



Stormwater Manual

**Lexington-Fayette Urban County Government
Lexington, Kentucky**

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CHAPTER 1
STORMWATER MANAGEMENT REQUIREMENTS

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1.1 Regulatory Basis of the Stormwater Manual

The regulatory basis of the Lexington-Fayette Urban County Government (LFUCG) Stormwater Manual is contained in the Zoning Ordinance, Subdivision Regulations, and Code of Ordinances as follows:

- The Zoning Ordinance requires that stormwater facilities be designed and constructed in accordance with the Stormwater Manual as part of the building permit application process, major subdivision plan proposals, and development plan proposals
- The Subdivision Regulations require that stormwater facilities be designed and constructed for all subdivisions in accordance with the Stormwater Manual
- The Code of Ordinances incorporates the Stormwater Manual by reference in Section 16-85

The Stormwater Manual establishes the following:

- Overall stormwater management policies of LFUCG
- Minimum uniform standards to assure quality in the design and construction of stormwater infrastructure in development projects
- Construction site stormwater runoff control standards and post-construction stormwater management standards that comply with the requirements of the Commonwealth of Kentucky Municipal Separate Storm Sewer System (MS4) permit issued to LFUCG
- Stormwater management design information that must be submitted to LFUCG by the developer's engineer
- National Flood Insurance Program requirements.

The manual includes stormwater planning, design, and construction standards for the infrastructure that is routinely designed and constructed in development projects, including conventional engineering principles and practices. The Planning Commission may impose additional requirements to address issues that arise during the approval process for development plans and subdivision plans.

The Director of the Division of Engineering may require higher standards for unusual conditions not specifically covered in this manual or where otherwise appropriate from an engineering standpoint to assure public safety and quality in infrastructure design and construction. The Director may approve alternative standards if they can be demonstrated to be equivalent to the current standards in the manual.

The Stormwater Manual is one of six technical manuals that provide the standards for the design, review, construction, repair, and inspection of infrastructure. The technical manuals are: Stormwater; Roadway; Structures; Geotechnical; Sanitary Sewers and Pumping Stations; and Construction Inspection. In addition, there is a Procedures Manual for Infrastructure Development that establishes the responsibilities of the Developer, Engineer, and LFUCG. Collectively, these manuals are known as the *Engineering Manuals*.

Post-Construction Stormwater Management Standards

The requirements in the manual address the stormwater management criteria in Table 1-1 from the EPA publication entitled *Managing Stormwater in Your Community—A Guide for Building an Effective Post-Construction Program*, by the Center for Watershed Protection, 2008.

TABLE 1-1 – STORMWATER MANAGEMENT CRITERIA

Stormwater Management Criteria	LFUCG Stormwater Manual Requirement
Natural Resources Inventory	Section 1.4.2 – The manual establishes a 50-foot vegetative buffer zone along each side of a stream and around wetlands. Section 1.5.4 – The manual generally prohibits development within the 100-year floodplain.
Runoff Reduction in New Development	Section 1.7 – The manual requires a portion of the runoff volume from impervious areas to be retained on-site using green infrastructure stormwater controls.
Water Quality Volume in New Development	Section 1.7 – The manual requires that all runoff from impervious areas must pass through a stormwater control sized for the 90 th percentile storm of 1.2 inches.
Channel Protection in New Development	Section 1.7 – To minimize stream bank erosion, the manual requires that detention facilities be provided for drainage areas greater than 10 acres, sized to provide 24-hour detention of the runoff volume for the 10-year 6-hour storm.
Flood Control in New Development	Section 1.6 – The manual requires that stormwater controls be provided to reduce post-development peak flows to pre-development levels.
Redevelopment	Section 1.8 – The manual requires that redevelopment projects reduce the baseline (conditions prior to demolition) impervious area by 20%, or provide stormwater controls for 20% of the baseline impervious area, or a combination thereof. In addition, if a redevelopment project results in a net increase of impervious area, the new development standards shall apply to the net increase.

A summary of the post-construction standards in the Stormwater Manual is provided in Table 1-2.

TABLE 1-2 – SUMMARY OF POST-CONSTRUCTION WATER QUANTITY AND WATER QUALITY STANDARDS

	New Development	Redevelopment
Water Quantity	Peak flow shall be reduced to pre-development levels for the 10-year, 100-year, 1995, and 2006 storms.	Peak flow shall be reduced to baseline (before demolition) levels for the 10-year, 100-year, 1995, and 2006 storms. No detention is required if the impervious area is not increased.
Water Quality	Water Quality Volume – All runoff from impervious areas shall pass through a stormwater control sized for the 90 th percentile storm of 1.2 inches. Runoff Reduction – Green infrastructure controls shall be designed to retain on-site the runoff volume equal to 0.8 inches multiplied by the impervious area. Channel Protection – To minimize stream bank erosion, detention shall be provided for drainage areas greater than 10 acres, sized to provide 24-hour detention of the runoff volume for the 10-year 6-hour storm.	The baseline impervious area shall be reduced by 20%, or stormwater controls shall be provided for 20% of the baseline impervious area, or a combination thereof. If a redevelopment project results in a net increase of impervious area, the new development standards shall apply to the net increase.

History of the Manual

The manual was adopted by the Urban County Council in 2001. Several revisions have been made to the manual and they are summarized in Table 1-3.

TABLE 1-3 – HISTORY OF KEY CHANGES TO THE LFUCG STORMWATER MANUAL

2001	<ul style="list-style-type: none"> • Manual adopted by the Urban County Council. The manual included new development design standards for water quantity and water quality stormwater controls. • Revised hydrologic modeling standards and curb inlet design standards later in 2001
2002	<ul style="list-style-type: none"> • Revised design standards for inlets, manholes, extended detention basins, downspout disconnections, and prefabricated treatment devices • Clarified requirements for mitigating stream construction impacts • Clarified hydrologic modeling methods • Added National Flood Insurance Program requirements
2004	<ul style="list-style-type: none"> • Added redevelopment standards • Added program that allows a fee-in-lieu of on-site stormwater management
2005	<ul style="list-style-type: none"> • Clarified water quality design requirements • Revised modeling standards • Updated design storm rainfall values • Revised design standards for inlets, open channels, sediment ponds, detention basins, and erosion and sediment control
2009	<ul style="list-style-type: none"> • Added National Flood Insurance program requirements • Added concrete washout standards for sediment control
2011	<ul style="list-style-type: none"> • Revised Chapters 2 and 11 to reflect the requirements of the new erosion control ordinance in the Code of Ordinances
2014	<ul style="list-style-type: none"> • Implemented the Stormwater Management Executive Summary Form

1.2 Municipal Separate Storm Sewer System (MS4) Permit

LFUCG owns and operates the MS4 under the conditions of the MS4 permit issued by the Commonwealth of Kentucky. The definition of the MS4 from the permit is provided below:

“Municipal Separate Storm Sewer System” means a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, and storm drains): owned or operated by LFUCG that discharge to the Waters of the Commonwealth:

- a. designed or used for collecting or conveying stormwater;
- b. which is not a combined sewer; and
- c. which is not part of a Publicly-Owned Treatment Works (POTW) as defined at KRS 224.01-010.”

LFUCG’s interpretation of the MS4 is as follows:

1. Stormwater infrastructure is part of the MS4 if the city owns the infrastructure or operates it. “Operate” means maintenance of the structural components necessary for the storm sewers and stormwater controls to operate properly.
2. Storm sewers in residential areas served by public streets are part of the MS4 because the city owns the storm sewers.
3. Stormwater controls in residential areas served by public streets are part of the MS4 if the control is within an appropriate easement and LFUCG maintains the structural components.
4. Storm sewers on commercial property are not part of the MS4 because LFUCG does not own or operate the storm sewer system on commercial property.
5. Stormwater controls on commercial property are generally not part of the MS4 because LFUCG does not own or operate them. LFUCG requires the developer to install the stormwater controls to minimize the discharge of pollutants into LFUCG’s MS4 as required by the post-construction stormwater management section of the MS4 permit. In addition, LFUCG requires the property owner to operate and maintain the facility.

Requirements of the MS4 Permit

- The MS4 permit requires LFUCG to maintain a program to minimize the discharge of pollutants into LFUCG’s MS4 from new development and redevelopment projects that disturb one or more acres of land. These standards are contained in Chapter 1 (Sections 1.6, 1.7 and 1.8).
- The MS4 permit requires LFUCG to maintain a program to reduce pollutants in runoff from construction sites that disturb one or more acres of land. LFUCG’s standards for construction sites are contained in Chapter 11.
- The MS4 permit requires LFUCG to ensure long-term operation and maintenance of post-construction best management practices (BMPs) on private property. The maintenance requirements for private property are contained in Chapter 16, Article X, Division 2, of the LFUCG Code of Ordinances.

1.3 Infrastructure Covered by the Manual

The Stormwater Manual design and construction standards apply to the stormwater infrastructure (storm sewers, inlets, manholes, culverts, bridges, constructed channels, and post-construction stormwater controls) that will be installed in the public drainage system as defined in Section 1.4. The Stormwater Manual standards also apply to the stormwater controls that will be installed on commercial development or other private property to meet the post-construction stormwater management requirements of the manual.

The manual does not apply to the following:

- Storm sewers and inlets in commercial development that convey stormwater runoff only from that parcel and do not convey off-site stormwater runoff
- Stormwater infrastructure on property zoned as agricultural
- Stormwater infrastructure on state highway projects

The manual does not apply to capital projects. Capital projects are typically constructed in existing developments to improve the drainage conditions and often have space limitations and other constraints that limit the ability to meet all of the design standards in this manual, such as the design storms in Chapter 5. However, the manual can be useful as a guidance document for the planning and design of capital projects.

1.4 Key Terms

1.4.1 Public Drainage System and Drainage Easements

The Department of Planning, Preservation, and Development may designate certain elements of the proposed stormwater infrastructure to be part of the public drainage system. The public drainage system shall be placed in a drainage or storm sewer easement. Stormwater infrastructure that may be designated as part of the public drainage system includes, but is not limited to, the following:

- Proposed stormwater controls, such as detention basins and green infrastructure, in single-family residential subdivisions with public streets
- Proposed storm sewers and constructed channels in single-family residential subdivisions with public streets
- Proposed storm sewers and constructed channels in commercial development or other private property that are necessary to convey water through the site from off-site properties.

