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CHAPTER 3 DRAINAGE

3.1 OVERVIEW

This chapter provides policies and procedures to attain reasonable standardization of drainage design throughout the County.

3.1.1 Purpose

The purpose of this chapter is to discuss specific drainage and grading related criteria for projects that disturb surface soils within the unincorporated areas of the County. In addition, with the issuance of a County-wide National Pollutant Discharge Elimination System (NPDES) permit, this chapter and adopted Addendum presented in Appendix I provide specific criteria and standards for the management and protection of surface water quality.

3.1.2 Chapter Content and References

Table 3-1 outlines the chapter content and references used as a basis for the standards established in Chapter 3.

Table 3-1. Contents and Basis of Drainage Facility Standards

Intent Use	ECM Content	ECM Section(s)	Reference Document(s)
Planning			
	Plan Basis	3.2.1 - 3.2.3	2
	Plan Objectives and Policies	3.2.4 - 3.2.8 and Appendix I	2, 3
Design			
	Site Grading	3.3.1	2, 3
	Storm Sewers	3.3.2	2, 3
	Culverts	3.3.3	2, 3
	Open Channels	3.3.4	2, 3
	Drainage Ditches	3.3.5	2, 3
	Roadways	3.3.6	2, 3
Construction			
	Permitting	5.3, 5.6 and Appendix I	1, 3
	Inspections	5.11 and Appendix I	1, 3
	Acceptance	5.3 and Appendix I	1, 3

References

1. El Paso County Land Development Code
2. City of Colorado Springs Drainage Criteria Manual Volume 1 (DCM 1)
3. City of Colorado Springs Drainage Criteria Manual Volume 2 (DCM 2)

3.1.3 Standard Drawings

Table 3-2 identifies the standard drawings that are included in Appendix F as an enforceable part of these Standards. The standard drawings shall be used in all applications for which a public improvement is to be designed. Any change to a standard

drawing shall be approved by the ECM Administrator and noted on the construction plans.

Table 3-2. Standard Drawings

File Name	Detail/Description	Approval Date
SD_3-1	Storm Sewer Manhole Detail Type I	
SD-3-2	Storm Sewer Manhole Detail Type II	
SD_3-3	Storm Sewer Manhole Detail Type III	
SD_3-5	Storm Sewer Manhole Lid Detail	
SD_3-7	Storm Sewer Manhole Riser and Cover Detail	
SD-3-8	Grate Inlet for Common Areas (guidance)	
SD_3-14	Driveway Access on Rural Local Roadway	
SD_3-24	Sidewalk Underdrain w/ Curb Outlet Detail	
SD_3-25	Curb Opening w/ Drainage Chase Detail 1 of 2	
SD_3-25A	Curb Opening w/ Drainage Chase Detail 2 of 2	
SD_3-30	Desilting Basin Outlet	
SD_3-31	Temporary Desilting Basin at Inlet	
SD_3-32	Temporary Desilting Basin at Sump	
SD_3-33	On Street Temporary Desilting Basin Detail	
SD_3-34	Temporary Desilting Basin Detail (guidance)	
SD_3-35	Debris Cage for Desilting Basin Riser	
SD_3-36	Desilting Basin Riser Detail	
SD_3-41	Lined Ditch Splashwall Detail (plan and section)	
SD_3-44	Lined Ditch Behind Retaining Wall Detail	
SD_3-48	Beehive Grate Detail (guidance)	
SD_3-60	Temporary Street Sandbag Detail and Section	
SD_3-62	Typical Check Dam Detail	
SD_3-71	Canyon Subdrain Detail	
SD_3-81	Lug Connection Detail (cast in place concrete pipe)	

3.2 PLANNING

3.2.1 Developing a Plan for Drainage

All drainage systems being designed in the County shall take into account both minor intensity and major intensity storms. The objective of drainage system planning for minor intensity storms reoccurrence interval is to allow for the proper design of minor drainage systems (i.e., curb and gutters, storm sewers, culverts, open channels, and detention ponds) while minimizing minor damage and maintenance costs. The objective of drainage planning for major intensity storms (100-year reoccurrence interval) is to allow for proper design of major drainage systems (i.e., bridges, storm sewers, open channels, and detention ponds) while minimizing the possibility of major damage and/or loss of life.

It is the design engineer's responsibility to develop, justify, and submit values and calculations used in the preparation of drainage for county review and approval.

