SECTION 4

STORM SEWER DESIGN

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4.1 INTRODUCTION

General: A properly designed storm water management system shall be installed, consisting of pipes, manholes, inlets, and other necessary drainage structures, appurtenances, ditches, swales, detention/retention facilities, etc., that will adequately drain and manage storm water from the subdivision and/or development. All storm water management system components shall meet the requirements of the Kane County storm water management ordinance as adopted per ordinance 01-36, June 18, 2001, and any revisions made thereto.

4.2 ADOPTION OF BEST MANAGEMENT PRACTICES

The City of Batavia has adopted the Best Management Practices (BMP) approach for the design of all stormwater and floodplain management system components. The basis of this approach is the City's support of Kane County Stormwater Ordinance and its Technical Manual.

4.3 HYDROLOGIC ANALYSIS

4.3.1 General

The City of Batavia uses the term "Design Storm" to define precipitation events used in the design and analysis of all stormwater management facilities in the City. The Design Storm is the frequency with which a given rainfall event is equaled or exceeded, on average, once in a period of years. The probability of occurrence is equal to the reciprocal of the design storm frequency. For example, a 100-year design storm has a 1.0 percent probability of occurrence in any one year. The storm sewer system shall be designed to intercept and convey the storm water runoff resulting from a design rainfall event that has a statistical probability of occurring once every ten (10) years.

4.3.2 Rainfall Data

The Illinois State Water Survey (ISWS) publication entitled "Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois," commonly called "Bulletin 70" shall be used as the rainfall data reference source for the design of stormwater management facilities or any official update issued thereto.

4.3.3 Design Storm

The standard design storm for all Minor Drainage System components will be the appropriate “10- year recurrence interval” rainfall, as defined in ISWS Bulletin 70. The standard design storm for all Major Drainage System components will be the appropriate “100-year recurrence interval” rainfall, as defined in ISWS Bulletin 70.

4.3.4 Topographic Data

Topographic data shall be referenced to at least one established City of Batavia benchmark. Contour intervals shall be one foot and shall directly correlate to the City datum.

4.3.5 Rainfall-Runoff Modeling Methodology

The following summarizes the application of common rainfall-runoff models:

Model	Product	Usage	Assumptions	Limitations
Rational Method	Peak Discharge	For estimating peak discharge rate.	Watershed size 1-20 acres	
TR-20	Hydrograph	For developing: Runoff hydrographs, Channel and reservoir routed hydrographs, Separated or combined hydrographs.		
TR-55 Tabular Method	Hydrograph	For measuring the effect of land use and/or structure changes in sub-catchments on the composite hydrograph for the watershed	• Sub-catchment size less than 20 square miles. • Precipitation runoff volume not less than 1.5 inches. • Little to no variation in soil and land use characteristics within a sub-catchment.	The TR-55 Tabular Method was derived from TR-20 using curve numbers of 75 and rainfall amounts sufficient to produce 3 inches of runoff volume. Characteristics should not vary significantly from those used in the method derivation.
HEC-1 HEC-HMS	Hydrograph	For computation of flood hydrographs due to a single recorded or synthetic rainstorms, or snowfall-snowmelt conditions. Model can simulate dam-break conditions and compute expected annual flood damages.	Hydrologic processes can be simulated assuming that individual parameters can be used in representing average sub-basin temporal and special characteristics.	• Only one storm can be modeled for each program run because the model does not have a provision for soil moisture recovery during non-precipitation periods. • Results are in terms of discharge, not stage. If discharges are stage-dependent, a user specified rating curve must be provided. • Hydrologic routings used for open channel flow. If gradually varied, unsteady flow occurs, such as in very flat channels, then hydrologic routings are not accurate. • Hydrologic routings used for storage reservoirs. If reservoir outflow is dependent on downstream controls, then hydrologic routings are not accurate.