All stormwater infrastructure that is designated as part of the public drainage system shall be designed and constructed in accordance with the Stormwater Manual and LFUCG Standard Drawings.

1.4.2 Waterbodies of Fayette County

The following waterbodies shall be protected from construction:

- Jurisdictional streams and wetlands as determined by the U.S. Army Corps of Engineers under Section 404 of the Clean Water Act
- Groundwater flowing in a karst formation
- A vegetative buffer zone extending 50 feet horizontally from the edge of wetlands. The 50-foot criterion for the width of the buffer zone may be established on an average width basis at a project, as long as the minimum width of the buffer zone is 25 feet or more at any measured location.
- A vegetative buffer zone extending 50 feet horizontally from the top of each bank for perennial streams and 50 feet from each side of the centerline of intermittent streams. The 50-foot criterion for the width of the buffer zone may be established on an average width basis at a project, as long as the minimum width of the buffer zone is 25 feet or more at any measured location.
- 100-year floodplains
- Greenways along streams as shown on the LFUCG Greenway Inventory

1.4.3 1% Annual Chance (100-Year) Floodplain

The FEMA 100-year floodplain is shown on the effective Flood Insurance Rate Maps (FIRMs) as Zone AE and Zone A. For development projects greater than 5 acres or 50 lots that contain a stream in Zone A, the Engineer shall conduct a detailed watershed study in accordance with FEMA standards to determine the 100-year floodplain and 100-year base flood elevations (BFEs) using the procedures outlined in Chapter 3. The floodplain shall be based on a fully developed watershed as indicated in the Comprehensive Plan. The Engineer shall show the floodplain and associated BFEs on all submittals to LFUCG.

For unmapped streams with a drainage area of 50 acres or larger, the Engineer shall determine the floodplain and associated BFEs in accordance with the procedures in Chapter 3.

1.4.4 Stormwater Controls

Stormwater controls, also known as best management practices (BMPs), include infrastructure that is designed and constructed to meet the water quantity and water quality requirements of this manual. The acceptable stormwater controls are contained in Chapter 10.

1.4.5 Areas of Alluvial Soils

Article 19-13 of the Zoning Ordinance contains the building permit requirements where alluvial soils are present.

1.4.6 *Single-Family Residential Development*

Single-Family Residential Development refers to developments consisting of single-family and two-family dwelling units as defined in the Zoning Ordinance.

1.4.7 *Commercial Development*

Commercial Development refers to development other than single-family residential. It includes, but is not limited to, commercial, industrial, and institutional types of development.

1.5 General Criteria for New Development

1.5.1 Watershed Studies

Watershed studies are necessary to evaluate the impacts of a proposed development on the public drainage system and to determine the floodplain boundaries in areas where the floodplain has not been mapped. The procedures for conducting watershed studies are given in Chapter 3.

1.5.2 Regional Stormwater Management

LFUCG may require regional stormwater management facilities when LFUCG determines that this approach is in the best interest of LFUCG. LFUCG may allow two or more developers to jointly fund the construction of a common water quality and/or water quantity BMP.

1.5.3 Existing Stormwater Master Plans

Expansion Area 2

The regional stormwater master plan for Expansion Area 2 is contained in a report prepared by Commonwealth Technology, Inc., entitled “Preliminary Engineering Report – Stormwater Management in Expansion Area 2.” This report can be obtained from the Division of Engineering. The report contains the location and size of proposed stormwater management structures.

Stormwater Master Plans Prepared by Developers

The following developments currently have a regional stormwater master plan:

- Beaumont Centre (water quantity)
- Coldstream (water quantity and water quality)
- Hamburg (water quantity)
- Reynolds Road (water quantity)
- Masterson Station (water quantity)
- Sharkey Property (water quantity and water quality)

The Division of Engineering will continue to work with the Developer’s Engineer to ensure that off-site flooding impacts are evaluated. The objective will be to maintain the capacity of the drainage system, minimize the impact to existing flooding problems, and minimize the impact to streams from construction activities.

Areas not included in the above drainage studies must conduct hydrologic and hydraulic studies required by this manual.

1.5.4 Construction in the 100-Year Floodplain

In general, construction activities shall not be allowed in the 100-year floodplain. Filling the floodplain to allow more land to be developed shall be prohibited unless a special permit is obtained in accordance with Article 19 of the Zoning Ordinance. Excavation in the floodplain to lower flood levels shall also be prohibited unless a special permit is obtained in accordance with Article 19 of the Zoning Ordinance. In addition, a stream construction permit must be obtained from the Kentucky Division of Water for construction in the floodplain. Only the following infrastructure may be placed in the 100-year floodplain:

- Temporary sediment ponds designed to the standards of, and that will be converted to, a permanent stormwater management facility
- Roadways and utilities that cross at angles within 10 degrees of being perpendicular to the stream or floodplain
- Sanitary sewers with manhole covers set at an elevation one foot higher than the 100-year floodplain elevation
- Storm sewer pipe outfalls
- Stormwater management facilities that have obtained all state and federal permits and a special permit from LFUCG in accordance with Article 19 of the Zoning Ordinance

- Stream restoration projects
- Pedestrian crossings and trails

If situations arise where there are no feasible alternatives to construction in the floodplain, the construction will only be allowed if a mitigation plan is accepted by LFUCG.

1.5.5 Mitigation of Stream Construction Impacts

The U.S. Army Corps of Engineers and the Kentucky Division of Water regulate activities that involve construction in streams or wetlands. Mitigation plans approved by these agencies will satisfy LFUCG mitigation requirements if the mitigation is proposed to occur in Fayette County.

1.5.6 Ownership of Stormwater Controls

For Improvement Plans submitted on or after January 1, 2001, LFUCG may accept ownership of the stormwater controls in single-family residential and two-family residential developments if they are on a single parcel with adequate access for maintenance vehicles and dedicated to LFUCG.

In multi-family residential developments, LFUCG may accept ownership of the stormwater controls if they are on a single parcel with adequate access to a public street to allow maintenance vehicles to enter the property.

The property owner shall maintain the stormwater controls in commercial development. The stormwater controls shall be located on a single parcel and shall not be subdivided into multiple parcels.

1.5.7 Lot Drainage in Single-Family Residential Development

Constructed channels/swales shall be provided for drainage areas greater than one acre in single-family residential developments. The channel shall be designed to carry the 100-year storm. The drainage easement along the channel shall be 20 feet wide or the width of the 100-year flow plus 5 feet on each side, whichever is wider. The Engineer shall design these channels as part of the Improvement Plans. The design criteria are contained in Chapter 8.

Constructed channels in single-family residential areas that receive runoff from a storm sewer or culvert shall be designed with a low flow channel constructed of turf reinforcement, permeable pavers, or articulated blocks to prevent erosion. Concrete low flow channels may only be used if the above methods are not sufficient to prevent erosion. The design criteria for a low flow channel is contained in Chapter 8.

1.5.8 Maintenance of Drainage Easements

Chapter 16, Article X, Division 2 of the Code of Ordinances describes the maintenance responsibilities of LFUCG and private property owners.

1.5.9 Class C Impoundments

Construction of Class C Impoundments as defined by the Kentucky Division of Water shall be prohibited. Proposed new impoundments shall be evaluated to determine the hazard classification in accordance with the Kentucky Division of Water requirements. The evaluation shall be based on fully developed conditions upstream and downstream of the structure in accordance with the Comprehensive Plan.

1.5.10 Development Downstream of Existing Impoundments

Impoundments that are classified as Class A (Low Hazard) may sometimes become a Class B or C (Moderate or High Hazard) when vacant land below the impoundment is developed. Class B and Class C impoundments must meet design standards of the Kentucky Division of Water. These classifications apply to structures that temporarily or permanently hold water. More information on hazard classifications can be found in Chapter 2.

The Developer shall be responsible for making improvements to upstream structures, in accordance with the Kentucky Division of Water criteria, if the proposed development would cause the structure to be reclassified as a Class B or Class C impoundment. The appropriate agreements between the Developer and the owner of the impoundment shall be submitted to LFUCG. Rather than improve the upstream structure, the Developer may choose to establish an easement to ensure that the inundation area downstream of a failed impoundment is not developed.

1.5.11 Mitigation of Off-site Flooding Problems

Where off-site street or structure flooding has been documented by LFUCG, the Engineer shall conduct a watershed study to determine the existing capacity of the downstream drainage system and the depth of structure or street flooding for the 25-year 24-hour storm. To ensure that hydrograph timing effects are considered, the study area shall extend downstream to a point where the proposed development represents less than 10 percent of the total watershed area draining to that point.

The Engineer shall design on-site stormwater management facilities to:

- Reduce post-development peak flows to pre-development levels within the study area for the flood control design storms in Table 5-1
- Reduce the level of street and structure flooding within the study area for the 25-year 24-hour storm to the extent achievable using stormwater controls that are technically and economically feasible.

1.5.12 Coordination with the National Flood Insurance Program

Construction within the FEMA Special Flood Hazard Area shall comply with Article 19 of the Zoning Ordinance, the requirements of the Commonwealth of Kentucky, and the requirements of the National Flood Insurance Program (44 CFR 59 - 44 CFR 75). For developments containing the FEMA Special Flood Hazard Area, the following minimum requirements shall apply:

- The 1% Annual Chance Special Flood Hazard Area (100-year floodplain) shall be shown on Stormwater Management Plans, Improvement Plans, Record Drawings, and Plats.
- No construction that would affect the hydrologic or hydraulic characteristics of a flooding source and thus result in the modification of the existing regulatory floodway, the effective base flood elevations, or the Special Flood Hazard Area (SFHA) is permitted unless a Conditional Letter of Map Revision (CLOMR) or a CLOMR-F is obtained prior to construction (44 CFR 72.1).
- Upon completion of the construction described in the CLOMR or CLOMR-F, the developer shall obtain the final LOMR or LOMR-F from FEMA (44 CFR 72.1).
- Any other physical change which may affect flooding conditions shall be submitted to FEMA for a LOMR within six months of the change being made (44 CFR 65.3). The developer is responsible for submitting the information to FEMA.
- The Director of the Division of Engineering is the Local Floodplain Administrator. All CLOMR, CLOMR-F, LOMR, LOMR-F and any other applications to FEMA for map changes must be reviewed and signed by the Local Floodplain Administrator before being submitted to FEMA.
- All other provisions of the National Flood Insurance Program, whether specifically listed above or not, are applicable to all proposed development within Fayette County.
- In the event of conflict between Local, State, and Federal regulations, the more stringent regulation shall govern.

