SECTION 112 - DETENTION FACILITIES FOR FLOOD CONTROL

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This section covers the design of detention facilities whose primary purpose is to provide flood control by controlling rates of runoff. Detention facilities may also be utilized to improve the quality of urban stormwater runoff. The design of detention facilities for water quality improvement is covered in Section 115, Stormwater Quality. Both flood control and water quality benefits can be provided in one (1) basin, if properly designed. This policy replaces the draft detention policy and standards dated August 14, 1990.

112.1 POLICY

Prior to the development of the land, surface conditions provide a higher percentage of permeability and a longer time of concentration. With the construction of buildings, parking lots, etc., permeability and the time of concentration are significantly decreased, resulting in an increase in the rate, volume, and frequency of runoff.

These changes result in increased flooding risk to downstream structures, since flooding depths will rise as the rate of runoff increases. The increased volume and frequency of runoff can cause erosion damage.

In order to minimize these effects, stormwater detention requirements have been established as set forth in the Greene County Zoning Regulations and Subdivision Regulations. All new non-agricultural construction is required to provide stormwater detention facilities. Detention requirements may be waived upon written approval of the County Stormwater Engineer in the following cases:

1) Construction of such a facility would, due to timing of outflows, have an adverse effect on downstream properties by increasing peak rates of runoff, as demonstrated by engineering computations;

2) The developer enters into a written agreement with the County and affected property owners to provide storm drainage improvements downstream of the development in lieu of constructing on-site detention facilities as set forth below; or

3) Due to the small size of the development, it can be demonstrated that the detention facility would result in no beneficial effect to downstream properties. Detention basins having a required volume of five thousand (5,000) cubic feet or less are considered as providing only marginal benefits.

In Cases 1 and 3 above the County may, in the future, impose a fee in lieu of detention to be utilized for maintenance or improvement of storm drainage facilities in the same watershed in which the proposed development is located.

Detention requirements cannot be waived if there are residential or other structures downstream of the site which have a high flooding risk as defined in Section 112.2.

Construction of Improvements in lieu of Detention

In cases where channelization or other improvements can be shown to be more effective than detention in reducing the flooding hazard to downstream properties and where no adverse effects to downstream properties will result from construction of such improvements, the County may enter into an agreement with the applicant to accept compensation and/or construction of off-site improvements in lieu of constructing on-site detention facilities.

The developer's contribution will be determined based upon the net financial gain which the

developer would realize if the detention facility is not built. This amount will generally be equal to the construction cost of the detention facility plus revenue from sale of additional lots or increased value of lots, less the cost of developing the lots, including utilities and streets, financing costs, sales costs, and reasonable profit.

Where the developer's contribution is not sufficient to construct the necessary improvements to completely remedy flooding problems to structures downstream, the County must demonstrate that the necessary funding has been secured prior to accepting payment or improvements in lieu of detention. Where the developer's contribution is more than the actual cost of the necessary improvements, the County shall retain the balance and such funds shall be utilized for planning or construction drainage improvements in the same watershed.

112.2 DEFINITIONS

Pre-project conditions - the topography, surface cover, and other hydrologic conditions in the watershed being considered, as they exist prior to the proposed project.

Post-project conditions - the topography, surface cover, and other hydrologic conditions in the watershed as they will be after construction of the proposed project.

Fully urbanized conditions - the topography, surface cover, and other hydrologic conditions in the watershed as they will be after all areas in the watershed have been developed in accordance with current zoning designations, as provided in the Greene County Comprehensive Plan, or as can otherwise be reasonably anticipated.

High flooding risk - residences or other structures will be defined as having a high flooding risk when the lowest point on the structure at which surface runoff may gain entry is located at, or below, the estimated flooding level which would result from a storm with an annual exceedance probability (AEP) of 10% (ten percent) or greater under conditions existing in the basin prior to development of the applicant's property (i.e. affected by the "10-year" storm for pre-project conditions).

Dry detention basin - a detention basin which holds water only during and shortly after runoff events.

Wet detention basin - a basin which contains a permanent impoundment of water. Flood storage volume is provided above the permanent water surface.

Retention basin - this term is often utilized for wet basins and basins which retain runoff for an extended period of time. The term "detention basin" will be used to refer to all such facilities in Greene County.

On-line detention basin - a basin which is located on the main stream of a watercourse and which intercepts on-site as well as off-site flows.

Off-line detention facility - a basin or basins located outside of the primary watercourse, which usually allows off-site flows to pass through the site without passing through the detention basin. Where needed for peak flow reduction at the point of interest, a portion of the flow in the main watercourse may be intercepted and passed through the detention basin through the use of side-flow weirs or similar diversions.

112.3 GENERAL DESIGN REQUIREMENTS

Detention facilities should be designed and constructed in a manner to enhance the aesthetic and environmental quality of developments in the County as much as possible, adding to rather than detracting from property values. Greene County encourages designs which utilize and enhance natural settings, provide good quality open space, and minimize disturbance and destruction of wooded areas, natural channels, and wetlands.

Where detention volume can be provided by utilizing natural valleys, existing wooded areas should be allowed to remain. Detention ponds do not have to be graded to geometric shapes or cleared of forested areas in order to comply with County requirements.

The use of landscaping and alternative materials to improve the appearance of spillways, outlet structures, erosion control, and energy dissipation structures is encouraged.

Detention basins may be designed to be "wet" or "dry". Parking lots may be utilized for detention storage, provided the maximum depth does not exceed eighteen inches (18"). Underground detention storage may also be utilized. The use of rooftop detention is discouraged. Detention basins may be designed to be "on-line" or "off-line".

Construction of detention basins in designated floodplains is not prohibited. However, a floodplain development permit must be obtained. Due to timing problems and the large size of required overflow spillways structures, it will generally be impractical for individual developments to provide an on-line detention basin in floodplain areas. Off-line basins may encroach into the floodplain, provided the requirements of the Floodplain Management Ordinance (Article XIX of the Zoning Regulations) are met.

Large regional detention basins are more effective in providing flood control, as well as water quality benefits, than smaller facilities provided on each site. Greene County currently has no program for regional detention. Where feasible, developers are encouraged to work together to provide common detention areas.

Detention basins shall be located within a single lot or property.

112.3.1 Easements

All detention basins serving more than one (1) lot or property shall be located within a drainage easement.

At a minimum, the easement shall include the area of the dam, the area downstream of the dam to a point twenty feet (20') downstream of the end of the outlet structure, including the area provided for erosion control or energy dissipation; and the area covered by the reservoir including freeboard, plus an additional twenty feet (20') around the perimeter.
Detention basins for a development may be located on adjoining property downstream from the development provided that a drainage easement is obtained and adequate means of maintenance access (including ingress/egress easements where necessary) is provided. The easement shall be granted to the developer or to property owners' association. Where the detention basin does not immediately adjoin the development, a drainage easement covering the area inundated by the peak flow from the 1% AEP (100-year) storm shall be provided to connect the development site with the detention basin.