4.4 HYDRAULIC ANALYSIS

4.4.1 General

The following table summarizes the application of common hydraulic models:

Model	Usage	Assumptions	Limitations
HEC-2 (BFE Only)	For computing water surface profiles for subcritical or supercritical open channel flow.	One-dimensional, gradually-varied, steady flow conditions. Channel slopes are less than 10%.	Program is not capable of modeling movable flow boundaries such as those that occur due to sediment transport.
HEC-RAS (BFE Only)	For computing subcritical, supercritical, and mixed flow regime open channel flow water surface profiles. Model has improved routines for evaluating the effects of obstructions such as bridges, culverts weirs, and structures in the floodplain.	Gradually-varied, steady flow conditions.	
WSP2 (BFE Only)	For computing open channel water surface profiles for subcritical open channel flow.	Model assumes only gradually-varied flow in a given reach. Since only friction losses are considered, velocity changes must be relatively small.	• Cannot model supercritical flow regimes. • For accurate modeling of bridges, the channel needs to be straight, and have a uniform cross-section and slope. • Culverts can only be modeled as standard circular rectangular, and arch shapes.

4.4.2 Gravity Flow

All stormwater management facilities in the City of Batavia shall be designed for gravity- flow conditions without surcharging at any point within the system for the appropriate design storm. Stormwater pumping facilities will only be considered if it can be demonstrated that there is no means of providing for gravity- flow drainage. The design of each stormwater management component must be based on sub-critical flow conditions. Super-critic al or critical flow conditions have the potential for high velocities that are dangerous and damaging. Furthermore, these conditions are unstable and can result in widely fluctuating and unpredictable flow depths.

4.4.3 Pressure Flow

Pressure flow conditions occur in a closed-conduit system when the hydraulic grade line (HGL) is above the crown of the pipe. When it is not possible to restrict the HGL to the crown of the pipe, due to topographic constraints, the HGL may be contained within the rim, as approved by the City Engineer. Storm sewers shall be designed for the appropriate design storm based on flowing- full conditions without any pressure head. While pressure flow conditions may occur for runoff events in excess of the design storm, such conditions should be avoided by allowing excess flows to be channeled to overflow routes.

4.5 MINOR DRAINAGE SYSTEM

4.5.1. General

The minor drainage system consists of curb and gutter sections, storm sewers (with appurtenant inlets, catch basins, and manholes), swales (side yard, back yard), and small natural or man- made open channels. The function of the minor drainage system is to quickly collect and convey the runoff from the smaller, more frequent storms. Except as modified and/or appended herein, all minor drainage system components covered in this section shall be designed in accordance with the most current edition of the Illinois Department of Transportation (IDOT) Drainage Manual.

Specifications: All storm sewer system construction work shall be done in accordance with applicable sections of the "Standard Specifications For Sewer And Water Main Construction In Illinois", latest edition, with any special provisions specified, and in accordance with current city standards and specifications.

4.5.2 Swales

Side yard and rear yard swales shall be analyzed as open channels with a triangular cross-section and a mowed turf grass surface. The minimum longitudinal slope should be 2 percent. Where hardship is demonstrated, 1.5 percent may be permitted. The maximum slope allowed is 25 percent. The swale shall have sufficient hydraulic capacity to convey the design storm peak flow rate with the appropriate freeboard clearances. For residential developments, there shall be not less than 2 feet of freeboard between the design high water level in the swale and the lowest adjacent top of foundation elevation. For commercial developments, there shall be no less than 2 feet of freeboard between the design high water level in the swale and the lowest adjacent top of foundation elevation.

Yard Drainage: Positive rear and side yard drainage shall be required in all developments. Side slopes on swales, ditches, berms, and storm water detention/retention facilities shall not exceed 4:1.

Minimum as built swale grades shall be two percent (2%). Swale drainage shall be picked up with inlets prior to reaching street right of way and conveyed by pipe into the storm sewer system. Yard drainage plans shall be part of the site grading plans. Yards shall not have more than 18" of ponding.

