SECTION 12

STORM SEWER DESIGN

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12.1 General

All storm sewers, whether private or public, and whether constructed on private or public property, shall conform to the design standards and other requirements contained herein.

12.2 Design Storm Frequencies

A. All storm sewers, inlets, catch basins, and street gutters shall accommodate (subject to the “allowable spread” provisions discussed later in this Section), as a minimum, peak runoff from a twenty-four (24) hour, ten (10) year return frequency storm calculated based on methodology described in **Section 11**. Additional discharges to storm sewer systems allowed must be considered in all design calculations. For Rational Method analysis, the duration shall be equal to the time of concentration for the drainage area. In computer-based analysis, the duration is as noted in the applicable methodology associated with the computer program.

B. Culverts shall be capable of accommodating peak runoff from a twenty-four (24) hour, fifty (50) year frequency storm when crossing under a road which is part of the INDOT Rural Functional Classification System or is classified as freeway, arterial, and/or collectors by the City or City Engineer or provides the only access to and from any portion of any commercial or residential developments.

C. For portions of the system considered minor drainage systems, the allowable spread of water on Collector Streets is limited to maintaining two (2) clear ten (10) foot moving lanes of traffic. One lane is to be maintained on Local Roads, while other access lanes (such as a subdivision cul-de-sac) can have a water spread equal to one-half of their total width. An overflow channel/swale between sag inlets and overflow paths or basin shall be provided at sag inlets so that the maximum depth of water that might be ponded in the street sag shall not exceed seven (7) inches measured from elevation of gutter.

12.3 Manning’s Equation

Determination of hydraulic capacity for storm sewers sized by the Rational Method analysis must be done using Manning’s Equation.

Where:

$$V = (1.486/n)(R^{2/3})(S^{1/2})$$

Then:

$$Q=(V)(A)$$

Where: Q = capacity in cubic feet per second

V = mean velocity of flow in feet per second

A = cross sectional area in square feet

R = hydraulic radius in feet

S = slope of the energy grade line in feet per foot

N = Manning's "n" or roughness coefficient

The hydraulic radius, R, is defined as the cross-sectional area of flow divided by the wetted flow surface or wetted perimeter. Allowable "n" values and maximum permissible velocities for storm sewer materials are listed in **Table 12-1.**

Table 12-1
Typical Values of Manning's "n"

Material	Manning's "n"	Maximum Velocities (feet/second)
Closed Conduits		
Concrete	0.013	10
Vitrified Clay	0.013	10
HDPE	0.012	10
PVC	0.011	10
Circular CMP, Annular Corrugations, 2 2/3 x ½ inch		
Unpaved	0.024	7
25% Paved	0.021	7
50% Paved	0.018	7
100% Paved	0.013	7
Concrete Culverts	0.013	10
HDPE or PVC	0.012	10
Open Channels		
Concrete	0.013	10
Concrete	0.015	10
Granite	0.018	10
Riprap Placed	0.030	10
Riprap Dumped	0.035	10
Gabion	0.028	10
New Earth[1]	0.025	4
Existing Earth [2]	0.030	4
Dense Growth of Weeds	0.040	4
Dense Weeds and Brush	0.040	4
Swale with Grass	0.035	4

Source of manning "n" values: HERPICC Stormwater Drainage Manual, July 1995.

[1] New earth (uniform, sodded, clay soil)

[2] Existing earth (fairly uniform, with some weeds). Various computer modeling programs such as HYDRA, ILLUDRAIN, and STORMCAD are available for analysis of storm drains under these conditions. Computer models to be utilized, other than those listed, must be accepted by the City and City Engineer.

12.4 Backwater Method for Pipe System Analysis

For hydraulic analysis of existing or proposed storm drains which possess submerged outfalls, a more sophisticated design/analysis methodology than Manning's equation will be required. The backwater analysis method provides a more accurate estimate of pipe flow by calculating individual head losses in pipe systems that are surcharged and/or have submerged outlets. These head losses are added to a known downstream water surface elevation to give a design water surface elevation for a given flow at the desired upstream location. Total head losses may be determined as follows:

Total head loss = frictional loss + manhole loss + velocity head loss + junction loss

12.5 Minimum Size for Storm Sewers

The minimum diameter of all storm sewers shall be twelve (12) inches. When the minimum twelve (12) inch diameter pipe will not limit the rate of release to the required amount, the rate of release for detention storage shall be controlled by an orifice plate or other device, subject to acceptance of the City and City Engineer.

