JOPLIN, MISSOURI

STORMWATER MANAGEMENT CRITERIA

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Consulting Engineers and Surveyors

CITY OF JOPLIN, MISSOURI
STORMWATER MANAGEMENT CRITERIA

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1.0 GENERAL

1.1 Introduction: This document provides uniform procedures for designing and checking the design of storm drainage systems under the rainfall and land characteristics typical of Joplin, Missouri. Specific criteria have been developed and are applicable to the types of drainage systems and facilities ordinarily encountered in local urban and suburban areas. Other special situations may be encountered that require added criteria or more complex technology than included herein. Any design procedure conforming to current accepted engineering practice, including the application of computers, may be used for the design of storm drainage system in lieu of the computation methods presented in these criteria providing equivalent results are obtained.

1.2 Applicability: These criteria are applicable to all new storm drainage systems and facilities and to the rehabilitation of existing drainage system facilities.

1.3 General Requirements: The design shall be accomplished under the direction of a Registered Professional Engineer. The design shall also be based on land use in the tributary area as zoned, actually developed, or indicated by the City's current comprehensive land use plan, whichever basis produces the greatest runoff.

1.4 Definitions/Abbreviations:

A. **Annual Probability (AP):** The probability, likelihood, or chance, of the magnitude of a storm event of a specified duration, being equaled or exceeded in any given year. Usually expressed as a percentage.

B. **Bank Line:** The line of intersection, above the normal depth of flow at design capacity, of the side slope of an open channel and the adjacent ground.

C. BMP: Best Management Practice.

D. CFS: Cubic feet/foot per second.

E. **City:** The City of Joplin, having jurisdiction and authority to govern.

F. **City Engineer:** The municipal public works engineer or official having jurisdiction and authority to review and approve plans and designs for storm drainage systems.

G. **Developer:** Any person, partnership, association, corporation, public agency, or governmental unit proposing to engage or currently engaged in "development" as defined below excluding the widening, resurfacing, or other improvement to existing streets, alleys, and sidewalks.

H. **DCIA:** Directly Connected Impervious Area.

I. **Diversion:** Discharge or conveyance of stormwater to a watershed other than the watershed of origination.

J. **Development:** Any man-made change to improved of unimproved real estate, including but not limited to buildings, other structures, pavement, filling, grading or storage of equipment or materials.

K. **Easement:** Authorization by a property owner for the use of any designated part of the property by another for a specified purpose.

L. **FEMA:** Federal Emergency Management Agency.

M. **Floodplain:** The normally dry land adjoining rivers, streams, lakes or other bodies of water that is inundated during flood events. In order to provide a standard national procedure for floodplain management, the U.S. Federal Emergency Management Agency (FEMA) has adopted the 1% Annual Probability (AP) flood as the base flood.

N. **Floodway:** The channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment in order for the 1% AP flood to be carried without substantial increase in flood heights. FEMA's easements preclude any improvement to the land occupied by the easement.

O. **Flowage Easement:** Easement acquired for the right to periodically use an open channel and its overbank floodway, or the overflow channel above an enclosed system element, to convey drainage. Flowage easements preclude any improvement to the land occupied by the easement.

P. **Freeboard:** The difference in elevation between the top of a structure, such as a dam or open channel, and the maximum design water surface elevation or high water mark. It is an allowance against overtopping by waves or other transient disturbances.

Q. **Improved Channel:** Any new open channel which has been constructed or existing channel which has been changed by grading or by the construction of lining materials.

R. **MDNR:** Missouri Department of Natural Resources.

S. **Natural Channel:** An existing channel that has not been altered by previous construction.

T. **Owner:** The owner of record of real property.

U. **Registered Professional Engineer:** A licensed engineer who is registered with and authorized by the Missouri Board for Architects, Professional Engineers and Professional Land Surveyors to practice.

V. **Return Period:** Also referred to as return frequency or recurrence interval. A statistical term for the average frequency that a given event may be expected to occur although it does not imply that the event will occur regularly at even intervals. It can also be defined as the reciprocal of the annual probability of an event. For example, a 50-year storm has a probability of 1/50 = 0.02 (2% AP) of occurring in any given year.

W. **Site:** A tract, or contiguous tracts, of land owned and/or controlled by a developer or owner. Platted subdivisions, industrial and/or office-commercial parks, and other planned unit developments shall be considered a single site.

X. **Storm Drainage System:** All of the natural and man-made facilities and appurtenances such as ditches, natural channels, swales, pipes, culverts, bridges, open improved channels, street gutters, inlets, and detention facilities which serve to convey surface drainage.

Y. **Storm Water Detention Facility:** Any structure, device, or combination thereof with a controlled discharge rate less than its inflow rate.

   a. Controlled Area: That part of the tributary area for which a detention facility is designed to control peak discharge rates.

b. Detention Storage: The volume occupied by water between the levels of the principal and emergency spillway crests during operation of the facility.
c. Dry Detention Facility: Any detention facility designed to permit no permanent impoundment of water.
d. Emergency Spillway: A device or devices used to discharge water under conditions of inflow that exceed the design inflow. The emergency spillway functions primarily to prevent damage to the detention facility that would permit the sudden release of impounded water.
e. Principal Spillway: A device such as an inlet, pipe, weir, etc., used to discharge water during operation of the facility under the conditions of the 1% AP or more frequent event.
f. Private Detention Facility: Any detention facility controlling discharge from a site wholly owned and controlled by one owner or entity and not platted for future subdivision of ownership. Also, all facilities incorporating detention storage of stormwater in or on areas also used for other purposes such as parking lots, building or structure roofs, and open channels. Private detention facilities may be located off-site with approval of the City Engineer contingent upon documentation that drainage easements have been obtained for both the detention basin and the channel connecting the provisions for maintenance of the facilities.
g. Public Detention Facility: Any detention facility controlling discharge from a tributary area owned by more than one owner and/or platted for future subdivision of ownership, except as defined as private detention facility herein.
h. Regional Detention Facility: Any detention facility designed and located to provide detention on major drainage channels and with a tributary area of 100 acres or greater.
i. Sediment Storage: The volume allocated to contain accumulated sediments within the detention facility.
j. Wet Detention Facility: A detention facility that is designed to include permanent storage of water in addition to the temporary storage used to control discharge rates from the facility.

Z. **Tributary Area:** All land draining to the point of consideration, regardless of ownership.

1.5 Design Probabilities: All enclosed and improved open channel conveyance system components shall be designed for the 10% AP peak flow or the capacity of the existing upstream improved system, whichever is greater with the following exceptions:

1. Facilities located within the Federaly designated floodway of the 1% AP floodplain shall be designed for the 1% AP peak flow.
2. Bridges, pipes and culverts crossing arterial streets shall be designed for the 2% AP peak flow, unless subject to the requirements of No. 1, above.
3. With consent of the City Engineer.

1.6 System Types and Applications:

A. Enclosed Pipe-Inlet Systems: Enclosed systems consisting of underground pipes, culverts, curb inlets and similar functional underground structures shall be used to convey stormwater under the following conditions.

1. Within the right-of-way of improved streets, regardless of system design capacity.
2. In all areas other than residential where the bank line of an open channel, either natural or improved, would be within 30 feet of any existing or proposed habitable structure, regardless of system design capacity.
3. In residential areas where the bank line of an open channel, either natural or improved, would be within 60 feet of any existing or proposed residential structure.

Enclosed systems may be used to convey stormwater at all locations where open systems are permitted.

B. Improved Channels: Open systems consisting of improved open channels with intermittent culverts or bridges crossing streets and other surface areas may be used to convey stormwater in all areas except those excluded in the previous section. Lining of an improved channel is required in all developed areas where the 10% AP design discharge is equal to or greater than 200 CFS and less than or equal to 500 CFS.

C. Natural Channels: Existing natural channels may be retained in the drainage system of a developed area where the 10% AP peak discharge exceeds 500 CFS subject to the same exclusions as improved channels and with the additional requirement that the flow velocity of the 99% AP peak discharge does not exceed the following based on soils present in the channel bed and bank. Where design velocity exceeds the maximum, the channel should be improved as necessary or an enclosed system constructed.

Soil Type	Max. Velocity of 1-Yr Peak Flow (fps)
Fine sand, sandy loam	2
Silt loam, noncolloidal silts	3
Colloidal clays & silts, fine gravel	4
Coarse gravel, cobbles	5
Shale	6
Limestone bedrock	15

Additional easement and bank stabilization requirements are outlined in Sections 3.2 and 9.0, respectively.

D. Overflow Systems: As an integral part of the stormwater drainage system, whether enclosed or open, overflow channels shall be required in all areas in addition to, and above, the 10% AP conveyance elements. Each overflow component shall have sufficient hydraulic capacity, when combined with the capacity of the conveyance element, to convey the 1% AP peak discharge without damage to land or buildings.

1. The combined conveyance system shall provide sufficient capacity so that the 1% AP stage, plus 1 foot of freeboard, is at an elevation equal to or below the lowest elevation at which water may enter any proposed or existing building or structure.
2. An overflow depth not exceeding seven (7) inches at the lowest point of the traveled way will be permitted where culverts cross streets.
3. Permissible concurrent surface uses of overflow areas include lawns, gardens or other open uses; vehicular parking; or any other use not permanently obstructing the floodway.
4. Prohibited concurrent surface uses include fencing; structures such as sheds, garages or outbuildings; materials storage; or any other use obstructing the floodway.

E. Stormwater Detention Facilities: Detention facilities shall be provided in connection with the development of land. Public and private detention facilities may be either wet or dry. Joint uses, such as parking and recreation, not interfering with detention functions are permitted for dry facilities. Rooftop and parking lot detention are acceptable for private facilities only.

1.7 Existing Drainage System: Existing drainage system component pipes, structures, and appurtenances within the project limits may be retained as elements of an improved system providing:

1. They are in sound structural condition.
2. Their hydraulic capacity, including surcharge, is equal to or greater than the capacity required by these criteria.
3. Easements exist or are dedicated to allow operation and maintenance.

Discharge from an existing upstream storm drainage system shall be computed in accordance with the requirements of these criteria. The computed discharge shall be used to design the new downstream system even though the actual capacity of the existing upstream system may be less.

1.8 Waivers: The City Engineer may waive specific criteria or requirements to provide specific types of stormwater facilities as follows:

A. Detention Facilities: Provision to provide detention may be waived in part or in whole provided one or more of the following are met:

1. Development is to discharge within a Federal Insurance Study defined 1% AP floodplain
2. Developer provides downstream improvements to meet the tributary area peak discharge requirements to the satisfaction of the City Engineer
3. Development cannot be fully and/or practically served by surface or underground detention facilities
4. It is shown that construction of detention facilities will resulting in an increase of peak flow in the drainagway

If detention requirement is waived for one of the above reasons, a pro-rated fee of $8,500.00 per acre for R1 type development and $11,600.00 per acre for all other development will be charged for all undetained areas. The fee will be adjusted at a rate of +3% per year with the first adjustment occurring on January 1, 2009. The fee may be offset by the construction of downstream improvements. The improvements must be approved by the city engineer, and the cost of such improvements will be set by the city engineer.

For the following development, detention is not required:

1. Additions to, improvements, and repair of existing single-family and duplex dwellings.
2. Construction of any buildings, structures, and/or appurtenant service roads, drives, and walks on a site having previously provided storm water control as part of a larger unit of development.
3. Additions, remodeling, repair, replacement, and improvements to any existing structure or facility and appurtenances that does not cause an increased area of impervious surface on the site in excess of 1,000 square feet of that previously existing.
4. Construction of any one new single-family or duplex dwelling unit, irrespective of the site area on which the same may be situated.

B. Overflow Channels: In previously developed areas, requirements to provide for 1% AP storm conveyance by means of overflow channels may be reduced in circumstances where 1% AP protection is not reasonably attainable due to the location of damageable improvements with respect to the drainage system.

1.9 Amendments: The City Engineer may amend this criteria as he deems necessary.

1.10 Other References: Other agencies have technical and administrative criteria and regulations pertaining to the design, permitting and operation of drainage systems which are in addition to and

which may complement these criteria. When conflicts are encountered, the most rigorous criteria shall govern. Some of the more important references used in the preparation of this document include:

A. American Public Works Association (APWA) Standard Specifications and Design Criteria: The design criteria in this document is largely based upon national drainage standards outlined in American Public Works Association (APWA) "Standard Specifications and Design Criteria," and on Greene County, Missouri, Stormwater Design Standards modified to meet the City's requirements. Other specific references are contained throughout this document. The Criteria and Technical Design Aids contained in the Appendix provide specific references to their sources.

B. Federal Insurance Agency - Floodplain Regulations and Implementing Ordinances Adopted by Municipalities: Drainage systems designed within the limits of the designated 1% AP floodplain on the principal stream shall be designed to convey the flood as defined by applicable published floodplain information studies. For areas located in FIS Zone "A" outside the detailed study area, the developer shall prepare studies and calculations establishing the floodplain, elevation and width. These calculations shall be submitted to the reviewing agency for approval.

C. Missouri Department of Natural Resource: Rules and regulations of the Department of Natural Resources dealing with such issues as stream obstructions, channel changes, dams, and permits shall apply.

2.0 HYDROLOGIC CRITERIA AND METHODS

2.1 Scope: This section sets forth the hydrologic methods and parameters to be used for computations of runoff and peak rates to be accommodated by the storm drainage system.

2.2 Computation Methods for Runoff. Runoff rates to be accommodated by each element of the proposed storm drainage system shall be calculated using the criteria for land use runoff factors, rainfall, and system time outlined in the following sections. Computer models may be utilized so long as they produce calculated runoff to the system that is substantially the same as that calculated by the following criteria.

A. Rational Method: The Rational Method may be used to calculate peak rates of runoff to elements of enclosed and open channel systems, including inlets, when the total upstream area tributary to the point of consideration is less than 40 acres and does not include detention facilities. The Rational Method is defined as follows:

Q = C i A , where:

Q = Peak rate of runoff to system in C.F.S.
C = Runoff Coefficient (from Table C)
i = Rainfall intensity in inches per hour
A = Tributary drainage area in acres, The tributary area is either the total upstream tributary area or the total upstream tributary directly connected impervious area.

Rainfall intensity, used only for the Rational Method, shall be as indicated in Table A corresponding to the calculated time of concentration for either the total tributary area or the directly connected impervious area. The greater of the computed flow rate for a) the total tributary area or b) the directly connected tributary area shall be used for design.

B. Hydrograph Methods: The application of hydrograph methods is required for all conveyance systems having greater than 40 tributary acres and for all detention facilities. Computer models or manual methods are permissible.

1. Acceptable computer models

   a. SCS Technical Release No. 55 (TR-55) - "Urban Hydrology for Small Watersheds," 2nd Edition, June, 1986.
   b. SCS Technical Release No. 20 - "Project Formulation - Hydrology," 2nd Edition, May 1983.
   c. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-1 Flood Hydrograph Package," Version 4.1, June, 1998.
   d. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-HMS, Hydrologic Modeling System," Version 3.3, (or newer) October 2008.

   Copies of the above are available for purchase through National Technical Information Service (NTIS), U.S. Department of Commerce, Springfield, VA., 22161. The HEC-1 and TR-55 packages are also available through PC-TRANS Software Distribution Service, University of Kansas Transportation Center, 2011 Learned Hall, Lawrence, Kansas, 66045 and a number of other private software. U.S. Army Corps of Engineers programs are available for free from the Hydrologic Engineering Center web page.

C. Rainfall: Rainfall data for runoff computations are presented in Table B. For Hydrograph methods, rainfall shall be distributed in time using the appropriate Huff's Quartile distribution.

2.3 Runoff Coefficients: Runoff coefficients relative to development and land use shall be as indicated in Table C. The indicated "C" values are applicable to the Rational Method and the "CN" values to hydrograph methods.

The runoff coefficients given in Table C are appropriate for 20% or 10% AP events. Estimation of peak flows for less frequent storms requires the use of a higher runoff coefficient because infiltration and other abstractions have proportionately less effect on the amount of rainfall that becomes runoff. To obtain runoff coefficients for other frequency events, the "C" value from Table C is multiplied by a frequency correction factor. The frequency correction factor is 1.10 for the 4% AP event, 1.20 for the 2% AP event, and 1.25 for the 1% AP event. However, the resulting runoff coefficient (original "C" multiplied by the frequency correction factor) may not be greater than 0.98.

Coefficients shall be based on the more runoff-intensive surface condition of either planned future land use or existing developed land use. Future land use shall be defined by the City's adopted comprehensive land use plan.

Undeveloped areas not zoned, but for which future land use is defined by the City's land use plan, shall be assigned runoff coefficients for the land use indicated by such plan. Undeveloped areas designated as agricultural or those for which no specific future land use is indicated shall be assigned a minimum of 35 percent impervious surface for purposes of the design of storm drainage systems.

As an alternative to the coefficients and for areas not listed in Table C, a composite runoff coefficient based on the actual percentages of pervious and impervious surfaces shall be used.

2.4 Time of Concentration (T_c): The time of concentration, T_c, for hydrograph method analysis shall be calculated as the sum of the overland flow time, and the channel flow (travel) time. The time of concentration, T_c, for the rational method shall be calculated as the channel travel time as described in 2.4.B, below. The total T_c shall not be less than 5.0 minutes regardless of the calculated time.

A. Overland Flow Time: For Hydrograph methods only. Overland flow time is determined using the Kerby-Hathaway equation. The maximum sheet flow distance for calculations shall not be greater than 200 feet in developed areas and 300 feet in undeveloped areas.

$$T_{OL} = \left(\frac{0.667 \cdot n \cdot L_{OL}}{\sqrt{S_{OL}}} \right)^{0.467}$$

Where: T_{OL} is the overland flow time in minutes

n is the overland flow roughness coefficient shown in Table 1

L_{OL} is the representative length of the overland flow path in feet

S_{OL} *is* the slope of the overland flow path in feet/foot

B. Channel Flow (Travel) Time: Determined from Kirpich equation. The "system" includes flow in street gutters, street ditches, enclosed pipe or box storm sewers, and improved or natural open channels.

$$T_{CH} = 0.0078 \cdot L_{CH}^{0.77} S_{CH}^{-0.385}$$

Where: T_{CH} is the channel flow time in minutes

L_{CH} is the length of channel flow in feet. For hydrograph methods, L_{CH} is measured from the end of the hydraulically most remote overland flow path to the point of interest. For the Rational method, L_{CH} is measured from a) the hydraulically most remote point on the drainage divide to the point of interest or b) the hydraulically most remote point of the directly connected impervious area to the point of interest.

S_{CH} is the slope of L_{CH} in feet per foot.

C. Lag Time: For use in the SCS Dimensionless Unit Hydrograph method, lag time shall be equal to 60 percent of the time f concentration (0.6 x T_c).

3.0 EASEMENTS

3.1 General Requirements: Developers shall be required to dedicate (plat) easements for all system components to be maintained by the City including enclosed pipe systems, improved channels, and public detention facilities as well as maintenance access connections to street rights-of-way. Easements are also required, although not for City maintenance purposes, along open channels and around private detention facilities as indicated below and in all other areas deemed necessary by the City Engineer.

3.2 Permanent Drainage Easement Requirements:

A. Enclosed Systems: 15 feet minimum width or the structure/pipe O.D. plus 6 feet on each side.

B. Improved Channels: 30 feet minimum width or the top of bank width plus 10 feet on each side. The top of one bank shall have a minimum 10-foot wide strip graded for vehicle access with a maximum slope of 12 percent perpendicular to the contours.

C. Detention Facilities: 15 feet clear of any structure and 10 feet clear around the perimeter of the greatest of 1) the top of bank lines, 2) the 1% AP water-surface contour, or 3) 1 foot outside of security fences.

3.3 Access Easements: For facilities which are the City's responsibility, access easements for maintenance shall be connected to public street rights-of-way and shall not be spaced greater than 800 feet apart, public detention facilities. The maximum slope perpendicular to the contours shall be 12 percent. Access easements shall extend to the bottom of all improved channels with bottom widths greater than 7 feet and to the top of bank for narrower channels. These easements may overlay other permanent easements subject to maximum grade requirements.

3.4 Flowage Easements: Flowage easements shall be required in addition to and overlaying other permanent easements where applicable, including other public and private utility easements, where the 10% AP peak discharge exceeds 100 CFS. The flowage easement shall cover the overflow area for the conveyance element, whether open channel or enclosed system, determined as the 1% AP flood elevation plus one foot. Flood elevations shall be on file with the City and easement lines indicated on plats or permit plans. Limitations on permanent obstructions shall be included in the dedication with all other concurrent uses reserved to the property owner.

3.5 Natural Channels: For natural channels retained in the storm drainage system, permanent easements for undeveloped green space including the channel itself, shall be platted at a width of the 1% AP flood plain boundary plus 10 feet, or the top of bank width of the channel plus 10 ft. on each side, whichever is greater. (See Figure 3 for illustration.) These easements will be dedicated to the City but maintenance of the green space and the channel will be the responsibility of the individual property owner.

In lieu of dedicating the specified width of easement, bank stabilization may be constructed along the channel. For stabilized channels, easement requirements shall be the same as for improved channels. Refer to Section 9.0 for additional information on bank stabilization.

4.0 HYDRAULIC CALCULATION METHODS

4.1 Pipes and Open Channels: Flow shall be calculated by Manning's equation.

$$Q = \frac{A\,(1.486)\,(R^{2/3})\,(S^{1/2})}{n}$$, where:

Q = Discharge in cubic feet per second.

A = Cross sectional area of flow in square feet.

n = Roughness coefficient (see Table F).

R = Hydraulic radius (R = A/P) in feet.

S = Slope in feet per foot.

P = Wetted perimeter in feet.

Head losses, except friction losses, shall be calculated by

$$h = k\,(V^2/2g)^{1/2}$$, where:

h = Head loss in feet.

V = Velocity of flow in feet per second at point of interest.

2g = 64.4 feet per second.

k = Coefficient (as shown in Table G).

4.2 Street Gutters: Flow shall be calculated by Izzard's formula, below. Figure 4 indicates a graphical solution for the formula.

$$Q = \frac{0.56\,(z)\,(S^{1/2})\,(D^{8/3})}{n}$$, where:

Q = The gutter flow in cubic feet per second.

Z = The reciprocal of the average cross-slope, including gutter section in feet per foot.

S = The longitudinal street grade in feet per foot.

D = The depth of flow at curb face in feet.

n = Manning's "n" (see Table F).

The following formula shall be used to determine the street grade (Sx) at any point on a vertical curve for use in calculating gutter flow. Grades shall be "plus" when ascending forward and "minus" when descending forward with all grades in feet per foot.

$$Sx = S1 + \frac{X}{L}(S2 - S1)$$, where:

Sx = The street grade on a vertical curve at point x.

S1 = The street grade at the PC of a vertical curve.

S2 = The street grade at the PT of a vertical curve.

X = The distance, in feet, from the PC of the curve to point x.

L = The total length of a vertical curve, in feet.

4.3 Head Losses: The following values for head losses in inlets, manholes and junction boxes may be used for design.

Structure	Head Loss (ft)
Inlet - One exit pipe only	0.5
Inlet - Thru flow @ less than 45° angle (one entry & one exit line)	0.1
Inlet - Thru flow @ greater than 45° angle (one entry & one exit line)	0.2
Inlet - Two or more entering lines	0.3

4.4 Culverts: Culvert flow capacity shall be calculated according to standard engineering practice.

4.5 Computer Methods: Computer models may be used for hydraulic calculations. For open channels the following models are permissible.

1. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-2 Water Surface Profiles."
2. U.S. Army Corps of Engineers, Hydrologic Engineering Center - "HEC-RAS River Analysis System."
3. Federal Highway Administration - "HY-7 WSPRO - A Computer Model for Water Surface Profile Computations.

5.0 ENCLOSED SYSTEM DESIGN

5.1 General Requirements: All enclosed drainage system components (pipes, culverts and structures except bridges) shall be structurally designed for an H-20 live load, a unit weight of 120 pcf for soil cover, and minimum lateral earth pressure of 40 pcf equivalent fluid pressure. The lateral earth pressure shall be increased as necessary for special conditions when present on a project.

5.2 Pipes and Culverts:

A. Minimum Cover: Minimum cover over all pipes and culverts shall be equal to 1.5 feet unless otherwise approved by the Director of Public Works.

B. Minimum Size: Minimum pipe size shall be 15-inch diameter.

C. Downstream Conduit Size: Conduit sizes, based on square feet of end area shall not decrease from upstream to downstream regardless of the calculated capacity of each conduit.

D. Surcharge: Surcharging of pipes under entrance control is permitted in structures subject to freeboard criteria for the structure and provision for pressure joints throughout surcharged lengths.

E. Pipe Slopes: Minimum invert slopes shall conform to the following:

Pipe Diameter (in)	Min. Invert Slope (%) for Round or Arch Pipe	
	RCP	CSP
15	0.32	0.64
18	0.26	0.52
24	0.17	0.34
30	0.13	0.26
36	0.10	0.20
42	0.08	0.16
48	0.07	0.14
54	0.06	0.12
60	0.05	0.10
72	0.05	0.10

5.3 Storm Sewer Inlets:

A. Inlet Types: Curb-opening inlets are preferred in street installations. Grated inlets may be used in addition to curb-opening inlets if necessary to control spread or depth of flow in the street. In off-street locations, only grated area-type inlets sized and designed for the specific location shall be permitted. Gutter deflectors shall be required for inlets installed on slopes greater than 4.0 percent.

B. Configuration: In street installations, the following dimensions apply to curb inlets.

Clear opening length	5.0 ft (min)
Clear opening height	5.0 in (min)
Clear inside width, perpendicular to curb line	3.0 ft (min)
Gutter depression depth at inlet	2.0 in (min)
Gutter transition length	
(a) Both sides in sump and upstream	

	side on slopes	5.0 ft (min)
(b)	Downstream side on slopes	3.0 ft (min)

C. Capacity: Inlet hydraulic capacity for new construction shall be determined from Table H for curb-opening inlets on slopes and from Figure 9 for curb-opening inlets in sumps. For area inlets in off-street locations, submit calculations based on specific inlet configuration, size, etc.

D. Location Requirements: Inlets shall be located along streets as required to limit the depth of flow in the gutters during the 10%AP discharge to the following:

Street Class	**Max. Width of Flow (ft)**
Undivided Streets (no median):	
<30 ft. back-to-back	10
30 to 35 ft. back-to-back	11
>35 ft. back-to-back	12
Divided Streets (with medians):	
Each directional roadway	As above
Intersections - all streets	6
Pedestrian Crosswalks - all streets	6

E. Freeboard Requirements: At inlets and other points of surface water entry into the enclosed drainage system, a minimum of 0.5-ft. shall be required between the peak design water surface elevation in the structure and the lowest elevation of the inlet opening. (Figure 10 illustrates the freeboard requirement). The water surface elevation in the structure shall be calculated as follows:

1. Invert elevation of the exit/outlet line (pipe), plus;
2. Depth (diameter) of the exit/outlet line (pipe), plus;
3. Minor losses, "h".

Minor losses shall be calculated by the equation, $\mathbf{h = k * (V^2/2g)}$ where the coefficient "k" is determined from Table G and "V" is the velocity of the exiting line determined by dividing the flow, Q, by the area, A, of the exiting line.

F. Other Requirements:

1. A minimum drop across the invert of inlets, manholes and junction boxes shall be required as follows:

For flow angle change equal to or less than 30^o	0.1 ft.
For flow angle change greater than 30^o	0.2 ft.
For three or more lines, all flow angles	0.3 ft.

2. The crown elevation(s) of pipe(s) entering a structure shall be at or above the crown of the pipe exiting the structure.
3. Maximum spacing of manholes for pipes less than 30 inches in diameter shall be 600 feet.

6.0 STREET CROSSINGS

6.1 General Requirements: The following requirements apply both to culverts and/or bridges on open channels and to enclosed system conduits which cross arterial streets (unless otherwise approved by the City Engineer):

A. Hydraulic Capacity: The hydraulic capacity of the culvert or conduit shall be the 4% AP peak discharge with 0.5 ft. minimum freeboard at the lowest point in the street gutter grade. The capacity of the culvert or conduit shall be increased as required to provide the 0.5-ft. minimum freeboard below the lowest point of entry to any existing upstream habitable structure.

B. Overflow: Overflow of the street is permitted at the 1% AP peak discharge with the depth of flow over the street not to exceed 0.6 ft.

6.2 Enclosed Systems: In addition to the same general requirements listed above, surcharge of the conduit is permitted.

7.0 ENERGY DISSIPATION

7.1 General Requirements: Energy dissipation shall be required where enclosed systems or detention basin spillways discharge to open channels with design discharge outlet velocities greater than the following.

System Discharge Velocity (fps)	Receiving Channel Lining Type
4.0	Natural, unlined
5.0	Constructed, turf-lined
7.0	Reinforced vegetation
12.0	Riprap or gabions
15.0	Concrete
15.0	Natural limestone

7.2 Structure Types:

A. Pipes and Pipe-Arches (d≤24"): For pipes and pipe-arches less than 24 inches in diameter, either

1. Prefabricated end sections with cast-in-place toe walls, or
2. Enclosed vertical drop structures in accordance with Figure 11.