112.4 OWNERSHIP AND MAINTENANCE

Greene County provides no maintenance of detention facilities located on private property. Maintenance must be provided by the owner of the property upon which the detention basin is located.

Where detention basins are located in common areas or adjoining off-site areas, the property upon which the basin is located shall remain in the ownership of the property owners' association.

Where a property owners' association is formed, restrictive covenants which provide for collection of fees for maintenance of the detention facilities shall be filed in the office of the Greene County Recorder of Deeds. Restrictive covenants must be approved by the County legal counselor prior to filing of the final plat.

112.5 STORAGE VOLUME COMPUTATIONS

112.5.1 Analytical Methods

Detention storage volume shall be determined by hydrograph methodologies and reservoir routing techniques. Preferred methods for use in detention basin design are those included in the Corps of Engineers HEC-1 Flood Hydrograph Package (Reference 112.1) and the Soil Conservation Service's TR-55 and TR-20 (References 112.2 and 112.3).

The designer may choose to use other methods than those listed above provided that the method is documented in generally accepted engineering literature and is used within the limitations stated for the method.

112.5.2 Computations for Small Sites

Where the site area is less than five (5) acres of one (1) and two (2) family dwellings, or where the site area for other zoning designations is less than two (2) acres, detention volume computations may be performed by the methods of the Soil Conservation Service TR-55

(Reference 112.2).

Runoff volumes shall be computed for pre- and post-project conditions, and the required volume determined by subtracting the pre-project runoff volume from the post-project runoff volume. The outlet structure shall be designed to limit the runoff rate for the design storms set forth in Section 112.3.2 to pre-project values at the stage where the required volume for each storm frequency is contained in the basin.

112.5.3 Design Storms

Detention basins shall be designed on the basis of multiple storm recurrence frequencies to ensure that they provide flood protection for both frequent storms and large infrequent storms. A minimum of three (3) recurrence frequencies, the 50%, 10% and 1% AEP storms (the "2-year, 10-year and 100-year" storms) must be considered.

The duration of the design storm used to compute the difference in runoff volume between pre-project and post-project conditions shall be that which produces the maximum rate of runoff at the point under consideration for post-project conditions. The minimum design storm duration utilized shall be one (1) hour.

112.5.4 Runoff Models

The runoff model must include the entire drainage basin upstream of the proposed detention pond. The model shall be prepared in sufficient detail to ensure that peak runoff rates are reasonably accurate.

Runoff models shall be developed for the following cases:

Case 1. Pre-project conditions.

Case 2. Post-project conditions.

Case 3. Fully urbanized conditions in the entire drainage basin.

Cases 1 & 2 are utilized to determine the required detention volume and the type of outlet structure to be provided, and shall be analyzed for the three (3) storm recurrence frequencies required above.

Detention facilities shall be designed such that peak outflow rates from the facility for Case 2 are no greater than the rates determined in Case 1 for each of the three (3) storm recurrence frequencies required.

The storage volume provided shall not be less than the difference in total runoff volume between Case 1 and Case 2.

Case 3 is used to determine the size of the overflow spillway. Case 3 need only be analyzed for the 1% AEP ("100-year") storm.

112.5.5 Spillways and Outlet Structure Hydraulics

Outlet structures be composed of culverts, weirs, orifices, and other hydraulic elements for which reliable data is available. Weir coefficients shall be as given in King's Handbook of Hydraulics (Reference 112.4). Coefficients for broad-crested weirs interpolated from the values given in King's Handbook are given below in Table 112.1.

TABLE 112.1

DISCHARGE COEFFICIENTS FOR BROAD-CRESTED WEIRS

Depth (ft.)	Coefficient for 6" thick wall	Coefficient for 8" thick wall	Coefficient for 12" thick wall
0.20	2.80	2.77	2.69
0.25	2.83	2.79	2.70
0.30	2.86	2.80	2.71
0.40	2.92	2.84	2.72
0.50	3.00	2.90	2.74
0.60	3.08	2.95	2.75
0.70	3.19	3.03	2.80
0.75	3.25	3.08	2.83
0.80	3.30	3.12	2.85
0.90	3.31	3.16	2.92
1.00	3.32	3.20	2.98
1.25	3.32	3.25	3.11
1.50	3.32	3.29	3.24
1.75	3.32	3.31	3.27
2.00	3.32	3.32	3.30
2.50	3.32	3.32	3.31
>2.5	3.32	3.32	3.32

Capacity of broad-crested slot and V-notch weirs shall be determined by the following formula, developed by Joe Wilson, Kerry Scott, and Larry Wolf at the University of Missouri-Rolla:

$$Q = 0.86H + (3.65w + 5.82z)H^{1.5}$$, where

Q = flow rate in cubic feet per second.
H = upstream head (ponded depth above slot invert plus any velocity head) in feet. H = 6 feet maximum.
w = slot invert width perpendicular to flow, in feet

$0.333 < w < 2.0$ feet.
z = slope of slot sides expressed in terms of z horizontal to 1 vertical. $0 < z < 0.6$

A definition sketch and capacity charts for V-notch spillways are shown in Figures 112.1 through 112.9.

Weir coefficients for trapezoidal weirs shall be determined based upon the ratio of headwater depth to crest width (Reference 112.5), as shown in Figure 112.10.

Culvert capacities shall be determined using the methods in Federal Highway Administration HDS-5 (Reference 112.5).

Weir coefficients for trapezoidal weirs where the depth of flow over the weir is small in comparison to the width of the weir crest shall be determined in accordance with Figure III-11 of Federal Highway Administration HDS-5 (Reference 112.5).

Discharge coefficient for all orifice shapes shall be 0.6 (six tenths) unless supporting data is submitted for other values.

Where outlet structure capacities are determined automatically by the software used in performing the detention basin analysis, values included in the software package may be used provided they are generally accepted and properly documented.

112.5.6 Submittals

The following information must be submitted with detention basin designs:

1.Information regarding analytical methods and software to be used, including:

- Name of software to be used.
- Type and distribution of precipitation input.
- Method for determining precipitation losses.
- Type of synthetic hydrograph.
- Method for routing hydrographs.
- Method used for reservoir routing.

2. Map(s) showing sub-basin delineation, topography, presumed flow routes, and pertinent points of interest for pre-project, post-project and fully urbanized conditions.

3. Map showing hydrologic soil types.

4. Routing diagram for each runoff model condition.

5. A summary of sub-basin characteristics used for program input.

6. Stage-area or stage-storage characteristics for the basin in tabular or graphic form.

7. Stage-discharge characteristics for the outlet structure and overflow spillway in tabular or graphic form; hydraulic data for weirs, orifices, and other components of the control structure.

8. A printout of the input data file.

9. A printout of program output, including plots of hydrographs. (These are intended to be the printer plots generated by the software.)

112.6 CONSTRUCTION REQUIREMENTS

112.6.1 Maximum and Minimum Slopes

Maximum slopes of excavated or embankments slopes shall be 3:1. 4:1 slopes are preferred. Natural slopes exceeding 3:1 may be utilized provided that they remain undisturbed.