3.2.2 Natural and Artificial Systems

Conveyance systems include drainage facilities, both natural and artificial, that collect, contain, and convey stormwater runoff. Natural conveyance systems include, but are not limited to, swales, wetlands, drainage courses, streams, and rivers. Artificial conveyance systems include, but are not limited to, gutters, ditches, pipes, catch basins, manholes, constructed wetlands, open channels, and swales. Requirements for artificial conveyance systems, where natural systems already exist, shall not be interpreted to supersede County requirements for protection of natural systems.

3.2.3 Requirements of Adequate Drainage Systems Required

Adequate drainage designs shall provide for removal of runoff from the roadway or the upstream end of any development, and for carrying runoff water from the upstream side to the downstream side. These functions shall be accomplished without causing objectionable backwater, causing excessive or increased velocities, creating damages to downstream ownerships, unduly affecting the safe operation of traffic on the roadway, damaging the roadway or damaging water quality.

3.2.4 Suitable Outfall Location Definition

A suitable outfall location refers to a stream which is a hydraulically adequate historic natural stream or channel segment which developed conveyance systems (i.e. storm drain systems, channels, and detention basin outlets) shall utilize for ultimate discharge of stormwater runoff from development. A suitable outfall stream may be a perennial or ephemeral stream in its previously undeveloped, natural condition. The other choice for a new stormwater outfall is a connection to an existing hydraulically adequate man-made system.

Any and all proposed man-made systems for stormwater conveyance shall outfall to a location as identified above, which is capable of receiving developed flows without negative impacts to streambed stability and/or natural sediment transport functions. Man-made conveyance systems are not limited to storm drain systems, detention basin outlets, and lined channels, but also include any change in the land configuration by

grading which results in a new runoff pattern in terms of flow direction and quantity of runoff.

All suitable outfall streams as defined above shall be defined on a map of the basin and included in the applicable drainage basin planning study. In the event an older planning study does not define a suitable discharge point for a new stormwater discharge in the basin, the above criteria shall still apply.

3.2.5 Basic Objectives

The purpose of the drainage system is to collect, transmit, and discharge drainage consistent with the following objectives:

A. Space Planning

Adequate space shall be provided and properly allocated for drainage facilities to ensure that downstream water damage has been eliminated and that the functionality of urban systems has been maintained. At no time shall concentrated flows be allowed in developed lots.

B. Multi-Use Resource

Stormwater runoff shall be treated as a multi-use resource and the design of storm drainage management facilities shall be planned to ensure that the multi-use aspects of drainage facilities are maintained.

C. Jurisdictional Boundaries and Master Planning

Drainage boundaries are non-jurisdictional and regional cooperation is required to receive approval of facilities that have potential multi-jurisdictional and regional impacts through the preparation of a new or use of an existing Drainage Basin Planning Study.

D. Floodplain Management

The design of drainage facilities shall consider the general purpose of the County's Floodplain Regulations and to reduce the hazard of floods to life and property, protect and preserve hydraulic characteristics of water courses used for conveyance of floodwaters, protect the public from the extraordinary financial expenditures for flood control and relief, and promote the multi use resource concept with the intent to provide and preserve quality open space, trails, and tree lines.

E. Stormwater Quantity and Quality

Land disturbance activities shall properly manage and mitigate both stormwater quantity and quality related impacts. Quantity related impacts shall be mitigated in a manner that controls possible damage caused by the amount of surface water being transported to any one design point. Quality related impacts shall be mitigated using approved BMPs discussed in the adopted Addendum presented in Appendix I.

F. Water Rights

When proposed drainage systems interfere with existing water rights, the value and use of the water are affected; therefore, the design of any proposed stormwater drainage system incorporating retention shall identify the impact to water rights, and shall be approved by the State Engineer as appropriate.

3.2.6 County Policy on Drainage Diversion

Colorado drainage law recognizes the inequity in transferring the burden of managing storm drainage from one location or property to another. Liability questions may also arise when the historic drainage continuum is altered. Therefore, diversion of stormwater runoff from one basin to another is discouraged unless specific and prudent reasons justify such a transfer without impacting the historical drainage paths within the basin and the appropriate legal agreements have been recorded.

3.2.7 County Roadside Ditches

Consistent with Section 3.2.5, the County's existing roadside ditch and ditch systems shall not be used as an outfall conveyance for developed runoff. The main purpose of these ditch systems is to collect and properly convey stormwater from adjacent public roadways and they should not be considered as a suitable outfall for conveyance of developed runoff. Should a roadside ditch be the only true option, downstream capture and storage of sediment shall be planned for and provided for in the construction plans.