B. Enclosed System (Q<100 CFS): For enclosed system structures having a design discharge capacity less than 100 CFS, one of the following.

1. Enclosed vertical drop structures in accordance with Figure 11.
2. Bureau of Reclamation Basin VI impact basin - Figure 12.

C. Enclosed System (100 CFS ≤ Q 400 CFS): For enclosed system structures having a design discharge greater than or equal to 100 CFS but less than 400 CFS, one of the following.

1. Bureau of Reclamation Basin VI impact basin - Figure 12.
2. Bureau of Reclamation Basin IX baffled chute - Figure 13.

D. Enclosed System (Q ≥ 400 CFS): For enclosed system structures having a design discharge greater than or equal to 400 CFS,

1. Bureau of Reclamation Basin IX baffled chute - Figure 13.
2. Bureau of Reclamation Basin III SAF basin - Figure 14.

7.3 Channel Lining:

A. Lengths: Channel lining shall be required for a distance of 50 feet downstream from all energy dissipating structures. Where enclosed system pipes or structures, which are part of the major system, discharge into a channel, either improved or natural, at an angle greater than 15 degrees from the axis of the channel, lining shall be required for a distance of 30 feet along the channel, centered on the structure outlet. The major system is defined for the purposes of this paragraph as all drainage facilities equivalent to or larger than a 36-inch diameter pipe.

B. Materials: Acceptable lining materials are riprap, gabions, concrete or in-situ limestone.

8.0 IMPROVED CHANNELS

8.1 Geometric Criteria:

A. Bottom Width: The minimum bottom width for improved channels shall be 4.0 feet.

B. Side Slopes: The maximum side slopes for trapezoidal channels shall be as follows:

1. 4 horizontal to 1 vertical for turf or reinforced vegetative lining and the overflow channel area above the lining materials.
2. 2 horizontal to 1 vertical for all other lining materials except vertical concrete or gabion walls.
3. Flatter if necessary for stability of slopes.

C. Alignment Changes: Horizontal alignment changes shall be achieved by circular curves only having a minimum radius of:

$$\mathbf{R = \frac{V^2W}{8D}}$$, where:

R = Radius of channel centerline, in ft.

V = Velocity of 10% AP design flow, in feet per second

W = Channel width at 10% AP water surface elevation, in ft.

D = Depth of 10% AP design flow, in ft.

8.2 Lining Height:

A. Minimum Height: Channel lining material shall extend above the channel invert to the depth of the 10% AP design discharge plus 6 inches of freeboard. The invert of all constructed channels shall be lined with concrete, riprap or gabions to a minimum height of 6 inches above the invert.

B. Increase on Curves: Along the outer side of horizontal curves, the lining height shall be increased as follows:

$$\mathbf{y = \frac{D}{4}}$$, where:

y = Increased vertical height of lining, in feet.

D = Depth of 10% AP design flow, in feet.

Increased lining height shall be transitioned from "y" feet to zero feet over a minimum of:

1. 30(y) feet downstream from the point of tangency (P.T.) of the channel curve.
2. 10(y) feet upstream from the point of curvature (P.C.) of the channel curve.

8.3 Lining Material Requirements: The following types of lining materials are acceptable alternatives based on the peak flow velocity in the channel. Other types of lining materials not specifically listed may be used when approved by the City Engineer.

10% AP Peak

Velocity (fps)	Permitted Lining Material
> 12.0	Sound in-situ limestone Concrete Grouted riprap
>7.0 to 12.0	Sound in-situ limestone Concrete Grouted riprap Gabions Riprap
5.1 to 6.9	In-situ limestone Concrete Grouted riprap Gabions Riprap Reinforced turf above invert lining
5.0 and less	In-situ limestone Concrete Grouted riprap Gabions Riprap Reinforced turf above invert lining Turf above invert lining

8.4 Optional Design for Improved Channels: In lieu of sloping banks and linings as specified above, vertical walls may be constructed for improved channels conveying greater than 400 CFS at design discharge with the following requirements.

A. Vertical Walls: Shall be designed and constructed as retaining wall structures.

B. Materials: Acceptable materials for vertical walls are reinforced concrete or gabions.

C. Wall Height: The minimum wall height shall be the greater of 1.5 feet or the depth of the 1-year peak water surface plus 0.5 ft. The height shall be increased at transitions and bends.

D. Fence: Any veritical wall height 30" or greater shall be protected by 4 ft. high (or higher) chain link fencing installed along the wall lines on both sides of the channel.

E. Access: Adequate provisions shall be made for pedestrian entry/exit from the channel.

8.5 Subdrainage for Linings: All channel linings, except turf, shall provide for relieving back pressures and water entrapment beneath and/or behind the lining material.

A. Materials: The following are acceptable alternative methods for providing subdrainage.

1. Nonwoven geotextile filter fabrics.

2. Graded aggregate filter material with a minimum thickness of 4 inches and gradation based on filter design criteria.

B. Weep Holes: For concrete or riprap-lined channels, screened 4-inch diameter "weep holes" shall be required located at the base of the sloped sides, at a maximum spacing of 15 feet on-center.

8.6 Diversions: Proposed diversions of tributary areas greater than 0.5 acres may not have an adverse impact on downstream properties. Supporting computations for peak flow rates, channel capacities and water-surface elevations for both pre and post diversion conditions shall be submitted.

9.0 NATURAL CHANNELS

9.1 Maintenance: The developer and later the individual property owner(s) shall be responsible for maintenance of the entire area of the drainage easement to be dedicated or platted along all natural channels retained in the storm drainage system. This maintenance shall consist of removal of obstructions including debris and foreign objects; deadfall, drift and dead trees; trees on the banks with substantially undercut roots; and fences and other improvements. Trees to be removed shall be cut to within one foot of the ground line. Grubbing will not be required.

9.2 Bank Stabilization: Bank stabilization may be constructed along the entire channel length to minimize the easement width as specified in Section 3.2. Stabilization must be constructed where the required easements would otherwise extend off of the developer's property. The following requirements shall apply to the design of bank stabilization. (See Figure 15 for illustration of a typical installation.)

A. Vertical Walls: Vertical wall channels with lined inverts and gabion walls shall be provided. The criteria for improved vertical wall channels are applicable to this design except as modified in this section.

B. Channel Bends:

1. Bank stabilization shall be constructed with the convex (outside) side wall within the existing incised channel.
2. The channel shall be graded to the average clear width of the existing channel.
3. The minimum radius of the convex wall shall be as necessary to clear a 1.5:1 theoretical slope from the existing top of bank to the top of wall location.

C. Wall Height: The minimum wall height shall be the greater of 3.0 feet or the one-year peak discharge flow depth above the channel invert.

D. Grading: Grading shall be performed as required to 1) remove sloughage, if any, and to backfill to the top of the wall elevation on the convex, or high, bank side, and 2) to excavate the slopes above the top of wall to 2:1 or flatter on the concave, of low, side.

E. Slope Cover: Reinforced vegetative cover shall be planted on all graded slopes.

10.0 STORM WATER DETENTION

10.1 Other Regulatory Requirements: In addition to these criteria, the requirements of the Missouri Dam and Reservoir Safety Council shall apply to all detention dams greater than 35 feet in height. Such facilities shall be classified as Downstream environmental zone class I and designed per MDNR regulations.

10.2 Maximum Release Rates: The detention facility allowable release rate shall be calculated with the assumption that the site is an undeveloped condition The engineer shall use an appropriate time of concentration and curve number to fit that assumption.

10.3 Storage Volume Requirements:

A. General: Detention storage for all facilities shall be established by hydrograph routing methods. The volume shall be as required to limit the release rates to the maximums indicated in 10.2.

B. Additional Requirements: All detention facilities shall provide additional storage volume (beyond required flood storage) below the elevation of the principal spillway for five years of sediment accumulation in accordance with Figure 16. In addition, all facilities designed as wet basins shall provide permanent storage volume as necessary to maintain a minimum water depth of 3.0 feet.

10.4 Hydrograph Routing Methods:

A. General: Hydrograph routing is required for each return period to determine maximum inflow, detention volume and release rates.

B. Rainfall Distribution: To compute the design inflow hydrograph, Huff's Quartile Rainfall Distributions (50% curves) shall be used for developing the hydrographs. Durations of 1-hour, 2-hours, 3-hours, 6-hours, 12-hours and 24-hours shall be evaluated to determine the critical duration design event.

C. Runoff Computation: Runoff shall be computed by the SCS curve number method. Applicable curve numbers shall be obtained from Table C. The curve number shall be weighted by proportional land use in the tributary area.

D. Routing Interval: The routing time (hydrograph ordinate) interval shall be appropriate for the method used with a maximum time interval of 5 minutes unless otherwise approved.

E. Routing Method: Detention routing shall be by the storage-indication, or Modified plus, method.

F. Required Steps: In designing a detention facility, the following steps are required:

1. From proposed spillway characteristics, calculate rating curves of spillway stage vs. discharge.
2. Calculate detention stage vs. storage volume from pond configuration and depth.
3. Develop inflow hydrograph.
4. Perform storage routing through the proposed detention facility.

G. Simplified Design: A simplified design method is acceptable only for detention facilities having a tributary area of 10.0 acres or less.

1. The SCS TR-55 computer model may be utilized for computer methods.

10.5 Principal Spillways (Outlets):

A. General: The principal spillway shall be designed to convey all discharge from the detention facility from the 1% AP and more frequent (inflow and discharge equal to or less than the 1% AP) storms and shall function without mechanical or electrical components.

B. Hydraulic Characteristics: The principal spillway shall have the hydraulic characteristics of a weir, pipe or orifice, or a combination of these. Pipes shall be a minimum of six inches in diameter except in parking lot and rooftop detention where the minimum size and configuration of opening shall be designed specifically for each condition.

C. Capacity: The spillway shall have sufficient capacity to discharge 80 percent of the detention storage volume within 24 hours after the peak inflow has entered the basin, excluding the water quality capture volume.

D. Trash Racks: Trash racks, screens, etc., shall be provided at the principal spillway as necessary to keep the facility fully operational.

10.6 Emergency/Overflow Spillways;

A. Required Installations: Emergency spillways shall be required for all detention facilities formed by earth embankments or dams greater than 10.0 feet in height.

B. Return Period for Operation: Emergency spillways shall operate only for storms less frequent (higher inflow and discharge) than the 1% AP storm.

C. Regulatory Criteria: The Missouri Dam and Reservoir Safety Council criteria shall apply to the design of emergency spillways with sufficient capacity to discharge the 0.5*6-hour PMP hydrograph without overtopping the dam.

D. Exemptions: Emergency spillways are <u>not</u> required for

1. Excavated detention basins.
2. Detention basins on structure roofs.
3. Detention basins utilizing surface parking areas.

10.7 Other Requirements:

A. Wet Basins: The design of wet detention facilities shall include the following:

1. Provisions for complete drainage to permit sediment removal and other periodic maintenance activities.
2. The limits of maximum ponding shall be no closer than 30 feet horizontally and no less than two feet below the lowest sill elevation of any habitable building or structure.
3. The entire area covered by fluctuating water levels shall be seeded, fertilized and mulched, sodded, or otherwise surfaces to protect against erosion.

B. Dry Basins: Dry detention facilities with storage on other than roofs or paved surfaces shall conform to the following:

1. The bottom shall be graded at a minimum of 2 percent to drain across grass. A minimum of 0.5 percent slope may be used if an interior trickle channel is installed. The trickle channel shall be 4.0 feet or greater in width.
2. The limits of maximum ponding shall be no closer horizontally than 10 feet to a habitable building or structure unless waterproofing of the building and pedestrian access areas to the building are properly documented.
3. Vertically, the limits of maximum ponding shall not be less than two feet below the lowest sill elevation of any adjacent building.
4. The entire basin shall be seeded, fertilized and mulched, sodded or paved.

C. Side Slopes: Slopes on the banks, dams, dikes or berms around and forming the basin shall not be steeper than 3 horizontal to 1 vertical (3:1) for all excavation or embankment slopes. Flatter slopes shall be required if necessary for stability with a safety factor of 2.0 for dams greater than 10 feet in height, and 1.5 for all other slopes.

D. Open Channels. Normally-permitted open channels may be used as detention areas provided that:

1. The limits of maximum ponding conform to the requirements for both wet and dry basins.
2. The maximum depth of detention does not exceed four feet.
3. The minimum flow line grade is 0.5 percent.
4. The maximum side slopes of the detention area are 3:1 in trapezoidal channel sections. For other channel sections, features shall e designed in consideration of safety, stability and ease of maintenance.
5. The entire detention area is seeded, fertilized and mulched, sodded or paved.
6. No ponding occurs within public rights-of-way without specific written approval of the City Engineer, and the hydraulic elevations resulting from channel detention do not adversely affect adjoining properties.

E. Erosion Control: Principal spillways and outlet works, as well as conveyance system entrances to detention basins, shall be equipped with energy dissipating devices as necessary to limit the peak discharge velocity in conformance with Section 7.0.

F. Rooftop Detention: Detention storage may be met in total or in part by detention on roofs. Details of such designs shall include the depth and volume of storage, details of outlet devices and downdrains, and elevations and details of overflow scuppers. Connections of roof drains to sanitary sewers are prohibited. Design loadings and special building and structural details shall be subject to approval by the City Engineer. Rooftop detention areas are exempt from sediment storage requirements.

G. Parking Lot Detention: Paved parking lots may be designed to provide temporary storage of storm water on a portion of their surfaces as follows:

1. Detention areas shall not be located in a primary parking lot which is defined as the most accessible 80 percent of the total parking for a facility.
2. Depth of storage shall be limited to a maximum of 12 inches.
3. The maximum limits of ponding are no closer horizontally than 10 feet to any building unless waterproofing of the structure and pedestrian access to the building are documented, and vertically not less than two feet below the lowest building sill elevation.

4. Retaining walls or curbs used to contain storm water in parking lots must be constructed of reinforced concrete.
5. Parking lot detention areas are exempt from sediment storage requirements.

10.8 Construction, Operation and Maintenance:

A. Easements: Access and permanent drainage easements shall be required as outlined in Section 3.

B. Public Facilities:

1. Public detention facilities shall be constructed by the developer where approved by the City and after plan approval and issuance of a permit. Dedication of easements to the City will be required.
2. Regional detention facilities may be dedicated as public facilities upon conceptual approval of the location and final approval of the design and construction by the City.
3. Operation and maintenance shall become the responsibility of the City after dedication of the easements and acceptance of the facility by the City.

C. Private Facilities:

1. Private detention facilities shall be constructed by the developer or property owner after plan approval and issuance of a permit by the City. Dedication of permanent drainage easements to the City will be required.
2. Operation and maintenance of private detention facilities shall be the responsibility of the property owner and successors.

D. Maintenance Activities: For both public and private drainage facilities, required maintenance activities include but are not limited to, debris removal and cleaning, cutting of vegetation that impairs the function of the structure or otherwise creates a public nuisance, repair of erosion, removal of silt, and maintenance of structural facilities including outlet works.

E. Construction Record Drawings: Construction record drawings showing as-built elevations and dimensions for detention structures are required. Both grading and outlet structure as-built data is to be submitted. Construction record drawings shall have field verified dimensions and elevations noted by revision clouds.

11.0 DRAINAGE PLAN REQUIREMENTS

11.1 General: This section governs the preparation of drainage plans which shall include all information, including drawings, and calculations concerning a subdivision's internal storm water systems; the method of handling off-site drainage; and the discharge of runoff from the proposed subdivision. The drainage plan shall be prepared by a registered professional engineer in accordance with the requirements contained herein and shall be submitted to the City Engineer for review and approval.

11.2 Required Information: The drainage plan shall conform to the following requirements and show the indicated information on the drawing(s).

A. Scale: The drainage plan shall be prepared at 1" = 100" or larger unless otherwise approved by the City Engineer.

B. Identification: The drawing shall specify the subdivision, landowner, developer, engineer and date of submittal.

C. Contours: A contour interval of 1 foot or 2 feet is acceptable. All existing topography shall also be included with the date of topo survey indicated.

D. Bench Marks: At least one (1) bench mark adjacent to or within the proposed subdivision shall be shown on the drainage plan. Use Mean Sea Level (MSL) datum/National Geodetic Vertical Datum (NGVD).

E. Plat Layout: The outline of all lots and blocks plus all drainage easements, dedications and reserves shall be shown. Lot dimensions, setback lines and utility easements are not required.

F. Storm Sewers: All storm sewers shall be shown with the following data:

1. Pipe size or diameter (inches).
2. Inlet sizes - length and width (feet).
3. Drainage basin and sub-basin boundaries.
4. Q_{10} for each sub-basin/inlet.

G. Channels: Improved channels shall be depicted on the drainage plan with the following data indicated.

1. Channel slope.
2. Bottom width (feet).
3. Side slopes.

H. Detention Areas: All detention areas as required by these regulations shall be shown on the drainage plan with the following data.

1. Static pool elevation where applicable.
2. Maximum water surface elevations for the 50%, 10% and 1% AP storms.
3. Discharge rates for the 50%, 10% and 1% AP storms.
4. Size and type of control structure.

I. FEMA Data: The limits of the FEMA floodway and floodplain shall be shown along with the appropriate base flood elevations (BFE). Where new subdivisions are proposed adjacent to unstudied or nondetailed studied streams, the developer shall submit the appropriate backwater

(HEC-2) calculations, encroachment analysis, and floodway data to be submitted to FEMA for review and approval.

J. Minimum Pad Elevations: Minimum pad elevations shall be shown for each lot adjacent to natural streams, improved channels or detention areas.

K. Off-Site Drainage: All off-site drainage areas which discharge into the subject subdivision shall be labeled with the basin size, in acres, and the 50%, 10% and 1% AP runoff rates, or peak flows.

L. Street Grades: Preliminary street grades and elevations at sumps and crests shall bed shown on the drainage plan using arrows to indicate direction of drainage flows.

M. Permits: Indicate on the drainage plan all permits required by local, state and federal agencies and the status of each one.

N. Drainage Calculations: All calculations supporting the drainage plan as required herein shall be submitted to the City Engineer for review and approval.

11.3 Document Format: The drainage plan shall be a complete, bound document containing all drawings and supporting calculations. Pockets shall be provided for drawings to allow easy removal. All data shall be organized in such a manner as to allow a systematic and timely review. A minimum of two (2) copies of the document shall be submitted to the City at the time of final plat application.

12.0 CONSTRUCTION PLAN REQUIREMENTS

12.1 Scope: This section governs the preparation of plans for storm water system projects.

12.2 General: The plans shall include all information necessary to build and check the design of storm drainage systems. The plans shall be arranged as required by the City Engineer. Standard details of the City may be included by reference. Plans shall be sealed by a registered professional engineer and shall be submitted to the City Engineer for review and approval.

12.3 Scale: Plans shall be drawn at the following minimum scales. Larger scales may be needed to clearly present the design. Bar scales shall be shown on each sheet for each scale.

Plan:	1-inch	=	50 feet
Profile			
Vertical:	1-inch	=	5 feet
Horizontal:	1-inch	=	50 feet
Drainage Area Map			
On site:	1-inch	=	200 feet
Off site:	1-inch	=	1,000 feet
Structural Plans:	1/4-inch	=	1 foot
Graphic Drawings:	Varies		
SWPPP Drawings:	Varies		

12.4 Required Information:

A. Drainage Area Map: A drainage area map shall included and shall indicate the following:

1. Ridge line of the area tributary to each principal element of the system.
2. The area in acres.
3. The runoff coefficient "C" or “CN” for each area.

B. Plan View: All designed storm drainage systems shall be drawn in plan view and shall contain the following:

1. North arrow and bar scale.
2. Ties to permanent reference points for each system located outside of the street right-of-way.
3. Identification and location of each pipe, culvert, inlet, structure and existing utility affecting construction.
4. Right-of-way, property, and easement lines, and the 1% AP flood-plain and setback from the top of bank of an open channel to any building.
5. Existing man-made and natural topographic features, such as buildings, fences, trees, channels, ponds, streams, etc., and all existing and proposed utilities.
6. Location of test borings.
7. Existing and finish grade contours at intervals of 2.0 feet or less indicating existing and finish grades and slopes.
8. A uniform set of symbols and abbreviations subject to approval by the City Engineer.
9. The centerline of open channels within 50 feet of an enclosed drainage system and showing the direction of flow.

C. Profile View: All designed storm drainage systems shall be drawn in profile view and shall contain the following:

1. Existing and finish surface grade along the centerline of pipe except street centerline may be used when construction includes street construction.
2. Length, size and slope of each line or channel segment. Slope shall be expressed in percent.
3. Headwater elevation at the inlet end of each culvert.
4. Flow line (invert elevation in and out) at each structure.
5. Each existing utility line crossing the alignment shall be properly located and identified as to type, size and material.
6. Test borings.
7. All station and invert elevations of manholes, junction boxes, inlets or other structures.
8. The profile shall show existing grade above the centerline as a dashed line and proposed finish grades or established street grades by solid lines. It shall also show the flow line of any drainage channel, either improved or unimproved, within 50 feet on either side of the centerline. Each line shall be properly identified. The proposed storm sewer shall be shown as double solid lines properly showing the top of the pipe.
9. All manholes, inlets or other structures shall be shown and labeled with appropriate "Standard Drawing" designation, if applicable.

D. Design Information for Each Part of the System: The plans shall present design information for each culvert, structure, facility, pipe and channel segment and shall contain the following:

1. Tributary area in acres.
2. Design discharge and capacity in cubic feet per second.
3. Runoff coefficient "C", design storm return frequency, rainfall intensity and Manning's "n" value.
4. Discharge velocity at design flow.
5. Hydraulic grade line.
6. Type and grade of material (gage, class, etc.).

Schedules which indicate all variable dimensions and elevations covered by standards or "typical" drawings shall be shown on the plans. All design details for nonstandard structures shall be indicated on the plans. A minimum of one plan view and one sectional view shall be shown on the plans for each type of structure. Additional views may be required if necessary to clearly define the design. A reinforcing bar list is not required; however, the grade, type, size and location of the bars shall be clearly indicated on the plans.

E**. Stormwater Pollution Prevention Plan (SWPPP):** The SWPPP shall present information for each erosion and sediment control structure, construction entrance location and dimensions, construction sequence, seeding specifications and BMP details.

* * * * *

13.0 WATER QUALITY PROTECTION

13.1 Introduction: This section covers the design of Best Management Practices (BMPs) to minimize the adverse effects of urban stormwater runoff on the quality of receiving waters.

It is recognized that specific water quality standards, other than those contained in the Missouri Clean Water Laws, have not been developed or adopted for these receiving waters. The objective of this policy is not to meet specific reductions of targeted pollutants, but rather to provide a generally effective level of pollutant removal by using reasonable, cost effective measures. The goal is to minimize, to the maximum extent practical, adverse impacts on the quality of the receiving waters.

It is important to recognize that the *structural Best Management Practices* (BMPs) for which design guidance is given in this section represent only one aspect of stormwater quality management. The most effective means of managing stormwater quality lie in overall watershed planning and zoning controls, and other *nonstructural* practices which are generally beyond the control of an individual development.

Data from communities across the country has shown that, as the total impervious area in a watershed exceeds ten to fifteen percent (10-15%), water quality declines unless mitigative measures are taken. The most important management tool is to limit the impervious area in these watersheds to these values. While these limits may be attainable for the watershed as a whole, they may not be possible for individual development or sub-basins. Structural BMP's will be required for these developments.

13.2 GENERAL DESIGN GUIDELINES

a. Minimize the amount of runoff. The total quantity of pollutants transported to receiving waters can be minimized most effectively by minimizing the amount of runoff. Both the quantity of runoff and the amount of pollutant wash-off can be minimized by reducing the amount of *directly connected impervious area (DCIA)*. Impervious areas are considered connected when runoff travels directly from roofs, drives, pavement, and other impervious areas to street gutters, closed storm drains or concrete, or other impervious lined channels. Impervious areas are considered disconnected when runoff passes as sheet flow over grass areas, or through properly designed BMP's, prior to discharge from the site.

b. Maximize contact with grass and soil. The opportunity for pollutants to settle out is maximized by providing maximum contact with grass and soil. Directing runoff over vegetative filter strips and grass swales enhances settling of pollutants as the velocity of flow is reduced. Infiltration of runoff into the soil is also increased.

c. Maximize holding and settling time. According to ASCE (Reference 13.1), the most effective runoff quality controls reduce the runoff peak and volume. The next most effective controls reduce peak runoff rates only. For small storms the runoff rate should not exceed the pre-project peak flow rate from the fifty percent (50%) AP (2-year) storm. Most obnoxious pollutants (exceptions include water soluble nutrients and metals) can be settled out. By reducing the rate of outflow and increasing the time of detention storage, settling of pollutants and infiltration of

runoff is maximized.

d. Design for small, frequent storms.Drainage systems for *flood control* are designed for large, infrequent storm events. In contrast, stormwater quality controls must be designed for small, frequent storm events. In the Joplin area, eightysix percent (86%) of all twenty-four (24) hour rainfalls are one inch (1") or less (see Figure 5). Most pollutants are washed off in the "first flush", generally considered the first one-half inch (½") of runoff.

e. Utilize BMP's in series where possible. Performance monitoring of BMP's in Florida, Maryland, and Delaware has shown that the combined effect of providing several BMP's in a series can be much more effective in reducing the level of pollutants than providing a single BMP at the point of discharge. To the greatest extent practical, runoff should be directed first to vegetative filter strips, then to grass swales or channels, and then to extended detention basins, sand filters, etc.

f. Incorporate both flood control and water quality objectives in designs, where practical. Incorporating both flood control and water quality criteria into a single stormwater management facility is not only possible, but is encouraged. Whenever practical, combining several objectives, such as water quality enhancement and flood control, maximizes the cost- effectiveness of stormwater management facilities.

13.3 REQUIREMENTS

The following requirements will apply to all development.

a. Stormwater runoff from any new development for which the total impervious area exceeds ten percent (10%) of the total land area of the development,must be directed through an extended wet or dry detention basin, or other properly designed BMP, prior to discharge from the site.

b. Runoff from fueling areas and other areas having a high concentration of pollutants will be required to be directed to a sand filter or other properly designed BMP which provides filtration as well as settling.

c. The required volume for capture and treatment shall be designed as the *water quality capture volume* (WQCV), and shall be determined as set forth in Section 13.4.1.

d. Detention storage must be provided to limit the peak flow rate from the fifty percent (50%) AP (2-year) storm to pre-project values. Detention facilities for peak flow control shall be designed as set forth in Section 10.0.

13.4 DESIGN CRITERIA

13.4.a Water Quality Capture Volume

Water quality BMPs shall be designed to capture the runoff from the 86th percentile rainfall for the Joplin area as well as to capture the first flush of pollutants from directly connected impervious areas within the proposed development.

The required water quality capture volume (WQCV) to be used in design of extended wet and dry detention basins and other BMPs whose design is based upon capture and treatment of storm

water, shall be the greater of the following:

1) the first one-half inch (½") of runoff from the directly connected impervious area (DCIA) in the development, or

2) the *runoff* resulting from total rainfall depth of one inch (1") in twenty-four (24) hours over the entire development.

13.4.b Directly Connected Impervious Area

Impervious areas are considered connected when runoff travels directly from roofs, drives, pavement, and other impervious areas to street gutters, closed storm drains or concrete, or other impervious lined channels. Connected and disconnected impervious areas are illustrated in Figure 33.

In order for an impervious area to be considered disconnected, runoff from the area must pass through a vegetative filter strip or other BMP meeting the requirements set forth in this section.

For determining the amount of impervious area, the following assumptions shall apply in the absence of more detailed data:

Single Family Lots

Average roof area:	2500 square feet
Average drive area:	800 square feet
Average impervious area per lot:	3500 square feet

If gutter downspouts are directed to drain toward lawn areas, seventy-five percent (75%) of the roof area shall be considered disconnected.

Duplexes and Patio Homes

Average roof area:	2500 square feet
Average drive area:	1600 square feet
Average impervious area per lot:	4500 square feet

If gutter downspouts are directed to drain toward lawn areas, seventy-five percent (75%) of the roof area shall be considered disconnected.

Multi-Family,Commercial and Other Areas

The amount of impervious area contained in multi-family, commercial, office and manufacturing developments shall be determined based upon the site plan for the development.

13.4.c Vegetative Filter Strips

Vegetative filter strips consist either of areas of undisturbed vegetation in good condition, including trees, grass, sod or other vegetative cover which meets the objectives for this BMP, or areas where new vegetation has been established. Vegetative filter strips shall be provided in areas of sheet flow only. The hydraulic loading for filter strips shall not exceed 0.05 cfs per lineal foot of filter strip length for the fifty percent (50%) AP (2-year) storm (equal to the runoff per unit width from a four hundred feet (400') length of impervious area).

The minimum width of the filter strip shall not be less than twenty percent (20%) of the length of the sheet flow from the upstream impervious surface, and in no case shall be less than six feet (6'). The slope along the width of the filter strip shall not exceed 4:1 (25%).