The minimum allowable slope on the bottom of the basin shall be 1% (one percent) unless a trickle channel is provided. Trickle channels shall be designed as provided in Section 111.4.3.

112.6.2 Earth Dams

Dams shall be constructed to the maximum slopes specified above. Dams shall be constructed of properly compacted earth fill and shall be keyed into existing ground to reduce the risk of leakage or failure.

Dams less than ten feet (10') in height shall be keyed in a minimum of two feet (2') below existing grade. Deeper keys may be required for taller dams.

The minimum embankment width at the top of the dam shall be three feet (3'). Greater widths may be required for dams exceeding ten feet (10') in height.

Dams greater than thirty-five feet (35') in height are subject to regulation by the State dam safety program, and shall meet requirements of the dam safety program (Reference 112.6).

112.6.3 Concrete Retaining Walls

The use of vertical retaining walls for detention basin impoundments is discouraged, due to cost and appearance considerations. However, concrete retaining walls are frequently utilized to minimize the area required for detention basins.

Where concrete retaining walls exceed three feet and six inches (3' 6") in height, a four feet (4') high chain link or solid fence must be provided.

The maximum depth of detention basins using vertical walls shall be four feet (4').

Concrete retaining walls shall be designed to withstand earth and hydrostatic pressures. Walls longer than fifty feet (50') shall be provided with expansion and contraction joints at appropriate intervals.

112.6.4 Other Types of Retaining Walls

Where retaining walls must be utilized to conserve space, the use of other types of materials is encouraged in order to reduce cost and improve appearance of detention basins. Alternative retaining wall materials include gabions and precast concrete units, such as Keystone blocks, Loffelstein units, Windsor stone, and many other types of precast units.

In specifying any type of these linings, the manufacturer's installation instructions shall be strictly followed.

112.6.5 Freeboard

For basins with a surface area of two (2) acres of less, a minimum freeboard of twelve inches (12") shall be provided above the design stage for the 1% AEP (100-year) storm. For surface areas greater than two (2) acres but less than ten (10) acres, two feet (2') of freeboard shall be provided. Greater depths of freeboard may be required for impoundments having a surface area greater than ten (10) acres.

112.6.6 Spillways and Outlet Structures

Any type of outlet structure and overflow spillway can be utilized provided the required hydraulic characteristics of the structure can be maintained and provided that no undue maintenance burdens are placed upon the owner of the detention basin.

Outlet structures and spillways shall be provided with an adequate stilling area downstream to reduce velocities to acceptable levels. Outlet structures shall be set back a minimum distance from the downstream property line to allow for the pre-project velocity and spread of flow to be maintained at the downstream property line.

Where concrete or other types of retaining walls exceed three feet and six inches (3' 6") in height, a four feet (4') high chain link or solid fence must be provided.

Spillways and outlet structures shall be provided with toewalls extending a minimum depth of eighteen inches (18") below finish grade at the upstream and downstream ends in order prevent undercutting.

Spillway sidewalls shall extend in height to the top of the dam.

112.6.7 Wet Ponds

Where wet ponds are specified, the pond lining must be designed to retain water. Geologic conditions in Greene County frequently make it difficult for impoundments to hold water. Site soil conditions shall be evaluated by a soils engineer and an appropriate lining provided.

Wet ponds shall have a minimum permanent pool depth of four feet (4') to minimize algae growth. Designers and developers are encouraged to consult with the Missouri Department of Conservation regarding pond management techniques, stocking fish, etc.

112.7 REFERENCES

1. Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package: User's Manual, U.S. Army Corps of Engineers, Davis, CA, 1990.

2. U.S. Soil Conservation Service, Urban Hydrology for Small Watersheds. Technical Release 55, NTIS PB87-101580, 2nd ed., U.S. Department of Agriculture, Springfield, VA, 1986.

3. U.S. Department of Agriculture, Computer Program for Project Formulation - Hydrology. Technical Release 20, 2nd. ed. Soil Conservation Service, U.S. Department of Agriculture, Available from NTIS, Springfield, VA, 1983.

4. Brater, Ernest F. and King, Horace Willams, Handbook of Hydraulics, 6th Edition, McGraw-Hill Book Company, New York, NY, 1976.

5. Hydraulic Design of Highway Culverts (1985) Federal Highway Administration, Hydraulic Design Series No. 5, Report No. FHWA-IP-85-15, Washington, D.C.

6. Missouri Dam Safety Regulations.

7. American Society of Civil Engineers Manuals and Reports of Engineering Practice No. 77 (WEF Manual of Practice FD-20), Design and Construction of Urban Stormwater Management Systems, Chapter 5. American Society of Civil Engineers, New York, NY, 1992.

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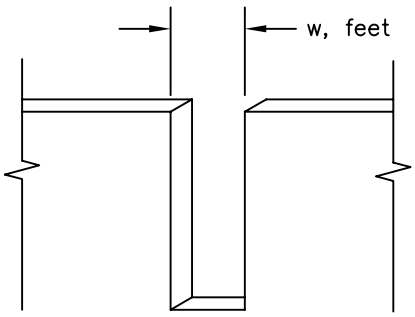
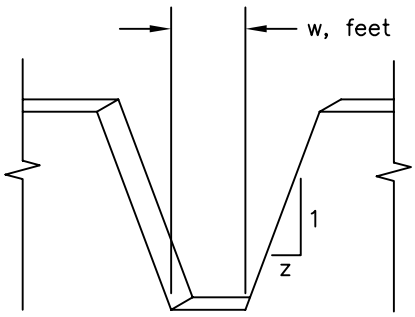
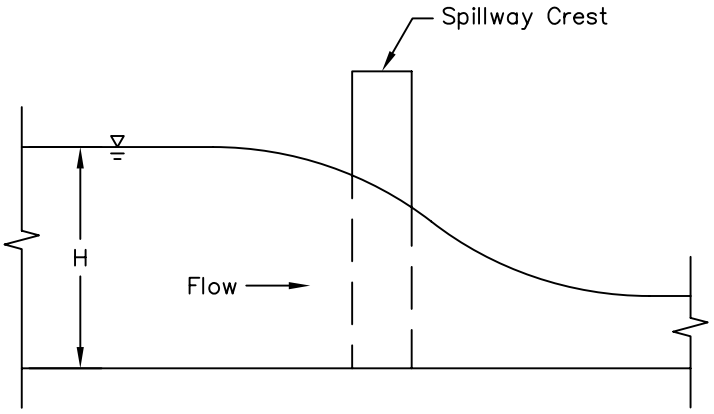


