SECTION 15

OPEN CHANNEL DESIGN STANDARD & SPECIFICATIONS

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15.1 General

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

A. Design Storm Frequencies

1. All channels and swales shall accommodate, 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**. For Rational Method analysis, the storm 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.

2. Channels with a carrying capacity of more than thirty (30) cfs at bank-full stage shall be capable of accommodating peak runoff for a twenty-four (24) hour, fifty (50) year return frequency storm within the drainage easement.

3. Channel facilities functioning as a major drainage system must also meet IDNR design standards.

4. The ten (10) year storm design flow for residential rear and side lot swales shall not exceed four (4) cfs. The maximum length of rear and side lot swales before reaching any inlet shall not exceed four hundred (400) feet.

5. Regardless of minimum design frequencies stated above, the performance of all parts of drainage system shall be checked for the one hundred (100) year flow conditions to ensure that all buildings are properly located outside the one hundred (100) year flood boundary and that flow paths are confined to designated areas with sufficient easement.

B. Manning's Equation

The waterway area for channels shall be determined using Manning's Equation, where:

$$A = Q/V$$

A = Waterway area of channel in square feet

Q = Discharge in cubic feet per second (cfs)

V = Steady-State channel velocity, as defined by Manning's Equation

C. Backwater Method for Drainage System Analysis

The determination of one hundred (100) year water surface elevation along channels and swales shall be based on accepted methodology and computer programs designed for this

purpose. Computer programs HEC-RAS, HEC-2, and ICPR are preferred programs for conducting such backwater analysis. The use of other computer models must be accepted in advance by the City or City Engineer.

D. Channel Cross-Section and Grade

1. The required channel cross-section and grade are determined by the design capacity, the material in which the channel is to be constructed, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains, tributary ditches, or streams. The channel grade shall be such that the velocity in the channel is high enough to prevent siltation but low enough to prevent erosion. Velocities less than two (2) feet per second are not acceptable, as siltation will take place and ultimately reduce the channel cross-section area. The maximum permissible velocities in vegetated-lined channels are shown in **Table 15-1.** In addition to existing runoff, the channel design should incorporate increased runoff due to the proposed development.

2. Where depth of design flow is slightly below critical depth, channels shall have freeboard adequate to cope with the effect of hydraulic jumps.

3. Along the streets and roads, the bottom of the ditch should be low enough to install adequately sized driveway culverts without creating "speed bumps". The driveway culvert inverts shall be designed to adequately consider upstream and downstream culvert elevations.

4. Flow of a channel into a closed system is prohibited, unless runoff rate and head loss computations demonstrate the closed conduit to be capable of carrying the 100-year channel flow for developed conditions, either entirely or in combination with a defined overflow channel, with no reduction of velocity.

Table 15-1
Maximum Permissible Velocities in Vegetal-Lined Channels (1)

Cover	Channel Slope Range (%) (3)	Permissible Velocity (2)	
		Erosion Resistant Soils (feet per sec.)(4)	Easily Eroded Soils (feet per sec.)(4)
Bermudagrass	0-5 5-10 Over 10	8 7 6	6 5 4
Buffalograss Kentucky Bluegrass Smooth Brome Blue Grama	0-5 5-10 Over 10	7 6 5	5 4 3
Grass Mixture	0-5 **(3)**	5	4
Reed Canary Grass	5-10	4	3
Lespedeza Sericea	**(4)**		
Weeping Lovegrass			
Yellow Bluestem	0-5	3.4	2.5
Redtop	5-10		
Alfalfa			
Red Fescue			
Common Lespedeza**(5)** Sudangrass**(5)**	0-5 **(6)**	3.5	2.5

(1) From Soil Conservation Service, SCS-TP-61, "Handbook of Channel Design for Soil and Water Conservation".

(2) Use velocities exceeding 5 feet per second only where good channel ground covers and proper maintenance can be obtained.

(3) Do not use on slopes steeper than 10 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

(4) Do not use on slopes steeper than 5 percent except for vegetated side slopes in combination with a stone, concrete, or highly resistant vegetative center section.

(5) Annuals - use on mild slopes or as temporary protection until permanent covers are established.

(6) Use on slopes steeper than 5 percent is not recommended

E. Side Slopes

1. Earthen channel and swale side slopes shall be no steeper than three (3) horizontal to one (1) vertical (3:1). Flatter slopes may be required to prevent erosion and for ease of maintenance.

