City of Aurora
Green Infrastructure Implementation Project

Stormwater Toolkit

IEPA FAA #3190604
CMAP Project #10-8674-20-09

May 2010

STORMWATER TOOLKIT

CITY OF AURORA

TABLE OF CONTENTS

1.0 PURPOSE

The purpose of the Toolkit is to educate and assist homeowners, businesses, and developers to comply with the City of Aurora's stormwater management requirements. The Toolkit was developed to specifically assist commercial or industrial redevelopment projects that opt to pay a fee-in-lieu of detention but still must demonstrate a "net benefit" in water quality.

The Toolkit supplements the Kane County BMP Manual by providing background that may assist in the selection and planning of BMPs that will conform with the intent of the stormwater water quality retention requirements of the Kane County Stormwater Management Ordinance. This Toolkit contains discussions, tables, figures and exhibits covering some of the more common BMPs that are in use. This document has no authority to mandate new criteria or use of certain BMPs. The Toolkit is not intended to limit or be all inclusive of the BMPs that may be available or developed for a site. It is only a guide to individuals in the planning and selection of their approach to meet the intent and criteria of the City's Stormwater Management Ordinance. Individuals are responsible for demonstrating that their design conforms with the criteria of the Ordinance.

The information contained within this document is not intended to supersede or negate any requirements set forth in the City's Ordinances. In the case of a conflict between this Toolkit and the City's Ordinances, the Ordinances shall take precedence.

2.0 STORMWATER REGULATIONS AND CRITERIA

It is the intent of the City of Aurora that development and redevelopment, which is regulated by the Kane County Stormwater Ordinance, provide adequate retention and stormwater quality BMPs to improve the water quality of the stormwater that is discharged from the site and meet the release rates required by the Stormwater Ordinance.

2.1 Requirements for Stormwater Management

Developments are required to meet the stormwater management performance criteria that are specified in Article 2 of the Kane County Stormwater Management Ordinance.

1. The first requires the runoff from a design storm with a one percent (1%) probability of occurring to be detained so that the rate that it is discharged from the site does not exceed the release rate of 0.1 cfs per acre. (**§ 203. Site runoff storage requirements (detention)(b)**)
2. The second criterion is the retention of the runoff from the first 0.75 inches of rainfall from the Hydraulically Connected Impervious Area.
    a. Hydraulically Connected Impervious Area refers to "*those areas of concrete, asphalt and gravel that, along with building roof surfaces, convey flows directly to an improved drainage system consisting of storm sewers or paved channels and includes roadways drained by curb and gutter and storm sewers and driveways hydraulically connected to those roadways, but does not include roof surfaces which discharge to unpaved surfaces which absorb and filter stormwater runoff nor roadways whose primary conveyance is through open ditches and swales*". (**§ 104. Definitions, (61)**)

b. Stormwater that is retained is expected to leave the site by infiltration into the ground, evaporation or transpiration through the leaves of plants.
c. However, should on-site soil conditions limit the ability of water to soak into the ground the Administrator has the option of reducing the retention volume. (**§ 203. Site runoff storage requirements (detention)(g)(1)**)
d. Design of retention facilities are required to infiltrate the retention volume at a rate no greater than five days after the storm event (**§ 203. Site runoff storage requirements (detention)(g)(4)(A)**) to allow for adequate filtration and pollutant removal of the stormwater by the soil before it reaches the groundwater. Should soil conditions warrant it subsurface drainage systems may be constructed to augment the infiltration of the retention volume.

3. Developers of commercial or industrial redevelopment sites may request to pay a fee-in-lieu of on-site storage. Developments may qualify as long as BMPs are incorporated into the site plan that will result in a "net benefit" in water quality (**§ 200. General information (c)(2)**).

2.2 Fee-In–Lieu of Site Runoff Storage

Under Article 2 of the Kane County Stormwater Management Ordinance redevelopments and developments consisting of mass grading only have the option of paying a fee-in-lieu of site runoff storage (described in Article 13). To qualify for fee-in-lieu of runoff storage, projects must meet two criteria:

1. demonstrate that the project will not increase peak runoff discharges, and
2. provide BMPs that will result in a "net benefit" in water quality.

2.3 Defining Net Benefit

The City of Aurora interprets the implementation of one of the following two methods or a combination of both as sufficient means to result in a net benefit in water quality:

1. Retention Volume Practices: Retention of the first 0.75 inches of runoff from the hydraulically connected impervious area within the volume provided by the BMPs constructed on the site.

2. Filtration Practices: Installation of manufactured storm water quality units that provide a 40 percent reduction in total suspended solids for a maximum particle size of 80 microns for the 1 year storm event, critical duration peak discharge (regardless of the rainfall depth associated with the critical duration event).

BMPs that employ retention are the preferred method of achieving the net benefit in water quality for a site, although some sites or portions thereof may not be suitable for the use of retention type BMPs.

3.0 STORMWATER

Stormwater pollutants are washed from common sources into our rivers, lakes and streams during each rain event and after snow melt. A level of development representing as little as ten (10) percent imperviousness within a watershed has been shown to negatively impact receiving waters (*Center for Watershed Protection*, 2003). Pollutant levels in stormwater have sometimes been found to exceed those in wastewater. Pollutants typically contained in stormwater runoff include: sediment, heavy metals, fertilizers, pesticides, herbicides, bacteria, nutrients, oils, and grease (**Table 1**).

