CHAPTER 6 STORMWATER QUANTITY AND QUALITY MANAGEMENT

6.1 Introduction

Urban and suburban development typically increases impervious surfaces (ie. pavement and rooftops) which in turn increases the volume and velocity of stormwater discharges. These changes can impact the integrity of the natural stream corridor which can degrade water quality through the discharge of eroded bank material. Additionally, stormwater runoff from development typically carries a higher load of nutrients and pollutants that can degrade the water quality of receiving lakes and streams.

A nested approach to capturing and treating stormwater runoff will alleviate many of the impacts of development on downstream water quality in addition to providing flood protection. This approach includes runoff reduction, the treatment of the water quality volume, channel protection, reduction in downstream flooding by detention/retention, and routing of the overflow condition for extreme flood events. Each step in this nested stormwater management strategy provides varying levels of runoff quality and quantity control.

6.2 Runoff Reduction

The idea behind runoff reduction is the removal of a portion of the runoff volume as opposed to capturing that runoff and delaying its release. Runoff reduction can be accomplished through any one or a combination of the following: infiltration, interception/evapotranspiration or capture/reuse. These alternatives allow the post-developed hydrograph to more closely mimic the pre-developed condition and increases groundwater recharge. Per the Stormwater Management Ordinance, at least 10% of the water quality volume must be addressed through runoff reduction.

6.2.1 Infiltration

Nearly every type of soil has some infiltrative capacity. Steps should be taken in the planning and phasing of construction to protect this capacity to the maximum extent practicable. Areas where infiltration will be relied upon for runoff reduction and/or stormwater treatment will need to be protected from compaction by vehicle and construction equipment traffic. These areas will also need to be protected from sedimentation from construction site runoff.

For preliminary planning and design, the soil infiltration rates indicated in the Callaway County Soil Survey may be used for determining the volume reduction from infiltration. The design of various BMPs will have to take into account the need to store the volume long enough to achieve the infiltration. It is recommended that soil testing be performed prior to final design to verify the infiltration capacity of the soil.

Green-Ampt model calculates cumulative infiltration by assuming water flow into a vertical soil profile like a piston flow.

(1) $f_t = K ([\psi \Delta\theta]/ F_t + 1)$

(2) $F_{t+\Delta t} = F_t + K \Delta t + \psi \Delta\theta \ln[(F_{t+\Delta t} + \psi \Delta\theta)/(F_t + \psi \Delta\theta)]$

Where f_t is infiltration rate, in mm/hr or inches/hr; ψ is the initial matric potential of the soil, (mm or inches); $\Delta\theta$ is the difference of soil water content after infiltration with initial water content, K is hydraulic conductivity, (mm/hr or in/hr); F_t is the cumulative infiltration at time t, (mm or inches); $F_{t+\Delta t}$ + is the cumulative infiltration at time t+ Δt , (mm or inches); Δt is the time incremental in hr.

Equation (1) is used for determining ponding situation and (2) is used for calculating the cumulative infiltration after ponding. Trial and error method is the most popular method to solve equation (2) (Chow et al., 1988). Parameters ψ, $\Delta\theta$, K were tabulated by Chow et al. (1988) for all soil classes. Chow et al. (1988) developed a procedure to solve infiltration with changing rainfall intensity by Green-Ampt method in a table. However, since it simplifies the water movement as a piston flow, the wetting front is distorted.

Typical values suggested by Rawls, Brakensiek, and Miller (as reflected in Chow (1988) are shown in the table below:

GREEN-AMPT INFILTRATION PARAMETERS

USDA Soil Classification	Suction Head (Ψ) in/hr	Hydraulic Conductivity (K) in/hr	Porosity (η)	Effective Porosity (θe)
Sand (A)	1.95	4.64	0.437	0.417
Loamy Sand (A)	2.42	1.18	0.437	0.401
Sandy Loam (A)	4.34	0.43	0.453	0.412
Loam (B)	3.5	0.13	0.463	0.434
Silt Loam (B)	6.57	0.26	0.501	0.486
Sandy Clay Loam (C)	8.61	0.06	0.398	0.330
Clay Loam (C)	8.23	0.04	0.646	0.309
Silty Clay Loam (C)	10.76	0.04	0.471	0.432
Sandy Clay (D)	9.42	0.02	0.430	0.321
Silty Clay (D)	11.51	0.02	0.479	0.423
Clay (D)	12.46	0.01	0.475	0.385

Note: The hydrologic soil group is indicated in parentheses.