12.6 Pipe Cover, Grade, and Separation from Sanitary Sewers and Water Mains

Pipe grade shall be such that, in general, a minimum of two (2) feet of cover is maintained over the top of the pipe. If the pipe is to be placed under pavement, then the minimum pipe cover shall be two and one half (2.5) feet from top of pavement to top of pipe. Pipe cover less than the minimum may be allowed per manufacturer's specifications or recommendation and used only upon written acceptance from the City and City Engineer. Uniform slopes shall be maintained between inlets, manholes and inlets to manholes. Final grade shall be set with full consideration of the capacity required, sedimentation problems, and other design parameters. Minimum and maximum allowable slopes shall be those capable of producing velocities of between two and one half (2.5) feet and ten (10) feet per second, respectively, when the sewer is flowing full. Maximum permissible velocities for various storm sewer materials are listed in **Table 12-1**. Based on Kutter's formula using an "n" value of 0.013, the following are the minimum slopes should be provided. Slopes greater than these are desirable:

Sewer Size (inch)	Minimum Slope in Feet Per 100 Feet
12	0.22
14	0.17
15	0.15
16	0.14
18	0.12
21	0.10
24	0.08
27	0.067
30	0.058
36	0.046

A minimum of two (2) feet of vertical separation between storm sewers and sanitary sewers shall be required. When this is not possible, the sanitary sewer must be encased in concrete or ductile steel within five (5) feet, each side, of the crossing centerline. Storm sewers shall be laid at least ten (10) feet horizontally from any existing or proposed water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, the appropriate, the reviewing agency may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the storm sewer closer to a water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one side of the storm sewer and at the elevation so the bottom of the water main is at least eighteen (18) inches above the top of the storm sewer.

12.7 Alignment

Storm sewers shall be straight between manholes and/or inlets.

12.8 Manholes/Inlets

All Inlets must be pre-stamped with an appropriate “clean water” message. Manholes and/or inlets shall be installed to provide human access to continuous underground storm sewers for the purpose of inspection and maintenance. The casting access minimum inside diameter shall be no less than thirty-six (36) inches or a rectangular opening of no less than twenty-two (22) inches by twenty-two (22) inches. Manholes shall be provided at the following locations:

A. Where two (2) or more storm sewers converge.

B. Where pipe size or the pipe material changes.

C. Where a change in horizontal alignment occurs.

D. Where a change in pipe slope occurs.

E. At intervals in straight sections of sewer, not to exceed the maximum allowed. The maximum distance between storm sewer manholes shall be as shown in **Table 12-2**.

Table 12-2
Maximum Distance Between Manholes

Size of Pipe (Inches)	Maximum Distance (Feet)
12 through 42	400
48 and larger	600

In addition to the above requirements, a minimum drop of 0.1 foot through manholes and inlet structures should be provided. When changing pipe size, match crowns of pipes, unless detailed modeling of hydraulic grade line shows that another arrangement would be as effective. Pipe slope should not be so steep that inlets surcharge (i.e. hydraulic grade line should remain below rim elevation).

F. Manhole/inlet inside sizing shall be as shown in **Table 12-3**.

Table 12-3
Manhole/Inlet Inside Sizing

Depth of Structure	Minimum Diameter	Minimum Square Opening
Less than 5 feet	36 inches	36” x 36”
5 feet or more	48 inches	48” x 48”

12.9 Inlet Sizing and Spacing

Inlets or drainage structures shall be utilized to collect surface water through grated openings and convey it to storm sewers, channels, or culverts. The inlet grate opening provided shall be adequate to pass the design ten (10) year flow with fifty (50) percent of the sag inlet areas clogged. An overload channel from sag inlets to the overflow channel or basin shall be provided at sag inlets. Inlet design and spacing may be done using the hydraulic equations by manufacturers or orifice/weir equations. Use of the U.S. Army Corps of Engineers HEC-12 computer program is also an acceptable method. Gutter spread on continuous grades may be determined using the Manning's equation, or by using **Figure 12-1**. Further guidance regarding gutter spread calculation may be found in the latest edition of HERPICC Stormwater Drainage Manual, available from the Local Technical Assistance Program (LTAP). At the time of printing of this document, contact information for LTAP was:

Indiana LTAP
Purdue University
Toll-Free: (800) 428-7369 (Indiana only)
Phone: (765) 494-2164
Fax: (765) 496-1176
Email: inltap@ecn.purdue.edu
Website: www.purdue.edu/INLTAP/

12.10 Special Hydraulic Structures

Special hydraulic structures required to control the flow of water in storm runoff drainage systems include junction chambers, drop manholes, stilling basins, and other special structures. The use of these structures shall be limited to those locations justified by prudent planning and by careful and thorough hydraulic engineering analysis. Certification of special structures by a certified Structural Engineer may also be required.

12.11 Connections to Storm Sewer System

To allow any connections to the storm sewer system, provisions for the connections shall be shown in the drainage calculations for the system. Specific language shall be provided in the protective covenants, on the record plat, or with the parcel deed of record, noting the ability or inability of the system to accommodate any permitted connections, for example, sump pumps and footing drains.