Typical details for vegetative filter strips are shown in Figure 34.

13.4.d Grass Swales

Grass swales may be provided to convey runoff from vegetative filter strips and impervious areas to BMP's designed for capture and temporary storage of runoff. Design criteria for grass swales shall be as follows:

Maximum side slopes: 4:1.

Maximum longitudinal slope: 5%.

Minimum longitudinal slope: 1%.

Maximum velocity: 2 feet per second for peak flow from the 50% AP (2-year) storm.

Grass swales shall be lined with sod or seeded and covered with suitable erosion control blanket and mulch.

Typical details for grass swales are shown in Figure 35.

13.4.e Extended Dry Detention Basins

Extended dry detention basins may be provided to capture and provide temporary storage for the required water quality capture volume. Extended dry detention basins shall be placed outside of the primary watercourses which allow off-site flows to pass through the development (i.e., "off-line") where possible.

Design criteria for extended dry detention basins shall be as follows:

Volume: Minimum volume shall be one hundred and twenty-five percent (125%) of the required water quality capture volume (WQCV). Detention basins for water quality may be combined with detention basins for flood control. Effects of the WQCV may be considered in the design for flood

control.

Drain time: The WQCV shall be released over a minimum period of twenty four (24) hours and a maximum period of seventy-two (72) hours.

Outlet structure: Outlet structures shall consist of a perforated riser pipe, outlet pipe and gravel filter material as shown in Figures 36 and 37. The minimum allowable riser pipe diameter is eight inches (8"). The riser pipe shall be connected to an outlet pipe of equal of greater diameter. The outlet pipe shall have adequate capacity to carry the maximum rate of flow from the riser pipe. Material for the riser pipe shall be Schedule 40 PVC, ductile iron, or corrugated, galvanized metal.

A removable cap shall be provided at the top of the riser pipe. The cap shall have a one inch (1") diameter hole for air relief.

The outlet pipe shall be bedded in firmly compacted clay, free of stones. For dams exceeding ten feet (10') in height, an anti-seep collar shall be provided around the pipe.

Number of rows of perforations, number of perforations per row and diameter of perforations for the riser pipe shall be specified on the plans. Perforation pattern shall be determined based upon orifice calculations to provide for release of the WQCV over the specified time. Perforations shall meet the following requirements:

Minimum perforation diameter:	1/4 inch
Maximum perforation diameter:	1 inch
Minimum number of holes per row:	4
Maximum number of holes per row:	8
Minimum row spacing:	4 inches
Maximum row spacing:	12 inches

Freeboard: Where the basin is to be utilized as a water quality BMP only, twelve inches (12") minimum freeboard shall be provided above the WCQV.

Forebay: It is preferred that a forebay be provided to dissipate energy from incoming flows and to trap settleable sediment entering the basin. The forebay should be separated from the remainder of the basin by an earth dike meeting the requirements of Section 10. The top of the dike shall be set six inches (6") above the stage of the WQCV. Outflow from the forebay to the basin shall be through a gravel filter meeting the requirements of Section 14.5.2 (Figure 24). The top of the gravel filter shall be set equal to the stage of the WQCV.

The volume of the forebay shall be a minimum of ten percent (10%) and a maximum of twenty percent (20%) of the WQCV. The volume of the forebay is considered to be part of the required WQCV, not additional volume.

General construction requirements: The optimal length to width ratio for a water quality detention basin is four (4). The length to width ratio should be no less than two (2). The minimum allowable length to width ratio is one (1). Side slopes, dams or dikes, and retaining walls shall meet the

requirements of Section 10.

Overflow spillways: Where the basin is to be utilized as a water quality BMP only, a spillway or outlet structure meeting the requirements of Section 10 and capable of passing the peak flow from a 1% AP (100-year) storm for the drainage area upstream of the basin, shall be provided. The lowest point on the spillway or outlet structure shall be set at the top of the WCQV.

Trickle channels: Trickle channels shall be provided to provide grade control and to minimize chronic wet areas. Trickle channels shall be constructed of six inch (6") stone or other porous medium. A typical trickle channel cross section is shown in Figure 37.

A typical plan and section for extended dry detention basins are shown in Figure 38.

13.4.f Extended Wet Detention Basins

Extended wet detention basins may be provided to capture and provide temporary storage for the required water quality capture volume. Extended wet detention basins shall be placed outside of the primary watercourses which allow off-site flows to pass through the development (i.e., “off-line”) where possible.

Design criteria for extended wet detention basins shall be the same as for extended dry detention basins, with the following exceptions:

The volume of the permanent pool should not be less than 1.0 to 1.5 times the WQCV.

A bench area (littoral zone) with a width of ten feet (10') shall be provided as shown in Figure 13.8. It is preferred that emergent aquatic vegetation be provided in this zone.

It is recommended that a minimum of twenty-five percent (25%) of the WQCV be provided in the upper eighteen inches (18") of depth. A maximum of fifty percent (50%) of the permanent pool volume shall be provided in the upper eighteen inches (18") of depth.

Depth of the principal portion of the permanent pool shall be a minimum of four feet (4').

It is preferred that a forebay meeting the same requirements as specified for dry detention basins, be provided.

Where perforated riser pipes are not encased in gravel, only corrugated metal or ductile iron pipe may be used.

Typical details for extended wet detention basins are shown in Figure 39.

13.4.g Sand Filters

Runoff from fueling plazas, vehicle maintenance areas, solid waste storage or transfer areas, and other areas having potentially high concentrations of contaminants shall be passed through a sand filter prior to discharge to receiving waters.

Total impervious area draining to a sand filter will generally be one (1) acre or less. Sand filters shall be provided with a sedimentation chamber and a filtration chamber. Design of sand filters shall be based upon the Austin, Texas first flush filtration basin (full sedimentation design) as described in Debo and Reese pp. 596-598 (Reference 13.2). A schematic cross section of a sand filter is shown in Figure 40.

13.4.h Other Structural BMPs

Constructed wetlands, porous pavements and other structural BMPs for which detailed design criteria can be documented in generally accepted literature can be provided in addition to, or in lieu of, the BMPs described above, provided the objectives of this section can be met. The use of infiltration basins and trenches is discouraged due to possible adverse impacts on groundwater.

13.5 OPERATION AND MAINTENANCE

The City of Joplin provides no maintenance of water quality BMPs located on private property. Maintenance must be provided by the owner of the property upon which the BMP is located. Maintenance includes, but is not limited to, removal of debris, control of vegetation, removal of accumulated sediment when the WQCV volume has been reduced by 25% or more.

Extended detention basins and wetlands or other “capture and storage” BMPs shall be located within a single lot or property, within a designated drainage easement. Where BMPs are located in common areas or adjoining off-site areas, the property upon which the BMP is located shall remain in the ownership of the developer or property owners’ association.

Where a property owners’ association is formed, restrictive covenants which provide for collection of fees for maintenance of the BMPs shall be filed in the office of the Jasper or Newton County Recorder of Deeds, as appropriate. Restrictive covenants must be approved by the County legal counselor prior to filing of the final plat.

13.6 REFERENCES

1. American Society of Civil Engineers, Manuals and Reports of Engineering Practice No. 77 (WEF Manual of Practice FD-20), Design & Construction of Urban Stormwater Management Systems, Chapter 12. American Society of Civil Engineers, New York, NY, 1992.

2. Debo, T.N. and Reese, A.J., Municipal Stormwater Management, Chapter 13, Lewis Publishers, Boca Raton, FL, 1995.

SECTION 14 - EROSION & SEDIMENT CONTROL

14.1 Introduction: The purpose of this section is to provide detailed design criteria and standards for the design of erosion and sediment control measures as required by the City of Joplin's National Pollutant Discharge Elimination System permit.

14.2 GENERAL GUIDELINES

The goal of the regulation is to effectively minimize erosion and discharge of sediment from construction sites by application of relatively simple and cost effective Best Management Practices (BMPs). General guidelines for erosion and sediment control are listed below. Sediment and erosion control plans must demonstrate consistency with these guidelines.

- Minimize the area disturbed by construction at any given time.

- Stabilize disturbed areas as soon as possible by re-establishing sod, other forms of landscaping, and completing proposed structures, pavements, and permanent storm drainage systems.

- Provide for containment of sediment until areas are stabilized.

- Provide permanent erosion control by constructing and maintaining the permanent storm drainage system and maintaining vegetative cover, pavements, and other surface coverings in good condition.

- Avoid environmentally sensitive areas. Streams, springs, sinkholes, lakes, or wetlands are easily affected by sediment from construction sites. Careful planning and additional controls are needed when construction site are located in, or in close proximity, to these areas.

- Recognize sheet flow vs. concentrated flow. In areas where runoff occurs primarily as sheet flow, containment of sediment is relatively simple. In these areas, straw or hay bales, silt fences, and vegetative filter areas can be very effective. Where flow is concentrated, containment of sediment becomes more difficult as the rate and volume of flow increase. In these areas, more elaborate controls such as sedimentation basins must be provided.

- Recognize temporary vs. permanent controls. The greatest potential for soil erosion occurs during construction. Temporary controls are those which are provided for the purpose of controlling erosion and containing sediment until construction is complete. Temporary controls include straw or hay bale dikes, silt fences, erosion control blankets, etc., which are not needed after the area is stabilized. Permanent controls consist of vegetative cover, riprap, concrete trickle channels, detention basins, etc., which will

remain in place through the life of the development. It is possible for the same feature to serve both a temporary and permanent purpose. The difference between temporary and permanent erosion control should be clearly recognized in preparing an erosion and sediment control plan.

14.3 GRADING PERMITS

14.3.a Grading Permit Requirements.

A Grading Permit must be obtained before any land is graded for non-agricultural purposes.

Grading is defined as any excavation or filling or combination thereof. Grading of agricultural land is considered non-agricultural whenever soil is excavated for sale off the site or soil from other properties is brought onto the site.

The Public Works Department may waive the requirement for a Grading Permit in the following cases:

1. Sites where one (1) acre or less is graded, provided the graded area is located a distance of twenty-five feet (25') or more from a spring, sinkhole, cave, wetland, watercourse, or floodplain, and where the proposed construction does not include the construction of stormwater detention basins or other drainage facilities.

NOTE: Lots in new subdivisions will be considered part of the entire subdivision site area.

2. The following activities, provided they are not located within twenty-five feet (25') of a spring, sinkhole, cave, wetland, or watercourse:

a. Grading for single family residences.

NOTE: Lot grading done as a part of an overall subdivision plan in order to make lots buildable or prepare lots for sale is not exempt.

b. Grading and repair of existing roads or driveways.

c. Cleaning and routine maintenance of roadside ditches or utilities.

d. Utility construction where the width of the disturbed area for trench excavation and backfill is twenty feet (20') or less.

3. Emergency construction required to repair or replace roads, utilities, or other items affecting the general safety and well being of the public.

For emergency construction sites which would otherwise be required to obtain a permit and for which remedial construction will take more than fourteen (14) calendar days, application for the permit must be made within three (3) calendar days from the start of construction.

14.3.b Permit Procedure

The following items must be submitted prior to issuance of a Grading Permit:

b.1. Completed grading permit application signed by the property owner or his legally authorized agent.

b.2. Grading permit fee. Checks must be made payable to Joplin City Clerk.

b.3. An approved sediment and erosion control plan (SECP).

b.4. Performance bond or other required security.

b.5. For sites where five (5) acres or more of land are disturbed the following additional items are required:

a. A copy of the Missouri State Operating Permit.
b. An approved Stormwater Pollution Prevention Plan (SWPPP).

b.6. Other State or Federal permits, if required (see Section 14.4).

The submittal and approval procedure is as follows:

1. Subdivisions

A sediment and erosion control plan (SECP) shall be submitted for review along with the plans for the subdivision improvements.

Grading permits for subdivisions can be issued after approval of the plans for the subdivision improvements by the Public Works Director, and the items listed above are received.

2. Buildings

Two (2) copies of the sediment and erosion control plan (SECP) shall be submitted to the Public Works Department along with the building plans.

Grading permits can be issued after approval of the SECP and storm drainage plans by the Public Works Director and the items listed above are received.

For sites served by septic systems or other individual on-site wastewater systems, the wastewater systems plans must also be approved prior to issuance of the grading permit.

3. Other Sites

Other sites include borrow and spoil areas, gravel mining areas, and any other sites where a subdivision plat or a building permit is not required.

Two (2) copies of the sediment and erosion control plan (SECP) shall be submitted to the Public Works Director for review.

A grading permit can be issued after approval of the SECP by the Public Works Director and the items listed above are received.

14.3.c Sediment & Erosion Control Plan (SECP)

1. Professional Qualifications

Sediment and Erosion Control plans must be prepared by and bear the seal of an engineer, land surveyor, architect, landscape architect, or geologist registered to practice in the State of Missouri or by a Certified Professional in Erosion and Sediment Control (CPESC) who has attained certification by the Soil & Water Conservation Society. When the total area of the site exceeds five (5) acres, or the drainage area of any watershed for which an element of the plan must be designed exceeds five (5) acres, the plan must be prepared under the supervision of an engineer registered in Missouri.

2. Plan Requirements

The sediment & erosion control plan must be drawn to scale and must include the following items:

1) Location map at a scale of 1" = 2000'.
2) Legal description of property.
3) North arrow and scale.
4) One-Call utility notification symbol.
5) Title block.
6) Signature block for Public Works Director.
7) Design professional's seal.
8) Existing topographic contours at five feet (5') maximum intervals.

   NOTE: Contours cannot be interpolated from U.S.G.S. maps. Each fifth (5^{th}) contour (index contour) shall be labeled and shown in heavier line weight. Index contours must be labeled in a a sufficient number of locations to allow the plan to be followed. Labels for existing and finish grade contours shall be distinguished by use of different symbols or fonts.

9) Proposed grades.
10) Existing and proposed utilities.
11) Existing ground covering (open areas, tree masses, etc.).
12) Existing buildings, drives and pavements.
13) Proposed buildings or other structures, drives, and pavements.
14) Limits of area to be disturbed (shading preferred).
15) Location of erosion and sediment controls.
16) Details of non-standard erosion and sediment controls.
17) Seeding & mulching requirements.
18) Total site area, total disturbed area.
19) Location of stockpile areas, staging areas, etc.
20) Location of temporary construction entrance.

14.3.d Bond Requirements

1. Subdivisions

A security agreement or other form of security acceptable to the City in the amount of the value of the required sediment and erosion controls, including the storm drainage system, must be received prior to issuance of the grading permit.

2. Buildings

If the grading permit is issued prior to the building permit, the only type of bond accepted will be a cash bond. After issuance of the building permit, the cash bond can be converted to an escrow, security agreement, or other form of bond allowed in the Zoning Regulations.

3. Other Sites

Only cash bonds will be accepted for sites where a subdivision plat or building permit is not required. A cash bond is obtained by submitting the required bond amount to the Joplin City Clerk's office in the form of cash, cashier's check or money order, and obtaining a receipt.

4. Amount of Security

The amount of security will be one thousand dollars ($1,000.00) per graded acre for seeding and mulching, plus the estimated construction cost for permanent sediment and erosion control measures specified on the SECP. This includes all elements of the storm drainage system.

5. Release of Bond

Bond will be released one (1) year after seeding and mulching is complete, provided vegetation is firmly established. If vegetation is not firmly established at this time, the bond will be forfeited and the work will be completed under the direction of the City.

Bonds may be released sooner if vegetation is firmly established. Vegetation will be considered firmly established when it has survived from the permanent seeding season in which it is placed to the next permanent seeding season and growth has been established on all eroded areas which have been noted for repair.

14.4 OTHER PERMITS

14.4.a NPDES Stormwater Permit

When the area of land disturbance is one (1) acre or more, an application for a stormwater discharge permit must be submitted to the Missouri Department of Natural Resources. Permit requirements are set forth in 10 CSR 20-6.200 of the Missouri Clean Water Laws.

For sites requiring a State permit, the following procedure applies:

1. The sediment and erosion control plan is submitted to the Public Works Director.

2. If the plan is in substantial compliance with City requirements, the Public Works Director will issue a letter of "Conditional Approval of Stormwater Management Plan". The conditions of approval are the items noted by the Public Works Director in the letter as being deficient on the first submittal.

3. The applicant submits MDNR forms E and G, the MDNR fee (with check made payable to "Director of Revenue"), and the Joplin Public Works Director's letter of conditional approval to MDNR.

4. MDNR reviews the application.

5. A City permit can be issued upon receipt of a copy of the State permit. Construction can commence only after issuance of the City grading permit.

City Projects

City-funded projects are covered under general permit MO-R1000. Separate applications are not required for each project.

14.4.b "404" Permit

Grading activities in streams or wetlands may require a Department of the Army Permit under Section 404 of the Clean Water Act. It is the obligation of the property owner or operator to contact the Corps of Engineers to determine whether a permit is required whenever working in these areas. A copy of the Corps of Engineers written determination, where applicable, shall be provided prior to issuance of the grading permit.

14.4.c Floodplain Development Permit

A Floodplain Development Permit must be obtained from the Department of Public Works for development within Special Flood Hazard Areas designated on the Flood Insurance Rate Maps for Joplin, Missouri.

14.4.d Industrial Mineral Mines Permit

Sand and gravel excavation, quarries, and gravel mines must obtain a permit from the Missouri Department of Natural Resources, Land Reclamation Division. Contact the Division of Land Reclamation at P.O. Box 176, Jefferson City, MO 65102 for information concerning these permits.

14.5 DESIGN STANDARDS & CRITERIA

14.5.a Grading

1. Maximum grades

Cut or fill slopes shall not exceed three (3) horizontal to one (1) vertical (3:1).

2. Maximum height

Cut or fill slopes shall not exceed fifteen feet (15') feet in vertical height unless a horizontal bench area at least five feet (5') in width is provided for each fifteen feet (15') in vertical height.

3. Minimum slope

Slope in grassed areas shall not be less than one percent (1%).

4. Construction Specifications

Construction of private and public streets must comply with specifications set forth by the Joplin Public Works Department.

For all other areas, construction specifications stating requirements for stripping, materials, subgrade compaction, placement of fills, moisture and density control, preparation, and maintenance of subgrade must be included or referenced on the plans or accompanying specifications.

5. Spoil Areas

Broken concrete, asphalt, and other spoil materials may not be buried in fills within proposed building or pavement areas.

Outside of proposed building and pavement areas, broken concrete, asphalt or stone may be buried in fills, provided it is covered by a minimum of two feet (2') of earth.

Burying of other materials in fills is prohibited.

6. Stockpile Areas

Location of proposed stockpile areas shall be outlined on the plans and specifications for proper drainage included.

7. Borrow Areas

The proposed limits of temporary borrow areas shall be outlined in the plans and a proposed operating plan described on the SECP.

At the time borrow operations are completed, the area shall be graded in accordance with the criteria set forth above and vegetation re-established.

14.5.b Sediment Control

1. Existing Vegetative Filter Area

Existing vegetative filter areas may be used where:

a) unconcentrated sheet flow occurs,

b) an area of existing vegetation a minimum of twenty-five feet (25') in width can be maintained between the area to be graded and a property line, watercourse, sinkhole, spring, wetland, or waterbody,

c) existing ground slope is no greater than five to one (5:1) or twenty percent (20%),

d) the existing vegetative growth is of sufficient density and in sufficiently good condition to provide for filtration of sediment.

The minimum width of the vegetative filter area shall be twenty percent (20%) of the width of the tributary area. Vegetative filter areas can be used as both a temporary and permanent practice.

2. Straw bale dike or silt fence

Containment areas constructed of hay or straw bales or silt fence may be provided in areas where:

1) unconcentrated sheet flow occurs.

2) an area of existing vegetation a minimum of twenty-five feet (25') in width cannot be maintained between the area to be graded and a property line, watercourse, sinkhole, spring, wetland, or classified lake.

3) the maximum width of cleared area upslope of the bale dike or silt fence is as set forth below:

Slope of cleared area (%)	Maximum width upslope of dike/silt fence (feet)
2 to 5	100
5 to 20	50
> 20	25

Either cereal grain straw or hay may be used for bale dikes. Straw bale dikes shall be constructed as shown in Figure 17.

Silt fence may be used in lieu of hay or straw bales. Silt fence shall be constructed as shown in Figure 18.

Straw bale dikes must be installed level, that is, "along the contour", in order to avoid creating points of concentrated overflow. Straw/hay bale dikes and silt fences must be periodically inspected and replaced as necessary if deteriorated.

Hay bale dikes and silt fences are temporary practices.

3. Temporary Containment Berm

Temporary containment berms may be used in lieu of straw bale dikes or silt fence, under the same conditions set forth above. An overflow area six inches (6") below the top of the berm and five feet (5') in length or an approved alternative must be provided for each two hundred feet (200') of berm length. The overflow area shall be lined with six (6) mil or thicker polyethylene plastic, six (6) ounces or heavier non-woven filter fabric, or other approved lining. Plastic and fabric liners shall be held in place by covering the perimeter with earth or weighting down with large rock or sandbags.

Containment berms and swales must be installed level, "along the contour".

Accumulated sediment must be removed when it reaches one-third (1/3) of the berm height.

Temporary containment berms and accumulated sediment must be completely removed after the tributary area is stabilized.

Temporary containment berms shall be constructed as shown in Figure 19.

4. Inlet Protection

This practice consists of protecting the inlet perimeter or opening with straw bales, silt fence or sandbags. The purpose of this practice is to keep sediment from collecting in storm drains. This practice is also useful when site conditions prevent locating a sediment basin downstream of the storm sewer outfall.

NOTE: Inlet protection described in this paragraph cannot be used where blockage of the inlet opening would result in flooding of residential dwellings, buildings, streets or roads, or off-site property.

a. Curb Inlets

Curb inlets can be protected from sediment entry by placing sand bags over the inlet opening. Sand bags must be replaced when deteriorated and removed when the area has been stabilized. Curb inlet protection is shown in Figure 20.

Accumulated sediment must be removed from the street after each rainfall.

b. Area Inlets

In paved areas, area inlets can be protected by placing gravel filled sandbags up to two (2) courses high around the perimeter of the inlet.

Outside of paved areas or before pavement is placed, area inlets can be protected by installing a silt fence of straw bale dike around the inlet perimeter.

Type DI-1 inlets can be protected by placing sandbags over the openings.

Accumulated sediment must be removed prior to final approval.

Area inlet protection is shown in Figure 21.

5. Diversion

Where flow must be diverted into sediment basins or other sediment retaining facilities, diversion berms or swales or other approved means of diverting runoff may be specified.

Where sediment enters a street which is up-grade from an existing street, means must be provided to divert runoff to a sediment basin before discharge from the site. The method of diversion will vary depending upon the phase of construction. After initial grading, an earth berm can be used. This is no longer possible after the street subgrade is completed and curbs are installed. After the street pavement is completed, sand bags can be used to divert the runoff into inlets for discharge into the sediment basin. Diversion of street runoff is shown in Figures 22 and 23.

6. Gravel Filter Dam

Where concentrated flow occurs and less than two (2) acres of tributary drainage area are graded (i.e. a sediment basin is not required) or where construction of a sediment basin is not feasible, a gravel filter

dam shall be provided prior to discharge of runoff from the property.

Gravel filter dams consist of a layer of filter fabric and crushed rock covering the upstream side of a riprap dike. Riprap shall be six and twelve inches (6"and12") in size. Filter fabric may be woven or non-woven, Mirafi 500X, Mirafi 150NL, or equal. The purpose of the filter fabric is to remove sediment particles as water flows through it. The layer of crushed rock provides additional filtration protects the filter fabric, and holds it in place.

Where gravel filter dams are used as sediment basin outlets, one (1) square foot of filter fabric area shall be provided for each one thousand (1,000) cubic feet of storage. The minimum area provided shall be four (4) square feet.

Where gravel filter dams are used as ditch checks in channels, the gravel filter area shall extend throughout the width of the dam.

Riprap stilling basins shall be provided downstream of the filter dam where discharge is to a grass channel.

Gravel filter dam details are shown in Figures 24 and 25.

7. Sediment Basin

Sediment basins shall be provided for all areas where concentrated flow occurs from an area of two (2) or more acres and vegetative cover has been stripped from more than one (1) acre. Sediment basins shall be designed to detain the first one-half inch (½") of runoff from the graded area for a period of at least twenty-four (24) hours (approximately two thousand (2,000) cubic feet per acre graded).

Sediment basins shall have an outflow control structure capable of providing the required detention time. Outflow control structures shall consist of a gravel filter dam meeting the requirements of Section 14.5.2.F, or a perforated riser pipe.

Sediment basins shall also be provided with an overflow structure capable of passing the peak flow rate for storms up to and including the 10% AEP (10-year) storm. The required sediment control volume shall be provided below the elevation of the overflow structure. One foot (1') of freeboard shall be maintained over the 10% AEP high water elevation.

Perforated riser pipes shall have a minimum diameter of eight inches (8") and shall be constructed of schedule 40 or stronger PVC pipe, galvanized corrugated metal pipe, or other approved pipe material. Riser pipes must be provided with a cap. Plans shall specify the height of the riser pipe above the basin floor, the number and spacing of rows of perforations, and the number and diameter of perforations per row. One and one-half inch (1 ½ ") crushed rock shall be placed around the riser pipes to act as a filter. A typical riser pipe detail is shown in Figure 28.

Outlet pipes shall have a minimum diameter of eight inches (8") and may be constructed of corrugated polyethylene pipe, corrugated metal pipe, Schedule 40 or stronger PVC or reinforced concrete pipe.

Overflow spillways must be constructed of riprap, concrete or other approved, non-erodible material.

Typical sediment basin details are shown in Figures 26, 27 and 28.

Sedimentation basins can be provided as temporary or permanent practices and can also serve as a

permanent water quality BMP with appropriate design modifications to meet the criteria set forth in Section 135.

Detention ponds can be used for temporary sediment basins, provided it can be demonstrated that flood control requirements can be met as well as sediment control requirements.

Accumulated sediment must be removed and vegetation established prior to final release of security.

14.5.c Erosion Protection

1. Seeding and mulching

All disturbed areas must be re-vegetated before temporary sediment controls can be removed. Requirements for re-vegetated areas are as follows:

a) Topsoil

Spreading of topsoil is required for permanent seeding areas only. Topsoil stripped from the site shall be stockpiled for reuse. A minimum of four inches (4") loose depth (before rolling or compacting) of topsoil must be spread on the area to be seeded.

b) Lime

After topsoil is spread, lime shall be spread at the rate of eight hundred to nine hundred (800 to 900) pounds effective neutralizing material (ENM) per acre.

c) Fertilizer

Fertilizer shall be 13-13-13, (thirteen (13) pounds each of nitrogen, phosphorus, and potassium per one hundred (100) pounds) and shall be applied at a rate of two hundred to three hundred (200 to 300) pounds per acre.

d) Seed

Seed mix shall consist of sixty percent to eighty percent (60% to 80%) Kentucky 31 tall fescue and twenty percent to forty percent (20% to 40%) annual ryegrass. Purity shall be at least ninety-seven percent (97%), germination shall be at least eighty-five percent (85%). Seed mixture shall be applied at a rate of one hundred to one hundred fifty (100 to 150) pounds per acre.

e) Mulch

Type 1 Mulch

Where slopes are less than 4:1, cereal grain mulch is required at the rate of one hundred (100) pounds per one thousand (1,000) square feet (forty-five hundred (4,500) pounds per acre). Cereal grain mulch shall meet the requirements of Section 802 of the Missouri State Specifications for Highway Construction (State specifications) for Type 1 mulch. Mulch may be applied by hand, however it must be evenly spread. It is preferred that mulch be applied with a mechanical blower.

Type 1 mulch must be thoroughly wetted after application.

Type 3 Mulch

Where slopes are 4:1 or greater Type 3 mulch ("hydromulch") meeting the requirements of Section 802 of the State specifications. Type 3 mulch shall be applied at a minimum rate of two thousand (2,000) pounds per acre.

f) Permanent seeding season

Permanent seeding seasons run from March 1 to June 1 and from August 15 to November 1. Where possible, operations shall be scheduled to allow final seeding during these periods. When seeding cannot be completed during these times, areas shall be seeded and mulched upon completion of grading with the amounts of lime, fertilizer, seed, and mulch specified above, regardless of the season. Any areas where growth has not been established shall be re-seeded during the next seeding season.

g) Temporary seeding

Temporary seeding shall be applied to lot areas, building areas and other areas planned to receive other permanent coverings. Spreading of topsoil is not required in temporary seeding areas. Lime, fertilizer, seed, and mulch shall be applied at the rates specified above.

h) Maintenance

Areas seeded between March 1 - June 1 or between August 15 - November 1 must be maintained until growth is firmly established as set forth in Section 14.3.4.E.

i) Other specifications

Other seeding and mulching specifications may be used with the written approval of the Public Works Director.

2. Cut and Fill Slopes

Cut and fill slopes shall be protected from erosion by construction of straw bale dikes, silt fences, diversion berms, or swales along the top of the slope.