6.2.2 Interception/Evapotranspiration

Although smaller landscaping plants and bushes can provide some interception/evapotranspiration, substantial runoff reduction will come from retaining existing trees and planting new ones. Trees provide runoff reduction via interception, transpiration, and increased infiltration. Additional environmental benefits include improved air quality, reduced heat island effects, pollutant removal and habitat preservation or formation. The degree of runoff reduction provided by trees depends mainly on the tree type (i.e., evergreen or deciduous), canopy area, and the maturity/size of the tree.

A. Applications and Limitations

Trees are a landscape amenity with runoff reduction benefits that can be applied in most settings. Similarly, retention of existing deep-rooted native prairie vegetation can increase infiltration and provide some interception of rainfall and runoff. Retaining or planting trees anywhere on a development site provides credit towards the 10% (or greater) reduction in runoff.

B. Newly Planted Trees

Site Considerations: An important consideration for planting trees includes establishing appropriate tree setbacks. Mature tree height, size and rooting depth should be considered to ensure that the tree location is appropriate given adjacent, and above- and below-ground infrastructure. Although setbacks will vary by species, some general recommendations are presented below:

- Minimum 5 to 10 foot recommended setback from structures.
- Minimum 5 foot recommended setback from underground utility lines.
- Minimum 10 foot recommended setback from street pavement
- Minimum 4 foot recommended from edge of any other paved surface.

Design Criteria: The following provides requirements and recommendations associated with tree planting for runoff control credit. Submittal for review shall include the following elements on the plan set:

- Tree species
- Tree size
- Tree location (showing setbacks from structures and above and below ground utilities).

Tree Size: To receive runoff reduction credit, new deciduous trees shall be at least 1.5 inches in diameter measured 6 inches above the ground. New evergreen trees shall be at least 4 feet tall.

Tree Location: Trees should be sited according to sun, soil, and moisture requirements. Planting locations should be selected to ensure that sight distances and appropriate setbacks are maintained given mature height, size and rooting depths. To receive a credit, the tree must be planted on the development site. To help ensure tree survival and canopy coverage, the minimum tree spacing for newly planted trees should accommodate the mature tree's canopy spread.

Irrigation: Provisions may need to be made for supplemental irrigation during the first two seasons after installation to help ensure tree survival.

Long-term Tree Retention and Protection: Trees shall be maintained and protected on the site after construction and for the life of the development or until any approved redevelopment occurs in the future. During the life of the development, trees approved for stormwater credit shall not be removed. Trees that are removed or die shall be replaced with like species during the next optimal planting season (typically in fall). This information should be reflected in the Operation and Maintenance program for the stormwater management facilities.

Runoff Reduction Credit: Runoff Reduction credits for newly planted trees are provided in the table below by tree type. These credits can be applied to reduce the effective impervious surface area used in drainage calculations. Credits range from 25 to 50 square feet per tree.

Impervious Surface Reduction Credit for Newly Planted Trees:

Evergreen = 50 square feet/tree
Deciduous = 25 square feet/tree

Effective Impervious Area = Ground Level Impervious Surface Area – Total Tree Credit

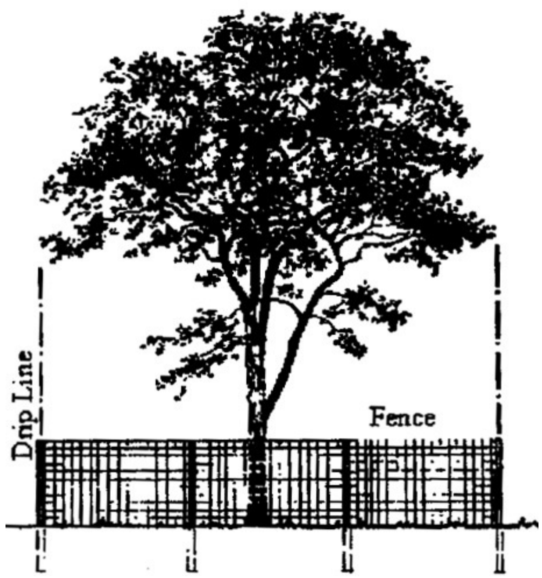
C. Retained Trees

Site Considerations: Setbacks of proposed infrastructure from existing tree should be considered. Tree protection requirements may limit grading and other disturbances in tree vicinity.