TABLE 1
COMMON POLLUTANTS AND SOURCES IN STORMWATER

Contaminant	**Sources**
Sediment and Floatables	Streets, lawns, driveways, construction activities, channel erosion, atmospheric deposition
Nutrients	Lawn fertilizer, atmospheric deposition, automobile exhaust, soil erosion, animal waste
Bacteria and Viruses	Lawns, roads, leaky sanitary sewers, septic systems, animal wastes, wildlife
Pesticides and Herbicides	Residential lawns and gardens, roadsides, commercial landscaping, soil erosion, utility right-of-ways
Oils and Hydrocarbons	Roads, driveways, parking lots, vehicle maintenance areas, gas stations, illegal dumping
Heavy Metals	Automobiles, metal roofs and flashing, combustion, industrial areas, corroding metal surfaces, atmospheric deposition
Organic Materials	Residential lawn and gardens, commercial landscaping, animal wastes

4.0 STORMWATER PLANNING STRATEGY

Water quality protection strategies are often constructed in series (a treatment train) to maximize the opportunities to detain, infiltrate, and treat stormwater; starting at the initial source of runoff (roofs, parking lots, etc.) and then moving to larger and larger drainage areas (**Table 2**). The treatment train consists of four levels ranging from regional applications to the specific source areas that consist of: 1) individual source areas – areas of similar infiltration and runoff characteristics, 2) the site or block watershed, 3) the neighborhood or community watershed, and 4) the regional or large watershed. In general, different stormwater management processes are best effective at different levels, though some can be applied across multiple levels. Strategies related to broad growth and development issues, for example, are often implemented at the regional or watershed level, while techniques that minimize impervious surfaces or encourage bio-filtration and rain gardens may be applied at the neighborhood, site and source levels.

TABLE 2
BMPS OF A STORMWATER TREATMENT TRAIN

Source Controls	Site Controls	Neighborhood System Controls	Regional Controls
Vegetated Buffers Rain Gardens Oil-water separator Rain Barrel Porous pavement Infiltration Trench Street Trees/Rain Trees Green Roofs	Bioretention Treatment Swales Detention Ponds Infiltration Basins Manufactured Devices	Detention Ponds Infiltration Basins Wetland Treatment	Detention Ponds Floodplain Restoration

A primary objective of stormwater management programs is public safety and the protection of property from flood damage. A "green" stormwater program differs from the traditional "grey" approach by the hierarchy of management controls. A "green" strategy is a decentralized approach that tries to replicate natural hydrologic processes by applying a wide variety of controls with the intent of decreasing runoff rates and volumes, thereby reducing NPS pollution.

4.1 Management Technologies

Nonpoint source pollution originates from many diffuse sources, not a single point of origin like point source pollution. Therefore, the technologies to reduce nonpoint source pollution must be tailored to accommodate the characteristics of various land uses, soil conditions, and drainage patterns. Technologies revolve around two general treatment strategies either storage or conveyance. Technologies treating stormwater target the removal of particles suspended in the stormwater runoff. Using hundreds of water quality analyses from across the United States, the U.S. EPA's National Urban Runoff Program (NURP) established an average particle size distribution (Table 3). The NURP distribution is made up of 11 percent clay, 51 percent silts and 38 percent sand.

TABLE 3
NURP AVERAGE PARTICLE SIZE DISTRIBUTION

Particle Texture	Particle Size (µm)	Percent Greater Than	Settling Velocity
Clay (29%)	0	100%	< 0.00039 inches/sec
	1	99.9	
	2	97	
	3	93	
	4	91	
Silt (55%)	5	89	< 0.087 inches/sec
	6	86	
	7	84	
	8	82	
	9	80	
	10	78	
	11	75	
	12	73	
	13	71	
	14	69	
	15	68	
	20	62	
	25	57	
	30	53	
	35	49	
	40	47	
	50	42	
Sand (16%)	60	38	> 0.087 inches/sec
	80	33	
	100	28	
	150	22	
	200	18	
	300	12	
	500	7	
	800	4	
	1000	3	
	2000	0	

Source: U.S. EPA 1983

4.1.1 Storage Technology

The effectiveness of storage based BMPs is dependent on how much stormwater runoff is held (detained or retained) and treated. The target design volume specified by the Kane County Stormwater Ordinance requires the retention of the runoff from 0.75-inches of rainfall from all directly connected impervious areas.

4.1.2 Conveyance Technology

Effectiveness of conveyance BMPs is measured by the time (and velocity) that it takes stormwater to pass through the device or structure. Most conveyance based BMPs work on the principle of Stoke's Law that describes the particles falling by gravity through water; although infiltration in conveyance BMPs can also be a significant pathway for pollutant reduction. The velocity at which particles drop out of stormwater moving through a treatment device, which is often referred to as the settling velocity, is a function of the size of the particle and its density. Most stormwater calculations assume that all particles in stormwater have the same specific gravity of 2.65. Under ideal conditions sand, silt and clay particles will settle at average rates of: greater than 0.087 inches/second (in/s), less than 0.087 in/sec and less than 0.00039 in/s respectively.

5.0 PLANNING APPROACH

5.1 Green versus Grey Approach

The primary objective of all stormwater management programs is public safety and the protection of property from flood damage. What makes a "Green" stormwater program different from the traditional "Grey" approach is the hierarchy of management controls. A "Green" strategy is a decentralized approach that tries to replicate natural hydrologic processes by applying a wide variety of controls. In doing so the objective is to reduce the volume of stormwater that is discharged from the site in the form of surface flow. By reducing the volume of stormwater that may enter conveyance systems, basement flooding and the release of untreated stormwater and combined sewage into lakes, rivers, and streams will be reduced.

5.2 Green Approach Hierarchy

As sites are evaluated for a "green" stormwater management approach, planners and engineers should go through an evaluation of a hierarchy of BMPs (Table 4) to select those best suited for a particular location.

- The green strategy starts by preventing stormwater from coming into contact with possible sources of pollutants. This is accomplished by removing potential pollutant sources, covering sources with a roof or tarp or isolating contaminated runoff for treatment later.
- Opportunities to intercept stormwater are then evaluated. Interception reduces the volume of runoff, before it enters the drainage system. This could be accomplished by planting vegetation with large surface areas, such as trees, or capturing stormwater in tanks for non-potable uses like flushing toilets or used as irrigation water.
- Once rainwater hits the ground, opportunities to infiltrate stormwater are sought. A goal of these strategies is to try to restore as much of the infiltrative capacity of as site as can be achieved. Infiltration devices may be small depressions that capture runoff from small catchment areas, porous pavement for the construction of sidewalks, patios and parking lots or a larger infiltration basin that collects runoff from the entire site.
- Evapotranspiration processes are often employed to augment infiltration of stormwater. These include practices such as bioretention basins and rain gardens. Plants may be selected for a bioretention facility to be part of the landscaping of the site. Vegetation, particularly deep rooted plants, have the added benefit of maintaining the permeability and infiltration capacity of the soil.
- When conditions prevent infiltration as a viable option various biofiltration or biodetention devices may be considered. These could take the form of engineered soils with underdrains.
- Manufactured devices try to remove pollutants by facilitating settling or separation of pollutants by removing particles and debris through hydrodynamics, screens or filters.
- Detention of stormwater has been a standard practice and best proven design for mitigating the adverse quantity and water quality impacts of urban stormwater.