Where drainage must be carried down the slopes, pipe drains, concrete flumes, riprap chutes, or other impervious areas must be provided. Suitable erosion control measures such as riprap stilling basins, must be provided at the bottom of the slope.

Diversions shall be maintained until permanent growth is firmly established on the slopes.

Typical diversion details are shown in Figure 29. Riprap chute details are shown in Figure 30.

3. Channels and Swales.

Permanent channels and swales shall be provided with a stabilized invert, as provided in Section 8.

4. Storm Sewer and Culvert Outlets

Erosion protection shall be provided at storm sewer and culvert outlets as provided in Section 7.

5. Ditch Checks

Straw bale ditch checks have proven to be generally ineffective due to improper installation and inability of bales to withstand the force of concentrated flow of water. Ditches, channels, and swales should be stabilized as soon as possible after grading by lining with erosion control blanket, sod, or installing permanent linings as described in Section 8.

Where ditches, channels, or swales cannot be stabilized within thirty (30) days after grading, rock check dams or sand bag check dams must be provided. Rock check dams may be used in ditches with a design water depth of up to two feet (2') for the 2-year storm. Sand bag check dams may be used in ditches with a design water depth of up to one foot (1') for the 2-year storm.

Rock check dams are shown in Figure 31. Sand bag check dams are shown in Figure 32.

14.5.d Temporary Construction Entrance

A minimum of one (1) temporary construction entrance is required at each site. Additional temporary entrances may be provided if approved. The location of each construction entrance shall be shown on the SECP.

Only construction entrances designated on the sediment and erosion control plan may be used. Barricades shall be maintained if necessary to prevent access at other points until construction is complete.

Construction entrances shall be constructed of one and one-half inches (1 ½") clean crushed limestone and shall be a minimum of twenty-five feet (25') wide and fifty (50') feet long. Minimum thickness of crushed limestone surface shall be six inches (6"). Additional two inch (2") lifts of crushed limestone shall be added at the discretion of the City if the surface of the initial drive deteriorates or becomes too muddy to be effective.

In locations where an existing drive or street extends at least fifty feet (50') into the site, the existing drive may be designated as the construction entrance, and construction of a new gravel entrance is not required, unless job conditions warrant.

A permit must be obtained from the Joplin Public Works Department for temporary construction entrances on City roads. A permit must be obtained from the Missouri Department of Transportation (MODOT) whenever the entrance is located on State right-of-way.

14.5.e Cleaning Streets

Streets, both interior and adjacent to the site, shall be cleaned of sediment after each rainfall of one-half inch (½") or more and at the end of construction and prior to release of escrow.

14.5.f Dust Control

The contractor will be required to use water trucks to wet haul roads and construction areas to minimize dust leaving the site when conditions warrant.

14.5.h Sequencing and Scheduling

Costs of sediment and erosion control can be minimized if proper consideration is given to sequencing and scheduling construction.

Any special sequencing and scheduling considerations must be noted on the SECP. The contractor must provide a sequence of construction activities as a part of the SWPPP.

Rainfall Intensity-Duration-Frequency, Joplin, Missouri						
Duration Hr:Min	Annual Probability, Percent					
	1	2	4	10	20	50
	Rainfall Intensity, Inches per Hour					
00:05	10.20	9.30	8.41	7.25	6.47	5.39
00:06	9.82	8.97	8.09	7.01	6.23	5.19
00:07	9.48	8.68	7.79	6.75	6.00	5.02
00:08	9.16	8.35	7.49	6.51	5.79	4.84
00:09	8.83	8.07	7.26	6.28	5.59	4.66
00:10	8.53	7.79	7.03	6.06	5.40	4.51
00:11	8.24	7.52	6.77	5.86	5.22	4.35
00:12	7.97	7.26	6.55	5.66	5.05	4.22
00:13	7.71	7.03	6.36	5.49	4.90	4.08
00:14	7.48	6.82	6.16	5.32	4.75	3.96
00:15	7.27	6.63	5.96	5.16	4.61	3.83
00:16	7.10	6.49	5.86	5.05	4.49	3.73
00:17	6.96	6.34	5.72	4.92	4.37	3.64
00:18	6.82	6.23	5.61	4.84	4.29	3.54
00:19	6.72	6.14	5.51	4.74	4.20	3.46
00:20	6.62	6.04	5.40	4.67	4.11	3.38
00:21	6.52	5.96	5.31	4.59	4.04	3.30
00:22	6.44	5.87	5.23	4.52	3.97	3.22
00:23	6.36	5.79	5.16	4.48	3.92	3.15
00:24	6.28	5.74	5.09	4.41	3.84	3.09
00:25	6.20	5.66	5.00	4.35	3.79	3.01
00:26	6.14	5.61	4.95	4.31	3.73	2.95
00:27	6.07	5.54	4.89	4.25	3.68	2.91
00:28	5.99	5.49	4.82	4.21	3.62	2.84
00:29	5.94	5.41	4.77	4.16	3.57	2.79
00:30	5.88	5.37	4.72	4.10	3.52	2.74
00:35	5.54	5.08	4.42	3.88	3.29	2.51
00:40	5.22	4.78	4.14	3.64	3.08	2.32
00:45	4.91	4.50	3.89	3.42	2.86	2.13
00:50	4.61	4.20	3.64	3.20	2.67	1.99
00:55	4.32	3.95	3.42	3.00	2.52	1.86
01:00	4.11	3.75	3.25	2.86	2.38	1.80

Rainfall Depth-Duration-Frequency, Joplin, Missouri						
Duration Hr:Min	Annual Probability, Percent					
	1	2	4	10	20	50
	Rainfall Depth, Inches					
1:00	4.10	3.73	3.27	2.87	2.40	1.80
1:15	4.42	4.00	3.48	3.01	2.50	1.91
1:30	4.68	4.22	3.70	3.19	2.60	2.00
1:45	4.87	4.39	3.87	3.32	2.70	2.10
2:00	5.01	4.55	4.06	3.45	2.82	2.19
2:15	5.21	4.69	4.20	3.55	2.92	2.29
2:30	5.32	4.82	4.33	3.67	3.04	2.38
2:45	5.46	4.95	4.45	3.77	3.14	2.47
3:00	5.54	5.05	4.56	3.85	3.26	2.54
3:30	5.73	5.25	4.69	3.98	3.41	2.66
4:00	5.88	5.44	4.80	4.06	3.51	2.74
4:30	6.04	5.62	4.87	4.13	3.61	2.79
5:00	6.19	5.79	4.94	4.20	3.69	2.85
5:30	6.32	5.92	4.99	4.25	3.75	2.87
6:00	6.45	6.06	5.04	4.30	3.79	2.91
7:00	6.72	6.27	5.18	4.41	3.90	2.96
8:00	6.99	6.44	5.35	4.53	4.02	3.02
9:00	7.28	6.61	5.53	4.66	4.11	3.12
10:00	7.55	6.75	5.70	4.80	4.20	3.17
11:00	7.79	6.87	5.88	4.94	4.27	3.23
12:00	8.01	7.02	6.03	5.05	4.35	3.30
15:00	8.44	7.31	6.40	5.35	4.55	3.48
18:00	8.74	7.60	6.66	5.60	4.72	3.65
21:00	8.96	7.86	6.90	5.82	4.88	3.82
24:00	9.08	8.05	7.06	6.01	5.01	3.96

Source: Bulletin 71, Rainfall Frequency Atlas of the Midwest, Huff and Angel, 1992
National Weather Service Hydro 35, Five– to 60-Minute Precipitation Frequency for the Eastern and Central United States, 1977.

Huff's Median Time Distributions of Heavy Storm Rainfall. Cumulative storm rainfall (%) versus cumulative storm time (%). Source: *Rainfall Frequency Atlas of the Midwest*, F.A. Huff and J. R. Angel, Midwestern Climate Center, 1992.

Cum % of storm time	Point Rainfall				Cum % of storm time	10 to 50 Square Miles				Cum % of storm time	50 to 400 Square Miles				Cum % of storm time
	Quartile					Quartile					Quartile				
	1st	2nd	3rd	4th		1st	2nd	3rd	4th		1st	2nd	3rd	4th	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	16	3	3	2	5	12	3	2	2	5	8	2	2	2	5
10	33	8	6	5	10	25	6	5	4	10	17	4	4	3	10
15	43	12	9	8	15	38	10	8	7	15	34	8	7	5	15
20	52	16	12	10	20	51	14	12	9	20	50	12	10	7	20
25	60	22	15	13	25	62	21	14	11	25	63	21	12	9	25
30	66	29	19	16	30	69	30	17	13	30	71	31	14	10	30
35	71	39	23	19	35	74	40	20	15	35	76	42	16	12	35
40	75	51	27	22	40	78	52	23	18	40	80	53	19	14	40
45	79	62	32	25	45	81	63	27	21	45	83	64	22	16	45
50	82	70	38	28	50	84	72	33	24	50	86	73	29	19	50
55	84	76	45	32	55	86	78	42	27	55	88	80	39	21	55
60	86	81	57	35	60	88	83	55	30	60	90	86	54	25	60
65	88	85	70	39	65	90	87	69	34	65	92	89	68	29	65
70	90	88	79	45	70	92	90	79	40	70	93	92	79	35	70
75	92	91	85	51	75	94	92	86	47	75	95	94	87	43	75
80	94	93	89	59	80	95	94	91	57	80	96	96	92	54	80
85	96	95	92	72	85	96	96	94	74	85	97	97	95	75	85
90	97	97	95	84	90	97	97	96	88	90	98	98	97	92	90
95	98	98	97	92	95	98	98	98	95	95	99	99	99	97	95
100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

SURFACE RUNOFF COEFFICIENTS

LAND USE	PROPORTIONAL SURFACE CONDITION IMPERV.	TURF OR =	RATIONAL METHOD "C"
Residential Low-Medium Density (Single Family & Duplex)	0.35	0.65	0.44
Residential Medium-high Density (6 or fewer D.U. per bldg. and mobile home parks)	0.60	0.40	0.62
Residential High Density (Over 6 D.U. per bldg.)	0.80	0.20	0.76
Public/Semi-Public (Schools, Gov't.,Institutional)	0.65	0.35	0.66
Commercial/Industrial; Office Parks	0.70	0.30	0.69
Neighborhood Commercial	0.85	0.15	0.80
General Commercial (Shopping Centers)	0.95	0.05	0.87
Central Business District	1.00	0.00	0.90
Industrial	0.80	0.20	0.76
Open Space, Parks, Golf Courses	0.10	0.90	0.27
Agricultural/Cultivated	0.05	0.95	0.24
All Land Uses:			
100 % Impervious Surfaces			0.90
100 % Pervious Surfaces (With maintained turf cover or =)			0.20

Ref: SCS, APWA (3/90)

Runoff Curve Numbers (Average Watershed Conditions, $I_a = 0.2S$)

Land Use Description	Average % Impervious[b]	Curve Numbers for Hydrologic Soil Group A	B	C	D
Fully developed urban areas[a] (vegetation established)					
Lawns, open spaces, parks, golf courses, cemeteries, etc.					
Good condition; grass cover on 75% or more of the area		39	61	74	80
Fair condition; grass cover on 50% to 75% of the area		49	69	79	84
Poor condition; grass cover on 50% or less the area		68	79	86	89
Paved parking lots, roofs, driveways, etc.		98	98	98	98
Streets and roads					
Paved with curbs and storm sewers		98	98	98	98
Gravel		76	85	89	91
Dirt		72	82	87	89
Paved with open ditches		83	89	92	93
Industrial, commercial and business areas	85	89	92	94	95
	80	86	91	93	94
	75	83	89	92	93.5
	70	80	87	91	92.7
Row houses, town houses, and residential with lot sizes 1/8 acre or less	65	77	85	90	92
Residential: average lot size					
1/4 acre	38	61	75	83	87
	30	57	72	81	86
	25	54	70	80	85
	20	51	68	79	84
	12	46	65	77	82
Developing urban areas[c] (no vegetation established)					
Newly graded area		77	86	91	94

Runoff Curve Numbers

Land Use Description	Hydrologic Condition	Curve Numbers for Hydrologic Soil Group A	B	C	D
Meadow	-	30	58	71	78
Forestland-grass or	Poor	55	73	82	86
orchards -evergreen or	Fair	44	65	76	82
Deciduous	Good	32	58	72	79
Brush	Poor	48	67	77	83
	Good	20	48	65	73
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	25	55	70	77
Farmsteads	-	59	74	82	86
Forest-Range					
Herbaceous	Poor	-	79	86	92
	Fair	-	71	80	89
	Good		61	74	84

Land use	Treatment of Practice	Hydrologic Condition	A	B	C	D
Cultivated agricultural land						
Fallow	Straight row	-	77	86	91	94
	Conservation tillage	Poor	76	85	90	93
	Conservation tillage	Good	74	83	88	90
Row crops	Straight row	Poor	72	81	88	91
	Straight row	Good	67	78	85	89
	Conservation tillage	Poor	71	80	87	90
	Conservation tillage	Good	64	75	82	85

Land use	Treatment of Practice	Hydrologic Condition	A	B	C	D
Row crops	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Contoured and	Poor	69	78	83	87
	conservation tillage	Good	64	74	81	85
	Contoured and terraces	Poor	66	74	80	82
	Contoured and terraces	Good	62	71	78	81
	Contoured and terraces and	Poor	65	73	79	81
	conservation tillage	Good	61	70	77	80
Small grain	Straight row	Poor	65	76	84	88
	Straight row	Good	63	75	83	87
	Conservation tillage	Poor	64	75	83	86
	Conservation tillage	Good	60	72	80	84
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Contoured and	Poor	62	73	81	84
	conservation tillage	Good	60	72	80	83
	Contoured and terraces	Poor	61	72	79	82
	Contoured and terraces	Good	59	70	78	81
	Contoured and terraces and	Poor	60	71	78	81
	conservation tillage	Good	58	69	77	80
Close-seeded	Straight row	Poor	66	77	85	89
legumes or	Straight row	Good	58	72	81	85
rotation meadow[c]	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Contoured and terraces	Poor	63	73	80	83
	Contoured and terraces	Good	51	67	76	80

Land use	Treatment of Practice	Hydrologic Condition	A	B	C	D
Noncultivated	No mechanical treatment	Poor	68	79	86	89
agricultural land	No mechanical treatment	Fair	49	69	79	84
pasture or range	No mechanical treatment	Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79

[a] For land uses with impervious areas, curve numbers are computed assuming that 100% of runoff from impervious areas is directly connected to the drainage system. Pervious areas (lawn) are considered to be equivalent to lawns in good condition and the impervious areas have a *CN* of 98.

[b] Includes paved streets.

[c] Use for the design of temporary measures during grading and construction. Impervious area percent for urban areas under development vary considerably. The user will determine the percent impervious. Then using the newly graded area *CN* and Figure 8.7.1*a* or *b*, the composite *CN* can be computed for any degree of development.

[d] For conservation tillage poor hydrologic condition, 5% to 20% of the surface is covered with residue (less than 750-lb/acre row crops or 300-lb/acre small grain).

For conservation tillage good hydrologic condition, more than 20% of the surface is covered with residue (greater than 750-lb/acre row crops or 300-lb/acre small grain).

[e] Close-drilled or broadcast.

For noncultivated agricultural land:
Poor hydrologic condition has less than 25% ground cover density.
Fair hydrologic condition has between 25% and 50% ground cover density.
Good hydrologic condition has more than 50% ground cover density.

For forest–range:
Poor hydrologic condition has less than 30% ground cover density.
Fair hydrologic condition has between 30% and 70% ground cover density.
Good hydrologic condition has more than 70% ground cover density.

Source: U.S. Department of Agriculture Soil Conservation Service (1986).

MANNING'S ROUGHNESS COEFFICIENTS ("n")

TYPE OF CHANNEL	n
Closed Conduits	
Reinforced Concrete Pipe	0.013
Reinforced Concrete Elliptical Pipe	0.013
Corrugated Metal Pipe:	
2-2/3 x 1/2 in Annular Corrugations unpaved -plain	0.024
2-2/3 x 1/2 in Annular Corrugations paved invert	0.021
3 x 1 in Annular Corrugations unpaved - plain	0.027
3 x 1 in Annular Corrugations paved invert	0.023
6 x 2 in Corrugations unpaved - plain	0.033
6 x 2 Corrugations paved invert	0.028
Vitrified Clay Pipe	0.013
Asbestos Cement Pipe	0.012
Open Channels (Lined)	
Gabions	0.025
Concrete	
Trowel Finish	0.013
Float Finish	0.015
Unfinished	0.017
Concrete, bottom float finished, with sides of	
Dressed Stone	0.017
Random Stone	0.020
Cement Rubble Masonry	0.025
Dry Rubble or Riprap	0.030
Gravel bottom, side of	
Random Stone	0.023
Riprap	0.030
Grass (Sod)	0.035
Open Channels (Unlimited) Excavated or Dredged	
Earth, straight and uniform	0.027
Earth, winding and sluggish	0.035
Natural Stream	
Clean stream, straight	0.030
Stream with pools, sluggish reaches, heavy underbrush	0.100
Flood Plains	
Grass, no brush	0.030
With some brush	0.090
Street Curbing	0.014

Ref: APWA (3/90)

HEAD LOSS COEFFICIENTS (k) FOR HYDRAULIC CALCULATIONS

CONDITIONS	k
Manhole, junction boxes and inlets with shaped inverts:	
Thru Flow	0.15
Junction	0.4
Contraction Transition	0.1
Expansion Transition	0.2
90 degree bend	0.4
45 degree and less bends	0.3
Culvert outlet	1.0
Culvert inlets:	
Pipe, Concrete	
Projecting from fill, socket end (grooved end)	0.2
Projecting from fill, sq cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (grooved end)	0.2
Square edge	0.5
Round (radius = 1/12D)	0.2
Mitered to conform to fill slope	0.7
Standard end section	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side-or-slope-tapered inlet	0.2
Pipe, or Pipe-Arch, corrugated Metal	
Projecting from fill (not headwall)	0.9
Headwall or headwall and wingwalls square edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
Standard end section	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side-or-slope-tapered inlet	0.2
Box Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square edge on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.20
Wingwall at 10° to 25° to barrel	
Square edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square edged at crown	0.7
Side-or-slope-tapered inlet	0.2

Ref: APWA (3/90)

CURB OPENING INLETS CAPACITY INSTALLED ON SLOPING GUTTERS

INLET INTERCEPTION CAPACITY IN CUBIC FEET PER SECOND (CFS)

FLOW DEPTH @ CURB (FEET)	INLET OPENING LENGTH IN FEET								
	4	5	6	7	8	9	10	11	12
0.05	0.14	0.17	0.20	0.22	0.24	0.25	0.27	0.28	0.28
0.10	0.33	0.41	0.48	0.54	0.60	0.66	0.71	0.77	0.81
0.15	0.55	0.67	0.79	0.91	1.02	1.13	1.23	1.33	1.43
0.20	0.78	0.96	1.14	1.31	1.48	1.65	1.81	1.96	2.11
0.25	1.03	1.27	1.51	1.75	1.98	2.20	2.42	2.64	2.85
0.30	1.29	1.60	1.91	2.21	2.51	2.80	3.09	3.37	3.65
0.35	1.58	1.96	2.33	2.70	3.07	3.43	3.79	4.14	4.49
0.40	1.87	2.33	2.78	3.22	3.66	4.10	4.53	4.95	5.37
0.45	2.18	2.72	3.24	3.77	4.29	4.80	5.31	5.81	6.31
0.50	2.51	3.12	3.73	4.34	4.93	5.53	6.12	6.70	7.28
0.55	2.85	3.55	4.24	4.93	5.61	6.29	6.96	7.63	8.29
0.60	3.20	3.98	4.76	5.54	6.31	7.07	7.83	8.59	9.34

INSTALLATION CRITERIA:

Gutter Depression At Inlet	= 4.0" (Minimum)
Clear Height Of Opening	= 6.0" (Minimum)
Capacity Reduction For Clogging	= 20 %

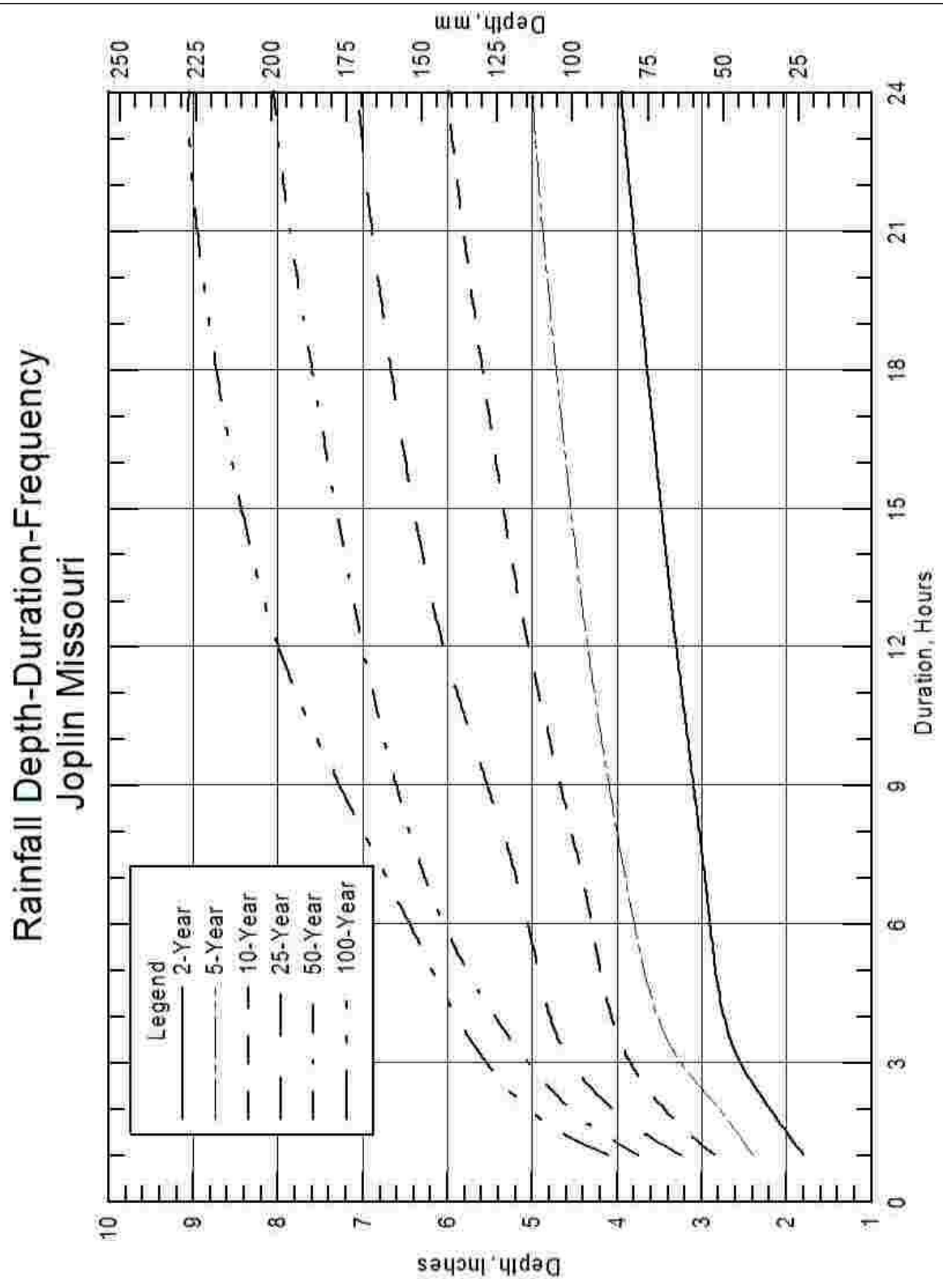
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RAINFALL
IDF CURVES

FIGURE 1

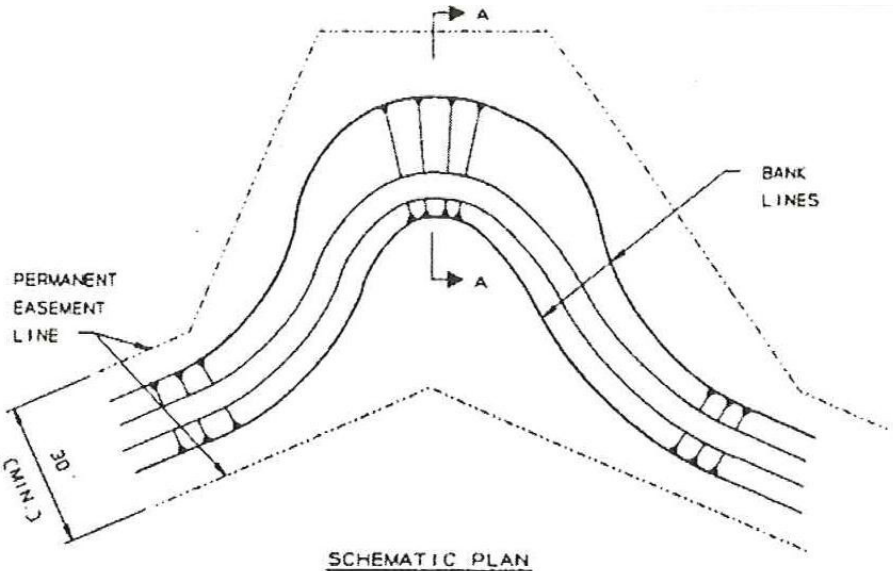


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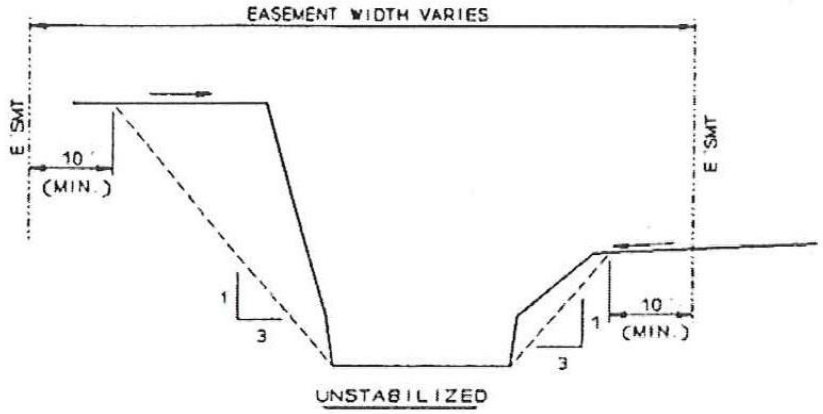
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RAINFALL
DDF CURVES