Design Criteria: The following provides requirements and recommendations associated with tree retention for runoff reduction credit. Submittal for review should include the existing tree species, size and location on the plan set. Additional considerations include tree health, viability, nuisance potential, and danger of damage during construction.

Tree Size: To receive runoff reduction credit, retained trees shall be at least 4 inches in diameter measured 4.5 feet above the ground. For existing trees smaller than this, but larger than 1.5 inches in diameter measured 6 inches above the ground (or evergreens taller than 4 feet) the newly planted tree credit may be applied as presented in above. The retained tree canopy area shall be measured as the area within the tree drip line. A drip line is the line encircling the base of a tree, which is delineated by a vertical line extending from the outer limit of a tree's branch tips down to the ground. Overlapping canopies can be counted twice.

Tree Protection Measures during Construction: The existing tree roots, trunk and canopy should be protected during construction activities to use the trees for runoff reduction. At a minimum, construction fencing should be placed even with the tree's drip line and maintained throughout construction activities.



Long-term Tree Retention and Protection: Trees should be maintained and protected on the site after construction and for the life of the development as explained for newly planted trees.

Runoff Reduction Credit: Runoff reduction credits for retained trees are provided in the table below by tree type. These credits can be applied to reduce the effective impervious surface area used in drainage calculations. Credits range from 7.5 percent to 15 percent of the existing tree canopy area. The minimum credit for existing trees ranges from 37.5 to 75 square feet. This minimum is based on the credit for a tree with a 500 square foot canopy (i.e., 25-foot spread).

Impervious Surface Reduction Credit for Retained Trees:

Evergreen = 15% of area within dripline (minimum 75 square feet/tree)
Deciduous = 7.5% of area within dripline (minimum 37.5 square feet/tree)

Effective Impervious Area = Ground Level Impervious Surface Area – Total Tree Credit

D. Native Vegetation Preservation: When deep-rooted native prairie vegetation is retained as part of the stormwater management plan, the calculations can utilize one step increase in the hydrologic soil group (ie. use B soil runoff coefficient instead of C or C instead of D).

6.2.3 Capture/Reuse

As many sites look for additional ways to address sustainability, capture and reuse of stormwater – also known as stormwater harvesting – has become an increasingly popular method of runoff reduction. Storage and reuse techniques range from small scale systems such as rain barrels to cisterns (underground or otherwise) that may hold large volumes of water.

The water captured from a roof tends to be relatively clean (depending on atmospheric conditions, roof material and condition) and often can be used to reduce the potable water used for fire suppression, toilet/urinal flushing or custodial uses with minimal treatment (some facilities rely on a simple swimming pool filter and chlorine injector). This does require a parallel water system (gray water lines) as this water should not be combined with the potable water source.

Captured rain water can also be used for landscape irrigation during dry periods. This water would not need to be treated to the same degree as that used for the toilet flushing, but care may need to be taken to remove any solids of a size that could clog the irrigation system. This is especially important if parking lot runoff is used.

Some of these systems can rely on gravity to convey the water while others require some kind of pressurization. This issue should be considered in the design. Cost and frequency of maintenance should also be considered.

The City will allow the designer to assume that the facility will be completely drained between storms. An overflow system should be provided when the capacity of the facility is exceeded.

6.3 Treatment of the Water Quality Volume

In order to reduce nonpoint source pollution from a development, the engineer should review the types of pollutants expected from the various surfaces and work to address the pollutant load in the “first flush”, typically defined as the water quality volume (defined in Chapter 3) less any volume subtracted through runoff reduction. In order to do this, the engineer should look for ways to reduce runoff (system disconection and infiltration, evapotranspiration and/or capture-reuse) to the maximum extent practicable. Then, the remainder of the water quality volume should be treated in BMPs appropriate to the types of pollutants expected. At this time, specific numeric discharge limits and/or pollutant removal rates are not being dictated. However, as state and federal laws change, the City may re-evaluate the need to set pollutant limits.