1.5.13 Coordination with the Royal Spring Water Supply Protection Committee

The Royal Spring Aquifer's *Fayette and Scott County Wellhead Protection Plan* was adopted by the Planning Commissions of Fayette and Scott County and approved by the Kentucky Department of Environmental Protection, Division of Water, Groundwater Branch (August 2003) as per the Kentucky Water Supply Planning Regulations (401 KAR 4:220). The plan was prepared by and is administered through the Royal Spring Water Supply Protection Committee charged with the responsibility of evaluation of the hydrology and potential groundwater contamination problems that could occur within the Royal Spring Aquifer Recharge Area. See Figure 1-1 for the general location of the Royal Spring Aquifer and its boundaries.

For new development or redevelopment projects in the Royal Spring Wellhead Protection Area (WPA), the developer shall:

1. Provide notification through the Major Subdivision and Development Plan Application and provide a note on the plan that the site is located in the WPA.
2. If requested, present the stormwater management plan for the proposed development to the Royal Spring Water Supply Protection Committee for comment and recommendation to the Planning Commission. Plans should address the following committee concerns at a minimum: identify all potential groundwater contaminant sources and proposed practices to treat or minimize the potential for contamination of groundwater or stormwater runoff from the site.
3. As part of the stormwater management plan designed in accordance with the LFUCG Stormwater Manual, consider the following recommendations of the Royal Spring Water Supply Protection Committee:
 - a. Provide post-construction stormwater quality controls that treat runoff for anticipated pollutants of concern for the Royal Spring Water Supply including, but not limited to, chemicals or petroleum products. Controls should be located prior to water quantity controls such as detention basins or underground storage areas to prevent contamination of the basin soils.
 - b. Stormwater quality controls should be designed with means for spill containment in locations where the potential for contaminant spills is greatest.
 - c. Practices designed to reduce the water quality volume (WQV) through infiltration should rely on runoff sources not subject to pollutants of concern or potential contaminant spill areas (such as rooftop runoff, depending on roofing materials). Pervious driving/parking surfaces are not typically recommended in the WPA depending on the intensity of use.
4. File a Groundwater Protection Plan with the Kentucky Division of Water, Groundwater Protection Branch per regulatory requirements (401 KAR 5:037) where potential contaminant sources meet established minimum thresholds.

1.5.14 Erosion Control Requirements

The erosion control requirements in Chapter 11 shall apply to all construction activities.

1.6 Water Quantity Criteria for New Development

1.6.1 Quantity Impacts

The runoff from impervious services created by development can result in impacts to property caused by increases in the peak flow and volume of runoff. Impacts to property may occur due to:

- Flooding from loss of channel capacity caused by sediment deposition
- Flooding due to an increase in peak flow from the addition of impervious areas
- Flooding due to the capacity of the drainage network being exceeded
- Increases in the area subject to flooding

The stormwater infrastructure in new development shall be designed and constructed in a manner that addresses these potential quantity impacts.

1.6.2 Applicability

Detention (flood control) facilities shall be required on new development projects where necessary to reduce the peak flows to pre-development levels. LFUCG may require additional detention where necessary to mitigate existing downstream flooding problems as described in Section 1.5.11.

Situations where detention may not be required are described below:

1. Detention may not be required on development sites that are part of a regional stormwater quantity master plan.
2. Detention may not be required if LFUCG has no documented downstream flooding problems **and** the Engineer can demonstrate through a detailed watershed study that:
 - Undetained runoff will have no increase (0.00 feet) on downstream water surface elevations, or
 - Detention basins will increase flood elevations downstream due to the location of the detention basin in the watershed and the associated hydrograph timing effects.

The procedures for demonstrating that detention is not needed are provided below:

1. The Engineer shall conduct a watershed study to evaluate the impact on the drainage system (storm sewers and open channels) and receiving stream. The design storms shall be the flood control storms listed in Table 5-1 and the 25-year 24-hour storm.
2. The study area of the receiving stream shall extend downstream to a point where the proposed development represents less than 10% of the total watershed area draining to that point.
3. Detention may not be required if it can be shown that there is no increase (0.00 feet) in the water surface elevations within the study area for each of the design storms.

1.6.3 Flood Control Design Criteria

Stormwater controls shall be designed and constructed to reduce post-development peak flows to pre-development levels. The design storms used for this analysis are contained in Chapter 5. Stormwater controls for controlling peak flows are contained in Chapter 10. The stormwater controls that may be used for residential and commercial development are shown in Table 1-4.

TABLE 1-4 – OPTIONS FOR STORMWATER MANAGEMENT

Stormwater Control	Single-Family Residential Subdivision Development		Commercial Development	
	Quantity	Quality	Quantity	Quality
Green Infrastructure				
Impervious Area Disconnection		•		•
Bio-retention and Rain Gardens	•	•	•	•
Permeable Pavement			•	•
Bio-infiltration Swales	•	•	•	•
Infiltration Basins and Trenches	•	•	•	•
Groundcover for Vehicular Parking				•
Tree Trenches and Planter Boxes				•
Rainwater Harvesting				•
Vegetated Roofs				•
Riparian Buffer Restoration		•		•
Manufactured Treatment Devices (allowed only for redevelopment projects; or infill projects; or new development projects where Green Infrastructure is not feasible)				•
Detention Basin	•		•	
Extended Detention Basin	•	•	•	•
Wet Ponds	•	•	•	•
Underground Detention			•	•
Constructed Wetlands	•	•	•	•

1.6.4 Downstream Drainage System Capacity and Study Limits

The Engineer shall ensure that runoff from the development site discharges to an existing storm sewer or open channel on the downstream property.

The on-site stormwater facilities for the development shall be designed so that the capacity of the existing pipes, culverts, channels, and other components of the downstream drainage system are not exceeded.

If no detention is proposed in accordance with Section 1.6.2, the Engineer shall determine the existing flow capacity of the downstream drainage system to ensure that it has sufficient capacity to convey the runoff from the proposed development. Table 1-5 lists the design criteria for the drainage system components. The study area of the receiving drainage system shall extend downstream to a point where the proposed development represents less than 10 percent of the total watershed area draining to that point.

1.6.5 Capacity of the Proposed Drainage System

Storm sewers, inlets, culverts, and constructed channels shall be designed to meet the design criteria in Table 1-5.

1.6.6 Flood Protection Requirements

Structures on Lots Containing a Mapped FEMA Floodplain

The lowest floor elevation of all new residential and commercial structures shall be constructed at or above the Flood Protection Elevation (see Article 19 of the Zoning Ordinance). The Flood Protection Elevation (FPE) shall be determined by the Engineer and shall be two feet above the FEMA base flood (100-year) elevation. The outside wall of the structure shall be at least 25 feet from the 100-year floodplain.

Structures on Lots Not Containing a Mapped FEMA Floodplain

All new residential and commercial structures shall be constructed such that the lowest adjacent (finished) grade (LAG) next to the building is:

- At least one foot above the channel flow line of constructed channels/swales (see Section 1.5.7)
- At least one foot above the top of curb at low points in streets if there is no overflow channel
- At least one foot above the grate elevation of surface inlets in yards
- At least two feet above the embankment crest of detention basins and permanent pool ponds

TABLE 1-5 – DESIGN CRITERIA FOR STORMWATER FACILITIES

Stormwater Infrastructure	Design Criteria¹	Chapter No.
Road Inlets on Grade	The maximum allowable spread of water at a rainfall intensity of 4 inches per hour shall be: <ul style="list-style-type: none"> • ¾ of the driving lane for local streets • ½ of the driving lane for collector streets • 4 feet in the driving lane for arterial streets 	Chapter 6
Road Inlets in Sags	The maximum depth of water shall be 6 inches at the gutter flow line based on a rainfall intensity of 4 inches per hour	Chapter 6
Storm Sewers	<ul style="list-style-type: none"> • The flow shall be gravity flow for the 10-year storm and, • The hydraulic grade line shall be below the overflow elevation at inlets and manholes for the 100-year rainfall intensity 	Chapter 6
Culverts	The HW/D (headwater/barrel height) shall be no greater than 1.2 for the 100-year storm	Chapter 7
Constructed Channels	The 100-year storm shall be contained within a drainage easement	Chapter 8

¹Additional design criteria are contained in Chapters 6, 7, and 8

1.6.7 Setback from Floodplain

Developments shall be designed so that the wall of any principal or accessory structure can be located a minimum of 25 feet from the 100-year floodplain.

1.6.8 Rural Service Area

Developments in the Rural Service Area containing less than one acre of directly connected impervious area shall not require water quantity controls, but will require erosion and sediment controls.

1.7 Water Quality Criteria for New Development

1.7.1 Impairment of Uses

The changes in long term runoff characteristics from new development can result in impacts to the water quality of Fayette County streams. Impairment to aquatic life may occur because of:

- The loss of aquatic habitat due to destruction of riparian vegetation
- Decrease in the base flow during non-runoff periods
- Increase in stream bank erosion from higher velocity, greater frequency, and longer flow duration caused by additional runoff volume
- Bottom scour from higher velocities through culverts and bridges
- Increase in toxicity from the increased chemical content
- The growth of algae and other nuisance aquatic plants resulting from the excess nutrients in runoff
- Decrease in dissolved oxygen levels due to increased algae
- Decrease in light penetration from suspended material
- Increase in the sediment deposited on the stream bottom
- Increase in water temperature due to runoff flowing over heat-retaining impervious surfaces

Impairment to primary and secondary contact recreation uses may result from:

- Increase in bacteriological content due to small animal wastes
- Increase in the presence of petroleum products

Impairment to public water supply uses may result from:

- The growth of algae and other nuisance aquatic plants resulting from the nutrients in runoff
- Increase in bacteriological content due to small animal wastes
- Increase in the presence of petroleum products
- Increase in suspended solids resulting in an increased cost of water treatment
- Decrease in reservoir water storage capacity resulting from sedimentation

The infrastructure in new development shall be designed and constructed in a manner that addresses these potential impacts to minimize the impairment to water quality.

