City of Chicago

Stormwater Management Ordinance Manual

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Department of
Water Management
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City of Chicago
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Use of this Manual

This Manual has been prepared to be used in conjunction with:

- *Chapter 11-18 Stormwater Management of the Municipal Code of Chicago, and*
- *The Department of Water Management Regulations for Sewer Construction and Stormwater Management*

Updates and Revisions

Updates or revisions to the Regulations and Manual may be available. Please check for any available updates by going to: www.cityofchicago.org/water to check the Department of Water Management website and following these links:

(Under Featured Services and Programs) click Sewer Regulations

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Foreword

The City of Chicago (City) is committed to protecting, conserving and managing our water wisely. The City has developed “Chicago’s Water Agenda 2003” (Water Agenda) to encapsulate its goals for water management in the City and to outline its strategies for accomplishing these goals. As the quote below from the Water Agenda shows, one of the City’s main concerns is stormwater management.

”When it rains, some of the stormwater that falls in our neighborhoods soaks into the ground and some flows into the City’s sewer system. With more and more hard surfaces, such as rooftops and roadways, there are fewer and fewer places where rain water can infiltrate the soil, nourish plants and remain part of the natural system. Without green space to absorb it, the sewer system is required to handle more and more water. Stormwater sent to our sewers is no longer available to irrigate our lawns or recharge groundwater. Further, when the sewer system becomes full it discharges into our waterways. The City’s Department of Water Management spends approximately $50 million per year to clean and upgrade 4,400 miles of sewer lines and 340,000 related structures. Additionally, the City acknowledges the importance of the Tunnel and Reservoir Plan, known as Deep Tunnel, in the long-term management of stormwater. However, the City believes that the “built” infrastructure alone will not meet all of our needs for managing wastewater and stormwater. Managing stormwater and protecting the quality of our water resources will require a combination of upgrading our “built” infrastructure and creating a “green” infrastructure. Through this green infrastructure, the City will demonstrate forward thinking ways to reduce the burden on our sewer system and keep stormwater in the environment.” (City of Chicago, 2003).

The Water Agenda details many steps that the City has taken to address stormwater management issues. First, it has begun promoting green building design and best management practices (BMPs). By encouraging applicants to obtain Leadership in Energy and Environmental Design (LEED) certification and incorporate BMPs into design plans, the City hopes to reduce impacts from stormwater runoff. Second, the City has taken steps to prevent polluted stormwater from roadways from discharging directly into Lake Michigan and the Chicago and Calumet Rivers. The reconstruction of Wacker Drive was designed to divert first-flush stormwater from the roadway to sewage treatment facilities. Third, the City has also developed a sewer inlet control system called the “Rainblocker Program” to reduce combined sewer overflows and reduce basement flooding. Wherever appropriate, residents are asked to disconnect their downspouts from the sewer system and allow the downspouts to drain instead onto permeable surfaces such as lawns. The City is also working to comply with National Pollutant Discharge Elimination System (NPDES) Phase II requirements. Primarily, the City has focused on stormwater control areas, such as areas relying on separate storm sewers and riparian areas that allow stormwater to flow directly into water bodies.

Within the context of this broader push for improved stormwater management, the City recently passed its “Chicago Stormwater Management Ordinance” (Ordinance). The Ordinance applies to certain types of new developments and redevelopment and requires specific practices to ensure that stormwater is responsibly managed in accordance with the goals of the Water Agenda. The purpose of this “Stormwater Manual” (Manual) is to help applicants understand and comply with the Ordinance and accompanying Chapter III “Requirements for Stormwater Management” of the “Regulations for Sewer Construction and Stormwater Management” (Regulations).

1.0 General Policies and Procedures

1.1 Introduction

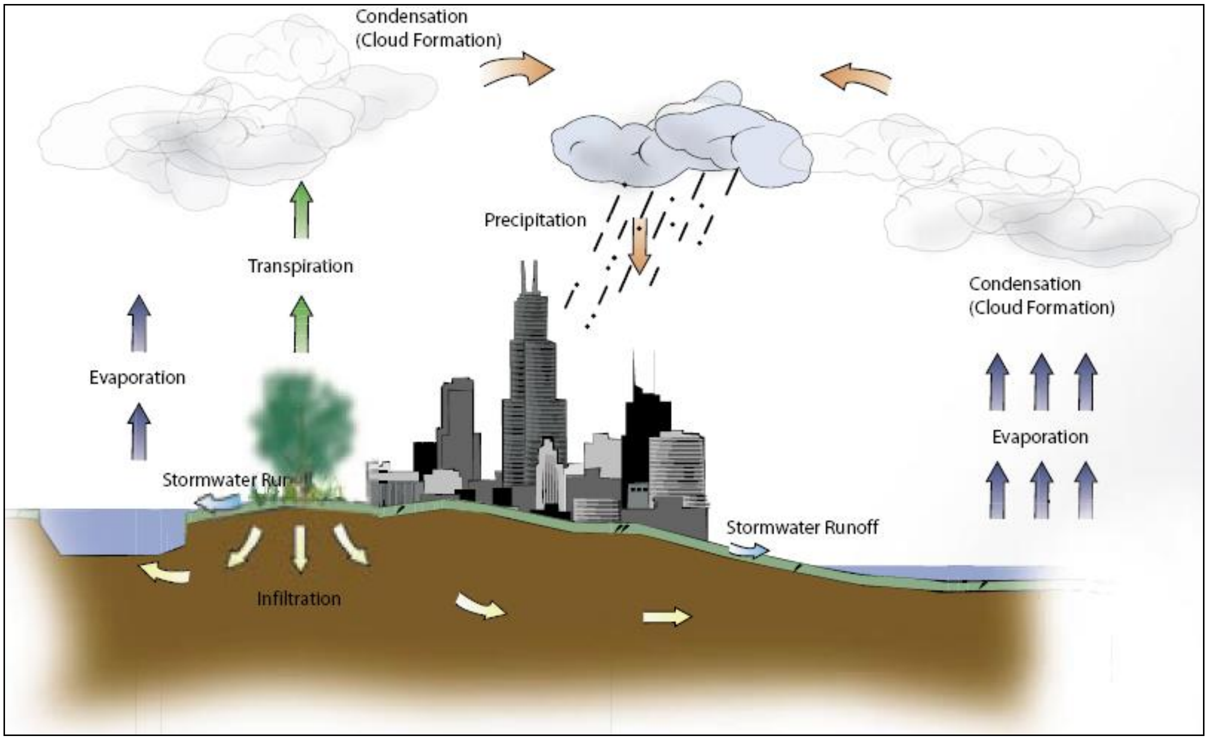
This Stormwater Manual (Manual) was created for developers, engineers and architects preparing development plans in the City of Chicago. The goals of the Manual are to provide the technical tools and guidelines necessary to comply with the Stormwater Ordinance and Chapter III of the Regulations for Sewer Construction and Stormwater Management.

This Manual addresses a set of best management practices (BMPs) to control the stormwater-related impacts of development and redevelopment in the City. Stormwater BMPs should be understood and incorporated into development designs because they efficiently achieve both development and environmental goals in the most cost effective manner.

1.2 The Need for Stormwater Management

The impacts from development occur both during construction and after the development is complete. The conversion of pervious land to impervious surfaces results in increased rate and volume of stormwater runoff, reductions in groundwater recharge and reduction of evapotranspiration. These new impervious surfaces change the hydrologic characteristics of the landscape by reducing infiltration into the soil and the evapotranspiration from vegetation (See Figure 1).

Figure 1. The Hydrologic Cycle



The result of development is a dramatic increase in the rate and volume of precipitation that runs off the landscape as stormwater. New impervious surfaces, compaction of soils, and loss of native vegetation reduces the amount of precipitation that infiltrates into the ground. Without adequate stormwater management controls, this can create additional burden for a sewer system that may already be experiencing flooded conditions and combined sewer overflows. In areas served by combined sewers, flooding or surcharged sewers can lead to basement backups and combined sewer overflows. Uncontrolled, the impacts of development on stormwater runoff can lead to increased flooding, combined sewer overflows, degraded water quality, stream channel erosion, hydrologic modifications, and destruction of sensitive habitats and landscapes. Properly designed and implemented stormwater management facilities can prevent these unacceptable impacts. The Ordinance includes the following provisions to mitigate the impacts of new development.

Rate Control – Provisions for controlling the rate of stormwater discharge ensure that new regulated developments release stormwater at a rate consistent with the capacity of the City's sewer system. This prevents negative impacts such as sewer surcharging, basement backups, street flooding, or combined sewer overflows as a result of new development.

Volume Control – Provisions controlling of the volume of stormwater ensure that new regulated developments capture and retain a portion of the runoff that is generated. This reduces the hydrologic modification effects of new development, recharges groundwater and provides water quality benefits. Volume control can help prevent sewer flooding and combined sewer overflows, as well as reduce the volume of runoff that is sent for wastewater treatment.

Sedimentation and Erosion Control – There is clear evidence from around the country that watershed urbanization has adverse impacts on the ecologic integrity and beneficial uses of downstream water bodies. Some impacts result from the direct modification or destruction of streams, lakes, and wetlands. Other impacts occur due to uncontrolled erosion from construction activities. Erosion during construction can generate enormous quantities of sediment that leads to water quality impairment, clogging of sewers, loss of floodwater conveyance and storage, and safety and nuisance problems. In order to avoid these problems, the Ordinance includes provisions for sedimentation and erosion control.

1.3 Stormwater Management Policy

It is the policy of the City to encourage and promote programs that:

- Minimize the negative stormwater impacts of new development and redevelopment.
- Protect and conserve land and water resources in conjunction with orderly and responsible property development;
- Prevent pollution of local waters, groundwater, and land;
- Minimize stormwater flows into the combined sewer system by minimizing impervious surfaces, promoting infiltration or discharging to local waters where appropriate;
- Preserve the natural characteristics of stream corridors in order to moderate flood and stormwater impacts, improve water quality, reduce soil erosion, protect aquatic and riparian habitat, provide recreational opportunities, provide aesthetic benefits, and enhance community and economic development;

- Preserve the natural hydrologic and hydraulic functions of watercourses, flood plains, and wetlands;
- Facilitate existing and future intergovernmental agreements for stormwater management; and
- Manage stormwater on the site of a Regulated Development to the fullest feasible extent.

To achieve these goals, the primary stormwater management objectives for development sites are to (1) reduce impervious areas, (2) capture stormwater on site, and (3) either use or retain the stormwater on site for evaporation and absorption into the ground. Stormwater that is not used or retained, may be discharged into a City-owned combined sewer, storm sewer, or open waterway.

1.4 Development Review Process

The City desires applicants to plan their developments thoroughly and has set up a review process to allow applicants to design developments that satisfy both the City's and applicant's objectives. For any work outside the public right-of-way, the review process will be handled by the Department of Buildings (DOB) for the Department of Water Management (DWM).

Developments that are subject to the requirements of the Chicago Stormwater Management Ordinance and Regulations must submit design documentation directly to DOB. The function of DOB is to review, collect fees and issue permits for any construction activity, either in private property or in the public way. In some cases (as identified in this Manual), it may be helpful or required to conduct a pre-application meeting. The initial site plans, Stormwater Management Plan (SMP), Stormwater Spreadsheet Tool and all other supporting documentation must be submitted to DOB at the following address.

Department of Buildings
City Hall, Room 906
121 N. LaSalle Street
Chicago, Illinois 60602

The applicant must meet the requirements of all City building and zoning codes and any applicable federal and state permit requirements. In addition to DWM/DOB review and approval, the development may require permits or approvals from other local, state and federal agencies, including, but not limited to, the following:

- City Departments:
  - Department of Planning and Development
  - Department of Transportation
- Chicago Park District
- Metropolitan Water Reclamation District of Greater Chicago
- Illinois International Port District
- Illinois Environmental Protection Agency
- Illinois Department of Natural Resources – Office of Water Resources
- Illinois Department of Transportation
- U.S. Army Corps of Engineers.

The applicant is responsible for obtaining the required approvals and permits from all agencies with jurisdiction over the development.

1.5 Design Responsibilities

This Manual discusses minimum design recommendations and provides information to assist the designer in complying with the Ordinance and Chapter III of the Regulations. When unusual circumstances or complex problems arise, the applicant and applicant's designer (engineer, wetland specialist, surveyor, or landscape architect) are responsible for identifying such conditions and notifying the appropriate review agencies. In such cases, the applicant and applicant's designer shall propose an alternative solution consistent with good planning, engineering practices, and scientific principles, and the designer or applicant shall obtain approval of the change from DWM/DOB before continuing with the design. Use of this Manual or issuance of a permit does not release the designer from design responsibilities.

This Manual is not intended to specify limitations on the creative design process. Designers have flexibility in devising solutions, however, the City must approve the final SMP. The analytical procedures and techniques presented herein are consistent with available data and principles of hydrology as they are currently understood. Procedures selected for use by the City are from commonly used and recognized sources. Manual users are responsible for the integrity and design of the various facilities proposed.

1.6 Applicability of Performance Standards

All regulated developments are subject to the Ordinance and Regulations, however the applicable performance requirements vary depending on various aspects of the development. A Regulated Development (Ordinance 11-18-020) is:

> *Any construction activity, excavation or grading, commencing on or after January 1, 2008, that:*
>
> *(a) disturbs a land area or substantially contiguous land areas of 15,000 or more square feet in the aggregate. Land areas separated by public right-of-way at the conclusion of development shall not be deemed "substantially contiguous" to each other for purposes of this definition. For purposes of calculating square footage pursuant to this paragraph (a), "land area" shall include twenty-five percent of the square footage of the sidewalls of a building that directly connects to the sewer system via side gutters, and shall also include any average dry-weather flow based on a conversion rate of 1.0 cfs (cubic feet per second) into one acre (43,560 square feet), or*
>
> *(b) creates an at-grade impervious surface of 7,500 or more substantially contiguous square feet, or*
>
> *(c) results in any discharges of stormwater into any waters or separate sewer system. For purposes of this definition, square footage shall be calculated based upon the project as a whole, regardless of whether construction proceeds in phases.*
>
> *A Regulated Development shall not include projects located entirely within the public right-of-way at the conclusion of development. With respect to a project located both on the public*

right-of-way and on private property at the conclusion of development, that portion of the project located on the public right-of-way will not be included in calculating the square footage thresholds of subparagraphs (a) and (b) of this definition. If a project includes Residential Development, the Residential Development will not be included in calculating the square footage thresholds of subparagraphs (a) and (b) of this definition.

Flow rate control requirements may apply to regulated developments discharging to combined sewers, separate sewers, and open water bodies. Any at-grade impervious open space where more than 7,500 square feet of substantially contiguous area will be created or reconstructed or disturbs over 15,000 SF of land area, rate control measures are required. Rate control is not required for projects that directly discharge to Lake Michigan, but all other stormwater performance standards apply to these projects. Volume control requirements apply to all regulated developments except for new roofs on a vertical building addition. Table 1-1 provides a summary of the applicable performance requirements

Table 1-1: Performance Standards Applicability

Developments Discharging to Combined Sewers					
		Rate Control	Volume Control		
				Options Available	
Proposed Activity	Regulated under Stormwater Management Ordinance	Required	Required [1]	Storage	Reduce Imperv. by 15%
Residential Development [5]	No	-	-	-	-
Creates or reconstructs at-grade impervious area of less than 7,500 SF	No	-	-	-	-
Creates or reconstructs at-grade impervious area of 7,500 SF or more	✓	✓	✓[3]	✓	✓
Disturbs land areas of 15,000 SF or more	✓	✓	✓[3]	✓	✓
New roof for vertical building addition (plus sidewall and additional DWF) equivalent to 15,000 SF or more	✓	✓[2]	No	-	-

Developments Discharging to Waters					
		Rate Control	Volume Control		
				Options Available	
Proposed Activity	Regulated under Stormwater Management Ordinance	Required	Required [1]	Storage	Reduce Imperv. by 15%
Residential Development [5]	No	-	-	-	-
Creates or reconstructs at-grade impervious area of less than 7,500 SF	✓	No	✓	✓	-
Creates or reconstructs at-grade impervious area of 7,500 SF or more	✓	✓[4]	✓	✓	-
Disturbs land areas of 15,000 SF or more	✓	✓[4]	✓	✓	-
New roof for vertical building addition (plus sidewall and additional DWF) equivalent to 15,000 SF or more	✓	✓[2, 4]	No	-	-

Notes:

1. Additional exceptions (airport surfaces, Industrial NPDES permitees) apply (see Ordinance 11-18-040)
2. Only requires delay or decrease in peak discharge from the roof.
3. Only if site is >15% impervious.
4. If site drains to Lake Michigan, there is no rate control requirement.
5. For the purposes of the Stormwater Ordinance, Residential Development is defined as detached single-family and two-family dwellings.

2.0 Flow Rate Control: Managing Stormwater Leaving the Site

2.1 Introduction and Applicability

As permeable areas in the City are developed, water from precipitation events cannot be absorbed. During severe storm events, water runs off rooftops and streets into the sewer system. If uncontrolled, the high rate at which water enters the system creates basement backups and combined sewer overflow problems. During severe storms, water flows into the sewer system at a rate exceeding the system's capacity and bypassing treatment. This allows raw sewage to discharge directly to water bodies and creates water quality problems. To combat these problems, the City requires new developments to limit the flow rate of stormwater leaving a site. The rate control performance standards are designed to prevent flow from reaching the sewer system at a rate that is faster than the sewer can carry it away. Flow rate control is accomplished by implementing onsite stormwater detention. Detaining water on site or slowing it down as it leaves the site helps to prevent many of the problems discussed above. It also ensures that new developments do not negatively impact the existing sewer system. When older properties without stormwater detention are redeveloped, the performance of the existing system is actually improved.

Applicants will typically use the maximum allowable release rate and the Modified Rational Method to calculate the maximum volume of stormwater that must be contained by detention. For small sites (less than ½ acre), the ability to control the maximum stormwater discharge rate may be limited by the minimum allowable restrictor size. The Modified Rational Method is not appropriate for development sites greater than 20 acres or at sites where complex flood routing schemes are proposed. In these cases, the Applicant should conduct a pre-application meeting with DOB to discuss the appropriate analysis methods. Under such circumstances, DOB may require a hydrograph-producing modeling approach with regional rainfall data to determine stormwater detention and release rate requirements.

2.2 Design Requirements

The Ordinance includes the following requirements related to rate control:

> *Stormwater Drainage Systems shall manage the peak rate of discharge from the Regulated Development, incorporating the maximum permissible release rate. Provided, however, that Developments that create an at-grade impervious surface of less than 7,500 substantially contiguous square feet and that directly discharge to waters shall not be subject to the rate control requirements of this subparagraph (a)(1).*

The Ordinance requires that no more than 400 square feet of impervious surface area be allowed to sheet flow to the public right-of-way without detention. A minimum of 0.1 feet of freeboard from the high-water level within any detention facility to the overflow invert to the right-of-way must be provided. A development must have an overland flow path which safely conveys the 100-year storm event to the public right-of-way. There must be at least 0.1 feet of freeboard between the overland flow route high water level and the low grade to adjacent properties.

An overland flow route could be pavement or grass that can be approximated as a trapezoidal channel. The flow route can be designed to meet the freeboard requirements by using the calculated overflow for the 100-year storm event and Manning's equation shown below.

$$Q = 1.486\, A\, R^{2/3}\, S^{1/2} / n$$

Where,
Q = hydraulic capacity (in cfs)
A = area (channel cross section) (in sf)
R = Hydraulic Radius, A(Area)/P(wetted perimeter)
S = slope of channel (in ft/ft)
n = Manning's Coefficient which generally ranges from 0.03 to 0.05 for grass lined channels

Another option would be to design the overland flow route to act as a broad-crested weir.

The depth of flow for the overland flow route must meet the freeboard requirements in the Regulations. Velocities through the overland flow route should be checked to assure that erosion will not occur. If there is the possibility of erosion during the 100-year storm event, then appropriate erosion protection measures must be included.

2.3 Allowable Release Rate

Table 2-1 presents a summary of information on the allowable release rates and storage requirements for various categories of developments.

Table 2-1 Rate Control for Regulated Developments

Regulated Development Type	Key Rate Control Requirements
Development ≤ 1.75 acres	Allowed to use standard release rates from Standard Maximum Release Rate Chart. (Section 2.3.1)
Development > 1.75 acres	Applicant must compute allowable release rate based on downstream sewer capacity. (Section 2.3.2)
Lot to Lot	Rate control for the 10-year storm must be provided for roof surfaces. Remaining areas (less than 15 percent of site or it is not considered a lot to lot development) must provide storage for a minimum of the 100-year event. (Section 2.3.4)
Buildings with Multi-Level Roofs and/or Side Gutters	When multi-level roofs or side gutters catch runoff from sidewalls, 25 percent of the face of the critical sidewall must be considered as drainage area. This also includes multiple level roofs that collect runoff from the sidewalls above them. (Section 2.3.5)
Significant Dry Weather Flow (DWF)	If average DWF exceeds 10% of the maximum allowable release rate then it is considered significant and the maximum allowable release rate must be reduced accordingly. If necessary, a minimum value of 25 gpm must be used as the release rate to determine the required storage. A pump storm discharge rate of 25 gpm may be required if the total proposed discharge rate from the site exceeds the existing discharge for a 5-year storm event. (Section 2.3.5)
Open Space Discharging to Combined Sewers	When over 75 percent of the site is substantially contiguous at-grade open space and conducive to ponding water, the

	release rate shall not exceed 0.75 cfs/acre. (Section 2.3.6)
Direct Discharge to Waters	Roof areas do not require detention when directly discharged to Waters (as defined in section 11-18-20 of the Ordinance). To the extent possible, the maximum release rate for non-roof areas discharging directly to Waters is 1.0 cfs/acre for the 100-year event. To the extent possible, sites larger than 5 acres must not exceed existing release rates for up to the 10-year event (Section 2.3.7)
Building Rehabilitation	When the project only involves roof replacement exceeding 15,000 SF over new additional stories, provisions must be made to delay or decrease the peak discharge. (Section 2.3.8)
Residential Land Use	In certain cases, required storage may be provided within the right of way. (Section 2.4.4.)

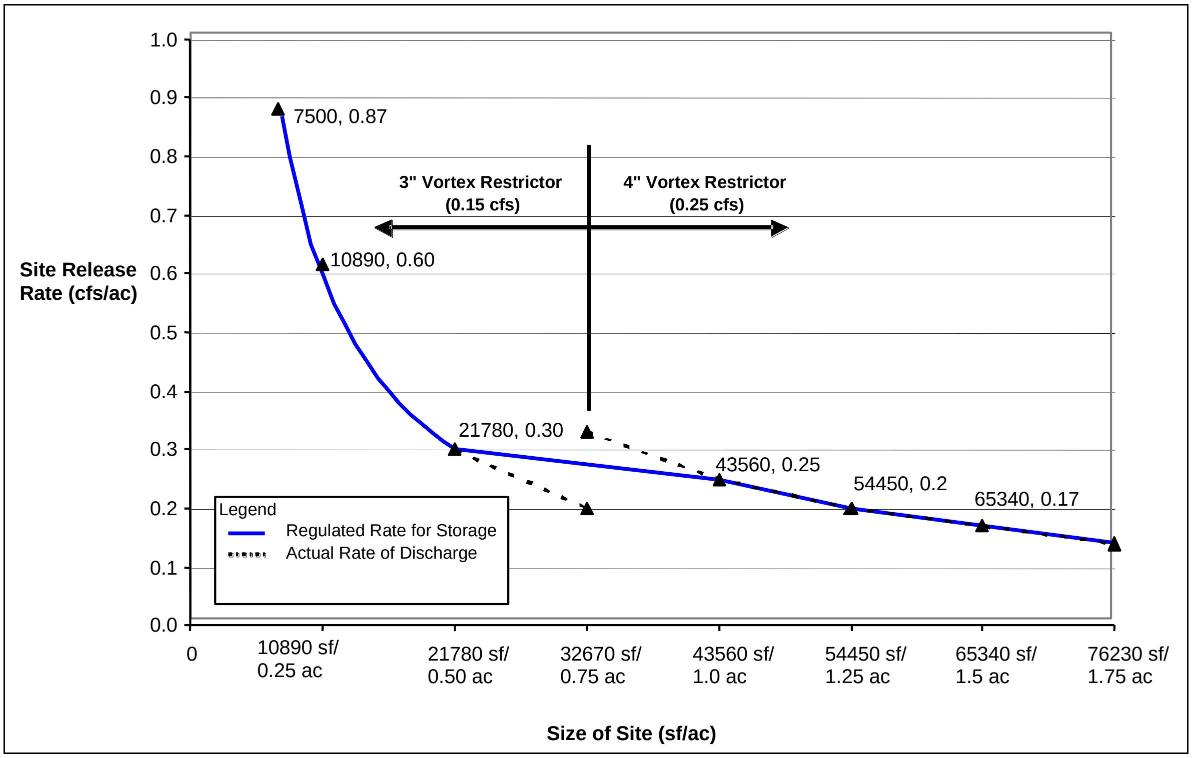
2.3.1 Standard Maximum Release Rate

Small developments (between 7,500 and 76,230 square feet) may use a release rate based on the Standard Maximum Release Rate Chart (Figure 2-1). However, these sites are not precluded from using the methodology presented in 2.3.2 to compute a site specific release rate based on the capacity of the downstream sewer. Other requirements may apply if the development is one of the specialized types listed in Table 2-1 or discussed in Sections 2.3.3 through 2.3.7.

The vortex restrictors referenced below are designed to fit into an 8-inch diameter pipe and limit flow to either 0.15 cfs (3-inch opening) or 0.25 cfs (4-inch opening). City of Chicago Standard 3-inch vortex restrictors are available for purchase from the DWM. For sizes other than 3-inch, custom vortex restrictors must be purchased from approved manufacturers. The standard maximum release rates according to the Regulations are below.

- *For sites between 7,500 square feet and 21,780 square feet (one-half acre), the maximum allowable release rate is 0.15 cfs, the maximum release rate from a standard 3-inch vortex restrictor. The required storage is based on 0.15 cfs subject to Chapter 2, Section 3.5 – Dry Weather Flows.*
- *For sites between 21,780 square feet (one-half acre) and 43,560 square feet (one acre), the maximum regulated release rate is a linear interpolation between 0.15 cfs (equivalent to use of a standard 3-inch restrictor on a one-half-acre site) and 0.25 cfs (equivalent to use of a custom 4-inch restrictor with 0.25 cfs release rate on a one-acre site), respectively. The required storage is based on the linear interpolation of the two release rates, subject to Chapter 2, Section 3.5 – Dry Weather Flows.*
- *For sites between 43,560 square feet up to 76,230 square feet, the maximum allowable release rate is 0.25 cfs, the maximum release rate from a custom 4-inch vortex restrictor. The required storage is based on 0.25 cfs, subject to Chapter 2, Section 3.5 – Dry Weather Flows.*

Figure 2-1 Standard Maximum Release Rate



2.3.2 Computed Maximum Release Rate

In lieu of the standard maximum release rate, any regulated development may compute the maximum allowable release rate based on the lesser of two computations, the “Outlet Sewer Capacity” and the “Critical Local Sewer Capacity.” The lesser of these two sewer capacities (provided in cfs/acre) must be multiplied by the size of the disturbed area that is tributary to the restricted control structure to compute the maximum allowable release rate. Developments that exceed 76,230 SF are required to compute the maximum allowable release rate in this manner. The outlet sewer capacity is the 5-year capacity of a sewer line based on the ratio of its estimated capacity to its corresponding tributary area. The critical local sewer capacity is the ratio of the most restrictive sewer segment’s 5-year full flow capacity divided by the respective drainage area adjusted for land use. The following sections describe each computation.

2.3.2.1 Outlet Sewer Capacity

Appendix III-A of the Regulations contains the outlet sewer capacity map and tables based on the latest available information. The outlet sewer that serves the proposed development is located on the appropriate map and table in the Regulations. The capacity of that outlet sewer is provided on the table in cfs/acre. This capacity in cfs/acre multiplied by the development size in acres yields the maximum release rate in cfs based on the outlet sewer capacity. This value should be recorded for comparison with the critical local sewer capacity to determine which is more restrictive.

2.3.2.2 Critical Local Sewer Capacity

The local sewer capacity calculations are only limited to those developments that are connecting to local sewer segments 3.5 feet or smaller. If a development connects directly to a sewer larger than 3.5 feet, then only the outlet sewer capacity is needed to determine the maximum release rate.

For the critical local sewer capacity calculations, the drainage area upstream of the development must be delineated and assigned land uses. The procedure for delineating the drainage area and assigning a land use is detailed in Section 3.4.2 of the Regulations. The drainage areas must be based on Sewer Atlas Maps and Drain Atlas Maps which can be obtained from the City through DOB. Land uses are determined by multiplying the appropriate weighting factor to the land use drainage area as detailed in Chapter III, Part 3.4.2 of the Regulations. It should be noted that the development's land use and drainage area must be included in the overall drainage area calculation for the main sewer line at the development's connection point.

The local sewer capacity in cfs/acre is defined in Section 3.4.3 of the Regulations and must be calculated for each consecutive downstream main sewer segment from the first sewer segment of the development to the last sewer segment equal to 3.5 feet in diameter (or first segment larger than 3.5 feet if there is no 3.5-foot diameter sewer) or the downstream end of a sewer line. This is completed by first computing the hydraulic capacity of the local sewer segment by utilizing Manning's equation or if necessary, a pressure flow equation which are both shown below

Q is solved for using: $Q = KS^{1/2}A$

Q = hydraulic capacity (in cfs)
K = flow conveyance
S = slope between manholes (in ft/ft)
A = area (pipe cross section) (in sf)

The flow conveyance (K) is calculated by using the following formula:

$K = 1.486R^{2/3}/n$

R = Hydraulic Radius, A(Area)/P(wetted perimeter)
n = Manning's Coefficient and is dependent on pipe material.
- If pipe diameter is 21 in or less (material is VCP) then n = 0.011
- If pipe diameter is 24 in. and larger (Dimensions on Sewer Altas Map in inches are concrete) and material is concrete then n = 0.013
- If pipe diameter is 24 in. and larger (Dimensions on Sewer Atlas Map in feet are brick) and material is brick then n = 0.015

A sewer segment comprises of a sewer line of the same size and material. The slope (S) is calculated for a sewer segment by selecting the upstream and downstream invert elevations within two end manholes. If any needed invert elevations on the Sewer Atlas are absent, the invert elevation in question should be interpolated from those available. There may be other manholes between the two selected manholes. If this is true, then flattest slope between the two selected manholes within the segment should be used. The manhole inverts and pipe lengths are used to solve for S as shown below:

S = (Invert Upstream Manhole– Invert Downstream Manhole)/Length

The area (A) depends on the pipe diameter. The hydraulic capacity, Q (in cfs), calculation is performed on pipes of the same material and diameter. Generally, it can be assumed that the pipe(s) between the upstream and downstream manholes are of the same diameter and material. If there are no survey or invert elevations on the Sewer Atlas Maps to utilize Manning's Equation, then it may be assumed that the sewer flows at a velocity of 3.0 feet/second.

If a sewer segment has a zero or negative slope, then a pressure flow equation may be used to determine Q. This method may also be considered if the existing sewer in question has more than 11.0 feet of ground cover. The pressure flow equation will not be accepted in any other cases. The following assumptions can be made in the pressure flow analysis:

1. Basement drain level is the ordinance grade less 5 or 6 feet (in upstream areas)
2. The sewer outfall is full plus 1 to 2 foot of surcharge
3. Sewer segment of main may be used to set L (in feet)

The following formula is solved for the velocity (V) in feet/second:

$$\Delta H = [1 + K_c + (29\, n^2\, L)/R^{1.33}][V^2/2g]\text{, in feet}$$

The parameters are as follows:

L = Total Pipe Length
R = Hydraulic Radius
K_c = 0.5
n=Manning's coefficient
2g = 64.4 ft/sec^2
ΔH = Upstream Head – Downstream Head
Upstream Head = Upstream Ordinance Grade – Basement Drain Level
Downstream Head = Downstream Pipe Invert + Pipe Diameter + Surcharge

After V is calculated, the following formula is used to solve for flow:

$$Q = VA\text{, (in cfs)}$$

where A is the cross sectional area of the sewer segment (in sf).

In order to complete the local sewer capacity analysis, the total weighted drainage areas to each local sewer segment must be calculated. The total drainage area will increase in value with each additional sewer segment downstream of the development. The local capacity of a sewer line (in cfs/acre) is obtained by the ratio of the sewer segment's capacity (Q) divided by the respective drainage area adjusted for land use (in acres). The critical local sewer capacity, as defined in Section 3.4.4 of the Regulations, is the sewer segment with the lowest cfs/acre from the development to the last sewer segment equal to 3.5 feet in diameter (if available) or the downstream end of the sewer line. Typically, the critical local sewer capacity can be found at the downstream end of a sewer line, but each upstream sewer segment to the point of the development's connection should be examined to determine the critical section. An example of the maximum release rate computations for critical local sewers is presented in Appendix D.

2.3.3 Special Requirements

The following special requirements must be considered for the determination of the maximum release rate.

<u>2.3.3.1 Flow Diversions</u>

Requirements for any proposed flow diversions are provided in Chapter II, Part 3.6 of the Regulations. A flow diversion occurs when an existing connection to a main sewer line is relocated to another main sewer line that is not within the same drainage area of the original main line, or if a new source of water is introduced into the line. If the existing connections to a site are unknown, it will be assumed that an existing connection was made to the street where the majority of the site's frontage is situated. A flow diversion is created whenever flow is redirected from existing conditions. . In general, flow diversions should be avoided whenever possible. A site that has been vacant and without any structure for over 10 years will be considered a flow diversion upon development. However, in some cases, a flow diversion may be beneficial by increasing the capacity of a sewer line with poor capacity (less than 0.3 cfs/acre), while reducing it slightly in another with excess capacity (over 1.0 cfs/acre). When proposing a flow diversion, the critical local sewer capacity (discussed in 2.3.2.2 must be determined for both the original sewer line and the proposed diversion line. The requirements for flow diversions are waived for sites less than 0.5 acres or if the connection to a larger sewer is mandated.

2.3.3.2 Multiple Sewer Connections

Requirements for connections to the sewer system are provided in Chapter II, Part 3.4.2 and Chapter III, Part 3.5.1 of the Regulations. The number of connection(s) required is generally a function of the size of the site. The number of new connections to the City's main sewer shall be limited whenever possible to avoid the extra time and cost of construction within the street. Except for developments that are less than 0.5 acres or which adopt the standard maximum release rate, all multiple connections require an alternative analysis.

To determine the optimum split in flow, an alternative analysis must be performed. The alternatives analysis must demonstrate that the selected alternative will maximize use of the sewer system, thereby optimizing the hydraulic benefit to the surrounding neighborhood. At least two alternatives must be examined. At no time can the proposed release rates exceed the existing release rate at the site. For developments that do not meet these criteria or that are over 5.0 acres, the DWM/DOB may require an additional alternative of upgrading sewers within the right-of-way.

Separate rate control worksheets should be completed for each connection to the sewer system.

2.3.3.3 Dry Weather Flows

The maximum allowable release rate for stormwater may need to be reduced to compensate for undetained dry weather flow (DWF). When the average DWF (without peaking factor) exceeds 10 percent of the maximum allowable release rate, then peak discharge rate from the site must be reduced accordingly to offset 90 percent of the DWF, or to a minimum value of 25 gpm, whichever is greater. A pump station discharge of 25 gpm will be required if the total proposed discharge from the site exceeds the existing discharge.

The average DWF (without peaking factor) can be computed by the anticipated per capita load and land use of the development. The following table can be used as a guide for this purpose.

Land Use	Average Gallons per Capita-Day (gpcd)
Hospitals (per bed)	250
Hotels (2.0 per room w/ laundry)	150
Single Family (3.5 persons)	100
Muti-Family	80
Condominium	75
Hotel (2.0 per room w/o laundry)	60
Boarding Homes	50
Factories (excluding process water)	35
Convention Center/Airports	5

Reference: Estimated Numbers Based on IEPA Title 35, Subtitle C, Part 370-170, Appendix B

DWF is also converted to equivalent site area for determining whether or not a development is a regulated development. The conversion is 1.0 cfs of DWF equates to 1.0 acre of disturbed site area (See 2.3.5).