3.2.8 Hydrology

A. Design Storm

Design storm flows shall be calculated based on appropriate criteria and guidelines presented in the DCM 1 to assure minimum design standards and that a regional drainage solution is developed. Information presented in these Standards do not replace information presented in the other referenced standards, but instead should be considered as additional criteria and shall be used in determining design storm runoff for both on-site and off-site flows.

B. Peak Volumes and Times of Concentration

Peak volumes and times of concentrations shall consider fully developed land use scenarios to determine runoff coefficients and changes in flow patterns (from the undeveloped site conditions). Estimated times of concentration shall be based on proposed grading. The proposed project or developed land use shall not change historical runoff values, cause downstream damage or adversely impact adjacent properties.

C. Entire Project Area

Phased or partial development analysis will not be accepted. The entire project area shall be analyzed based on full build-out to properly site and size storage areas and conveyance systems.

D. Off-Site Runoff

The analysis of off-site runoff is dependent on regional drainage characteristics, the existing/proposed land use, and topographic features. If an existing storm drainage master plan is available for the area, the storm drainage master plan shall be used as a baseline document and updated with proposed information. Should no off-site information be available for fully developed flows, the design engineer must perform a regional analysis to ensure that the project does not change historic runoff values, cause downstream damage or adversely impact adjacent properties.

E. Design Runoff

Design runoff shall be based on the following information:

- The 5-year minor design storm may be used in accordance with City of Colorado Springs adopted revisions to DCM 1..
- Within floodplain and floodplain fringe areas, as defined by the FEMA, the runoff criteria shall be based on a 100-year frequency storm
- For all drainage channels and storm drain systems, which will convey drainage from a tributary area equal to and greater than one square mile, the runoff criteria shall be based on a 100-year frequency storm.
- For tributary areas under one square mile, (1) the storm drain system shall be designed so that the combination of storm drain system capacity and overflow will be able to carry the 100-year frequency storm without damage to or flooding of adjacent existing buildings or potential building sites, and (2) the runoff criteria for the minor storm and underground storm drain systems shall be based upon a frequency storm consistent with DCM 1 and 2.

F. Design Runoff Methods

Storm discharge flows shall be based on the adopted storm drainage master plan. If no established storm discharge flows are available, the storm drainage flows shall be based on the following:

- Design flows for watersheds less than 100 acres shall be developed using the Rational Method. Methods other than Rational Method shall not be accepted for watersheds less than 100 acres in size.
- Design flows for watersheds greater than 100 acres shall be developed using Soil Conservation Service (SCS) Methods, tabular or computer modeling or U.S. Army Corps of Engineers HEC I or HEC HMS computational methods.
- When determining design flows for floodplain management and flood proofing, design runoff shall be based upon existing conditions in accordance with the Regional Building Development's Floodplain Management Requirements and FEMA Regulations.

G. Design Points

Basin delineation within a development or specific design area is problematic with relation to the design of proper drainage systems and the long-range management of discharge quantities. Therefore, specific design points shall be analyzed in the design process. Discharge volumes for minor and major storm events shall be calculated at all design points. Examples of typical design points include:

- Curb inlets/catch basin;
- Area drains;
- Discharge points: pipes, swales, channels, detention basins, and sedimentation basins to a suitable outfall (existing or natural system);
- Transition points: pipe to channel or swale, crosspans, at any location where developed runoff exits the project boundary and at any point where off-site runoff enters the project boundary;
- Ditchout locations;
- Intersections; and
- Inflow and outflow from sedimentation basins and detention basins.

3.2.9 Site Grading

A. Basic Objectives

The goal of site grading is to develop features that direct and store surface water in a manner consistent with the following objectives:

- Assist in directing surface away from existing and proposed structures and towards well-developed conveyance/storage systems to minimize property damage;
- Minimize the amount of surface erosion and sediment transport by limiting steep grades in excess of 4:1 through terracing and using applicable permanent BMPs;
- Site grading shall be designed in a manner that minimizes the use of retaining walls and limits severe transitions at property boundaries;
- Storing surface runoff on site to minimize downstream impacts and control discharge flows; and
- Enhance surface water quality through the use of BMPs designed to remove constituents of concern collected during smaller storm events.

Site grading should imitate natural landforms and work effectively with the developed drainage plan to minimize erosion. The overall area being graded should be kept to a minimum per provisions presented in an approved ESQCP. Once construction is complete, all disturbed areas must be revegetated or other permanent BMPs must be installed.