1.7.2 Applicability

The requirements of this section apply to projects that will disturb one or more acres of land, or projects less than one acre that are part of a larger common plan of development.

The requirements of this section do not apply to development projects that are part of a regional stormwater quality master plan.

1.7.3 Water Quality Volume Criteria

The impact of the increase in the volume of runoff from a development site shall be mitigated by managing the runoff from the 90th percentile storm, known as the water quality volume (WQV). The design storm for the WQV is 1.2 inches in Fayette County. The stormwater controls that may be used to manage the WQV are listed in Table 1-4.

The design WQV shall be determined as follows:

Residential Subdivisions – Lots 6,000 square feet and larger

- Multiply 1.2 inches times the area of the roads and driveways. Rooftops are not counted because the downspouts typically discharge to grass areas, which provides sufficient runoff reduction.

Residential Subdivisions – Lots less than 6,000 square feet

- Multiply 1.2 inches times the area of the roads, driveways, sidewalks, and rooftops

Commercial

- Multiply 1.2 inches times the total impervious area (rooftops, parking lots, sidewalks, and driveways)

1.7.4 Runoff Reduction Criteria

Green infrastructure shall be used to reduce the volume of runoff from impervious areas. The runoff reduction design volume shall be 0.8 inches multiplied by the impervious area, and can be counted as part of the WQV above. The volume reduction provided by various green infrastructure practices is listed in Table 1-6.

TABLE 1-6 – VOLUME PROVIDED BY GREEN INFRASTRUCTURE PRACTICES

Green Infrastructure Practice	Runoff Reduction Volume
Impervious Area Disconnection to Developed Greenspace – directing impervious area runoff to greenspace whose soils will be impacted by construction equipment	2.2 inches x the greenspace area (based on a soil depth of 12 inches with a void ratio of 0.18)
Impervious Area Disconnection to Protected Greenspace – directing impervious area runoff to greenspace that will be protected from grading and construction equipment (including the area between the stream bank and the 100-year floodplain boundary)	4.3 inches x the greenspace area (base on a soil depth of 24 inches with a void ratio of 0.18)
Bio-retention / Rain Gardens	Volume of the void space in the filter media, plus the surface ponding volume. Underdrains are required if the underlying soils have an infiltration rate less than 0.5 inches per hour.
Permeable Pavement	Volume of the void space in the stone media. Underdrains are required if the underlying soils have an infiltration rate less than 0.5 inches per hour.
Bio-infiltration Swale	Volume of the void space in the filter media plus the surface ponding volume. Underdrains are required if the underlying soils have an infiltration rate less than 0.5 inches per hour.
Infiltration Basin / Trench	Volume of the void space in the soil/stone media plus the surface ponding volume. Underdrains are required if the underlying soils have an infiltration rate less than 0.5 inches per hour.
Groundcover for Vehicular Parking	Zero. Surface is considered pervious.
Tree Trench, Planter Box	Volume of the void space in the soil media plus the surface ponding volume. Underdrains are required if the underlying soils have an infiltration rate less than 0.5 inches per hour.
Rainwater Harvesting	Volume of the storage facility
Vegetated Roofs	Zero. Surface is considered pervious.
Riparian Buffer Restoration (this area cannot be counted in the greenspace areas above)	6.0 inches multiplied by the buffer restoration area (based on a soil depth of 24 inches with a void ratio of 0.25)

The runoff reduction design volume shall be determined as follows:

Residential Subdivisions – Lots 6,000 square feet and larger

- Multiply 0.8 inches times the area of the roads and driveways. Rooftops are not counted because the downspouts typically discharge to grass areas, which provides sufficient runoff reduction.

Residential Subdivisions – Lots less than 6,000 square feet

- Multiply 0.8 inches times the area of the roads, driveways, sidewalks, and rooftops

Commercial

- Multiply 0.8 inches times the total impervious area (rooftops, parking lots, sidewalks, and driveways)

Runoff reduction is not required if the Engineer can demonstrate that all of the following conditions are present:

- the soil infiltration rate is less than 0.5 inches per hour. Infiltration rates shall be determined in accordance with ASTM D3385 - *Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer*
- subdrains cannot be designed for the practices in Table 1-6 because the subdrain cannot freely discharge to a storm sewer or open channel
- no other green infrastructure practices in Table 1-6 are feasible

In cases where runoff reduction is not required, the water quality volume criteria in Section 1.7.3 must still be met.

1.7.5 Channel Protection Criteria

To minimize stream bank erosion, detention shall be provided for drainage areas greater than 10 acres, sized to provide 24-hour detention of the runoff volume for the 10-year 6-hour storm.

1.7.6 Outfall Velocity Criteria

Storm sewer and culvert outfalls shall be designed with energy dissipaters where necessary to prevent downstream erosion.

1.7.7 Erosion Controls

Non-structural and structural erosion and sediment control BMPs shall be designed and constructed in accordance with an erosion and sediment control plan, as described in Chapter 11.

1.7.8 Rural Service Area

Developments in the Rural Service Area containing less than one acre of directly connected impervious area shall not require any water quality BMPs, but will require erosion and sediment controls.

1.8 Stormwater Standards for Redevelopment Projects

1.8.1 Objectives

The objectives of these standards are to (1) comply with the MS4 permit provisions related to post-construction stormwater management for redevelopment projects; (2) provide flexible standards that do not act as a disincentive for redevelopment projects; and (3) achieve incremental improvement to water quality in previously developed areas.

1.8.2 Application of the Redevelopment Stormwater Standards in Fayette County

1. The redevelopment standards shall apply to parcels that were previously developed (i.e., contained structures or parking lots), where one acre or more of land will be disturbed, or areas less than one acre that are part of a larger common plan of development. The following definitions apply:
 - Redevelopment refers to “alterations of a property that change the “footprint” of a site or building in such a way that results in the disturbance of equal to or greater than 1 acre of land. The term is not intended to include such activities as exterior remodeling, which would not be expected to cause adverse storm water quality impacts and offer no new opportunity for storm water controls” (EPA, Phase II Stormwater Rule, 1999).
 - Larger common plan of development or sale means a “contiguous area where multiple separate and distinct construction activities are planned to occur at different times on different schedules under one plan, e.g., a housing development of five ¼ acre lots” (EPA, Phase II Stormwater Rule, 1999).
2. Redevelopment projects are typically commercial projects and begin as a demolition project, then proceed to the construction of new buildings and new parking lots. The Division of Building Inspection issues demolition permits, building permits, and paving permits for new parking lots. A paving permit is not required to repave, resurface, or reconstruct an existing parking lot. Several LFUCG agencies participate in the review of the permit applications. The Division of Engineering reviews the application to determine if the redevelopment standards apply to the project, as follows:
 - a. The redevelopment standards do not apply to remodeling projects or to pavement maintenance projects, such as repaving, resurfacing, or reconstructing existing parking lots within the original footprint.
 - b. Buildings and parking lots that are demolished and replaced with vegetation will be evaluated as redevelopment for future permit applications. The baseline condition will be the condition on the site prior to demolition.
3. The conditions on the site prior to demolition is termed the “baseline” condition and is an important factor in applying the redevelopment standards. The baseline condition consists of two components: (1) impervious surface on the site prior to demolition, and (2) stormwater controls on the site prior to demolition.
4. The redevelopment standards will generally be applied as shown in Table 1-7. The baseline stormwater controls on a site vary depending on when the site was developed. In general, there were no stormwater management requirements in Fayette County before 1974. Between 1974 and 2001, there were typically only water quantity (i.e., detention) requirements. New water quantity and water quality standards were adopted in 2001.
5. Some redevelopment projects drain to existing stormwater controls (water quantity and/or water quality) that were designed and constructed in accordance with the Stormwater Manual (2001 or later) standards for new development or redevelopment. In these cases, the existing stormwater controls must remain in place or be replaced in-kind. If the project results in a net increase in impervious area, the stormwater controls must be modified to (a) reduce peak flows to baseline conditions in accordance with Section 1.6 and (b) provide water quality controls in accordance with Section 1.7 for 100% of the net increase in impervious area.
6. In situations where there is more than one outfall on the site, the standards apply to the area draining to each outfall.
7. The following stormwater management requirements apply to all redevelopment projects:
 - QUANTITY – No additional detention is required if the impervious area does not increase from the baseline condition; however, if there is a net increase in the impervious area, then stormwater controls shall be required to reduce peak flows to baseline conditions in accordance with Section 1.6.
 - QUALITY – The baseline impervious area shall be reduced by 20%; or stormwater quality controls shall be provided for 20% of the baseline impervious area; or a combination thereof. Water quality controls shall be provided in accordance with Section 1.7 for the net increase in impervious area.

- The Division of Engineering New Development Section may require additional controls where necessary to protect downstream property.