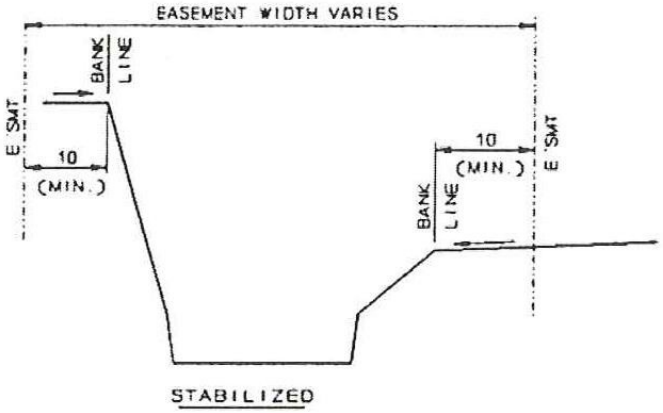
FIGURE 2



SCHEMATIC PLAN
NOT TO SCALE



UNSTABILIZED



STABILIZED

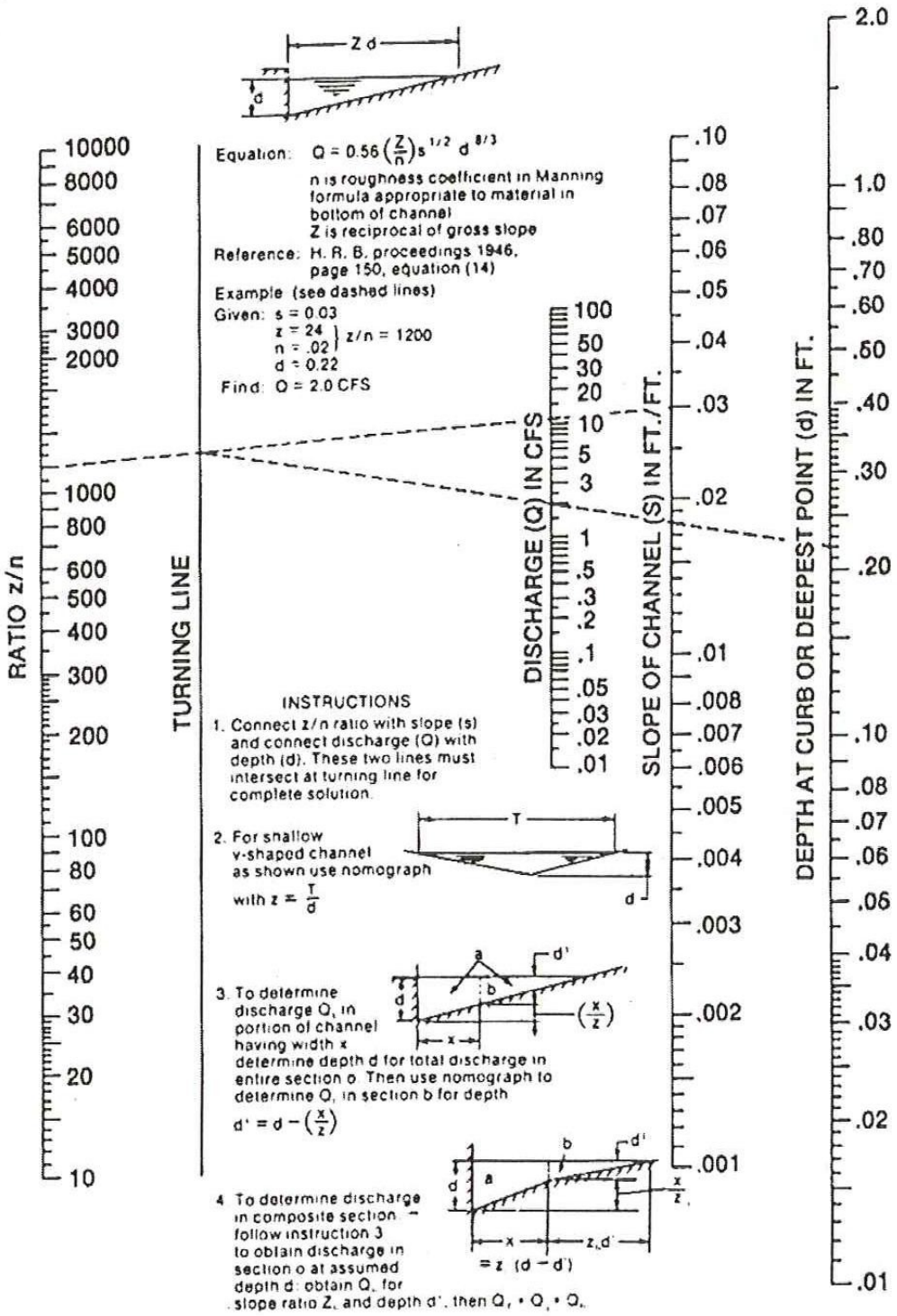
SECTION A
NOT TO SCALE

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PERMANENT EASEMENT
CHANNELS

FIGURE 3



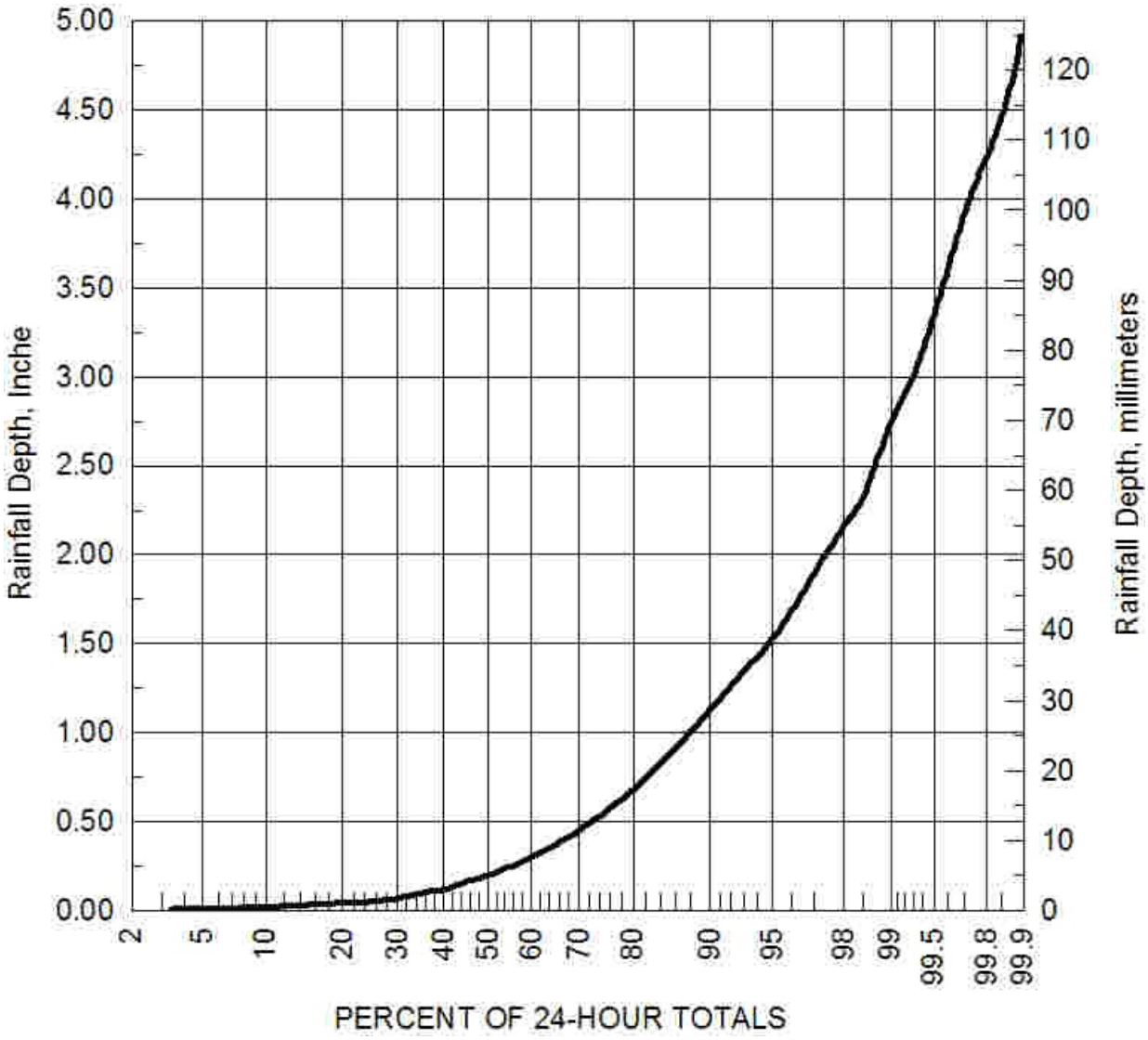
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STREET GUTTER
HYDRAULICS

FIGURE 4



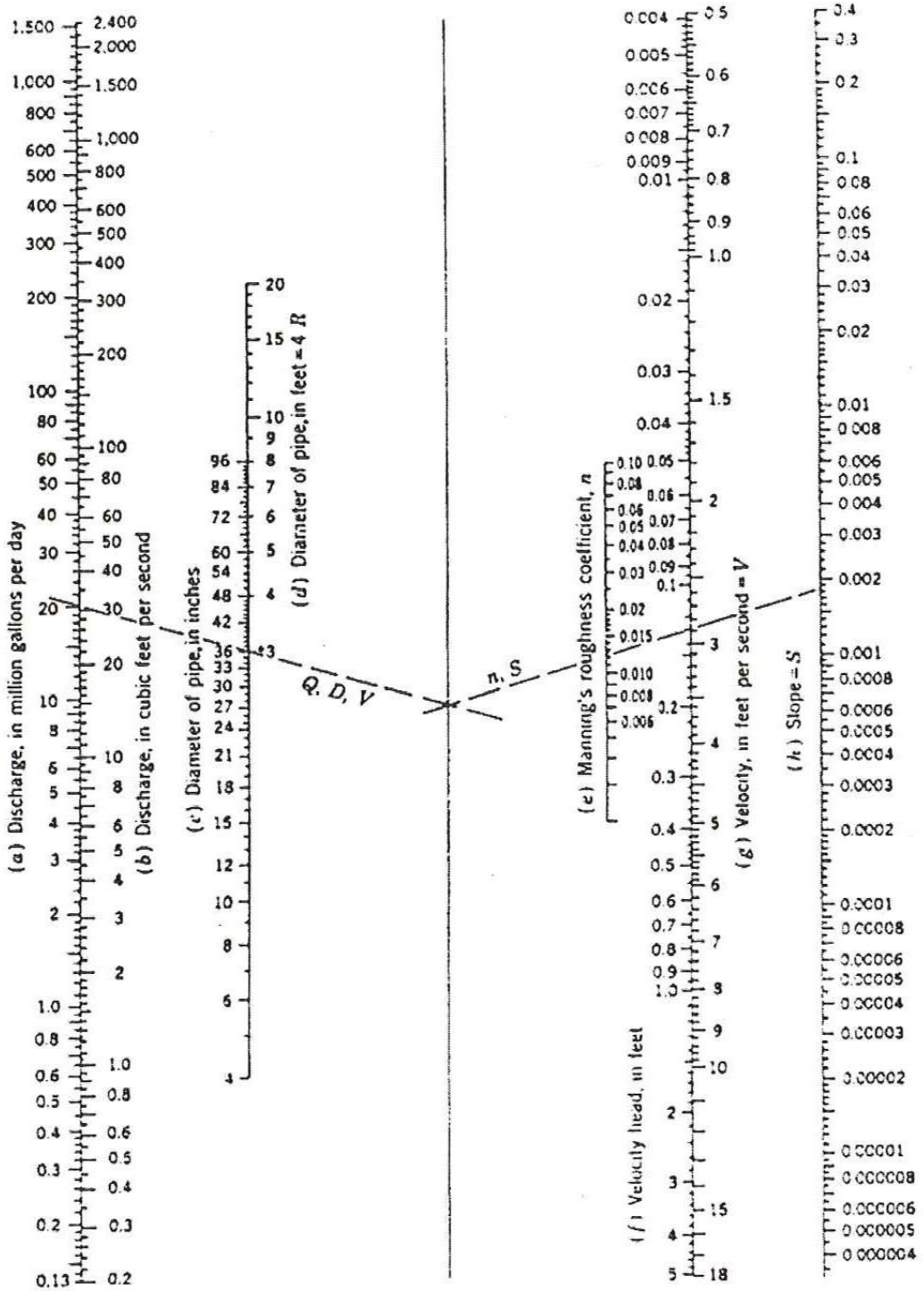
NATIONAL WEATHER SERVICE, HOURLY PRECIPITATION, JOPLIN, MISSOURI
PERIOD OF RECORD July 1, 1948— December 31, 2006

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RAINFALL
24-HOUR TOTALS

FIGURE 5



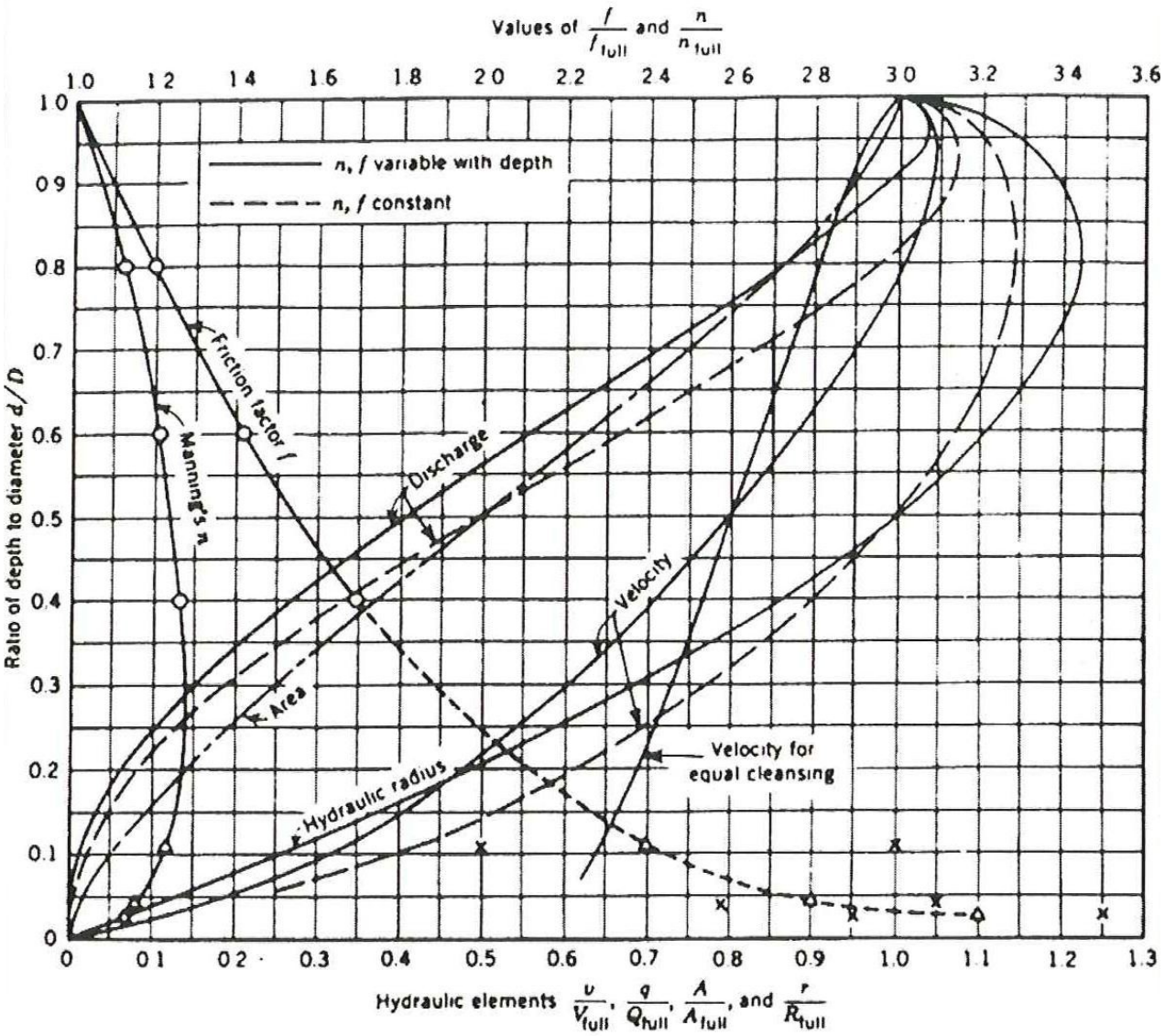
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FLOW IN PIPES
MANNING ' S FORMULA

FIGURE 7



v = Actual velocity of flow (fps)

V_{full} = Velocity flowing full (fps)

q = Actual quantity of flow (cfs)

Q_{full} = Capacity flowing full (cfs)

A = Area occupied by flow ($ft.^2$)

A_{full} = Area of pipe ($ft.^2$)

r = Actual hydraulic radius (ft.)

R_{full} = Hydraulic radius of full pipe (ft.)

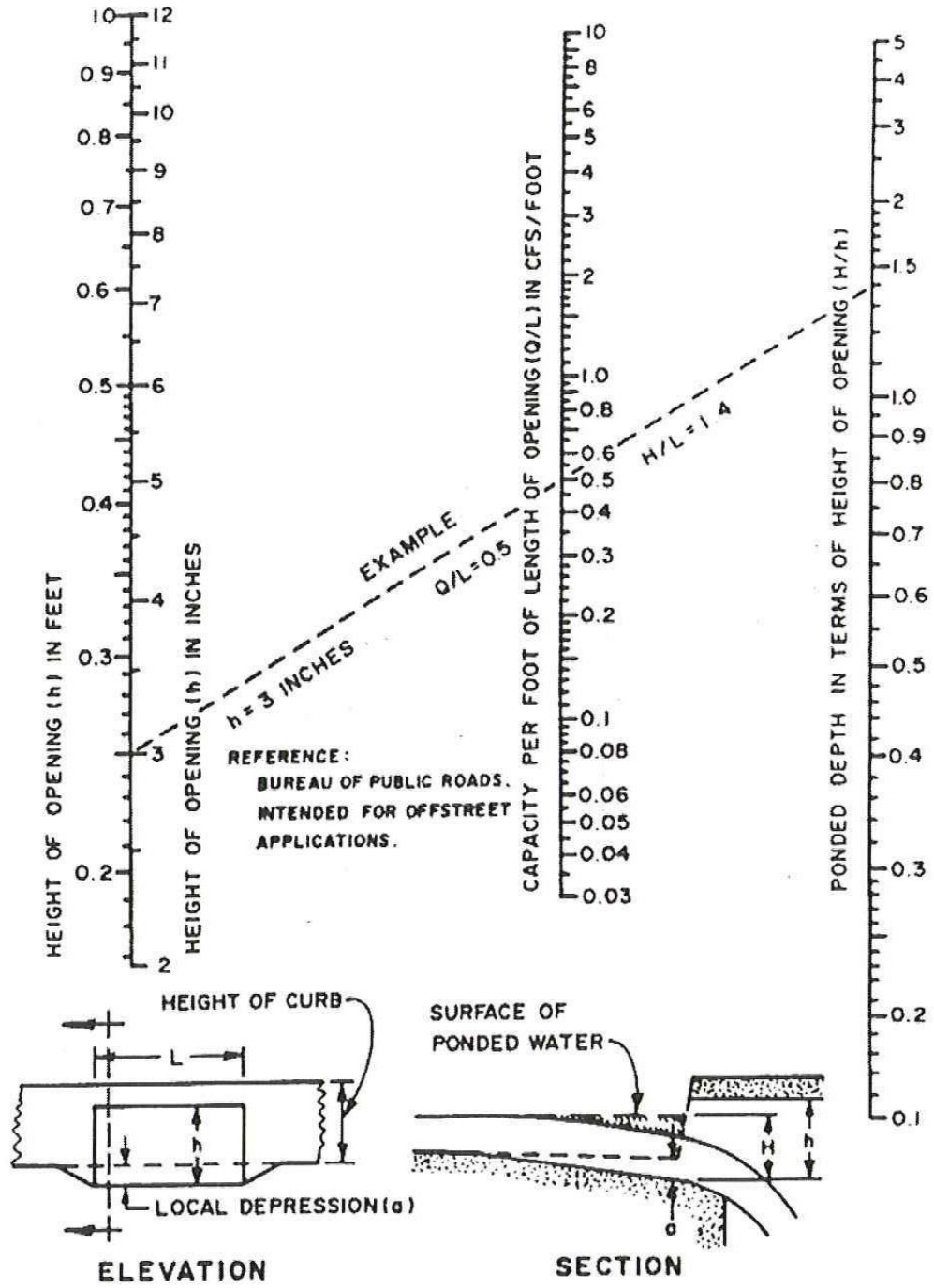
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HYDRAULIC ELEMENTS
CIRCULAR CONDUIT

FIGURE 8



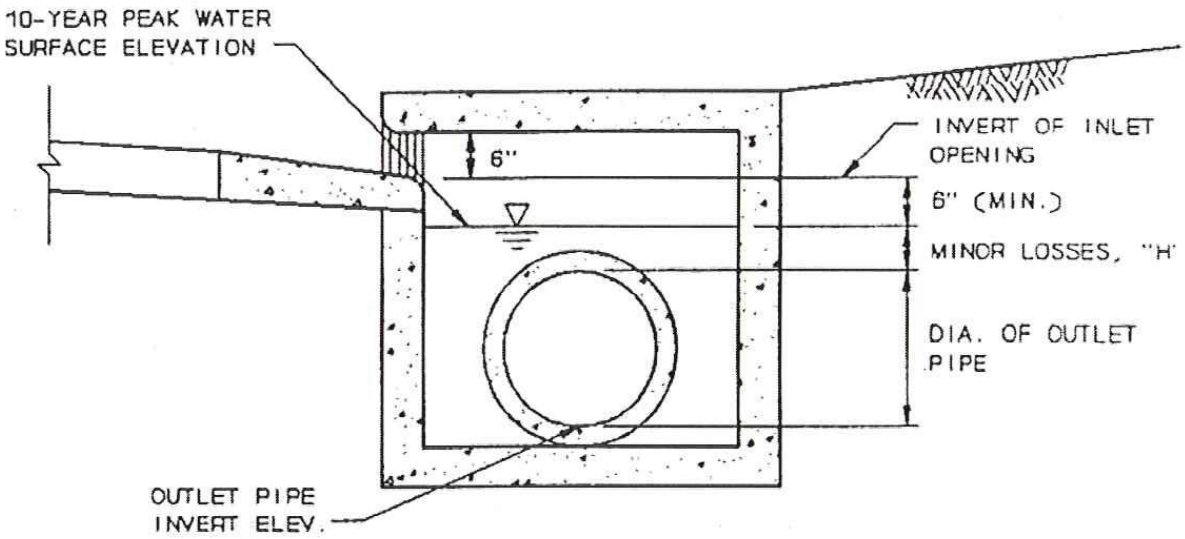
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CURB OPENING INLETS
CAPACITY IN SUMP

FIGURE 9



$$"H" = K(V^2/2G)$$

NOTES:

1. SEE TABLE F FOR VALUES OF "K".

2. V = Q/A WHERE
   Q = FLOW, IN CFS
   A = CROSS-SECTIONAL AREA OF OUTLET PIPE, IN SQ. FT.

3. 2G = 64.4 FT. PER SEC. PER SEC.

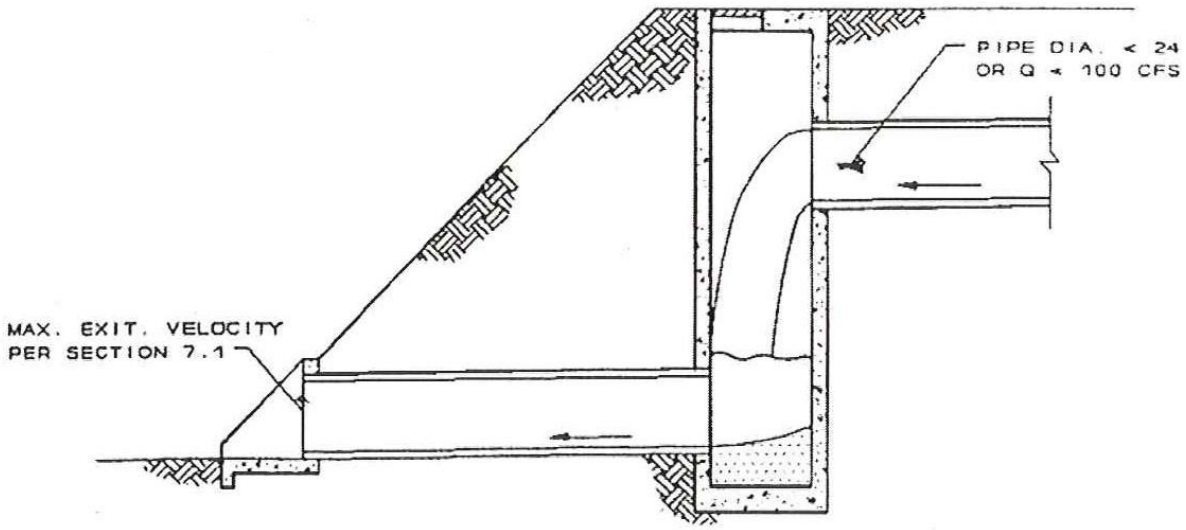
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CURB OPENING INLETS
DIMENSIONAL CRITERIA

FIGURE 10



SECTION

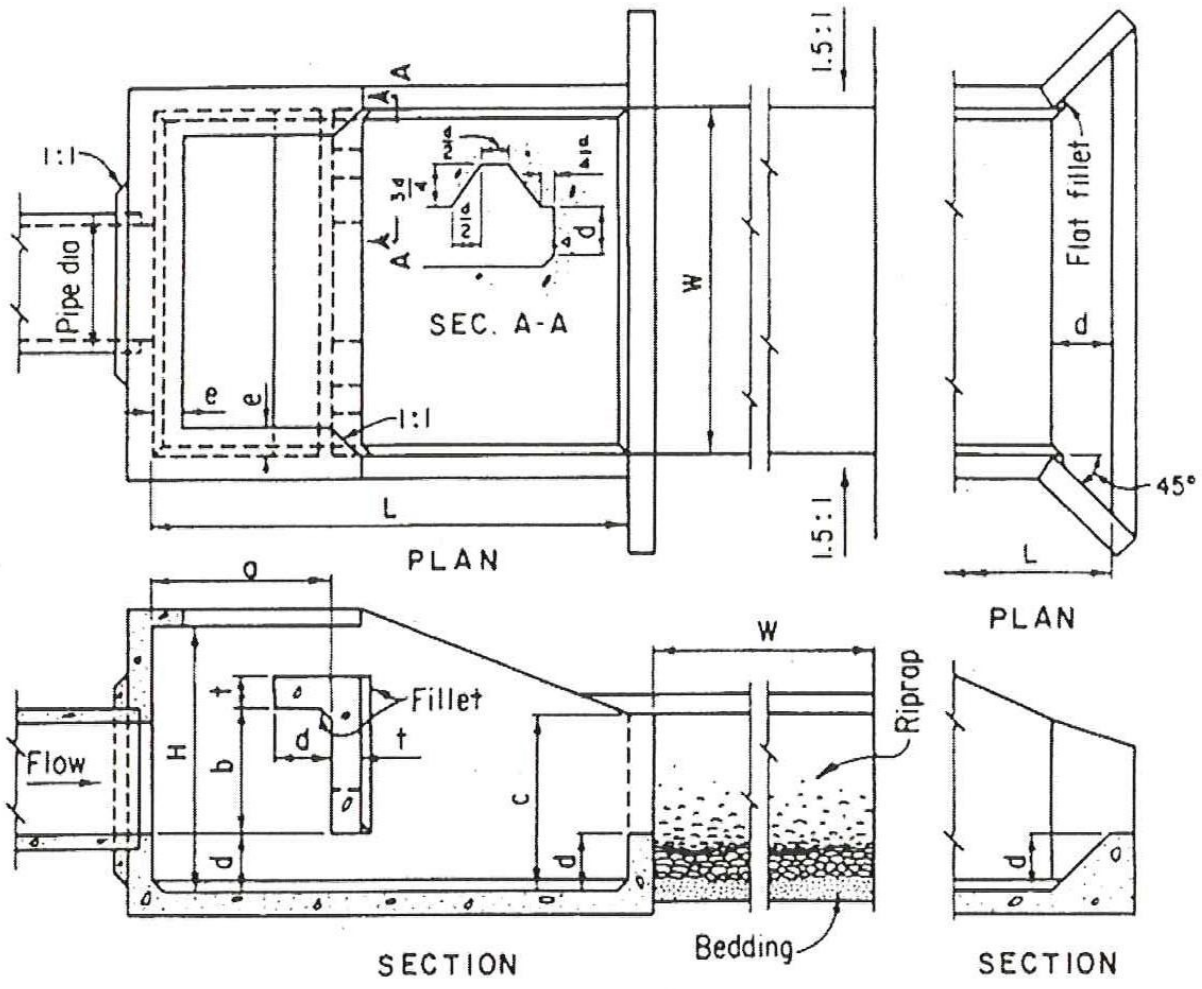
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ENCLOSED DROP
ENERGY DISSIPATORS

FIGURE 11



ALTERNATE
END SILL AND
WING WALL

H = 3W/4 c = W/2
L = 4W/3 d = W/6
o = W/2 e = W/12
b = 3W/8 t = W/12 suggested minimum thickness

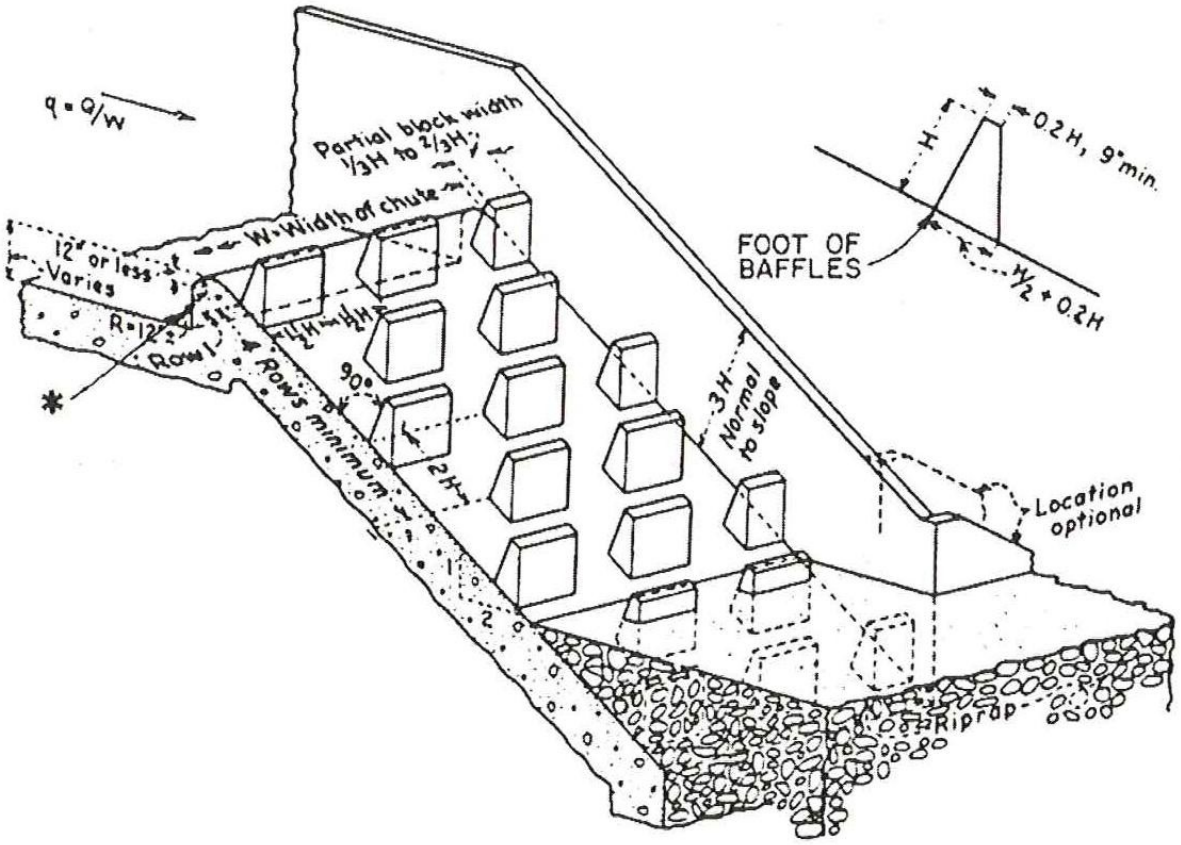
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BUREAU OF RECLAMATION
TYPE IV BASIN

FIGURE 12



* SILL IS REQUIRED WHERE ENTRANCE VELOCITY CANNOT BE CONTROLLED BY THE UPSTREAM CHANNEL CONSTRICTION, BUT FOR GRASS-LINED CHANNEL THE SILL ELEVATION NEEDS TO BE THE SAME AS THE CHANNEL, OTHERWISE UPSTREAM SILTATION WILL OCCUR.