One of its disadvantages is the amount of land that is needed to construct a properly designed facility. The cost of the land and the loss of the land for other uses are deterrents to this practice in highly urbanized areas.

- The last strategy is to collect and safely convey stormwater runoff to area waterways through a system of pipes, sewers and ditches. Conveyance strategies should also account for the overland flow of stormwater during extremely large rainfall events. The disadvantage is that this approach does nothing to reduce pollutants carried by stormwater runoff to area waterways. In some cases, conveyance facilities discharge runoff at such high rates into streams that streambanks are eroded destroying habitats and at times damage adjacent properties.

A more in depth discussion of "Green" BMPs are presented in the Kane County BMP Manual.

TABLE 4
HIERARCHY OF BMP CONTROLS

	STRATEGY	**BMP WATER QUALITY CALCULATION**	**GENERAL MANAGEMENT PRACTICES**
Green Solutions	Separation / Avoidance	NA	Roofs / Shelters Dikeing / Isolation Downspout Disconnection
	Interception	V	Stormwater Trees Rain Barrels Cisterns
	Infiltration	V	Infiltration Trench (Basins or French Drains) Porous Pavement
	Evapotranspiration	V	Green Roofs
	Biologically Enhanced Practices	V	Rain Gardens Bio-swales
	Filtration	C	Sand Filters Proprietary Devices Cartridge Filters Mechanical Separation Netting / Screening / Racks / Baskets
	Detention	V	Wet Detention Pocket Wetlands
		V – Volume **C - Conveyance**	

5.3 Site Evaluation and Design for "Green" Stormwater Management Improvements

Evaluation of sites for the possible suitability for "Green" stormwater practices consists of four steps

Step A. Establish site limitations, prohibitions and set backs
Step B. Delineation of Drainage Patterns
Step C. Identification of Source Areas

Step D. Soil and Infiltration Capabilities
Step E. Design and Evaluation of the proposed BMPs

5.3.1 Step A. Establish site limitations, prohibitions and set backs.

The Kane County BMP Manual provides a discussion of the limitations for each of the BMPs. However the information contained in the BMP manual is intended to be used as a guide line and should not take the place of good engineering judgment.

Stormwater practices should avoid being placed in wetlands, floodplains and areas that may already be contaminated or could cause contamination of groundwater.

Set backs from property lines in accordance with City zoning requirements should be determined and adhered to. The City requires easements to be established over all stormwater improvements that are necessary to meet the requirements of the City's Stormwater Ordinance, or are to be taken into account in the Fee-In-Lieu of calculation.

In order to provide a funding mechanism for maintaining neglected BMPs, a Special Service Areas (SSAs) must be established in accordance with Section 605 of the Kane County Stormwater Ordinance. In the event that the property owner refuses to properly maintain the required BMPs, the City will activate the SSA, perform the necessary remedial work and assess the owner for the cost of maintenance. It should be noted, that property owners who choose to install stormwater improvements that are not required as part of an approved stormwater management plan are exempt from the easement and SSA requirements.

5.3.2 Step B. Delineation of Drainage Patterns

The delineation of drainage patterns and drainage catchment areas are important in the sizing and selection of BMPs. Catchment areas determine the volume of stormwater to be treated and sizing of the storm sewers. Planning of BMPs need to factor in stormwater that may be draining onto the site from offsite tributary areas.

5.3.3 Step C. Identification of Source Areas

Source areas are areas with uniform drainage characteristics, type of impervious area and soil permeability. Examples of source areas include roofs, parking, landscaped / lawn areas and roadways. Runoff from source areas generally has uniform pollutant concentrations and runoff coefficients. To maximize controls stormwater BMPs should target roads and parking first, then roof tops and then landscaped areas.

5.3.4 Step D. Soil and Infiltration Capabilities

Infiltration capacity of soils is a major factor in the design of most BMPs. For example, sites with higher permeable soils may be appropriate for BMPs that rely on infiltration into the underlying soil. Sites that contain lower permeable soils may be better suited for BMPs that include bioretention such as rain gardens fitted with underdrains. In addition, seasonally *high groundwater levels* and depth to bedrock are important field conditions. However neither groundwater nor bedrock is expected to be factors in the study area.

5.3.5 Step E. Design and Evaluation of the Proposed BMPs

Stormwater volumes, velocities, and flow rates should be determined in accordance with the guidance given in the BMP Manual and per the Kane County's Stormwater Ordinance. Infiltration BMPs and improvements that include subsurface storage, such as Bioretention facilities should include monitoring wells.

BMPs that do not involve infiltration or retention should be evaluated in accordance with the manufacturer's recommendations. Such BMPs should be designed to ensure a reduction of at least 40% of the total suspended solids.

6.0 SEPARTION / AVOIDANCE

6.1.1 Source Control Measures

Description

Stormwater can become contaminated when it comes into contact with spills and leaks, raw materials, by-products, finished products, containers, and material storage areas. Stormwater may wash off or dissolve pollutants as it comes in contact with exposed sources of pollutants. To prevent or reduce the discharge of pollutants to stormwater from material delivery and storage, pollution prevention and source control measures must be implemented. Source control measures include enclosing or covering materials, storing materials in a designated area, installing secondary containment, conducting regular inspections, preventing stormwater run-on and runoff, and training employees and subcontractors.

Benefits

Successful source control practices prevent pollutants from getting into stormwater in the first place. This reduces the cost of clean up of the stormwater and the environmental damage that it might cause.

Design Considerations

Successful implementation depends on effective training of employees in proper materials handling and procedures to respond to spills

Applicability

Common applications where these types of controls might be employed include garbage cans / dumpsters, bulk storage barrels, and grease pits. Projects are expected to cover raw materials and waste containers (garbage cans) with a roof, canopy, tarp, or lid. Liquids stored outside are expected to have a secondary containment to minimize stormwater that may come into contact with the liquid from contaminating runoff from the site.