TABLE 1-7 – TYPICAL APPLICATION OF THE REDEVELOPMENT STANDARDS

Date of original development	Typical stormwater requirements at the time of original development	Impact of Redevelopment Requirements
Before 1974	None	<p>Reduce baseline impervious area by 20%; or provide stormwater quality controls for 20% of the baseline impervious area; or a combination thereof.</p> <p>If the project results in a net increase in impervious area:</p> <ul style="list-style-type: none"> • provide stormwater controls to reduce peak flows to baseline conditions in accordance with Section 1.6, • provide stormwater quality controls for 100% of the net increase in impervious area in accordance with Section 1.7.
1974-2001	Typically, detention basin for water quantity and no water quality BMPs.	<p>Reduce baseline impervious area by 20%; or provide stormwater quality controls for 20% of the baseline impervious area; or a combination thereof.</p> <p>Existing quantity controls shall remain in place or be replaced in-kind to the same level of protection.</p> <p>If the project results in a net increase in impervious area:</p> <ul style="list-style-type: none"> • provide new or modify existing stormwater controls to reduce peak flows to baseline conditions in accordance with Section 1.6, • provide stormwater quality controls for 100% of the net increase in impervious area in accordance with Section 1.7.
2001-Present	Water quantity and water quality controls as required by the Stormwater Manual for new development or redevelopment.	<p>Existing controls shall remain in place or be replaced in-kind to the same level of protection.</p> <p>If the project results in a net increase in impervious area:</p> <ul style="list-style-type: none"> • modify stormwater controls to reduce peak flows to baseline conditions in accordance with Section 1.6, • provide stormwater quality controls for 100% of the net increase in impervious area in accordance with Section 1.7.

Note: The baseline condition is the site imperviousness and stormwater controls present prior to demolition.

1.9 Fee-In-Lieu for New Development and Redevelopment

New development projects and redevelopment projects are required to control the effects of stormwater runoff, including water quantity and water quality, in accordance with this manual. LFUCG recognizes that constructing on-site stormwater controls may not be the most effective method for controlling stormwater runoff in all situations. Therefore, LFUCG may establish a fee-in-lieu of constructing on-site stormwater controls.

Where water quantity or water quality controls are required by this manual, LFUCG may allow the Developer to pay a fee instead of constructing on-site stormwater controls whenever the Director of the Division of Engineering (Director) determines that on-site controls are not the most effective method of controlling stormwater runoff. This includes, but is not limited to, situations where the Director has reviewed studies and evaluations conducted by the developer and determined that constructing on-site BMPs:

- will not effectively improve water quality, or
- will not effectively reduce peak flows, or
- is not feasible because of topography and/or design constraints

1.10 Allowable Uses in the Floodplain

Table 1-8, along with Figures 1-2 and 1-3, show the allowable uses in floodplains.

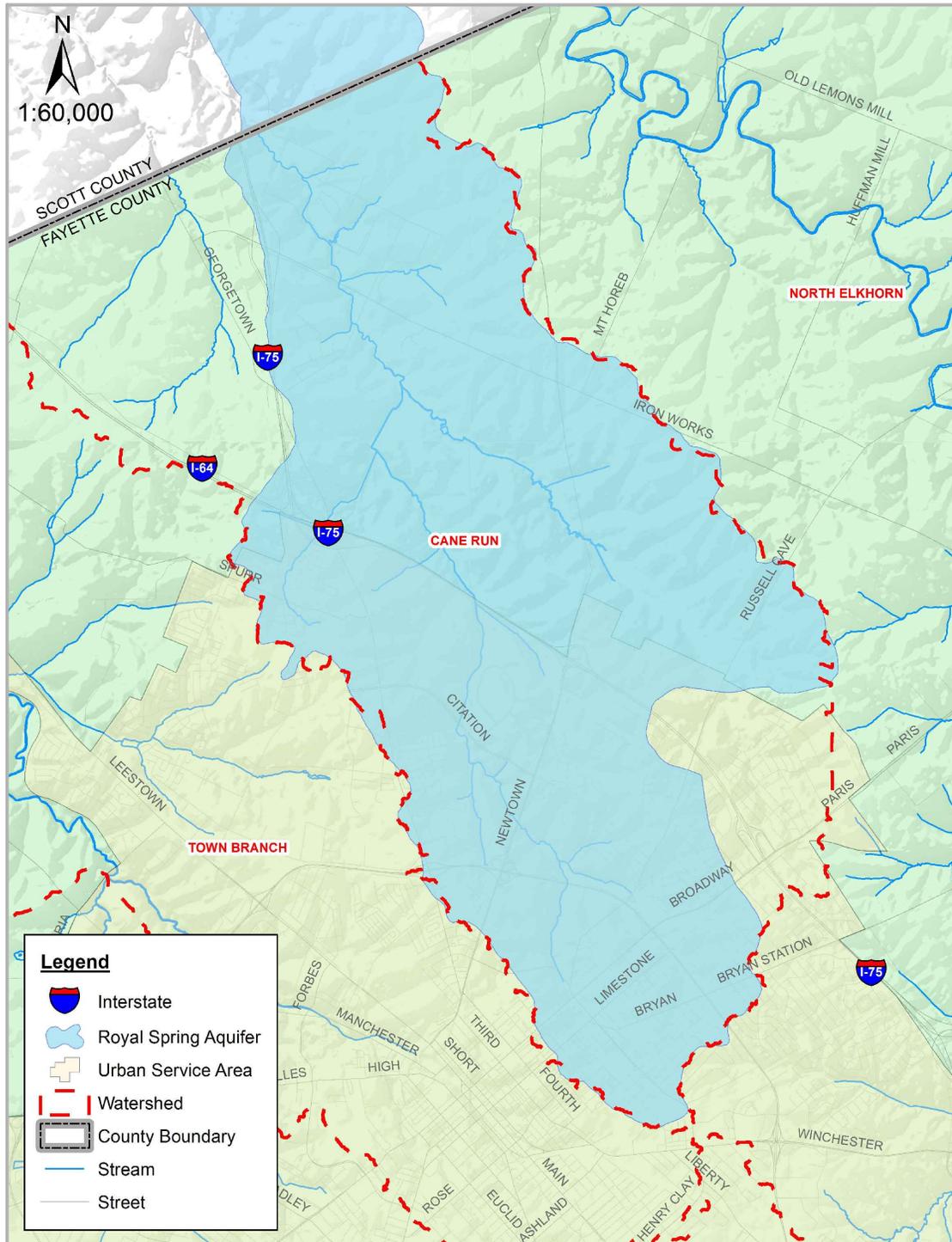
TABLE 1-8 – ALLOWABLE USES IN THE FLOODPLAIN

Activity or Use	Zone 1 Vegetative Buffer Zone	Zone 2 Floodplain	Zone 3 Floodplain Setback
Detention Basins that Temporarily Serve as Sediment Ponds	N	Y	Y
Detention Basins/Retention Ponds in Perennial Streams	N	Y	Y
Detention Basins/Retention Ponds in Intermittent Streams	Y	Y	Y
Temporary Sediment Ponds	N	N	N
Constructed Wetlands	Y	Y	Y
Bank Stabilization	Y	Y	Y
Roads Parallel to Stream	N	N	Y
Road Crossing – Perpendicular	Y	Y	Y
Utility Crossing – Perpendicular	Y	Y	Y
Utilities Parallel to the Stream	N	Y	Y
Filling to Create Lots	N	Special Permit	Y
Excavation to Lower Flood Levels	N	Special Permit	N/A
Principal Structures (Homes, Businesses)	N	Special Permit	Special Permit
Swimming Pools	N	N	Y
Detached garages and storage buildings	N	Special Permit	Special Permit
Fences	N	Special Permit	Y
Lawns and gardens	N	Y	Y
Mowing	N	Y	Y
Large Tree removal (diam. > 4 inches)	N	N	Y
Shrub/Small Tree Removal (diam. < 4 inches)	N	Y	Y
Shared Use Paths	N	Y	Y
Parking Lots with Temporary Parking	N	Special Permit	Y
Tennis Courts	N	Special Permit	Y
Park trails, baseball fields, soccer fields	N	Y	Y
Playground Equipment	N	Y	Y
Elevated Parking Garages	N	Special Permit	Y
Greenhouses	N	N	Y
Decks, Gazebos, and Shelters	N	Y	Y
Cellular Phone Towers	N	N	Y
Cellular Phone Tower Fences	N	N	Y
Cellular Phone Tower Buildings	N	N	N



STORMWATER MANUAL

FIGURE 1-1
ROYAL SPRING WELLHEAD
PROTECTION AREA
(OCTOBER 1, 2016)