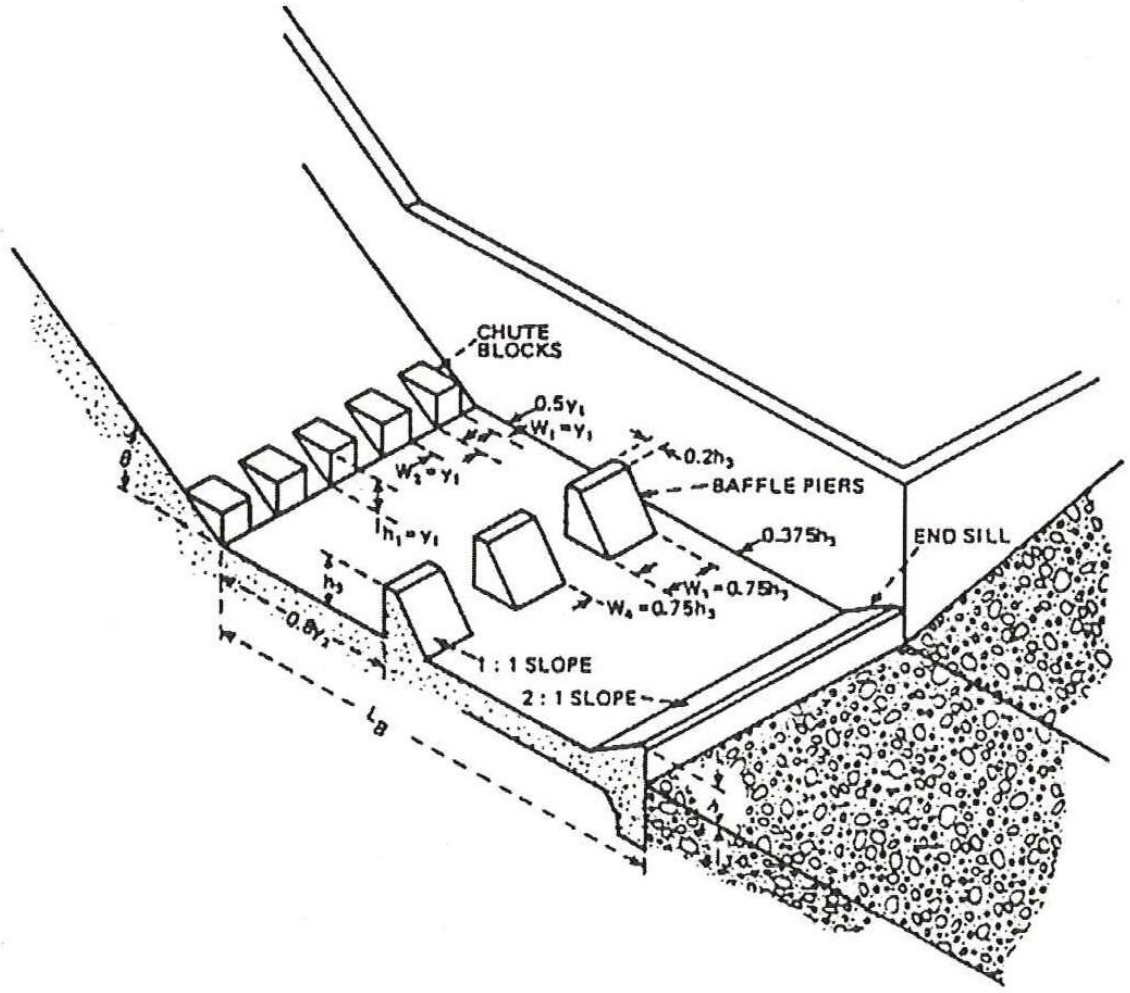
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BUREAU OF RECLAMATION
TYPE IX BASIN

FIGURE 13



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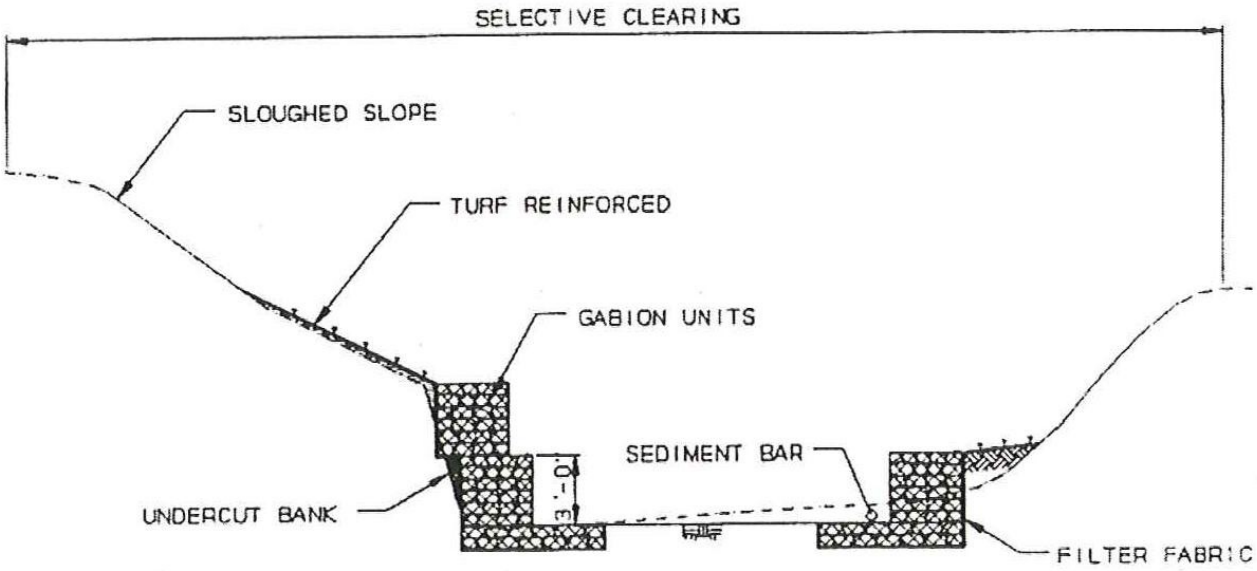
BUREAU OF RECLAMATION
TYPE III BASIN

FIGURE 14

NOTES:

1. SELECTIVE CLEARING TO REMOVE DEADFALL, TREES WITH UNDERCUT ROOTS, AND BRUSH. SOUND TREES MAY REMAIN.

2. HEIGHT OF GABION STRUCTURE VARIES. CONSTRUCT TO APPX. EQUAL HEIGHT OF EXISTING VERTICAL BANK FACE.

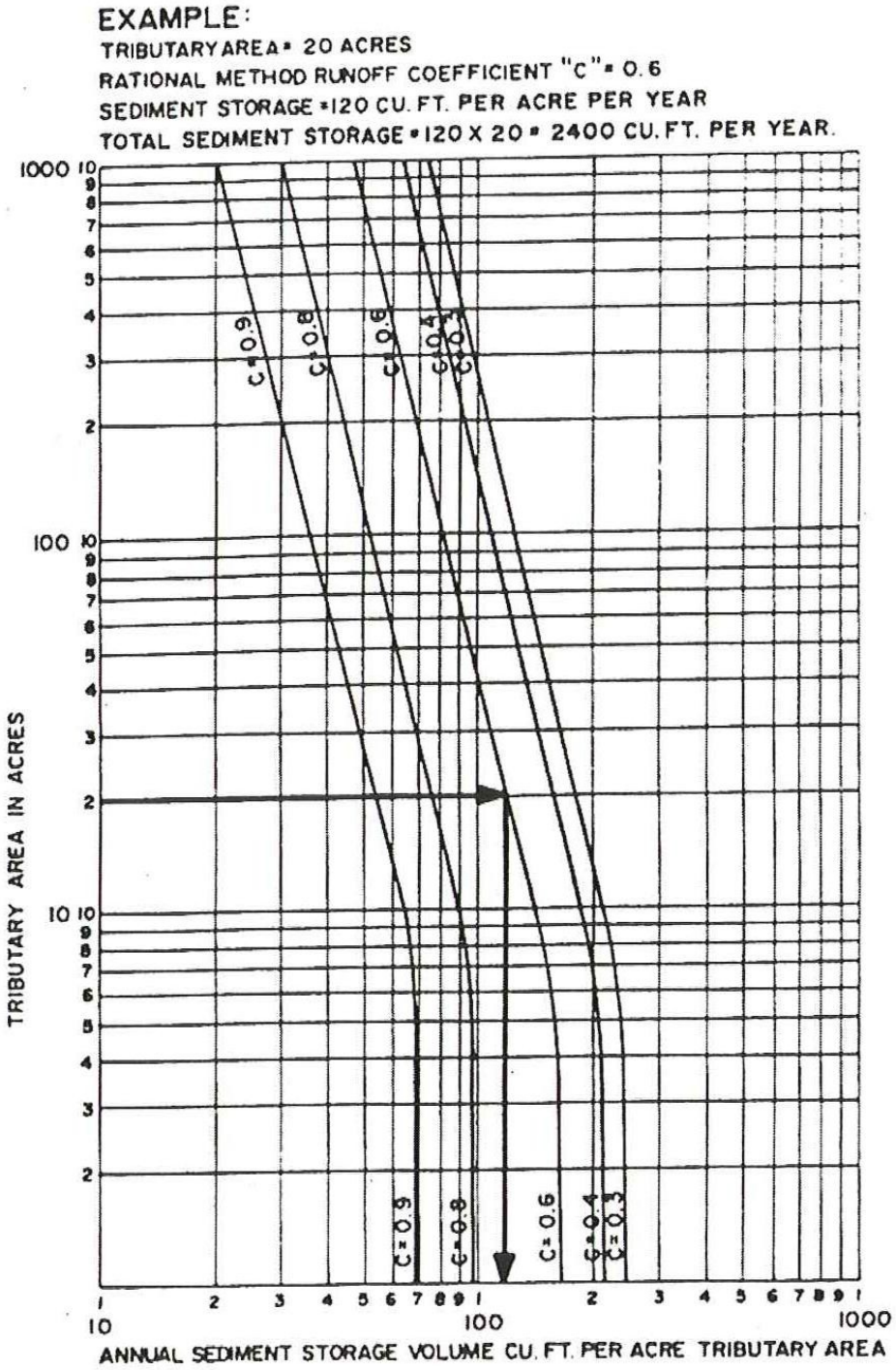


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BANK STABILIZAION
FOR STREAM OR CHANNEL

FIGURE 15



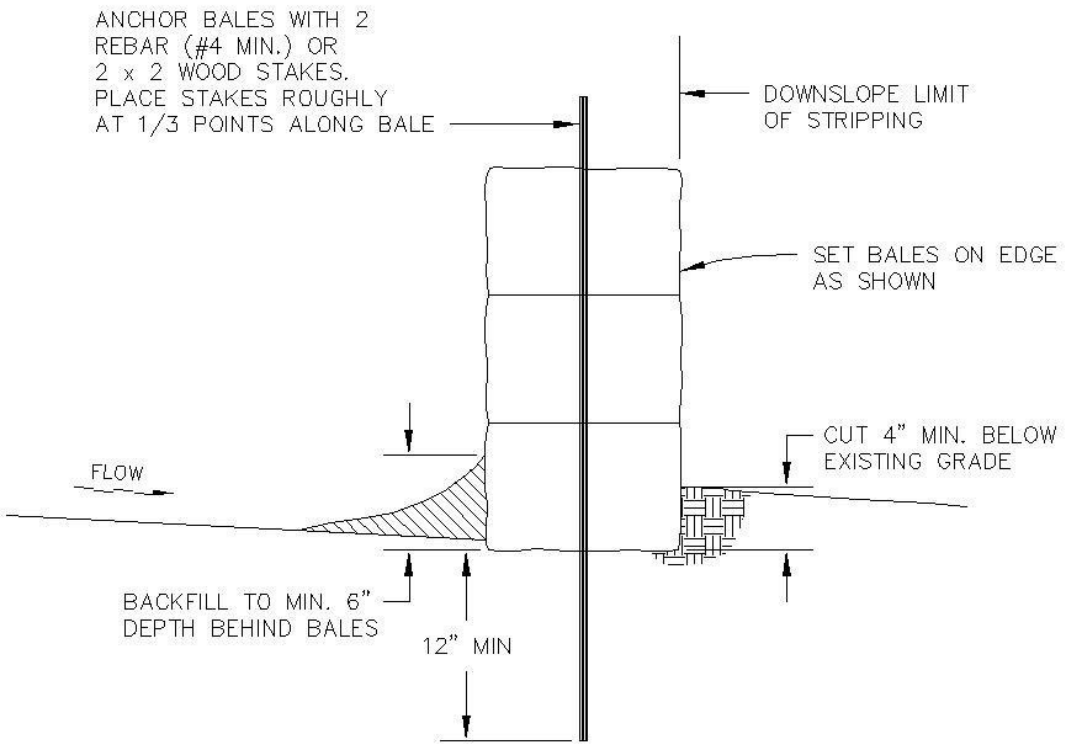
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ESTIMATED ANNUAL
SEDIMENT ACCUMULATION

FIGURE 16



NOTES:

1. PLACE HAY BALE DIKE AT DOWNSLOPE LIMIT OF AREA TO BE GRADED.
2. BALES SHALL BE PLACED IN A ROW WITH ENDS TIGHTLY ABUTTING THE ADJACENT BALES.
3. BALES SHALL BE PLACED ALONG A LEVEL CONTOUR WITH AN ALLOWANCE OF ±4 INCHES.
4. SEDIMENT TRAPPED SHALL BE DISPOSED IN AN APPROVED LOCATION IN A MANNER WHICH WILL NOT CONTRIBUTE ADDITIONAL SILTATION.
5. EACH BALE SHALL BE EMBEDDED IN THE SOIL A MINIMUM OF FOUR INCHES.
6. BALES SHALL BE SECURELY ANCHORED IN PLACE BY STAKES OR RE-BARS DRIVEN THROUGH THE BALES. THE FIRST STAKE IN EACH BALE SHALL BE ANGLED TOWARD PREVIOUSLY LAID BALE TO FORCE BALES TOGETHER.
7. INSPECTION SHALL BE FREQUENT AND REPAIR OR REPLACEMENT SHALL BE MADE PROMPTLY AS NEEDED BY CONTRACTOR.
8. BALES SHALL BE REMOVED WHEN THEY HAVE SERVED THEIR USEFULNESS SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.
9. ACCUMULATED SILT SHALL BE REMOVED WHEN IT REACHES A DEPTH OF 6 INCHES.
10. AT EACH END OF DIKE, TURN DIKE UPSLOPE AND EXTEND UNTIL GROUND SURFACE RISES 18 INCHES.

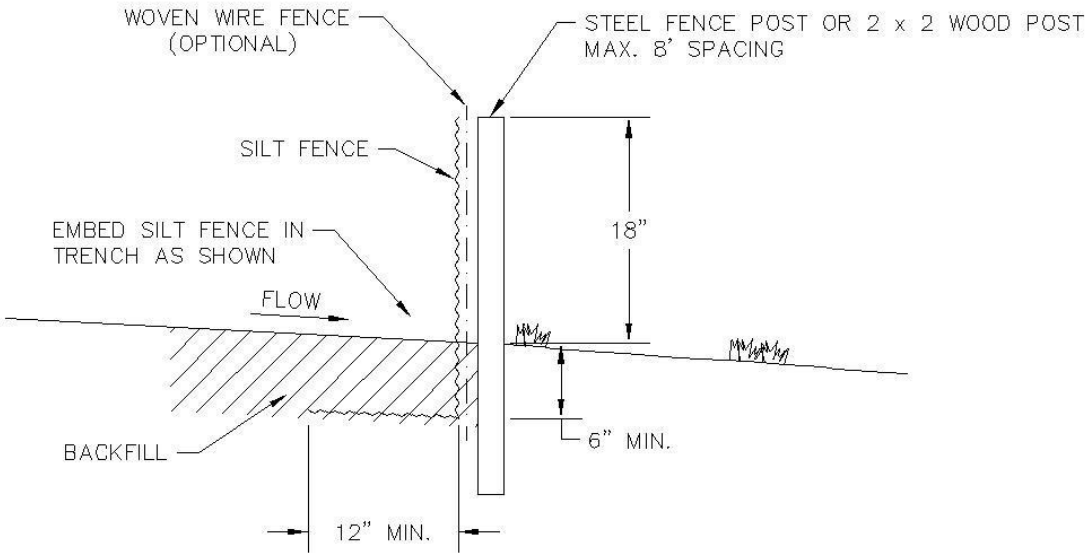
REFERENCE: Adapted from City of Austin & City of Tulsa Erosion and Sedimentation Control Manuals

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CRITERIA

HAY BALE DIKE

FIGURE 17



NOTES:

1. PLACE SILT FENCE AT DOWNSLOPE LIMIT OF AREA TO BE GRADED.
2. SILT FENCE SHALL BE PLACED ALONG A LEVEL CONTOUR WITH AN ALLOWANCE OF ± 4 INCHES.
3. SEDIMENT TRAPPED BY THIS PRACTICE SHALL BE DISPOSED OF IN AN APPROVED SITE IN A MANNER THAT WILL NOT CONTRIBUTE TO ADDITIONAL SILTATION.
4. SILT FENCE SHOULD BE SECURELY FASTENED TO EACH SUPPORT POST OR TO WOVEN WIRE, WHICH IS IN TURN ATTACHED TO THE STEEL FENCE POSTS.
5. INSPECTION SHALL BE FREQUENT AND REPAIR OR REPLACEMENT SHALL BE MADE PROMPTLY AS NEEDED.
6. SILT FENCE SHALL BE REMOVED WHEN IT HAS SERVED ITS USEFULNESS SO AS NOT TO BLOCK OR IMPEDE STORM FLOW OR DRAINAGE.
7. ACCUMULATED SILT SHALL BE REMOVED WHEN IT REACHES A DEPTH OF 6 INCHES.
8. AT EACH END OF SILT FENCE, TURN FENCE UPSLOPE AND EXTEND UNTIL GROUND SURFACE RISES 18 INCHES.

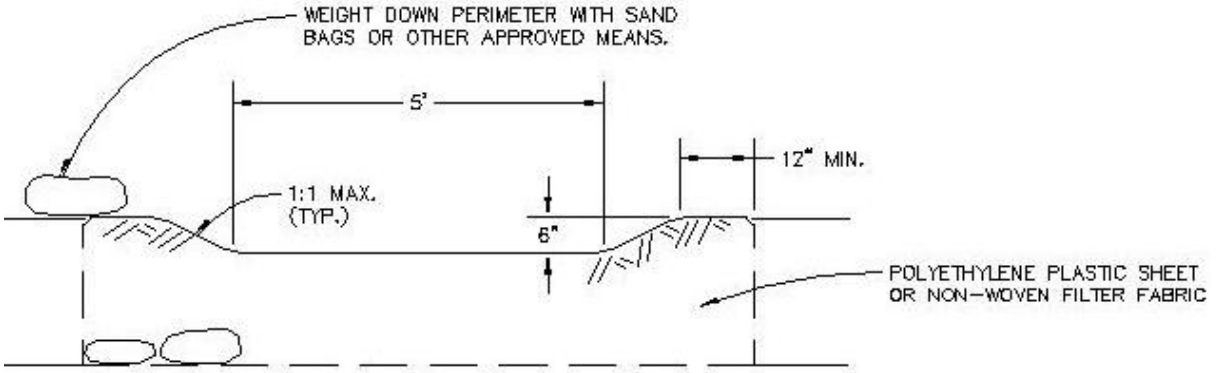
REFERENCE: Adapted from City of Austin & City of Tulsa Erosion and Sedimentation Control Manuals

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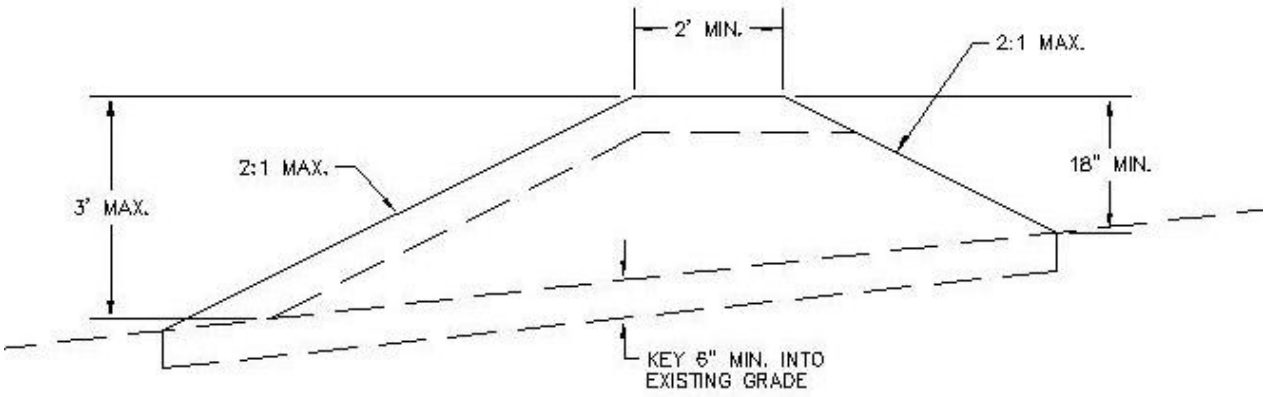
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CRITERIA

SILT FENCE

FIGURE 18



OVERFLOW AREA



NOTES:

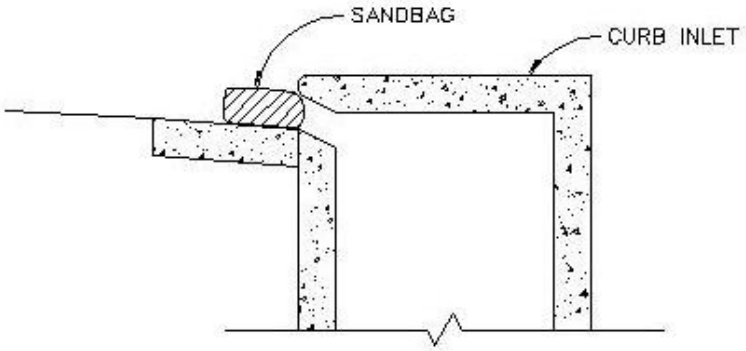
1. SOIL IN BERM SHALL BE FIRMLY COMPACTED.
2. AT EACH END OF BERM, TURN BERM UPSLOPE AND EXTEND UNTIL GROUND SURFACE RISES TO TOP OF BERM ELEVATION.
3. PROVIDE OVERFLOW AREAS AT 200 FT. MAX. INTERVALS.

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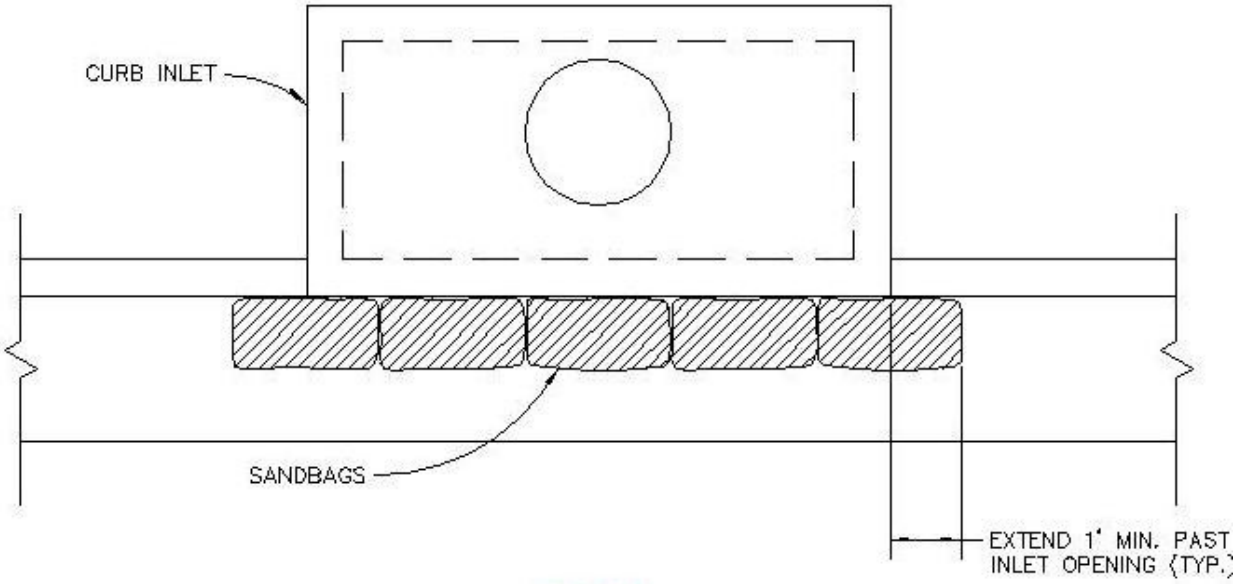
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TEMPORARY SILT
CONTAINMENT BERM

FIGURE 19



CROSS–SECTION



PLAN

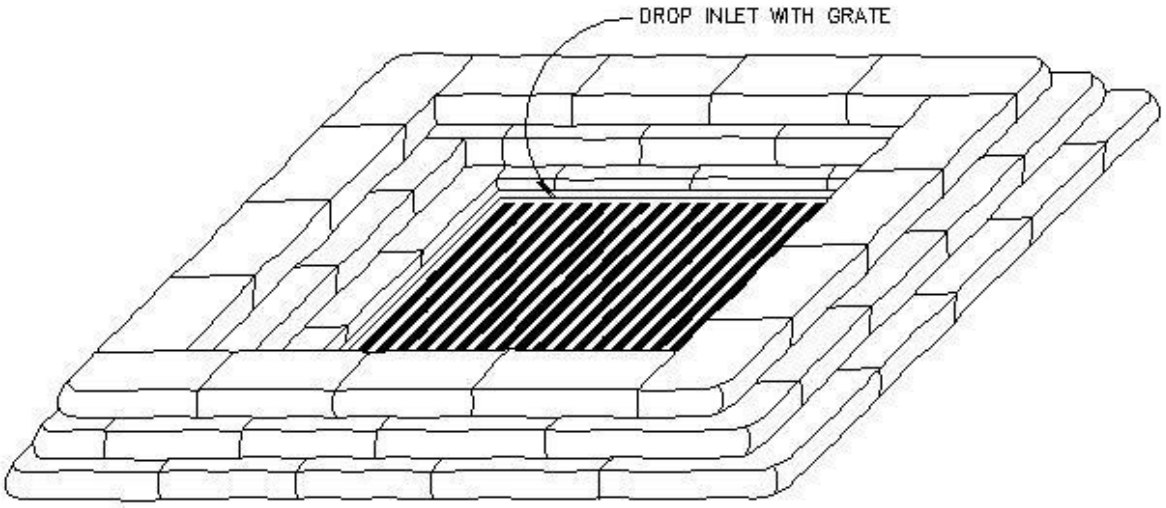
NOTES:
1. FILL BAGS WITH 5/8" CRUSHED LIMESTONE.
2. BAGS SHALL BE BURLAP OR BIODEGRADABLE PLASTIC.
3. BAGS SHALL BE INSPECTED AND REPLACED AS NEEDED.