When the dry weather flows are routed to the combined sewer using a combined connection with the stormwater management system, the designer must ensure that surcharging of the connection will not cause interior flooding. For this computation, both the peak DWF and peak stormwater flow should be used.

The DWF (with peaking factor) should be based on the number of fixture units (FTU), reference the Municipal Building Code, Table 18.29-1108.1. The conversion from the number of fixture units to drainage area (sf) to peak DWF (cfs) is as follows:

Drainage area = [(FTU – 150) * 7.2] + 4850 sf

Peak DWF = Drainage Area / 43,560 sf/acre * 1.0 cfs/acre

Average DWF = Peak DWF / 3

2.3.3.4 Unrestricted Areas

The maximum allowable release rate must be adjusted to account for any unrestricted areas of the site beyond the allowed 400 sf impervious area and 1,500 sf pervious area. The discharge penalty will be calculated as follows. The unrestricted area minus the 400 sf or 1500 sf allowable area must be used to generate a 100-year discharge (Q) using the Rational Method, Q = CIA, with an intensity corresponding to the appropriate time of concentration. This discharge must be subtracted from the maximum allowable release rate for the site.

2.3.4 Lot-to-Lot Buildings

Lot-to-lot developments present special challenges due to the need for detention storage for the roof surface. Any development where structures or buildings (defined as building footprint at ground surface or foundation wall footprint whichever is greater) occupy more than 85 percent of the site area may be considered a lot to lot development. In these cases, storage for a minimum 10-year event must be provided for the building area. Remaining areas on the site that are not part of the structure must still provide detention storage for the 100-year event. In these cases, two rate control worksheets will be needed, one for the building area and a second for the remainder of the site, with the allowable release rate divided proportionally between the building and site areas. The entire site must be designed to safely accommodate peak flows for the 100-year event. Peak flows are computed using the rational method. Hydraulic capacity calculations should be shown for all stormwater management features responsible for conveying the 100-year peak flow from the building. Storage vaults under buildings with less than 100-year capacity must provide documentation that pipes and foundations can withstand hydrostatic surcharge pressure in the event of a 100-year storm.

2.3.5 Buildings with Tributary Sidewalls or Significant DWF

Several factors may increase the effective size of the development for purposes of regulation. Buildings with multi-level roofs and/or side gutters discharging to the sewer must include 25 percent of the critical face of the sidewall from which flow is being captured as part of the drainage area. Multi-level roofs collect runoff from the sidewalls above them.

Dry weather flow (DWF) (without peaking factor) must also be included as an equivalent area based on a conversion rate of 1.0 cfs to one acre. Once these additional areas are accounted for, the regulatory status of the site may be determined.

2.3.6 Open Space Discharging to Combined Sewers

Sites with more than 75% of substantially contiguous at-grade open space that is conducive to surface ponding shall not have a maximum release rate of greater than 0.75 cfs/acre, unless the minimum practical release rate of 0.15 cfs is reached. If such a site discharges to Waters, then the maximum release rate of 1.0 cfs/acre may be used.

2.3.7 Direct Discharge into Waters

In order to maximize the available capacity of the City's sewers, sites adjacent to Waters must discharge directly to those Waters.

> *For Developments that discharge stormwater directly to Waters, the maximum release rate shall be 1.0 cfs/acre for at-grade open space. There is no release rate requirement for roof areas (without vehicular parking or waste storage) of any onsite buildings, provided the roof areas bypass the Development's stormwater detention system.*
>
> *Any development over 5 acres with existing discharge to a waterway shall not exceed the existing discharge rates, to the extent possible, for all storm events up to a 10-year, including any new roof areas. All overflow pathways from the stormwater management system must be directed towards the waterway.*

When both the open areas and direct discharge to waters conditions apply, the allowable release rate for direct discharge to waterways takes precedent over the open areas release rate requirement.

2.3.8 Building Rehabilitation

Building rehabilitations become a regulated development when any new roof areas (proposed over additional stories) and/or additional DWFs (converted to equivalent area) exceed 15,000 square feet. When this occurs, the peak discharge to the sewer system must be delayed or decreased. This may be accomplished by disconnecting existing downspouts, installing controlled roof drains or green roof systems. If the project does not involve any at-grade improvements, then no other rate control, volume control or erosion and sediment control performance requirements apply. An Operation and Maintenance plan should still be prepared if the proposed improvements warrant it.

2.4 Detention Design Requirements and Calculation Methods

The Ordinance and Regulations require stormwater detention in new regulated developments to limit peak flow rates. Maximum allowable stormwater release rates are determined as discussed in Section 2.3 of this Manual. Once a release rate has been determined, the required detention storage may be computed.

The **Stormwater Spreadsheet Tool** (available electronically) includes a number of spreadsheets that have been prepared to assist the applicant in preparing a SMP submittal. This tool was designed for simple and straightforward sites. Complex site designs may require calculations to be presented in a custom format to facilitate reviews. Included with the **Stormwater Spreadsheet Tool,** is the Release Rate spreadsheet (Figure 2-2), Orifice Sizing spreadsheet (Figure 2-3) and the Rate Control Spreadsheet (Figure 2-4) that is based on the Modified Rational Method and uses the City's rainfall intensity values, the land use information for the site, and the maximum allowable release rate to determine the required storage. Once this information is entered into the spreadsheet (either manually, or by answering a series of questions about the site) the critical storm is determined as the storm duration with the highest storage volume on the spreadsheet (critical storm). Applicants will have to run the calculation to reflect the active drainage area to each outfall or connection to the City sewer system.

The Modified Rational Method determines the maximum storage volume required to detain water from a storm of any duration or intensity up to the 100-year storm event. The calculation of flow detention volume is based on the assumption that the storm has a small time of concentration (Tc) for a project site, which essentially implies that peak runoff is generated almost instantaneously and is maintained as a constant throughout the duration of the storm. This assumption is justified for most development sites less than 20 acres in size in the City. In most cases, the Modified Rational Method in conjunction with the Chicago rainfall intensity curve (see Appendix B) yields lower storage requirements than hydrograph methods; therefore, for the purposes of calculating detention volume, the City will ignore the effect that BMPs have on slowing the Tc on the peak flow rate calculated using the Modified Rational Method. However, the City encourages the use of BMPs to reduce impervious areas and the resulting lower runoff coefficients (C-values) or credit received for BMP storage reduce the required detention volume.

DWM/DOB may require that the applicant use alternative methods for calculating the required detention volume such as hydrograph methods with regional rainfall data for larger or more complex sites. Appendix B discusses the Modified Rational Method and other hydrologic analysis methods for determining required detention volumes. Offsite flow can be bypassed around the site’s stormwater drainage system provided it can be done safely via a driveway and effectively with adequate drainage capacity in the right-of-way. If any offsite flows are routed through the detention system, it must not overflow to the public right-of-way for storms up to and including the 25-year event. This may require additional onsite storage to accommodate the bypass flow. The standard **Stormwater Spreadsheet Tool** is not equipped to handle bypass flow computations. Supplemental and detailed computations must be submitted to the document the stormwater management system’s design.

The City has grouped land types together into different categories according to their perviousness, or ability to absorb and retain water and has assigned C-values to each land type, as shown in the Spreadsheet. All applicants performing rate control calculations for submittal to the City must determine how much area of the proposed development site falls into each land category. Each land type is described below. No other land types will be accepted in calculations submitted to the City. The applicant should use best professional judgment in assigning land types within a drainage area to one of these categories.

- Lawns, Sandy–Land consisting of lawns with known sandy areas underneath, slopes vary
- Lawns, Heavy – Land consisting of lawns with heavy clay soils, slopes vary
- Woodlandss – Land that has trees whose canopy completely covers the ground
- Native Vegetation – Areas with prepared soils and planted with native deep-rooted vegetation
- Dry bottom detention basins– dry bottom detention basins up to the high water level
- Wetland – Land that is wet with standing vegetation except open water areas

- Gravel – Primarily gravel-covered land (such as a gravel parking lot)
- Pavement
- Roofs
- Wet bottom detention basins or ponds – wet bottom detention basins up to the high water level (HWL) or area of ponds
- BMPs– Best Management practices are specifically computed based on the design of the BMP and how the designer wishes to treat them for computational purposed. The **Stormwater Permit Application Worksheet** helps the designer complete this process.

Figure 2-2 Release Rate Spreadsheet

City of Chicago
Department of Water Management

Name of Project: ____________________
Address: ____________________
A/E of Record: ____________________

0.0 Release Rate

Step 1: Sewer Capacity of Each Sewer Segment

Sewer Segment:	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
Street Name:						
Upstream End (street name):						
Downstream End (street name):						
Upstream Invert (ft):						
Downstream Invert (ft):						
Pipe Segment Length (ft):						
Pipe Slope (S):						
Pipe Characteristics:						
Pipe Size (in):						
Pipe Area (sq ft):	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wetted Perimeter (ft):	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hydraulic Radius (ft):						
Roughness Coefficient (n):						
Flow Conveyance (K):						
Manning's Equation:						
Velocity (fps):						
Hydraulic Capacity (cfs):						

Roughness Coefficient (n):
VCP: use 0.011, typical for pipe <= 21 in
RCP: use 0.013, for pipe >=24 in when pipe size shown on atlas in inches
brick sewer: use 0.015, for pipe >=24 in when pipe size shown on atlas in feet

Step 2: Tributary Area to Each Sewer Segment

	Segment 1			Segment 2		
Total Tributary Area (ac):		**Adj. Factor**	**Adjusted Area**		**Adj. Factor**	**Adjusted Area**
Residential Area (ac):	0.00	1.0	0.00	0.00	1.0	0.00
Commercial Area (ac):		1.3	0.00		1.3	0.00
Industrial Area (ac):		1.5	0.00		1.5	0.00
		Total Adjusted Area:	**0.00**		**Total Adjusted Area:**	**0.00**
	Segment 3			**Segment 4**		
Total Tributary Area (ac):		**Adj. Factor**	**Adjusted Area**		**Adj. Factor**	**Adjusted Area**
Residential Area (ac):	0.00	1.0	0.00	0.00	1.0	0.00
Commercial Area (ac):		1.3	0.00		1.3	0.00
Industrial Area (ac):		1.5	0.00		1.5	0.00
		Total Adjusted Area:	**0.00**		**Total Adjusted Area:**	**0.00**
	Segment 5			**Segment 6**		
Total Tributary Area (ac):		**Adj. Factor**	**Adjusted Area**		**Adj. Factor**	**Adjusted Area**
Residential Area (ac):	0.00	1.0	0.00	0.00	1.0	0.00
Commercial Area (ac):		1.3	0.00		1.3	0.00
Industrial Area (ac):		1.5	0.00		1.5	0.00
		Total Adjusted Area:	**0.00**		**Total Adjusted Area:**	**0.00**

Note: Total tributary areas entered for segments 1 through 6 must include the cumulative tributary area for each segment. All upstream tributary areas must be included.

Step 3: Determine Release Rates of Each Segment

	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 6
Release Rate (cfs/ac):						

Critical Local Sewer Capacity (cfs/ac): **0.00**

Step 4: Compare Outlet Sewer Capacity and Determine Release Rate

Name of Outlet Drainage Basin (as shown on the map):
Outlet Sewer Capacity (cfs/ac):

Maximum Allowable Release Rate (cfs/ac): **0.00**

Figure 2-3 Restrictor Sizing Spreadsheet

City of Chicago
Department of Water Management

Name of Project: ______________________
Address: ______________________
A/E of Record: ______________________

1.3 Restrictor Sizing

		Type Yes or No	Notes
Question 1:	Does the design include Oversized Detention with an associated reduction in the allowable release rate?		
Question 2:	Does the design exceed the Stormwater Ordinance requirements by achieving strategy 3.1 or 3.2 of the Sustainable Development Policy with an associated reduction in the allowable release rate?		

This worksheet takes the allowable release rate from Tab 1.0 (typically) or Tab 2.1.9 (for Oversized Detention) of Tab 3.1 (for Exceeding the Stormwater Ordinance to meet the Sustainable Development Policy), and sizes an orifice to provide this peak discharge rate. Discharge through infiltration is not included when sizing the restrictor.

Summary of Release Rates:

Release Rate from Tab 1.0 Rate Control	Q	0.000	cfs
Release Rate from Tab 2.1.9 Oversized Detention	Q		cfs
Release Rate from Tab 3.1 Exceed Rate Control	Q		cfs
Controlling (Smallest) Release Rate	Q	0.000	cfs

Restrictor Head Calculation (for both Orifice Plate and Vortex Restrictors):

100-Year High Water Level	HWL	20.00	feet
Upper Invert of Half-Trap		16.00	feet
Calculated Head	h	4.00	feet

Orifice Plate Sizing Calculation:

This calculation is used to size the appropriate diameter orifice in a steel plate. See Sewer Detail A-19.

General Formula: $Q = C_d A(2gh)^{0.5}$

Where: C_d = 0.61 for sharp-edged plate bolted to a catch basin
C_d = 0.82 for pipes less than 2 feet long grouted into sewer

Orifice Description:		Orifice Plate	
Discharge	Q	0.000	cfs
Discharge coefficient	C_d	0.61	unitless
Calculated Head	h	4.00	feet

Orifice Diameter	d		inches

Specify a Vortex Restrictor:

Calculated Head	h	4.00	feet
Release Rate for Vortex Restrictor	Q		cfs

Figure 2-4 Rate Control Spreadsheet

City of Chicago
Department of Water Management

Name of Project: ______________________
Address: ______________________
A/E of Record: ______________________

1.0 Rate Control (Sheet 1 of 2)

Step 1: **Runoff Calculation**

		Proposed Area (sq ft)	C-Value 100-Year	Storage Volume (cu ft)
Pervious Land	Lawns - Sandy soil, flat, 0% to 2%		0.18	
	Lawns - Sandy soil, avg, 2% to 7%		0.27	
	Lawns - Sandy soil, steep, >7%		0.36	
	Lawns - Heavy soil, flat, 0% to 2%		0.30	
	Lawns - Heavy soil, avg, 2% to 7%		0.42	
	Lawns - Heavy soil, steep, >7%		0.47	
	Woodlands, flat, 2%		0.39	
	Native Vegetation with prepared soils		0.10	
	Dry bottom basins to HWL		0.75	
	Wetland		0.80	
	Green Roof		0.50	
Impervious Land	Gravel		0.70	
	Pavement		0.95	
	Roofs (conventional)		0.95	
	Critical building sidewall (enter 25% of the face of the largest sidewall draining to lower level roofs or side gutters)		0.95	
	Wet bottom basins to HWL		1.00	
BMP areas	BMPs providing storage that WILL COUNT toward detention storage (from Worksheet 1.2)	0	1.00	
	BMPs providing volume control storage that WILL NOT BE COUNTED toward detention (from Worksheet 1.2)	0	Storage Provided will be used to factor the adjusted C-value in Cell D38	0

Summary	Total pervious area	0	sq ft		
	Total impervious area	0	sq ft		
	Total BMP area	0	sq ft		
	Total project area including sidewall	0	sq ft	0.00	acres
	Total project area excluding sidewall	0	sq ft	0.00	acres
	Weighted C- value (non BMP areas)	0.00	unitless		
	Adjusted C-value (including BMPs)	0.00	unitless		
	Notes:	*Make note of any adjustments made for purposes of detention calcs here (such as removal of roof area that will discharge directly to Waters)*			

Step 2: **Allowable Release Rate Assessment**

		Type Yes or No for all that apply	Notes
Question 1:	Does the site drain directly to Waters?		
Question 2:	Does the site only include residential land use?		
Question 3:	Is the Regulated Development a Lot-to-Lot Buillding (85% or more of site footprint is occupied by buildings)?		
Question 4:	Do you plan to use the standard maximum release rate (only available to sites less than 1.75 acres)?		
Question 5:	Is the site more than 75 percent of substantially contiguous at-grade open space that is conducive to ponding of surface waters (Answer "No" if site discharges to waterway or is a service station)?		
Question 6:	Does the development involve flow diversions (existing sewer connection to be relocated to a different main) or multiple sewer connections (only available to sites over 1.75 acres)?		
Question 7:	Are there widespread contaminated soils on the site, high ground water table, or is this development classified as a lot-to-lot building?		

City of Chicago
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1.0 RATE CONTROL
Page 1

Figure 2-4 Rate Control Spreadsheet (cont.)

City of Chicago
Department of Water Mangement

Name of Project: ____________________
Address: ____________________
A/E of Record: ____________________

1.0 Rate Control (Sheet 2 of 2)

Step 3: **Achieving Rate Control Measures**

Unadjusted Detention Release Rate	0.000	cfs	Waiting for Answer to Question 1 and 4	0.000
Average Dry Weather Flow Rate (From Tab 1.1)	0.000	cfs	Waiting for Dry Weather Flow worksheet to be completed	
Infiltration Facility Release Rate	0.000	cfs	No BMPs with infiltration beds entered on BMP Summary Worksheet or soil's infiltration rate is less than 0.5 in/hr	
Release rate for detention storage computations	**0.000**	cfs		
Required Storage Volume	0	cu ft		

Detention Storage Calculations
(Based on Bulletin 75 Rainfall Data)

STORM EVENT (5,10,25,50 or 100) = **100**

Allowable release rate **0.000** cfs

Storm Duration (minutes)	Runoff Coefficient C	Rainfall Intensity (in/hr)	Drainage Area A (acres)	Inflow Rate Q=CIA (cfs)	Total Storm Vol (cu ft)	Release Rate Qo (cfs)	Storage Rate Qi-Qo (cfs)	Storage Volume Rate (Qi-Qo)*t*60 (cu ft)
5	0.00	12.360	0.00	0.00	0	0.000	0.00	0
10	0.00	10.800	0.00	0.00	0	0.000	0.00	0
15	0.00	9.280	0.00	0.00	0	0.000	0.00	0
30	0.00	6.340	0.00	0.00	0	0.000	0.00	0
60	0.00	4.030	0.00	0.00	0	0.000	0.00	0
120	0.00	2.485	0.00	0.00	0	0.000	0.00	0
180	0.00	1.830	0.00	0.00	0	0.000	0.00	0
360	0.00	1.072	0.00	0.00	0	0.000	0.00	0
720	0.00	0.622	0.00	0.00	0	0.000	0.00	0
1080	0.00	0.448	0.00	0.00	0	0.000	0.00	0
1440	0.00	0.357	0.00	0.00	0	0.000	0.00	0
2880	0.00	0.193	0.00	0.00	0	0.000	0.00	0
4320	0.00	0.137	0.00	0.00	0	0.000	0.00	0
7200	0.00	0.089	0.00	0.00	0	0.000	0.00	0
14400	0.00	0.053	0.00	0.00	0	0.000	0.00	0
							Required Detention Volume (cu ft)	0

Note: 1) the calculation assumes that the rising and recessing limb of inflow and outflow hydrograph are vertical

City of Chicago
Dept. of Water Management

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1.0 RATE CONTROL
Page 2

2.4.1 Restrictors

Restrictors or flow restricting outlets limit the outflow rate from detention facilities to allowable release rates. For all practical purposes, any outlet from a detention basin is "flow restricting" or else detention could not be provided. Key considerations in the design of the detention outlet are clog protection and hydraulic control. Clog protection can be achieved by using submerged orifices in catch basins or other permanent pools. Where applicable, one of the City's standard vortex restrictors should be used to control the discharge rate. The minimum allowable plate orifice size is 2.5 inches in diameter. For more restrictive flow rates, the City's standard 3-inch (0.15 cubic-foot-per- second [cfs]) or custom 4-inch (0.25-cfs) vortex restrictors can be used. These restrictors require an 8-inch diameter receiving pipe for proper installation in a catch basin.

The design plans should show the location of all restrictors used on the sites and a detail should be provided for each flow restricting device. All restrictors must be installed in catch basins or manholes with at least a 2-foot sump. Restrictor calculations should show that the maximum allowable release rate is not exceeded at the design stage of the detention facility. Maintenance access must be provided for all flow-restricting outlets.

For sites that combine sanitary sewage and stormwater downstream of a restrictor, the design must incorporate means to prevent sanitary sewage from flowing backward through the restrictor into the detention system. The recommended method would be to combine the storm sewer and sanitary sewer in a manhole in which the invert of the sanitary sewer is at least 0.2 feet below the invert of the storm sewer draining from the restrictor.

2.4.2 Calculation of Storage

Calculations substantiating the volume of storage provided by detention structures must be provided. For detention basins or parking lot storage, the frustum of cone equations must be used as follows.

Volume = (H/3)*(A1+A2+SQRT(A1*A2)), where H=depth of storage and A= areas between the depth.

Average end area method must be used for irregular topography or for street storage. Dimensions of structures such as vaults or oversized pipes may be used to calculate storage. When storage is to be provided within an aggregate, the void ratio of that aggregate must be documented. Void spaces within in-situ material cannot be counted toward storage.

2.4.3 Stormwater Capture Facilities

The City encourages the capture of water for reuse in irrigation. Up to 10 percent of a detention facility may be set aside for capture and reuse of the water. These detention facilities will be partitioned in a manner that allows for seasonal capture of water. The partition must include a valve or gate that allows for a freely draining condition during months when irrigation water cannot be used. It must also include an overflow connection placed below the design HWL to ensure that the detention basin operates as intended under the design event. The irrigation system must be capable of using all water stored in the reuse partition within 14 days of capture. The Operations and Maintenance Plan for the development must include provisions for ensuring that water is used within 14 days and that explain the seasonal operation of any valves or gates.

2.4.4 Residential Land Uses—Right-of-Way Storage

When proper site and roadway grades permit, a regulated development for residential purposes may utilize right-of-way storage (subject to the restrictions in Chapter III, Part 3.7.1 of the Regulations) as part of the required detention storage volume. The 100-year high water level must still meet the 0.1 foot freeboard requirement for adjacent properties (Chapter III, Part 3.1 of the Regulations). Also, onsite storage must still be provided for a minimum of the 5-year storm event.

2.4.5 Commercial/Industrial/Public Developments

All detention storage must be contained within the proposed development, right-of-way storage is not allowed.

2.5 Rate Control BMPs

Drainage features of a development site usually consist of two components: (1) conveyance structures such as storm sewers or ditches for moving stormwater from one location to another and (2) detention structures such as basins to temporarily store water and reduce the rate of flow discharging from a development site. Detention structures usually require the use of a flow-restricting outlet to meet the allowable discharge rate. The choice of a particular design for stormwater detention may be influenced by available site area, cost, and constructability. The City would like to encourage the use of the non-structural BMPs described below (expanded descriptions in Appendix C) comply with the Ordinance. This includes use of ditches, swales and natural channels to convey stormwater when possible. Use of these BMPs will result in a lower C-value and smaller required detention volumes as well as smaller required volume control storage. It is recognized that in some cases the use of elements such as oversized pipes or vaults may also be necessary. Design elements and BMPs that can be used to comply with the Ordinance are listed below.

Conveyance Structures

- Combined Sewers
- Ditches, Swales, and Natural Channels
- Storm Sewers

Detention Structures

- Detention Basins
- Detention Vaults (may also be designed for infiltration)
- Oversized Pipes
- Parking Lot Detention
- Rooftop Detention

The City has prepared a design guidesheet (see Appendix C) for detention structures. Each design element and BMP is discussed below.

2.5.1 Conveyance Structures

Most development sites will require conveyance structures such as combined sewers; drainage swales; and storm sewers to move stormwater from one location to another. These drainage features are discussed below.

Combined Sewers

Combined sewers are the most common sewer system available in the City. They are designed to accept both stormwater and sanitary system waste. As described in the sections above, significant sanitary system flows (dry weather flow - DWF) should be included in the determination of the maximum allowable release rate from a site.

Ditches, Swales, and Natural Channels

Runoff can be conveyed through a constructed channel (such as a ditch or swale) or a natural channel. When feasible, constructed channels should be unlined and vegetated. Swales are open-channel drainageways used as an alternative to conventional storm sewers. Swales and ditches can convey high flows more economically than pipe systems and may be especially useful when designing to accommodate the 100-year flow. If at all possible, natural drainageways should be preserved as part of the development's drainage system.

Storm Sewers

Storm sewers convey site runoff to a downstream receiving structure such as a swale, ditch, detention basin, natural stream or a City sewer. Storm sewers are designed as "minor" drainage systems for small storm events of up to the 5-year storm event (20-percent-annual-chance storm); however, overland flow paths should be designed for storm events including the 100-year storm event (1-percent-annual-chance storm). Onsite storm sewers and any overland flowpaths must be designed to prevent overflow to adjacent properties for storm events up to the 100-year event. Storm sewers do not provide any water quality benefits and in fact can contribute to the greater peak flows observed in developed watersheds. Storm sewers may be chosen instead of swales or ditches for stormwater conveyance based on land availability, maintenance issues, cost, and public safety issues.

2.5.2 Detention Structures

Detention structures include detention basins, detention vaults, oversized pipes, parking lot detention, and rooftop detention. Key considerations in the choice of the design element to use are available space, cost, maintenance issues, and safety considerations.

Detention Basins

Detention basins are depressions that temporarily store stormwater and release it gradually to a downstream drainage system. Wet detention basins are designed to permanently retain water and can be made to appear manicured or naturalized. Dry detention basins are designed to drain completely between storms. They may also be designed to provide infiltration and storage below the outlet elevation to satisfy volume control requirements. When discharging to waterways or storm sewers, wet detention basins are preferable to dry detention basins because of their effectiveness in removing runoff pollutant loads, especially suspended solids. In order to achieve optimum pollutant removal efficiency, the basin inlet and outlets should be located hydraulically as far apart as possible to prevent "short circuiting" and to increase the retention time. In addition to providing pollutant removal, detention basins can be designed to be aesthetically pleasing and to provide recreational benefits.

Detention basins may be naturalized to incorporate features such as plunge pools, stilling basins, variable topography to lengthen low flow pathways, and native upland buffer and wetland plantings. Detention basins that incorporate these features can replicate some of the flood storage, water quality and habitat benefits provided by natural systems such as wetlands, lakes or ponds. Naturalized detention basins may be created on almost any site, but the provision of wetlands may be constrained by site hydrology and soil conditions. Constructed wetland detention basins are feasible in areas with a high water table or relatively impermeable soils. In some cases, it may be possible to provide detention within an existing degraded wetland area by developing a plan to rehabilitate the area. In addition to reducing peak flows, wetland detention basins are very effective in removing pollutant loads. The principal advantages of stormwater wetlands are their ability to prevent settled pollutants from resuspending and washing out during subsequent storms and their ability to remove dissolved pollutants and organic matter through biological processes. High-quality wetlands should not be used to treat stormwater.

Detention Vaults

Detention vaults are usually precast reinforced concrete tanks constructed below grade. They are provided with restrictors to limit release rates. Most vaults permanently retain water in order to dissipate energy, settle out large solids particles, and act as an oil separator. However, the provision of an open bottom to encourage infiltration in areas of permeable soil is also an option. This option may be used to satisfy volume control requirements but above-ground naturalized infiltration facilities are preferred. Detention vaults are appropriate for development sites where space is limited or surface ponding is not feasible.

Oversized Pipes

Oversized pipes are designed like storm sewers. Oversized pipes serve as both detention and conveyance structures. They are very commonly used at small developments to fulfill detention requirements. To serve as a storage structure, the oversized pipe requires a flow restrictor at the downstream end of the pipe to limit the capacity of the sewer outlet to the required release rate. In this way, when inflow into the sewer is greater than the release rate, stormwater is “stored” in the pipe behind the restrictor. Oversized pipes offer a feasible alternative to detention basins when a site has limited space; however, oversized pipes do not provide volume control or water quality benefits.

Parking Lot Detention

Parking lot detention are facilities where some or all of the storage is provided on the pavement surface. Parking lots can be significant sources of runoff pollutants and these areas are often directly connected to the storm drain system. Reducing the paved surface area in parking lots and incorporating BMPs such as bioinfiltration, permeable pavement or filter strips into the parking lot design can reduce runoff volume and pollutants discharges from the site. Parking lot detention can be designed to receive overflow from BMPs during intense storms or to pond to a certain depth and then overflow into downstream BMPs. City regulations allow up to 12 inches of water to be ponded directly on the parking lot surface with the owner’s consent. The Operations and Maintenance Plan must identify or describe any surface ponding areas that will be over 10 inches in depth.

Rooftop Detention

Rooftop detention consists of either an enclosed chamber or a constructed ponding area designed to fill with stormwater during large storm events, slowly releasing it over a number of hours. There are numerous components to these systems. Drain inlet pipes convey stormwater into a detention chamber, which accumulates stormwater during a storm event. An orifice structure or outlet drainpipe restricts the flow out of the detention chamber, allowing it to fill up and slowly drain out. Rooftop detention does not provide water quality or volume control benefits.

3.0 Volume Control: Managing Stormwater Onsite

3.1 Introduction and Applicability

The Ordinance requires control of the volume of runoff from a site. The following sections discuss how to implement volume control measures. The volume of stormwater leaving a site can be reduced by permanently retaining the water on site so that it can percolate into the ground or evaporate into the air. The City encourages developments to treat stormwater as a resource rather than diverting it off site as quickly as possible. Volume control can be achieved by reducing the imperviousness of a site (if not discharging to Waters), or by installing BMPs that enhance the onsite retention and absorption of water. BMPs are discussed in detail in Appendix C.

3.2 Design Requirements and Calculation Methods

The Ordinance includes the following requirements related to volume control:

> *Stormwater drainage systems shall reduce the volume of runoff from a Regulated Development by one of the following measures:*
>
> *(A) Capture one-half inch of runoff from all impervious surfaces in accordance with volume control BMPs; or*
>
> *(B) For Developments that do not directly discharge to Waters or to a municipal separate storm sewer system, achieve a fifteen-percent reduction in impervious surfaces from existing conditions.*
>
> *The volume control requirements of a Plan shall not apply to the following:*
>
> *(1) Developments that do not directly discharge to Waters or to a municipal separate storm sewer system and that will upon completion of development have less than fifteen percent impervious surfaces.*
>
> *(2) Developments consisting of surfaces at an airport that are intended for aircraft operation.*
>
> *(3) Developments taking place at any facility that is operating under a permit issued pursuant to the National Pollution Discharge Elimination System, 40 C.F.R. Part 122, as amended, for industrial or municipal discharges.*

As part of the **Stormwater Management Permit Worksheet**, the City has developed a **Volume Control Spreadsheet** (Figure 3-1) to aid the applicant in determining the required volume of storage or the reduction in imperviousness needed for volume control. The spreadsheet is divided into three sections. The first step tabulates basic information on the site such as total site area, total pervious and impervious areas, and imperviousness percentages. For each drainage area on the site, the square footage of land cover present in existing and proposed conditions is entered. Step 2 provides a summary of the volume control storage required, or the site imperviousness which much be achieved. Step 3 documents the answers to three feasibility questions related to the implementation of infiltration based BMPs. The third step summarizes information on the available options to satisfy the volume control requirement.

Figure 3-1 Volume Control Spreadsheet

City of Chicago
Department of Water Management

Name of Project: __________
Address: __________
A/E of Record: __________

2.0 Volume Control

Step 1: **Runoff Calculation**

		Existing Area (sq ft)	Proposed Area (sq ft)
Pervious Surface or Land Cover not Counted as Impervious for Volume Control Calculations	Bare Earth		
	Lawn or Landscaped Areas		
	Woodlands		
	Wetland		
Impervious Land	Gravel		
	Pavement		
	Roofs (conventional)		
	Water (including Wet Bottom Basin to HWL)		
BMPs	Green Roof	-	
	Permeable Pavement	-	
	Bioinfiltration	-	
	Swales	-	
	Stormwater Trees	-	
	Roof Runoff Planters	-	
	Filter Strips	-	
	Dry Bottom Basins to HWL	-	

Summary	Total pervious area (sq ft)	0	0
	Total impervious area (sq ft)	0	0
	Total BMP areas treated as impervious area (sq ft)	-	0
	Total BMP areas treated as pervious area (sq ft)	-	0
	Total site area (sq ft)	0	0
	Imperviousness percentage (%)	0.0	0.0

Step 2: **Volume Control Assessment**

		Type Yes or No for all that apply	Note
Question 1:	Does the site drain directly to Waters?		
Question 2:	Are infiltration BMPs allowable? (See Chapter III Sections 4.1.2 of the Regulations.)		
Question 3:	Do you wish to use permeable pavement only as a pervious surface to achieve impervious surface reduction goal?		

Step 3: **Achieving Volume Control Measures**

Achieve I. or II. below in accordance with the Ordinance.

I.	Capture 0.5" of runoff from impervious surfaces. Storage required =	0	cubic feet	Go to spreadsheet 2.1 BMP Volume Summary if electing volume control storage option
or, II.	Reduce proposed imperviousness to:	-	percent	

3.2.1 Practicability of Infiltration BMPs

For use of infiltration-based BMPs, the Applicant must demonstrate that subsoil infiltration rates are 0.5 inches per hour or greater. Section 3.2.1.1 describes the steps and techniques that can be used to determine the design infiltration rate. The high groundwater table must be at least 2 feet below the bottom of all proposed infiltration BMP. If connected to a combined sewer system, the high water table must be at least 3.5 feet below the bottom of the infiltration BMP. The bottom of the infiltration BMP is considered the lowest grade which is excavated prior to the placement of aggregate or prepared soils that will be used for storage and infiltration.

Care should be taken to also ensure that infiltration BMPs are not employed in areas that could lead to water quality contamination. Chapter III, Part 4.1.2 of the Regulations details areas where infiltration BMPs are not allowable.

Also, sites that could be potential water quality hotspots should identify how the proposed BMPs will function in the context of the proposed development. Any special measures required onsite to prevent water pollution should be identified in the SMP. Sites with these concerns could include auto recycler facilities and junk yards; commercial laundry and dry cleaning; commercial nurseries; vehicle fueling stations, service and maintenance areas; toxic chemical manufacturing and storage; petroleum storage and refining; public works storage areas; railroads and rail yards; heavy manufacturing and power generation; metal production, plating and engraving operations; waste transfer and hazardous waste handling facilities, sites on subsurface material such as fly ash known to contain mobile heavy metals and toxins.

3.2.1.1 Geotechnical Investigations

An important factor to consider when designing an infiltration-based BMP is the infiltration rate of water into the soil at the development site. If a site utilizes a subsurface infiltration BMP or detention storage BMP designed for infiltration, then soil boring information must be submitted. Developers should consult the soil type map shown in Figure 3-2 for an initial idea of the permeability of soils in the area of the proposed development. Soil borings will provide the next level of detail regarding expected soil permeability. If sand or loamy sand is found, then detailed infiltration tests are not necessary but are still encouraged. Infiltration rates vary locally and should be tested prior to finalizing the design for an infiltration based BMP. Testing should follow the procedures described below or the applicable ASTM standards such as D3385-03, which can be found on the Internet at http://www.astm.org/.

Site evaluation is required before an infiltration system can be designed. The site evaluation process for determining the optimal location of an infiltration system should be a three-step procedure. The process entails: 1) performing the initial screening of the site; 2) obtaining soil borings; and 3) field testing of infiltration rates. All results must be summarized as part of the stormwater management plan (SMP) and submitted as part of the development submittal.