4.5.3 Pavement Drainage

Maximum flow depths on any roadway shall not exceed 6 inches during the base flood condition. Inlets are to be located such that these encroachments are not exceeded and that flow will not cross-intersecting streets. These standards will apply to all local and collector streets. The following table provides equations that should be used in computing inlet spacing. The equations are based on the standard City of Batavia gutter width of 12 inches, and a recommended pavement roughness coefficient of 0.015. The maximum flow depth at the face of curb is about 1.7 inches which occurs for the steepest cross-slope of 2.5%. These equations; therefore, are applicable for both roll and barrier curb situations

Flow Component	Pavement Cross-slope		
	3/16" per foot (1.56%)	**1/4" per foot (2.08%)**	**5/16" per foot (2.5%)**
Q_{Total}	$(2.147)\ S^{1/2}$	$(3.068)\ S^{1/2}$	$(3.902)\ S^{1/2}$
Q_{Gutter}	$(1.464)\ S^{1/2}$	$(1.966)\ S^{1/2}$	$(2.412)\ S^{1/2}$
$Q_{Grate\ Capacity}$	(0.014) K	(0.019) K	(0.024) K

S = longitudinal pavement slope in feet per foot.

K = conveyance factor that is unique to the geometry of each grate. Values for the conveyance factors are provided in "Inlet Grate Capacities" published by the Neenah Foundry Company.

For the ponded water condition, stormwater flow bypassed from uphill inlets accumulates at a low point. At lower depths, the flow into most inlet grates takes on the characteristics of flow though a weir. As the ponding depth increases, the inlet grate opening acts more like an orifice. The equations and assumptions applicable for both types of ponded condition flow are found in the above referenced Neenah Foundry publication.

4.5.4 Storm sewers

Storm sewers shall be designed in accordance with the procedures outlined in Chapter 8 of the IDOT Drainage Manual. These procedures use the Rational Method to determine peak stormwater flow rates for both inlet spacing and storm sewer sizing.

All storm sewers that will be within the City of Batavia right-of-way shall be designed with the appropriate ASTM Class of reinforced concrete pipe (RCP). Every effort shall be made to minimize the placement of storm sewers in side yard easements. All storm sewer pipes within side yard easements shall have gasketed joints. For RCP, these joints shall be in accordance with ASTM specification C-361.

Storm sewers sizes are to be determined based on flowing- full (non-surcharging) conditions for the appropriate design storm. The minimum and maximum allowable subcritical design flow velocities are 2.5 fps and 10 fps, respectively. A conventional development has one or more storm sewer networks that discharge to the detention facility for the site. To avoid surcharging conditions, storm sewer outfalls to detention facilities shall be designed such that the invert of the outfall pipe is at or higher than the normal high water elevation of the facility. An exception to this policy will be made if the hydraulic grade line calculations can demonstrate that the design water surface is kept below the street edge of pavement elevation throughout the site.

All storm sewer calculation tables shall be included for review. These calculations must include all necessary rainfall, soil and watershed data. The calculation table must include at a minimum, the pipe length, pipe slope, velocity, design capacity, pipe capacity, time of concentration, and HGL. In addition a tributary area map for the overall site with subcatchment areas must be delineated including Time of Concentration and Area for each subbasin. The City uses 100 feet as the maximum distance for the sheet flow flow length when calculating the time of concentration.

The minimum pipe size in any storm sewer system shall be twelve inches (12") in diameter. All storm sewer pipe shall be reinforced concrete pipe (RCP), with a minimum class IV strength rating as defined using the most current version of ASTM specification C76 unless otherwise approved by the city engineer. The minimum depth of cover over the top of the pipe shall be thirty inches (30") unless site conditions prevent it and the city engineer or his/her authorized representative approves a lesser depth.

For pipe 36" or less in diameter, the maximum spacing between manholes shall be no more than 300'. A maximum spacing of 500' may be used for pipe diameters greater than 36".

