage of storm water runoff while preserving surface space and reducing peak runoff flow rates and flow volume.

Construction Methods: Storm water storage may occur in pipe galleries or tanks placed underground. Often times these systems are installed under parking areas to minimize land requirements.

Maintenance Activities: Tanks need to be inspected at least annually and debris and sediment removed.

Benefits

- Provides temporary storage of storm water
- Reduces surface space requirements for storm water storage
- Design could incorporate infiltration, depending on site conditions to reduce runoff volume

Potential Drawbacks

- Poor sediment and nutrient removal; can be improved with infiltration
- Requires annual cleaning and inspection
- Costly to construct
- Replacement cost very expensive

Other Considerations: Pipes and tanks should be designed to prevent freezing.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Underground Storage Systems No Infiltration/With Infiltration	○/●	○/●	●	○/●	◗/●	Low	High	High

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Vegetated Swales and Filter Strips

Definition: A vegetated section of land designed to accept overland runoff and filter water through the vegetation. These areas occur as depressions, shallow channels, or as a vegetation break between developed areas.

Purpose: Reduce pollutants from storm water by filtering the water through vegetation such as buffers and swales.

Construction Methods: The swale/strip is graded if needed or left in its natural state. The area is planted with suitable vegetation or natural vegetation is preserved.

Maintenance Activities: Removal of sediment and trash that is collected in the area; outlet structure can be designed to catch trash in localized area.

Benefits

- Reduces sediment and other pollutants from runoff
- Reduces volume of storm water runoff
- Provides habitat and biological diversity

Potential Drawbacks

- Vegetation should remain unmowed; residents may not find area aesthetically pleasing
- Encroachment by landowners can become an issue
- Annual inspections should be undertaken to review health of vegetation and to remove debris and excess sediment

Other Considerations: Rate of sheet flow in swale should be taken into account to avoid erosion. Mowing could occur twice per year to manage healthy vegetation.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Vegetated Swales	◗	◗	◗	◗	◗	Medium	Low	Medium

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In-line Treatment Structures

Definition: Structure system connected directly with the storm sewer system to treat storm water. Includes products such as DrainPac, HydroKleen, Stormceptor, and Vortechnics.

Purpose: Remove floating pollutants and suspended solids from runoff.

Construction Methods: Often precast concrete installed with storm sewer system.

Maintenance Activities: Regular and annual maintenance with vacuum truck.

Benefits

- Alternative for difficult locations
- Removes coarse sediment
- Removes floatables

Potential Drawbacks

- Poor nutrient removal
- Requires frequent maintenance with vacuum truck
- Maintenance agreement needed for privately installed systems

Other Considerations: There are many manufacturers of these systems; consideration should be given to the system that will work best for the location. Manufactures starting to include nutrient removal systems, but these systems are costly and require additional maintenance.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
In-Line Treatment Structures	◗	○	○	○	○	Low	High	High

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Rural Street Curb Section

Definition: Flat, at-grade concrete "curb"

Purpose: Allows storm water to sheet flow off from street into adjacent swale to allow infiltration and treatment. Provides "hard edge" to bituminous rural section roads.

Construction Methods: Bituminous rural section road with concrete ribbon as "curb".

Maintenance Activities: Typical street maintenance and management.

Benefits

- Reduces storm water runoff discharged downstream
- Provides groundwater recharge
- Assists in maintaining bituminous road edge in rural section road construction
- Reduces need for storm sewer system construction
- Residents maintain right-of-way in same manner as traditional neighborhood

Potential Drawbacks

- Infiltration in adjacent swales may not occur during snow melt conditions
- Parking may occur on grassy areas
- Not suitable in areas where there is no space for swales or ditches to convey storm water runoff

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Rural Street Curb Section	◗	◗	◗	◗	◗	Low	Low	Low

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Photo from Lower Columbia River Partnership

Pavers and Green Parking Lots

Definition: Permeable or semi-permeable surfaces that can replace asphalt and concrete.