6.1.2 Downspout Disconnection

Description

Traditionally, downspouts have been required to be directly connected to the City's sewer systems or are directed to impervious areas, such as driveways and streets, which provide a direct connection to a public sewer. This has allowed roof runoff to be conveyed very quickly to sewers, sometimes causing the system to be over loaded which may flood adjacent properties and basements.

Benefit

Disconnecting roof downspouts from sewer systems and directing runoff onto pervious areas, landscaping beds, rain barrels or cisterns reduces the hydrologic load on the sewer system and allows the runoff to soak (infiltrate) into the ground. This also traps nonpoint source pollutants, carried by the roof runoff, in the soil matrix.

Design Considerations

Downspout disconnection is most appropriate for external downspouts. Downspouts that run internally through a building will be more difficult to disconnect. The most important issue is the planning of where the runoff from the downspout will be directed. First, the point of discharge of the down spout must extend at least 5 to 10 feet from the foundation onto ground that slopes away from the foundation of the building to prevent the runoff from infiltrating into the building's foundation drains. Second, it is preferred that downspouts discharge runoff onto lawns or landscaped areas or detained in rain barrels or cisterns.

Applicability

It is expected that whenever possible that all new downspouts will discharge onto landscaped areas.

7.0 RETENTION PRACTICES

7.1 Interception

7.1.1 Rain Barrels

Description

Rain barrels can be used by most residential, commercial and institutional developments. Rain barrels are typically placed at a downspout to collect and store rainwater from the roof. Barrels typically hold 50 to 100 gallons and are commonly constructed from plastic or wood. The collected water can be used for irrigating lawns or gardens or other non-potable uses. Used as irrigation water runoff is able to infiltrate into the ground and reduce runoff and stormwater nonpoint source pollution from entering the City's storm or combined sewer systems.

Benefit

The rain water collected is good for plant watering because it is not chlorinated and is mildly acidic, which helps plants take up important minerals from the soils. In a simple residential example, a 1,200 square foot roof could utilize 55-gallon barrels to store runoff from downspouts at the four corners of the house. The resultant storage is equivalent to about 0.3 inches of runoff. While this volume will not substantially reduce flooding from large storms, the cumulative impact of many rain barrels throughout the City can considerably reduce the runoff and the associated pollutant loads from the more frequent smaller storms.

Design Factors

Before employing this practice, planners should factor in the potential for controlling algae growth, mosquito control, physical site suitability, and homeowner ability and willingness to operate the rain barrel effectively should be considered. The components of a rain barrel system include the roof catchment area, collection gutters, piping and downspouts, a collection barrel with a cover and screening for child protection and particulate and pest control, piping for distribution of the water and overflow protection. The barrel should be located on a stand that ensures stability. The overflow should be directed away from building foundations. To allow for greater capacity, barrels can be piped together.

Applicability

Rain barrels should be placed at each downspout. A standard 55-gallon rain barrel is capable of retaining the runoff from the first 0.75 inches of rainfall from about 118 square feet of roof area. Users may consider using larger barrels or using more than one rain barrel per downspout.

7.1.2 Cistern

Description

Cisterns are typically larger than rain barrels and can be constructed either above ground or below ground. Cisterns can be constructed out of wood, metal, or plastic. Since cisterns are often below ground, a pump is sometimes needed to withdraw the water for use by the owner. Cistern systems typically consist of gutters, pipes, and channels that collect stormwater from roofs and other areas and then direct the stormwater into the cistern.

Benefits

Just like rain barrels, the water collected in the cistern may be used for irrigating landscape. A cistern may also be used as a storage tank to reduce peak runoff rates during storm events. Larger cistern systems with pumps allow the stormwater to be used for a larger range of applications such as non-potable household uses as well as irrigation. Using stormwater as an alternative source of water may conserve potable supplies and lower water utility bills.

Design Factors

Because cisterns may store water for an extended period of time (as an example a growing season) the removal of contaminants and debris, such as leaves, dust, and bird droppings, is a concern. Therefore some systems may have a purification/filter system such as leaf screens and roof washers (a length of pipe that stores the initial flush of water) to remove contaminants. Cisterns typically range in size from 200 gallons to 6,500 gallons, but can be as large as 10,000 gallons and typically detain water from multiple rainfall events. Underground installations cost almost twice as much as an aboveground installation. The cistern system should be inspected and maintained bi-annually to remove sediment accumulation and to check for system leaks. Local plumbing ordinances should be reviewed prior to installing underground cisterns or when planning to use the stored water as household gray water.

Applicability

Cisterns are effective tools to harvest rain for other uses. Irrigation is the most common use, but other uses could include exterior wash water, cooling water and flushing toilets. 100 percent of the volume captured in a cistern is assumed to remove 100 percent of the nonpoint source pollutants that are contained in the stormwater runoff.

7.2 Evapotranspiration

7.2.1 Green Roofs

Description

Green roofs are layers of living vegetation installed on top of buildings, which may range in size from small garages to large industrial structures. Green roofs may be designed for either pitched or flat roofs. They are designed to retain stormwater and contribute to improved water quality by filtering rainwater through the soil and the roots of plants. There are two systems of green roofs, extensive (modular) systems and intensive (built-in-place) systems. Both designs are generally composed of six layers

1. vegetation,
2. growing medium,
3. filter fabric,
4. drainage layer,

5. root barrier and
6. waterproof membrane.

Rainfall is intercepted by the vegetation, soaks into the growing medium where it is absorbed by the roots of plants. Any remaining water filters through the growing medium and is drained away by the drainage layer. For small rainfall events little or no runoff will occur and the majority of the precipitation will return to the atmosphere through evaporation and transpiration.

Extensive (modular) systems are lighter, typically have between two to four inches of growing medium. The limited thickness of growing media requires the selection of drought tolerant vegetation. Extensive systems are lighter than intensive systems, weighing between 12 to 40 pounds per square foot and thus can be used on a greater number of buildings. The self supporting module simplifies installation and can structurally support limited pedestrian traffic.