A. **Sump pumps** installed to receive and discharge groundwater or other stormwater shall be connected to the storm sewer where possible or discharged into a designated storm drainage channel/swale. Sump pumps installed to receive, and discharge floor drain flow or other sanitary sewage shall be connected to the sanitary sewers. A sump pump shall be used for one function only, either the discharge of stormwater or the discharge of sanitary sewage.

B. **Footing drains and perimeter drains** shall be connected to Manholes or Curb inlets, where possible, or to designated storm sewers or discharged into designated storm drainage channels/swales.

C. All **roof downspouts**, roof drains, or roof drainage piping shall discharge onto the ground and shall not be directly connected to the storm drainage system. Variation from this requirement may be requested and granted by the City or City Engineer in special circumstances. No downspouts or roof drains shall be connected to the sanitary sewers.

D. **Swimming Pool drains** shall not be connected to the storm sewers.

In addition, none of the above-mentioned devices shall be connected to any street underdrains, unless specifically authorized by the City or City Engineer.

Table 12-4
Building Pad Elevations with Respect to Overflow Path Invert Elevations

Drainage Area (Acres)	Building Pad Above Overflow Path Invert (Feet)	Building Pad Above Overflow Path Invert [if overflow is in the street] (Feet)
Up to 5	2.5	1.5
6-10	3.0	1.5
11-15	3.25	1.75
16-20	3.5	1.75
21-30	4.0	2.0
30-50	4.25	2.0

If **Table 12-4** is used, the City or City Engineer reserves the right to require independent calculations to verify that the proposed building pads provide approximately one (1) foot of freeboard above the anticipated overflow path/ponding elevations.

In the case of existing upstream detention, an allowance equivalent to the reduction in flow rate provided may be made for upstream detention only when:

(1) such detention and release rate have previously been accepted by the City or City Engineer official charged with the approval authority at the time of the acceptance, and

(2) evidence of its construction and maintenance can be shown.

Figure 12-1
Street and Gutter Capacities (continuous grade)