VERTICAL SLOT OUTLET



SLOPING SLOT OUTLET



GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

SLOT OUTLET DEFINITION SKETCH

FIGURE 112.1

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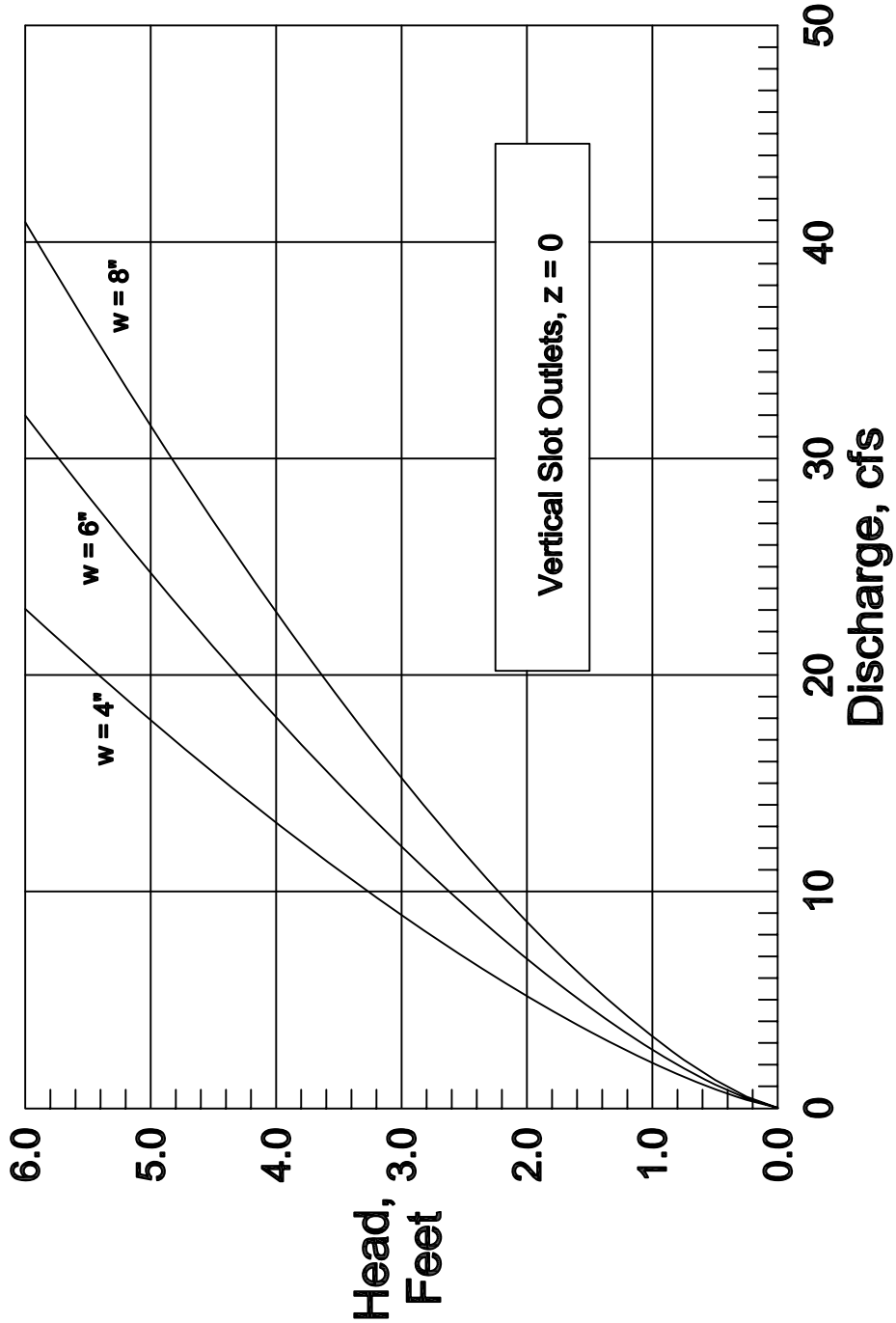

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
VERTICAL SLOT OUTLET, 4" – 8" SLOT, z = 0.0

FIGURE 112.2

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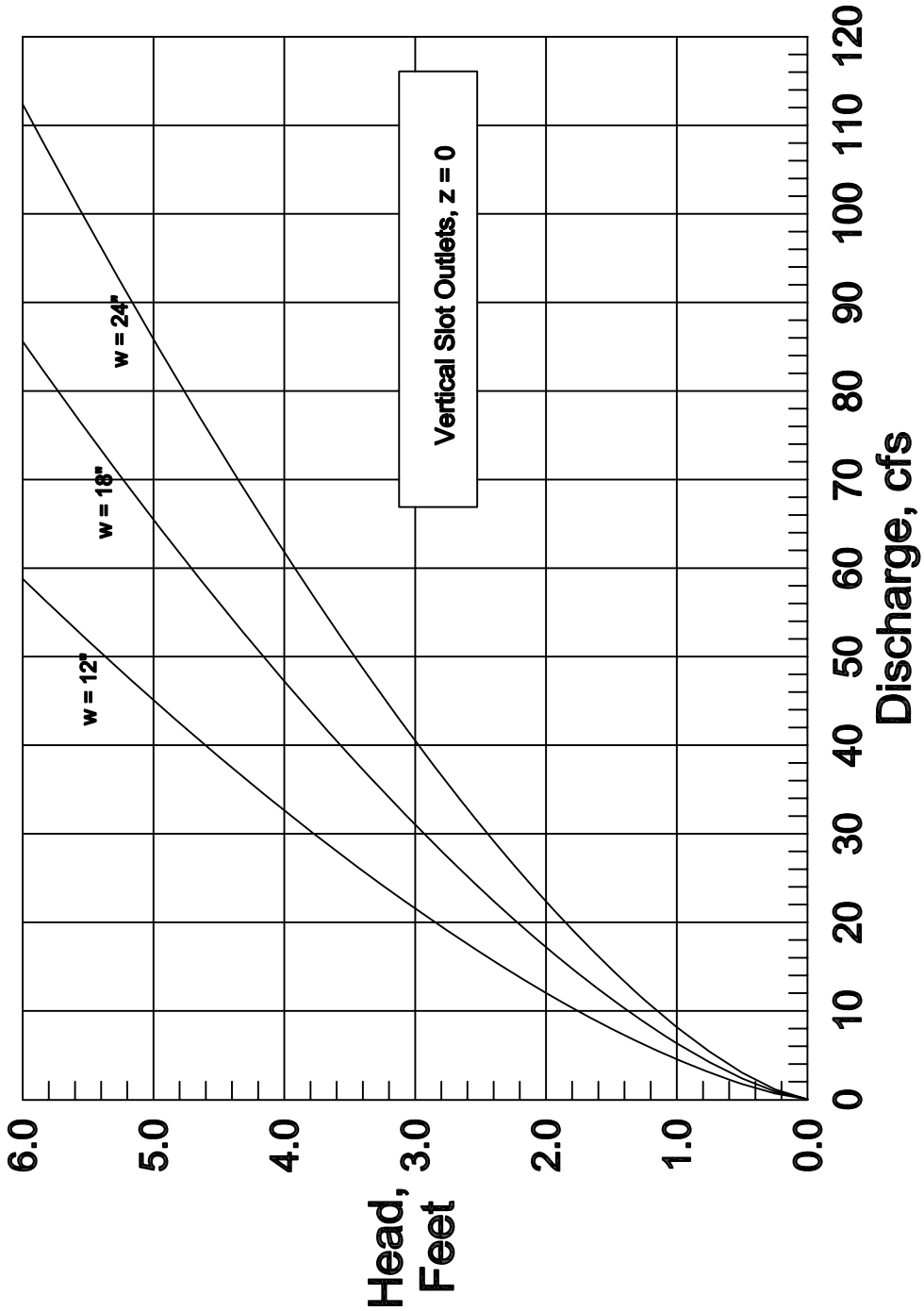