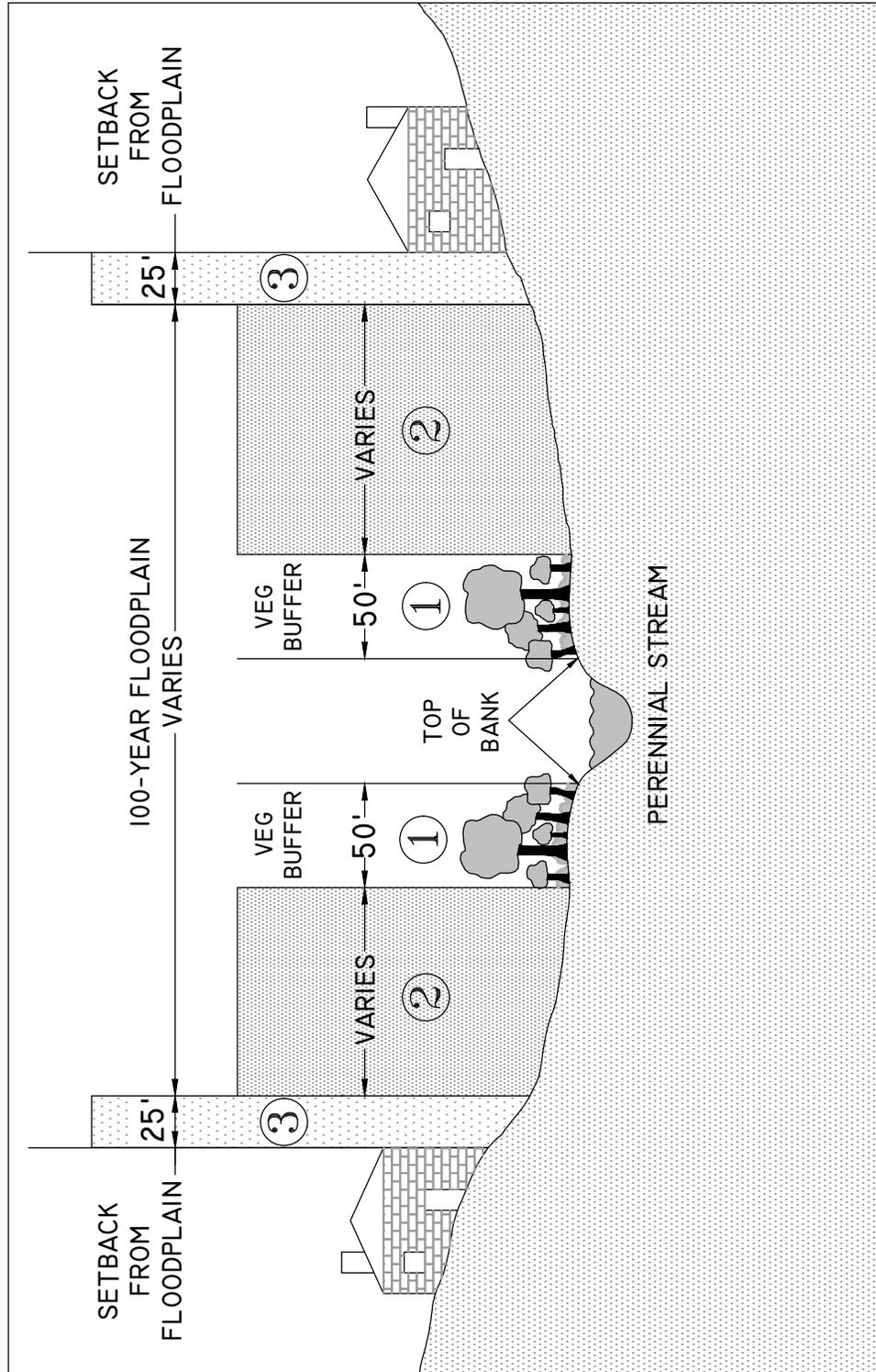




STORMWATER MANUAL

FIGURE 1-2
PERENNIAL STREAM FLOODPLAIN

(OCTOBER 1, 2016)

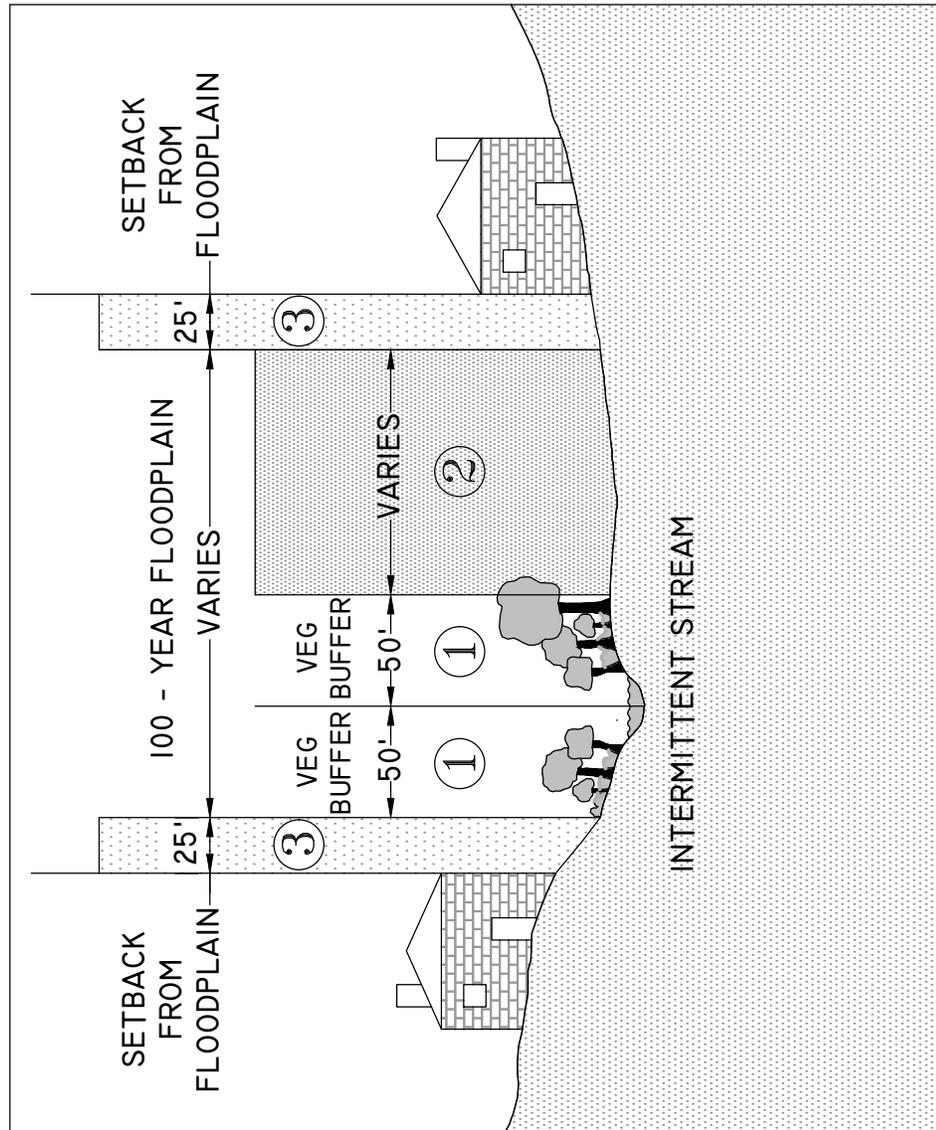




STORMWATER MANUAL

FIGURE 1-3
INTERMITTENT STREAM FLOODPLAIN

(OCTOBER 1, 2016)



CHAPTER 2
PERMITS

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2.1 Land Disturbance Permit

2.1.1 Purpose

A Land Disturbance Permit shall be obtained from the Division of Engineering in accordance with Chapter 16, Article X, Division 5 of the LFUCG Code of Ordinances. Checklists and other information can be found on the LFUCG Division of Engineering webpage.

2.1.2 Procedure

See Chapter 11.

2.2 Kentucky Division of Water Floodplain Construction Permits

2.2.1 Purpose

Pursuant to Kentucky law, dams or other improvements obstructing the movement of water in the floodplain are regulated by the Kentucky Division of Water (KDOW). The purpose of the procedure described here is to comply with the provisions of Chapter 19 in the Zoning Ordinance requiring that the KDOW first review obstructions to the flow of water in floodplains.

A Floodplain Construction Permit is required from the KDOW prior to the construction, reconstruction, relocation, or improvement of any dam, embankment, levee, dike, bridge, fill, or other obstructions across or along any stream or in the floodway of any stream. Permits are required for any such activity in designated 100-year floodplains or areas known to be flood prone. Exemptions may exist for activities in watersheds of less than one square mile of drainage. A permit from the KDOW is also required to deposit or cause to be deposited any matter that will in any way restrict or disturb the flow of water in the channel or in the floodway of any stream. In addition, a KDOW permit is required prior to the construction of structures qualifying as dams.

2.2.2 Procedure

In instances where KDOW permits are required, construction shall not begin until evidence of the Floodplain Construction Permit, or a determination that no permit is required, is provided to the Division of Engineering. In the case of dams, where water will be impounded on a temporary basis, construction shall not begin on facilities dependent upon the dam until an approval by the KDOW to impound water has been obtained. The permitting requirements apply to dams constructed for sediment and erosion control, stormwater detention, or aesthetic amenities. The requirements also apply to other flow obstructions such as bridges and culverts. The following procedure outlines the process for deciding whether a KDOW permit is required.

2.2.3 Determination of Need for Permit

This section describes the process for determining whether a KDOW permit is required.

Step 1: Determine 100-year Floodplain Boundaries

The NFIP Flood Insurance Rate Maps show the floodplains that have been studied and mapped by FEMA. For areas that have not been mapped, the procedures for determining the 100-year floodplain are contained in Chapter 3 of this manual.

Step 2: Determine the Hazard Classification of the Obstruction per KDOW Criteria

Hazard Classification A - This classification may be applied for structures located such that failure would cause loss of the structure itself, but little or no additional damage to other property. Such structures will generally be located in rural or agricultural areas where failure may damage farm buildings other than residences, agricultural lands, or county roads.

Hazard Classification B - This classification may be applied for structures located such that failure may cause significant damage to property and project operation, but loss of human life is not envisioned. Such structures will generally be located in predominantly rural agricultural areas where failures may damage isolated homes, main highways, or major railroads, or cause interruption of use or service of relatively important public utilities.

Hazard Classification C - This classification must be applied for structures located such that failure may cause loss of life, or serious damage to homes, industrial or commercial buildings, important public utilities, main highways or major railroads. This classification must be used if failure would cause probable loss of human life.

The Division of Engineering methodology for characterizing the hazard is based on the height of the structure. If the height is less than 15 feet, an A classification may be assumed if no roadways, walkways, residences, commercial buildings, or agricultural buildings are located, or could be located in the future, in the downstream floodplain within

a distance from the structure defined by the equation given below, unless visual analysis indicates that a higher hazard classification is more appropriate.

Equation for calculating distance from the structure to a roadway, walkway, or building:

$$X = 40Y$$

Where X is the downstream distance (ft) measured from the downstream toe of the structure and Y is the height (ft) of the structure measured vertically from the downstream toe to the top of the dam.

If the height of the structure is greater than 15 feet, the justification for the hazard classification shall be made based on a failure analysis. The analysis shall be conducted using the National Weather Service Dam Break Model. The results of the analysis shall be submitted to the Division of Engineering as documentation of the compliance with the KDOW procedures.

Step 3: Determine if the Structure is a Dam

A structure is defined by the KDOW as a dam if the distance from the downstream toe to the crest of the embankment is 25 feet or greater or if the structure has the potential for impounding, either temporarily or permanently, 50 acre-feet or more, measured to the crest of the embankment.

A KDOW Permit is required if:

- (1) From step 3, the obstruction is a dam
- (2) From step 2, the hazard classification is a C
- (3) From step 2, the hazard classification is an A or B and the drainage area above the obstruction is greater than 1 square mile

2.2.4 Fills

Placing of fill in the floodplain requires approval from KDOW and shall be in accordance with Article 19 of the Zoning Ordinance.