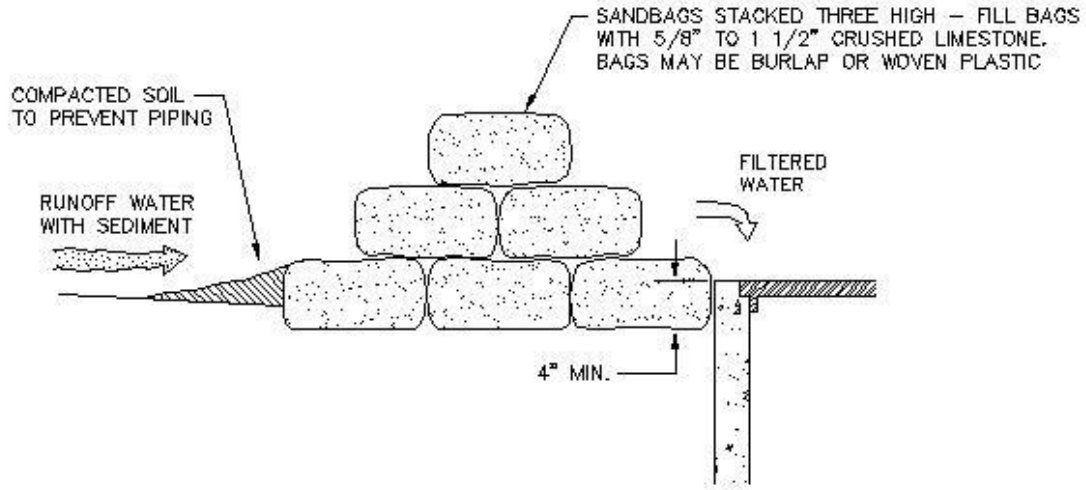
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STORMWATER MANAGEMENT
CRITERIA

SAND BAG SEDIMENT TRAP
FOR CURB INLETS

FIGURE 20





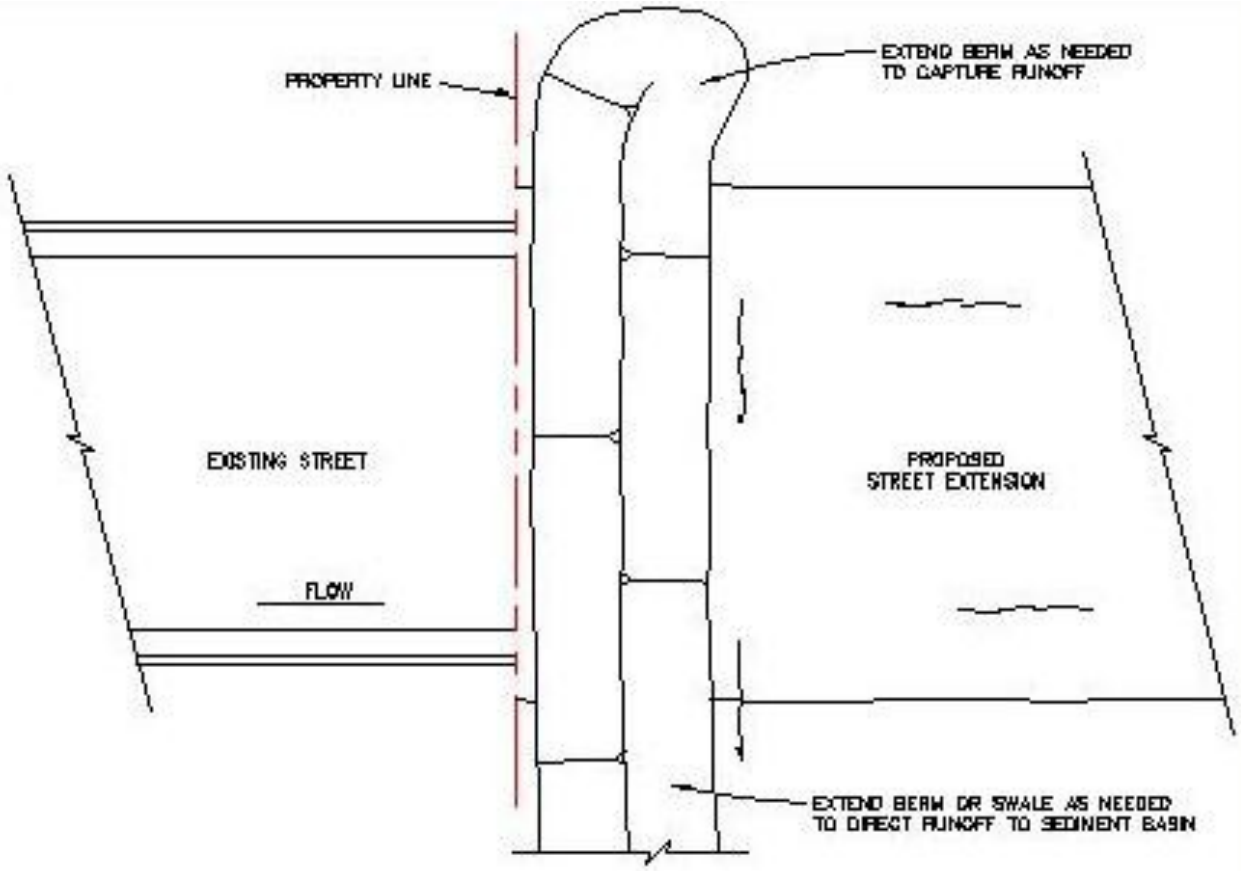
DROP INLET SEDIMENT FILTER

CITY OF JOPLIN MISSOURI

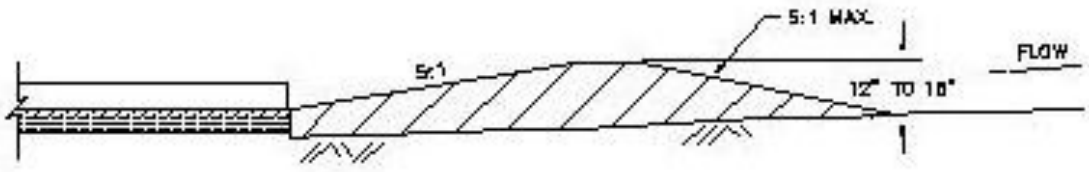
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STORMWATER MANAGEMENT
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AREA INLET
PROTECTION

FIGURE 21



PLAN



CROSS–SECTION

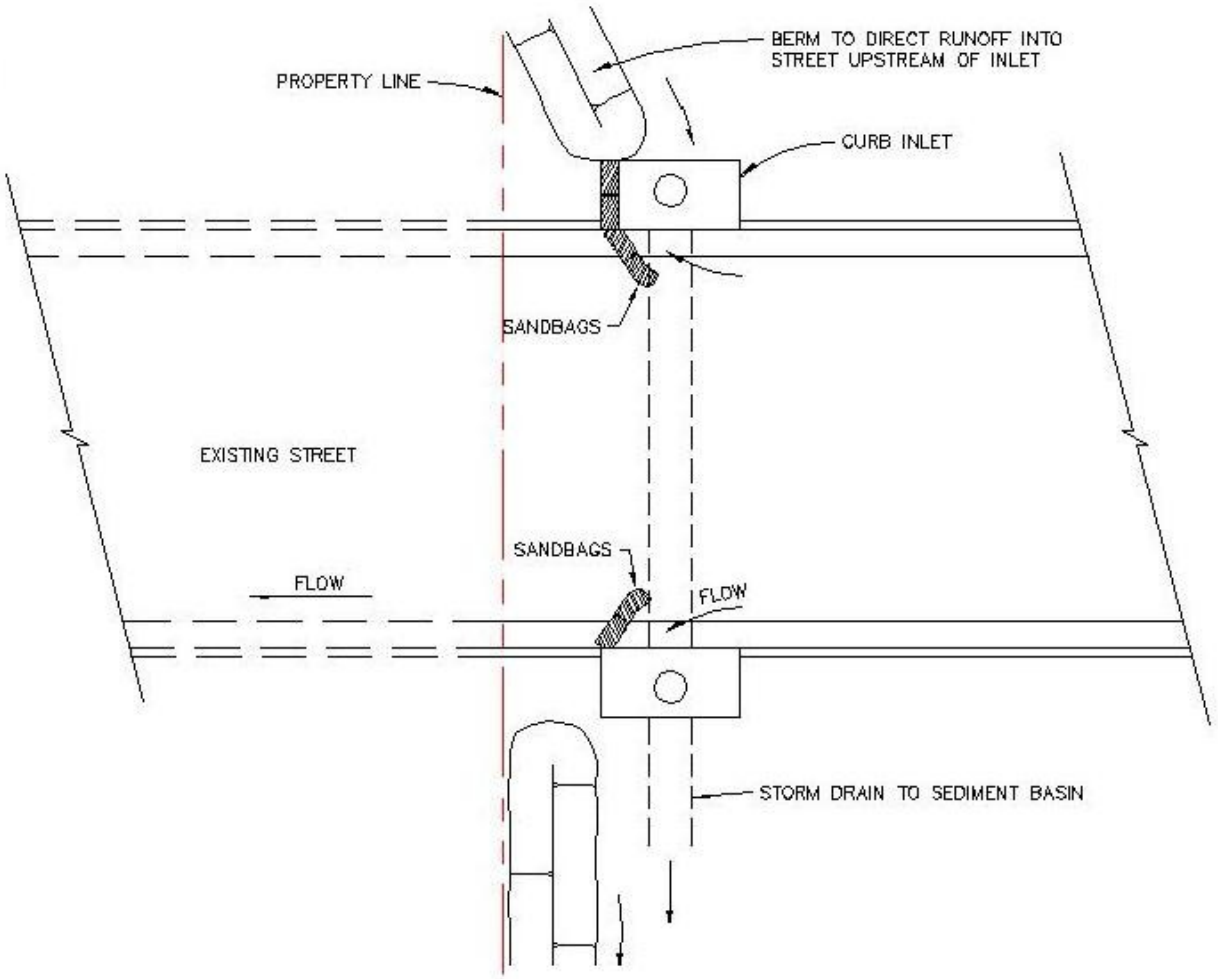
CASE 1
AFTER INITIAL EXCAVATION
OF SUBGRADE

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CRITERIA

DIVERSION OF RUNOFF
CURBED STREET

FIGURE 22



NOTE: FILL SANDBAGS WITH CHAT OR LIMESTONE SAND

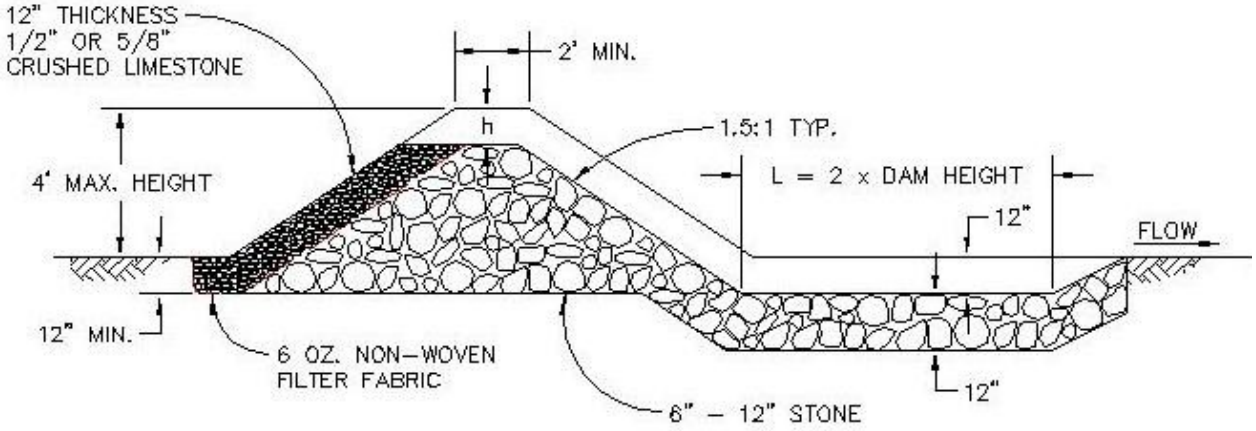
CASE 2
AFTER PAVEMENT AND
INLETS COMPLETED

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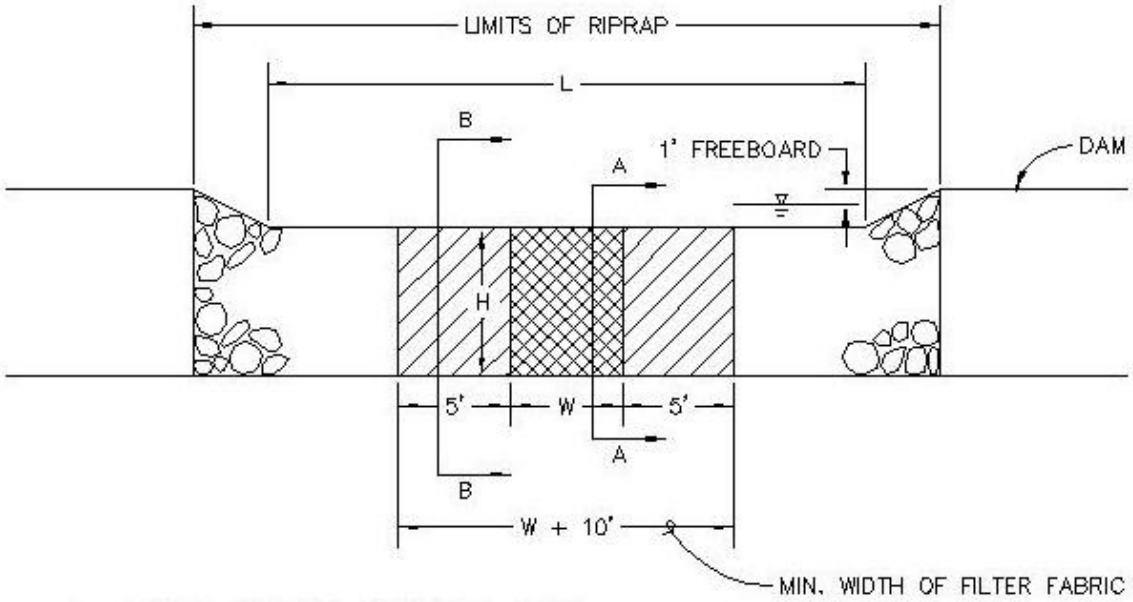
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STORMWATER MANAGEMENT
CRITERIA

DIVERSION OF RUNOFF
CURBED STREET

FIGURE 23



SECTION A - A (THRU GRAVEL FILTER)



L = LENGTH REQUIRED TO PASS Q_{10} WHILE MAINTAINING 1 FT. OF FREEBOARD

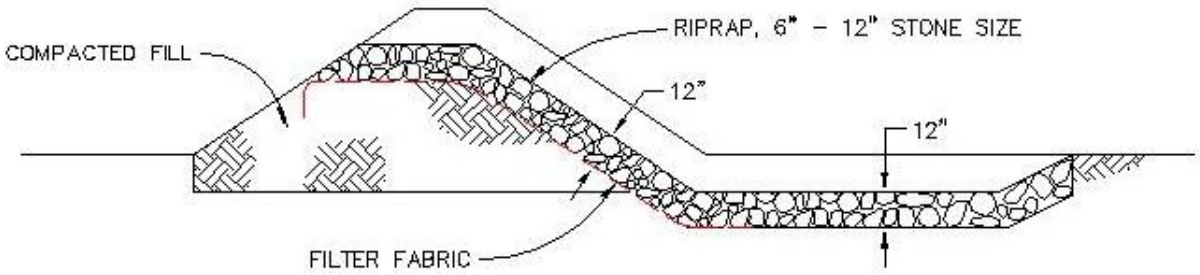
W = WIDTH OF ROCK FILTER AREA

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STORMWATER MANAGEMENT
CRITERIA

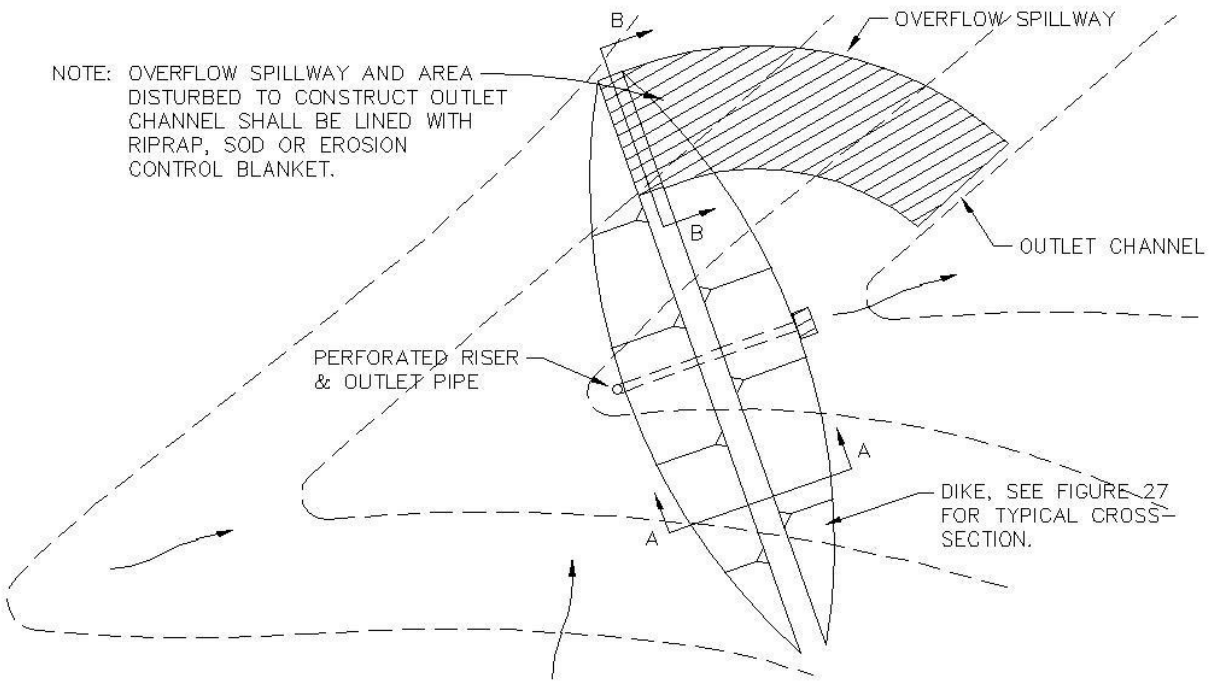
GRAVEL FILTER DAM

FIGURE 24



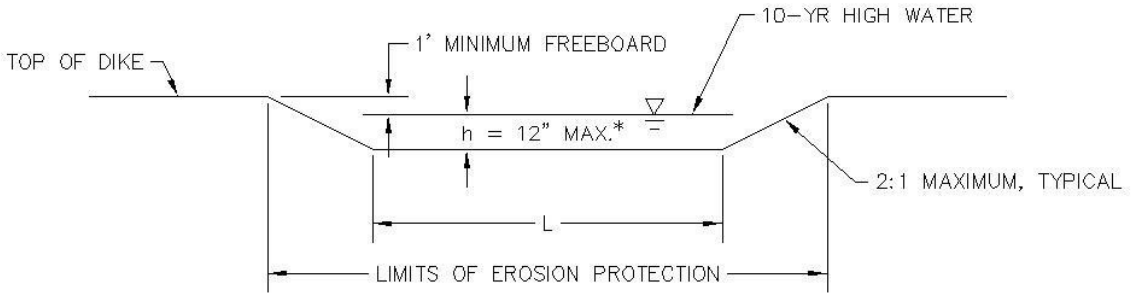
SECTION B – B

(FIGURE 24)



TYPICAL COMPONENTS OF TEMPORARY SEDIMENT BASIN PLAN

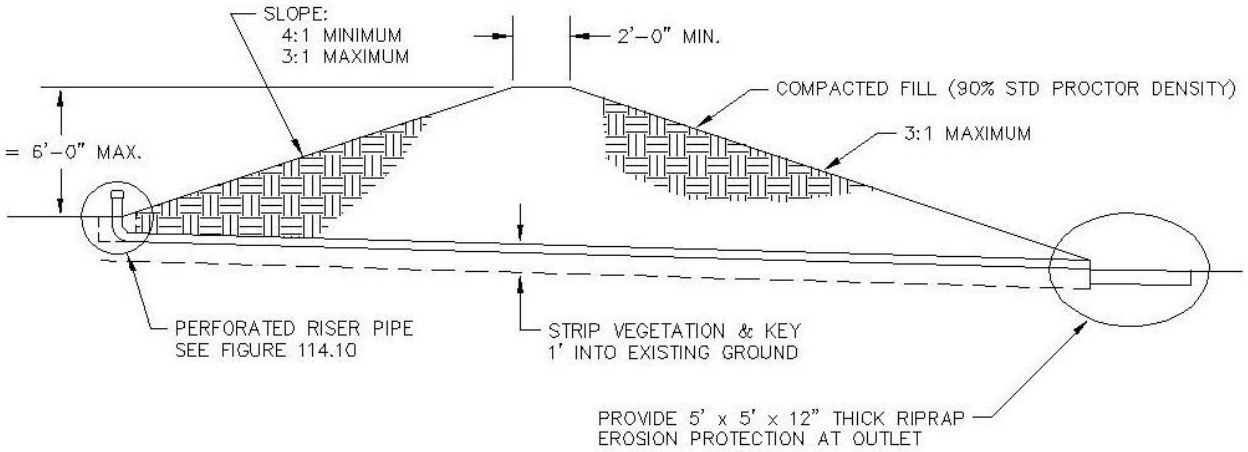
(PERFORATED RISER PIPE AND OVERFLOW SPILLWAY SHOWN. GRAVEL FILTER DAM AND RIPRAP OVERFLOW SPILLWAY AS SHOWN IN FIGURES 24 AND 25 MAY ALSO BE USED.)



*h = 6" MAX. IF SOD LINING USED

SECTION B -B
TYPICAL OVERFLOW SPILLWAY CROSS-SECTION

CITY OF JOPLIN MISSOURI	JOPLIN, MISSSOURI STORMWATER MANAGEMENT CRITERIA	TEMPORARY SEDIMENT BASIN
		FIGURE 26



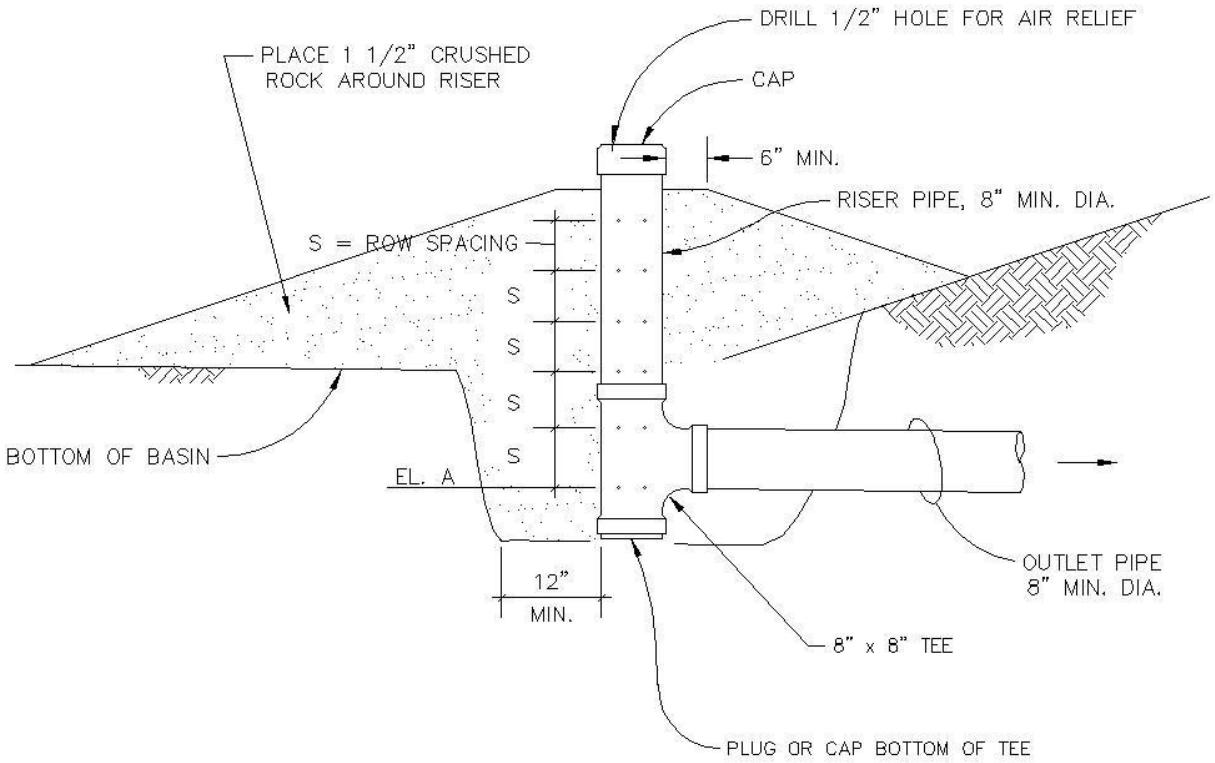
SECTION A – A

(FIGURE 26)

CITY OF JOPLIN MISSOURI	JOPLIN, MISSSOURI STORMWATER MANAGEMENT CRITERIA	TYPICAL SECTION SEDIMENT BASIN BERM & OUTLET FIGURE 27

n = NUMBER OF HOLES PER ROW

d = HOLE DIAMETER



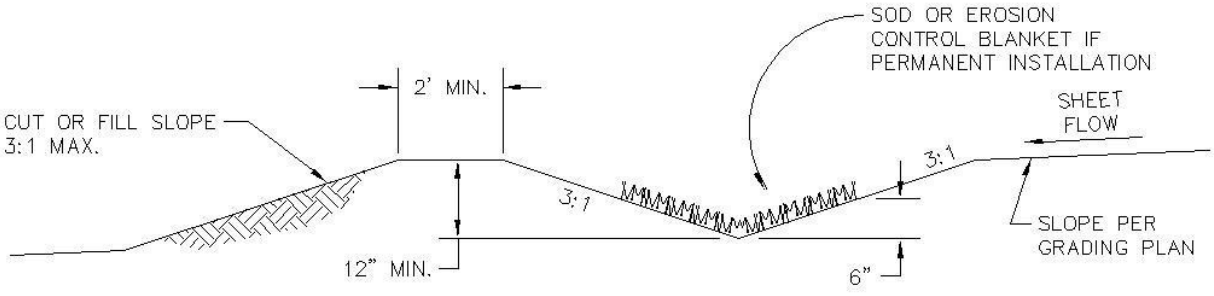
NOTE: BOTTOM ROW OF HOLES SHALL BE SET NO HIGHER THAN BOTTOM OF BASIN. ELEVATION OF BOTTOM ROW OF HOLES SHALL BE SET EQUAL TO INVERT ELEVATION OF OUTLET PIPE (EL. A). THIS ELEVATION MUST BE SPECIFIED ON THE DRAWING.

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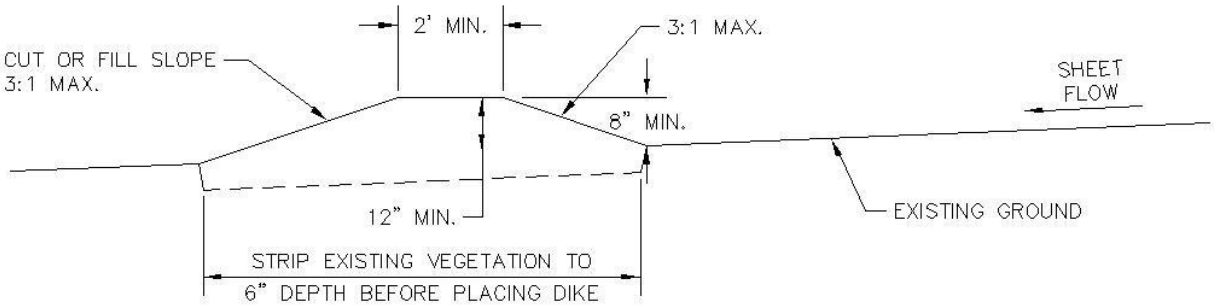
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STORMWATER MANAGEMENT
CRITERIA

SEDIMENT BASIN
PERFORATED RISER OUTLET

FIGURE 28



SWALE



DIKE

NOTES:

1. DIKE SHALL BE COMPACTED TO DENSITY EQUAL TO THAT SPECIFIED FOR ADJOINING AREA (90% STANDARD PROCTOR DENSITY, MINIMUM).
2. MINIMUM 1% GRADE MUST BE PROVIDED FOR SWALE OR ALONG UPSLOPE SIDE OF DIKE FOR PROPER DRAINAGE.