B. County Policy on Site Grading

Site grading shall be designed to the level of detail necessary to ensure that the developed drainage plan is followed for each parcel or lot. In most cases, this will require lot templates to be developed showing the direction of overall lot drainage, key drainage features/structures, slopes exceeding 10 percent, and approved discharge points. Lot templates are recommended for all commercial development and proposed residential development densities of one unit per acre or more. Where drainage conditions across individual lots are critical to the function of the overall drainage systems or where otherwise required by the ECM Administrator, lot templates shall be developed.

3.3 STORMWATER DESIGN

3.3.1 Storm Sewers

A. Design Basis

The installation of storm sewer systems is required when the other parts of the minor system (i.e., curb, gutter, and roadside ditches) no longer have capacity for additional runoff and required spread widths are exceeded.

The design of storm sewers shall be done in accordance with these Standards, the DCM1 and 2, and other references cited for additional discussion and basic design concepts. Hydraulics, debris and detritus, maintenance, inlet conditions, outlet conditions, safety, the effects on traffic, property, economics, and aesthetics shall be considered in the design of all underground storm drainage conduits.

B. Service Life

1. Minimum Service Life

The minimum design service life for storm sewer systems shall be 50 years.

2. Extended Service Life Required

The service life for storm sewer systems shall be increased to 100 years when:

- The depth of cover exceeds 15 feet,
- A portion of the system is or may be located under a structure or the overhang of a structure,
- The system is located within the traveled way of 4-lane or major and minor arterial roadways (rural and urban),
- The centerline of a storm sewer pipe is located 15 feet or less horizontally from a structure, and
- A storm sewer pipe is under a pressure head (typically caused by an installation on a steep slope).

C. Minimum Pipe Size

Storm sewers shall be designed and sized to convey the minor storm runoff peaks without surcharging the sewer. To ensure that this objective is achieved, the hydraulic and energy grade lines shall be estimated by calculating both the major and minor losses (i.e., friction, expansion, contraction, bend, and junction losses). The final energy grade line shall be at or below the proposed ground surface.

The minimum allowable pipe size for storm sewers is dependent upon the estimated flows and a practical diameter from a maintenance standpoint.

D. Minimum Gradient

The minimum gradient shall be 0.5% or a minimum velocity of 4 feet per second (fps) with the pipe flowing one quarter full. Storm sewer pipes shall be designed to flow full and free of pressure heads except for short runs where the grade changes and a small pressure head cannot be avoided. Where it is necessary to design for a pressure head, it shall be approved by the ECM Administrator and shall use pressure pipe with watertight joints with a 100-year service life.

E. Vertical Alignment

The storm sewer grade shall withstand AASHTO HS-20 or higher loading on the pipe. The minimum cover depends upon the pipe size, type and class, and soil bedding condition.

The minimum clearances between the proposed storm sewer, water main, and sanitary sewer (either above or below) shall be in accordance with the applicable district standards and Chapter 4.

F. Horizontal Alignment

In most cases, the curvilinear storm sewer shall be avoided. Where a demonstrated need exists and where the pipe will have a diameter of 48-inches or less, a curvilinear alignment may be approved. The limitations on the radius for pulled-joint pipe are dependent on the pipe length and diameter, and the amount of opening permitted in the joint per the pipe manufacturer's recommendations.

G. Manholes

Maximum spacing and locations of manholes and cleanouts are to be installed per requirements described in DCM 1, except as modified by Section 3.3.1J (2)

H. Inlets

The capacities of standard inlets under various flow conditions shall be calculated or obtained from the DCM Volumes I and II.

I. Angle of Confluence

In no case shall a component of lateral velocity oppose the mainline velocity by an angle of confluence. The angle of confluence shall be 90° or less, except

where lateral measures 36 inches in diameter or more, in which case the angle of confluence shall be 60° or less. The change in energy gradient in the cleanout or junction shall not exceed 3 feet. In no case shall the energy gradient exceed the elevation of 6 inches below the gutter grade on inlets, grate for grated inlets, or 6 inches below the bottom of the roof slab on cleanouts.

J. Design Criteria Summary

1. Minimum Class of Pipe

All storm sewers within the County's right-of-way (right-of-way) are required to be RCP (minimum Class 3). Other materials for storm pipe may be allowed, assuming a comparable service life can be achieved and the design criteria presented in this section are met.

2. Changes in Conduit Size

Where the conduit size increases, the inside top slopes of the conduits shall be continuous in elevation. Change in conduit sizes shall be accomplished in a reinforced concrete manhole or cleanout structure only.