Built-in-place (intensive) systems are heavier, weighing around 80 to 150 pounds per square feet. They have a greater soil depth (growing medium) of 6 to 12 inches allowing them to support a wider range of plants, including deeper-rooted trees and shrubs. The greater structural requirements of the intensive systems have allowed designs to incorporate more of a park setting.

Benefits

Green roof systems can be incorporated into new building designs or installed on existing buildings. The water that does leave the roof is slowed, kept cooler and is filtered. Green roofs can also further insulate the building, reducing cooling and heating costs. Research conducted at Southern Illinois University at Edwardsville, through the Green Roof Environmental Evaluation Network (www.green-siue.com), indicates that green roofs can reduce cadmium, copper, lead and zinc concentrations in roof runoff.

In addition to the stormwater benefits, green roofs extend the life of roofs by two to three times. They can help preserve habitat and biodiversity in an otherwise sterile urban environment. Green roofs can also improve air quality by helping to reduce the "urban heat island" effect. Finally, they can provide garden areas and attractive views for other buildings.

Design Factors

Key considerations for implementing green roofs include:

1. The appropriate structural analysis of the load-bearing capacity of the building,
2. A waterproofing layer is important for most installations as well, because typical roofs are not designed to withstand hydrostatic pressure of standing water of the green roof.
3. Vegetation should be well-adapted to the growing conditions, expected amount of rainfall, temperature fluctuations and wind loads.

Applicability

Both new building designs and rehab projects are opportunities for green roofs as long as the structure has the load-bearing capacity to support the roof.

7.2.2 Stormwater Trees

Description

Stormwater trees are tree species together with installation practices that maximize the stomwater benefit from the full tree structure, roots to canopy. Tree species that tolerate periodic wet soil conditions and develop broad and full canopies are the preferred species. Installation practices should specify the use of tree pits, tree box filters, stormwater planters or structural soils specially designed to increase infiltration and promote healthy trees. The trees are planted in urban areas to reduce the rate and quantity of stormwater runoff. Trees have the greatest effects during the growing season and during smaller storm events.

Benefits

The trees help to manage stormwater flow by intercepting the rainfall and slowing the rate at which it falls to the ground. The slower flow rate allows for increased infiltration into the soil and reduced runoff. A 40% canopy cover is the goal identified by the USEPA. Runoff reduction from stormwater trees occurs in the following ways:

- Above the ground by interception of the rain, evaporation, and adsorption into the tree leaves and stems.
- At the ground surface where leaf litter and organic matter hold precipitation, and roots and tree trunks create hollows for water to collect.
- Below the ground where organic matter from the trees increases the infiltration and absorption ability of the soil; roots break up the soil, thereby improving infiltration and increasing percolation into deeper soils; and water is taken up by the roots.
- The roots also take up pollutants that are with in stormwater, such as nitrogen, phosphorus, and potassium.

Design Factors

For siting and costing purposes, the average canopy of a stormwater tree is assumed to be 20 feet in diameter, or about 314 square feet. It is important to consider the time it will take newly planted trees to develop the planned canopy and root system. The minimum weekly water requirement of a typical tree is estimated at five gallons plus five gallons per caliper inch. When planning the location for stormwater trees, one must consider potential damage the roots may cause on nearby paved areas and sewers and the amount of debris each type of tree will produce. For example, river birch and willow are typically not prescribed for urban street settings because their roots can clog sewers and laterals. Also, willows generate a lot of debris throughout the year that can clog storm sewer inlets.

7.3 Biologically Enhanced Practices

7.3.1 Drainage Swales

Description

A swale is a broad, vegetated channel used for the movement of runoff with side slopes of 4:1 or flatter. Swales also can move a portion of the runoff into the ground and filter out runoff pollutants. Drainage swales that are planted with native vegetation are commonly called bioswales.

Benefits

Drainage swales can provide pretreatment prior to other BMPs. Swales can be effective alternatives to enclosed storm sewers and lined channels, whose only function is the rapid movement of runoff from a developed site. In contrast to conventional curb-and-gutter/storm sewer systems, swales can reduce both the rate and volume of stormwater runoff on a site. Volume reduction is achieved via infiltration of runoff into the soil; swales in sandy soils will be much more effective than swales in clay soils. Pollutant removal rates in swales are highly variable depending on its slope, soils, and vegetation. Estimated removal rates range from 30 percent to 70 percent of suspended solids and metals (such as cadmium and lead) and 10 percent to 30 percent of nutrients (such as phosphorus and nitrogen), biochemical oxygen demand, and other organic compounds. Swales can provide limited wildlife habitat when planted with native vegetation.

Design Factors

Effectiveness of a swale as a stormwater BMP is dependent on the time that it takes runoff to move the length of the swale, longer travel times allow greater volumes of runoff to infiltrate and greater quantity of pollutants to settle out. As general guidelines flow velocity should not exceed 1.5 feet per second and the flow depth should not exceed 12-inches. Estimation of the volume of runoff that is infiltrated should be calculated using the effective width of the swale, length of the swale, infiltration rate of the soils in the swale and the time that there is runoff in the swale. The effective width (ft) of the swale is one half of the wetted perimeter (ft) of the design flow to take into consideration the loss of infiltration capacity due to the accumulation of sediments. To maximize the effective width of the swale side slopes of should be kept to 4:1 of flatter. Ditch checks in the swale may be installed to reduce velocities, extend detention time, or retain a design volume. If utilizing ditch checks, ensure that the design allows for no standing water within 24 hours after a rainfall / runoff event.

Applicability

Drainage swales are applicable on virtually all development sites. In dense urban settings swales generally will be used in conjunction with storm sewers, rather that in lieu of storm sewers. One type of swale is a recessed landscaped median within paved surfaces as an alternative to raised parking lot islands. Runoff flows into them from the surrounding pavement where it infiltrates and the vegetation filters contaminants.

7.3.2 Kane County BMP Manual - Retention Based BMPs

The Kane County BMP Manual provides guidance on a number of retention based stormwater BMPs.