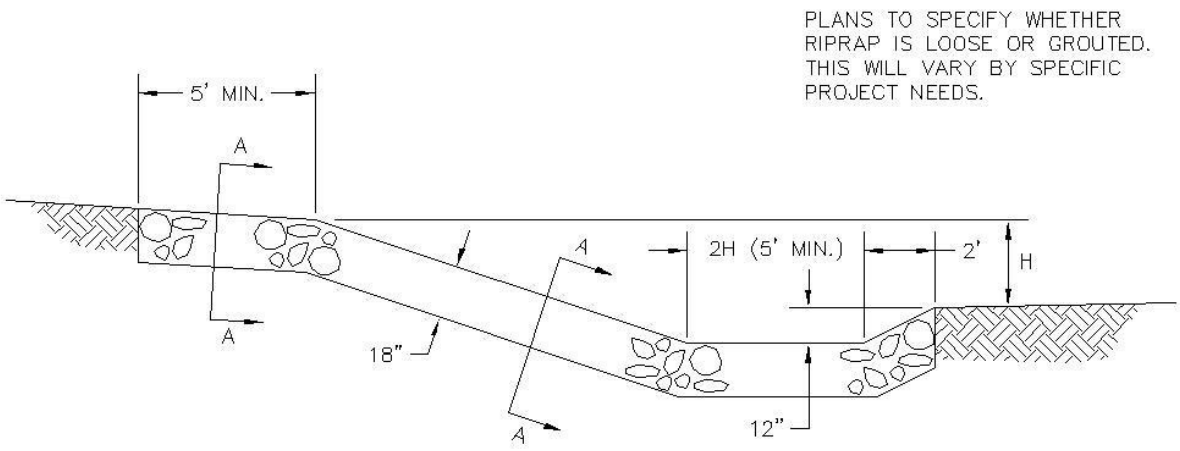
REFERENCE: Adapted from City of Austin & City of Tulsa Erosion and Sedimentation Control Manuals

CITY OF JOPLIN MISSOURI

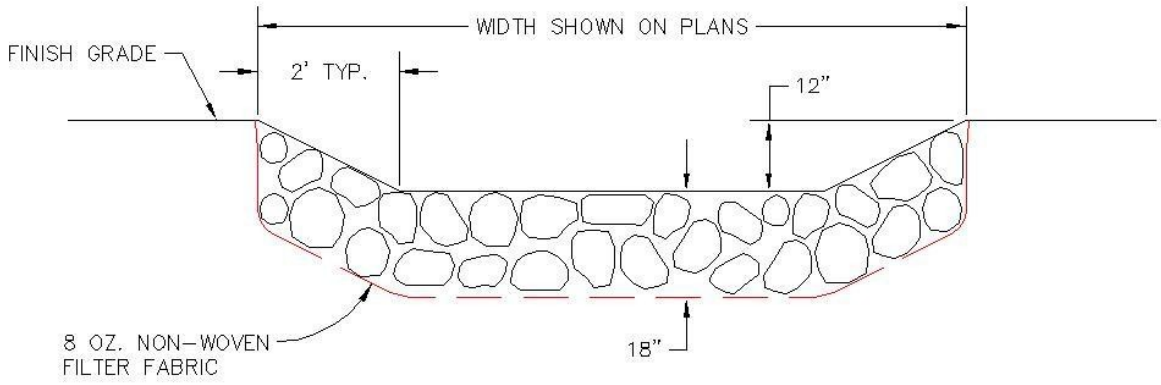
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STORMWATER MANAGEMENT
CRITERIA

DIVERSION DIKES AND SWALES

FIGURE 29



TYPICAL SECTION



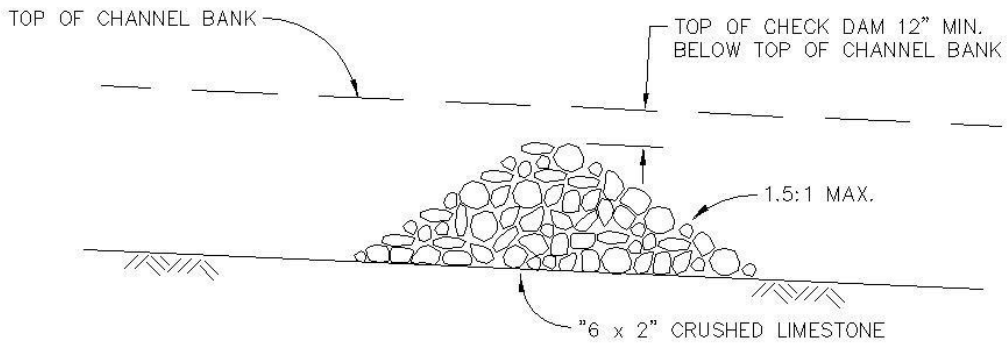
SECTION A – A

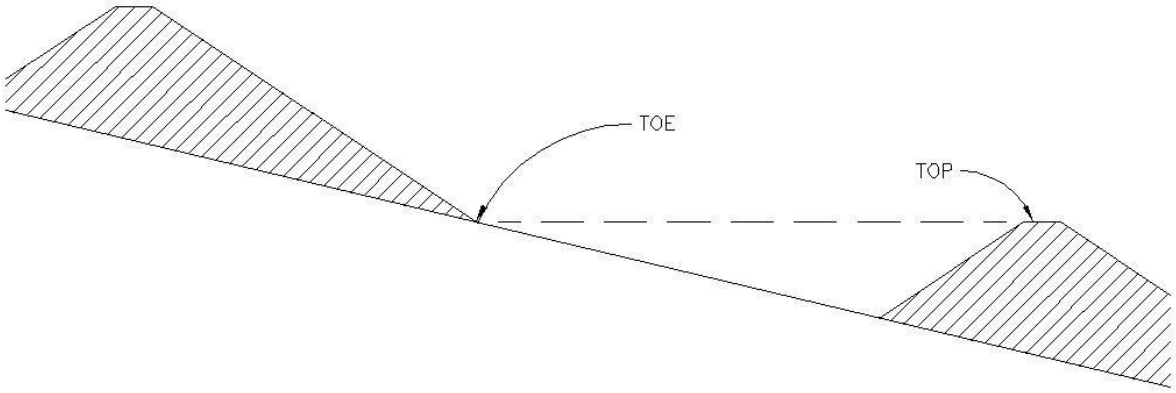
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STORMWATER MANAGEMENT
CRITERIA

RIPRAP CHUTE
CROSS SECTION

FIGURE 30





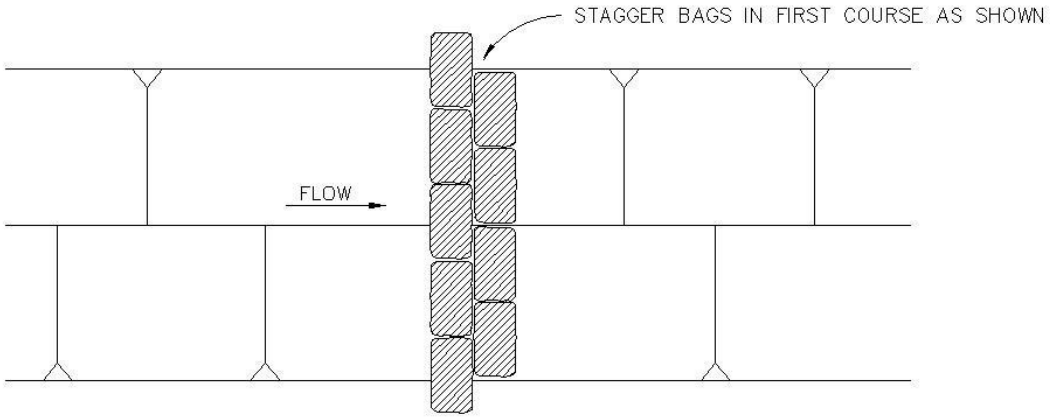
TYPICAL CHECK DAM SPACING

CITY OF JOPLIN MISSOURI

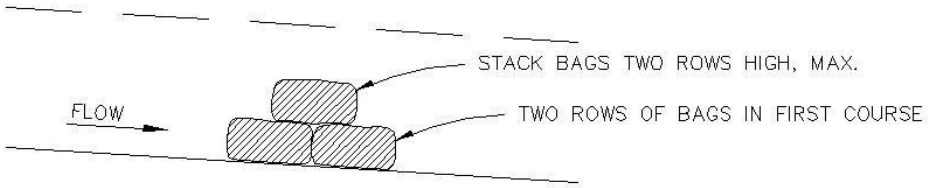
JOPLIN, MISSSOURI
STORMWATER MANAGEMENT
CRITERIA

ROCK CHECK DAM

FIGURE 31



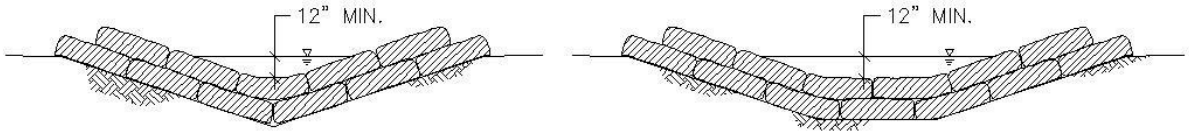
PLAN



PROFILE

NOTES:

FILL BAGS WITH 5/8" TO 1 1/2" CRUSHED LIMESTONE.
BAGS MAY BE BURLAP OR WOVEN PLASTIC.
SPACE CHECK DAMS AS SHOWN IN FIG. 31 OR AS SPECIFIED ON SEDIMENT & EROSION CONTROL PLAN.



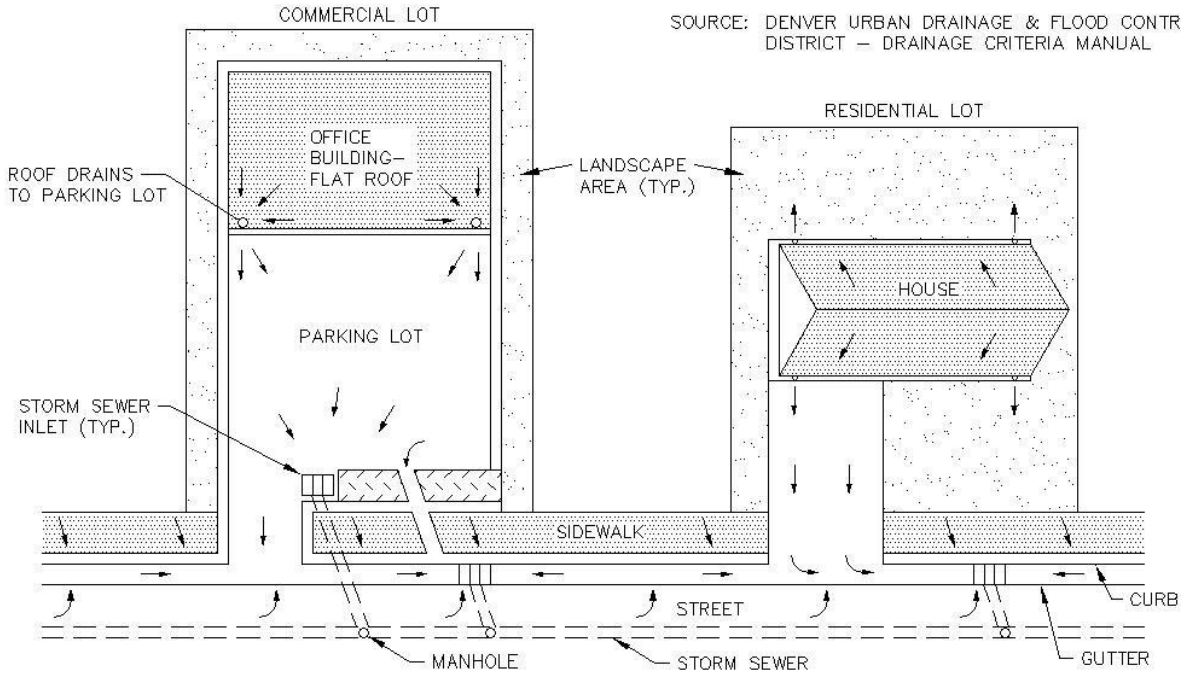
TYPICAL CROSS-SECTIONS

CITY OF JOPLIN MISSOURI

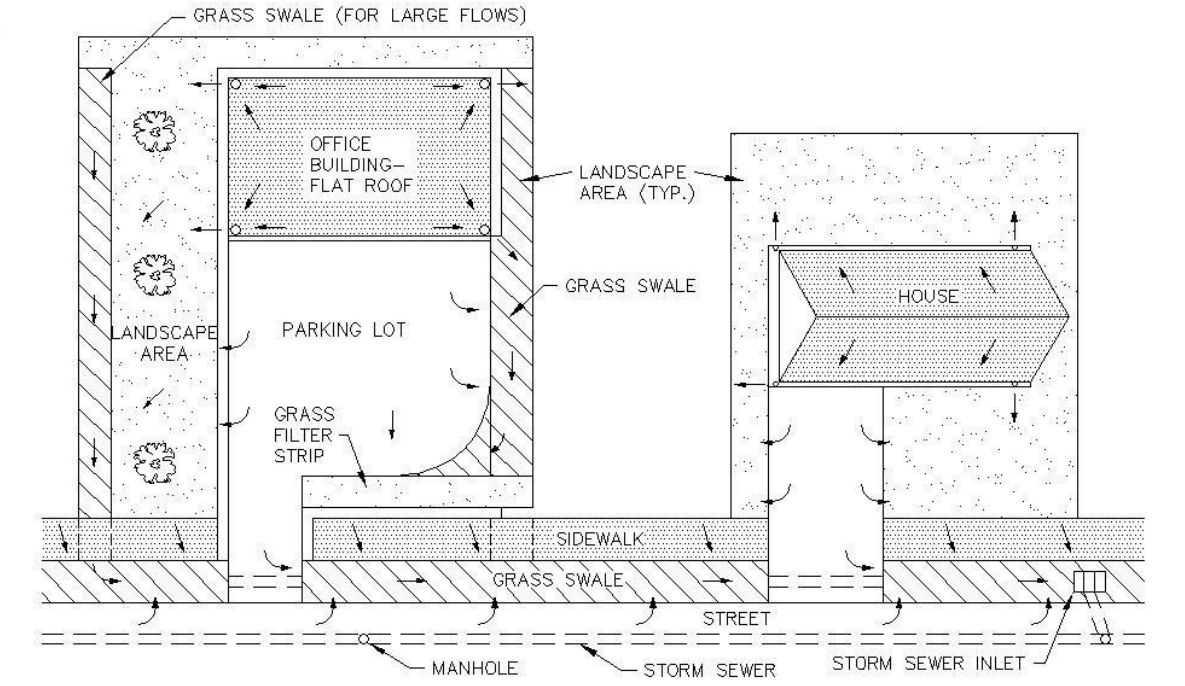
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CRITERIA

SANDBAG CHECK DAM

FIGURE 32



TRADITIONAL SITE & STREET DRAINAGE DESIGN



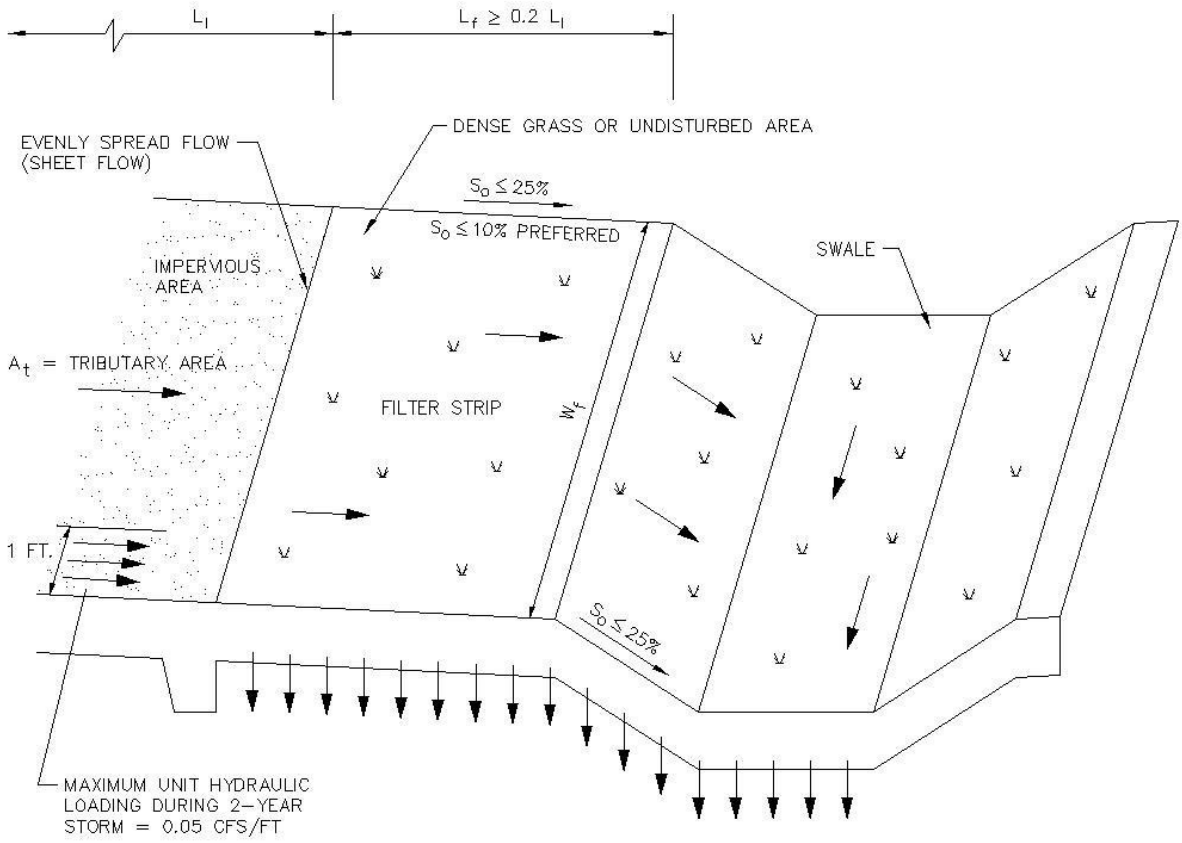
MINIMIZING DIRECTLY CONNECTED IMPERVIOUS AREAS

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CRITERIA

EXAMPLE OF
MINIMIZING DCIA

FIGURE 33



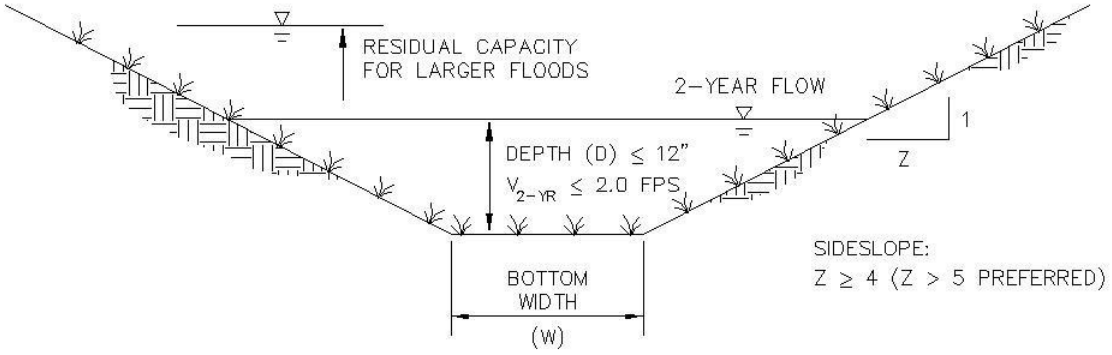
ADAPTED FROM DENVER URBAN DRAINAGE & FLOOD CONTROL DISTRICT – DRAINAGE CRITERIA MANUAL

CITY OF JOPLIN MISSOURI

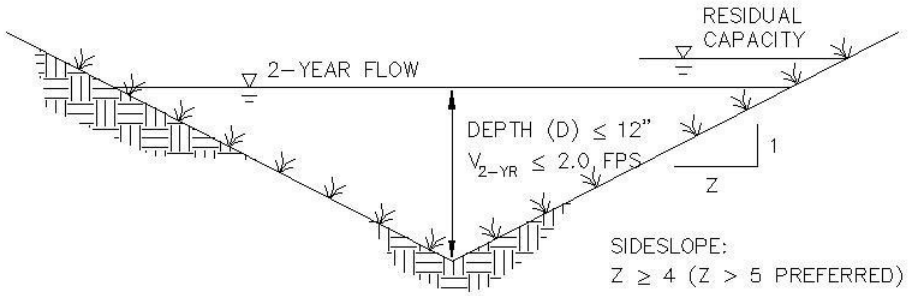
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VEGETATVIE FILTER STRIP
WATER QUALITY BMP

FIGURE 34



TRAPEZOIDAL GRASS-LINED SWALE SECTION



TRIANGULAR GRASS-LINED SWALE SECTION

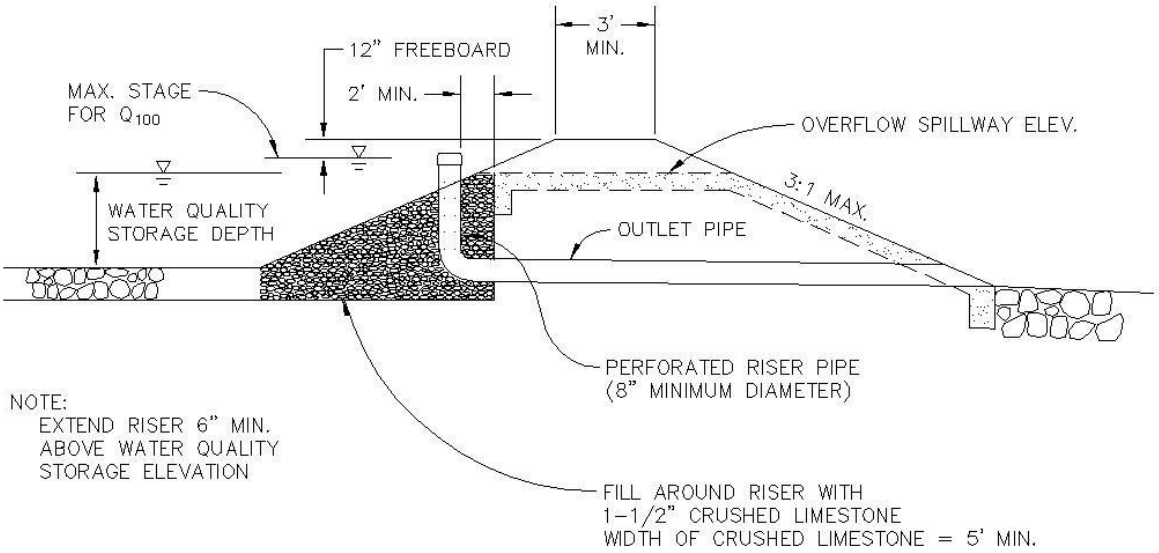
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GRASS SWALE
WATER QUALITY BMP

FIGURE 35

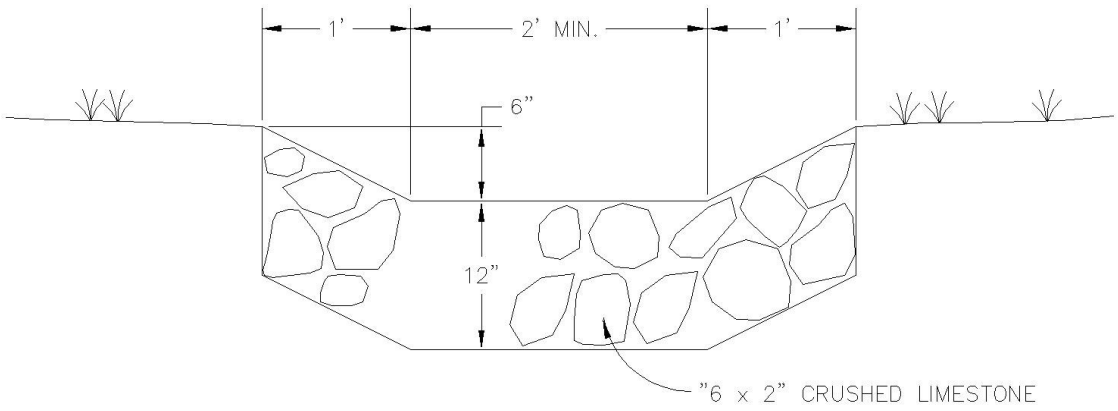


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EXTENDED DRY DETENTION
WATER QUALITY BMP

FIGURE 36



ROCK TRICKLE CHANNEL FOR
EXTENDED DRY DETENTION BASINS
TYPICAL CROSS SECTION
WATER QUALITY BMP

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EXTENDED DRY DETENTION
BASIN TYPICAL DETAILS

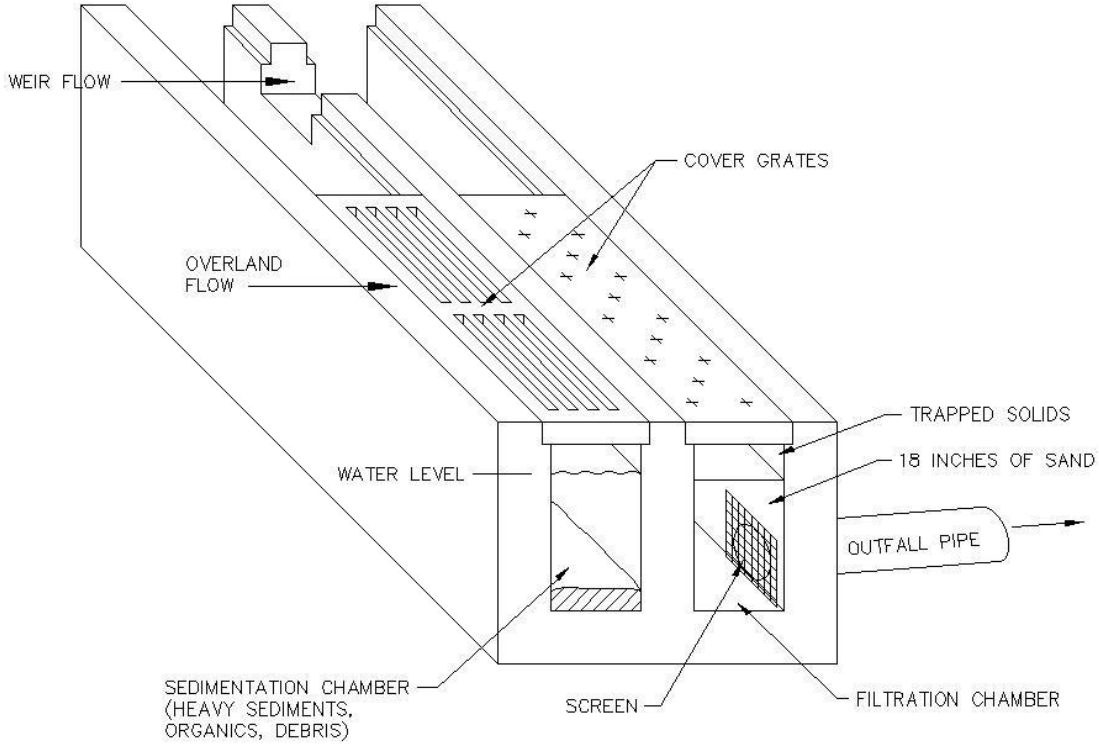
FIGURE 38

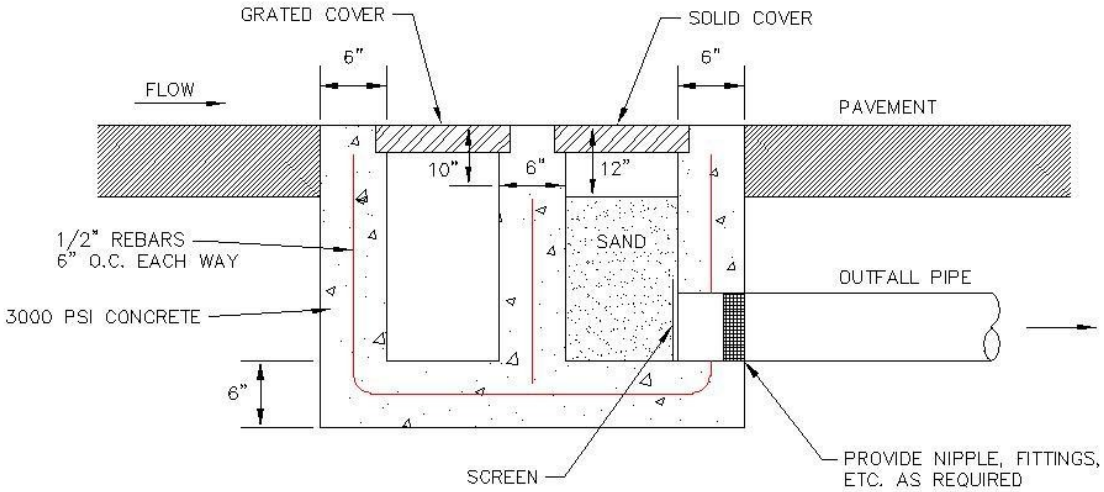
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WET EXTENDED DETENTION BASIN TYPICAL DETAILS

FIGURE 39





FROM: EPA 1992

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CRITERIA

SAND FILTER
SCHEMATIC

FIGURE 40