3. Consistent with Plans

All pipes in the storm sewer system shall have size and slope indicated in the profiles on the plans.

4. Stationing

Storm sewer stationing shall run upgrade from the lower end of the drain. When a storm sewer runs longitudinally in a roadway, the stationing may be the roadway stationing.

5. Minimum and Maximum Cover

Minimum and maximum cover for storm pipes shall be determined based on loading, type and class of pipe, manufacturer's recommendations, and soil bedding conditions. Should a design warrant a cover depth of greater than 15 feet, an extended service life shall be accommodated (see Section 3.3.1 B2).

6. Alignment Priority

Drainage alignment priority shall be given to the larger of any two connecting storm drain systems. Pipes larger than 36 inches shall not run into and out of storm drain inlets in lieu of manholes without a specially designed inlet structure.

7. Changes in Flow from Supercritical to Subcritical

Hydraulic calculations shall be provided when the flow changes from supercritical to subcritical flow.

8. Maximum Velocity

The maximum storm sewer velocity shall be 18 fps.

9. No Diversions of Drainage

Diversion of drainage to other than an approved storm system is not permitted.

10. Concrete Cutoff Walls and Anchoring

Reinforced cast-in-place concrete cutoff walls shall be installed at intervals of no greater than 30 feet (horizontally) for all pipes placed in slopes where there is the possibility of erosion of the pipe trench on the slope. In addition, anchoring shall be installed at intervals of no greater than 30 feet for all culvert pipe placed on or within slopes 3:1 or steeper.

11. Special Bedding Requirements

When other pipe materials such as High Density Polyethylene (HDPE) are proposed, the bedding of the pipe will be performed in a manner that is consistent with the material manufacturer's recommendations to achieve the required service life and meet the design criteria presented within these Standards.

K. Storm Sewer Easements

1. Minimum Widths

Table 3-3 is a general guide for establishing minimum easement widths, although special conditions, such as deep locations, may require additional widths. The minimum easement width should be as shown in the table or twice the pipe depth plus the pipe diameter (rounded to the nearest 5 feet), whichever is larger. In general, storm sewer pipes should be centered in the easement.

Table 3-3. Easement Width Minimums

Pipe Diameter or Equivalent (inches)	Minimum Width (feet)
18–35	15
36–60	15
Over 61	30

2. Location

Storm sewers and easements are to be placed on one side of the lot ownership lines in a new development and in existing developments where conditions will permit.

3. Joint Easements Permitted and Separations

In general, storm sewer easements are to be established exclusively for drainage facilities. Joint use easements will be permitted, such as sewer, water, non-motorized public access, where necessary. Each

underground line shall be separated by a minimum of 10 feet horizontally.

4. Access to Storm Sewer

Physical access shall be provided to all storm sewer easements. Should special access to storm sewer easements be required because of grade differential, a minimum access easement of 15 feet shall be established. A 15-foot wide access road shall be provided within the access easement. The access road shall have a maximum grade of 15 percent. Maintenance vehicle access is required every 1,500 feet or more often if site conditions demand. Joint use for non-motorized public use access may be permitted.

5. Surface Use

In areas to be improved over a storm sewer easement, only at-grade parking lots or fences may be constructed. Permanent structures are not permitted over or within storm sewer easements.

3.3.2 Culverts

A. Selection of Culvert

The selection of a culvert for installation shall be based on information outlined in the DCM1. The required pipe strength shall be determined from the actual depth of cover, true load, and proposed field conditions.

B. Service Life

The minimum design service life for all culverts shall follow the design service life for storm sewer systems outlined in Section 3.3.1B.

C. Minimum Pipe Size

The minimum allowable culvert size shall follow the minimum size criteria for storm sewer systems in Section 3.3.1C. The minimum culvert size shall have a cross-sectional area equivalent to an 18-inch circular pipe.

D. Minimum Gradient

In designing culverts, both the minimum and maximum velocities must be considered. A flow velocity greater than approximately 3 fps is required to ensure that self-cleaning conditions exist. A velocity less than approximately 7 to 12 fps (subcritical flow regime) minimizes possible culvert damage due to scouring and downstream channel erosion.

E. Culvert Entrances

1. Entrances

Entrances shall be rounded, beveled or expanded, whichever is appropriate, to increase the capacity of the culvert, whether the outlet is free or submerged and whether the slope is above or below critical.

2. Flared End Sections Required

Flared end sections are required for outlets and inlets of culverts that do not have headwalls (except for private driveway culverts).