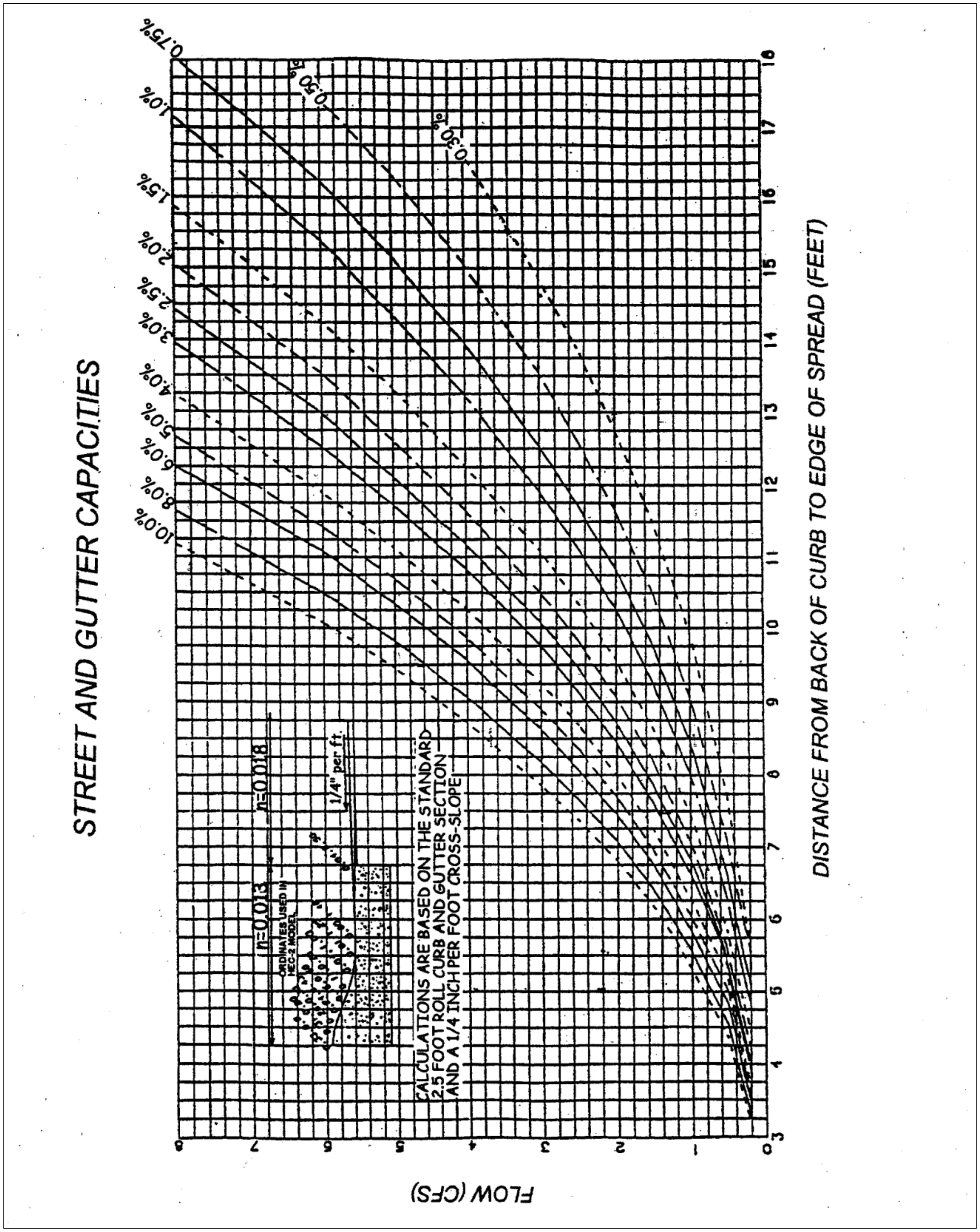
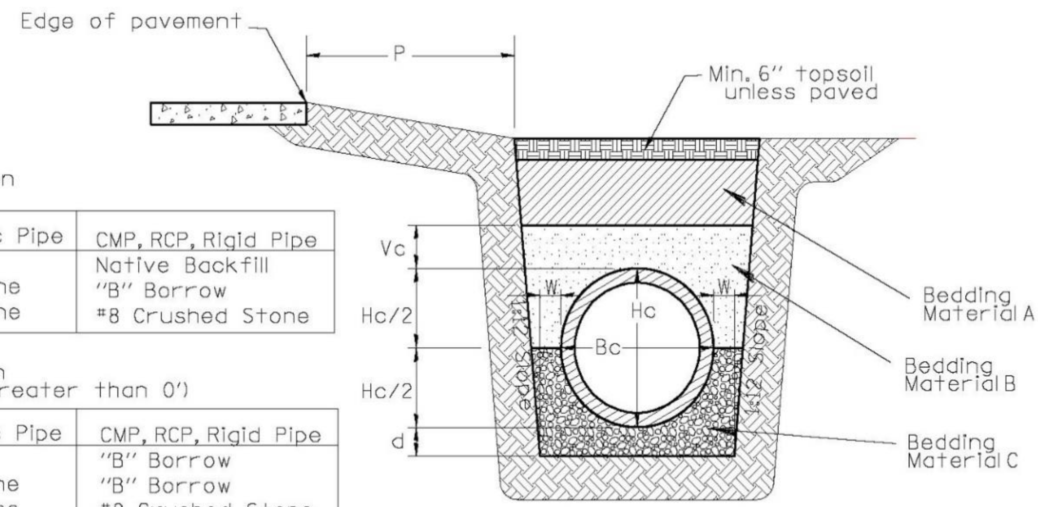


Figure 12-2
Bedding and Backfill Standards for Storm Sewers



Bedding Material Designation
(P greater than 5')

	PVC, HDPE, Plastic Pipe	CMP, RCP, Rigid Pipe
Material A	Native Backfill	Native Backfill
Material B	#8 Crushed Stone	"B" Borrow
Material C	#8 Crushed Stone	#8 Crushed Stone

Bedding Material Designation
(P less than than 5', but greater than 0')

	PVC, HDPE, Plastic Pipe	CMP, RCP, Rigid Pipe
Material A	"B" Borrow	"B" Borrow
Material B	#8 Crushed Stone	"B" Borrow
Material C	#8 Crushed Stone	#8 Crushed Stone

Bedding Material Designation
(Pipe Under Pavement or Driveway)

	PVC, HDPE, Plastic Pipe	CMP, RCP, Rigid Pipe
Material A	Pipe Not Allowed	"B" Borrow
Material B		"B" Borrow
Material C		#8 Crushed Stone

LEGEND

P = Distance from edge of pavement
Hc = Outside diameter or rise
Bc = Outside diameter or span
d = Depth of bedding material below pipe
= 8" min. for fill height up to 16'
= 12" min for fill height of 16' or more
Vc = 12" for Bc up to 18"
= 18" for Bc > 18"
W = 0.3 Bc or 9", whichever is greater

NOTES:

1. INDOT Type 1 pipe required for storm sewers/culverts under pavement
2.. INDOT Type 2 pipe required for storm sewers/culverts outside of pavement
3. All bedding shall be installed in 6" to 12" balanced lifts
4. For backfill purposes, paved shoulders, curbs, gutters, and sidewalkss are considered pavement
5. Flowable backfill shall be encased by a minimum of 2 feer of compacted earth backfill
6. Plastic pipes fabricated on hydrostatic design basis rated resins considered rigid for backfill purposes

Figure 12-3
Bedding and Backfill Standards for Sub-drains under Swales