Purpose: Reduce impervious surfaces and decrease storm water runoff volume.

Construction Methods: Construct granular road base and place paver type materials over top as parking lot or roadway surface.

Maintenance Activities: Mowing and vegetation maintenance; may require irrigation.

Benefits

- Reduces volume of storm water runoff
- Reduces impervious surfaces
- Increases infiltration in areas that previously had been paved

Potential Drawbacks

- Not recommended for high traffic areas
- Wheelchair access may be limited
- Potential snow and ice removal issues
- Require regular maintenance such as mowing, cleaning, and watering
- Expensive to construct and maintain

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Pavers and Green Parking Lots	◗	◗	◗	◗	◗	Low	High	High

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Porous Pavement

Definition: Pavement that has the capability to infiltrate water.

Purpose: To reduce storm water runoff volume from impervious surfaces.

Construction Methods: Special pavement mix and subgrade. Pavement must not be over compacted during construction.

Maintenance Activities: Requires frequent sweeping.

Benefits

- Reduces storm water runoff volume from impervious surfaces
- Reduces costs for storm sewer and ponding

Potential Drawbacks

- Requires frequent inspection and maintenance such as sweeping or vacuuming
- Use of sand and salt for de-icing needs to be restricted
- Increased pavement cost
- Needs to be used in tandem with other rate/volume control practices

Other Considerations: Works best in low traffic areas. Research shows a 75% failure rate within five years due to improper installation or maintenance.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Porous Pavement	◗	◗	◗	◗	◗	Low	High	High

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Photo from rainbarrelguide.com

Rain Barrels

Definition: An artificial reservoir for storing rainwater from residential or commercial areas.

Purpose: To capture rainwater for private use and reduce storm water runoff.

Construction Methods: Purchase and place rain barrel at end of roof gutters.

Maintenance Activities: Minimal; occasional cleaning of barrel.

Benefits

- Diverts water from the municipal storm system
- Reduces runoff from individual sites for small storm events
- Allows residents to use water for lawn or gardening, thus reducing municipal water use

Potential Drawbacks

- Not recommended for human consumption
- Systems may require seasonal maintenance
- Requires insect control
- Uncovered barrels pose threat for small children and small animals

Other Considerations: This can generally be an encouraged practice through education rather than regulation.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Rain Barrels	○	◗	◗	◗	○	Low	Low	Low

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Photo from Mississippi Watershed Management Organization

Green Roofs

Definition: Vegetated roof designed to mitigate the effects of urbanization on water quality.

Purpose: Reduce runoff and heat generated by buildings.

Construction Methods: Roof must be specifically designed and engineered to bear the structural load of the plants and soil.

Maintenance Activities: Plant maintenance is needed to establish the roof. Long-term maintenance is contingent upon design but should outlast conventional roofs by 20 years.

Benefits

- Provides some water quality benefits
- Reduces runoff volume from rooftops
- Reduces energy costs for building
- Reduced "heat island" effect in urban areas

Potential Drawbacks

- Structures must be constructed to accommodate green roof
- Construction is costly
- Maintenance is higher than with traditional roof

Other Considerations: A leak detection system is recommended as undetected leaks can be costly.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Green Roofs	◗	◗	◗	○	◗	Low	High	High

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Vegetation Establishment and Maintenance

Definition: Maintenance activities that are needed to encourage desirable plant growth in buffers, along ponds, in swales, and in infiltration areas.

Purpose: To establish desirable vegetation within certain BMP's to provide habitat, reduce erosion, and improve storm water treatment.

Construction Methods: Seeding and monitoring growth.

Maintenance Activities: Annual inspection and maintenance activities such as mowing, prescribed burning, and spot treating with herbicide are needed to establish and maintain healthy, effective, and attractive vegetated BMP's.