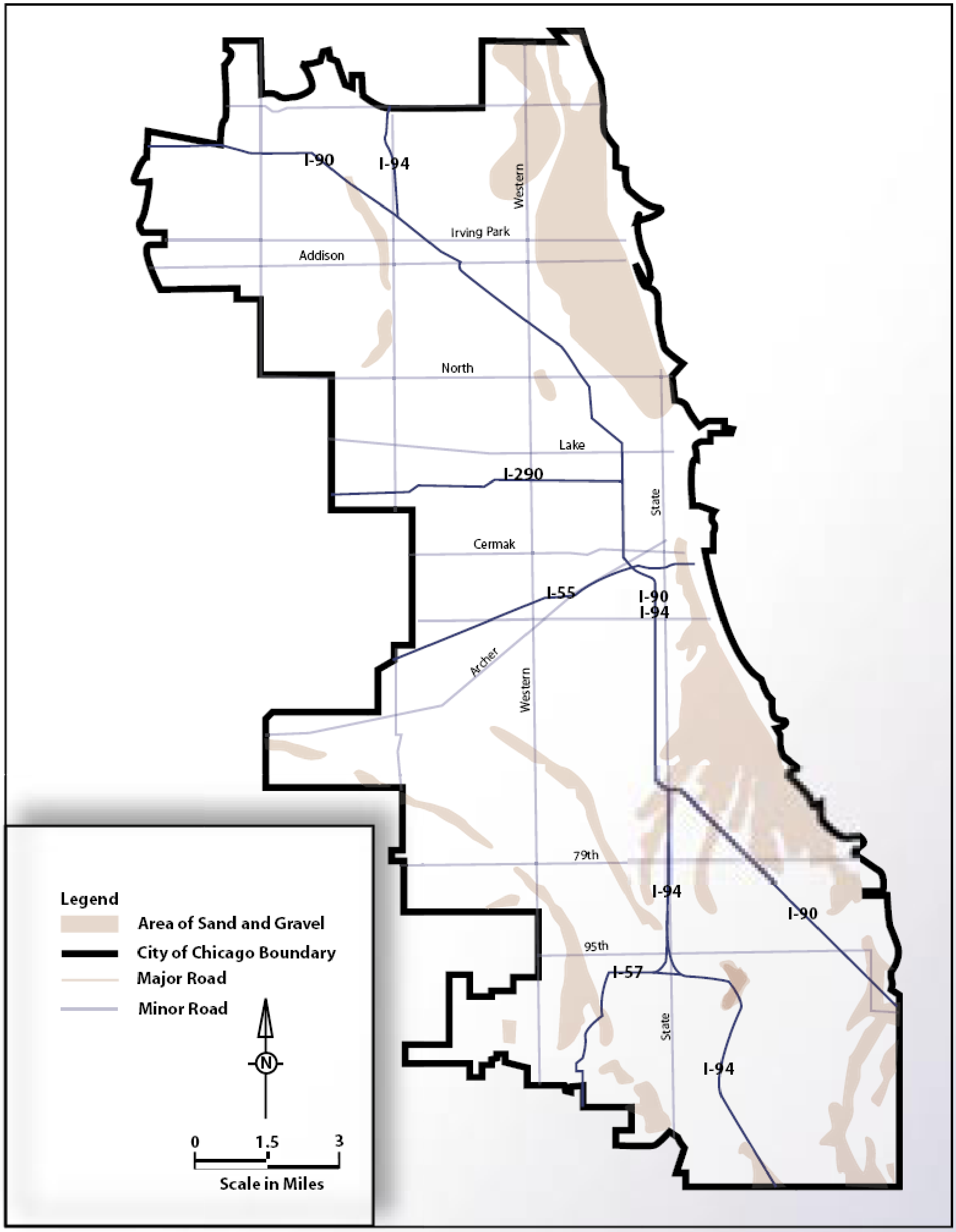
Step 1: Initial Screening

The initial screening identifies the potential locations for infiltration practices within a development. The screening process is used to evaluate infiltration capability of a site and to determine the number and location of field tests. The following information should be provided in the site evaluation phase.

1. Site topography from the site-specific survey of the existing property.
2. Existing soils data based on Figure 3-2.

This information should be included in the SMP as described in Step 4.

Figure 3-2 Chicago Soils Map



Step 2: Soil Borings

Soil borings confirm the feasibility of infiltration designs, refine the location of infiltration practices and provide data to select the type of infiltration device to be used. The number of soil borings required is based on the size of the development and expected BMPs (minimum one boring per 15,000 square feet of BMP area). Soil borings are required at the location of all proposed infiltration devices. Information submitted shall include, at a minimum:

1. The name of the professional and firm who collected the data, and the date the data was recorded.
2. A scaled map of the entire site showing the location of all soil borings taken on the property.
3. Soil boring logs shall be submitted for each boring. Boring method and sample collection method shall be described. The boring logs shall contain the following data, at a minimum:
    a. Surface elevation of boring
    b. Site topography at one-foot contour interval
    c. NRCS textural description of each strata encountered and at what depth
    d. Water content and porosity of each strata
    e. Groundwater level during and after drilling
    f. Grain size analysis (D10, D60, D90) for strata where infiltration is proposed and immediately adjacent strata
    g. Borings shall extend at least five feet below the elevation at which groundwater is encountered
    h. Each boring shall be a minimum of 2-inches in diameter
4. If native soils are proposed for infiltration without disturbance, then soil profile descriptions written in accordance with the Field Book for Describing and Sampling Soils by the USDA, NRCS, 1998 also are required. Additionally, the description for each soil horizon or layer shall include the following information:
    a. Thickness, in inches or feet
    b. Munsell soil color notation
    c. Soil mottle or redoximorphic feature color, abundance, size and contrast
    d. USDA soil textural class with rock fragment modifiers
    e. Soil structure, grade size and shape
    f. Soil consistence, root abundance and size
    g. Soil boundary
    h. Occurrence of saturated soil, groundwater, bedrock or disturbed soil

All soil boring data shall be submitted to the City as part of the SMP. The soil borings data should show that the required infiltration parameters are available for the location of each infiltration device.

Design infiltration rates for the USDA soil classifications are shown in Table 3-1. If the soil at the depth of the proposed bottom of the infiltration BMP is found to be sand or coarser, then field-testing of infiltration rates is not required and the maximum infiltration rate can be assumed to be 1.4 inches per hour.

Table 3-1 Design Infiltration Rates for USDA Soil Textures (Univ. of Wisconsin, Madison, 2006)

USDA Soil Texture	Design Infiltration Rate (in/hr)
Sand	3.60
Loamy Sand	1.63
Sandy Loam	0.50
Loam	0.24
Silt Loam	0.13
Sandy Clay Loam	0.11
Silty Clay Loam	0.19
Clay Loam	0.03
Sandy Clay	0.04
Silty Clay	0.07
Clay	0.07

Step 3: Field Infiltration Rate Test Procedures and Methods

Field testing to determine design infiltration rates is encouraged. The complex nature of surficial geology makes actual site data necessary for the development of design parameters. Field testing must quantify sustainable infiltration rates. Infiltration designs must be highly reliable and self-sustaining. The failure of an infiltration device may create an unsolvable drainage problem since surface discharge is not available or would cause flooding downstream. For this reason, good design data, based on appropriate field-testing, is essential. It is the design engineer’s responsibility to ensure that the infiltration system will be able to meet and sustain the design infiltration rate. Infiltration tests should be performed as described below.

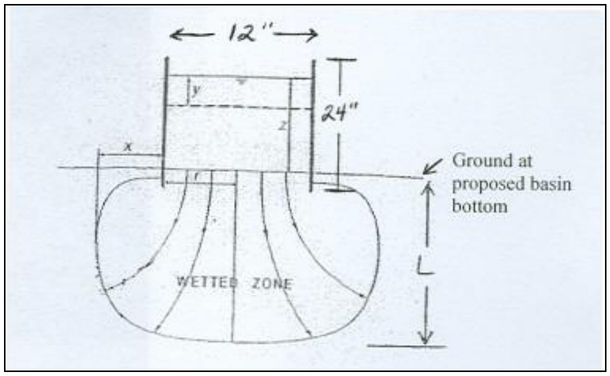
Determination of Field Infiltration Rate

Infiltration testing will generally be one of two methods. For sites where soils with suitable infiltration rates are within a few feet of the surface, single-ring infiltration testing can be used. The procedures described below for the single-ring test are modified from Bouwer 1978 and 2001. Alternatively, a double-ring infiltrometer test may be performed based on ASTM standards.

Infiltrometer Test Method

The single-ring infiltrometer method consists of driving a 12-inch open cylinder 24 inches long partially into the ground (at the proposed elevation of the bottom of the infiltration facility), filling the ring with clean water, and then observing the water level drop over time (Figure 3-3). Water is added to the ring as needed to restore the liquid level. The test should be performed with a sufficiently small time interval so that the total change in water level per time interval is less than 12 inches. The cumulative volume infiltrated during timed intervals is plotted versus elapsed time. The test is performed over several hours until a steady state infiltration rate develops.

Figure 3-3 Single Ring Infiltrometer



z = ~ 20-24 inches
y = maintain after 12 inches drop

Test Site

- The soil strata to be tested should be based on the soil borings data and the proposed basin bottom.
- The test site should be nearly level, or a level surface should be prepared.
- The test may be set up in an excavated pit if needed to reach the stratum to be tested.

Placing the Infiltration Ring

The cylinder is driven straight down to a depth of about 2-4 inches into the ground. The soil is packed against the inside and outside of the cylinder to achieve good soil-cylinder contact. Course gravel may be added inside the cylinder for erosion prevention when adding the water.

Adding Water and Measurement

The cylinder is filled to the top with clean water, and clock time is recorded. The decline is measured at regular intervals with a ruler, and clock time is recorded. Water is allowed to lower about 12 inches before refilling. This procedure is repeated for several hours or until steady state infiltration rate has been reached. The last decline y is measured and clock time is recorded to obtain the time increment Δt for y.

Calculations

Table 3-1 presents an example of tabulated water level drops and infiltration rate calculations for a single-ring infiltration test.

The corresponding downward flow rate, or flux i_w in the wetted area below a cylinder of radius r, is then calculated as:

$$i_w = \frac{i\pi r^2}{\pi(r + x)^2}$$

where x is the distance of lateral wetting from the cylinder wall (Fig. 2.1). x should be assumed to equal one-half *r (the value of x may be adjusted if in-field physical observations suggest otherwise)*. The rate, *i*, is calculated from the last measurement in the test ($y/\Delta t$).

The depth L of the wet front at the end of the test is calculated from the total accumulated declines y_t of the water level in the cylinder as:

$$L = \frac{y_t \pi r^2}{n\pi(r + x)^2}$$

where n is the assumed in-situ porosity of the soil. For permeable soils, a value of 0.2 to 0.3 would be typical. Darcy's equation can be used to calculate the downward flow in the wetted zone:

$$i_w = \frac{K(z+L)}{L}$$

where z is the average depth of water in the cylinder during the last water-level decline. To solve for K:

$$K = \frac{i_w L}{(z + L)}$$

This calculated value of K is used as an estimate of long-term infiltration rates in infiltration devices (the design infiltration rate, subject to rules below). It does not consider clogging of the surface of the device or restricting layers below the infiltration stratum.

Design Infiltration Rate

A design infiltration rate for use in BMP computations may be selected based on results of the field measurements. While field infiltration rates are an indication of actual infiltration device performance, there are elements that may cause actual infiltration rates to be less than the measured infiltration rate. These include, but are not limited to: soil variability over the bottom of the infiltration device, actual construction procedures, variability in construction materials, clogging due to fines during construction, and clogging over time due to stormwater pollutants that escape pretreatment and biological growth. Design infiltration rates should be selected as follows:

- For field permeability greater than 3.6 in/hr (4.6 x10-5 fps), a design rate of 3.6 inches should be used.
- For rates less than 3.6 in/hr, the actual field permeability should be used.
- Field permeability less than 0.5 in/hr requires additional design features as described in Section 3.2.1.2 in order to implement infiltration based BMPs.

If percolation testing is necessary, at a minimum, one percolation test must be provided for each separate BMP area. If a BMP area is larger than 15,000 square feet, additional percolation tests will be required for every 15,000 square feet of BMP area.

A Soil and Site Evaluation Report shall be submitted as part of the SMP. The report should contain all information outlined above in Steps 1, 2, and 3. It also should present the time versus infiltration rate results graphically and field observations of all tests. A field determined infiltration rate should be calculated for each infiltration-based BMP when soil borings did not reveal sand or loamy sand soils.

Table 3-1 Single Ring Infiltrometer Infiltration Rate Determination

12-inch Infiltrometer
Volume Rate= 0.785 cubic feet / foot of drop

Elapsed Time (minutes)	Change in Time (minutes)	Water Decline (feet)	Cumulative Volume (cubic feet)
0	0	0.00	0.0000
15	15	0.09	0.0707
45	30	0.09	0.1413
75	30	0.13	0.2434
105	30	0.06	0.2905
135	30	0.10	0.3690
165	30	0.11	0.4553
195	30	0.12	0.5495
225	30	0.10	0.6280
255	30	0.10	0.7065
285	30	0.10	0.7850
315	30	0.10	0.8635
345	30	0.10	0.9420
	Totals:	**1.20**	**0.9420**

Infiltration Rate

$i_n = y_n / t_n$ = 0.10 / (30 x 60) 0.000056 feet per second (fps)

$z =$ 1.66 feet

$y_t =$ 1.20 feet

$i_w = i_n \pi r^2 / \pi (r + 0.5r)^2$

$i_w =$ 0.000056 x π x 0.5^2 / π (0.5 + 0.5 x 0.5)^2

$i_w =$ 0.0000249 feet per second (fps)

$L = y_t \pi r^2 / n \pi (r + 0.5r)^2$

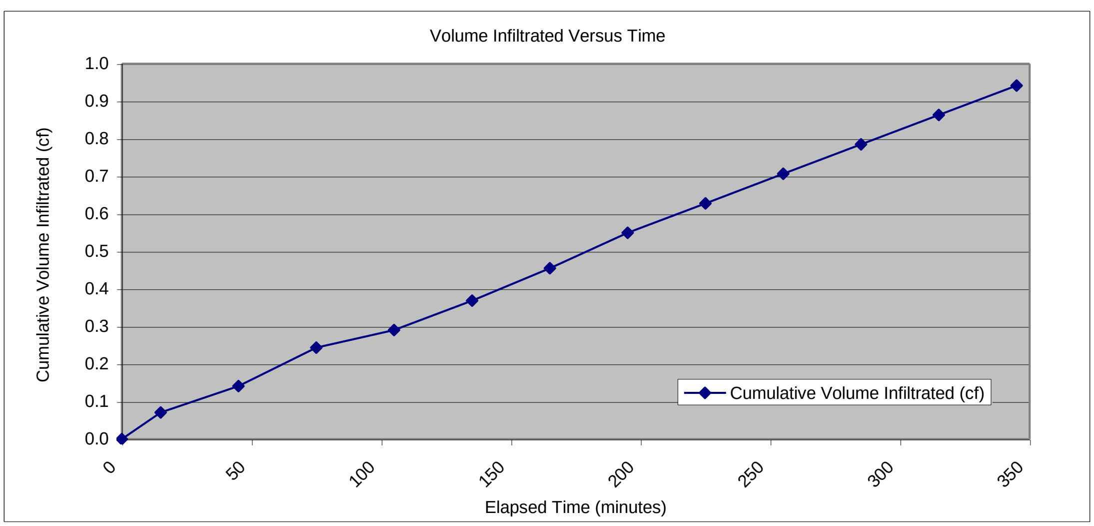
L = 1.2 π x 0.5^2 / 0.2 x π (0.5 + 0.5 x 0.5)^2

L = 2.67 feet

$K = i_w L / (z + L)$

K = 0.0000153 feet per second (fps)

K = 0.66 in/hr



3.2.1.2 Underdrains

When underlying soils do not meet the minimum permeability of 0.5 inches per hour, an infiltration BMP may still be implemented with the use of underdrains. Underdrains may be placed within the aggregate layer of permeable paving, swales or bioinfiltration basins. Outflow from underdrains must not bypass the detention facility serving the site. The high groundwater table must be at least 3.5 feet below any underdrain system discharging to a combined sewer.

3.2.2 Drainage Areas and Volume Control

Many regulated developments will drain to one or more discharge points leading to waterway, water body, combined sewer or separate storm sewer. It is allowable to construct an oversized volume control BMP in one subarea to compensate for reduced or lacking volume control measures in other areas of the site. The following criteria must be met when using this approach:

- When draining only to the combined sewer system, oversized volume control BMPs can receive storage credit for up to the volume of runoff generated by a 1-inch rainfall event over the tributary area. This ensures that the oversized volume control measures will be sufficiently effective. When applicable, the BMP spreadsheets in the **Stormwater Management Permit Worksheet** provide a check for this volume.
- When draining to a storm sewer or waterway, all subareas must provide the required volume control because of the pollution reduction benefits that are provided.

3.2.3 Direct Discharge to Waters

Sites that discharge directly to Waters or a storm sewer must provide volume control for all subareas except for roofs that bypass the stormwater management system. When infiltration BMPs are impractical due to the conditions described in Chapter III, Section 4.1.2 of the Regulations, oversized detention may be used to capture and control the required volume control storage. Oversized detention facilities that discharge to Waters or a storm sewer shall have a maximum release rate of 0.04 cfs per acre for the volume control storage. This may require the use of a two stage outlet device. Also, when volume control is achieved through oversized detention, no credit toward rate control storage is provided. The volume control storage must be in addition to any required rate control storage.

3.2.4 Alternative Volume Control Measures

Depending on the site characteristics, several alternatives to implementation of infiltration based BMPs may exist for achieving compliance with the volume control provision.

3.2.4.1 Reduction of Impervious Areas

Sites that do not directly discharge to Waters or to a separate storm sewer system may achieve the volume control requirements by reducing the existing conditions imperviousness by 15 percent (i.e. – 85 percent impervious existing conditions site must be 70 percent impervious under proposed conditions). Sites that will be less than 15 percent impervious under proposed conditions are not subject to the volume control requirements. Once the existing conditions for a site have been identified, the **Volume Control Worksheet** indicates the proposed conditions imperviousness required to meet the volume control requirements. The Ordinance defines **existing conditions** as:

> *The condition of a site in the ten years prior to the date of a Plan submission, as shown on historical aerial photographs or other verifiable documentation. If a site has been demolished*

and/or cleared within such ten-year period, its conditions prior to such demolition and/or clearing may be used as a basis for existing conditions.

If the reduction of impervious areas option is used, then the SMP submittal should include documentation of the existing conditions. Tributary sidewalls are not included in the computation of proposed conditions site imperviousness for the purposed of impervious surface reduction computations.

3.2.4.2 Oversized Stormwater Detention

When infiltration is impracticable due to the conditions described in Section 4.1.2 of the Regulations, the volume control requirement may be fulfilled by detaining the required volume control storage. Detention of the volume control storage is also allowable on lot to lot developments (when structures exceed 85 percent of the site).

When volume control storage is detained, it shall be held separate from (in its own facility) or in addition to the required detention for rate control. In either case, it should be fully utilized under the minimum required design storm applicable to the appropriate subarea of the site (10-year if a building roof, 100-year for other areas). When this storage is to be added to the detention facility, the release rate shall be reduced accordingly to make use of the additional storage (see oversized detention worksheet) If the computed volume control release rate is less than 0.15 cfs (the rate of the minimum allowable restrictor), then the volume control storage shall be provided in addition to the required detention volume for rate control, and a pump discharge may be required.

When off-site flows drain through a stormwater management system, the 25-year storm analysis must be done using the reduced release rate calculated in the oversized detention worksheet.

3.3 Volume Control BMPs

This section discusses volume control BMPs that can be used to comply with the Ordinance and Regulations. The list of volume control BMPs is not all-inclusive. The City has identified common volume control BMPs that can be implemented to meet the goals and objectives of the Ordinance. The City has prepared BMP guide sheets (Appendix C) that include additional information on the implementation of these stormwater BMPs. Calculation spreadsheets are provided in the **Stormwater Management Permit Worksheet** and they should be used as the basis for compliance with the Ordinance and Regulations.

3.3.1 Volume Control BMPs

These BMPs are generally applicable to volume control and are discussed below.

- Green Roofs
- Rooftop Runoff BMPs (Planter Boxes, Rain Barrels and Cisterns)
- Permeable Paving
- Natural Landscaping
- Vegetated Filter Strips
- Bioinfiltration Systems
- Drainage Swales
- Infiltration Vault (also see Section 2.5.2)

Green Roofs

In green roof systems, runoff is absorbed and retained by living vegetation installed on a rooftop. There are two types of green roof systems: extensive and intensive systems. Extensive systems usually contain shallower soil, put less weight on rooftops, and are easy to maintain. They generally contain shorter plants with shallower root systems. Intensive systems have deeper soil; add more weight to a rooftop; and generally contain a more diverse mixture of deep-rooted plants, trees, and shrubs. Intensive systems require more maintenance but provide added benefits in the form of water filtration and wildlife habitat. Green roof systems provide insulation and prolong the life of a roof by protecting it from the elements. Green roof systems also improve air quality by reducing the urban heat island effect. Maintenance of green roof systems is minimal and mostly involves watering and weed removal during the first few years of establishment.

For rate control, green roof benefits are accounted for by computing a weighted C-value based on the amount of storage provided in the roof's substrate. In most cases, a green roof will not cover all surfaces of a roof. The green roof will be counted as a pervious surface to aid in achieving the required impervious area reduction. In addition, the lower C-value of the green roof will have the effect of reducing the volume of storage required to meet the rate control requirements. The **2.1.3 Green Roof** spreadsheet in the **Stormwater Management Permit Worksheet** guides the use through both computations.

Roof Runoff BMPs (Planter Boxes, Rain Barrels and Cisterns)

Roof runoff BMPs include planter boxes, rain barrels, and rain cisterns. Planter boxes are used in heavily paved areas to reduce the area of impervious areas. Planter boxes can be aboveground or at grade and are designed to retain water in the substrate or in an underlying aggregate. Planter boxes come in a wide variety of shapes and sizes and may be planted with native or ornamental plants. Planter boxes at grade can be designed to drain part of the surrounding paved area. Planter boxes can also be designed to infiltrate water into the ground or to capture water through an underdrain system that discharges excess water into a sewer system. The storage provided in the voids of underlying aggregate and in the contained air space (reservoir) above the soil may be counted as volume control storage.

Rain barrels and cisterns collect and store stormwater runoff from rooftops. The volume of rain barrels or cisterns may be counted as volume control storage. Credit is also received toward rate control storage, but this cannot exceed 10 percent of the total required rate control storage. Water collected in rain barrels and cisterns can be used to water lawns and landscaped areas between storms. Rain barrels and cisterns are therefore most useful during the growing season. They require periodic cleaning to remove debris. Filters to keep out most debris can be installed, but periodic cleaning is still advised. In addition, rain barrels should be sealed to prevent mosquito breeding and must be drained before winter to prevent any damage from freezing and thawing. Rain barrels do not have a significant effect on C-values for 100-year storm events.

The **2.1.7 Roof Runoff** spreadsheet in the **Stormwater Management Permit Worksheet** provides a guide for computing volume control for Roof Runoff BMPs.

Permeable Paving

Permeable paving provides many benefits in urban environments by reducing the quantity of stormwater runoff and pollutants discharged from a site. Permeable pavement systems come in many different forms. The most common forms are paving blocks with a cutout to facilitate infiltration or grids that have openings filled with a porous material such as rock, sand or soil. Paving blocks work best on areas that have sandy, permeable soils, however, they may also be implemented on low permeability soils by using aggregate and an underdrain system. Permeable pavement systems are most useful in areas that do not receive high traffic volumes or heavy weight loads.

Areas of permeable pavement may be counted as permeable surfaces, unless the aggregate layer includes an underdrain or the aggregate storage is being used for detention. In these cases, the permeable pavement should be treated as an impervious surface for volume control and detention requirements. The storage provided in permeable paving systems is based on the void space of the aggregate. The **2.1.6 Permeable Pavement** spreadsheet in the **Stormwater Management Permit Worksheet** shows how to determine the total storage provided under different design scenarios.

Natural Landscaping

Natural landscaping involves the planning and implementation of naturalized or native vegetation on permeable soils or prepared soils. Care must be taken to ensure that the proposed vegetation and existing soils are compatible. If existing soils are unsuitable for implementation of native vegetation, alternative landscaping plans should be devised, or a prepared soil should be brought into the site. Natural landscaping on prepared soils has a greater capacity to infiltrate stormwater than lawns on heavy soil. As shown on the detention design spreadsheet, areas with natural landscaping on permeable or prepared soils have a lower C-value and can reduce the amount of required detention storage. There is no volume control benefit specifically related to natural landscaping, however, natural landscaping can be an integral part of the design of other BMPs such as vegetated swales, filter strips and bioinfiltration basins.

Trees can also be used for minor volume control benefits and to reduce urban heat island effects. Trees slow down rain from small storms, holding the water on leaves and branches and allowing the water to evaporate. Urban heat island effects are reduced because trees provide shade to impervious surfaces, thereby decreasing the temperature of the surfaces and subsequently the temperature of the surrounding air and of any stormwater that passes over the impervious area. Lowering the temperature of stormwater runoff can be beneficial in improving the water quality of receiving streams. Existing trees located on the development site that are preserved as part of the site plan and proposed trees located on the development site that are planted within 20 feet of on-site impervious areas may count as a deduction of impervious areas on site for volume control calculations. The tree species must be chosen from the approved list provided by the CDOE. New trees planted must be planted within 20 feet of ground level impervious surfaces. New trees must be at least 2-inch caliper at 4.5 feet above ground level to be eligible for the reduction. A 50 sq.-ft. reduction in impervious area is permitted for each new tree. Only 50% of the canopy area of an existing tree of at least 4-inch caliper, within 20 feet of ground level imperviousness, may be credited towards a reduction in impervious area. The **2.1.5 Trees** spreadsheet in the **Stormwater Spreadsheet Tool** shows how to determine the total benefits of providing stormwater trees.

Vegetated Filter Strips

Filter strips are designed to receive stormwater runoff from impervious surfaces and disperse it over wide, vegetated areas. Filter strips should be implemented in areas with little or no slope to provide the maximum impact by slowing and infiltrating runoff and allowing pollutants and sediment to deposit or be filtered out. When implemented on permeable or prepared soils, filter strips can effectively reduce runoff volume for small storm events, especially when they receive runoff from areas no more than four or five times their size. If designed according to the guidelines, the filter strip may satisfy the volume control requirements for up to a 1 to 1 ratio of impervious area to the area the filter strip. For example, if one acre of parking lot was discharged to a one-quarter-acre filter strip, additional volume control measures would be needed for only the three quarters of an acre of parking lot. Maintenance requirements for filter strips are simple. Normal maintenance requires occasional mowing or weed removal and periodic cleaning. Filter strips can decrease maintenance requirements of downstream stormwater devices by capturing and controlling sediment. The **2.1.8 Filter Strips** spreadsheet in the **Stormwater Spreadsheet Tool** shows how to determine the volume control benefits of providing filter strips.

Level spreaders should be used to disperse runoff to the filter strip and avoid channelization. A level spreader intercepts concentrated flows and disperses runoff in a uniform manner to the filter strip. It may consist of a gravel-filled trench running perpendicular to the direction of concentrated flow. Water fills the trench, spreading evenly along the trench's axis before overflowing on the downstream side. Level spreaders improve the effectiveness of the filter strip or other BMPs that depend on sheet flow to operate. Level spreaders can be used at the edges of parking lots, loading areas, driveways, roof downspouts, and other discharge points when a point source discharge should be spread over a larger level area. Level spreaders are inexpensive and require very little maintenance.

Bioinfiltration Systems

Bioinfiltration systems are features such as basins or trenches that collect stormwater from surrounding impervious areas. These flow regulating structures pass inflow through a shallow depressed area containing plants, mulch, and a prepared soil. A rain garden is a good example of a bioinfiltration system, which is relatively easy to construct. Bioinfiltration is very effective at reducing runoff volume and removing pollutants, especially when used as parking lot islands. As with drainage swales and vegetated filter strips, bioinfiltration systems work best when used to collect runoff from small storm events. In some cases, bioinfiltration systems can be used in conjunction with sewer systems by incorporating underground perforated pipes or overflow inlets.

Bioinfiltration systems should be located away from structures so that water does not drain into the foundations of the structures. As with the other infiltration BMPs, the subsoils must have a permeability of at least 0.5 inches per hour. Bioinfiltration systems work best when pretreatment is provided in the form of drainage swales or vegetated filter strips to reduce the amount of sediment that reaches the infiltration facility. If pretreatment is not provided by an upstream BMP, then it can be designed into the bioinfiltration system as a plunge pool or sediment forebay. The **2.1.1 Bioinfiltration** spreadsheet in the **Stormwater Spreadsheet Tool** shows how to determine the volume control provided by a bioinfiltration facility.

Drainage Swales

Runoff can be conveyed through either a constructed channel (such as a ditch or swale) or a natural channel. Constructed channels can be designed purely for conveyance,or can include measures to enhance infiltration such as check dams. If designed according to the design guidelines, the swale may satisfy the volume control requirements for up to a 1 to 1 ratio of impervious area to the area the swale. Swales with check dams or that are underlain by storage aggregate can provide additional volume control. The storage behind check dams may be counted as volume control storage. Storage may also be provided in the voids of underlying storage aggregate when minimum infiltration requirements are met or when underdrains are provided. Swales can reduce the volume of stormwater runoff from a site, especially during small storm events, if the swale is situated in permeable soils. Swales or unlined ditches and natural channels are superior to conventional storm sewers because they allow water infiltration and can remove pollutants if they are vegetated. Vegetated swales can be planted with native vegetation to provide enhanced wildlife habitat and to increase the amount of runoff removed by transpiration and evaporation. If at all possible, natural drainageways should be preserved as part of the development site's drainage system. Another advantage of swales, ditches, and natural channels is their low capital cost. Swales and ditches can be designed to convey both high and low flows but may be difficult to implement where space is limited. The **2.1.2 Swales** spreadsheet in the **Stormwater Spreadsheet Tool** how to determine the total volume control provided by a drainage swale.

Infiltration Vault (edit based on perm paving)

Detention vaults are box-shaped underground stormwater storage facilities typically constructed with reinforced concrete. Infiltration vaults are detention vaults with an open bottom to encourage infiltration in areas where permeable subsoil conditions are found. This option may be used to satisfy volume control requirements but above-ground naturalized infiltration facilities are preferred. Infiltration vaults must include a design for pretreatment. In many cases this can be provided within the vault itself, but a definitive long-term maintenance plan will be required for the removal of sediment. When the infiltration rate has been verified by geotechnical investigations and pretreatment is provided, the infiltration rate may be counted in addition to the allowable release rate when computing required storage volumes. The **2.1.4 Infiltration Vault** spreadsheet in the **Stormwater Spreadsheet Tool** how to determine the total volume control provided by an infiltration vault.

4.0 Erosion and Sediment Control

4.1 Introduction and Applicability

Sediment erosion and sedimentation have become major concerns in northeastern Illinois during recent years because of the ever-increasing pace of development. Controlling erosion and sedimentation, especially during construction, is essential for maintaining water quality and reducing the potential for damage to adjacent sites or the sewer system. Dust creation and sediment transport are two major problems at construction sites. Construction work creates large amounts of dust that can be stirred up by vehicle traffic and settle onto surrounding areas. Sediment can be directly transported in runoff or by vehicles entering and leaving the development site. Environmental impacts from erosion and sedimentation are summarized below.

- Water quality impairment: Sediment that enters the water column increased turbidity and delivers nutrients which can lead to undesirable algae growth. Sediment reduces sunlight penetration and can deposit and cover bottom substrates which degrades the habitats and spawning areas of aquatic organisms.
- Loss of storage volume: Excess sediment from construction sites fills storm sewers and ditches, detention basins, wetlands, and stream and river channels, thereby reducing their ability to convey runoff. Sediment may also collect in ponds and lakes leading to reduced depth and aesthetic problems.
- Degradation of natural areas: Over time, sediment accumulation and deposition can lead to the degradation of natural plant communities such as prairies and wetlands. The sediment can bury or suffocate existing plants, smother the native seed bank, and act as a medium for the germination of invasive plant seeds that were carried in with the sediment.

Sediment deposits are expensive to remove from sewers, culverts, ditches, lakes, and streams. In addition, areas degraded from excessive erosion are more expensive to landscape and maintain. Because of these economic concerns and the environmental impacts listed above, and to meet state and federal regulations, the City of Chicago (City) regulates erosion and sedimentation created during construction activities. All developers subject to the Ordinance and Regulations must install and maintained soil erosion and sediment control (SESC) measures during construction to reduce or prevent the discharge of sediment and other pollutants in stormwater runoff from the Development. In addition, the City encourages development projects to meet the standards in the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System. Erosion and sedimentation control is a prerequisite included in the LEED™ Rating System. To evaluate ECPs, the LEED™ system uses standards set forth in (1) the U.S. Environmental Protection Agency's (EPA) "Storm Water Management for Construction Activities" (Document No. EPA 832/R-92-005) or (2) more stringent local standards (if applicable). Although not required, the LEED™ system can help developers create environmentally sustainable developments that will be a continuing source of pride in the City.

4.2 General Requirements

All developers subject to the Ordinance and Regulations must install and maintain SESC measures during construction to reduce or prevent the discharge of sediment and other pollutants in stormwater runoff from the development. The SESC measures should be installed prior to land disturbing activities and be maintained in functional order until the property has been permanently stabilized. A site is considered permanently stabilized when all land disturbing activities have been completed, all construction SESC measures have been removed, and a uniform perennial vegetative cover with a density of 70 percent for unpaved areas and areas not covered by permanent structures has been established or equivalent permanent stabilization measures have been completed.

The "Illinois Urban Manual" prepared for the Illinois Environmental Protection Agency (IEPA) by the U.S. Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS) has become the industry standard for selecting and designing SESC measures (also refereed to as SESC best management practices (BMPs)) and permanent stabilization measures. All SESC measures utilized on the Regulated Developments must be constructed and maintained in accordance with standards and specifications set forth in the most recent version of the Illinois Urban Manual

Information for purchasing or downloading the "Illinois Urban Manual" can be accessed at http://www.il.nrcs.usda.gov/technical/engineer/urban/index.html (USDA-Natural Resources Conservation Service and IEPA 2002).

4.3 Submittal Requirements

Applicants with Regulated Developments over one acre in size are required by the Ordinance to comply with all IEPA NPDES for construction activities. For Regulated Developments over one acre in size that discharge to a waterway, water body, or storm sewer, the Regulated Development must obtain and operate in accordance with a General NPDES Permit for Stormwater Discharges from Construction Site Activities (General NPDES permit ILR10). In addition, as required by both the Ordinance and the ILR10 permit, a copy of the Stormwater Pollution Prevention Plan (SWPPP) developed for the property and the Notice of Intent (NOI) filed with the EPA to obtain the ILR10 permit must be kept on-site during construction and be made available for review upon the request of all field inspectors.

For Regulated Developments over one acre in size that discharge to the combined sewer system a ILR10 permit does not need to be obtained from the IEPA. However, in order for this exception to apply, the entire Regulated Development must discharge to the combined sewer system. If any portion of the Regulated Development discharges to a waterway, water body, or storm sewer, a ILR10 permit must be obtained for the entire Regulated Development.

The IEPA's stormwater website presents more detailed information about IEPA NPDES requirements for construction activities and the ILR10 permit. It is available at: http://www.epa.state.il.us/water/permits/stormwater/construction.html

4.3.1 Development Sites Discharging to Combined Sewers

Applicants with Regulated Developments regardless of size discharging to combined sewers must submit a signed Design/Construction Affidavit in Support of Soil Erosion and Sediment Control Measures during Construction to the DOB as part of their Stormwater Ordinance submittal.

The Affidavit ensures that functional and effective construction SESC measures will be installed and operational on the Regulated Development in order to reduce or prevent the discharge of sediment and other pollutants in stormwater runoff from the development. The Affidavit provides a list that identifies the SESC BMPs that will be installed and maintained on the Regulated Development. The Affidavit must be signed by the General Contractor and Developer/Owner.

4.3.2 Developments Discharging to Waters

All Regulated Developments regardless of size that discharge directly to a waterway, water body, or storm sewer are required to develop an Erosion Control Plan (ECP) for the proposed construction activities. The ECP must include the following and be submitted to DOB for review as part of the Regulated Development Stormwater Ordinance submittal:

- Temporary erosion and sediment control measures applicable to each phase of construction activity
- Permanent stabilization measures including landscape seeding and sodding plans
- Means of accommodating 2-year stormwater flows onsite and by-passed during construction
- A maintenance schedule for each erosion control measure. During construction, each erosion control measure shall be inspected weekly or after more than 0.5-inch of rainfall.
- Means to protect infiltration BMPs during construction

The most recent edition of the "Illinois Urban Manual" should be used as a source book for information about selecting, installing, and maintaining specific BMPs that are to be incorporated into the developer's ECP. When selecting and implementing the SESC BMPs to be utilized on a construction site, it is important to understand them in context of an overall construction site plan. It is recommended that the following site design, management, and maintenance principles be implemented on all Regulated Developments requiring an ECP.