A trench of three times the width and four times the depth of the pipe diameter must be excavated. Maximum trench width and depth are as follows: (Max Trench Width=Outside Pipe Diameter +2') (Maximum Trench Depth= Outside Pipe Diameter +2.5'). A stone bed 6" in depth shall be placed prior to the placement of any pipe. The pipe shall then be centered in the trench, which shall be 3/4 filled with washed stone. The remainder of the trench shall be filled with topsoil in non-pavement areas or other approved backfill and then graded to match the adjacent existing ground. Stone must extend past the top of pipe regardless of depth.

4.5.5 Sump Pumps

A sump pump junction box, a minimum of twenty four inches (24") in diameter by thirty inches (30") deep, shall be provided for each lot or pair of lots and generally located in the parkway centered on the side lot line. The sump pump junction box shall have an east Jordan number 1020 type M1 frame and lid, or approved equal, at finished grade.

House or building sump pump services shall be a minimum four inch (4") diameter pipe, PVC pipe with a maximum SDR of 26 ASTM D-3034, and shall be connected to the junction box. All sump pumps shall have an air gap (no solid connection) at the house, an air gap should be located where the pipe exits the house and continues to the exterior sump pump discharge line to allow spill over in the event the pipe freezes or breaks.

Where properly located, curb and yard inlets may be used in lieu of a sump pump junction box.

At no time will a sump pump line be permitted to discharge into sanitary sewers or onto the street or sidewalk. In areas where a storm sewer system is not present, sumps will be allowed to discharge into swales at the rear of the lot.

4.5.6 Subdrainage (Underdrain)

In areas with poorly drained soils and/or a high water table, perforated pipe subdrains, six inch (6") minimum diameter, will be required as directed by the city engineer or his/her authorized representative. Subdrains shall be designed in accordance with the most current IDOT procedures and requirements. The subdrain trench shall be lined with the appropriate geotextile fabric. The pipe shall have two (2) rows of perforations and shall be laid with the perforations down. The trench shall be backfilled with crushed rock, IDOT class CA-7 or approved equal to the top of subgrade elevation with geotextile folded over the top of the backfill. The minimum depth of cover over the top of the subdrain pipe shall be eighteen inches (18") unless site conditions prevent it and the city engineer or his/her authorized representative approves a lesser depth. The minimum trench width shall be eighteen inches (18"). Subdrains will be provided at all roadway sag locations.

4.5.7 Culverts

All culverts that will be within the City of Batavia right-of-way shall only be designed with approval of the City Engineer. The preferred material for Culverts that are being replaced is the appropriate ASTM Class of RCP, but can be replaced in-kind materials at the discretion of the City Engineer or their designee. All new culverts shall be designed with the appropriate ASTM Class of RCP and will have the appropriately sized precast concrete flared-end section on each end. All culverts shall be a minimum of 12 inches in diameter and shall have the appropriate grating covering the flared-end section opening. Culverts shall have a positive pitch of a minimum of 0.50%.

4.5.8 Structures

Storm sewer structures will be permitted in the back yards of residential areas only to the minimum extent needed to effectively drain these areas as determined by the city engineer or his/her authorized representative. Storm sewer mains will not be allowed in rear yard easements. Storm sewer structures in back yards must be connected directly to storm sewer mains in the city right of way using lateral sewers in side yard easements. All storm sewer pipes within side yard easements shall have gasketed joints in accordance with ASTM specification C-361-03a.

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Storm Sewer Structures: Storm sewer structures consist of inlets, storm manholes, catch basins, and sump pump junction boxes. Inlets shall be a minimum twenty four inch (24") diameter precast concrete type A inlets as shown on the current City of Batavia Engineering Department standard construction detail drawings. Storm manholes and catch basins shall be sized, located and constructed in accordance with the referenced city construction details. Inlet and manhole structures shall have a poured concrete invert or slope, finished in accordance with the city construction details, to prevent standing water in these structures. The most downstream structure in every development shall be a catch basin fitted with a grit/oil separation device as shown on the city construction details. Additional catch basins with grit/oil separators within the development may be required as directed by the city engineer or his/her authorized representative. Two (2) inlets or catch basins shall be provided on each side of the road at all sag locations.