Various land uses and cover types produce different types of pollutants and impact stormwater volumes and velocities in different, but predictable, ways. This section provides general information related to stormwater quality BMPs in addition to a discussion of how each land use type can be addressed.

6.3.1 Design Guidance for Water Quality BMPs

Design criteria for the sizing of the more common stormwater quality BMPs appear in the Mid-America Regional Council (MARC) Manual of Best Management Practices for Stormwater Quality dated March 2008. BMP design criteria are rapidly developing and regularly being refined. If the Engineer prefers to use another source for design guidance, the source should be cited within the design calculations. Sizing information for proprietary BMPs is usually available from the manufacturer and should also be cited as such.

6.3.2 Protection of Water Quality BMPs from Construction Site Runoff

BMPs that rely on infiltration such as bioretention, rain gardens and infiltration basins or trenches, will clog if exposed to excessive sediment. Most permanent stormwater treatment BMPs will need to be installed only after the construction site has been stabilized. BMPs that rely on settling and filtration could likewise require extensive maintenance to preserve functionality.

6.3.3 Pre-treatment for Water Quality BMPs

Even after site stabilization, BMPs may need adequate pre-treatment to filter coarse pollutants such as sediment and grit to promote long term functionality. Some fine media filter systems such as sand filters and some proprietary products may also need pre-treatment in order to minimize operation and maintenance costs and activity intervals. A coarse stone diaphragm, settling forebay, vegetative swale/buffer or hydrodynamic separator could serve this purpose.

Pre-treatment may also be needed for BMPs that detain/retain runoff to reduce the operation and maintenance requirements. Detention/retention ponds should have a forebay or similar pre-treatment to protect from over-sedimentation that would require expensive dredging or cleaning.

6.3.4 Treatment of Discharge from Buffer Areas and Forests

Natural vegetation provides filtration, infiltration and evapotranspiration of most of the rainfall in these areas and therefore no specific treatment is required for runoff from these areas. Protection of these areas and guidelines for maintenance should be included in the overall post-construction stormwater management operation and maintenance plan. These areas should still be included in the overall runoff calculations for stormwater quantity management.

6.3.5 Treatment of Discharge from Rooftops

The runoff discharged from rooftops is relatively clean. The biggest concerns are the temperature of the runoff, any pollutants picked up from the atmosphere and the overall quantity of the water. This water is sometimes reused as a nonpotable source which is addressed above in Runoff Reduction. When rooftop water is captured and reused, this will serve as both the water quantity and quality BMP. The only additional treatment necessary will be dictated on the type of reuse. For instance, if roof runoff is used for toilet flushing, the water may need additional treatment (filter, chlorination, uv, etc) to be suitable for this purpose. Likewise, if the runoff is used for irrigation, treatment may be needed to prevent clogging of the irrigation system.

If rooftop water is not going to be captured and reused, measures must be taken to address the impacts of the runoff. However, if this water is allowed to discharge across a driving surface, it could pick up significantly more contaminants. Therefore, this should be avoided whenever possible. Additionally, remove direct connection of rooftop water from the storm sewer system whenever feasible.

The following Best Management Practices (BMPs) are pre-approved to address the quantity and quality of water from rooftops although alternatives will be discussed at concept review and/or the pre-application meeting as necessary:

- Green roofs
- Vegetated swales
- Bioretention
- Rain gardens
- Wetlands
- Infiltration basins or trenches (although these may also act as “filtration” systems if soil conditions are unsuitable for infiltration)
- Underground detention
- Proprietary products that address the identified pollutants

6.3.6 Treatment of Discharge from Managed Lawns/Landscaped Areas

The runoff discharged from managed lawn and landscaped areas can contain a variety of pollutants from pesticides, herbicides, fertilizers, and animal sources. Poorly maintained areas that have erosion can also be a source of sediment discharge. Where these areas are near pedestrian or vehicle traffic, litter may be an additional issue. Runoff resulting from the water quality volume that has not been removed through runoff reduction will need to be treated to address these issues. Up to 10% of the managed lawn/landscape area may discharge in a sheet flow condition through existing established vegetation such as may exist in a stream buffer without otherwise being treated. Additionally, non-structural measures should be included in the overall post-construction stormwater management operation and maintenance plan. This may include standard operating procedures for care of these areas related to agrochemical application, mowing height, litter removal, etc.