1. Plan the development site to fit the natural topography, soil, drainage patterns, and vegetation.
2. Preserve and protect areas of natural vegetation. Areas to be preserved shall be protected with fencing to prevent damage from construction operations.
3. Take special precautions to prevent damage that could result from development activities near watercourses, lakes, and wetlands.
4. Minimize the extent and duration of the area exposed at one time.
5. Apply temporary erosion control practices as soon as possible to stabilize exposed soils and prevent on-site damage.
6. Install sediment basins or traps, filter barriers, diversions, and perimeter control measures prior to site clearing and grading to protect the disturbed area from off-site and on-site runoff and to prevent sediment transport to areas downgradient from the development site.
7. Keep runoff velocities low, and retain runoff on site as much as possible.

8. Provide measures to prevent sediment from being tracked onto public or private roadways.

9. Implement final grading and install permanent vegetation on disturbed areas as soon as possible.

The ECP should include a description of all erosion and sediment control BMPs that will be implemented on the site. All erosion and sediment control BMPs selected and implemented at the site are required by the Ordinance to comply with the standards and specifications set forth in the "Illinois Urban Manual." The ECP should also clearly describe each major construction activity (grubbing, excavation, grading, etc.) what BMPs will be utilized and the timing during the construction process that the BMPs will be implemented.

The Ordinance requires that all Regulated Developments that discharge stormwater to a waterway, water body, or storm sewer to conduct site inspections. Inspections must be completed weekly, or after each storm resulting in more than 0.5 inches of rainfall. The purpose of the inspections is to assess and determine whether the SESC measures identified in the ECP are operating properly and effectively, and to initiate maintenance as needed. Inspections should include a visual observation of all disturbed areas of the Regulated Development, material storage areas, sediment and erosion control measures, locations where vehicles enter or exit the Regulated Development, and accessible discharge points (outfalls). The inspection should be completed by qualified inspectors who are familiar with the ECP plan and the BMPs implemented at the site.

Inspection reports should be completed at the time of inspection. At a minimum, the inspection reports should contain:

1. The inspector's name and qualifications

2. Date of inspection

3. A summary of the scope of the inspection (property information)

4. A discussion of the BMPs implemented on-site and an opinion to whether the BMPs are operating properly and effectively based the specifications provided in the Illinois Urban Manual. If a BMP is identified as not operating properly or is not effective, the inspection report should contain recommendation and/or strategies for alleviating the identified deficiency.

SESC measures and other BMPs should be maintained in effective operating condition. In general, if inspections indicate that a BMP is not operating properly, it is recommended that maintenance and modification of the BMP be performed as soon as possible and before the next storm event whenever practicable and no later than seven (7) calendar days from the inspection date, to ensure its continued effectiveness. Minimum maintenance standards for each specific BMPs are included in the Illinois Urban Manual and are required by the Ordinance to be included in the ECP.

The Regulated Development must keep a copy of the ECP on-site at all times during construction and make the ECP available for review by a City field inspector upon request.

5.0 Operation and Maintenance Requirements

5.1 Introduction and Applicability

Operations and maintenance (O&M) is essential for proper stormwater management. The BMPs and stormwater management design elements discussed in Sections 2.0 through 4.0 of this Manual require certain O&M activities in order to ensure their long-term performance. By making a commitment to regular O&M activities, developers will be able to achieve desired design results while maintaining the aesthetic qualities of the overall landscape. Regular O&M activities also prolong the optimal function of landscape designs and treatments, allowing developers to avoid significant repair and restoration costs that would be associated with more traditional stormwater management methods. The O&M and inspection guidelines presented below are not all-inclusive. Some BMPs may require other measures not discussed here. It is the designer's responsibility to decide whether additional measures are necessary. The O&M requirements in this chapter apply to all BMPs identified in Sections 2.0 through 4.0 except as discussed below.

- Developments with less than 15,000 sf and less than 7,500 sf of at-grade impervious surface do not require O&M plans unless they discharge to a waterway or separate sewer.
- O&M plans do not need to be submitted for the existing tree canopy.

The BMP Guidesheets in Appendix C identify the minimum O&M requirements for each type of BMP included in this Manual. For stormwater management facilities not included in this Manual (such as a manufactured stormwater treatment technology), it is still necessary to prepare and submit an O&M plan that complies with the requirements discussed in this section. Proper training and written guidance should be provided to all personnel who will be involved in O&M. Copies of applicable O&M plans should also be provided to all property owners and tenants. This information should include, at a minimum, the general O&M requirements discussed below.

5.2 General Requirements

Developers whose sites will contain rate control facilities or the BMPs discussed in Section 3.3 or other BMPs approved by the City will need to create an O&M plan. An O&M plan must cover all activities necessary to ensure the smooth functioning of all BMPs in the stormwater management plan (SMP). O&M procedures must be reviewed and assessed annually. All O&M plans must include information summarized below.

5.2.1 Owner Information

The first section of the O&M plan must contain information about all people involved with the O&M plan. It must list the names and contact information of all responsible parties, including property owners, maintenance workers, and people who will be performing inspections. The responsibilities of each person listed should be clearly defined in this section.

5.2.2 Site Map

The O&M plan must include a site map showing the locations of all BMPs that will be present at the development. The site map should show the flow of stormwater through the site and provide an overview of the stormwater's path through the onsite BMPs. The map must, at minimum, include the following information: (1) discharge points and outfall locations; (2) drainage patterns; (3) stormwater runoff flow direction; (4) the extent and depth of high water levels; (5) structural controls used to control stormwater flows; and (6) locations of all selected BMPs on site.

5.2.3 O&M Practices

Each BMP will require a specific inspection and maintenance regimen. In addition, the minimum requirements below shall be incorporated into the inspection and maintenance regimen.

- O&M Plan must be signed by the owner and notarized using the Operation and Maintenance Plan Owner's Certification Statement found in the Regulations, Appendix II-A, Sheet A.22. A copy of the O&M Plan must be provided to each new owner before the consummation of a sale, and the O&M Plan must be signed by the new owner, notarized, and submitted to the City to be kept on record.
- O&M Plan procedures and practices must be reviewed and assessed annually
- Access routes including roadways and sidewalks shall be inspected annually and maintained as needed
- Drainage structures and flow restrictors must be inspected and cleaned semi-annually
- Volume control BMPs shall be inspected semi-annually and after significant rainfall events exceeding 1.5 inches
- The Owner shall keep an updated log book documenting the performance of the required O&M activities for perpetuity. Log books must be produced upon the request of a City inspector.
- Vegetation shall be maintained on a regular basis.
- Pest control measures shall be implemented to address insects and rodents.
- Signage and fencing shall be installed and maintained where necessary to protect property and the public.
- Underground vaults must include design measures to facilitate cleaning and maintenance. Confined space safety procedures must be followed.

The BMP guidesheets discuss the particular O&M needs of each BMP. The O&M plan in the SMP should contain this BMP-specific information. The developer must create an O&M sheet for each BMP not listed in this Manual.

5.2.4 Implementation Schedule

An inspection and maintenance schedule should be created as part of the O&M plan. This schedule should provide for routine examination of all BMPs and incorporate the varying maintenance needs of each BMP. The City requires that property owners keep an O&M inspection and maintenance logbook. In general, the logbook should note all inspection dates, facility components inspected, and any maintenance performed and repairs made. All inspections and maintenance, both routine and emergency, should be recorded in the logbook. Each BMP-specific O&M sheet should serve as a checklist for design elements that require inspection, the frequency of inspections, and conditions that indicate that maintenance is needed.

5.2.5 Employee Training

Specific individuals should be assigned responsibility for O&M of all onsite BMPs. Employee training should be conducted so that these individuals are aware of proper inspection and O&M procedures. This training schedule should also be incorporated into the O&M plan. All personnel should be familiar with the components of the O&M plan and their personal level of responsibility.

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Appendices

A. Submittal Checklists

B. Hydrologic Analysis Methods

C. BMP Guidesheets

D. Case Studies

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Appendix A: Submittal Checklists

The applicant should review this plan review checklist used by DOB.

PLAN REVIEW CHECK LIST

STORM SEWER AND SANITARY SEWER REQUIREMENTS:		
	Ch II, 3.2.1	RCP not allowed for pipe sizes less than 24” diameter
	Ch II, 3.2.3	Maintain minimum pipe slopes
	Ch II, 3.2.3	Confirm storm sewer flowing full velocity does not exceed 10 ft/sec
	Ch II, 3.3	Confirm that structures are large enough to make pipe connections
	Ch II, 3.2.2	Provide a 5 year minimum storm sewer calculation with a scaled drainage area map (required only at request of reviewer)
	Ch II, 3.2.2, 3.1	Provide 100 year capacity calculations for storm sewer system-maintain overflow routes (only required when storm sewers are used to convey overflow runoff)
	Ch II, 3.2.1	Confirm that there is adequate horizontal and vertical spacing between utilities
	Ch II, 3.2.1	Confirm all crossings are labeled with elevations for each pipe
	Ch II, 3.2.1, 3.2.3	Label all pipes with size, length, slopes, and material type
	Ch II, 3.2.4	Provide minimum pipe cover: VCP=3.0’, RCP=IDOT standards, and sanitary=3.5’
	Ch II, 3.3.1	Provide minimum structure spacing: 6”-10”=150’, 12”-54”=330’, 60”+=660’
	Ch II, 3.4.4	Do not exceed maximum connection size to sewer
	Ch II, 3.4	Maintain minimum spacing of 15 feet between private drain connections to the city sewer.
	Ch II, 3.4.4	Label size of existing city sewer; provide city sewer invert elevation at connection and invert of connecting sewer at connection.

GRADING AND DRAINAGE PLAN:		
	Ch III, 3.9 Ch II, 2.1	Provide sufficient grades to demonstrate proper drainage, as noted or checked below:
	Ch II, 3.1	Drainage from ROW and private property must be kept separate.
	Ch II, 3.1	No more than 400 sf impervious area sheet flow to the ROW.
	Ch II, 3.1	No more than 1500 square feet or 5 foot wide strip of contiguous at grade pervious area must sheet flow directly to the ROW.
	Ch II, 2.1.1	Show limits of maximum ponding and overflow locations.
	Ch III, 3.1	Min. freeboard requirement, 0.1 feet for HWL, overflow, and adjacent property.

	Ch II, 3.1	Min. gutter slope, 0.4%.
	Ch II, 3.1	Min. pavement slope, 1.0%.
	Ch II, 3.1	Provide CDOT standard detail of public alley cross-section.
	CDOT Std.	Follow CDOT/ADA standards for proper street and sidewalk grades.
	Appendix IIE, EFP	Meet City ordinance grades to within 0.2 feet
	Ch III, 3.14	Sites adjacent to waterways must discharge to and overflow to the waterway.
	Appendix IIE, EFP	Show proper restrictors in catch basins in ROW.
	Appendix IIE, EFP	No structures in the ROW without proper justification.
	Ch II, 3.1.1 App. IIB	Show location of downspouts.

DWM STANDARD DETAILS:		
	Ch II, 2.1	Provide DWM standard details for sewer structures, as noted or checked below:
	Ch III, 3.9	Show detail of restrictor and/or control roof heads.
	Ch II, 3.4	Show proper connection detail.
	Ch III, 4.1.1	Include special infiltration lid details, as needed.
	Ch II, 3.4	Provide detail of collar connection (with SE seal) to brick sewers.
	Ch III, 5.2.2	Provide signage for stormwater outfalls to waterways.
	Appendix IIE, EFP	Provide restrictors in catch basins in the ROW.

RATE CONTROL BMPS:		
--Detention Basins		
	Ch III, 3.2	If the outlet from a dry bottom basin is less than 2 feet above of the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the basin.
	Ch III, 3.2	Dry bottom basins must be capable of draining within 72 hours of a storm event.
	Ch III, 3.2	Maintenance access to the facility must be provided.
	Ch III, 3.2	The bottom of the storage area in a detention basin must be above the seasonally high groundwater table.
	Ch III, 3.2	For wet detention basins, a safety ledge at least 4 feet in width must be constructed at a depth of 1 to 2 feet below the normal water surface.

	Ch III, 3.2	Wet detention basins without vegetation shall be at least 3 feet deep. The side slopes shall be no steeper than 3H:1V without erosion protection. The sides of the pond that extend below the safety and aquatic benches to the bottom of the pond must have a slope that will remain stable, and be no steeper than 2H:1V. For dry bottom detention basins, side slopes shall be 4H:1V or flatter.
	Ch III, 3.2	A sediment forebay shall be incorporated into all wet bottom detention basins.
	Ch III, 3.2	After excavation and grading of a stormwater wetland basin, at least 6 inches of topsoil must be applied to the basin bottom and sideslopes. Reference Stormwater Manual.
	Ch III, 3.2	At sites where infiltration is too rapid to sustain permanent soil saturation, analysis of the proposed plantings or intended wetland functions must be undertaken. If needed, an impermeable liner (geotextile fabric) shall be designed to maintain adequate hydrology. Where the potential for groundwater contamination is high, such as runoff from sites with a high potential pollutant load, the use of a liner is required.
	Ch III, 3.2	Basins incorporating wetlands shall include a buffer to separate the wetland from surrounding land where feasible.

--Detention Vaults		
	Ch III, 3.2	Detention vaults under buildings designed only for a 10-year storm capacity shall be provided with means to safely accommodate 100-year overflows.
	Ch III, 3.2	Detention vaults under buildings must be water tight and must be made of concrete—cast-in-place vault, pre-cast vault, or RCP.
	Ch III, 3.2	Buildings with underground storage vaults (with less than 100-year capacity) must have plans (with backup calculations) sealed by a licensed architect or structural engineer to safeguard against structural failure of floor foundations and downspouts due to hydrostatic pressures during sewer surcharges.
	Ch III, 3.2	Proper ventilation of underground vaults for buildings must be provided in accordance with Building Code Articles 9 and 11, as applicable, to equalize interior downspout pressures and to prevent siphoning effects through the piping and sewer systems.
	Ch III, 3.2	Vaults must be designed to be water-tight unless used for groundwater infiltration purposes or unless the bottom of the vault is at least 7 feet above the groundwater table.
	Ch III, 3.2	For vaults using infiltration*, the underlying soil must have at least a 0.5 in/hr infiltration rate and the bottom of the vault must be at least 3.5 feet above the groundwater table when connected to a combined sewer. Means to control sediment and/or debris from entering the vault must be provided. Pretreatment measures are required for all infiltration vaults.
	Ch III, 3.2	If the outlet from a vault is lower than the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the vault.

--Oversized Pipes		
	Ch III, 3.2	Locking manhole covers shall be provided for pipe diameters 4 feet and larger in areas where children may be present.
	Ch III, 3.2	If the outlet from an oversized pipe is lower than the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the oversized pipe.
	Ch III, 3.2	Structures for oversize pipe must be properly sized.

--Parking Lot Detention		
	Ch III, 3.2	Maximum allowable ponding in a parking lot shall be 12 inches. If more than 10 inches of ponding, the O&M Plan must indicate such.
	Ch III, 3.2	Adequate visible warning must be provided for any depressed islands during flood stage.

--Rooftop Detention		
	Ch III, 3.2	Provide a grading plan of the roof and inlets to verify available storage.
	Ch III, 3.2	Show details and hydraulic characteristics of any controlled roof drains in the Plan.
	Ch III, 3.2	Minimum orifice size for restricted roof drains is 0.75 inches.
	Ch III, 3.2	Provide scuppers or overflows to accommodate 100-year storm events.
	Ch III, 3.2	Include approval and seal from a Registered Structural Engineer or Licensed Architect.
	Ch III, 3.2	In addition to other applicable code requirements, Sections 18-29-1105, 1106, and 1110 of the Municipal Code must be complied with.

--Restrictors		
	Ch III, 3.2	The maximum discharge released is equal to or less than the maximum permissible release rate for the site.
	Ch III, 3.2	DWM standard 3-inch vortex restrictors utilize 8-inch diameter outlet pipes to achieve a release rate of 0.15 cfs. Standard 3-inch vortex restrictors shall be obtained from DWM. See the Appendix II-A Sheet A.21.
	Ch III, 3.2	If a release rate less than 0.125 cfs or greater than 0.20 cfs is required, a custom vortex restrictor must be specified unless a plate restrictor can be used. Custom vortex restrictors shall be obtained from approved manufacturers. The plans must clearly indicate the manufacturer, model number and opening size for custom vortex restrictors. Custom vortex restrictors shall be designed to utilize 8-inch diameter outlet pipes, and the minimum interior opening size shall be 2.5 inches. See Appendix II-F for approved manufacturers.
	Ch III, 3.2	Steel plate restrictors shall be specified when the minimum orifice size of 2.5 inches can be met. See Appendix II-A Sheet A.27.
	Ch III, 3.2	Vortex restrictors and plate restrictors shall be submerged in a catch basin to prevent clogging by providing a half-trap on the

		outlet pipe and a 2-foot minimum sump.
	Ch III, 3.2	Storage facilities upstream of restrictor with half trap must be clear of standing water.
	Ch III, 3.2	The restrictor must be easily accessible for DWM inspection and for owner inspection and maintenance.
	Ch III, 3.2	For sites that combine sanitary sewage and stormwater downstream from a restrictor, see the Stormwater Manual, Section 2.4.1 for recommended design guidelines.

VOLUME CONTROL BMPS:		
--Bioinfiltration Systems		
	Ch III, 4.2	The design of a bioinfiltration facility shall allow no more than 12 inches of depressional ponding in the vegetated area.
	Ch III, 4.2	The growing medium soil must be a mix of 40% sand, 30% topsoil and 30% compost. The soil must be at least 2 feet deep and must be 4 inches deeper than the largest planted rootball.
	Ch III, 4.2	The underlying soil shall have a permeability of 0.5 in/hr or greater. If the underlying soils do not meet the permeability requirement, underdrains may be installed.
	Ch III, 4.2	Bioinfiltration systems must be designed to drain within 5 days of a storm event.
	Ch III, 4.2	Soil borings or other data must verify that the depth to groundwater table is greater than 2 feet from the bottom of the BMP (or lowest excavated elevation), or 3.5 feet when connected to a combined sewer system.
	Ch III, 4.2	The water flowing to a bioinfiltration facility requires pretreatment for sediments. Where such pretreatment is not provided by an upstream BMP facility, it must be included in the bioinfiltration facility design.
	Ch III, 4.2	The bioinfiltration facility shall be located at least 10 feet down gradient from buildings, otherwise submit affidavit in Appendix IIB.
	Ch III, 4.2	Maintenance access to the facility must be provided.
	Ch III, 4.2	Measures to avoid clogging and compaction of the bioinfiltration facility are required during construction.
	Ch III, 4.2	If the bioinfiltration system includes storage in the void spaces of an aggregate layer, the aggregate layer must be completely surrounded by filter fabric and must be comprised of crushed angular stone free of fines. For IDOT gradations CA-1 and CA-7, the maximum aggregate porosity of 0.38 may be used.
	Ch III, 4.2	If the lowest underdrain invert under a bioinfiltration system is less than 1 foot above the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the bioinfiltration system.

--Drainage Swales		
	Ch III, 4.2	Velocities must be 1 ft/sec or less during the 2-year storm event.
	Ch III, 4.2	Longitudinal slope must be between 0.5 and 2.5%
	Ch III, 4.2	Utilize 3H:1V side slopes or flatter. Use slope protection when

		side slopes are steeper than 3H:1V.
	Ch III, 4.2	Surface volume control storage must be provided behind check dams or the infiltration benefit must be computed.
	Ch III, 4.2	The growing medium soil must be a mix of 40% sand, 30% topsoil and 30% compost. The growing medium soil must be at least 2 feet deep.
		If the drainage swale includes storage in the void spaces of an aggregate layer, the aggregate layer must be completely surrounded by filter fabric and must be comprised of crushed angular stone free of fines. For IDOT gradations CA-1 and CA-7, the maximum aggregate porosity of 0.38 may be used.
	Ch III, 4.2	Soil borings or other data must verify that the depth to groundwater table is greater than 2 feet from the bottom of the BMP (or lowest excavated elevation), or 3.5 feet when connected to a combined sewer system.
	Ch III, 4.2	The underlying soil shall have a permeability of 0.5 in/hr or greater. If the underlying soils do not meet the permeability requirement, underdrains may be installed.

--Green Roofs		
	Ch III, 4.2	A structural engineer or architect's seal must be included on the Plans to approve of load-bearing capacities of the proposed roofs.
	Ch III, 4.2	The maximum permissible slope for extensive green roof systems shall be 25 percent.
	Ch III, 4.2	The maximum permissible slope for intensive green roof systems shall be 10 percent.

--Natural Landscaping		
	Ch III, 4.2	Areas of natural landscaping shall be planted with deep-rooted vegetation.
	Ch III, 4.2	The soil must consist of sandy loam, loamy sand, or a loam with clay content less than 25% and sand content greater than 50%, or a prepared growing medium soil with a mix of 40% sand, 30% topsoil and 30% compost.

--Permeable Paving		
	Ch III, 4.2	Subsoils must have at least a 0.5 in/hr infiltration rate or greater. Otherwise, an underdrain system must be used if soil infiltration rates do not meet this requirement.
	Ch III, 4.2	The bottom of the aggregate shall be at least 2 feet above the groundwater table or bedrock; if discharging to a combined sewer, the outlet pipe must be at least 3.5 feet above the water table.
	Ch III, 4.2	Compaction of the soils underlying the permeable pavement system must be avoided during construction.
	Ch III, 4.2	Permeable pavement or infiltration systems must be situated at least 10 feet down gradient from buildings that are not water proofed against basement seepage, otherwise submit affidavit in Appendix II-B.
	Ch III, 4.2	Minimum and maximum slopes on permeable paving shall be 0.5

		percent and 5 percent, respectively.
	Ch III, 4.2	All aggregate material shall be crushed angular stone and free of fines. For IDOT gradations CA-1 and CA-7, the maximum aggregate porosity of 0.38 may be used. Aggregate material shall be surrounded by filter fabric on the bottom and sides but not the top.
	Ch III, 4.2	When using an underdrain system, the water level within the underlying stone base may not rise to within 8 inches of the permeable pavement surface for a 10 year storm event.
	Ch III, 4.2	The underlying stone base must be designed to drain within 48 hours of a storm event.
	Ch III, 4.2	When using an underdrain system, any impermeable subsoil material must be graded with a minimum 1 percent slope to such system, and the top 3 inches of impermeable soil must be mixed with at least 3 inches of sand.
	Ch III, 4.2	For pervious concrete, signage must be placed on the property that states, "This surface is pervious concrete pavement. No sealcoat or overlay material is to be used on this pavement. Call XXX-XXXX before treating this pavement with any material." Insert the number of the property management company.
	Ch III, 4.2	When an area of conventional impervious pavement drains toward permeable pavement, a maximum ratio of 3:1 impervious to permeable is allowed.
	Ch III, 4.2	If the lowest underdrain invert under permeable pavement is less than 1 foot above the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the permeable pavement.

--Rooftop Runoff BMPs (Planter Boxes, Rain Barrels and Cisterns)		
	Ch III, 4.2	If a rain barrel or above ground cistern will hold more than a 6-inch depth of water below the drain, it must be securely covered to prevent small children from gaining access to the standing water and to prevent mosquitoes from breeding.
	Ch III, 4.2	Above ground cisterns with a capacity of more than 55 gallons must be designed with proper structural foundations.
	Ch III, 4.2	Rain barrels and cisterns must include inlet screens to minimize the number of foreign objects entering the vessels.
	Ch III, 4.2	Excess water entering the rain barrel or cistern must be designed to overflow to a treatment train or stormwater conveyance system.
	Ch III, 4.2	The system must have a convenient and functional means of water withdrawal.
	Ch III, 4.2	The system, if applicable to stormwater detention, will receive credit for up to 10 percent of the required site storage and must be drained within 14 days of a storm event.

--Stormwater Trees		
	Ch III, 4.2	New trees or existing trees must be on the development site within 20 feet of an on-site impervious surface to count as a volume control BMP. They must also be at least 2 inches in diameter at 4.5 feet above ground level.

--Vegetative Filter Strips		
	Ch III, 4.2	The entire filter strip area shall be more than 2 feet above the groundwater table.
	Ch III, 4.2	Filter strips must have longitudinal slopes of 1 to 5 percent (2 percent optimum) in the direction of flow.
	Ch III, 4.2	The longest flow path of the contributing drainage areas must not exceed 75 feet.
	Ch III, 4.2	A level spreader is required whenever the tributary area is not uniformly sloped toward the filter strip..
	Ch III, 4.2	When filter strips are used to accept roof runoff for the purposes of volume control, a level spreader must be utilized. The hydraulic loading rate may not exceed 75 feet of roof per one foot of filter strip width.
	Ch III, 4.2	The soil must consist of sandy loam, loamy sand, or a loam with clay content less than 25% and sand content greater than 50%, or a prepared growing medium soil with a mix of 40% sand, 30% topsoil and 30% compost. The approved soil type must be at least 18 inches deep.
	Ch III, 4.2	The slope upgradient of a level spreader must be less than 1 percent for at least 20 ft while the slope downgradient must be less than 6 percent.
	Ch III, 4.2	The length and depth of the level spreader must be at least 6 inches.
	Ch III, 4.2	Level spreader must be absolutely level along its width.

STORMWATER CALCULATIONS:		
	Ch III, 4.4	Provide sufficient volume control runoff calculations, as noted or checked below:
	Ch III, 3.9	Provide sufficient rate control runoff calculations, as noted or checked below:
	Ch III, 3.4.2, 3.9	Provide sufficient backup for release rates, calculations and/or drainage areas.
	Ch III, 3.4.5	Proposed discharge rate cannot exceed existing discharge rate.
	Ch III, 3.7	Submit separate calculation form for each restrictor/drainage area.
	Ch III, 3.9	Submit documentation of existing drainage and DWF conditions.
	Ch III, 3.8.1	Utilize frustum of cone equation for available surface ponding.
	Ch III, 3.7.1	Storage in ROW must be accessible and conform with available street grades.
	Ch II, 3.5	DWF (without peaking factors) exceeding 10% of the release rate must be considered in the overall release rate.
	Ch II, 3.4.2	Uncontrolled runoff from impervious areas must be compensated by a decrease in discharge at other outlets.
	Ch III, 3.6	Restrictors must be sized in accordance with the maximum release rate and upstream tributary area.
	Ch II, 3.5 Ch III, 4.1.4	Reduce restrictor size to fully utilize available volume.
	Ch II, 3.6	Flow diversion must be considered (i.e., reduction in release rates) for vacant lots or change in existing connection locations.
	Ch II, 3.1.2	Provide 25 year calculation check for by-pass flows onto site.
	Ch III, 3.1.5	Provide calculations for building rehabilitations exceeding 15,000 sf.
	Ch III, 4.3	Provide adequate geotechnical information (i.e., # of soil borings).
	Ch III, 4.3	Provide percolation tests to substantiate infiltration rate above 1.4”/hr
	Ch III, 3.5.1	Submit sewer connection alternative analysis for sites greater than 1.75 acres.

SEDIMENT AND EROSION CONTROL PLAN:		
	Ch III, 5.2.2	Submit Erosion Control Plan for sites adjacent to waterways with revisions, as noted or checked below:
	Ch III, 5.2.2	Show permanent stabilization measures including landscape seeding and sodding plans.
	Ch III, 5.2.2	Provide means of accommodating 2-year stormwater flows onsite and by-passed during construction.
	Ch III, 5.2.2	Provide proper maintenance schedule for each erosion control measure. During construction, each erosion control measure shall be inspected weekly or after more than 0.5-inch of rainfall.
	Ch III, 5.2.2	Show temporary erosion and sediment control measures applicable to each phase of construction activity.

O&M PLAN:		
	Ch III, 6.1	Submit O&M Plan for Regulated developments with revisions, as noted or checked below:
	Ch III, 6.2	O&M Plan must be signed by the owner and notarized using the Operation and Maintenance Plan Owner's Certification Statement, Appendix II-A, Sheet A.22. A copy of the O&M plan must be provided to each new owner before the consummation of a sale, and the O&M Plan must be signed by the new owner, notarized, and submitted to the City to be kept on record.
	Ch III, 6.2	O&M Plan procedures and practices must be reviewed and assessed annually.
	Ch III, 6.2	Access routes including roadways and sidewalks shall be inspected annually and maintained as needed.
	Ch III, 6.2	Drainage structures and flow restrictors must be inspected and cleaned semi-annually.
	Ch III, 6.2	Volume control BMPs shall be inspected semi-annually and after significant rainfall events exceeding 1.5 inches.
	Ch III, 6.2	The Owner shall keep an updated log book documenting the performance of the required O&M activities for perpetuity. Log books must be produced upon the request of a City inspector.
	Ch III, 6.2	Vegetation shall be maintained on a regular basis.
	Ch III, 6.2	Pest control measures shall be implemented to address insects and rodents.
	Ch III, 6.2	Signage and fencing shall be installed and maintained where necessary to protect property and the public.

	Ch III, 6.2	Underground vaults must include design measures to facilitate cleaning and maintenance. Confined space safety procedures must be followed.
	Ch III, 3.8.2	Include dewatering schedule for stormwater capture facilities.
	Ch III, 3.2	Identify areas with more than 10-inches of surface ponding.

OTHER SUBMITTALS AND REQUIREMENTS		
	Ch III, 4.2	Provide Affidavit for Infiltration and Disconnection of Downspouts, Appendix IIB.
	Ch III, 5.2.1	Provide Affidavit for Soil Erosion and Sediment Control, Appendix IIC.
	Ch II, 4.0	Contact DWM for sewer work in the ROW/easements.
	Ch III, 2.0.2	Contact DWM for variances or unclear storage requirements.
	Ch III, 2.0.4	Requires Plan Amendment Submittal
	Ch II, 3.4, 4.0.1 Ch III, 2.0, 2.0.5	Provide proper professional seals on plans.

Reference DWM Stormwater Regulations, 11-18-110 of the Municipal Code

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Appendix B: Hydrologic Analysis Methods

Hydrologic Analysis Methodologies

Hydrologic analysis requires applying the concepts of urban hydrology to estimate the amount of runoff generated from precipitation falling on the development site. Hydrology is not an exact science, and hydrologic procedures are therefore approximate. In most situations, site-specific data are seldom available. It is therefore quite common to use semi-empirical relationships and alternative sources of data in hydrologic analyses. Calibration or adjustment of such data to reflect site-specific characteristics is highly recommended.

This appendix briefly discusses hydrologic analysis methodologies used in calculations required for stormwater management. The purposes of this appendix are (1) to assist the applicant in choosing the appropriate level of hydrologic analysis for the development site and (2) to provide the applicant with methodologies needed to design stormwater management systems for the development site. The Rational Method is described in detail as well as the Modified Rational Method used by the City of Chicago (City) for detention calculations. Several other methodologies are also discussed. These methodologies may be needed for more complex analysis.

RATIONAL METHOD

The Rational Method is an empirical approach used to estimate peak flows in small urban watersheds. The subsections below discuss data considerations, the equations and parameters for the method, and the applicability and limitations of the method. The basis for the discussion below is *Applied Hydrology* (Chow and others 1988). The charts, graphs, and tables included in this section are not intended to replace reasonable and prudent engineering judgment.

Data Considerations

Site-specific data must be gathered before hydrologic analysis can begin. Typical data to be gathered include topographic maps, storm sewer maps, aerial photographs, stream flow records, historical high water elevation data, flood discharge data, and locations of hydraulic structures such as outfalls and road crossings. Such data are used to determine the following:

- Watershed characteristics, including size, shape, slope, land use, soil type, surface infiltration, and storage
- Flow-path characteristics, including geometry, configuration, and natural and artificial controls

In addition, rainfall data must be collected. The quality of the rainfall data available is the single most important factor affecting the accuracy of final hydrologic analysis results. The Chicago Department of Water Management (DWM) requires the use of the City rainfall data to perform all hydrologic analyses of stormwater management facilities. The City rainfall data are included in Table B-1 and consist of rainfall intensity durations for various return frequencies and associated rainfall intensity frequency curves. For regulatory purposes, other jurisdictions such as the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) or Illinois Department of Transportation (IDOT) may require the use of sources of rainfall data that differ from the City rainfall data shown in Table B-1. The City of Chicago may require the use of the Illinois State Water Survey (ISWS) Bulletin 70 rainfall data (Huff and Angel 1989) on sites larger than 20 acres. The applicant must consult with the relevant jurisdictions to obtain approval of the rainfall data used prior to performing any hydrologic analyses.

Equations and Parameters

The basis for the Rational Method is that if a rainfall of intensity "i" begins instantaneously and continues indefinitely, the rate of runoff will increase until the time when the whole watershed is contributing to flow at the outlet - referred to as the time of concentration (T_c). The Rational Method is expressed by the following equation:

$$Q_p = k_c * C * i * A \quad \text{(B-1)}$$

where

Q_p	=	Peak flow (cubic feet per second [cfs])
k_c	=	Conversion factor to convert acre-inch per hour to cfs, approximately equal to 1
C	=	Runoff coefficient (unitless)
i	=	Rainfall intensity (inch per hour)
A	=	Catchment area contributing flow to the outlet (acres)

Equation variables C, i, and A are discussed below.

Runoff Coefficient (C) - The runoff coefficient is the least precise parameter in the Rational Method equation. It is known, however, that because impervious surfaces such as asphalt parking lots convert almost all rainfall into runoff, the coefficient for such surfaces is close to 1.0. By contrast, pervious surfaces such as lawns have much smaller C-values because a significant portion of the rainfall infiltrates (or is lost) into the ground. The DWM has developed a table that presents recommended C-values for different percentages of impervious area potential for various surfaces to generate runoff. These tables are presented in the MS Excel spreadsheet discussed in Section 2.0. Because few sites are homogenous, an overall representative C-value or composite runoff coefficient can be determined based in part on the percentage of different types of surfaces in the drainage area.

The composite or area-weighted runoff coefficient of a site can be calculated using the following equation:

$$C_w = (A_1C_1 + A_2C_2 + A_3C_3) / (A_1 + A_2 + A_3) \quad \text{(B-2)}$$

where

C_w	=	Area-weighted runoff coefficient (unitless)
A_n	=	Area of sub-area "n" (square feet [ft^2])
C_n	=	Runoff coefficient for subarea "n" (unitless)

TABLE B-1

CITY OF CHICAGO RAINFALL INTENSITIES AND DEPTHS

City of Chicago
Department of Water Management

Name of Project: ____________________
Address: ____________________
A/E of Record: ____________________

(FOR COMPUTATIONS AND REFERENCE)

City of Chicago Intensity-Duration-Frequency (IDF) Curve

(Based Bulletin 75 Rainfall Data)

		Storm Event in Years									
		5-Year 20% Annual Chance		10-Year 10% Annual Chance		25-Year 4% Annual Chance		50-Year 2% Annual Chance		100-Year 1% Annual Chance	
	Storm Duration (min)	Rainfall (in)	Average Intensity (in/hr)	Rainfall (in)	Average Intensity (in/hr)	Rainfall (in)	Average Intensity (in/hr)	Rainfall (in)	Average Intensity (in/hr)	Rainfall (in)	Average Intensity (in/hr)
5 minute	5	0.52	6.240	0.62	7.440	0.77	9.240	0.90	10.800	1.03	12.360
10 minute	10	0.90	5.400	1.08	6.480	1.35	8.100	1.58	9.480	1.80	10.800
15 minute	15	1.16	4.640	1.39	5.560	1.74	6.960	2.03	8.120	2.32	9.280
30 minute	30	1.59	3.180	1.91	3.820	2.39	4.780	2.78	5.560	3.17	6.340
1 hour	60	2.02	2.020	2.42	2.420	3.03	3.030	3.53	3.530	4.03	4.030
2 hours	120	2.49	1.245	2.99	1.495	3.74	1.870	4.35	2.175	4.97	2.485
3 hours	180	2.75	0.917	3.30	1.100	4.13	1.377	4.80	1.600	5.49	1.830
6 hours	360	3.23	0.538	3.86	0.643	4.84	0.807	5.63	0.938	6.43	1.072
12 hours	720	3.74	0.312	4.48	0.373	5.61	0.468	6.53	0.544	7.46	0.622
18 hours	1080	4.04	0.224	4.84	0.269	6.06	0.337	7.05	0.392	8.06	0.448
24 hours	1440	4.30	0.179	5.15	0.215	6.45	0.269	7.50	0.313	8.57	0.357
48 hours	2880	4.71	0.098	5.62	0.117	6.99	0.146	8.13	0.169	9.28	0.193
72 hours	4320	5.08	0.071	6.05	0.084	7.49	0.104	8.64	0.120	9.85	0.137
5 days	7200	5.63	0.047	6.68	0.056	8.16	0.068	9.39	0.078	10.66	0.089
10 days	14400	7.09	0.030	8.25	0.034	9.90	0.041	11.26	0.047	12.65	0.053

Rainfall Intensity (i) - Rainfall intensity is the average rate of rainfall in inches per hour. The intensity value is selected based on the design frequency of occurrence, a statistical parameter established by design criteria and rainfall duration. Rainfall intensities for various storm frequencies and durations are obtained from Table B-1, which depicts the City rainfall data up to a 100-year storm event and for storm durations from 5 minutes to 24 hours.