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
VERTICAL SLOT OUTLET, 12" – 24" SLOT, z = 0.0

FIGURE 112.3

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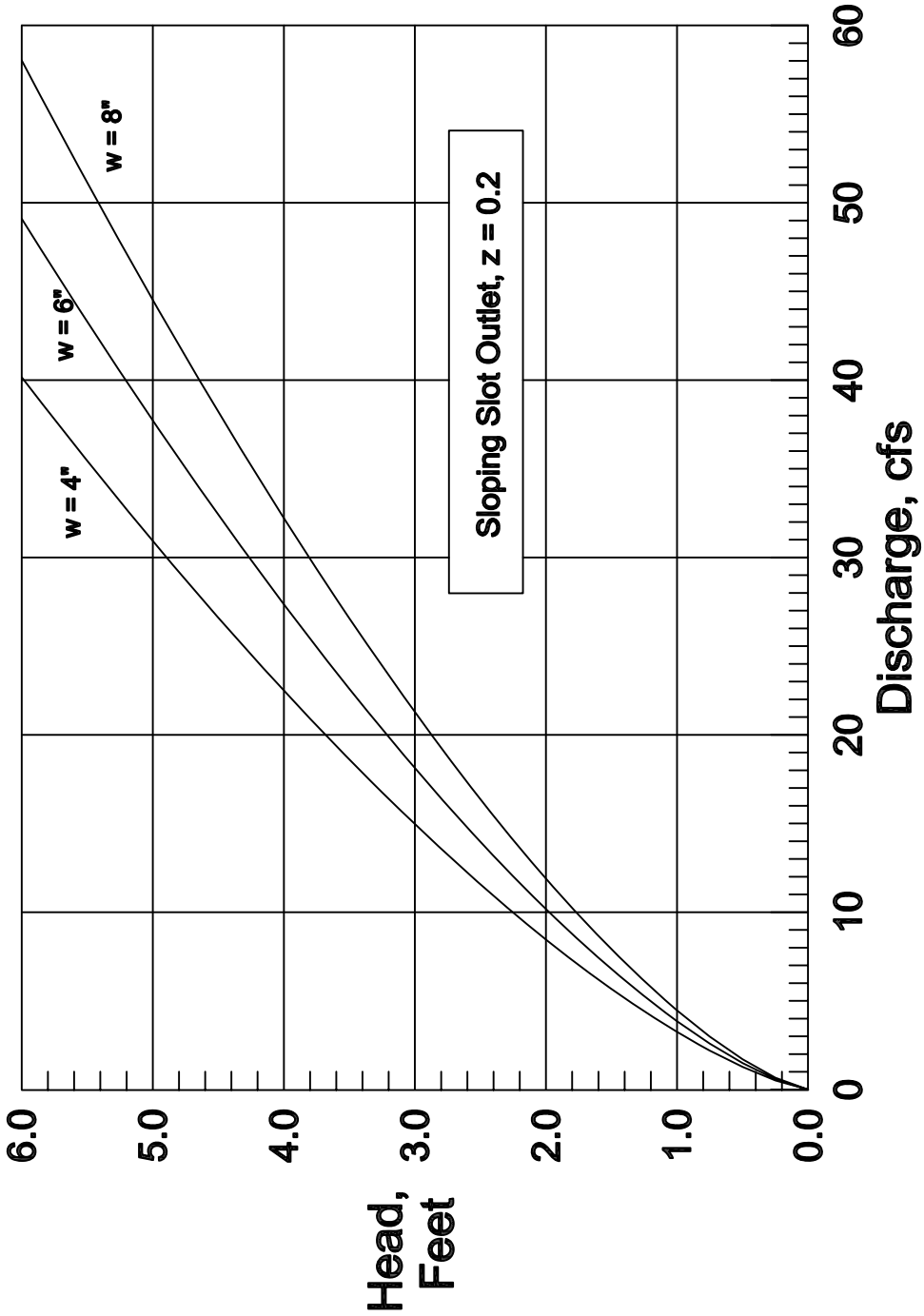

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
SLOPING SLOT OUTLET, 4" – 8" SLOT, z = 0.2

FIGURE 112.4

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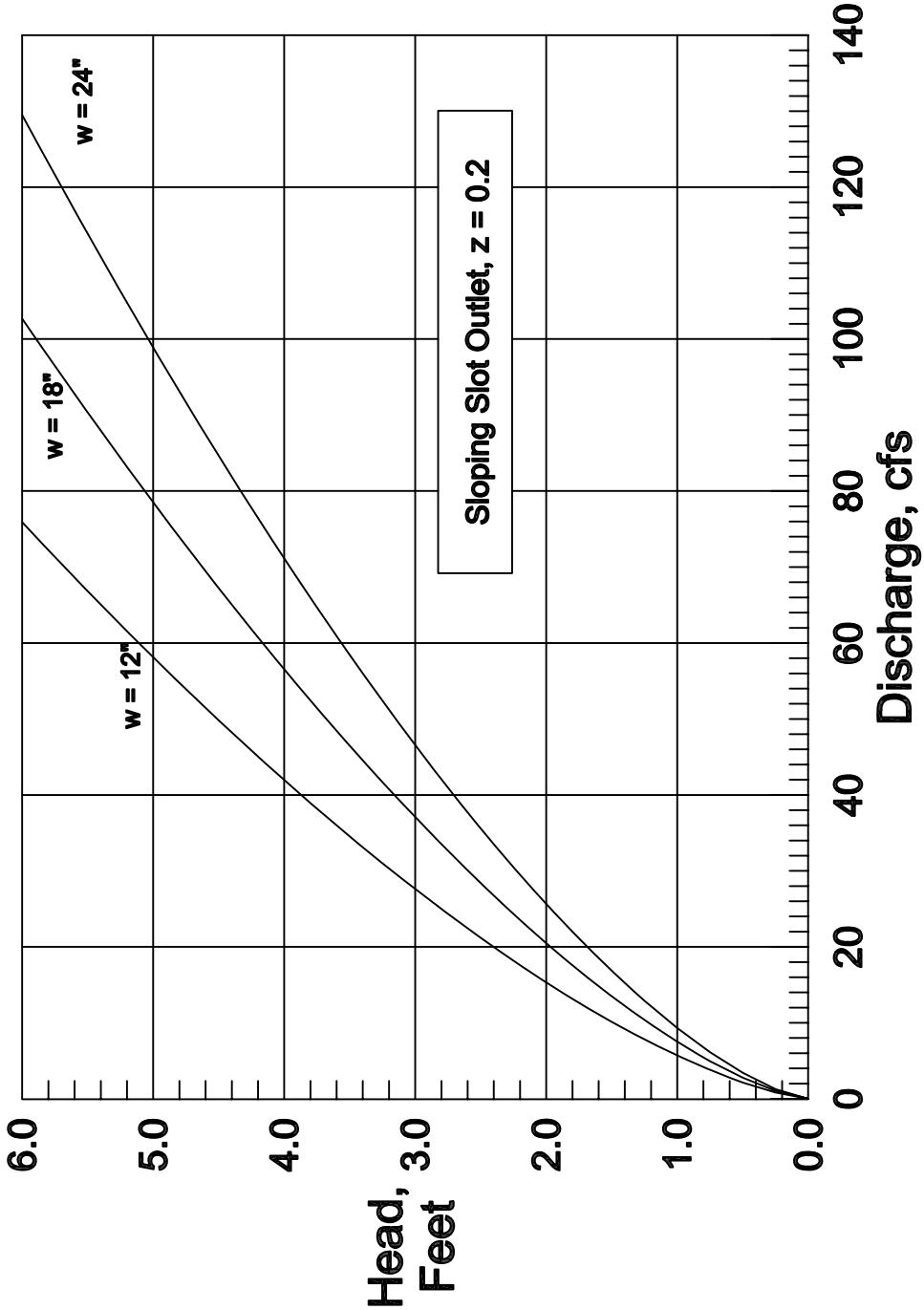