The following Best Management Practices (BMPs) are pre-approved to address the quality of water from managed lawn and landscape areas although alternatives will be discussed at concept review and/or the pre-application meeting as necessary:

- Stream buffers
- Vegetated swales
- Native soil preservation and restoration
- Filter strips
- Bioretention
- Rain gardens
- Wetlands
- Sand filters
- Infiltration basins or trenches (although these may act as “filtration” systems if soil conditions are unsuitable for infiltration)
- Proprietary products that address the identified pollutants

6.3.7 Treatment of Discharge from Parking Lots/Driveways/Roads

The runoff discharged from parking lots, driveways and roads can contain a wide variety of pollutants including particulates, nitrogen, phosphorus, lead, zinc, iron, copper, cadmium, chromium, nickel, manganese, cyanide, sodium chloride, calcium chloride and sulphates, and phenols. Additionally, litter from these areas is a primary source of floatables in the receiving water bodies. Temperature and overall quantity are also areas of concern. Runoff resulting from the water quality volume that has not been removed through runoff reduction will need to be treated to address these issues. Up to 10%, but not more than 1 acre, of a site’s total driving surfaces may discharge in a sheet flow condition through existing established vegetation such as may exist in a stream buffer without otherwise being treated. However, this quantity should still be considered in the overall stormwater quantity management.

Volumes that exceed the 10%, one acre threshold should apply the appropriate Best Management Practices (BMPs) to address the quality of water from driving surfaces. The following Best Management Practices (BMPs) are pre-approved

although alternatives will be discussed at concept review and/or the pre-application meeting as necessary:
These BMPs may include, but are not limited to:

- Vegetated swales
- Filter strips
- Bioretention
- Rain gardens
- Wetlands
- Pervious pavements
- Sand filters
- Infiltration basins or trenches (although these may act as "filtration" systems if soil conditions are unsuitable for infiltration)
- Proprietary products that address the identified pollutants

6.4 Channel Protection and Flood Control

Stormwater detention facilities are designed specifically to receive and temporarily hold stormwater runoff to provide channel protection and prevent downstream flooding. Detention facilities can delay the discharge of peak flows and reduce velocities to minimize streambank erosion in downstream waterbodies. Retention facilities are established for permanent storage of water; only releasing water during the design storm or through evaporation and groundwater recharge. Stormwater storage BMPs that rely primarily on infiltration and evapotranspiration can more closely mimic the pre-development hydrology of the site.

Extensive consideration should be given to Low Impact Development techniques that allow for dispersed microdetention to better mimic the site's original hydrology. Swales, rain gardens, bioretention and constructed wetlands, infiltration basins/trenches, etc can achieve both water quantity and water quality control goals. Many of these systems may not be sufficient to control peak flood control volumes. Overflow systems and additional storage may be necessary to fully control peak discharges

6.4.1 Rooftop Storage

Detention storage may be met in total or in part by detention on roofs. Details of such designs shall include the depth and volume of storage, details of outlet devices and downdrains, elevations and details of overflow scuppers, and emergency overflow provisions. Consideration shall also be given to wave action on structural loading conditions. Connections of roof drains to sanitary sewers are prohibited. Design loadings and special building and structural details shall be subject to approval by the City.

Additionally, “green” roof technology that utilizes plant material to provide storage, treatment and evapotranspiration of the stormwater can be utilized to achieve quantity control requirements as well as water quality objectives. The green roof industry has a resource portal at www.greenroofs.com.

6.4.2 Parking Lot Storage

Parking lots paved with traditional impervious pavements may be designed to provide temporary detention storage of stormwater on a portion of their surfaces. Generally, such detention areas shall be in the more remote portions of such parking lots. Depths of storage shall be limited to a maximum depth of six inches, and such areas shall be located so that access to and from parking areas is not impaired.