Area (A) – Area is the drainage area and is typically calculated in acres. The drainage area is the entire area from which runoff eventually ends up at one point. To apply the Rational Method, an accurate, detailed topographic map of the site is needed to define the boundaries of the drainage areas in question. A field inspection of the area should also be conducted to determine if natural drainage divides have been altered.

Applicability and Limitations of the Rational Method

The Rational Method is best applied to small watersheds of less than 20 acres. Characteristics of the Rational Method which limit its use to small watersheds are summarized below.

- The rate of runoff resulting from any storm is at a maximum when the storm lasts as long or longer than the time of concentration (T_c) (that is, the entire drainage area does not contribute to the peak discharge until the time of concentration has elapsed). This assumption limits the size of the drainage basin that can be evaluated using the Rational Method. For large drainage areas, the time of concentration can be so large that constant rainfall intensities for such long periods do not occur, and shorter, more intense rainfalls can produce larger peak flows.

- The fraction of rainfall that becomes runoff is assumed to be independent of rainfall intensity. This assumption is reasonable for impervious areas, such as streets, rooftops, and parking lots. For pervious areas, the fraction of runoff varies with rainfall intensity and the accumulated volume of rainfall. Thus, application of the Rational Method involves the selection of a coefficient that is appropriate for the storm, soil, and land-use conditions at the development site.

- The peak rate of runoff is assumed to be sufficient information for designing storm sewers and culverts. Modern drainage practices often include detention of urban storm runoff to reduce the peak rate of downstream runoff. The Rational Method severely limits the evaluation of design alternatives available in urban and in some instances rural drainage areas because it is based on peak runoff rates only.

- The frequency of peak discharges is the same as that of the rainfall intensity for the given time of concentration (T_c). Frequencies of peak discharges depend on rainfall frequencies, antecedent moisture conditions in the watershed, and the response characteristics of the drainage system. For small and largely impervious areas, rainfall frequency is the dominant factor. For larger drainage basins, the response characteristics control the frequency of the peak runoff. For drainage areas with few impervious surfaces, antecedent moisture conditions usually govern frequency of peak discharges, especially for rainfall events with a return period of 10-years or less.

- Restrictions to the natural flow (storage areas) such as highway crossings in the drainage area may cause the time of concentration (T_c) to increase, changing the runoff characteristics.

MODIFIED RATIONAL METHOD

The City uses the Rational Method in a slightly different manner. The same basic equation is used (Equation B-1), but the City incorporates several assumptions to simplify the process. Modifications to the Equation B-1 variables C, i, and A are discussed below as well as the methodology used to calculate detention volume requirements.

Runoff Coefficient (C) - By assuming an instantaneous time of concentration (T_c), the runoff coefficients (or C-values) can be defined in terms of runoff volume rather than runoff flow rate. This approach dramatically simplifies the stormwater management process because it allows the volume reduction calculations for the best management practices (BMP) to directly modify the C-values based on the following equation (this calculation is performed by the **Stormwater Spreadsheet Tool**):

$$C_r = C_o * (V_r/V_o) \qquad \text{(B-3)}$$

where

C_r = Runoff coefficient after the volume reduction BMP is considered (unitless)

C_o = Runoff coefficient without the volume reduction BMP (unitless)

V_r = Volume of runoff after volume reduction BMP is considered (ft^3)

V_o = Volume of runoff without volume reduction BMP (ft^3)

Rainfall intensity (i) - For the Rational Method, the critical rainfall intensity is the rainfall having duration equal to the time of concentration (T_c) of the drainage basin. To simplify calculations, the City usually does not require the calculation of T_c. The City has developed a simple table of different rainfall intensities for the 100-year storm (see Figure 3-1 in Section 3.2 of this Manual). The table calculates the detention volume required for each intensity, and the detention required is the maximum volume of all the intensities for each area combined.

Area (A) - Typically in the City, the drainage area is defined as the area that discharges into a sewer outlet.

Detention - The City methodology for determining detention or storage volume involves calculating a required storage volume for a series of storm durations and intensities from 5 minutes to 24 hours using the following equation:

$$V_s = (Q_i - Q_o) * t \qquad \text{(B-4)}$$

where:

V_s = Storage volume (cubic feet [ft^3])

Q_i = Inflow rate (cfs)

Q_o = Release rate (cfs)

t = Storm duration (seconds)

The largest calculated storage volume is then selected as the amount of detention or storage required.

The inflow rate is calculated using Equation B-1 with the runoff coefficient and drainage area specified as characteristics of the watershed. The inflow rate is the flow entering the detention basin; it would equal the peak flow calculated in Equation B-1 if the detention basin is designed to detain all the runoff from the area for which the peak flow was calculated. Otherwise, inflow rate is a percentage of peak flow. The rainfall intensities for each storm duration are presented in Table B-1. The release rate is determined by the detention facility outlet. Section 3.0 describes the calculation of detention volume.

OTHER METHODOLOGIES

Other methodologies can be used to determine the appropriate stormwater runoff volume from a watershed. Hydrograph methods predict the runoff or hydrograph from a site as a function of time. Hydrograph methods produce both peak discharges and runoff volumes. Hydrograph methods are further described as “single event” or “continuous” models depending on the manner used to generate the hydrograph. Continuous models are able to model the complex interactions of precipitation and evaporation over time.

For large watersheds exceeding 20 acres, a more complex approach to computing runoff may be more appropriate than use of the Rational or Modified Rational Methods. Complex approaches may also be necessary if the watershed drainage pattern is complicated by presence of significant flow-modifying structures. Such situations generally warrant a more complex hydrologic model using hydrograph procedures. The applicant should consult with DWM/DOB regarding appropriate hydrograph procedures for determining the stormwater detention requirements.

The most commonly used hydrograph modeling packages are summarized below.

HEC-1 and HEC-HMS - The U.S. Army Corps of Engineers Hydrologic Engineering Center (HEC) developed the Flood Hydrograph Package HEC-1. This model has been replaced by the Hydrologic Modeling System (HEC-HMS), which was derived from the HEC–1 model and which performs similar calculations within a graphical context. HEC-HMS is used to simulate single events or continuous precipitation covering a variety of precipitation and runoff processes. The precipitation model provides options to include historical or hypothetical storm event data or a specific weighted-gage method. Modeling can be performed in a linear or consolidated manner by using various methods to determine losses, including the use of National Resource Conservation Service (NRCS) Curve Numbers. Information for obtaining HEC-HMS software and support documentation is available at www.hec.usace.army.mil/

Technical Release No. 20 – NRCS developed Technical Release No. 20, “Computer Program for Project Formulation – Hydrology” (TR-20). This program has been modified by the NRCS and other groups. The program is used to simulate single-event precipitation covering a variety of runoff processes and can process data for multiple storm events in a single computer run. TR-20 uses the procedures described in the National Engineering Handbook, Section 4, Hydrology (NRCS NEH-4).

Information for obtaining TR-20 software and support is available at www.wwc.nrcs.usda.gov/water/quality/frame/hydrology.html

Technical Release No. 55 - Technical Release No. 55, "Urban Hydrology for Small Watersheds" (TR-55), presents simplified procedures to calculate storm runoff volume and peak rate of discharge, generate hydrographs, and calculate storage volumes required for detention structures. The release's primary function is determining curve numbers and times of concentration. Information for obtaining Technical TR-55 software and support is available at www.wwc.nrcs.usda.gov/water/quality/frame/hydrology.html

Stormwater Management Model (SWMM) - Under the sponsorship of the U.S. Environmental Protection Agency (EPA), a comprehensive SWMM capable of representing urban stormwater runoff and combined sewer overflow phenomena was developed. SWMM can be run in a single-event mode or in a continuous manner. SWMM simulates the runoff of a drainage basin for any prescribed rainfall pattern incorporating both water quantity and quality aspects associated with urban runoff and combined sewer systems. Information for obtaining the SWMM software and support documentation is available at www.epa.gov/ednnrmrl/swmm/

REFERENCES

Chow, V.T, and others. 1988. *Applied Hydrology.* McGraw-Hill, Inc., Burr Ridge, IL.

Huff, F.A., and J.R. Angel. 1989. "Rainfall Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois." Bulletin 70, Illinois State Water Survey.

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Appendix C: BMP Guidesheets

BIOINFILTRATION SYSTEMS GUIDESHEET

Overview

Bioinfiltration systems are features such as basins or trenches that collect stormwater from surrounding impervious areas. These flow regulating structures pass inflow through a shallow depressed area containing plants, mulch, and a prepared soil. A rain garden is a good example of a bioinfiltration system. Bioinfiltration is very effective at reducing runoff volume and removing pollutants, especially when used as parking lot islands. As with drainage swales and vegetated filter strips, bioinfiltration systems work best when used to collect runoff from small storm events. In some cases, bioinfiltration systems can be used in conjunction with sewer systems by incorporating underground perforated pipes or overflow inlets. The following sections provide Design Guidelines, Minimum Design Requirements, Maintenance Guidelines and a Worksheet for quantifying BMP performance to comply with the Chicago Stormwater Management Ordinance and Regulations.

Design Guidelines

Bioinfiltration systems should be located at least 10 feet downgradient (10 feet laterally, with flow directed away from structure) from structures so that water does not drain into the foundations of the structures. As with the other infiltration BMPs, the subsoils must have a design infiltration rate of at least 0.5 inches per hour. When subsoils do not meet the minimum design infiltration rate, the BMP may still be implemented by using an underdrain.

The primary components of a bioinfiltration system are:

- Pretreatment
- Inlet
- Surface storage (ponding area)
- Organic layer or hardwood mulch
- Growing medium soil
- Native plantings
- Gravel storage bed
- Underdrain, if necessary
- Positive overflow

Pretreatment Pretreatment is recommended for bioinfiltration facilities. Pretreatment prolongs the life of the system by reducing sediment and other pollutant inputs. Bioinfiltration systems work best when pretreatment is provided in the form of drainage swales or vegetated filter strips to reduce the amount of sediment that reaches the infiltration facility. If pretreatment is not provided by an upstream BMP, then it must be designed into the bioinfiltration system by using a plunge pool or sediment forebay sized for 10 percent of the total design storage. If pretreatment is provided within the BMP, the maintenance and the plan should identify the need for removal of sediment from the pretreatment area.

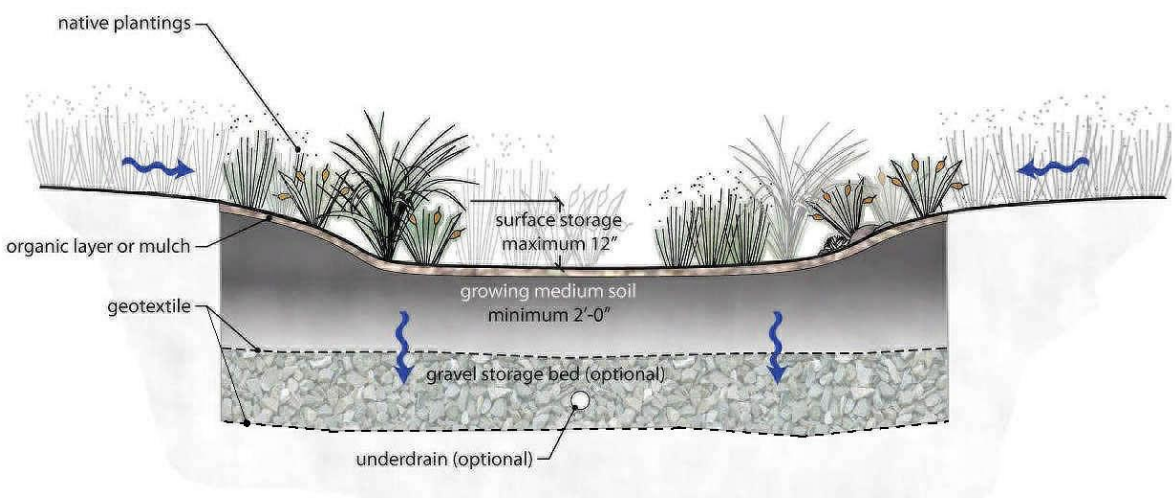


Figure 1: Typical Bioinfiltration Facility

Inlet It is preferred to route runoff to a bioinfiltration area via sheet flow over a filter strip. This is not always possible due to site constraints or space limitations. On sites where curb removal is not an option or where flow is concentrated by the time it reaches the bioinfiltration area, curb cuts coupled with energy dissipators provide an alternative runoff inlet. Disconnected roof leaders that flow into bioinfiltration areas also require energy dissipators to prevent erosion in the bed. Energy dissipation can be provided by cobbles underlain by geotextile fabric.

Surface Storage Surface storage provides temporary storage of stormwater runoff before infiltration and evaporation can occur within the bioinfiltration system. Ponding time provides water quality benefits by allowing larger debris and sediment to settle out of the water. Ponding design depths must be less than 12 inches in order to reduce hydraulic loading of underlying soils, minimize facility drainage time, and prevent standing water.

Organic Layer or Hardwood Mulch An organic layer or mulch can provide a medium for biological growth, decomposition of organic material, adsorption, and bonding of heavy metals. The mulch layer can also serve as a sponge that absorbs water during storms and retains water for plant growth during dry periods.

Growing Medium Soil The planting soil provides a medium suitable for plant growth. The planting soil also acts as a filter and as a hydrologic buffer between the surface storage and the native soil. The prepared planting soil must be at least 2 feet deep and provides additional storage while the water infiltrates into the underlying aggregate or native soil. Storage volume is a function of both soil porosity, soil depth and the size of the bioinfiltration area.

Native Plantings The plant material in a bioinfiltration system binds and removes nutrients and stormwater pollutants through vegetative uptake, removes water through evapotranspiration, and creates pathways for infiltration through root development and plant growth. A varied plant community is recommended to avoid susceptibility to insect and disease infestation and ensure viability. A mixture of groundcover, grasses, shrubs, and trees is recommended to create a microclimate that can ameliorate urban stresses as well as discourage weed growth and reduce maintenance.

Gravel Storage Bed A gravel storage layer can be included to provide storage below the growing medium soil. It must be separated from the growing medium with a layer geotextile fabric. The storage layer should be designed to drawdown in less than 5 days based simply on the design infiltration rate. For example, when considering the depth of surface storage (one foot) and growing medium soil (two feet) and the minimum required design infiltration rate of 0.5 in/hr, the storage bed could be up to 2 feet deep (0.5in/hr / 12in/ft * 5days * 24hours – (3 feet)).

Underdrain An underdrain is a perforated pipe that collects water at the bottom of the system and conveys it to the system outlet. Underdrains intercept, collect, and convey stormwater that has percolated through growing medium soil, a geotextile fabric and a suitable aggregate. When minimum native soil infiltration requirements cannot be met, an underdrain may be employed. Underdrains eliminate most infiltration because they provide a preferential pathway for flow. A sand layer or gravel filter should surround the underdrain to filter sediment and facilitate flow to the underdrain. Underdrains should be located at least six inches from the bottom of the facility.

Positive Overflows A positive overflow is provided at the maximum ponding depth. When runoff exceeds system storage capacity, the excess flow leaves the system through the positive overflow. The overflow can connect to a system that will provide peak rate control.

Minimum Design Requirements
The design of a bioinfiltration facility shall allow no more than 12 inches of depressional ponding in the vegetated area.
The growing medium soil must be a mix of 40% sand, 30% topsoil and 30% compost. The soil must be at least 2 feet deep and must be 4 inches deeper than the largest planted rootball.
The underlying soil shall have a permeability of 0.5 in/hr or greater. If the underlying soils do not meet the permeability requirement, underdrains may be installed.
Bioinfiltration systems must be designed to drain within 5 days of a storm event.
Soil borings or other data must verify that the depth to groundwater table is greater than 2 feet from the bottom of the BMP (lowest excavated elevation), or 3.5 feet when connected to a combined sewer system.
The water flowing to a bioinfiltration facility requires pretreatment for sediments. Where such pretreatment is not provided by an upstream BMP facility, it must be included in the bioinfiltration facility design.
The bioinfiltration facility shall be located at least 10 feet downgradient (10 feet laterally, with flow directed away from building) from buildings.
Maintenance access to the facility must be provided.
Measures to avoid clogging and compaction of the bioinfiltration facility are required during construction.
If the bioinfiltration system includes storage in the void spaces of an aggregate layer, the aggregate layer must be completely surrounded by filter fabric and must be comprised of crushed angular stone free of fines. For IDOT gradations CA-1 and CA-7, the maximum aggregate porosity of 0.38 may be used.
If the lowest underdrain invert under a bioinfiltration system is less than 1 foot above the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewage from backing up into the bioinfiltration system.

Maintenance Guidelines

Properly designed and installed bioinfiltration systems require little maintenance. During periods of extended drought, bioinfiltration systems may require watering approximately every 10 days.

Activity Schedule

As needed	• Water plants during first growing season • Water plants during dry periods after first growing season • Remulch void areas • Treat diseased trees and shrubs • Keep overflow free and clear of leaves
Monthly	• Inspect soil and repair eroded areas • Remove litter and debris • Clear leaves and debris from overflow
Twice per year	• Inspect trees and shrubs to evaluate health
Once per year	• Add additional mulch • Inspect facility and pretreatment areas for sediment buildup, erosion, vegetative conditions, etc.

Worksheet

The worksheet on the following page is available electronically as part of the City of Chicago Stormwater Spreadsheet Tool.

2.1.1 Bioinfiltration Systems

Section 1 Upstream Drainage Area				
1	Upstream impervious area including BMP area	A_t		square feet
2	Upstream weighted C-value (C-value=1.0 for bioinfiltration area for direct rainfall)	C		unitless
3	Volume of upstream runoff from a 1-inch storm = C * A_t * 1/12	$V_{upstream}$	0	cubic feet
4	Describe upstream drainage area			
5	Describe upstream pretreament or integration of pretreatment into BMP			

Section 2 BMP Feasibilty				
6	Design soil infiltration rate (must be 0.5 in/hr or greater unless underdrain system is used)	i		in/hr
7	Elevation of bottom of BMP (the infiltration surface)	$ELEV_{BMP}$		feet
8	Groundwater elevation	$ELEV_{GW}$		feet
9	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	0.0	feet

Section 3 BMP Specifications				
10	Dimensions of the bioinfiltration facility (length, width, or area)	L		feet
		W		feet
		A_{BMP}		square feet
11	Depth of prepared soil	D_1		feet
12	Prepared soil porosity (0.25 maximum unless detailed materials report provided)	P_1		feet
13	Depth of underlying aggregate (optional)	D_2		feet
14	Aggregate porosity (0.38 maximum unless detailed materials report provided)	P_2		feet
15	Surface storage volume (provide supporting calculations, max depth 12 inches)	V_{AIR}		cubic feet
16	Soil media storage volume = A_{BMP} * [(D_1 * P_1) + (D_2 * P_2)]	V_{SOIL}	0	cubic feet

Section 4 BMP Performance				
17	Volume of upstream runoff (Line 4)	$V_{upstream}$	0	cubic feet
18	Storage Provided = V_{AIR} + V_{SOIL}	V_{BMP}	0	cubic feet
19	V_{total} (equals lesser of V_{BMP} or $V_{upstream}$)	V_{total}	0	cubic feet

DRAINAGE SWALES GUIDESHEET

Overview

Runoff can be conveyed through either a constructed channel (such as a ditch or swale) or a natural channel. Constructed channels can be designed purely for conveyance, or can include measures to enhance infiltration such as check dams. If designed according to the design guidelines, the swale may take credit for the storage in the prepared soil layer. Swales may also be designed to provide additional storage by providing check dams or a gravel storage bed. The storage behind check dams may be counted as volume control storage as well as the void space in the underlying storage aggregate. Swales or unlined ditches and natural channels are superior to conventional storm sewers because they allow water infiltration and can remove pollutants if they are vegetated. Swales can be planted with native vegetation to provide enhanced wildlife habitat and to increase the amount of runoff removed by transpiration and evaporation. If at all possible, natural drainageways should be preserved as part of the development site's drainage system. Another advantage of swales, ditches, and natural channels is their low capital cost. Swales and ditches can be designed to convey both high and low flows but may be difficult to implement where space is limited. The following sections provide Design Guidelines, Minimum Design Requirements, Maintenance Guidelines and a Worksheet for quantifying BMP performance to comply with the Chicago Stormwater Management Ordinance.

Design Guidelines

Swale systems are designed to convey and infiltrate stormwater runoff. Swale systems often include the following components:

- Inlet
- Pretreatment
- Excavated Channel
- Soil
- Check dams
- Gravel Storage Bed
- Vegetation
- Underdrain (Limited Application)
- Outlet

Inlet Runoff can enter the swale through a curb cut, weir, or other design. Runoff may flow off a curbless parking lot or road and to a swale slope in a diffuse manner using a vegetated filter strip. When concentrated flows enter the swale, energy dissipation and erosion control features must used.

Pretreatment Pretreatment is optional but can extend the life of the design. Vegetated filter strips can be used upstream for pretreatment. A sediment forebay may be constructed at the swale inlet, or the first swale segment and a check dam may be designed as a sediment forebay. The forebay protects the filtering and infiltration capacity of the swale.

Excavated Channel The channel itself provides the storage volume and conveyance capacity of the swale. Swale design balances needs for infiltration during small storms with needs for conveyance during large storms. Bottom widths between 2 and 8 feet work best to prevent formation of pilot channels. Side slopes of 3:1 are required, but 4:1 or flatter is recommended.

Soil The soil provides a growing medium for plants and allows for infiltration. The minimum design guidelines specify the use of soil that will promote infiltration and plant growth. The designer must ensure that the proposed soil will also be stable under larger storm events. In some cases, it may be necessary to design a conveyance channel using heavier soils and short grass that do not promote infiltration. In these cases, the drainage swale will not count as a volume control BMP.

Check Dams Ponding behind check dams creates storage, increases infiltration, increases travel time, reduces peaks, and helps prevent erosion by dissipating energy. Check dams should be provided at every 1-ft drop in elevation but should be at least 50 ft apart. Check dams increase infiltration by spreading water over the entire length of the swale.

Gravel Storage Bed Gravel may be incorporated below the swale bed to increase storage and promote infiltration. Gravel will perform this function most effectively when placed in ponded areas, provided runoff has received pretreatment. When a gravel storage bed is used, it must be separated from the prepared soils layer with a geotextile fabric.

Vegetation A dense cover of water-tolerant, erosion-resistant grass or other vegetation must be established. Considerations for vegetation include:

- Ability to form a dense sod with vigorous, upright growth (vegetation that mats down should not be considered)
- Resistance to periodic inundation and periodic drought
- Appropriateness for the soil type and the amount of light available
- Salt tolerance

Underdrain When minimum subsoil infiltration rates are not met, an underdrain system must be used. The underdrain system typically consists of a gravel layer that encases a perforated pipe running the length of the swale. Stormwater percolates through the soil and flows into the underdrain, which conveys treated stormwater to the downstream stormwater conveyance system.

Outlet A swale will have an outlet structure control to convey water to a sewer or receiving water. Outlet should be designed to accommodate the peak flow from the 100-year event.

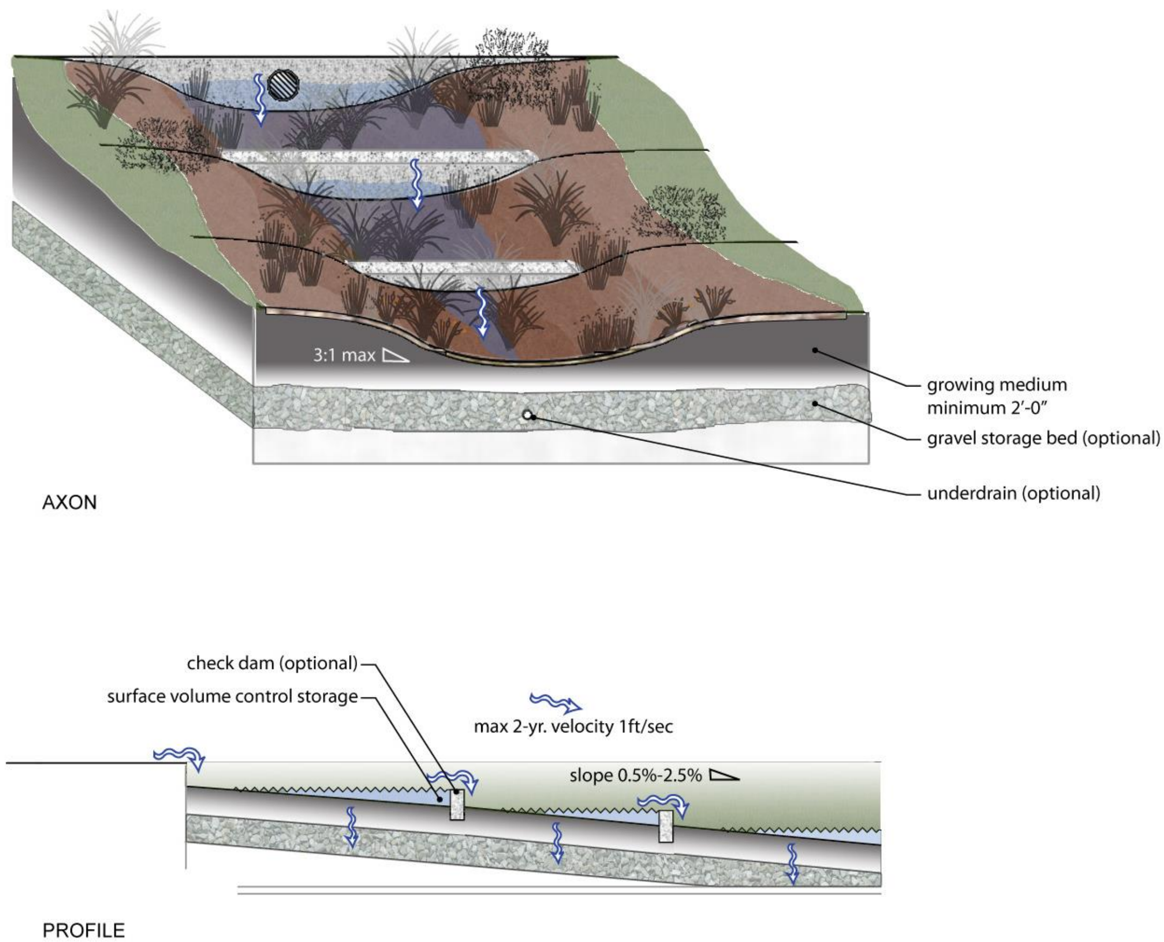


Figure 2: Typical Drainage Swale Configuration

Minimum Design Requirements
Velocities must be 1 ft/sec or less during the 2-year storm event.
Longitudinal slope must be between 0.5 and 2.5%
Utilize 3H:1V side slopes or flatter. Use slope protection when side slopes are steeper than 3H:1V.
Surface volume control storage must be provided behind check dams.
The growing medium soil must be a mix of 40% sand, 30% topsoil and 30% compost.. The growing medium soil must be at least 2 feet deep.
Soil borings or other data must verify that the depth to groundwater table is greater than 2 feet from the bottom of the BMP (lowest excavated elevation), or 3.5 feet when connected to a combined sewer system.
The underlying soil shall have a permeability of 0.5 in/hr or greater. If the underlying soils do not meet the permeability requirement, underdrains may be installed.

Maintenance Guidelines

Compared to other stormwater management measures, the required upkeep of swales is relatively low. The following schedule of inspection and maintenance activities is recommended:

Activity Schedule

As needed

- Mow and trim vegetation to ensure safety, aesthetics, proper swale operation, or to suppress weeds and invasive vegetation; mow only when swale is dry to avoid rutting.
- Re-seed bare areas; install appropriate erosion control measures when native soil is exposed or erosion channels are forming.
- Plant alternative grass species in the event of unsuccessful establishment.
- Remove litter.
- Clear obstructions and repair any channelization near check dams (if applicable)

Once per year

- Inspect and correct erosion problems, damage to vegetation, sediment and debris accumulation, and pools of standing water.
- Inspect for uniformity in cross-section and longitudinal slope, correct as needed.

2.1.2 Drainage Swales

Section 1 Upstream Drainage Area				
1	Upstream impervious area including BMP area	A_t		square feet
2	Upstream weighted C-value (C-value=1.0 for bioinfiltration area for direct rainfall)	C		unitless
3	Volume of upstream runoff from a 1-inch storm = C * A_t * 1/12	$V_{upstream}$	0	cubic feet
4	Time of Concentration for upstream area (use TR-55 or DWM approved method)	T_c		minutes
5	2-year Rain Intensity based on T_c (see chart)	I		in/hr
6	2-Year Design Flow: Q = C*I*A_u/43560	Q_2		cfs
7	Describe upstream drainage area			

Section 2 BMP Feasibilty				
8	Design soil infiltration rate (must be 0.5 in/hr or greater unless underdrain system is used)	i		in/hr
9	Elevation of bottom of BMP (the infiltration surface)	$ELEV_{BMP}$		feet
10	Groundwater elevation	$ELEV_{GW}$		feet
11	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	0.0	feet

Section 3 BMP Specifications				
12	Dimensions of the drainage swale [length L, side slope SS, bottom width (BW), swale flowline Slope, Manning's n]	L		feet
		SS		ft/ft
		BW		feet
		Slope (0.5% to 2.5%)		%
		Manning n		unitless
13	Depth of Flow (must be 6 inches or less)	2-Year Depth of Flow		inches
14	Check to see if selected depth can pass 2-year flow (result must be greater than or equal to 2-year flow in line 8) Q = 1.49/n*A*(R^0.67)*(S/100)^0.5	Q_{swale}	#DIV/0!	cfs
15	Velocity at 6-inch depth of flow	Vel	#DIV/0!	ft/sec
16	Check dam height (max = 1 foot)	H_{dam}		ft
17	Check dam area = BW*H_{dam}+SS*H_{dam}^2	A_{dam}	0.00	square feet
18	Spacing of dams = H_{dam}/Slope	Spacing	#DIV/0!	ft/dam

19	Total number of check dams = L/Spacing (round down)	N_{dam}	#DIV/0!	dams
20	Check dam storage = N_{dam}*A_{dam}*Spacing/2	V_{dam}	#DIV/0!	cubic feet
21	Depth of prepared soil	D_{soil}		feet
22	Prepared soil porosity (0.25 maximum unless detailed materials report provided)	P_{soil}		unitless
23	Soil storage volume = L*BW*D_{soil}*P_{soil}	V_{soil}	0	cubic feet
24	Depth of underlying aggregate (optional, provision of aggregrate only allowed when minimum infiltration feasibility requirements are met or when underdrains are provided)	D_{agg}		feet
25	Width of aggregate layer	W_{agg}		feet
26	Aggregate porosity (0.38 maximum unless detailed materials report provided)	P_{agg}		unitless
27	Aggregate storage volume = L*W_{agg}*D_{agg}*P_{agg}	V_{agg}	0	cubic feet

Section 4 BMP Performance				
28	Volume of upstream runoff (Line 4)	$V_{upstream}$	0	cubic feet
29	Check Dam Storage (Line 21)	V_{dam}	#DIV/0!	cubic feet
30	Soil Storage (Line 24)	V_{soil}	0	cubic feet
31	Aggregate Storage (Line 28)	V_{agg}	0	cubic feet
32	Storage Provided = V_{dam} + V_{soil} + V_{agg}	V_{BMP}	#DIV/0!	cubic feet
33	V_{total} (equals lesser of V_{BMP} or $V_{upstream}$)	V_{total}	0	cubic feet

GREEN ROOF GUIDESHEET

Overview

In green roof systems, runoff is absorbed and retained by living vegetation installed on a rooftop. There are two types of green roof systems: extensive and intensive systems. Extensive systems usually contain shallower soil, put less weight on rooftops, and are easy to maintain. They generally contain shorter plants with shallower root systems. Intensive systems have deeper soil; add more weight to a rooftop; and generally contain a more diverse mixture of deep-rooted plants, small trees, or shrubs. Intensive systems require more maintenance but provide added benefits in the form of water filtration and wildlife habitat. Green roof systems provide insulation and prolong the life of a roof by protecting it from the elements. Green roof systems also improve air quality by reducing the urban heat island effect. Maintenance of green roof systems is minimal and mostly involves watering and weed removal during the first few years of establishment. The following sections provide Design Guidelines, Minimum Design Requirements, Maintenance Guidelines and a Worksheet for quantifying BMP performance to comply with the Chicago Stormwater Management Ordinance.

Design Guidelines

There are rate control and volume control benefits of a green roof. A green roof will reduce the runoff coefficient for the project which will cause the required rate control volume to decrease. Also, a green roof can be counted as a pervious surface in order to reduce site imperviousness and help meet the volume control requirement..

A green roof system, extensive or intensive, is often comprised of the same components:

- Plant material
- Growing medium
- Filter fabric
- Drainage layer
- Membrane protection and root barrier
- Structural support

Plant Material The plant material chosen for green roofs is designed to take up much of the water that falls on the roof during a storm event. Plant selection is very important to the sustainability of the roof. About 50% of the vegetation on an extensive green roof should be sedums. Plant material also collects dust, creates oxygen, releases moisture, and provides evaporative cooling.

Growing Medium The growing medium is a critical element of stormwater storage and detention on a green roof, and provides a buffer between the roof structure and vegetation for root development. Storage is provided by a green roof primarily through water held in tension in the growing medium pores. The growing medium in an extensive green roof should be a lightweight mineral material with a minimum of organic material and should stand up to freeze/thaw cycles.

Filter Fabric An engineered filter fabric prevents fine soil particles from passing into the drainage layer of the green roof system.

Drainage Layer The drainage layer may be a lightweight granular medium that underlays the planting medium. The drainage layer needs to provide a balance between water retention and root aeration and is a critical component of the stormwater retention function.

Membrane Protection and Root Barrier To maintain structural integrity of the roof, a waterproof material is laid above the roof structure. Some waterproofing materials are inherently root resistant, whereas others require an additional root barrier.

Structural Support The load capacity of a roof structure must be taken into account when considering the installation of a green roof. Extensive green roofs typically weigh between 15 and 30 lbs per square foot and are compatible with wood or steel decks. Intensive green roofs weigh more than 36 lbs per square foot and typically require concrete supporting decks

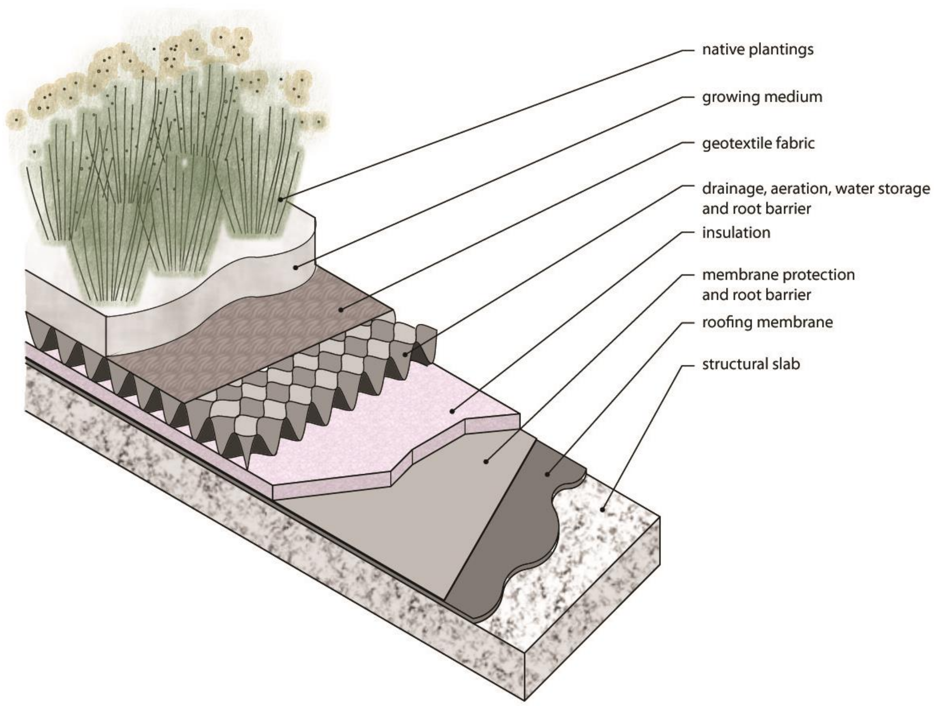


Figure 3: Structure of an extensive green roof

Minimum Design Requirements
A structural engineer or architect's seal must be included on the Plans to approve of load-bearing capacities of the proposed roofs.
The maximum permissible slope for extensive green roof systems shall be 25 percent.
The maximum permissible slope for intensive green roof systems shall be 10 percent.