The BMP Manual describes site selection criteria, design parameters, hydrologic analysis, sizing, written specifications and a standard detail that may be used within construction drawings. The BMPs included in the manual pertinent to use at a single residential site or for redevelopment sites include:

7.3.2.1 Permeable Interlocking Concrete Pavements

7.3.2.2 Rain Gardens

7.3.2.3 Infiltration Trenches

8.0 Filtration Practices

Filtration practices use a variety of media that physically sieve solid pollutants from stormwater runoff or provide for the removal of pollutants in manufactured units.

8.1.1 Manufactured Storm Water Quality Units

Description

A manufactured storm water quality unit is chamber used in a storm sewer to remove sediment and other solids from stormwater by linear settling and/or the use of centrifugal force. Sediments settle out to the floor of the unit. Floating solids are trapped by a surface weir or screen. The manufactured storm water quality unit is installed below the ground surface and it discharges to a storm sewer or downstream BMP.

Benefits

The units come in a variety of sizes and are manufactured by several different companies. The storm water quality units do not have moving parts and do not require a power supply. The units are typically prefabricated, which allows for relatively quick installation. The units can be installed in areas where surface space is limited. Components of a unit include piping for water inflow and outflow, a chamber(s) where solids and floatables can separate from the stormwater, and possibly a baffle-type chamber to further separate floatables. When runoff rates exceed the design flows of the units the excess flow may bypass treatment by the device.

Design Factors

The size of the unit is based on the tributary drainage area and associated flow rates and the design flow that does not by-pass the device.

Applicability

Manufactured devices are the best alternative for areas with a high percentage of impervious area, such as parking lots, where the runoff cannot be diverted to a green treatment BMP.

9.0 ASSESSMENT, MONITORING, AND OPERATION AND MAINTENANCE OF BMPs

Property owners who choose to install BMPs that are not part of an approved stormwater plan are not required to adhere to this section. However, performance monitoring and operation and maintenance (O&M) of Stormwater BMPs is strongly encouraged.

9.1 Assessment

The purpose for incorporating BMPs into site designs is to provide a net-benefit in water quality to the site runoff. In general, a net-benefit is accomplished by reducing the discharge (volume, velocity and peak runoff rate) of stormwater and by removing pollutants from the runoff prior to the runoff leaving the site. As mentioned earlier in this document, the City of Aurora presumes that if the runoff volume from the impervious surfaces generated by a 0.75 inch rainfall is intercepted, retained, and treated in accordance with the design standards included in the Kane County BMP manual, then both the discharge and pollutant removal goals will be met. Consequently, assessment of BMP performance will be based solely on volume/velocity based calculations. However, should the designer wish to vary from the BMP manual design guidelines, then a Pollutant Removal Analysis should be performed using appropriate water quality modeling software.

The effectiveness of most BMPs can be measured by the amount of sediment that is removed by the treatment device. Factors that need to be considered when evaluating and selecting BMPs include:

- A comparison of the drainage area tributary to BMPs versus the total project area. The greater percentage of the site discharging to a stormwater BMP, the greater chance the project will meet the intent of the City’s stormwater water quality goals.
- Infiltration practices will yield greater pollutant removal than detention practices.

- The velocity that stormwater travels through a BMP greatly influences the ability of the device to remove nonpoint source pollutants. The longer that stormwater may be in contact with the treatment device the greater amount of pollutants will be removed.

A form is provided in Appendix B to guide applicants through a Pollutant Removal Analysis for each BMP and the entire development to substantiate a water quality net-benefit is provided by the proposed BMPs for the site.

9.2 Monitoring Plan

The developer shall be required to submit a monitoring plan to the City for review, for any BMPs that are required as part of an approved stormwater plan. The monitoring plan must be approved by the City's Engineering Division prior to the issuance of a Stormwater Permit. The developer shall be required to follow the approved monitoring plan for a minimum of one (1) year after acceptance of the improvements by the City. Monitoring of all BMPs shall take place at least once a year, preferably in the spring after a rainfall event.

BMPs that involve infiltration and or subsurface storage, should include the installation of monitoring wells in accordance with the BMP manual.

9.3 Operation and Maintenance (O&M) Plan

A developer shall be required to submit an O&M Plan for any BMPs that are required as part of an approved stormwater plan. The O&M Plan must be approved by the City's Engineering Division prior to the issuance of a Stormwater Permit. The property owner shall be required to properly maintain the BMPs for the life of the development, unless a revised Stormwater Plan, that includes the removal or abandonment of the BMPs, is approved by the City's Engineering Division.

10.0 PULLING IT ALL TOGETHER – EXAMPLES

10.1 Residential Development

Description

Residential development dominates the landscape of the City of Aurora. The impact of one individual home installing stormwater practices may be perceived as insignificant but the cumulative impact of a large number of residential stormwater facilities has been shown to have a significant improvement on both reducing the quantity of stormwater entering the City's system as well as an improving the water quality of stormwater runoff. Other benefits include restoration of groundwater recharge and a reduction in the use of potable water for irrigation.

The City of Aurora encourages each resident to install one or more on-site stormwater BMPs. The City recognizes that construction projects to correct stormwater and combined sewer problems may be downsized if there is high level of participation by homeowners. This will reduce the cost of the projects that the City will have to construct resulting in fewer tax dollars and user fees paid by residents. Practices that may be used, as appropriate, include the following:

- Downspout disconnection from combined and storm sewers.
- Rain barrels at downspouts for garden and lawn irrigation.

- Rain gardens.
- Porous pavement for driveways, sidewalks and patios.