3. Inlet Aprons

Inlet aprons shall be used as transitions between the culvert and an improved approach channel, and may be used between the culvert and a natural approach channel. These shall be designed to prevent grade cutting of natural channels and to provide for a more efficient entrance condition.

F. Outlet Dissipater

A suitable energy dissipater shall be installed to reduce discharge velocities to non-erodible levels at each culvert outlet.

G. Slope Drains

1. Defined

A slope drain is a culvert placed on a grade of 5:1 (20%) or greater that does not fall within a road right-of-way. Slope drains may be permanent installations or temporary drains for a future extension of a permanent installation, above or below ground.

2. Concealed

Any slope drain that would be conspicuous or placed in landscaped areas shall be concealed.

3. Concrete Encasement

For installations on steep slopes or difficult topography, 6-inch concrete shall completely encase the pipe.

4. Watertight Joints

All slope drains shall have positive watertight joint connections in conformance with manufacturer's recommendations.

H. Debris and Silt Control Facilities

1. Flows Transporting Debris

When determined or observed by the ECM Administrator that flows are likely to carry floating debris, sediment or other abrasive materials in sufficient size to block or obstruct the conduit, a trash fence, rack or deflector is required. Vehicular access shall be provided to accommodate maintenance activities. These facilities shall be constructed upstream of the inlet so they will not obstruct the entrance.

2. Flows Transporting Silt

Where temporary drainage flows will be transporting silt, a temporary desilting basin shall be required to prevent silting of the culvert.

I. Design Criteria Summary

1. Minimum Class of Pipe

All culverts within the County's right-of-way are required to be RCP (minimum Class 3). Other materials for storm pipe may be allowed, assuming a comparable service life can be achieved and the design criteria presented in this section are met.

2. Consistent with Plans

Culverts in the storm drain system shall have classification indicated in the profiles on the plans.

3. Stationing

Culvert stationing shall run upgrade from the lower end of the drain. When a culvert runs longitudinally in a roadway, the stationing may be the roadway stationing.

4. Discharge Areas

Culvert outfalls shall extend to the nearest well-defined natural drainage channel that can adequately convey the discharge. Downstream conditions shall be investigated to verify the appropriateness of the point of discharge. This may require off-site storm drains or channel stabilization measures.

5. Abrasive Load

When the culvert is expected to carry a large amount of abrasive material, such as rocks and boulders, a special design to protect the full length of invert area (the lower 90°) and walls within curves to the spring line is required.

6. Superelevation Sections

Drainage must be picked up prior to reversing superelevation sections to prevent cross flows from one side of the roadway to the other side or median.

7. Minimum and Maximum Cover

Minimum and maximum cover for culverts shall be determined based on loading, type and class of pipe, manufacturer's recommendation, and soil bedding conditions. Should a design warrant a cover depth of greater than 15 feet, an extended service life shall be accommodated (see Section 3.3.2 B2).

8. Changes in Flow from Supercritical to Subcritical

Hydraulic calculations shall be provided when the flow changes from supercritical to subcritical.

9. Special Bedding Requirements

When other culvert materials such as High Density Polyethylene (HDPE) are proposed, the bedding of the culvert will be performed in a manner that is consistent with the material manufacturer's recommendations to achieve the required service life and meet the design criteria presented within these Standards.

3.3.3 Open Channels

A. Design Options

Due to the complexities of open channels, there are a wide range of design options available. Therefore, this section only covers those issues that are particularly useful in the design of a channel and have the greatest effect on the performance and costs. The exact method of analysis and design shall be clearly documented.

B. Conformance with Standards

All open channels shall conform to these Standards and the DCM1 and 2.

C. Channel Types

1. Soft-Lined Channels

Soft-lined channels may be used where the following conditions exist:

- A fully improved channel section is determined to be economically unfeasible.
- Adequate bank protection, where necessary, is to be installed for alignment control and for safeguarding adjacent property.
- Channel work will not significantly alter the watercourse or cause detrimental effects on adjacent property.
- Planted wetlands are not allowed within the lowest portion of a newly constructed channel.
- The channel conforms to the permissible velocities contained in the DCM1 and 2.
- A low-flow channel is required because the main channel grade has been determined to result in ponding during low flows.
- Drop structures will be used to accommodate changes in channel grades.

2. Hard-Lined Channels

Hard-lined channels shall be used where the conditions required for soft-lined channels do not exist. Concrete or other lining materials used in hard-lined channels shall be designed to withstand all loads including hydrostatic uplift, lateral earth pressures, velocities and debris loads, truck subcharge, and possible wheel loads.