Maintenance Guidelines

All facility components, including plant material, growing medium, filter fabric, drainage layer, waterproof membranes, and roof structure should be inspected for proper operations, integrity of the waterproofing, and structural stability throughout the life of the green roof. The manufacturer's maintenance schedule must also be followed and should be included with the stormwater management plan.

Activity Schedule

As needed

- Drain inlet pipe should be cleared when soil substrate, vegetation, debris or other materials clog the drain inlet.
- Sources of sediment and debris may be identified and corrected.
- Plant material should be maintained to provide 90% plant cover. Weeding should be manual with no herbicides or pesticides used. Weeds should be removed regularly and not allowed to accumulate.
- Irrigation, although not recommended, can be accomplished either through hand watering or automatic sprinkler systems if necessary during the establishment period.

Quarterly

- Growing medium should be inspected for evidence of erosion from wind or water. If erosion channels are evident, they can be stabilized with additional growth medium similar to the original material.

Once per year

- Inspect drain inlet pipe and containment system.

2.1.3 Green Roof

Section 1 BMP Specifications				
1	Dimensions of the green roof (length L, width W, substrate thickness T)	L		feet
		W		feet
		T		inches

Section 2 BMP Performance				
Volume control when green roof treated as a pervious surface				
2	Green roof counted toward pervious area	A_G	0.0	square feet

NATURAL LANDSCAPING AND STORMWATER TREES GUIDESHEET

Overview

Natural landscaping involves planting naturalized or native vegetation on permeable soils or prepared soils. Care must be taken to ensure that the proposed vegetation and existing soils are compatible. If existing soils are unsuitable for implementation of native vegetation, alternative landscaping plans should be devised, or a prepared soil should be brought onto the site. Natural landscaping on prepared soils has a greater capacity to infiltrate stormwater than lawns on heavy soil. As shown on the Rate Control Worksheet, areas with natural landscaping on permeable or prepared soils have a lower C-value and can reduce the amount of required detention storage. There is no volume control storage benefit specifically allowed for natural landscaping, however, natural landscaping can be an integral part of the design of other BMPs such as vegetated swales, filter strips and bioinfiltration basins.

Trees can also be used for minor volume control benefits and to reduce urban heat island effects. Trees slow down rain from small storms, holding the water on leaves and branches and allowing the water to evaporate. Urban heat island effects are reduced because trees provide shade to impervious surfaces, thereby decreasing the temperature of the surfaces and subsequently the temperature of the surrounding air and of any stormwater that passes over the impervious area. Lowering the temperature of stormwater runoff can be beneficial in improving the water quality of receiving streams. Existing trees located on the development site that are preserved as part of the site plan and proposed trees located on the development site that are planted within 20 feet of on-site impervious areas may count as a deduction of the on-site impervious area for volume control calculations (Figure 4). The tree species must be chosen from the approved list provided by the CDOE. New trees planted must be planted within 20 feet of ground level impervious surfaces. New trees must be at least 2-inch caliper at 4.5 feet above ground level to be eligible for the reduction. A 50-sq.ft. reduction is permitted for each new tree. Only 50% of the canopy area of an existing tree of at least 4-inch caliper, within 20 ft of ground level imperviousness, may be credited towards a reduction in impervious area.

Minimum design requirements for natural landscaping and stormwater trees are provided below. A worksheet for quantifying BMP performance to comply with the Chicago Stormwater Management Ordinance follows.

Minimum Design Requirements
Areas of natural landscaping shall be planted with deep-rooted vegetation.
The soil must consist of sandy loam, loamy sand, a loam with clay content less than 25% and sand content greater than 50%, or a prepared growing medium soil with a mix of 40% sand, 30% topsoil and 30% compost.
New trees must be planted within 20 feet of an on-site impervious surface to count as a volume control BMP. They must also be at least 2 inches in diameter at 4.5 feet above ground level.

Maintenance Guidelines

No special maintenance is required for natural landscaping or stormwater trees other than pruning and trimming in late fall or winter to remove dead wood and excess growth to maintain an open and healthy canopy. Native landscaping planting may be managed similar to the recommendations for bioinfiltration facilities. Trees counted as a stormwater management BMP that do not survive should be replaced.

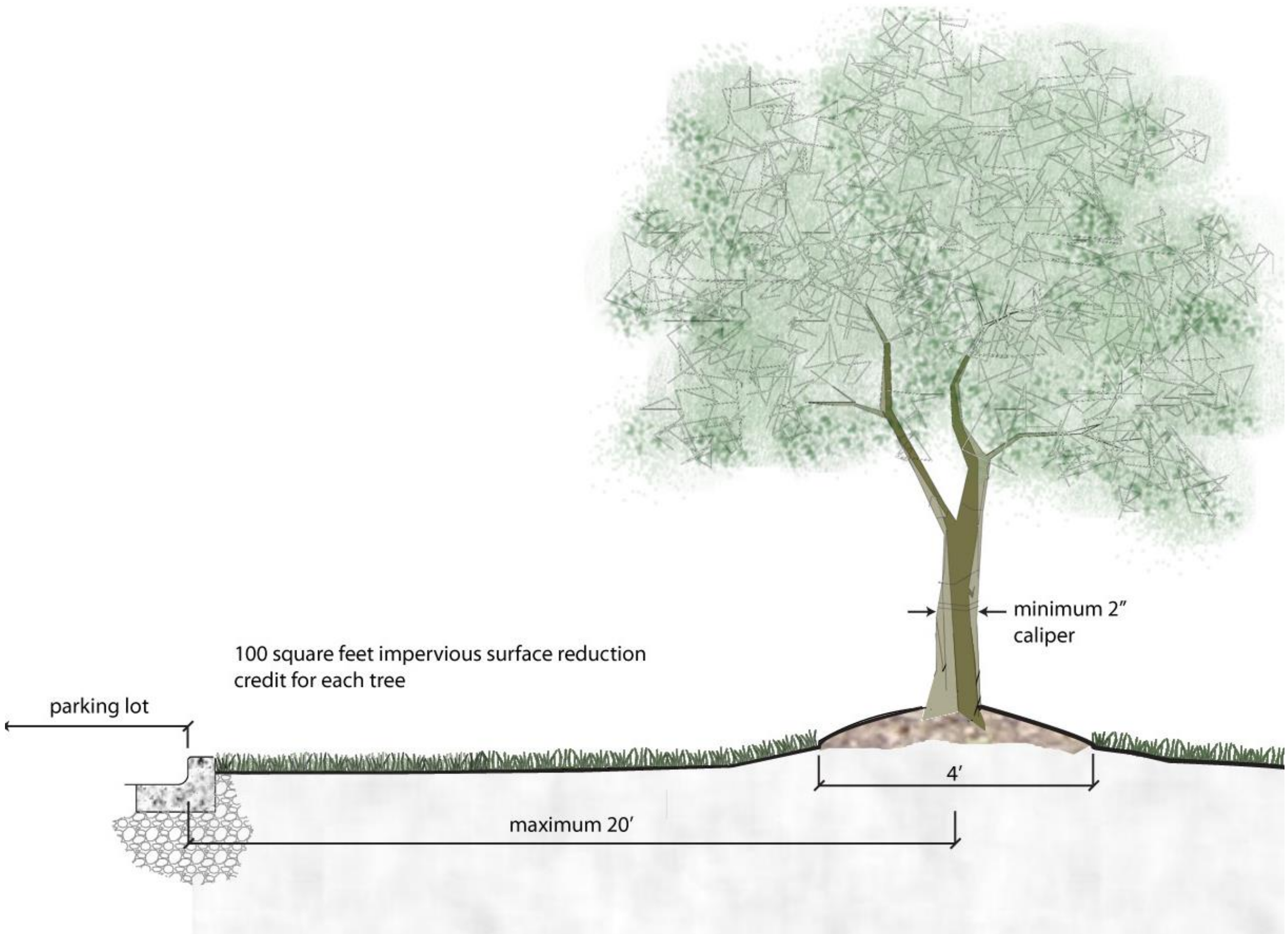


Figure 4: Stormwater Tree

2.1.5 Stormwater Trees

Section 1 Impervious Areas and Trees							
1	List impervious surfaces that will be effectively reduced by implementation or preservation of trees	Area (sf)	Number of new trees within 20 feet	Number of existing Trees within 20 feet	Total canopy size of existing trees	Area of Trees (New trees * 50 sf + existing tree canopy *0.5)	Effective Impervious Area for Volume Control = (Area - Trees Area)
	Gravel					0	0
	Pavement					0	0
	Ponds or wet bottom basins to HWL					0	0

Section 2 Detailed Tree Listing				
2	List trees and attach plan showing location and sizes of all proposed trees (Attach additional sheets if necessary)	Species	Caliper at 4.5 feet (must be >2 inch)	50% Canopy size (use 50 sq. ft. max)
3	List trees and attach plan showing location and sizes of all trees to be preserved (Attach additional sheets if necessary)	Species	Caliper at 4.5 feet (must be >4 inch)	Existing Canopy (sf)

PERMEABLE PAVEMENT GUIDESHEET

Overview

Permeable paving provides many benefits in urban environments by reducing the quantity of stormwater runoff and pollutants discharged from a site. Permeable pavement systems come in many different forms. The most common form is paver blocks with a cutout to facilitate infiltration. Permeable pavements work best on areas that have sandy, permeable soils, however, they may also be implemented on low permeability soils by using an underdrain system. The following sections provide Design Guidelines, Minimum Design Requirements, Maintenance Guidelines and a Worksheet for quantifying BMP performance to comply with the Chicago Stormwater Management Ordinance.

Design Guidelines

In order to meet the requirements of the Ordinance, areas of permeable pavement may be counted as a permeable surface or as a storage device. When counted as a permeable surface (answer yes to question 3 on the “2.0 Volume Control Worksheet” and complete entries on “1.2 BMPs-Rate Control Credit”), the facility is taken into account on the Rate Control Worksheet by adjusting the C-value and the storage is not credited toward volume control or detention storage. When treated as a storage device (answer no to question 3 on the “2.0 Volume Control Worksheet” and complete entries on “1.2 BMPs-Rate Control Credit”), the storage provided in permeable paving systems is based on the void space of the storage aggregate and may be counted toward the required volume control storage and detention storage. Figure 5 shows the typical components of a permeable pavement system.

Permeable pavements work by infiltrating runoff through a permeable surface into the gravel base below. Water is stored in the gravel subbase until it is exfiltrated into the underlying soil or carried away by an underdrain. The gravel base and subbase material must be sized for the expected traffic loading and for the desired amount of storage. The infiltration rate of the underlying native soils should be determined as explained in the Stormwater Management Manual. Based on design infiltration rate, the depth of the storage layer should be sized to drain by exfiltration within 48 hours. For instance, a site with a measured infiltration rate of 0.5 in/hr would have an allowable storage layer depth of 24 inches (0.5 in/hr * 48 hours). If additional storage was desired (such as in a combined volume control and rate control storage facility), an underdrain or outlet structure could be placed above the elevation at which the volume control storage is provided. If the measured soil infiltration rate does not meet the minimum requirement of 0.5 in/hr, then the underdrain could be placed at the bottom of the storage aggregate.

Finally, when computing the storage provided in a permeable pavement system, the slope of the pavement surface must be taken into consideration. No storage may be counted in aggregate that is located higher than the minimum pavement surface elevation. When large or linear permeable pavement areas are designed this becomes an important design consideration. If adjustments to the functional storage are needed, the “effective” depth of storage should be computed by the designer and then entered into Line 11 on the Permeable Pavement Worksheet.

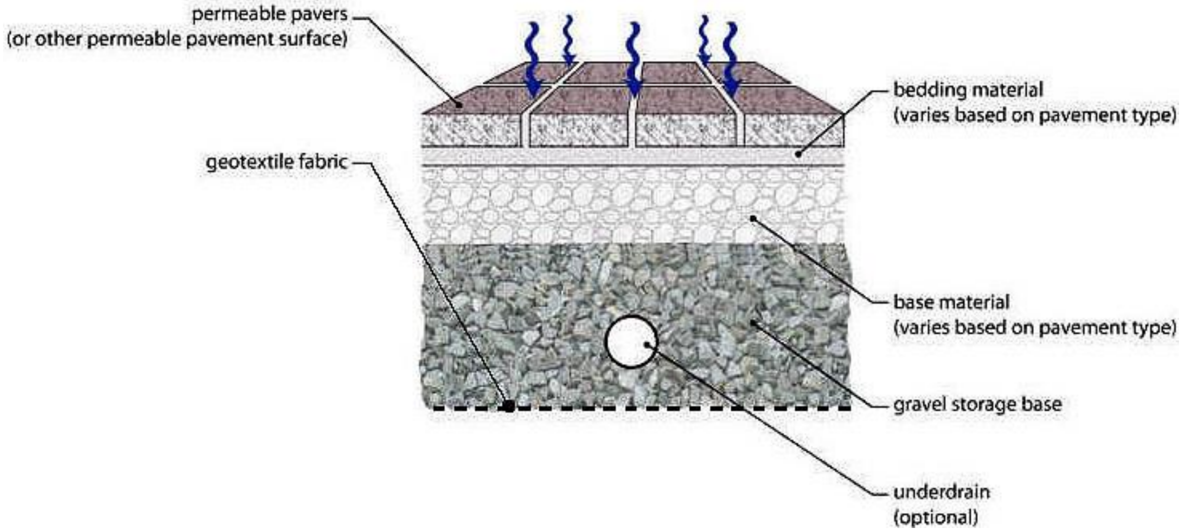


Figure 5: Permeable Pavement

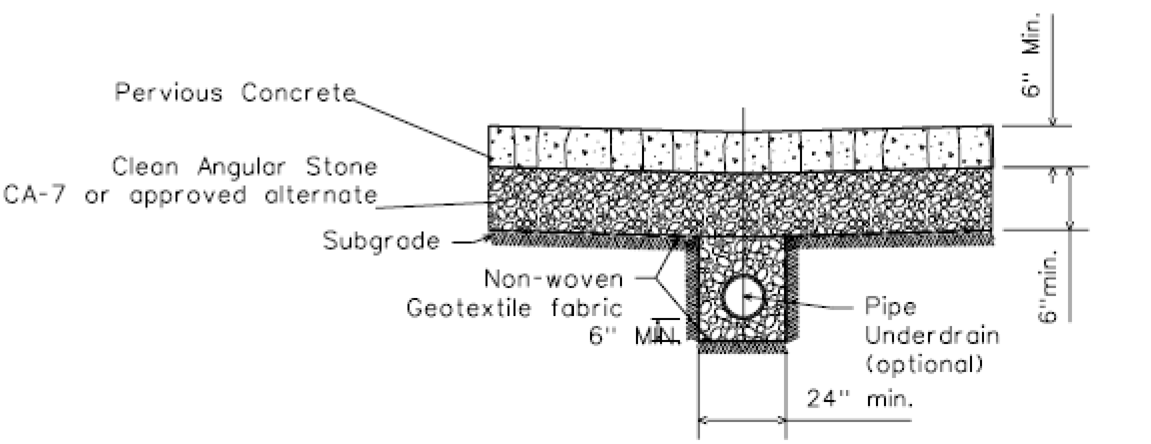


Figure 6. Pervious Concrete

Note: Concrete and Aggregate base depths must be designed based on average daily traffic and/or vehicle structural loads.

Minimum Design Requirements
Subsoils must have at least a 0.5 in/hr infiltration rate or greater. Otherwise, an underdrain system must be used if soil infiltration rates do not meet this requirement.
The bottom of the aggregate shall be at least 2 feet above the groundwater table or bedrock; if discharging to a combined sewer, the outlet pipe must be at least 3.5 feet above the water table.
Compaction of the soils underlying the permeable pavement system must be avoided during construction.
Permeable pavement or infiltration systems must be situated at least 10 feet downgradient (10 feet laterally, with flow away from building) from buildings that are not waterproofed against basement seepage, otherwise submit affidavit in Appendix II-B of the Regulations.
Minimum and maximum slopes on permeable paving shall be 0.5 percent and 5 percent, respectively.
All aggregate material shall be crushed angular stone and free of fines. For IDOT gradations CA-1 and CA-7, the maximum aggregate porosity of 0.38 may be used. Aggregate material shall be surrounded by filter fabric on the bottom and sides but not the top.
When using an underdrain system, the water level within the underlying stone base may not rise to within 8 inches of the permeable pavement surface for a 10 year storm event.
The underlying stone base must be designed to drain within 48 hours of a storm event.
When using an underdrain system, any impermeable subsoil material must be graded with a minimum 1 percent slope to such system, and the top 3 inches of impermeable soil must be mixed with at least 3 inches of sand.
For pervious concrete, signage must be placed on the property that states, “This surface is pervious concrete pavement. No sealcoat or overlay material is to be used on this pavement. Call XXX-XXXX before treating this pavement with any material.” Insert the number of the property management company.
When an area of conventional impervious pavement drains toward permeable pavement, a maximum ratio of 3:1 impervious to permeable is allowed.
If the lowest underdrain invert under the permeable pavement is less than 1 foot above the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewage from backing up into the permeable pavement.

Maintenance Guidelines

As with most stormwater management practices, permeable pavement systems require regular maintenance to ensure a prolonged lifespan. The following table displays maintenance recommendations for permeable pavement systems.

Activity Schedule for Permeable Pavers	
As needed	• Do not use sand during the winter months • Keep landscaped areas well-maintained and prevent soil from being transported onto the pavement. • Monitor regularly to ensure that the paving surface drains properly after storms. • Ensure that surface is free of sediment. • Remove vegetation established in gravel spaces in pavement
Twice per year	• Broom, blow, rotary brush or sweep entire surface (alternate – vacuum entire surface) • Replenish joint aggregate material after cleaning. • Clean out inlet structures within or draining to the subsurface bedding beneath surface
Once per year	• Inspect surface for signs of deterioration or settling.
Every 5 years	Vacuum or powerwash the entire surface and refill joint aggregate material

Activity Schedule for Pervious Concrete	
As needed	• Do not use sand during the winter months • Keep landscaped areas well-maintained and prevent soil from being transported onto the pavement. • Monitor regularly to ensure that the paving surface drains properly after storms. • Ensure that surface is free of sediment.
Twice per year	• Vacuum, pressure wash, or power blow entire surface • Clean out inlet structures within or draining to the subsurface bedding beneath surface

2.1.6 Permeable Pavement

Section 1 Upstream Drainage Area				
1	Upstream impervious area including area of permeable pavement	A_i		square feet
2	Upstream weighted C-value (C-value=0.95 for permeable pavement areas for nearly direct rainfall)	C	0.95	unitless
3	Volume of upstream runoff from a 1-inch storm = C * A_i * 1/12	$V_{upstream}$	0	cubic feet
4	Describe intended function of system (Is it standalone system designed for infiltration, is integrated as part of the detention storage, is it underdrained to downstream system, will it receive upstream runoff?)			

Section 2 BMP Feasibilty				
5	Design soil infiltration rate (must be 0.5 in/hr or greater unless underdrain system is used)	i		in/hr
6	Allowable depth of storage aggregate without provision of underdrain (=i/ 12 inches/ft * 48 hours)	D_{allow}	0.00	feet
7	Elevation of bottom of BMP (the infiltration surface)	$ELEV_{BMP}$		feet
8	Groundwater elevation	$ELEV_{GW}$		feet
9	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	0.0	feet

Section 3 BMP Specifications				
10	Dimensions of the permeable pavement (length, width, or area)	L		feet
		W		feet
		A_{BMP}	0	square feet
11	Depth of underlying aggregate (must be less than D_{allow})	D_1		feet
12	Aggregate porosity (0.38 maximum unless detailed materials report provided)	P_1		feet
13	Volume of Aggregate storage applicable to volume control = A_{BMP} * D_1*P_1	V_{BMP}	0	cubic feet

Section 4 BMP Performance				
14	Volume of upstream runoff (Line 4)	$V_{upstream}$	0	cubic feet
15	Volume Control Storage Provided = V_{BMP}	V_{BMP}	0	cubic feet
16	V_{total} (equals lesser of V_{BMP} or $V_{upstream}$)	V_{total}	0	cubic feet

ROOF RUNOFF BMPs GUIDESHEET

Overview

Roof runoff BMPs include planter boxes, rain barrels, and cisterns. Planter boxes are used in heavily paved areas to reduce the area of impervious areas. Planter boxes can be aboveground or at grade and are designed to retain water in the substrate or in an underlying aggregate. Planter boxes come in a wide variety of shapes and sizes and may be planted with native or ornamental plants. Planter boxes at grade can be designed to drain part of the surrounding paved area. Planter boxes can also be designed to infiltrate water into the ground or to capture water through an underdrain system that discharges excess water into a sewer system. The storage provided in the voids of underlying aggregate, prepared soil voids, and the contained air space (reservoir) above the soil may be counted as volume control storage.

Rain barrels and cisterns collect and store stormwater runoff from rooftops. The volume of rain barrels or cisterns may be counted as volume control storage and detention storage (up to a maximum of 10% of the total required detention storage) when minimum design guidelines are met. Water collected in rain barrels and cisterns can be used to water lawns and landscaped areas between storms. Rain barrels and cisterns are therefore most useful during the growing season. They require periodic cleaning to remove debris. Filters to keep out most debris can be installed, but periodic cleaning is still advised. In addition, rain barrels should be sealed to prevent mosquito breeding and must be drained before winter to prevent any damage from freezing and thawing.

The following sections provide Design Guidelines, Minimum Design Requirements, Maintenance Guidelines and a Worksheet for quantifying BMP performance in relationship to the Chicago Stormwater Management Ordinance.

Design Guidelines

Rain Barrels and Cisterns

Rain barrels and cisterns all require the following basic components:

- Roof leader or other means of conveying roof runoff to the storage element
- Screen to prevent debris and mosquitoes from entering
- Storage element
- Slow release mechanism or pump
- Reuse opportunity or infiltration area
- Overflow mechanism to bypass large storms

Roof Leader The gutter and roof leader system collects rooftop runoff and conveys it to the rain barrel, cistern, or other storage element. In most cases conventional roof leaders and downspouts can be used for this purpose.

Screen A screen keeps leaves and other debris from entering and clogging the storage element. A screen also prevents mosquitoes from breeding in the rain barrel. A screen is typically placed at the end of the roof leader, before flow enters the rain barrel. A leaf strainer may also be placed where the gutter connects to the roof leader.

Storage Element The storage element is the barrel, cistern, or tank itself. Rain barrels are typically made of plastic. Underground cisterns may be poured concrete or prefabricated plastic tanks similar to septic tanks. Proprietary products that store water in a variety of structures are also available. Some of these are designed to bear the weight of vehicles.

Slow Release Mechanism or Pump For the storage element to serve its stormwater control function, it must be completely drained within 14 days after a storm event. Larger surface tanks may drain by gravity or may be pumped. Operational experience has suggested that the best method for using water in large storage features like a cistern is to bring it to pressure and distribute it though an irrigation system. Other alternatives exist, but the plan should have a clear idea of how and where the water will be used if relying solely on gravity distribution.

Reuse Opportunity or Infiltration Area For rain barrels, cisterns, and other tanks to provide effective stormwater management, an opportunity for reuse or infiltration of the stormwater must exist. This opportunity might be provided by a garden or landscaped area that needs to be watered, or an opportunity to reuse stormwater for non-potable uses.

Overflow Mechanism The storage capacity of rain barrels, cisterns, and other tanks will be exceeded in large storms. The overflow can occur through a hose, weir, pipe, or other mechanism. The discharge from the overflow is directed to the same place flow from the roof leader would be directed if there were no rain barrel or cistern.

Planter Boxes

Planters are placed on impervious surfaces such as sidewalks and plazas. Contained planters should be treated as pervious surfaces and not as volume control BMPs because they are not designed to accept runoff from other surfaces. Drainage occurs through the bottom of a planter box onto the impervious surface.

The infiltration planter box is designed to intercept precipitation and accept runoff from downspouts. The box is designed to store water in planter soil and then allow the water to infiltrate into native soils; for this reason, the box must be positioned at least 10 feet from any buildings. An infiltration planter box reduces an amount of stormwater runoff equal to the available pore space in the soil, the size of the reservoir above the planter soil. If soil testing is conducted, infiltration can be used in addition to the detention release rate when sizing detention storage.

The flow-through planter box includes aspects of all three types pf planter boxes (Figure 7) has an impervious bottom and is designed to accept both precipitation and downspout runoff. The box is designed to store water in planter soil and overflow excess water to a storm sewer system. This type of planter box is preferred for use adjacent to buildings. Flow-through planter boxes reduce an amount of stormwater runoff equal to the available pore space in the planter soil and the size of the reservoir above the soil.

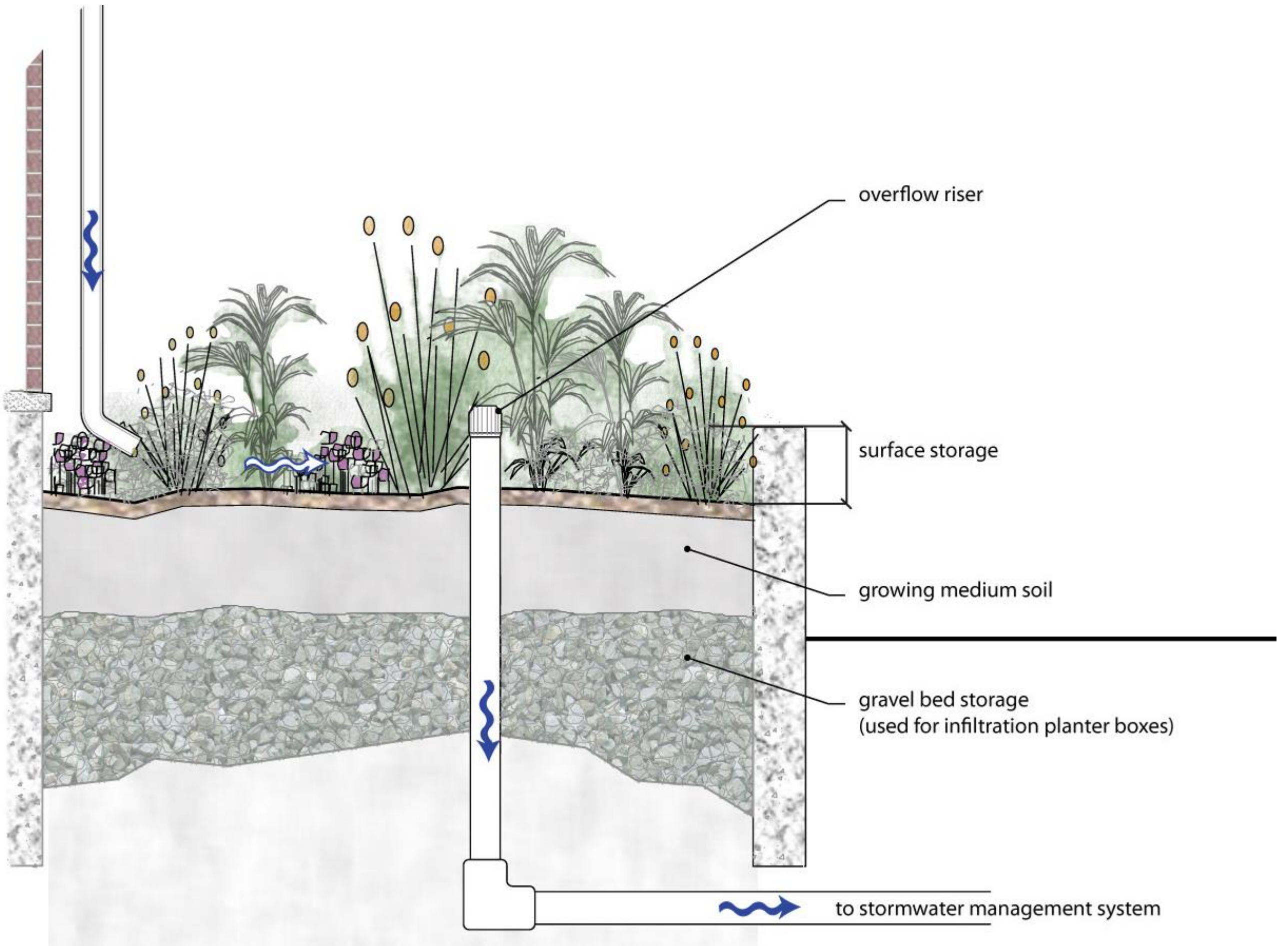


Figure 7: Flow-through Planter Box (Adapted from City of Portland, 2002)

Minimum Design Requirements
If a rain barrel or above ground cistern will hold more than a 6-inch depth of water below the drain, it must be securely covered to prevent small children from gaining access to the standing water and to prevent mosquitoes from breeding.
Above ground cisterns with a capacity of more than 55 gallons must be designed with proper structural foundations.
Rain barrels and cisterns must include inlet screens to minimize the number of foreign objects entering the vessels.
Excess water entering the rain barrel or cistern must be designed to overflow to a treatment train or stormwater conveyance system.
The system must have a convenient and functional means of water withdrawal.
The system, if applicable to stormwater detention, will receive credit for up to 10 percent of the required site storage and must be drained within 14 days of a storm event.

Maintenance Guidelines

As with other best management practices, these stormwater storage systems require regular maintenance to ensure a prolonged life. The following table suggests maintenance activities to perform on rain barrels, cisterns, and planter boxes.

Activity Schedule	
As needed	• Occasional cleaning may be necessary to remove debris, such as leaves, coming off the drainage area
2 weeks after every rainfall event	• Rain barrels and cisterns being used to provide rate control volume must be drained/pumped out.
Monthly	• Remove litter and debris • Clear leaves and debris from overflow pipe
Twice per year	• Inspect plants in planter boxes to evaluate health
Once per year	• Flush cisterns to remove sediment. • Brush the inside surfaces and thoroughly disinfect. • To avoid structural damage, the rain barrel should be drained prior to freezing weather.

2.1.7 Roof Runoff BMPs - Planter Boxes

Section 1 Upstream Drainage Area				
1	Upstream impervious area including BMP area	A_t		square feet
2	Upstream weighted C-value (C-value=1.0 for bioinfiltration area for direct rainfall)	C		unitless
3	Volume of upstream runoff from a 1-inch storm = C * A_t * 1/12	$V_{upstream}$	0	cubic feet
4	Describe system (Will planter box include aggregate, does it drain to underlying soils, is it underdrained to the stormater management system)			

Section 2 BMP Feasibilty				
5	Design soil infiltration rate (must be 0.5 in/hr or greater if planter box is to drain to subsoil)	i		in/hr
6	Elevation of bottom of BMP (the infiltration surface)	$ELEV_{BMP}$		feet
7	Groundwater elevation	$ELEV_{GW}$		feet
8	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	0.0	feet

Section 3 BMP Specifications				
9	Dimensions of the planter box (length, width, or area)	L		feet
		W		feet
		A_{BMP}	0.0	square feet
10	Depth of surface storage	D_1		
11	Depth of prepared soil	D_2		feet
12	Prepared soil porosity (0.25 maximum unless detailed materials report provided)	P_2		feet
13	Depth of underlying aggregate (optional)	D_3		feet
14	Aggregate porosity (0.38 maximum unless detailed materials report provided)	P_3		feet
15	Air space storage volume (A_{BMP} * D_1)	V_{AIR}	0	cubic feet
16	Planter box soil media storage volume = A_{BMP} * [(D_2 * P_2) + (D_3 * P_3)]	V_{SOIL}	0	cubic feet

Section 4 BMP Performance				
17	Volume of upstream runoff (Line 4)	$V_{upstream}$	0	cubic feet
18	Storage Provided = V_{AIR} + V_{SOIL}	V_{BMP}	0	cubic feet
19	V_{total} (equals lesser of V_{BMP} or $V_{upstream}$)	V_{total}	0	cubic feet

VEGETATED FILTER STRIPS GUIDESHEET

Overview

Filter strips are uniformly graded and densely vegetated sections of land, engineered to filter and infiltrate water. Filter strips should be implemented in areas with little or no slope to provide the maximum impact by slowing and infiltrating runoff and allowing pollutants and sediment to deposit or be filtered out. When implemented on permeable or prepared soils, filter strips can effectively reduce runoff volume for small storm events, especially when they receive runoff from areas no more than four or five times their size. The following sections provide Design Guidelines, Minimum Design Requirements, Maintenance Guidelines and a Worksheet for quantifying BMP performance to comply with the Chicago Stormwater Management Ordinance.

Design Guidelines

Filter strips are designed to receive stormwater runoff from impervious surfaces and disperse it over wide, vegetated areas. If designed according to the minimum design guidelines, volume control storage credit is given for a 1 to 1 ratio of impervious area to the area the filter strip. For example, if one acre of parking lot was discharged to a ¼-acre filter strip designed in accordance with the minimum design requirements, volume control would be satisfied for ¼ acre of impervious surface. Additional measures would be needed for the remaining ¾ acre of parking lot. Figure 8 depicts the minimum design requirements for filter strips.

Level spreaders should be used to disperse runoff to the filter strip and avoid channelization. Concentrated flow rates can have an erosive effect that can damage the filter strip, rendering the strip ineffective. A level spreader intercepts concentrated flows and disperses runoff in a uniform manner to the filter strip. It may consist of a gravel-filled trench running perpendicular to the direction of concentrated flow. Curb cuts combined with a gravel level spreader are a common type of flow control. Water fills the gravel trench, spreading evenly along the trench's axis before overflowing on the downstream side. A concrete curb or other fixed edge must be provided on the downstream side of the gravel to ensure that flow remains level. Level spreaders improve the effectiveness of the filter strip or other BMPs that depend on sheet flow to operate. Level spreaders can be used at the edges of parking lots, loading areas, driveways, roof downspouts, and other discharge points when a point source discharge should be spread over a larger level area. When receiving downspout flows, a level spreader must be sufficiently wide and deep in order to distribute runoff across the width of the level spreader. Level spreaders are inexpensive and require very little maintenance, however, it is critical that a level spreader is constructed level, or else it is rendered useless.

The vegetation for filter strips may be comprised of turf grasses, meadow grasses, shrubs, and native vegetation.