2. Where channels will be lined with riprap, concrete, or other acceptable lining method, side slopes shall be no steeper than two (2) horizontal to one (1) vertical (2:1) with adequate provisions made for weep holes.

3. Side slopes steeper than two (2) horizontal to one (1) vertical (2:1) may be used for lined channels provided that the side lining is designed and constructed as a structural retaining wall with provisions for live and dead load surcharge.

4. When the design discharge produces a depth of greater than three (3) feet in the channel, appropriate safety precautions shall be added to the design criteria based on reasonably anticipated safety needs.

F. Channel Stability

1. Characteristics for a stable channel are:

   a. It neither promotes sedimentation nor degrades the channel bottom and sides.

   b. The channel banks do not erode to the extent that the channel cross-section is changed appreciably.

   c. Excessive sediment bars do not develop.

   d. Excessive erosion does not occur around culverts, bridges, outfalls, or elsewhere.

   e. Gullies do not form or enlarge due to the entry of uncontrolled flow to the channel.

2. Channel stability shall be determined for an aged condition and the velocity shall be based on the design flow or the bankfull flow, whichever is greater, using an "n" value for various channel linings as shown in **Tables 12-1** and **15-1**. In no case is it necessary to check channel stability for discharges greater than that from a one hundred (100) year frequency storm.

3. Channel stability shall be checked for conditions representing the period immediately after construction. For this stability analysis, the velocity shall be calculated for the expected flow from a ten (10) year frequency storm on the watershed, or the bankfull flow, whichever is smaller, and the "n" value for the newly constructed channels in fine-grained soils and sands may be determined in accordance with the "National Engineering Handbook 5, Supplement B, Soil Conservation Service" and shall not exceed 0.025. This reference may be obtained by contacting the National Technical Information Service in Springfield. The allowable velocity in the

newly constructed channel may be increased by a maximum of twenty (20) percent to reflect the effects of vegetation to be established under the following conditions:

a. The soil and site in which the channel is to be constructed are suitable for rapid establishment and support of erosion controlling vegetation.

b. Species of erosion controlling vegetation adapted to the area, and proven methods of establishment are shown.

c. The channel design includes detailed plans for establishment of vegetation on the channel side slopes.

G. Drainage of Swales

Minimum swale slopes are 0.5%. All flow shall be confined to the specific easements associated with each rear and side lot swale that are part of the minor drainage system. Unless designed to act as a stormwater quality BMP, vegetated swales with a slope less than one (1) percent shall have tile underdrains to dry the swales. (See Figure 4-3). Tile lines may be outletted through a drop structure at the ends of the swale or through a standard tile outlet. Further guidance regarding this subject may be found in the latest edition of the Indiana Drainage Handbook.

H. Appurtenant Structures

The design of channels will include provisions for operation and maintenance and the proper functioning of all channels, laterals, travel ways, and structures associated with the project. Recessed inlets and structures needed for entry of surface and subsurface flow into channels without significant erosion or degradation shall be included in the design of channel improvements. The design will also provide for necessary floodgates, water level control devices, and any other appurtenance structure affecting the functioning of the channels and the attainment of the purpose for which they are built. The effects of channel improvements on existing culverts, bridges, buried cables, pipelines, and inlet structures for surface and subsurface drainage on the channel being improved and laterals thereto shall be evaluated to determine the need for modification or replacement. Culverts and bridges which are modified or added as part of channel improvement projects shall meet reasonable standards for the type of structure and shall have a minimum capacity equal to the design discharge or governmental agency design requirements, whichever is greater.

I. Appurtenant Structures

Spoil material resulting from clearing, grubbing, and channel excavation shall be disposed of in a manner that will:

1. Minimize overbank wash.

2. Provide for the free flow of water between the channel and floodplain

boundary unless the valley routing and water surface profiles are based on continuous dikes being installed.

3. Not hinder the development of travel ways for maintenance.

4. Leave the right-of-way in the best condition feasible, consistent with the project purposes, for productive use by the owner.

5. Be accepted by the IDNR or COE, if applicable.

J. Materials

Materials acceptable for use as channel lining are:

1. Grass
2. Revetment Riprap
3. Concrete
4. Hand Laid Riprap
5. Precast Cement Concrete Riprap
6. Gabions
7. Straw or Coconut Mattings (only until grass is established)

Other lining materials must be accepted in writing by the City or City Engineer. Materials shall comply with the latest edition of the INDOT, "Standard Specifications".