Parking lots paved with pervious pavements or that are designed with innovative turf reinforcement techniques may be designed to provided temporary detention storage of stormwater below their surface in the pore spaces of granular media. The designer should consider the infiltration rate of the soil beneath the media. Soil infiltration, underdrains or a combination of the two should provide discharge of at least 80 percent of the detention storage volume within 24 hours.

6.4.3 Underground Storage

All or a portion of the detention storage may also be provided in underground detention areas, including, but not limited to, oversized storm sewers, vaults, tanks, etc.

Design underground detention facilities with adequate access for maintenance (cleaning and sediment removal). Provide such facilities with positive gravity outlets. Design venting sufficient to prevent accumulation of toxic or explosive gases.

6.4.4 Pond Dam Design General Criteria

A. Dams which are greater than 10 feet in height but do not fall into State or Federal requirement categories shall be designed in accordance with the latest edition of NRCS (SCS) Technical Release No. 60, “Earth Dams and Reservoirs”, as highest hazard rated structures.

B. All lake and pond development must conform to local, state, and federal regulations. Legal definitions and regulations for dams and reservoirs can be found in the Missouri Code of State Regulations, Division 22.

In addition to the computational criteria, the following shall be applicable, depending on the alternative(s) selected:

6.4.5 Retention Facility or Wet Pond

For basins designed with permanent pools:

A. Sediment Forebay
A sediment forebay shall be provided to trap coarse particles.

B. Minimum Depth
The minimum normal depth of water before the introduction of excess stormwater shall be four feet.

C. Depth for Fish
If the pond is to contain fish, follow Missouri Department of Conservation recommendations provided in the "Missouri Pond Handbook", written by Ken Perry (http://mdc4.mdc.mo.gov/Documents/22.pdf).

D. Side Slopes
The side slopes shall conform as closely as possible to regraded or natural land contours, and should not exceed three horizontal to one vertical. Slopes exceeding this limit shall require erosion control and safety measures and a geotechnical analysis.

6.4.6 Detention Facility or Dry Pond

For basins designed to be normally dry:

A. Sediment Forebay
A sediment forebay shall be provided to trap coarse particles in a convenient place for removal. Generally, the forebay should be designed and maintained as follows:

Volume: V = 0.1-0.25 inches of volume per impervious acre in the practice drainage area

Surface area: SA (sq. ft.) = 0.66*WQV for $I<75\%$
SA (sq. ft.) = 0.008*WQV for $I\geq 75\%$

Where WQV = Water Quality Volume and
I = Site Imperviousness

Depth: D = 3 ft to avoid resuspension of particles

Forebays should be provided with an underdrain.

Typical maintenance activities include: removal of debris after major storm events, repair of embankment and side slopes, repair of control structure, removal of accumulated sediment annually or as needed.

B. Interior Drainage

Provisions must be incorporated to facilitate interior drainage to outlet structures. Grades for the interior drainage shall not be less than 1½ percent to prevent stagnant water and perpetually moist conditions that impede proper maintenance. Paved trickle channels are prohibited.

C. Earth Bottoms

Earth bottoms shall be sodded or vegetated with appropriate native, non-invasive vegetation. A turf-type tall fescue blend is an acceptable alternative.

D. Side Slopes

The side slopes of dry ponds should be relatively flat to reduce safety risks and help to lengthen the effective flow path. Exterior slopes shall not be steeper than three horizontal to one vertical and interior slopes shall not be steeper than 2:1. Wet ponds having a permanent pool greater than 4' deep may want to consider the use of a safety bench or provide for another method of emergency escape.

E. Multipurpose Feature

These shall be designed to serve secondary purposes for recreation, open space, or other types of use which will not be adversely affected by occasional or intermittent flooding, if possible.

6.4.7 Computational Methods

A. Time of Concentration and Travel Time

Refer to Chapter 3, Hydrology and Hydraulics for acceptable hydrology methods.