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
SLOPING SLOT OUTLET, 12" – 24" SLOT, z = 0.2

FIGURE 112.5

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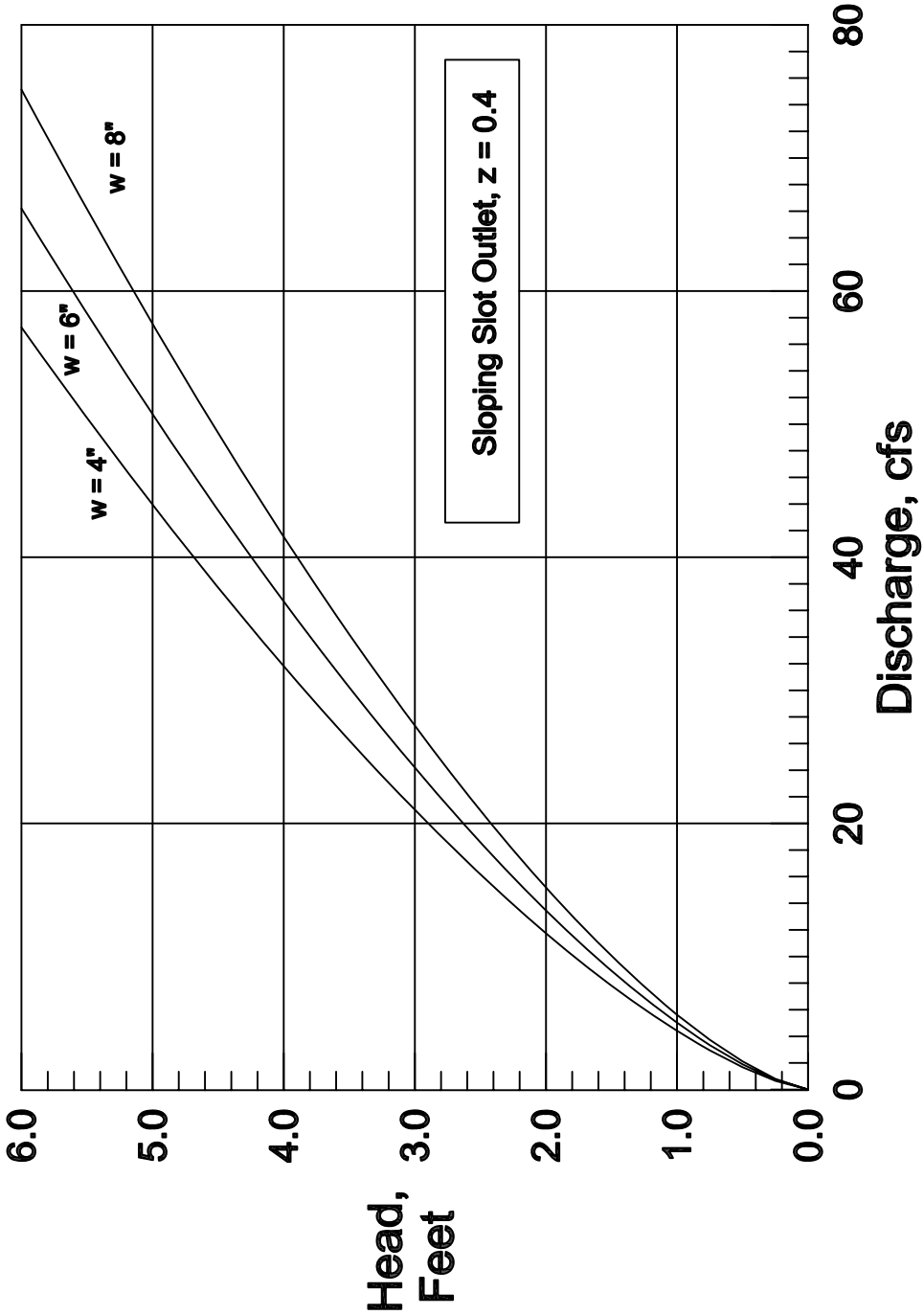

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
SLOPING SLOT OUTLET, 4" – 8" SLOT, z = 0.4