2.3 Kentucky Division of Water KPDES Stormwater Permit

2.3.1 Purpose

Erosion and Sediment Control on construction sites of one acre or greater is controlled by the Kentucky KPDES General Permit for Stormwater Discharges Associated with Construction Activities (KYR10). The permit requires, among other things

1. The submission of a Notice of Intent to the Division of Water before construction begins
2. The preparation of a stormwater best management practices plan, which includes an erosion and sediment control plan, to be kept on-site at all times
3. A description of procedures to maintain erosion and sediment control measures during the period of construction
4. The identification of each contractor or subcontractor who will install each erosion and sediment control measure
5. The signing by each contractor or subcontractor of a statement certifying the awareness of the requirements of KYR10
6. Regular inspections by qualified personnel as follows:
 - At least once every seven calendar days, or
 - At least once every fourteen calendar days and within 24 hours after any storm event of 0.5 inch or greater
7. The submission of a Notice of Termination to the Division of Water with a statement certifying that all stormwater discharges associated with the construction activity have been eliminated

2.3.2 Procedure

Construction shall not begin until the KYR10 permit has been issued and a copy provided to the Division of Engineering.

2.4 Federal Emergency Management Agency (FEMA)

2.4.1 Purpose

FEMA manages the National Flood Insurance Program (NFIP) based on maps showing floodplains and flood hazard areas. As part of the agreement for making flood insurance available in Fayette County, the NFIP required LFUCG to adopt floodplain management ordinances containing certain minimum requirements intended to reduce future flood losses. LFUCG is also responsible for ensuring that data is submitted to FEMA reflecting revised flood hazard information so that the NFIP maps can be revised as appropriate. Up-to-date maps allow risk premium rates and floodplain management requirements to be based on current data.

In instances where construction in the floodplain or floodway changes the elevations or the shape of the floodplain or floodway as shown on the NFIP maps, FEMA has a procedure for revising the maps. Where a floodplain is shown incorrectly, the filing of documents with FEMA is required to correctly define the floodplains.

2.4.2 Procedure

Construction activities within the FEMA floodplain shall comply with the requirements of Article 19 of the Zoning Ordinance.

For projects that change the FEMA floodplain, the Engineer shall submit the appropriate technical data to FEMA. The requirements for submitting the data can be obtained from FEMA.

2.4.3 Estimating Base Flood Elevations

Areas designated as Zone A on Flood Insurance Rate Maps do not have Base Flood Elevations (BFEs). Procedures for estimating base flood elevations are on the FEMA website.

2.5 401 and 404 Permits – Kentucky Division of Water and U.S. Army Corps of Engineers

2.5.1 Purpose

The KDOW Floodplain Construction Permit addressed above only relates to the potential flooding from the construction of an obstruction to the flow of water in the stream or floodplain. The KDOW has another permitting program (401 Water Quality Certification) related to construction which impacts the stream channel and areas below the ordinary high water level. In general, construction below the ordinary high water level is not envisioned in the waters of Fayette County. However, if situations arise where construction is necessary below the ordinary high water level or in wetlands, the Kentucky Division of Water (KDOW) has requirements for projects that impact these waters. In addition, the U.S. Army Corps of Engineers (COE) has requirements for projects that impact waters of the United States, including wetlands. Where the KDOW 401 or COE 404 permits, including coverage under the COE Nationwide Permits, are required, construction shall not begin until evidence of the 401 and/or 404 permits or a determination that no permit is required is provided to LFUCG.

2.5.2 Procedure

Permit applications and related plans shall be submitted to the COE and KDOW. Copies shall also be submitted to the LFUCG Division of Engineering. Blue-line streams on USGS topographic maps, or any stream with a drainage area greater than 50 acres, shall obtain a permit or waiver from KDOW.

CHAPTER 3
WATERSHED STUDIES

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3.1. Introduction

Watershed studies shall be conducted to:

- Determine the effects of a proposed development on the public drainage system
- Establish the 100-year floodplain
- Identify existing drainage problems
- Identify potential locations for regional stormwater facilities that address both flood control and water quality
- Establish design criteria over and above the design criteria specified elsewhere in this manual to correct or improve existing drainage problems
- Develop a stormwater management plan for the watershed to minimize future drainage problems and reduce existing problems

The study area for watershed studies shall extend downstream to the point where the proposed development represents less than 10% of the total watershed area draining to that point.

3.2. Data Collection

3.2.1 Data Sources

Contact LFUCG Geographic Information Services to obtain contours, floodplains, soils, location of streams and lakes, and other useful information.

3.2.2 Required Data

The following data shall be collected:

Watershed Characteristics

Determine the size of the contributing drainage area, expressed in acres, from the following:

- 2-foot contour maps with field checks to determine any significant changes in the contributing drainage area such as:
 - Lakes
 - Sinkholes
 - Flood control structures
 - Elevation changes which have occurred since preparation of the map

Watershed Land Use

Document the existing and future land use. Information on existing land use can be obtained from:

- Aerial photographs
- LFUCG zoning maps and the most current LFUCG Comprehensive Plan
- USGS and other maps
- Soil maps

Existing land use data for small watersheds can best be determined or verified from a field survey. Use field surveys to update information on maps and aerial photographs, especially in basins that have experienced changes in development since the maps or photos were prepared.

The Comprehensive Plan Land Use Map, Zoning Map, and the current Comprehensive Master Plan can be obtained from the LFUCG Division of Planning.

Streams, Rivers, Ponds, Lakes, and Wetlands

At all streams, rivers, ponds, lakes, and wetlands that will affect or may be affected by future development, collect the following data:

- Boundary (perimeter) and elevation of the water surface
- Water surface elevation for design storms specified in this manual
- Detailed description of any natural or manmade spillway or outlet works including dimensions, elevations, material, and operational characteristics
- Detailed description of any emergency spillway works including dimensions, materials, and elevations
- Profile along top of any dam and a typical cross section of the dam
- Existing data describing the physical, chemical, and biological water quality
- Identification of wetlands and sinkholes within the project boundaries or downstream of project in a location which may be impacted by storm water runoff

Roughness Coefficients

Estimate roughness coefficients, in the form of Manning's n values, for the entire flood limits of the stream within the reach to be evaluated. A tabulation of Manning's n values with descriptions of their applications can be found in Chapter 8.

Stream Profile

Obtain streambed profile data to determine the average slope. Where there is a stream gage relatively close, obtain the discharge, with date and time of the reading corresponding to the stream level.

Stream Cross-Sections

Obtain stream cross-section data where stage-discharge-volume relationships will be necessary.

Existing Structures

- Investigate any structures that may cause backwater or retard stream flow.
- Evaluate the manner in which existing structures have been functioning with regard to such things as scour, overtopping, damage, and debris.
- For bridges, determine span lengths, height, type of piers, and substructure orientation.
- For culverts, determine the size, inlet and outlet geometry, slope, end treatment, culvert material, and flow line profile.
- Take photographs of high water debris lines.
- Determine outlet structure (principal and emergency spillway) dimensions, material, inlet condition, headwater and backwater conditions, slope, and invert elevations.
- Determine an elevation profile along the top of the embankment for simple outlet structures.
- For water quality calculations, determine the storage volume below permanent pools.
- Identify local sources of contamination, such as livestock, siltation, junk piles, and other point sources.
- Make a record of the condition of the structure concerning erosion, degradation, and damage.
- Take photographs of all structures to document their overall and detailed condition.
- Inventory the sinkholes and their condition, and identify any sources of obstruction or local contamination. Take photographs to document the conditions of the sinkholes.

Flood Protection Elevation

Determine the lowest floor elevation of structures where flooding has been documented. The Flood Protection Elevation is defined in Article 19 of the Zoning Ordinance and Section 1.6.6 of this manual.

Flood History

Evaluate the history of past floods and their effect on existing structures. Information may be obtained from newspaper accounts, local residents, flood marks, or other evidence of the height of historical floods.

Obtain recorded flood data from the following agencies:

- U.S. Army Corps of Engineers
- USGS
- Kentucky Division of Water
- LFUCG Division of Water Quality and Division of Engineering

3.2.3 *Documentation*

Document the field review with dated field notes and photographs initialed by the reviewer. Include the documentation with the project plans and calculations submitted to LFUCG. Collect field data in accordance with GIS requirements of the LFUCG.

An example field inventory form is contained in Appendix A.

3.3. Runoff Models

3.3.1 General

Acceptable hydrologic models are listed in Chapter 5.

3.3.2 Subbasin Data

Subbasin data shall be collected in accordance with the following requirements:

- Delineate watershed subbasins so that average subbasin size is 10-50 acres and maximum subbasin size does not exceed 200 acres.
- Determine percent imperviousness based on the actual site conditions. Table 3-1 below shall be used as a guide.
- Calculate overland slope from an average of at least three slope measurements of the subbasin terrain.

**TABLE 3-1 –
LAND USE IMPERVIOUSNESS**

Land Use	Percent Impervious
<i>Residential</i>	
1/8 acre lots	65
1/6 acre lots	52
1/4 acre lots	38
1/3 acre lots	30
1/2 acre lots	25
1 acre lots	20
<i>Commercial</i>	85
<i>Industrial</i>	72

3.3.3 Open Channel and Pipe Data

Collect the following data:

- Length
- Size of the channel or pipe
- Manning's n (Chapter 8)
- Upstream and downstream invert elevations
- Slope

3.3.4 Structure Data

When assembling a watershed model, stage-storage-discharge relationships shall be determined for all structures in the model.

3.3.5 Error Analysis

When all the data is entered, run the model and check for errors in the run. Look for mass balance problems, model connectivity, correct data input, and proper model execution.

3.3.6 Calibration

The model should be calibrated against historic stream flow data if available.

3.4. Floodplain Analysis

3.4.1 General

Once the runoff model is complete, floodplains shall be determined with the United States Army Corps of Engineers' HEC-RAS computer program. This program will also provide results to indicate roadway and structure flooding. The design storm for floodplain analysis is contained in Chapter 5. Technical guidance on conducting floodplain analysis is contained on the FEMA website.