Benefits

- Creates an aesthetically pleasing BMP for ponds, infiltration areas, swales, etc.
- Creates habitat in developed areas
- Assists in reducing erosion
- Reduces presence of invasive species such as thistles, ragweed, and others

Potential Drawbacks

- Requires annual maintenance
- Cost and responsible party for maintenance needs to be considered
- Prescribed burning should be conducted by trained professionals

Considerations: Development of vegetation performance standards can be considered.

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Vegetation Establishment and Maintenance	◗	◗	◗	◗	◗	Low	Medium	Medium

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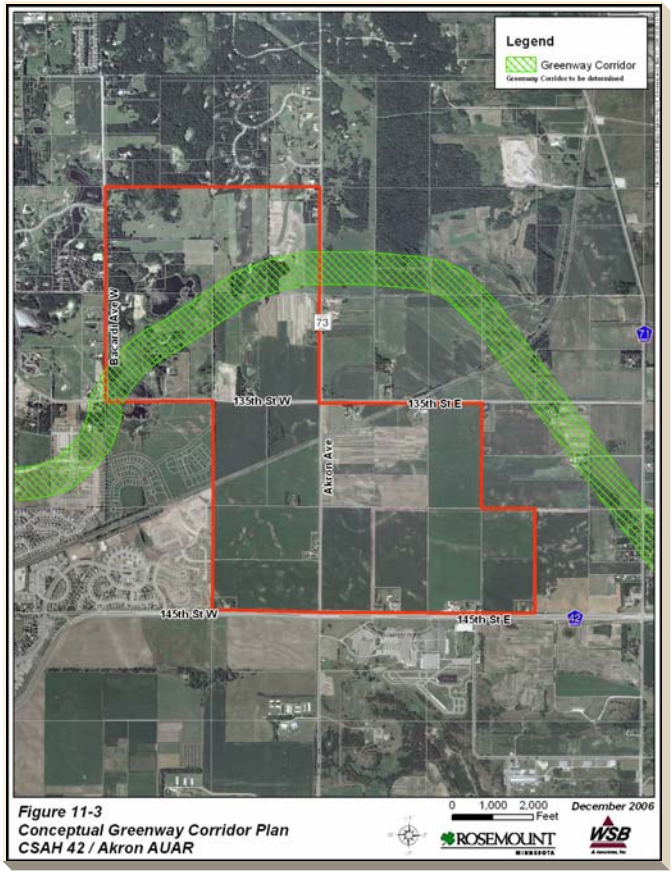

Figure 11-3
Conceptual Greenway Corridor Plan
CSAH 42 / Akron AUAR

Land Use Management

Definition: Manage land use in a way that will be most effective in treating storm water.

Purpose: Utilize techniques to manage land within the City to treat storm water runoff.

Examples:

- Rural section streets
- Building "up" and not "out"
- Incorporate ponding into opens pace and greenways

Methods:

- Consideration through an AUAR type process.
- Get early "buy-in" from stakeholders.
- Need to continuously evaluate successes and challenges.

Benefits

- Reduced size of storm water ponds
- Reduced runoff volume through reduction of impervious surfaces
- Ground water recharge potential
- Reduced fuel and energy needs

Potential Drawbacks

- Less developable acreage
- More dense development
- Construction costs increases
- Potential for increased inspection and maintenance

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

	Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Land Use Management	◗	◗	◗	◗	◗	High	Site Dependent	Site Dependent