FIGURE 112.6

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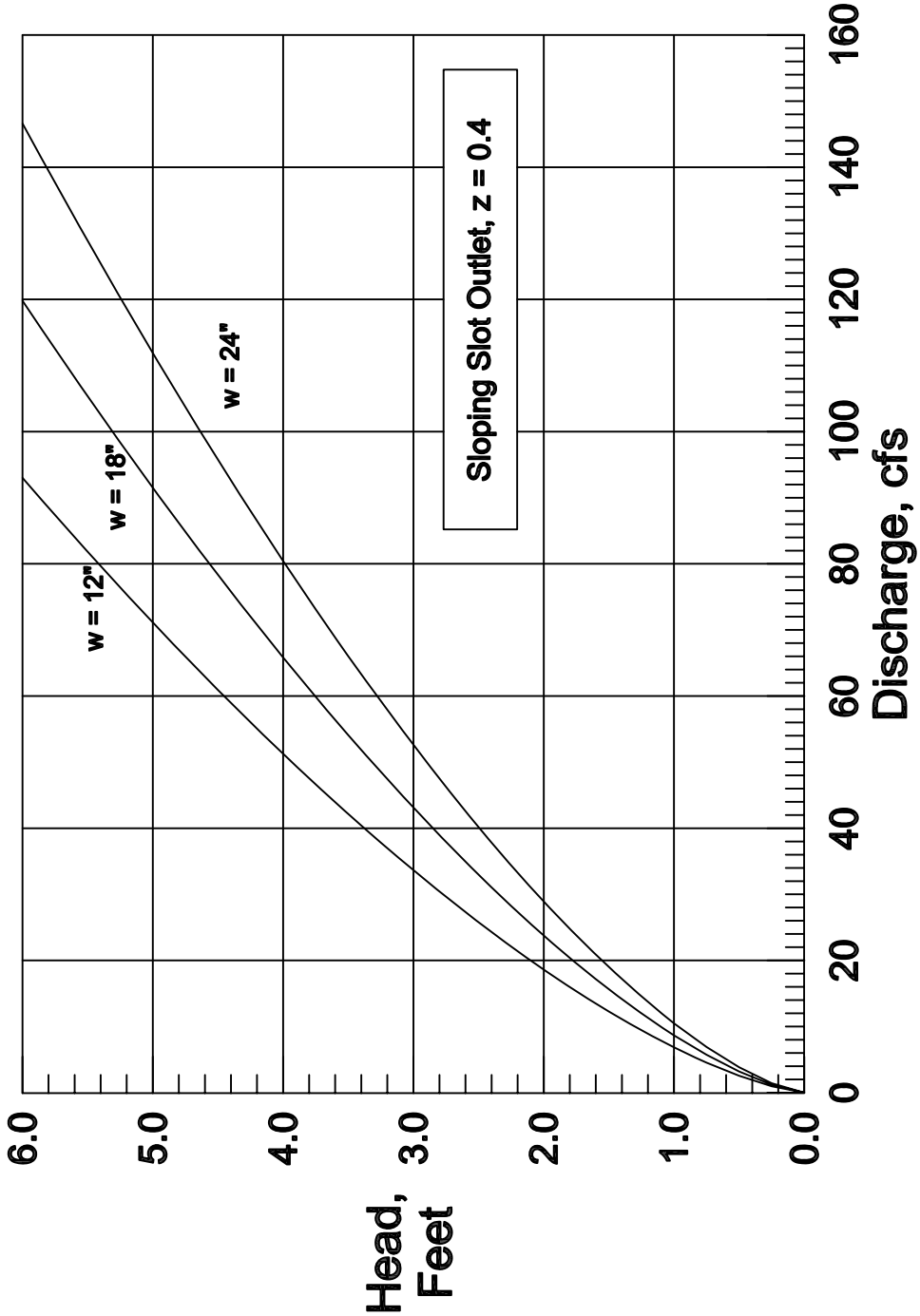

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
SLOPING SLOT OUTLET, 12" – 24" SLOT, z = 0.4

FIGURE 112.7

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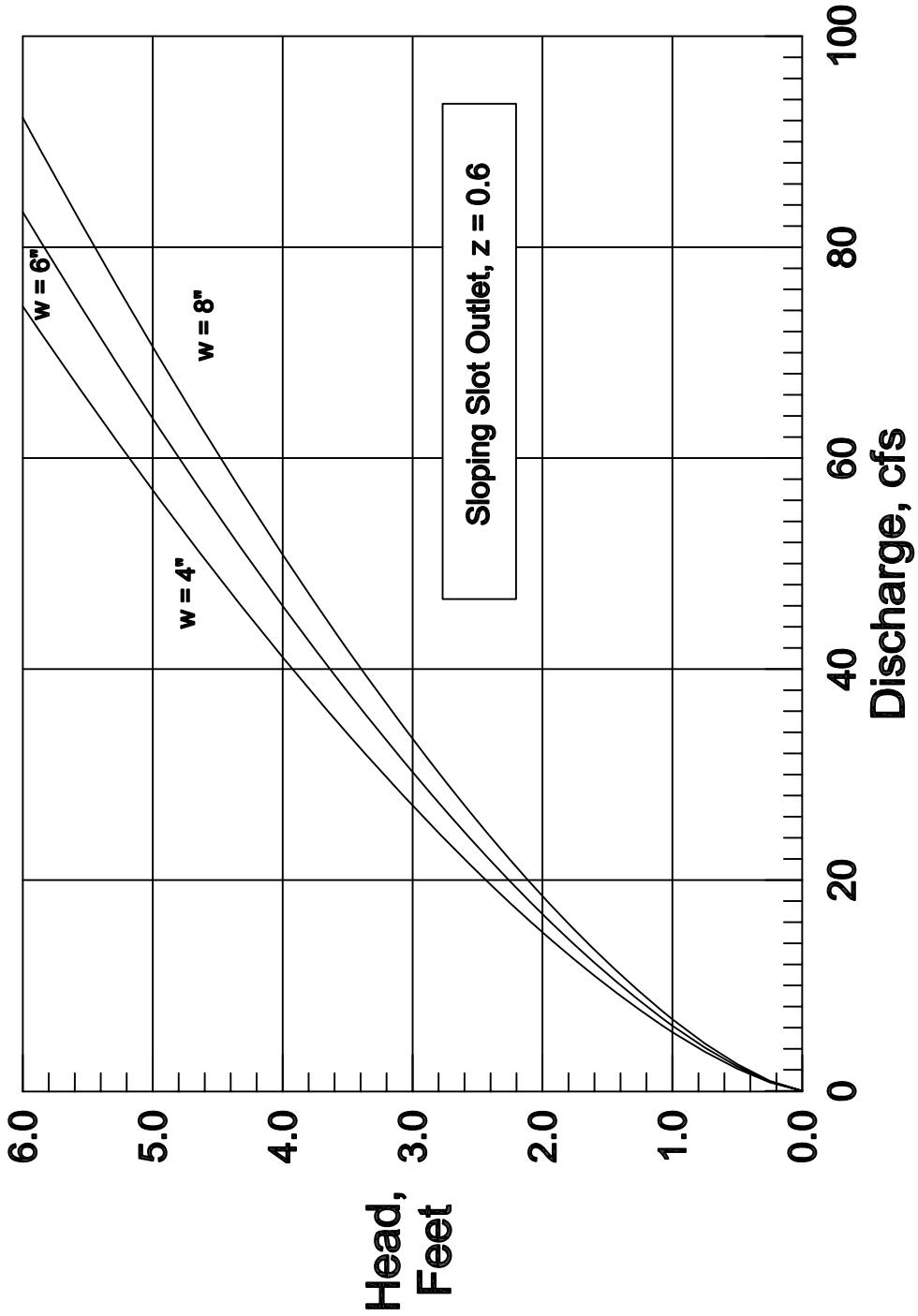

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
SLOPING SLOT OUTLET, 4" – 8" SLOT, z = 0.6