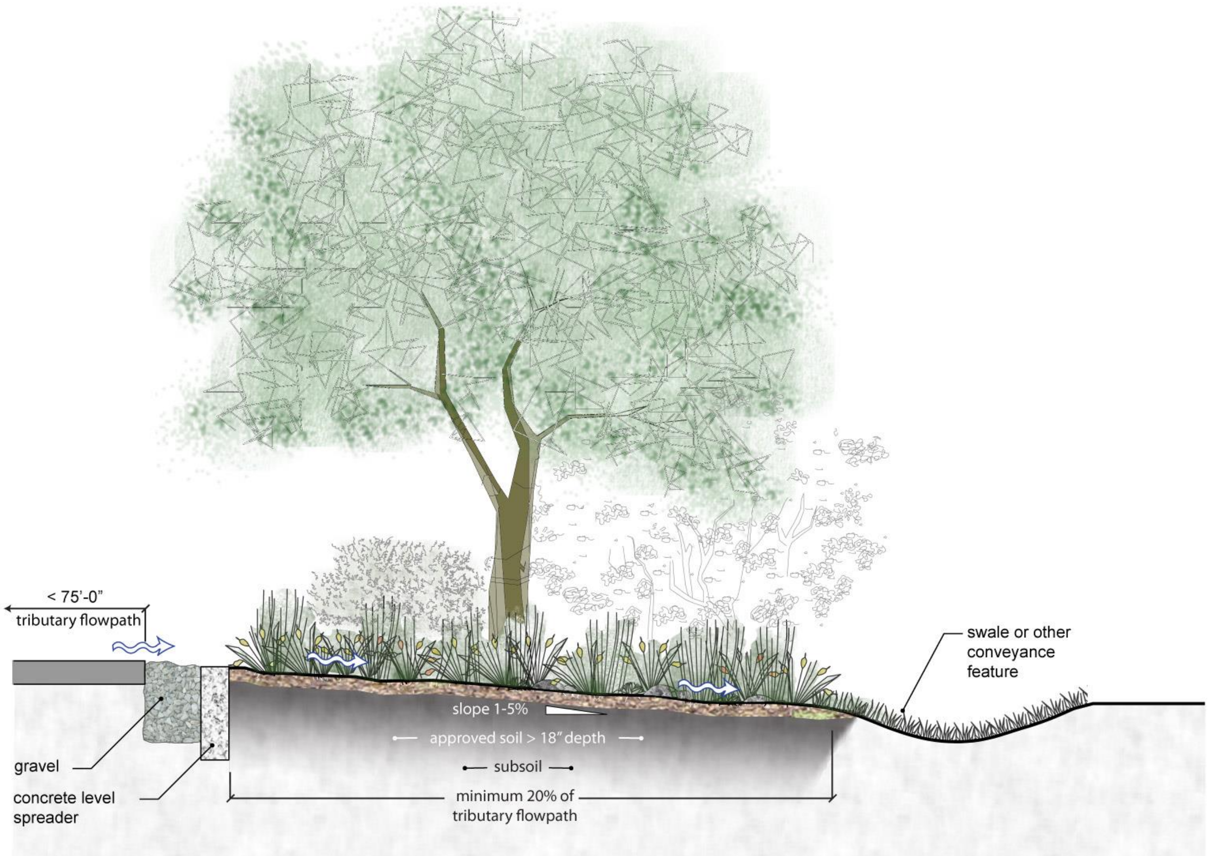


Figure 8: Filter Strip

Minimum design requirements for vegetated filter strips are provided below. A worksheet for quantifying BMP performance in relationship to the Chicago Stormwater Management Ordinance follows.

Minimum Design Requirements
The entire filter strip area shall be more than 2 feet above the groundwater table.
Filter strips must have longitudinal slopes of 1 to 5 percent (2 percent optimum) in the direction of flow.
The longest flow path of the contributing drainage areas must not exceed 75 feet.
A level spreader is required whenever the tributary area is not uniformly sloped toward the filter strip.
When filter strips are used to accept roof runoff for the purposes of volume control, a level spreader must be utilized. The hydraulic loading rate may not exceed 75 feet of roof per one foot of filter strip width.
The soil must consist of sandy loam, loamy sand, a loam with clay content less than 25% and sand content greater than 50%, or a prepared growing medium soil with a mix of 40% sand, 30% topsoil and 30% compost. The approved soil type must be at least 18 inches deep.
The slope upgradient of a level spreader must be less than 1 percent for at least 20 ft while the slope downgradient must be less than 6 percent.
The length and depth of the level spreader must be at least 6 inches.

Minimum Design Requirements
Level spreader must be absolutely level along its width.

Maintenance Guidelines

Maintenance requirements for filter strips are relatively simple. Normal maintenance requires occasional mowing or weed removal and periodic cleaning. Filter strips can decrease maintenance requirements of downstream stormwater devices by capturing and controlling sediment.

Activity Schedule

As needed	• Mowing and/or trimming of vegetation.
Monthly	• Inspect all vegetated strip components expected to receive and/or trap debris and sediment for clogging and excessive debris and sediment accumulation; remove sediment during dry periods.
Twice per year	• Vegetated areas should be inspected for erosion, scour, and unwanted growth. Erosion repair and removal of unwanted growth should have minimum disruption to the planting soil bed and remaining vegetation.
Once per year	• Inspect all level spreading devices for trapped sediment and flow spreading abilities. • Remove sediment and correct grading and flow channels during dry periods.

2.1.8 Filter Strips Worksheet

Section 1 Upstream Drainage Area				
1	Upstream impervious area	A_i		square feet
2	Volume of upstream impervious area runoff from a 1-inch storm = 0.95 * A_i * 1/12	$V_{upstream}$	0	cubic feet
3	Describe upstream drainage area			

Section 2 BMP Feasibilty				
4	Elevation of filter strip surface	$ELEV_{BMP}$		feet
5	Groundwater elevation	$ELEV_{GW}$		feet
6	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	0.0	feet

Section 3 BMP Specifications				
7	Dimensions of the filter strip [length L (length parallel to flow must be 20% or greater than the DA flowpath), width W, slope]	L		feet
		W		feet
		Slope (1% to 5%)		%
8	Check effective tributary flow length (must be less than 75 feet and level spreader required if not a uniformly sloping surface) Effective flow path of drainage area = A_i/W	DA Flowpath	#DIV/0!	feet
9	If minimum design requirements are met, compute minimum impervious area for which swale serves as volume control. Impervious Area controlled = Filter strip area (L * W)	Impervious Area Controlled	0	square feet

Section 4 BMP Performance				
10	Volume of upstream impervious area runoff (Line 2)	$V_{upstream}$	0	cubic feet
11	Equivalent Volume Control Storage (V = Area Controlled * 0.5 / 12)	V_{BMP}	0	cubic feet
12	V_{total} (equals lesser of V_{BMP} or $V_{upstream}$)	V_{total}	0	cubic feet

DETENTION SYSTEMS GUIDESHEET

Overview

There are various ways to store water on-site. Detention systems include: detention basins, detention vaults, infiltration vaults, oversized pipes, parking lot detention, and rooftop detention.

Detention Basins

Detention basins are depressions that temporarily store stormwater and release it gradually to a downstream drainage system. Wet detention basins are designed to permanently retain water and can be made to appear manicured or naturalized. Dry detention basins are designed to drain completely between storms. When discharging to waterways or storm sewers, wet detention basins are preferable to dry detention basins because of their effectiveness in removing runoff pollutant loads, especially suspended solids. In order to achieve optimum pollutant removal efficiency, the basin inlet and outlets should be located hydraulically as far apart as possible to prevent “short circuiting” and to increase the retention time. In addition to providing pollutant removal, detention basins can be designed to be aesthetically pleasing and to provide recreational benefits.

Naturalized detention basins incorporate features such as plunge pools, stilling basins, variable topography to lengthen low flow pathways, and native upland buffer and wetland plantings. Detention basins that incorporate these features can replicate some of the flood storage, water quality and habitat benefits provided by natural systems such as wetlands, lakes or ponds. Naturalized detention basins may be created on almost any site, but the provision of wetlands may be constrained by site hydrology and soil conditions. Wetland detention basins are feasible in areas with a high water table or relatively impermeable soils. In some cases, it may be possible to provide detention within an existing degraded wetland area by developing a plan to rehabilitate the area. In addition to reducing peak flows, wetland detention basins are very effective in removing pollutant loads. The principal advantages of stormwater wetlands are their ability to prevent settled pollutants from resuspending and washing out during subsequent storms and their ability to remove dissolved pollutants and organic matter through biological processes. High-quality wetlands should not be used to treat stormwater.

Detention Vaults

Detention vaults are usually precast reinforced concrete tanks constructed below grade. They are provided with restrictors to limit release rates. Most vaults permanently retain water in order to dissipate energy, settle out large solids particles, and act as an oil separator. Subsurface vault systems are suitable for any project where space is limited and other stormwater management systems are not feasible. Subsurface vaults may be used for commercial, industrial, or roadway projects. The presence of a subsurface vault in most cases does not alter the intended land use at the surface. The subsurface vault must meet structural requirements for overburden support and traffic loading to be applicable in urban settings.

Infiltration Vaults

Infiltration vaults are detention vaults with an open bottom to encourage infiltration in areas where permeable subsoil conditions are found (Figure 9). This option may be used to satisfy volume control requirements but above-ground naturalized infiltration facilities are preferred. Infiltration vaults must include a design for pretreatment. In many cases this can be provided within the vault itself, but a definitive long-term maintenance plan will be required for the removal of sediment. When the infiltration rate has been verified by geotechnical investigations and pretreatment is provided, the infiltration rate may be counted in addition to the allowable release rate when computing required storage volumes.

<u>Oversized Pipes</u>

Oversized pipes are designed like storm sewers. Oversized pipes serve as both detention and conveyance structures. They are very commonly used at small developments to fulfill detention requirements. To serve as a storage structure, the oversized pipe requires a flow restrictor at the downstream end of the pipe to limit the capacity of the sewer outlet to the required release rate. In this way, when inflow into the sewer is greater than the release rate, stormwater is “stored” in the pipe behind the restrictor. Oversized pipes offer a feasible alternative to detention basins when a site has limited space; however, oversized pipes do not provide volume control or water quality benefits.

<u>Parking Lot Detention</u>

Parking lots can be significant sources of runoff pollutants and these areas are often directly connected to the storm drain system. Reducing the paved surface area in parking lots and incorporating BMPs into the parking lot design can reduce runoff volume and pollutants discharges from the site. Parking lot detention can be designed to receive overflow from other BMPs during intense storms or to pond to a certain depth and then overflow into other BMPs. City regulations allow up to 12 inches (10 inches recommended) of water to be ponded directly on the parking lot surface.

<u>Rooftop Detention</u>

Rooftop detention consists of either an enclosed chamber or a constructed ponding area designed to fill with stormwater during large storm events, slowly releasing it over a number of hours. There are numerous components to these systems. Drain inlet pipes convey stormwater into a detention chamber, which accumulates stormwater during a storm event. An orifice structure or outlet drainpipe restricts the flow out of the detention chamber, allowing it to fill up and slowly drain out. Rooftop detention does not provide water quality or volume control benefits.

Minimum design requirements for detention systems are provided below. A worksheet for quantifying infiltration vault performance to comply with the volume control requirements of the Chicago Stormwater Management Ordinance follows.

Minimum Design Requirements
Detention Basins
If the outlet from a dry bottom basin is less than 2 feet above of the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the basin.
Dry bottom basins must be capable of draining within 72 hours of a storm event.
Maintenance access to the facility must be provided.
The bottom of the storage area in a detention basin must be above the seasonally high groundwater table.
For wet detention basins*, a safety ledge at least 4 feet in width must be constructed at a depth of 1 to 2 feet below the normal water surface.
Wet detention basins without vegetation shall be at least 3 feet deep. The side slopes shall be no steeper than 3H:1V without erosion protection. The sides of the pond that extend below the safety and aquatic benches to the bottom of the pond must have a slope that will remain stable, and be no

Minimum Design Requirements
steeper than 2H:1V. For dry bottom detention basins, side slopes shall be 4H:1V or flatter.
A sediment forebay shall be incorporated into all wet bottom detention basins.
After excavation and grading of a stormwater wetland basin, at least 6 inches of topsoil must be applied to the basin bottom and sideslopes. Reference Stormwater Manual.
At sites where infiltration is too rapid to sustain permanent soil saturation, analysis of the proposed plantings or intended wetland functions must be undertaken. If needed, an impermeable liner (geotextile fabric) shall be designed to maintain adequate hydrology. Where the potential for groundwater contamination is high, such as runoff from sites with a high potential pollutant load, the use of a liner is required.
Basins incorporating wetlands shall include a buffer to separate the wetland from surrounding land where feasible.
Detention Vaults
Detention vaults under buildings designed only for a 10-year storm capacity, shall be provided with means to safely accommodate 100-year overflows.
Detention vaults under buildings must be water tight and made of concrete—cast-in-place vault, pre-cast vault, or RCP.
Buildings with underground storage must have plans (with backup calculations) sealed by a licensed architect or structural engineer to safeguard against structural failure of floor foundations and downspouts due to maximum hydrostatic pressures during sewer surcharges.
Proper ventilation of underground vaults for buildings must be provided in accordance with Building Code Articles 9 and 11, as applicable, to equalize interior downspout pressures and to prevent siphoning effects through the piping and sewer systems.”
Vaults must be designed to be water-tight unless used for groundwater infiltration purposes or unless the bottom of the vault is at least 7 feet above the groundwater table.
For vaults using infiltration*, soil must have at least a 0.5 in/hr infiltration rate or greater and the bottom of the vault must be at least 3.5 feet above the groundwater table when connected to a combined sewer. Means to control sediment and/or debris from entering the vault must be provided. Pretreatment measures are required for all infiltration vaults.
If the outlet from a vault is lower than the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the vault.
Oversized Pipes
Locking manhole covers shall be provided for pipe diameters 4 feet and larger in areas where children may be present.
If the outlet from a vault is lower than the crown of the combined outlet sewer, a check valve must be installed to prevent combined sewerage from backing up into the vault.
Parking Lot Detention
Maximum allowable ponding in a parking lot shall be 12 inches. If more than 10 inches of ponding, the O&M Plan must indicate such.
Adequate visible warning must be provided for any depressed islands during flood stage.
Rooftop Detention
Provide a grading plan of the roof to verify available storage.
Provide details and hydraulic characteristic of any controlled roof drains in the Plan
Minimum orifice size for restricted roof drains is 0.75 inches.
Provide scuppers or overflows to accommodate 100-year storm events.
Include approval and seal from a Registered Structural Engineer or Licensed Architect.
In addition to other applicable code requirements, Sections 18-29-1105, 1106, and 1110 of the Municipal Code must be complied with.
Restrictors
The maximum discharge released is equal to or less than the maximum permissible release rate for the site.
DWM 3-inch and 4-inch vortex restrictors utilize 8-inch diameter outlet pipes to achieve release rates of 0.15 and 0.25 cfs, respectively.

Minimum Design Requirements
Flow-restricting outlets shall be submerged in a catch basin, i.e., with a half trap, to prevent clogging.
The minimum restrictor plate size is 2.5” in diameter.

Maintenance Guidelines

Maintenance is required for the proper operation of detention systems. Plans for detention systems should identify owners, parties responsible for maintenance, and an inspection and maintenance schedule for detention systems.

Activity Schedule (Detention Basins)

As needed
- Sediment should be removed from the basin as needed (at least once every 5 to 10 years)

Quarterly
- Inspect inlet pipe(s) and outlet control structure for clogging
- After every storm greater than one inch
- Remove trash and debris
- Remove invasive plants
- Grassed areas also require periodic prudent fertilizing, dethatching and soil conditioning
- Trees, shrubs, and other vegetative cover will require periodic maintenance such as fertilizing, pruning, and pest control
- Mow / trim detention basin vegetation

Once per year
- Inspect detention basin, potential problems include: subsidence, erosion, cracking or tree growth on the embankment; damage to the emergency spillway; sediment accumulation around the outlet; inadequacy of the inlet/outlet channel erosion control measures; changes in the condition of the pilot channel; and erosion within the basin and banks.

Activity Schedule (Underground detention systems)

Underground vaults must be designed so that the vault can have easy access for inspection and maintenance. Vault maintenance procedures must meet OSHA confined space entry requirements, which include clearly marking entrances to confined space areas. This may be accomplished by hanging a removable sign in the access riser(s), just under the access lid.

As needed
- Removal of sediment and debris from subsurface vault sedimentation chamber when the sediment zone is full as well as from inlet and outlet pipes. Sediments should be tested for toxicants in compliance with applicable disposal requirements if land uses in the catchment include commercial or industrial zones, or if indications of pollution are noticed.

Quarterly
- Floating debris should be removed.

Once per year
- Inspection of subsurface vault and control structures

Activity Schedule (Parking lot detention and Rooftop detention)

As needed	• Remove trash and debris
Quarterly	• Inspect outlet control structure for clogging and after every storm greater than 1 inch
Once per year	• Inspect storage area to ensure that encroachments or renovations do not reduce available storage.

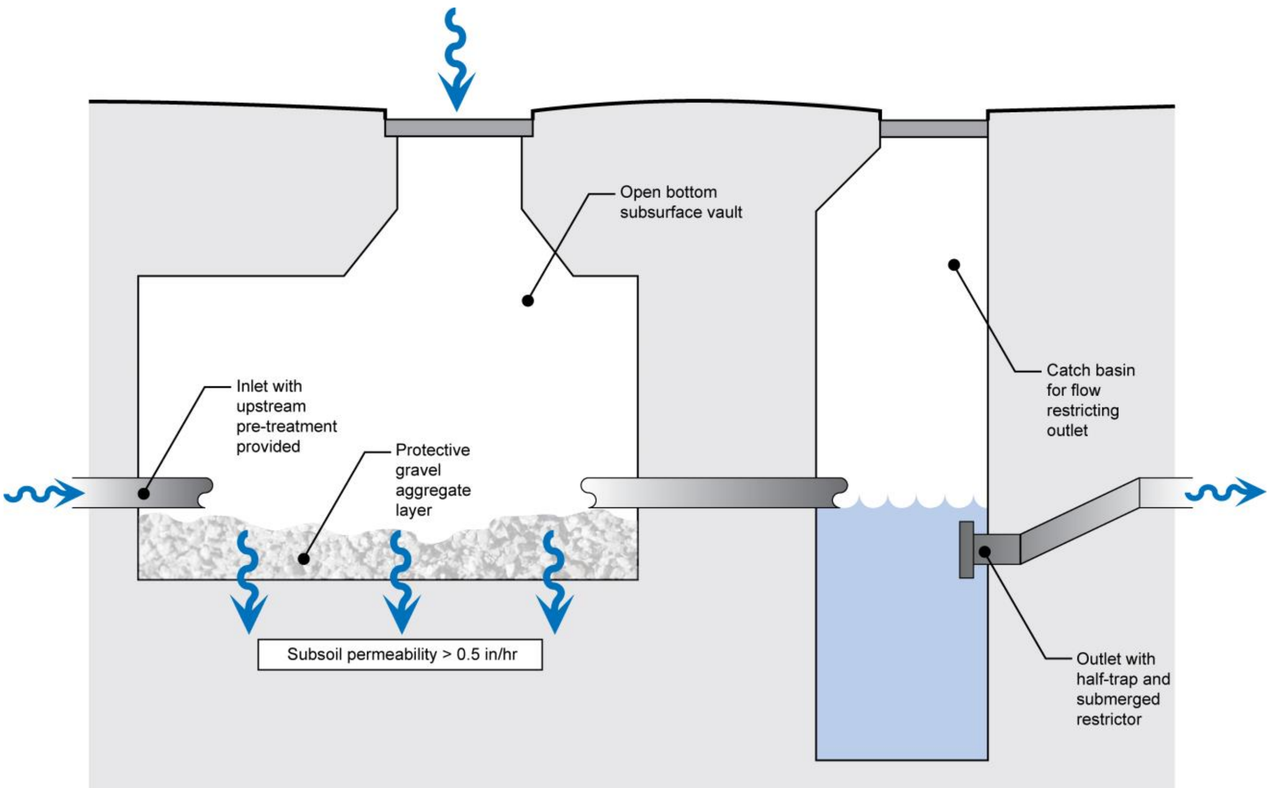


Figure 9: Infiltration Vault

2.1.4 Infiltration Vault

Section 1 Upstream Drainage Area				
1	Upstream impervious area	A_i		square feet
2	Upstream weighted C-value	C		unitless
3	Volume of upstream runoff from a 1-inch storm = C * A_i * 1/12	$V_{upstream}$	0	cubic feet
4	Describe intended function of system (Is it standalone system designed for infiltration, is it integrated as part of the detention storage?)			

Section 2 BMP Feasibilty				
5	Design soil infiltration rate (must be 0.5 in/hr or greater)	i		in/hr
6	Allowable depth of storage (distance below outflow invert plus depth of storage aggregate) = (i / 12 inches/ft * 48 hours)	D_{allow}	0.00	feet
7	Elevation of bottom of BMP (the infiltration surface)	$ELEV_{BMP}$		feet
8	Groundwater elevation	$ELEV_{GW}$		feet
9	Depth to seasonal groundwater (Must be 2 feet or greater, or 3.5 feet or greater if draining to combined sewer)	D_{GW}	0.0	feet

Section 3 BMP Specifications				
10	Dimensions of the infiltration area (length, width, or area)	L		feet
		W		feet
		A_{BMP}	0	square feet
11	Depth of open storage (distance between vault outflow invert and top of aggregate/infiltration bed (D_1 plus D_2 must be less than D_{allow})	D_1		feet
12	Depth of underlying aggregate	D_2		feet
13	Aggregate porosity (0.38 maximum unless detailed materials report provided)	P_1		feet
14	Storage applicable to volume control = (A_{BMP} * D_1)+(A_{BMP} * D1*P_1)	V_{BMP}	0	cubic feet

Section 4 BMP Performance				
15	Volume of upstream runoff (Line 3)	$V_{upstream}$	0	cubic feet
16	Volume Control Storage Provided = V_{BMP}	V_{BMP}	0	cubic feet
17	V_{total} (equals lesser of V_{BMP} or $V_{upstream}$)	V_{total}	0	cubic feet

Appendix D: Case Studies

CASE STUDY 1: Strip Mall Development

CASE STUDY 2: Parking Lot Development

CASE STUDY 3: High-Rise Building over Existing Parking Lot

CASE STUDY 4: High Rise Building over Existing Gravel Lot Without Drainage Structures

CASE STUDY 5: Example of Maximum Critical Local Sewer Release Rate Computations

CASE STUDY 6: Diverted Release Rate Computations

Case Study 1: Strip Mall Development

This case study walks through the use of the Stormwater Spreadsheet Tool.

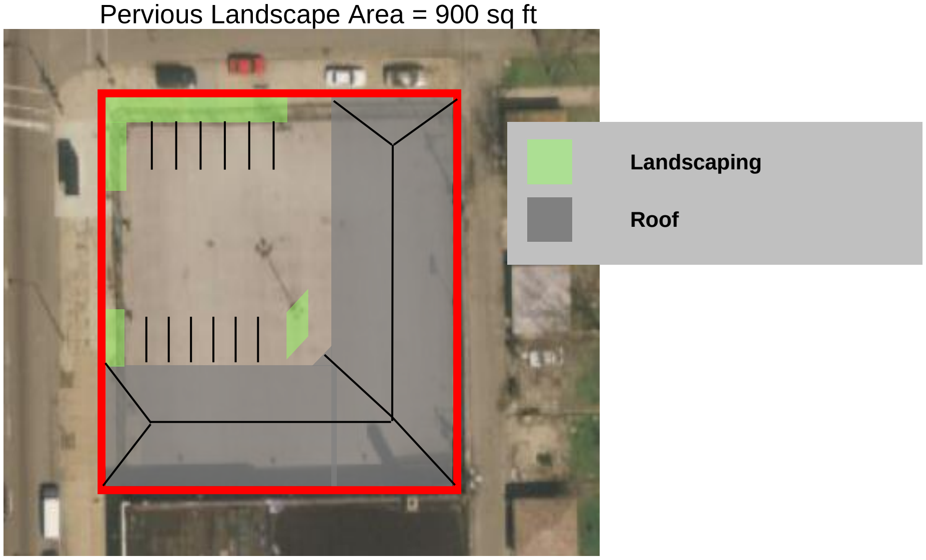
Step 1: Collect Existing/Proposed Site Information

Existing Conditions:

Area = 15,000 sq ft
Parking Lot = 15,000 sq ft

Proposed Conditions

Roof = 8,400 sq ft
Parking Lot / Driveways = 5,700 sq ft
Pervious Landscape Area = 900 sq ft



Define Regulatory Status

It is a regulated development due to 15,000 square feet of land disturbance. The development is subject to all performance requirements of the Ordinance.

Step 2: Enter data into the Rate Control Calculations Spreadsheet

<u>Initial 1.0 Rate Control Calculations:</u>

- Assumptions / Data Entry:
  - Lawns - Heavy soil, avg, 2% to 7% = 900 sq ft
  - Pavement = 5,700 sq ft
  - Roof (conventional) = 8,400 sq ft
  - Question 1: No
  - Question 2: No
  - Question 3: No
  - Question 4: Yes
  - Question 5: No
  - Question 6: No
  - Question 7: No
  - Storm Event: 100-Year
  - Dry Weather Flow = 0 (for commercial / retail development)
  - Total BMP Areas = 0
- Calculation Results:
  - Detention Release Rate = 0.15 cfs
  - Detention Storage to be provided = 4,629 cu ft

Step 3: Enter data into the Volume Control Calculations Spreadsheet

<u>Initial 2.0 Volume Control Calculations:</u>

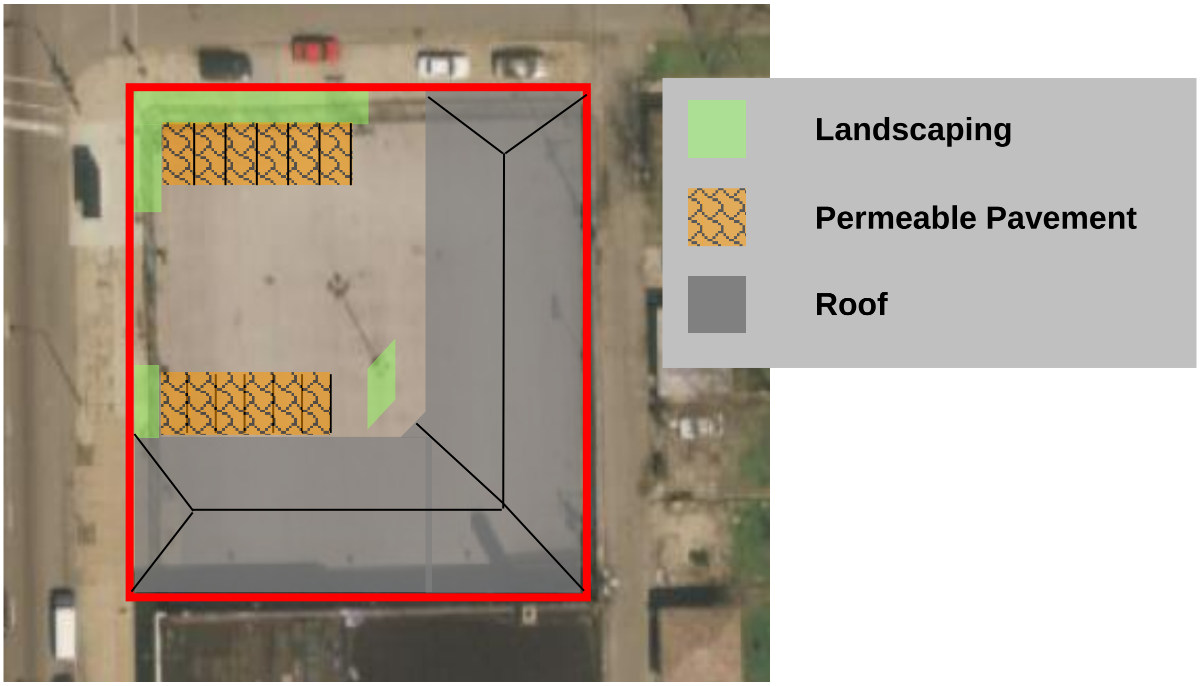
- Assumptions / Data Entry:
  - Existing Pavement = 15,000 sq ft
  - Proposed Lawn or Landscape Area = 900 sq ft
  - Proposed Pavement = 5,700 sq ft
  - Proposed Roofs (conventional) = 8,400 sq ft
  - Question 1: No
  - Question 2: Yes
  - Question 3: Yes
  - Total BMP Areas = 0
- Calculation Results:
  - Existing Impervious = 100%
  - Proposed Impervious = 94%
  - Storage required to be Captured = 588 cu ft
  - Impervious Reduction <u>**not**</u> met (need to be 85%)

Step 4: Determine option(s) to meet the required goals of the Ordinance and Regulations

Try to reduce Impervious % to meet the 85% goal from Volume Control Spreadsheet:

Use Permeable Pavement as pervious area (does not count for storage requirements)

Add 1,350 sq ft of Permeable Pavement. Pavement area reduced to 4,350 sq ft



Step 5: Enter data into the BMP Spreadsheets

2.1.6 Permeable Pavement spreadsheet calculations:

Site grading plan drainage delineations show that the Impervious Area (including the BMP) draining to the Permeable Pavement is 3,000 sq ft which comprises 1,350 sq ft of Permeable Pavement and 1,650 of Pavement. The remainder of the pavement either drains toward the roadway (400 sq ft max.) or to catch basins on site. The roof discharges to the on-site detention system.

Upstream Impervious Area (including BMP) = 3,000 sq ft
Infiltration = 0.6 in/hr (based on single ring infiltrometer test)
GWD = 5.0 ft (based on site soil boring)

Rather than entering the length and width of the BMP, the total area of the BMP is entered.

Area BMP = 1,350 sq ft
Depth of underlying aggregate = 1.0 ft (based on site design plans)
Porosity of Aggregate = 0.38 (assumed for this site)

Calculation Results:

Volume of Upstream Runoff = 238 cu ft
Volume of BMP Storage = 513 cu ft
Total Volume provided = 238 cu ft

The total volume provided is based on the minimum of the upstream runoff and BMP storage volumes. The calculations only allow the permittee to account for the volume of 1-inch of runoff when the volume provided by the BMP is greater than the runoff. However, if the volume provided by the BMP was less than the volume from 1-inch of runoff, then it would be assumed that the volume in the BMP would be fully utilized and this would be the total volume provided.

Step 6: Update Volume Control Calculations for any BMPs

<u>2.0 Volume Control Calculations:</u>

Assumptions / Data Entry:

- Existing Pavement = 15,000 sq ft
- Proposed Lawn or Landscape Area = 900 sq ft
- Proposed Pavement = 4,350 sq ft (changed some to permeable pavement)
- Proposed Roofs (conventional) = 8,400 sq ft
- Proposed BMPs – Permeable Pavement = 1,350 sq ft
- Question 1: No
- Question 2: Yes
- Question 3: Yes
- Total BMP Areas Treated as Impervious Area = 0 sq ft
- Total BMP Areas Treated as Pervious Area = 1,350 sq ft (Due to Q3 = Yes)

Calculation Results:

- Existing Impervious = 100%
- Proposed Impervious = 85%
- Storage required to be Captured = 531 cu ft
- Impervious Reduction <u>**is**</u> met

Step 7: Choose how to apply the BMPs for Rate Control

<u>1.2 BMPs – Rate Control Credit spreadsheet</u>

Only one BMP (Permeable Pavement) is used on this site. For this scenario, the Permeable Pavement <u>will count</u> towards Rate Control volume. Enter "Yes" in the spreadsheet adjacent to the Permeable Paving section under the <u>BMP Areas with Storage COUNTED toward Rate Control Volume</u> table.

Step 8: Update data into the Rate Control Calculations Spreadsheet

<u>1.0 Rate Control Calculations:</u>

Assumptions / Data Entry:

- Lawns - Heavy soil, avg, 2% to 7% = 900 sq ft
- Pavement = 4,350 sq ft (changed some to permeable pavement)
- Roof (conventional) = 8,400 sq ft
- Question 1: No
- Question 2: No
- Question 3: No
- Question 4: Yes
- Question 5: No
- Question 6: No
- Question 7: No
- Storm Event: 100-Year
- Dry Weather Flow = 0 (for commercial / retail development)

Calculation Results:

- Total BMP Areas counting toward Rate Control volume = 1,350 sq ft
- C-Value for BMP Areas counting toward Rate Control volume = 0.95
- C-Value for site (non BMP areas) = 0.92
- C-Value for site (adjusted for BMP areas) = 0.92

The size of the BMP for this site does not have a significant impact to the adjusted C-value for this site.

- Detention Release Rate = 0.15 cfs
- Infiltration Release Rate = 0.019 cfs (from Permeable Pavement)
- Release rate for detention calculations = 0.169 cfs
- Required Storage Volume = 4,442 cu ft
- Permeable Pavement Storage Volume = 513 cu ft (storage provided)
- Detention Storage to be provided in facility = 3,929 cu ft

Step 9: Design Detention Facility

Need to provide 3,929 cu ft of detention volume restricted at 0.15 cfs. Note that the release rate from the detention facility is 0.15 cfs while the release rate for the site is 0.169 cfs. The difference in release rate is due to flow being released through infiltration with the Permeable Pavement BMP.

Provide oversized pipe system:
201 ft of 60" Diameter RCP (Volume = 3,947 cu ft)
Utilize City of Chicago 3-inch standard vortex restrictor

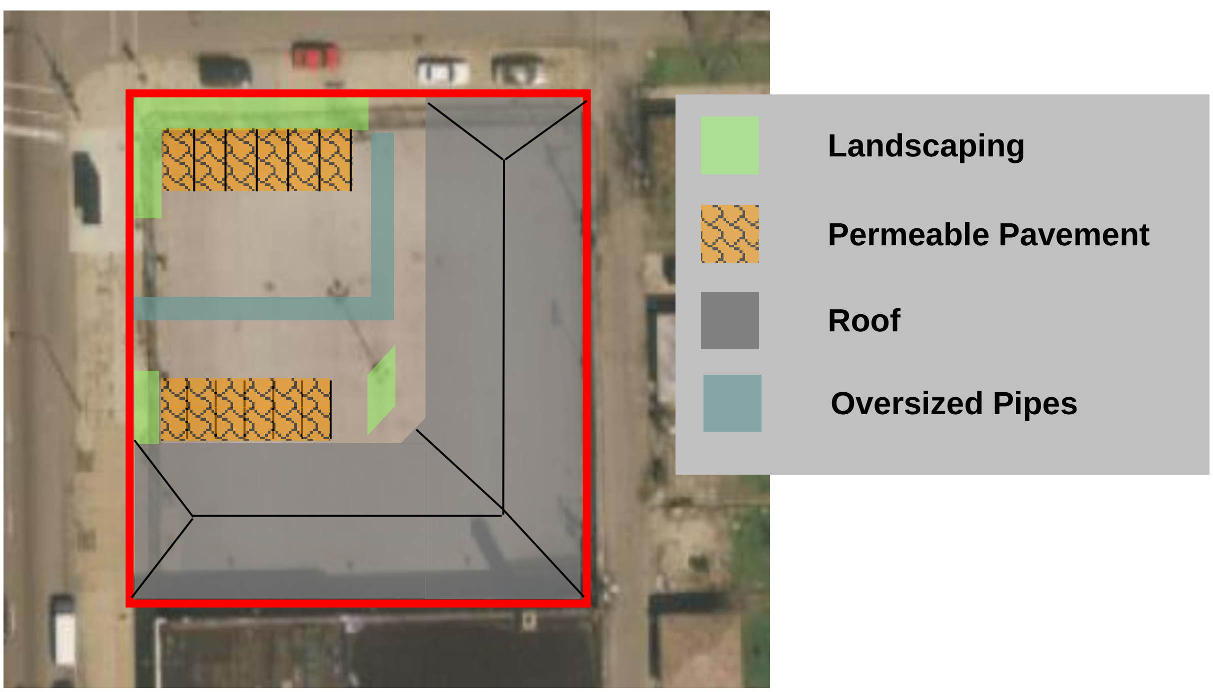
Summary

Rate Control Volume Requirement = 4,442 cu ft
Rate Control Release Rate = 0.169 cfs
Rate Control Volume Satisfied by:
- Permeable Pavement Volume = 513 cu ft
- <u>Oversized Pipe Volume = 3,947 cu ft</u>
- Total Volume = 4,460 cu ft

Rate Control Release Rate Satisfied by:
- Permeable Pavement Infiltration = 0.019 cfs
- <u>City of Chicago 3-inch standard vortex restrictor = 0.15 cfs</u>
- Total Release Rate = 0.169 cfs

Volume Control Requirement:
- Provide 531 cu ft of Volume Control volume or reduce the proposed site's impervious % to 85%.
- Volume control met by reducing the site's % impervious to 85%.