The maximum spacing of inlets shall be four hundred feet (400') unless otherwise directed by the city engineer or his/her authorized representative.

Frames and grates for storm sewer structures shall be as follows or approved equal:

Inlets or catch basins in the curb line	East Jordan number 7220, type 1 curb back, type M1 grate
Structures in ditches or detention/retention facilities	East Jordan number 6527 or 6517
Yard inlets	East Jordan number 1020, type M1 grate
Manholes	East Jordan number 1020, type M1 or type A
Sump pump junction box	East Jordan number 1020, type M1 or type A grate as appropriate

Restrictors: Restrictors will not be restricted to a pipe restrictor that is grouted-in-place or the weir within the structure. Restrictors shall be sized for the required release rate of 0.10 cfs per tributary acre, the pre-development release rate, or as codified in section 11-7-2 for areas within the McKee Tributary and Batavia Highlands (whichever is the lesser rate) at the high water elevation of the required storage. The minimum size for a single outlet storm detention release pipe shall be twelve inches (12”) RCP with a minimum restrictor size of four inches (4”). Restrictors less than four inches (4”) become maintenance issue and therefore are restricted.

4.5.9 Pipe Material

Storm sewer	Reinforced concrete pipe ASTM C76 class IV minimum
Sump pump lines	PVC pipe with a maximum SDR of 26 ASTM D-3034
Subdrainage	PVC perforated pipe with a minimum SDR of 35, 2 rows of perforations; pipe shall meet ASTM D-3034 requirements
Culverts	Reinforced concrete pipe ASTM C76 class IV minimum with precast concrete flared end sections on each end of the culvert. The minimum culvert size is 12 inch diameter. All culverts shall have the appropriate grating conforming to current city standards and specifications. The minimum depth of cover over the top of the culvert pipe shall be 12 inches.
Alternate materials may be considered.	

4.6 MAJOR DRAINAGE SYSTEM

4.6.1 General

The major drainage system consists of overflow routes (streets and larger natural or man- made open channels), man-made stormwater storage facilities (basins and ponds), large natural or man-made channels, and floodplains. The major drainage system serves both conveyance and storage functions. This may occur as a result of runoff from the larger, less frequent storms and/or from an obstruction in the minor system.

4.6.2 Overflow Routes

4.6.2.1 General

Overflow routes should exit a developed site in a common area that is preferably public property such as a park or public right-of-way. As a secondary choice, overflow routes can be designated along a common rear yard property line that is furthest away from homes and buildings. All overflow routes shall be designated on the plans with a large arrow and elevation.

4.6.2.2 Swales

Overflow route swales shall be analyzed as open channels with a triangular cross-section and a mowed turf grass surface. An overflow route swale shall have side-slopes that are a minimum of 2 percent and maximum of 25 percent. The longitudinal slope should be 2 percent. Where hardship is demonstrated, 1.5 percent may be permitted. The maximum slope allowed is 25 percent. The overflow route swale will have sufficient hydraulic capacity to convey the design storm peak flow rate with the appropriate freeboard clearances.

Swale cross sections shall be included on the final engineering plans as well as in the stormwater report to ensure they are properly constructed in the field. The cross sections shall include the bottom width of the channel, the side slope, the width of the channel at the high water level and the volume it can convey.

For both residential and commercial/industrial developments, there shall be no less than 2 feet of freeboard between the design high water level in the swale and the lowest adjacent top of foundation elevation.

4.6.3 Differentiation between Public and Private Storm Sewers

Public storm system and private storm system shall be indicated in the plans submitted for approval.