D. Minimum Channel Gradient

The minimum gradient shall be dictated by the calculated hydraulics for the estimated channel low flows (2 to 5 year storm events). In addition, soft-lined channels will be designed to accommodate low flow events by armoring the lowest portion of the channel. This armoring will allow these low flow events to be accommodated within the channel without causing excessive erosion or sediment transport.

E. Channel Alignment

1. Bends

A bend in channel alignment should be located where the velocity is lowest. Bends shall be as small as is practicable.

2. Radius of Curvature

The minimum radius of curvature of the centerline of a channel shall be at least 3 times the width of a rectangular channel or 3 times the bottom width of a trapezoidal channel to minimize development of spiral flow.

F. Channel Transitions

1. Change in Channel Shape

Transitions between two different shaped channels shall be designed to produce a smooth, low-head-loss transfer of flow. The water surface level of the downstream channel must be set below the water surface level of the upstream channel by at least the sum of the increase in velocity head, plus transition and friction losses.

2. Downstream of a Conduit

The channel downstream of a conduit shall have a water surface far enough below the conduit to prevent a submerged outlet for a design storm.

3. Maximum Angle of Deviation

The maximum angle of deviation in any transition shall be 12.5°.

G. Angle of Confluence

1. Determined by Downstream Flow

The angle of confluence shall be determined by the downstream flow characteristics. The angle shall be designed to produce a smooth, low-head-loss transfer of flow and shall consider flow-rate changes, roughness, shape, and slope.

2. Lateral and Main Velocity

In no case shall a component of lateral velocity oppose the mainline velocity by an angle of confluence.

3. Conduit Connection to Channel

A conduit connection to a channel shall be made at an elevation at the top of the channel water surface and the angle of confluence shall produce a smooth low-head-loss transfer of flow.

H. Cutoff Walls

1. Lined Channels

Lined channels shall have a cutoff wall constructed at each end of the lining along the full width of section. Intermediate cutoff walls shall be provided at 250-foot intervals.

2. Unlined Channels

Graded, unlined channels, or channels with rock slope protection, shall have a rock or other type of suitable cutoff wall at each end along the full width or section.

I. Debris and Silt Control Facilities

1. Flows Transporting Debris

When determined or observed by the ECM Administrator that flows into a channel are likely to carry floating debris or rocks in any quantity, a trash fence, rack or deflector is required upstream of the channel. This facility shall be designed and located to prevent an obstruction or blockage of the channel entrance. Maintenance access to debris/rock racks is required. The channel entrance and upstream area shall be designed to provide for overtopping of the rack without overtopping the channel or damaging adjacent property.

2. Flows Transporting Silt

Where flows will be transporting significant quantities of silt, a temporary or permanent desilting basin shall be required to prevent silting in the channel or downstream from the channel.

J. Outlet Dissipater

A suitable energy dissipater for all open channel flow shall be installed to reduce velocities to pre-improved conditions where:

- Channels discharge into an unimproved or natural channel and the velocities exceed those permissible for the material involved and
- Roadway gutters discharge onto natural ground with velocities exceeding those permissible for the material involved.

K. Open Channel Easements and Access

1. Minimum Width and Access Road

All easements shall be wide enough to provide for the channel structure and adequate maintenance access.

- For channels 30 feet or more in top width, a minimum access road width of 15 feet shall be provided on each side of the channel.
- For channels with a top width of less than 30 feet, a minimum access road width of 15 feet shall be provided on one side of the channel and 4 feet on the opposite side.
- The minimum width of any channel easement shall be the top width of channel plus 4 feet on each side of the channel.
- For channels with a depth greater than 10 feet and a length longer than 1,000 feet, access to the bottom of the channel in the form of a vehicular ramp shall be provided at an interval of 500 feet.
- Easement and maintenance access provisions shall be made for public road discharge (i.e., ditch outs) and for cross-lot drainage in subdivisions.

2. Exclusion of Access Road

When the lack of an access road is not considered detrimental to the maintenance and integrity of the channel, the access road can be omitted under the following conditions:

- Where suitable exit-entry ramps are provided to intermediate channels with a minimum bottom width of 8 feet at roadway crossings and at other approved, needed locations to facilitate travel or maintenance of emergency vehicles in the channel bottom. At a minimum, one access ramp must be provided at each end of a channel.
- Where vehicular access to the channel on a maximum spacing of 1,000 feet and at other approved, needed locations is provided to small channels with a bottom width of less than 8 feet.