10.2 Commercial Building

Description

Commercial building refers to a larger category of development which includes commercial, industrial, multifamily and institutional developments. Commercial development offers the widest range of opportunities to manage stormwater using green infrastructure. It is the goal of the City of Aurora to have all runoff from a commercial development passing through at least one BMP. The feasibility of achieving this goal depends on actual site conditions. However, it is hoped that commercial development will incorporate two or more BMPs in series in a stormwater Treatment Train. A conceptual example of the desired outcome is described below

1. Green roof to insulate the building, reduce heat island effect, and retain stormwater
2. Downspouts would divert stormwater to cisterns, landscaped areas, vegetated buffer or biotreatment device.
3. Runoff collected in cisterns would be used later as irrigation water for landscaped areas or slowly release to a manufactured stormwater treatment device or another biotreatment device where it could be filtered and infiltrated into the ground.
4. Bioswales would pickup and convey runoff from rooftops and parking lots. Bioswales could be augmented with engineered soils and native vegetation to improve the infiltration and filtration of runoff. Where it is necessary because of low permeability of the soils underdrains could pickup infiltrated water and discharge it to the City's sewer system.
5. Stormwater collection systems would divert runoff to rain gardens or bioretention basins where it would infiltrate into the ground.
6. Other "end of pipe" treatment devices include small created wetlands or manufactured treatment devices. Both effectively treat the stormwater runoff from smaller storm events, stormwater runoff from larger storm events may require bypass flow control.

10.3 Green Parking Lots

Description

Parking lot stormwater storage and treatment systems, also called green parking lots, are designed to reduce the impervious area and reduce the volume of stormwater runoff from the lot. Practices that may be used include the following:

- Construct bioretention systems, grassed swales, or infilatration systems to treat the runoff
- Plant stormwater trees to treat runoff and provide shading and cooling
- Install porous pavements for low traffic or overflow parking areas
- Detain stormwater on the surface of the parking lot by using inlet restrictors and contouring the parking lot to temporarily pond stormwater
- Install underground storage vaults
- Surface storage areas should have a minimum slope of 0.5% toward the outlet to ensure complete drainage.

The practices can be applied to new development as well as redevelopment projects. Application of green parking lot practices are most common in commercial, industrial, and multifamily land uses, and are most successful in low traffic, light use lots.

The benefits of green parking lots include reduction of impervious cover, reduction of stormwater runoff and peak discharge, pollutant removal, improved aesthetics, and groundwater recharge.

A. APPENDIX: DEFINITIONS

(1) ***Administrator*** means the person designated by the permitting authority to administer and enforce this ordinance;

(2) ***BMP*** or ***best management practices*** means a measure used to control the adverse stormwater-related effects of development, and includes structural devices (for example, swales, filter strips, infiltration trenches, and site runoff storage basins), designed to remove pollutants, reduce runoff rates and volumes, and protect aquatic habitats, and nonstructural approaches, such as public education efforts to prevent the dumping of household chemicals into storm drains;

(3) ***developer*** means a person who creates or causes a development;

(4) ***development*** means any manmade change to the land and includes—

(A) the construction, reconstruction, or replacement of a building or an addition to a building;

(B) the installation of utilities, construction of roads, bridges or similar projects;

(C) drilling and mining;

(D) the construction or erection of levees, walls, fences, dams, or culverts;

(E) channel modifications, filling, dredging, grading, excavating, paving, or other nonagricultural alterations of the ground surface;

(F) the storage of materials and the deposit of solid or liquid waste;

(G) the installation of a manufactured home on a site, the preparation of a site for a manufactured home, or the installation of a recreational vehicle on a site for more than 180 days;

(H) any wetland impact; and

a. any other activity of man that might change the direction, height, or velocity of flood or surface water, including the extensive removal of vegetation; development, however, does not include—

(I) maintenance and repair of existing buildings or facilities;

(J) repair or replacement of an existing parking lot outside the floodplain provided that no new impervious surfaces are added, there is no increase in peak flows, and there is no change in the location of the stormwater discharge;

(K) resurfacing of streets and highways outside the floodplain;

(L) resurfacing of publicly owned streets and highways within the floodplain provided the difference between the elevation of the road surface after resurfacing and the elevation of the road surface on the effective date is not more than two inches;

(M) for agricultural uses, maintenance of existing drainage systems for the limited purpose of maintaining cultivated areas and crop production; or

(N) for agricultural uses, improvements undertaken pursuant to a written NRCS conservation plan;

(5) ***drainage area*** means the land area above a given point that may contribute runoff flow at that point from rainfall;

(6) ***hydraulically connected impervious area*** means those areas of concrete, asphalt and gravel that, along with building roof surfaces, convey flows directly to an improved drainage system consisting of storm sewers or paved channels and includes roadways drained by curb and gutter and storm sewers and driveways hydraulically connected to those roadways, but does not include roof surfaces which discharge to unpaved surfaces which absorb and filter stormwater runoff nor roadways whose primary conveyance is through open ditches and swales;

(7) ***hydrologically disturbed*** means an area where the land surface has been cleared, grubbed, compacted or otherwise modified that changes runoff, volumes, rates or direction;

(8) ***net benefit in water quality*** means the institution of best management practices as part of a development that when compared to the pre-development condition can be judged to reduce downstream sediment or pollutant loadings;

(9) ***redevelopment*** means development on a developed site devoted to an existing urban land use the stormwater from which discharges into an existing stormwater facility either owned or maintained by a unit of local government, or discharges directly onto a regulatory floodplain; redevelopment includes the widening of an existing street or highway owned by a unit of local government;

(10) ***runoff*** means the waters derived from melting snow or rain falling within a tributary drainage basin that exceeds the infiltration capacity of the soils of that basin;

(11) ***sedimentation*** means the process that deposits hydraulically moved soils, debris and other materials on other ground surfaces or in bodies of water or stormwater drainage systems;

(12) ***sedimentation trap*** means a structure or area that allows for the temporary deposit and removal or disposal of sediment materials from stormwater runoff;

(13) ***stormwater management permit*** means the permit issued under Article 5 of the Kane County Stormwater Ordinance;

(14) ***subsurface drainage*** means the removal of excess soil water to control water table levels at predetermined elevations for structural, environmental or other reasons in areas already developed or being developed for agricultural, residential, industrial, commercial or recreational uses;

(15) ***Technical Manual*** means the manual adopted by the County which refers to this ordinance and provides additional explanations and examples;

(16) ***water table*** means the upper limit of a free water surface in a saturated soil or underlying material;

B. APPENDIX: NET BENEFIT ANALYSIS

This form walks applicants through the calculations to evaluate the water quality net benefit of a development project. Applicants will have to attach back up documentation and calculations for the information requested in this form.

Step 1. Delineate the individual drainage catchment areas of the project site. Each stormwater BMP should have at least one tributary drainage catchment area.