B. Temporary Storage Volume

A preliminary value of the storage requirement may be obtained through methods outlined in Chapter 6 of the US Soil Conservation Service (now NRCS) Technical Release 55 "Urban Hydrology for Small Watersheds (2nd edition, 1986) or other acceptable methods. The storage shall be checked during routing of design hydrographs through the basin and adjusted appropriately.

C. Hydrograph Routing

The storage indication method (Modified Puls) of routing a hydrograph through a detention basin may be utilized. Reference: (Chow, 1964).

D. Release Rate

The maximum release rate from any new development shall be controlled by limiting the storm water release rates for the channel protection volume to the predevelopment peak flow rates for the channel protection volume. Additional flood volume control may be required for sites known to have flooding issues downstream.

6.4.8 Primary Outlet Works

The primary outlet shall be designed to meet the following requirements:

A. The outlet shall be designed to function without requiring attendance or operation of any kind or requiring use of equipment or tools, or any mechanical devices.

B. All discharge from the detention facility when inflow is equal to or less than the channel protection volume peak discharge shall be via the Primary outlet.

C. The design discharge rate via the outlet shall continuously increase with increasing head and shall have hydraulic characteristics similar to weirs, orifices or pipes.

D. Retention basins (Ponds) shall be designed with a non-clogging outlet 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.

E. The City may require openings be protected by trash racks, grates, stone filters, or other approved devices to insure that the outlet works will remain functional.

6.4.9 Emergency Spillways

The emergency spillway may either be combined with the outlet works or be a separate structure or channel meeting the following criteria:

In cases where the impoundment/emergency spillway is not regulated by either State or Federal agencies, the emergency spillway shall be designed to pass the 100 year (1% annual chance) storm with 1 foot of freeboard from the design stage to the top of dam.

6.4.10 Erosion Control

Primary outlet works, emergency spillways, and dams, as well as conveyance system entrances to detention basins, shall be equipped with energy dissipating devices as necessary to limit shear stresses on receiving channels. See Table 5.1 at the end of Chapter 5 for permissable shear stress criteria.

6.4.11 Submittal Requirements

Refer to Chapter 2 for requirements related to the plan, calculation, and other supporting data for review of detention/retention best management practices.

6.5 Operation and Maintenance Plan Requirements

An operation and maintenance plan for all stormwater quantity and quality control facilities must include:

6.5.1 Responsible party designation

The responsible party designation can be related to the ownership of the tract or a designated continuing authority such as a homeowner's association.

6.5.2 Funding source

The operation and maintenance activities outlined in the plan should have estimated costs associated with them amortized over the life expectancy of the BMP. A funding source must be identified (such as homeowner's association dues) and a description on how these funds will be collected.

6.5.3 Outline of important maintenance procedures

Every BMP selected for the site will have its own operation and maintenance procedures. These may vary from very limited activities such as litter removal and regular landscaping maintenance (including tree retention) to more extensive activities such as dam inspection, dredging, outlet structure inspection and repair, etc. The maintenance procedures should be tailored and adjusted to the expected pollutant load.

6.5.4 Inspection forms

These forms should simplify the regular inspections and be customized to the structures being inspected. These should be primarily geared to a non-technical audience such that a property owner could do most inspections. Areas where a professional engineer should be engaged should be noted. The forms should provide for the date of the inspection, the name of the inspector, checklists and/or open comment space for the findings of the inspection.

6.5.5 Maintenance activities log

These forms should indicate what activities have been accomplished in providing maintenance and/or repair of the BMP. The forms should provide for the date of the activity, a description of the activity, who performed the activity (with contact name if not an individual) and any required follow up.

6.5.6 Emergency drainage procedures

Emergency drainage procedures are required for any retention BMP in order that a complete inspection can be performed as necessary. This may include what kind of pumping equipment would be necessary and the acceptable rate of discharge to drain down the facility. Alternatively, the Engineer could specify valved drain works as part of the spillway design.

6.5.7 Basin diagrams (if applicable) showing sediment removal elevation

All detention/retention pond plans indicating a permanent pool should be marked with a sediment removal elevation based on the storage needed to achieve the mitigation of stormwater runoff impacts. Diagram should also indicate the location of the access easement for inspection, maintenance and repair.

6.5.8 Recording statement in format deemed acceptable by the Callaway County Recorder's office.