3. Easement Location

- Easements shall be placed on one side of a lot or parcel lines in new developments and where conditions permit in existing developments.
- Easements for public road discharge and capture of created sediment shall be located where appropriate based on topography and available property.

4. Fencing

Fencing is required for all channels abutting residential developments, schools, parks, and pedestrian walkways based on the following criteria:

- All concrete-lined or rip-rapped channels where the design frequency storm provides a velocity that exceeds 5 feet per

second and 2 feet in depth, or a combination thereof, for a factor of ten. Fencing is not required for right-of-way ditches.

- All constructed channels steeper than 4:1 where the design frequency storm provides a velocity that exceeds 5 feet per second and 2 feet in depth, or a combination thereof.
- Fencing shall be installed on both sides of the channel easement, with gate openings at all access points.
- Fencing shall be located at a minimum of 6 inches inside the easement boundary lines.
- All new fences shall be chain link, a minimum of 6 feet in height with a top rail and vinyl-coated for natural color compatibility (green or brown).

3.3.4 Drainage Ditches

A. Application of Standards

A ditch located within a development, not including roadside ditches, that conveys less than 15 cubic feet per second of public drainage is considered a drainage ditch. The requirements for open channels shall apply to drainage ditches.

B. Right-of-way and Terrace Ditches

A right-of-way or terrace ditch is one that is located along the top of a slope and is designed to convey surface water towards designated downdrain locations. The following standards shall apply to right-of-way and terrace ditches.

1. Minimum Grade

Minimum grade shall be 2 percent or a grade that will produce a minimum velocity of 6 fps when flowing full and 4 fps when a quarter full.

2. Minimum Freeboard

Minimum freeboard shall be 0.5 foot. Where energy gradients necessitate, more freeboard is required.

3. Angle of Confluence

The maximum angle of confluence on any ditch connection shall be 60°. Connections at any angle of confluence may require some means to contain the drainage flow within the ditches (splash aprons, splash walls, etc.)

4. Downdrains

Downdrains may be either ditch or pipe. All drainage flow in an open ditch downdrain shall be totally contained within the ditch.

5. Outfall

Right-of-way ditch drainage must outfall either into a constructed channel within the development or a well-defined natural channel. An energy dissipater will be required upstream of the outfall in a natural channel.

6. Single Lot Right-of-way Ditches

Single lot right-of-way ditches may terminate at the toe of the slope within the lot, with an adequate energy dissipater.

C. Toe Ditches

Toe ditches shall be required at the toe of fill slopes where any drainage is directed toward or along the slope. Right-of-way or terrace ditch sections may be used as toe ditches if they have adequate capacity for the drainage flow.

3.3.5 Roadways

When the drainage in the roadway exceeds allowable limits, a storm sewer or an open channel system is required to convey the excess flows. The primary function of roadways is for traffic movement. Therefore, the drainage function is subservient to the traffic objective. Design criteria for the collection, conveyance, and protection of surface water runoff on public roadways shall meet the requirements of these Standards and the DCM1 and 2.

3.3.6 Subsurface Drainage

When localized groundwater impacts the design of public improvements, a subsurface drainage system may be constructed, provided an acceptable subsurface drain system from the drainage system to the point of connection within the County's right-of-way is provided.

A. Subsurface Drainage Required

Subsurface drainage systems shall be provided in the following situations:

- Where necessary for stability and protection of adjacent properties from the influence of groundwater on cut and fill slopes.
- Where natural or artificially introduced groundwater (i.e., derived from meteoric or landscape irrigation and similar sources, respectively) affects or is likely to affect the project in a potentially unstable, hazardous or otherwise deleterious manner.

B. Design Requirements

1. Minimum Pipe Size

The minimum size of a collector line within the County's right-of-way shall be 6 inches.

2. Materials

Polyvinyl chloride (PVC) pipe shall be allowable conduit for seepage collector lines within the County's right-of-way.

3. Cleanout

A suitable cleanout or manhole shall be located in the seepage collector line on 350-foot spacing for straight runs of pipe, and at each break in alignment or grade.

4. Outlets

All discharge outlets for new construction on existing lots or newly developed lots shall be taken to the nearest existing underground public storm drain system. Prior to connecting to the County's system, an approved Encroachment Permit must be obtained from the ECM Administrator.

5. Minimum Grade

The minimum allowable grade of seepage collector pipes shall be 0.5%.

6. Depth and Spacing

Depth and spacing of the collection system will depend upon the permeability of the soil, the elevation of the water table, and the quantity of water encountered.