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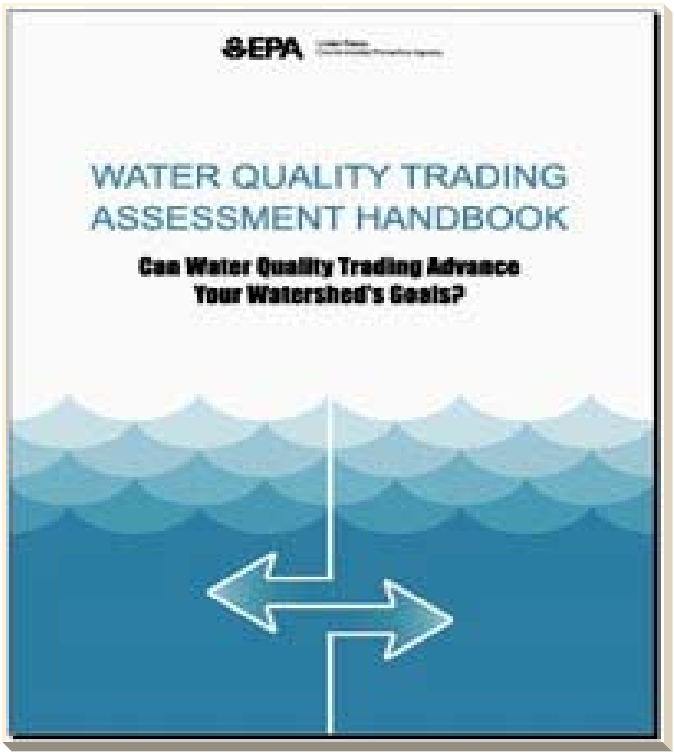

Buying and Selling Pollution Load Credits

Definition: Trading pollution control responsibility among sources.

Purpose: Reduce the overall cost of attaining water quality goals by completing a transaction between a pollutant buyer and seller.

Administrative Methods: If a treatment BMP has been approved by agencies, the City could sell credits or buy "outside" pollution control within the City's major subwatershed.

Possible Application: The City implements BMP's, such as the RESTORE Pond, and sells pollution credits created by pond to upstream polluters who cannot meet water quality requirements.

Benefits

- Can finance BMP's through "trading" excess pollutant credits
- Credits can also be purchased to meet downstream TMDL load allocations (i.e. Lake Pepin)

Potential Drawbacks

- Uncertainties due to no history of successful market test in Minnesota
- In states where markets have been established the administrative processes have been onerous

Other Considerations: The details of this type of system need to be worked out in cooperation with the MPCA as part of the impaired waters program.

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Summary of Storm Water Management Techniques

Performance of BMP
Key: ● Excellent
◗ Fair
○ Poor

		Water Quality Treatment	Volume Reduction	Rate Control	Groundwater Recharge	Temperature Control	Land Requirements	Cost Per Pound of Pollutant Removed	Annual Maintenance Cost
Comparison Relative to each BMP	Wet Ponds (NURP Ponds)	●	◗	●	◗	○	High	Low	Low
	Infiltration Basin	●	●	●	●	●	High	Low	Medium
	Rain Gardens	◗	◗	○	●	◗	Low	High	High
	RESTORE Pond	●	●	●	●	●	High	High	High
	Dry Ponds	◗	◗	●	◗	○	High	Low	Low
	Sand Filters	●	◗	◗	◗	◗	High	High	High
	Underground Storage Systems (No Infiltration / With Infiltration)	○/●	○/●	●	○/●	◗/●	Low	High	High
	Vegetated Swales	◗	◗	◗	◗	◗	Medium	Low	Medium
	In-Line Treatment Structures	◗	○	○	○	○	Low	High	High
Comparison of BMP vs. Traditional Method	Rural Street Curb Section	◗	◗	◗	◗	◗	Low	Low	Low
	Pavers and Green Parking Lots	◗	◗	◗	◗	◗	Low	High	High
	Porous Pavement	◗	◗	◗	◗	◗	Low	High	High
	Rain Barrels	○	◗	◗	◗	○	Low	Low	Low
	Green Roofs	◗	◗	◗	○	◗	Low	High	High
Operational Considerations	Vegetation Establishment and Maintenance	◗	◗	◗	◗	◗	Low	Medium	Medium
	Land Use Management	◗	◗	◗	◗	◗	High	Site Dependent	Site Dependent

The rankings described on this page and on the fact sheets are meant for general informational purposes only and are not meant to apply to any specific application. Effectiveness of each practice will vary based on specific application, location, land use, soils, and design.

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