Column	A	B	C	D	E	F	G
	Drainage Catchment Area Identification	Area of Catchment	Area of Perviousness	Non-Directly Connected Impervious Areas	Directly Connected Impervious Areas		
					Area of Rooftop	Area of Parking	Area of Other Imperviousness
Units							
1.							
2.							
3.							
4.							
Total	Total area of all catchment areas should equal the total area of the development project						

Step 2. If the water quality effectiveness of the selected stormwater BMP is based on the volume of stormwater runoff captured complete the following calculations. If the selected BMP is not based on the volume of stormwater runoff then go to Step 5. Possible Stormwater BMPs that may meet this criterion include:

- Reuse of Stormwater Runoff
- Rain Barrels / Cisterns
- Infiltration Basins
- Infiltration Trench / French Drains
- Porous Pavement
- Green Roofs
- Bioretention
- Rain Gardens

Column	A	B	C	D	E
	Drainage Catchment Area Identification	Area of Catchment	Type of BMP	Runoff Volume Captured by BMP	Runoff Volume Generated by the first 0.75 inches
Units					
1.					
2.					
3.					
4.					
Totals					

Go to Step 5.

Step 3. If the water quality effectiveness of the selected stormwater BMP is based on the volume of stormwater runoff captured and has underdrains complete the following calculations. If the selected BMP is not based on the volume of stormwater runoff then go to Step 5. Possible Stormwater BMPs that may meet this criterion include:

- Infiltration Basins with underdrains
- Bioretention with underdrains
- Rain Gardens with underdrains

Column	A	B	C	D	E	F
	Drainage Catchment Area Identification	Area of Catchment	Type of BMP	Runoff Volume Captured by BMP	Multiply Captured Runoff Volume by 50%	Runoff Volume Generated by the first 0.75 inches
Units						
1.						
2.						
3.						
4.						
Totals						

Note need to state assumptions for percentage reduction also percentage may also change.

Go to Step 5.

Step 4. If the water quality effectiveness of the selected stormwater BMP treats runoff as it is conveyed through the device. Possible Stormwater BMPs that may meet this criterion include:

- Swales
- Vegetative Filter Strips
- Proprietary Manufactured Devices

Compute the peak discharge for each catchment for the 1-year, 24-hour design storm and report the corresponding values below. If the flow velocity for surface BMPs equals or exceeds 3.0 fps, or if the flow velocity for proprietary manufactured devices exceeds the manufacturers recommendation **STOP -** BMP is not eligible for water quality benefit.

Column	A	B	C	D	E	F	G	H
	Drainage Catchment Area Identification	Area of Catchment	Type of BMP	Peak Runoff Discharge	Depth of Flow	Travel Time Through BMP	Enter Treatment Efficiency using Tables Below	Runoff Volume Generated by the first 0.75 inches
Units		**acres**		(cfs)	(ft)	**seconds**	**%**	**Cubic feet**
1.	**Example**	**0.5 ac**	**100' - Grass Swale**	**4.0 cfs**	**1.0 ft**	**100 sec**	**33%**	**1,225 cu.ft.**
2.								
3.								
4.								
Totals								

For an example, assuming a stormwater swale is flowing one foot deep through a 100-foot long swale at a velocity of one foot per second. For a 100-foot long swale the travel time through the swale is 100 seconds or one minute and forty seconds. Going to the last row in the first table below and interpolating between one and two minute travel times the estimated pollutant reduction should be around 33 percent.

ESTIMATED TREATMENT EFFICIENCY

Treatment Efficiency is based on the Midwest Particle Size Distribution and assumes laminar flow went computing settling velocities.

Depth of Flow (inches)	TRAVEL TIME THROUGH BMP (min.) .5	1	2	3	4	5	6	7	8
1	47%	51%	61%	64%	67%	70%	72%	74%	74%
2	42	48	56	61	61	62	64	66	67
3	38	44	51	56	56	56	61	62	62
4	34	41	48	51	53	54	58	60	61
5	33	38	44	50	51	52	56	58	59
6	32	36	43	48	49	51	54	56	57
7	30	34	42	46	48	50	52	54	56
8	25	33	40	44	46	49	51	52	54
9	23	32	39	43	45	48	50	51	52
10	22	31	38	42	44	46	49	50	51
11	21	30	36	40	43	45	48	48	50
12	20	30	34	38	42	44	44	48	48

Depth of Flow (inches)	TRAVEL TIME THROUGH BMP (min.) 9	10	15	30	60	360 (6 hrs.)	720 (12 hrs.)	1,440 (24 hrs.)
1	74%	76%	77%	82%	84%	90%	90%	90%
2	67	70	74	77	82	88	89	90
3	64	66	70	76	80	87	89	90
4	61	62	66	74	77	86	88	89
5	58	61	64	72	76	85	88	89
6	57	60	62	70	76	84	87	89
7	56	58	61	68	75	83	87	88
8	55	56	60	67	74	83	86	88
9	54	54	59	66	73	83	86	88
10	53	53	58	65	72	82	85	87
11	52	52	57	64	71	82	85	87
12	51	51	56	62	70	82	84	87
24	44	44	50	56	62	77	82	84
36	41	42	44	51	59	76	80	83
48	38	38	42	48	56	74	77	82

Step 5. Estimate the "Net Benefit" of the stormwater BMPs for development site by summarizing the results from Steps 2, 3 and 4. Note that if using a BMP from Step 4 multiply the Treatment Efficiency from Step 4.H by the Runoff Volume Generated by the first 0.75 inches in Step 4.F and enter the product in the Runoff Volume Captured by BMP column in the table below.

	A	B	C	D	E
Step and Column	Step1.A	Step 1.B	Steps 2.C, 3.C & 4.C	Step 2.D or Step 3.E or Step 4.H x 4.F	Step 2.E or Step 3.F or Step 4.H
	Drainage Catchment Area Identification	Area of Catchment	Type of BMP	Runoff Volume Captured by BMP	Runoff Volume Generated by the first 0.75 inches
Units					
1.					
2.					
3.					
4.					
Total	Total area of all catchment areas should equal the total area of the development project				
Estimate "Net Benefit" by dividing Column D by Column E					