FIGURE 112.8

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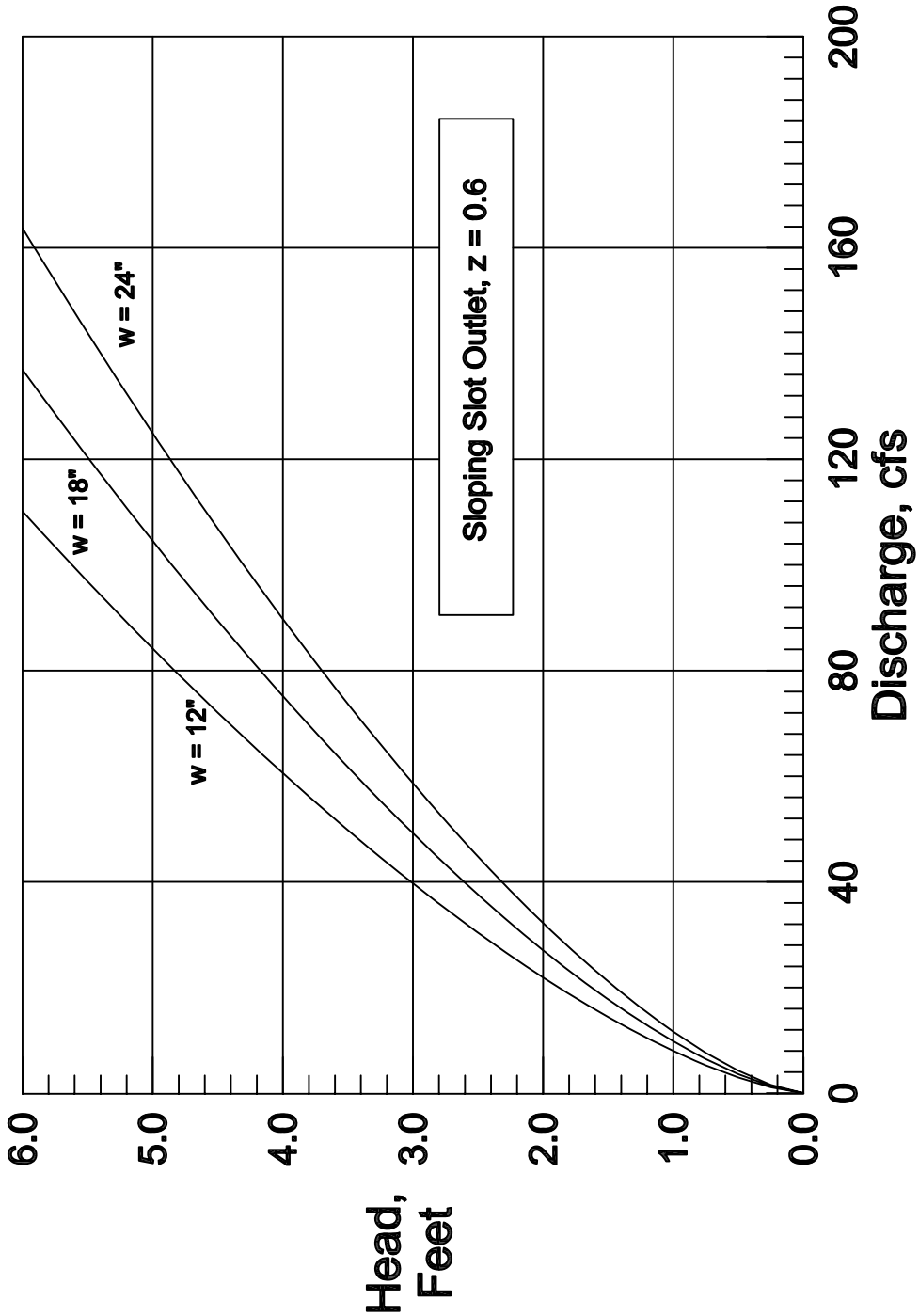

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
CAPACITY FOR STANDARD
SLOPING SLOT OUTLET, 12" – 24" SLOT, z = 0.6

FIGURE 112.9

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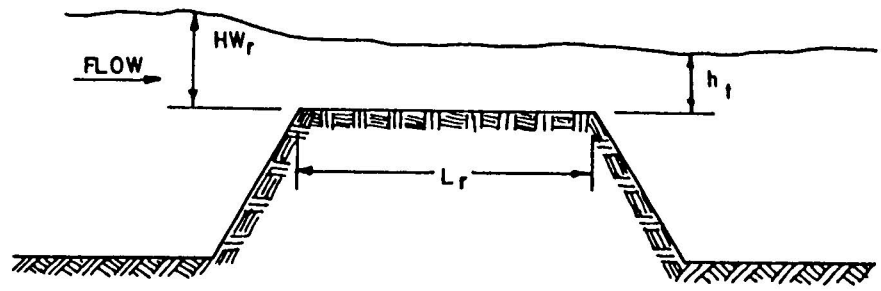
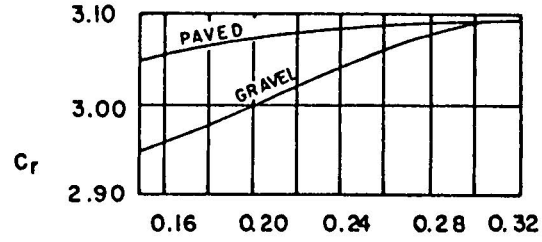
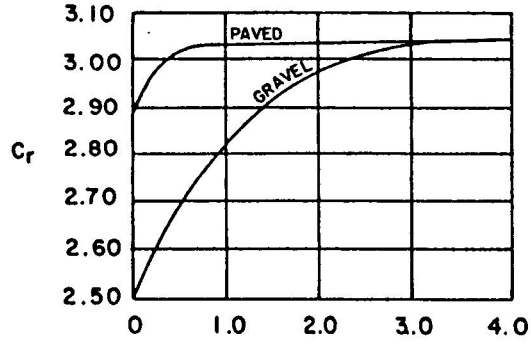


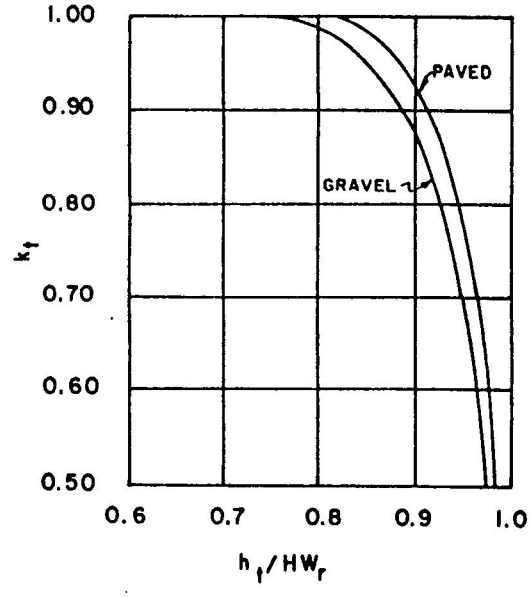


A) DISCHARGE COEFFICIENT FOR $HW_r / L_r > 0.15$



B) DISCHARGE COEFFICIENT FOR $HW_r / L_r \leq 0.15$

$C_d = k_t C_r$



C) SUBMERGENCE FACTOR

From "Hydraulic Design of Highway Culverts," HDS–5, Federal Highway Administration, 1985.

GREENE COUNTY MISSOURI – STORM WATER DESIGN STANDARDS

DETENTION FACILITIES
DISCHARGE COEFFICIENTS FOR FLOW
OVER WIDE EMBANKMENTS

FIGURE 112.10

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