<u>Final Proposed Conditions</u>



Case Study 2: Parking Lot Development

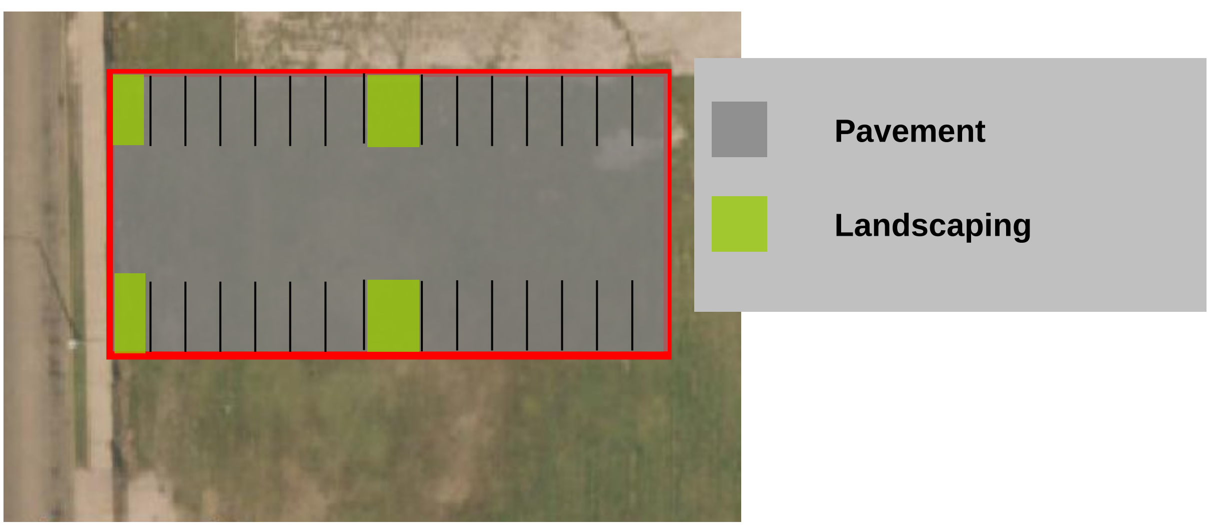
This case study walks through the use of the Stormwater Spreadsheet Tool.

Existing Conditions:

Area = 8,500 sq ft
Open Space = 8,500 sq ft

Proposed Conditions

Parking Lot / Driveways = 7,900 sq ft
Landscape Area = 600 sq ft



Define Regulatory Status

It is a regulated development due to 7,500 square feet new at-grade impervious area. The development is subject to all performance requirements of the Ordinance.

Initial 1.0 Rate Control Calculations:

Assumptions / Data Entry:

Lawns - Heavy soil, avg, 2% to 7% = 600 sq ft
Pavement = 7,900 sq ft
Question 1: No
Question 2: No
Question 3: No
Question 4: Yes
Question 5: No
Question 6: No
Question 7: No
Storm Event: 100-Year
Dry Weather Flow = 0
Total BMP Areas = 0

Calculation Results:

Detention Release Rate = 0.15 cfs
Detention Storage to be provided = 2,106 cu ft

Initial 2.0 Volume Control Calculations:

Assumptions / Data Entry:

Existing Lawn or landscape Area = 8,500 sq ft
Proposed Lawn or Landscape Area = 600 sq ft
Proposed Pavement = 7,900 sq ft
Question 1: No
Question 2: Yes
Question 3: Yes
Total BMP Areas = 0

Calculation Results:

Existing Impervious = 0%
Proposed Impervious = 92.9%
Storage required to be Captured = 329 cu ft
Impervious Reduction **not** met (cannot be met due to 0% existing impervious)

Add Bioinfiltration on a portion of the landscape areas to meet the Volume Control requirements.

2.1.1 Bioinfiltration spreadsheet calculations:

Based on proposed grading plans, 3,600 sq ft of pavement drains to the bioinfiltration BMPs (At = 3,980 sq ft = 3,600 sq ft + 380 sq ft BMP).

Provide 380 sq ft of Bioinfiltration BMPs in two landscaped areas.
Infiltration = 0.6 in/hr (based on single ring infiltrometer test)
GWD = 5.0 ft (based on site soil boring)
Depth of prepared BMP soil = 1.5 ft
Porosity of Soil assumed to be = 0.25
Depth of aggregate = 0.5 ft
Porosity of aggregate assumed to be = 0.38
Total depth of Bioinfiltration BMP = 2.0 ft (soil + aggregate)
Air Space (Surface) Storage: 126 cu ft (Assume that water can cover 4" of the BMP for simplicity's sake for this example. In a final engineering design, a separate calculation using the frustum of a cone equation would be required.)

The volume of upstream runoff is 332 cu ft and the volume of the BMP is 341 cu ft. The ordinance only allows the lesser of these to count toward the volume control requirement, so the volume of the BMP is 332 cu ft (based on the upstream runoff).

1.2 BMPs – Rate Control Credit:

For this scenario, the Bioinfiltration System will count towards Rate Control volume. Enter "Yes" in the spreadsheet adjacent to the Bioinfiltration Systems section under the BMP Areas with Storage COUNTED toward Rate Control Volume table.

1.0 Rate Control Calculations:

Assumptions / Data Entry:

Lawns - Heavy soil, avg, 2% to 7% = 220 sq ft
BMPs counted toward rate control = 380 sq ft
Pavement = 7,900 sq ft
Question 1: No
Question 2: No
Question 3: No
Question 4: Yes
Question 5: No
Question 6: No
Question 7: No
Storm Event: 100-Year
Dry Weather Flow = 0

Calculation Results:

Detention Release Rate = 0.15 cfs
Infiltration Release Rate = 0.005 cfs (from Bioinfiltration)
Release rate for detention calculations = 0.155 cfs
Required Storage Volume = 2,159 cu ft
BMP Storage Volume = 341 cu ft (from Bioinfiltration)
Detention Storage to be provided in facility = 1,818 cu ft

2.0 Volume Control Calculations:

Assumptions / Data Entry:

Existing Lawn or landscape Area = 8,500 sq ft
Proposed Lawn or Landscape Area = 220 sq ft
Proposed BMP Area = 380 sq ft
Proposed Pavement = 7,900 sq ft
Question 1: No
Question 2: Yes
Question 3: Yes

Calculation Results:

Existing Impervious = 0%
Proposed Impervious = 92.9%
Storage required to be Captured = 329 cu ft
Impervious Reduction **not** met (cannot be met due to 0% existing impervious)
Does not change from initial because BMP is still acting as pervious area.

Proposed Detention Facility for Rate Control Volume

Provide oversized pipe system:
93 ft of 60" Diameter RCP (Volume = 1,826 cu ft)
Utilize City of Chicago 3-inch standard vortex restrictor

CASE STUDY 3: High Rise Building over Existing Parking Lot

This case study provides sample computations for computing the DWM storage requirements for volume and rate control for a hypothetical 50-story, two-level building to be constructed over an existing parking lot.

Given:
The existing parking lot (C = 0.85) has an area 30,000 sf (0.688 ac) and has a 6-inch connection. The existing parking lot sheet flows toward the location of the proposed building and must be by-passed through the proposed detention facility. The disturbed area consists of the proposed building 12,000 sf (0.275 ac) and 2000 sf (0.046 ac) of surrounding open green area. The 12,000 sf building roof will be 50 percent green (5-inches thick). The critical sidewall area between the upper and lower level roof is 25,000 sf (0.574 ac). The proposed average DWF is 1.6 cfs. The maximum release rate has been calculated as 0.3 cfs/acres.

Disturbed Area:	0.275 + 0.046 = 0.321 ac, which is < 15,000 sf
Regulatory Area:	0.275 + 0.046 + (0.574*25%) + 1.6 = 2.06 ac, now > 15,000 sf Reg. Site
Lot-to-lot:	0.275/(0.275+0.046) * 100 = 0.857 > 85%, Considered as lot-to-lot

Volume Control Requirements:
Green Roof Area: 12,000 / 2 = 6000 sf, 0.137 ac
Check for 15% reduction:
0.046 + 0.137 = 0 .183 ac green
100- [0.183 / 0.321] * 100 = 43 % > 15 %, requirements met

Rate Control Requirements:
For lot-to-lot development:

Release Rate (RR): 0.321 ac * 0.3 cfs/acre= .0963 cfs < 0.15 cfs, Utilize Standard RR, subject to DWF

Check 10% DWF: 10% x 1.6 cfs > 0.15 cfs, May need 25 gpm as release rate

Check Existing Conditions:
Existing 5-year (5 min.) Discharge = 0.688 ac *0.85 * 6.24in/hr = 3.65 cfs
Existing 6" connection capacity, Q = 0.61*0.196 *SQRT(64.4*5') = 2.14 < 3.65 cfs
Use 2.14 cfs, as existing discharge rate based on an assumed 5 feet of maximum head

Proposed 5-year Discharge = 1.6 cfs + 0.15 cfs = 1.75 cfs < 2.14 cfs, maybe ok to use 3" vortex with 0.15 cfs.

10-year Building:
D.A.= 0.275+(0.574*25%) = 0.4185 ac
C = [(0.275)(0.95+0.3)/2 + (0.574*25%*0.95)] / 0.4185 = 0.74
RR = 0.15*(0.275/0.321)* 1.10 = 0.141 cfs (portion of release rate attributable to building)
10-yr Storage = 2,303 cf

100-year Open Area:
D.A. = 0.046 ac
C= 0.3
RR = 0.15*(0.046/0.321)* 1.1 = 0.024 cfs (portion of release rate attributable to ground surface)
100-yr Storage = 115 cf

Total Required Storage= 2,303 + 115 = 2,418 cf

<u>Check 25-year w/ Offsite:</u>
D.A. = 0.688 + (0.574*25%) = 0.832 ac
C = [(0.4185 * 0.74) + (0.046*0.3) + (0.832-0.4185-0.046)* 0.95] / 0.832 = 0.808
RR= 0.15 cfs, w/vortex restrictor
Required storage @ 0.15 cfs would be 8,455 cf >> 2,418 cf, NG
++Required Storage @ 0.5 cfs would be 5,521 cf
Utilize 5,521 cf as new total onsite required storage.

<u>Adopted Restrictor Size:</u>
Since the upstream drainage area (0.367 ac) is greater than the disturbed area (0.321 ac), the DWM will allow an increase in the 0.15 cfs release rate; however, the existing discharge rate of 2.14 cfs cannot be increased. A release rate of 0.5 cfs (for 25 year storm) would be acceptable since the proposed discharge rate of 0.5 + 1.6 = 2.10 cfs is less 2.14 cfs. Therefore, the restrictor size will be approximately 3-inches in diameter reflecting a 0.5 cfs maximum release rate for a 25-year storm event. Means to accommodate overflows up to a 100-year storm event must be considered.

<u>Check Actual 100-year w/ Offsite:</u>
D.A. = 0.832 ac
C= 0.808
RR = 0.5 cfs, w/3-inch orifice
Storage = 5,521 cf,
100–year Overflow Volume = 8,455-5,521 = 2,934 cf

CASE STUDY 4: High Rise Building over Existing Gravel Lot without Drainage Structures

This case study provides sample computations for computing the DWM storage requirements for volume and rate control for a hypothetical 50-story, two-level building to be constructed over a vacant gravel lot without drainage structures.

Given:
Same as Case 3, except the existing 30,000 sf (0.688 ac) parking lot consists of dirt/grass (C = 0.50) and sheet flows towards the proposed development. The proposed green roof does not have any other roof area tributary to it.

Volume Control Requirements:
Required volume: 0.5”/12*12,000 sf roof * 50% impervious = 250 cf
Utilize oversized detention

Rate Control Requirements:

Check Existing Conditions:
Since there are no onsite sewers and the equivalent disturbed area (2.06 ac) is greater than 0.5 acres, the development is considered a diversion. The existing discharge is considered as zero.

Proposed 5-year Discharge = 1.6 cfs + 0.15 cfs = 1.75 cfs >> 0 cfs
Must consider 25 gpm (0.055 cfs) release rate for site.

Check 100-year for Site:
D.A. = 0.4185+0.046 = 0.465 ac
C= [(0.4185*0.74)+(0.046*0.3)]/0.465 = 0.70
RR = 0.055 cfs
Minimum Storage = 6,279 cf

Check 25-year w/Offsite:
D.A. = 0.688 + (0.574*25%) = 0.832 ac
C = [(0.4185 * 0.74) + (0.046*0.3) + (0.832-0.4185-0.046)* 0.5] / 0.832 = 0.61
RR= 0.055 cfs
Maximum Storage = 11,180 cf

In this case, a negotiated settlement with the DWM is required since it may not be practical to have a pumped discharge with offsite runoff. Other alternatives, such as surface ponding on the existing lot should be considered. Since the capacity of the existing city sewer is poor (0.30 cfs/ac), no more than a 3-inch vortex would likely be allowed with a corresponding storage requirement of 5,521 cf (from case 3- w/offsite). With oversized detention, the total comes to 5,771 (5,521 + 250) cf.

Check Actual Capacity w/ Offsite:
D.A. = 0.688 + (0.574*25%) = 0.832 ac
C = [(0.4185 * 0.74) + (0.046*0.3) + (0.832-0.4185-0.046)* 0.50] / 0.832 = 0.61
RR= 0.15 cfs, w/3” vortex restrictor
Storage = 6,279 cf

Since 5,771 cf < 6,279 cf,
Acceptable to use 5,771 cf as the required onsite storage

CASE STUDY 5: Maximum Critical Local Sewer Release Rate Computations

Determine:

Compute Maximum Release Rate for a hypothetical 5 acre development located within 111th St., 112th St.,Bell Av. and Hoyne Av.

Step 1: Obtain Sewer Atlas Maps and Drain Atlas Maps

Locate the development on the maps and determine to which sewer the development will discharge. In this situation, the development ultimately discharges to both a 3.5 ft sewer and a 2.0 ft sewer at the railroad at Prospect and 111th. Since the size of the connection sewer is not larger than 3.5 feet, the local sewer capacity calculations must be completed.

Step 2: Delineate drainage areas and assign land uses from development to upstream end of drainage basin. (see exhibits at end of Case Study 3)

Drainage Area (acres)	Land Use	Weight Factor
22.8	Residential	1.0
34.1	Residential	1.0
9.81	Residential	1.0
7.22	Residential	1.0
11.7	Residential	1.0

Weighted Drainage Area =
=(22.8 x 1.0)+ (34.1 x 1.0) + (9.81 x 1.0) + (7.22 x 1.0) + (11.7 x 1.0)
= 85.63 acres

Step 3: Determine Outlet Sewer Capacity

Outlet Sewer Capacity is based on Appendix III-A of the stormwater regulations.
Laflin and Wood Outlet Basin
Outlet Sewer Capacity = 0.34 cfs/acre

Step 4: Determine Local Sewer Capacity

Sewer Segment 1

42" in Prospect at Railroad
- u/s= 34.58
- d/s= 31.33
- L= 780', n=0.013
- S=0.00416
- Q= 65.1 cfs

2' in 111th at Railroad
- u/s= 37.6
- d/s=36.8
- L=330', n=0.015
- S=0.0024
- Q=9.6 cfs

Weighted Drainage Area = Total area calculated above = 85.63 acres
Local Sewer Capacity (Segment 1) = (65.1+9.6)/85.63 = 0.87 cfs/acre

Sewer Segment 2

In 111th at Longwood
- Dia. =2.0’
- u/s= 58.85
- d/s=37.6
- L=380', n=0.015
- S=0.0559
- Q= 46.5 cfs

Weighted Drainage Area
11.7 (Residential) x 1.0 + 7.22 (Residential) x 1.0 + 9.81 (Residential) x 1.0 +
34.1 (Residential) x 1.0 = 62.83 acres
Local Sewer Capacity (Segment 2) = 46.5/62.83 = 0.74 cfs/acre

Sewer Segment 3
In 111th at Hoyne
Dia. =2.0'
u/s= 72.5
d/s=71.5
L=965', n=0.015
S=0.0010
Q=6.22 cfs

Weighted Drainage Area= 11.7 acres (Residential) x 1.0 = 11.7 acres
Local Sewer Capacity (Segment 3) = 6.22/11.7=0.53 cfs/acre

Sewer Segment 4
In Hoyne at 111th
Dia.= 1.25'
u/s=73.1
d/s=71.5-[(71.5-69.06)(100/230)]= 70.44
L=1200', n=0.011
S=0.0022
Q=3.59 cfs

Weighted Drainage Area= 7.22 (Residential) x 1.0 + 9.81 (Residential) x 1.0
=17.03 acres
Local Sewer Capacity (Segment 4) = 3.59/17.4=0.21 cfs/acre

Sewer Segment 5
In 112th at Hoyne
Dia.= 1.0'
u/s= 73.5
d/s= 73.1- [(73.1-71.5)(320'/1200')] = 72.67
L= 700', n=0.011
S=0.00118
Q=1.45 cfs

Weighted Drainage Area= 7.22 (Residential) x 1.0 = 7.22 acres
Local Sewer Capacity (Segment 5) = 1.45/7.22= 0.20 cfs/acre

Step 5: Determine the Critical Local Sewer Capacity

42" in Prospect at Railroad   2' in 111th at Railroad
Local Sewer Capacity = 0.87 (Sewer Segment 1)

In 111th at Longwood
Local Sewer Capacity = 0.74 (Sewer Segment 2)

In 111th at Hoyne
Local Sewer Capacity = 0.53 cfs/acre (Sewer Segment 3)

In Hoyne at 111th

Local Sewer Capacity = 0.21 cfs/acre (Sewer Segment 4)

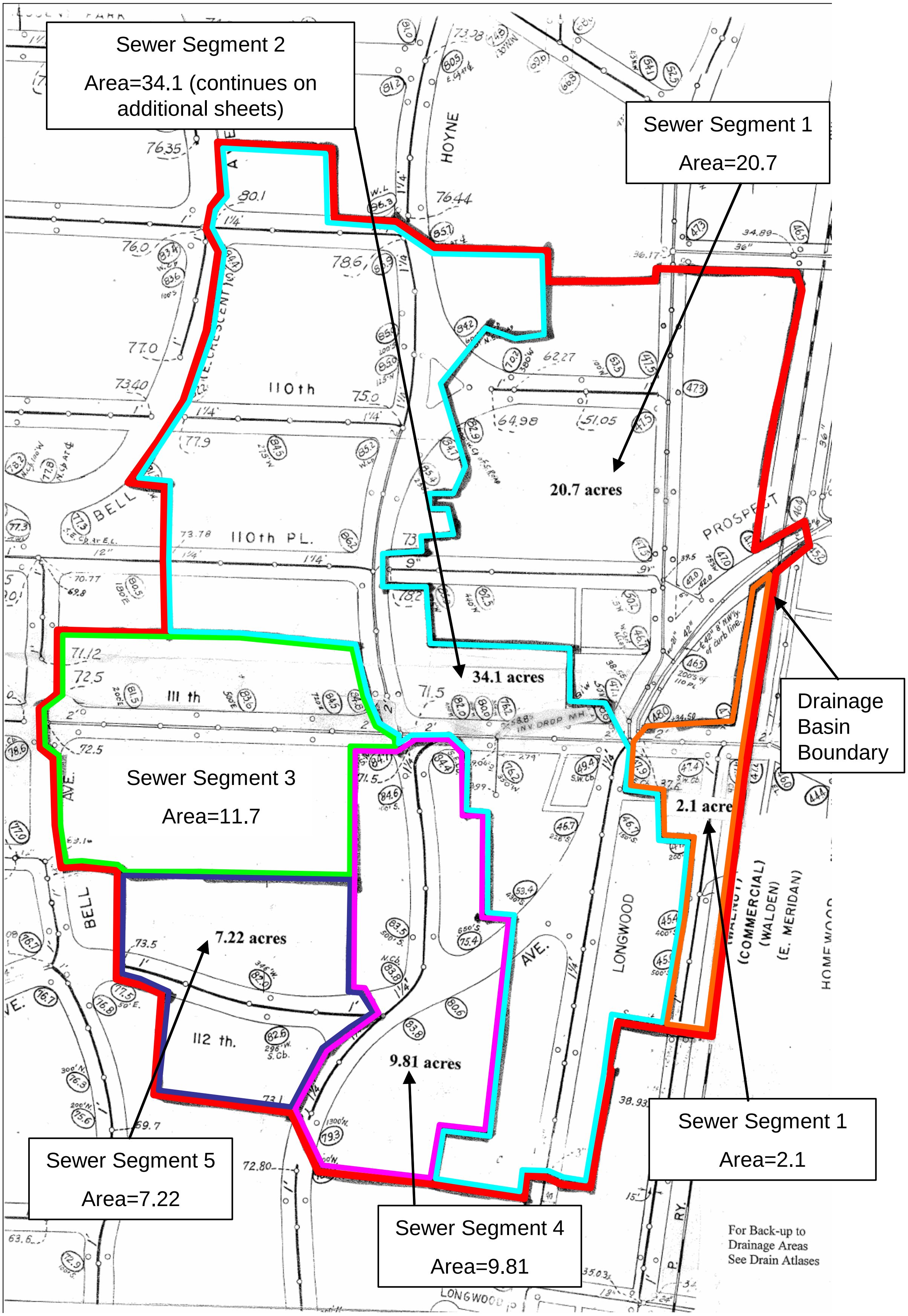
<u>In 112th at Hoyne</u>
Local Sewer Capacity = 0.20 cfs/acre (Sewer Segment 5)

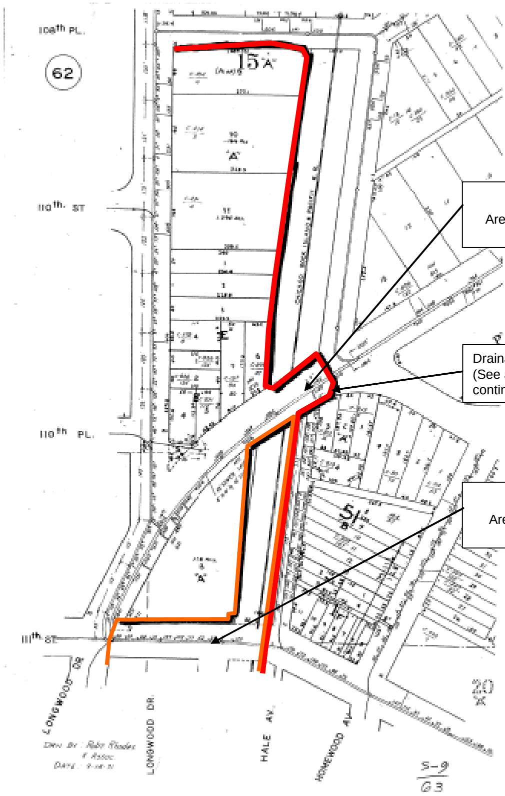
The Critical Local Sewer Capacity is the smallest of the Local Sewer Capcacities.
Critical Local Sewer Capacity = 0.20 cfs/acre

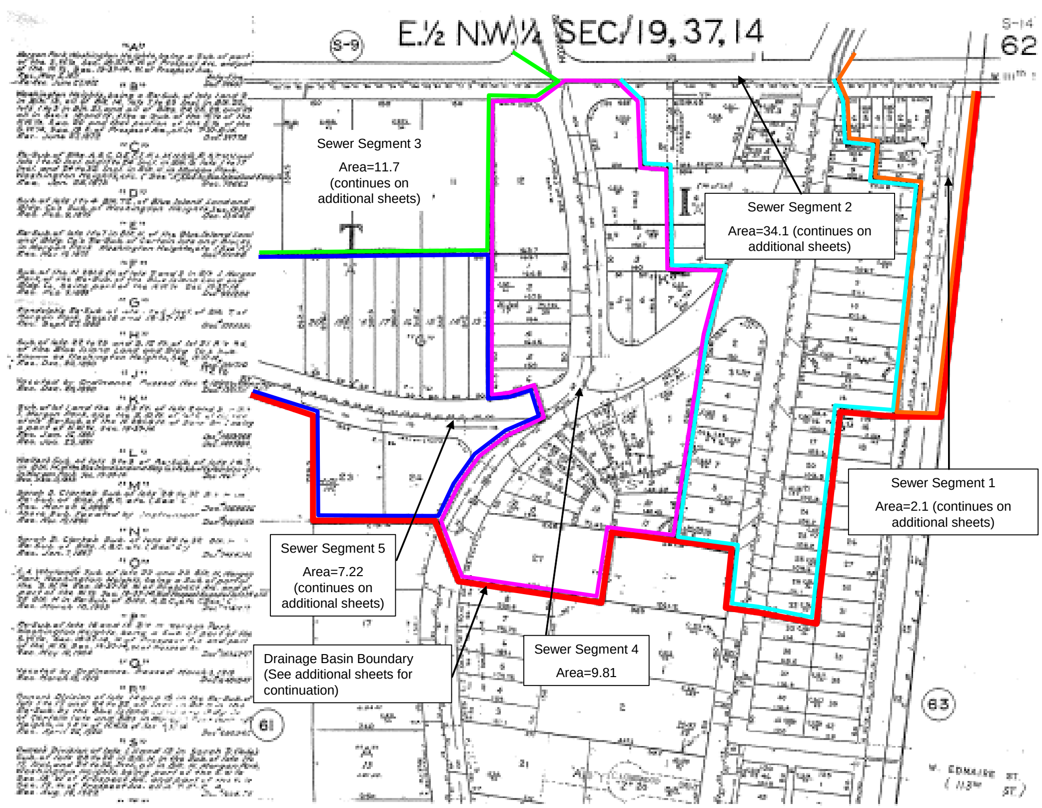
The Outlet Sewer Capacity for the drainage area named “Laflin and Wood” is 0.34 cfs/acre. Since the Critical Local Sewer Capacity is less than the Outlet Capacity, the Critical Local Sewer Capacity determines the allowable release rate for the site.

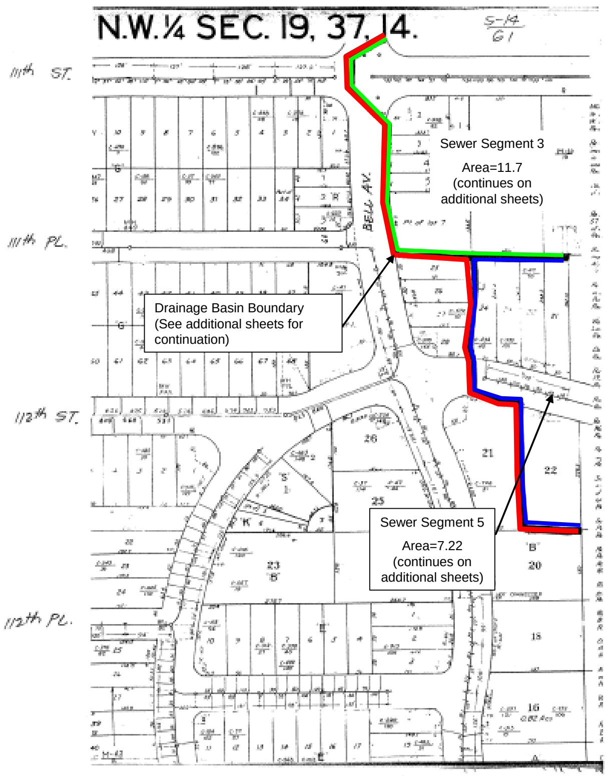
Release Rate: 0.20 cfs/acre (based on Sewer Segment 5)

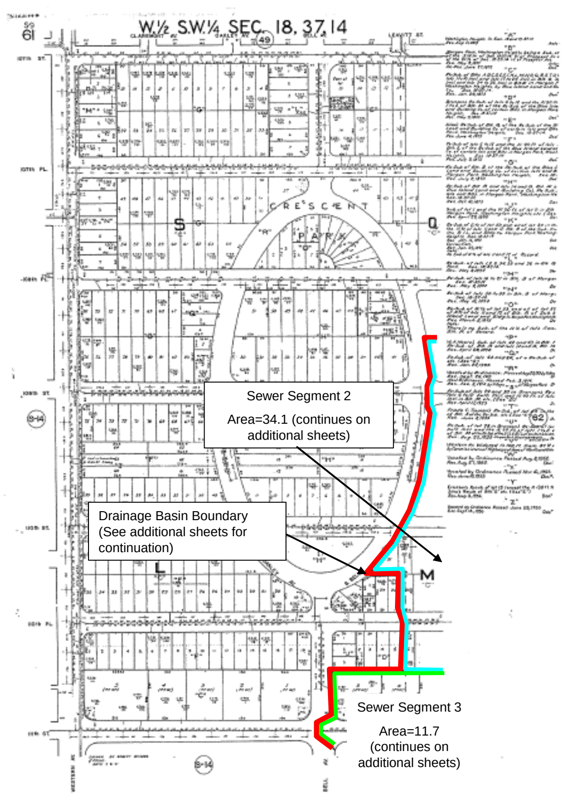
Sewer atlases depicting the drainage area delineations are included on the following pages.

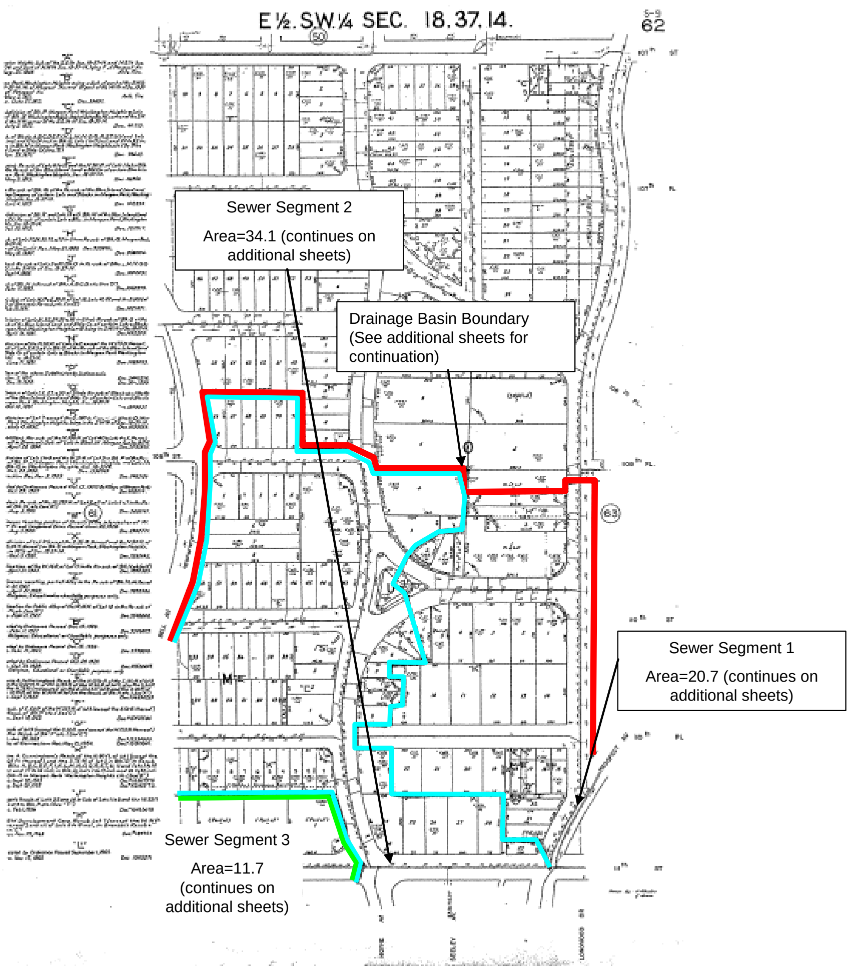

Sewer Segment 2
Area=34.1 (continues on additional sheets)
Sewer Segment 1
Area=20.7
20.7 acres
34.1 acres
Drainage Basin Boundary
Sewer Segment 3
Area=11.7
2.1 acre
7.22 acres
9.81 acres
Sewer Segment 5
Area=7.22
Sewer Segment 4
Area=9.81
Sewer Segment 1
Area=2.1
HOYNE
110th
110th PL.
111 th
112 th.
BELL
PROSPECT
LONGWOOD
AVE.
(COMMERCIAL)
(WALDEN)
(E. MERIDAN)
For Back-up to
Drainage Areas
See Drain Atlases


Sewer Segment 1
Area=20.7 (continues on additional sheets)
Drainage Basin Boundary (See additional sheets for continuation)
Sewer Segment 1
Area=2.1 (continues on additional sheets)


E.½ N.W.¼ SEC. 19, 37, 14
Sewer Segment 3
Area=11.7 (continues on additional sheets)
Sewer Segment 2
Area=34.1 (continues on additional sheets)
Sewer Segment 1
Area=2.1 (continues on additional sheets)
Sewer Segment 5
Area=7.22 (continues on additional sheets)
Drainage Basin Boundary (See additional sheets for continuation)
Sewer Segment 4
Area=9.81


N.W.¼ SEC. 19, 37, 14.
111th ST.
111th PL.
112th ST.
112th PL.
BELL AV.
Sewer Segment 3
Area=11.7
(continues on
additional sheets)
Drainage Basin Boundary
(See additional sheets for
continuation)
Sewer Segment 5
Area=7.22
(continues on
additional sheets)


W.½ S.W.¼ SEC. 18, 37,14
CRESCENT
PARK
Sewer Segment 2
Area=34.1 (continues on
additional sheets)
Drainage Basin Boundary
(See additional sheets for
continuation)
Sewer Segment 3
Area=11.7
(continues on
additional sheets)


E ½. S.W.¼ SEC. 18.37.14.
62
Sewer Segment 2
Area=34.1 (continues on additional sheets)
Drainage Basin Boundary (See additional sheets for continuation)
Sewer Segment 1
Area=20.7 (continues on additional sheets)
Sewer Segment 3
Area=11.7 (continues on additional sheets)

CASE STUDY 6: Diverted Release Rate Computations

Determine:
Compute a diverted release rate for a hypothetical development under 3 different scenarios having different diverted site areas.

<u>Given for scenario 1:</u>
Sewer capacity = 10 cfs
Existing Drainage area of sewer (not including diverted area)= 19.0 acres
Diverted site area = 1.0 acres

<u>Given for scenario 2:</u>
Sewer capacity = 10 cfs
Existing Drainage area of sewer (not including diverted area)= 19.0 acres
Diverted site area = 10 acres

<u>Given for scenario 3:</u>
Sewer capacity = 10 cfs
Existing Drainage area of sewer (not including diverted area)= 19.0 acres
Diverted site area = 0.5 acres

Step 1: Determine release rate without diverted area

Sewer capacity / existing drainage area of sewer
Scenarios 1-3: 10 cfs / 19 acres= 0.52 cfs/acre

Step 2: Determine release rate including maximum reduction (3%-5%)

Release rate from #1 x maximum reduction percentage of allowed based on release rate (see regulations Chap 2, Sect 3.6) = max. reduced release rate
Scenarios 1-3: 0.52 cfs/acre x 0.97 = 0.505

Step 3: Calculate maximum diverted area allowed

Sewer capacity / (existing drainage area of sewer + maximum diverted area) = max. reduced release rate
Scenarios 1-3: 10 cfs / (19 acres + Y) = 0.505 Y = 0.80 acres

Step 4: If actual diverted area is greater than maximum area allowed, solve for new site release rate

Actual diverted area > Max. allowed diverted area (calculated in #3)
Scenario 1: 1.0 acre > 0.80 acre
Scenario 2: 10.0 acre > 0.80 acre
Scenario 3: not applicable; skip this step

Existing drainage area of sewer x max. reduced release rate) + (Actual diverted area x release rate for diverted area)
Scenario 1: (19 acres x 0.505 cfs/acre) + (1.0 acre x Z) = 10 cfs Z = 0.405 cfs/acre
Scenario 2: (19 acres x 0.505 cfs/acre) + (10.0 acre x Z) = 10 cfs Z = 0.041 cfs/acre; use 25 GPM pump (0.056 cfs)
Scenario 3: not applicable; skip this step

Step 5: If actual diverted area is less than maximum area allowed, solve for new site release rate

Actual diverted area < Max. allowed diverted area (calculated in #3)
Scenario 1-2: not applicable; skip this step
Scenario 3: 0.50 acre < 0.80 acre

Sewer capacity / (existing drainage area of sewer + actual diverted site area) = site release rate
Scenario 1-2: not applicable; skip this step
Scenario 3: 10 cfs / (19 acres + 0.50 acres) = 0.513 cfs/acre

(End of Appendix D)