APPENDIX 3-A – EXAMPLE FIELD INVENTORY FORM

CHAPTER 4
DESIGN DOCUMENTATION

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4.1 Overview

4.1.1 Introduction

An important part of the design or analysis of any hydraulic facility is the documentation. Appropriate documentation is essential because of:

- The importance of public safety
- Future reference by engineers (when improvements, changes, or rehabilitations are made to the drainage facilities)
- Information leading to the development of defense in matters of litigation
- Public information

Frequently, it is necessary to refer to plans, specifications and analysis long after the actual construction has been completed. Documentation permits evaluation of the performance as anticipated or to establish the cause of unexpected behavior, if such is the case. In the event of a failure, it is essential that contributing factors be identified in order that recurring damage can be avoided.

4.1.2 Definition

The definition of hydrologic and hydraulic documentation as used in this chapter is the compilation and preservation of the design and related details as well as all pertinent information on which the design and decisions were based. This includes maps, field survey information, source references, photographs, engineering calculations and analyses, measured and other data, and flood history including narratives from newspapers and individuals such as highway maintenance personnel and local residents who witnessed or had knowledge of an unusual event.

4.2 Purpose

The purpose of this chapter is to present the documentation that will be included in the design files and on the construction plans. This chapter focuses on the documentation of the findings obtained in using the other chapters of this manual, and thus engineers should be familiar with the hydrologic and hydraulic design procedures associated with this manual. This chapter identifies LFUCG's system for organizing the documentation of hydraulic designs and reviews so as to provide as complete a history of the design process as is practical.

The major purpose of providing good documentation is to define the design procedure that was used and decisions that were made to arrive at the final design. Documentation should be viewed as the record of reasonable and prudent design analysis based on the best available technology. Thus, good documentation can provide the following:

- Identification of the situation at the time of design which might be very important if legal action occurs in the future
- Protection for the engineer by proving that reasonable and prudent actions were, in fact, taken
- Documentation that generally accepted procedures and analysis were used at the time of the design which were commensurate with the perceived site complexity and flood hazard
- A continuous site history to facilitate future reconstruction
- The file data necessary to quickly evaluate future site problems that might occur during the facility's service life
- Expedited plan development by clearly providing the reasons and rationale for specific design decisions

4.3 Improvement Plans

4.3.1 50 Percent Design

The following information shall be submitted on a 2-foot contour map at a scale of 1 inch = 50 feet. The drawing size shall be 22 inches x 34 inches.

- A map showing all drainage areas and subareas used to size hydraulic structures
- Proposed inlet, storm sewer, culvert, and manhole system and their sizing calculations
- Proposed stormwater controls
- Proposed constructed channels and their sizing calculations
- 100-year floodplain and floodway
- Sinkholes
- Caves
- Springs
- Ponds
- Streams
- Wetlands
- Tree stands
- Steep slopes greater than 15%
- Greenways shown in the Greenway Master Plan
- Existing and proposed underground utilities
- The sinkhole surface drainage analysis as described in the Subdivision Regulations

4.3.2 Final Design

Final design drawings shall be 22 inches x 34 inches in size. Plan view drawings shall be at a scale of 1 inch = 50 feet with 2-foot contours. Profile sheets shall be at a scale of 1 inch = 50 feet horizontal and 1 inch = 5 feet vertical.

Hydrology

Submit the following items:

- Watershed area size
- Peak discharge and hydrographs for design storms
- Expected level of development in upstream watershed over the anticipated life of the facility (include sources of basis for these development projections)

Inlets, Storm Sewers, and Manholes

Submit the following items:

- Computations for inlets and pipes, including hydraulic grade lines
- Complete drainage area map
- A schematic indicating storm drain system layout
- Pipe lengths, slopes, diameters, and material
- Structure types, labels
- Grate elevations
- Existing and proposed 2-foot contours
- Separate sheets for details

Plan View:

- Street layout, lot lines
- Catch basins: type, designation (station and number), invert elevation, and station offset
- Pipes: sizes, type, class, slope, and designation
- Manholes: size and type, station and offset
- Headwalls: type and invert elevation
- Sanitary sewer crossings
- Culvert size and shape

- Other utility line crossings
- Easements

Profile View:

- Underground utility crossings
- Existing and proposed ground surfaces
- Curb inlets: elevations and type
- Manholes: elevations and type
- Pipes with size, grade, type, class, length
- Headwall type and elevation
- All crossings (with elevations) of sanitary sewers and underground utilities
- All street sections at crossings and all regrade contours
- Capacity and proposed flows in pipes
- Hydraulic grade lines
- Manholes
- Inlet and outlet elevations of pipes
- Copies of all computer analyses, with input data listed and output clearly identified

Culverts and Bridges

Submit the following items:

- Culvert performance curves
- Allowable headwater elevation and basis for its selection
- Cross-section(s) used in the design highwater determinations
- Roughness coefficient assignments (n values)
- Observed highwater, dates, and discharges
- Stage discharge curves
- Performance curves showing the calculated backwater elevations and outlet velocities for the design storms
- Type of culvert entrance condition
- Culvert outlet appurtenances and energy dissipation calculations and designs
- Copies of all computer analyses, with input data listed and output clearly identified
- Roadway geometry (plan and profile)
- Detention easement if the culvert has been designed to provide detention

Constructed Channels

Submit the following items:

- Profiles
- Cross-section(s) used in the design water surface determinations and their locations
- Roughness coefficient assignments (n values)
- Channel velocities
- Water surface profiles through the reach for the design 100-year storm
- Design analysis of materials proposed for the channel bed and banks
- Energy dissipation calculations and designs
- Copies of all computer analyses, with input data listed and output clearly identified
- Easements

Stormwater Controls (Best Management Practices)

Submit the following items:

- Design calculations and schematics
- Complete drainage area map, delineating area draining to each practice and denoting total area and impervious area draining to each device
- Separate detail sheet for detention basins/retention ponds
- Detail of the outlet control structure

- Detail sheets for water quality treatment devices
- Water quality treatment practice (designate type of device, total area and impervious area draining to device, and volume used to size device)
- Embankment cross section
- Top of embankment elevation
- Peak stages
- Emergency spillway details
- Principal spillway details
- 2-foot contour plan view of detention volume
- Other utilities
- Easements

Water Quality Design Plan Sheet:

Submit the following items:

- Existing and proposed conditions
- 2-foot contour topography
- Plan and profile
- Details of the structures
- Calculations of the water quality volume
- Drainage area to each stormwater control
- Drainage patterns and flow direction arrows
- Discharge points/outfalls
- Maintenance plan
- Summary of pre-development and post-development peak flows
- Easements

Erosion and Sediment Control Plan

Submit the Erosion and Sediment Control Plan described in Chapter 11.

4.3.3 *Composite Drainage Plan*

This plan is intended to aid homebuilders and commercial/industrial builders in preparing their application for a building permit. The following information shall be shown on the Composite Drainage Plan.

- Surface drainage easements on each lot
- Flow arrows that indicate the direction of surface drainage through each surface drainage easement
- Sanitary sewers and manholes, and the elevations of the manhole lids
- Storm sewers and manholes
- Surface inlets, curb inlets, constructed channels, and stormwater controls
- Lowest floor elevation for proposed structures on lots containing a mapped FEMA floodplain
- Lowest Adjacent Grade for proposed structures on lots that do not contain a mapped FEMA floodplain if the lots are:
 - adjacent to or contain a constructed channel
 - at the low point of a street
 - adjacent to or contain a surface inlet
 - adjacent to or contain a detention basin/retention pond
- Environmentally sensitive areas
- Non-buildable areas such as sinkholes, floodplains, vegetative buffer strips, and wetlands
- Building setback of 25 feet from the 100-year floodplain
- Alluvial soils

4.4 Executive Summary

The Executive Summary Stormwater Management Form shall be submitted to the Division of Engineering. The form is located on the Division of Engineering webpage.

4.5 Record Drawings

A record drawing of all stormwater structures shall be submitted at the end of construction. Plan view drawings shall be at a scale of 1 inch = 50 feet with 2-foot contours. Profile sheets shall be at a scale of 1 inch = 50 feet horizontal and 1 inch = 5 feet vertical. Drawings shall be 22 inches x 34 inches in size.

The record drawings shall include the following:

- Plan sheet and profile of storm sewers and inlets, showing the invert elevation at each inlet and manhole
- Grate elevation of each curb and surface inlet
- Plan sheet and profile of constructed channels
- Plan sheet and profile of principal and emergency spillways, showing the inlet and outlet invert elevation
- Plan sheet and sections of risers, showing the size and elevation of orifices and weirs
- Plan sheet, profiles, and details of stormwater controls
- 2-foot contour map of detention basins and other stormwater controls
- Manhole and inlet structure types
- CCTV of the storm sewer system. An alternative form of photo documentation, such as a pole camera, will be accepted for pipe lengths of 50 feet or less.

CHAPTER 5
HYDROLOGY

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APPENDIX 5-A DESIGN STORM DISTRIBUTIONS

5.1 Introduction

5.1.1 Purpose

The analysis of the peak flow, volume of runoff, and time distribution of flow is fundamental to the design of stormwater drainage facilities. Errors in the estimates can result in a structure that is either undersized and causes drainage problems or oversized and costs more than necessary. On the other hand, it must be realized that any hydrologic analysis is only an approximation. The relationship between the amount of precipitation on a drainage basin and the amount of runoff from the basin is too complex to expect exact solutions.

The purpose of this chapter is to describe approved methods of hydrological analysis for watershed studies and for the design of sediment ponds, stormwater controls, inlets, storm sewers, culverts, and channels.

5.2 Approved Methods

5.2.1 *Hydrologic Modeling*

The following hydrologic models are acceptable:

- EPA Stormwater Management Model
- HEC-HMS
- Hydraflow (AutoCAD Civil 3D)
- CivilStorm (Bentley)
- StormCAD (Bentley)
- PondPack (Bentley)
- HydroCad

5.2.2 *Rational Method*

The Rational Method may be used to compute peak flows for drainage areas less than or equal to 100 acres when designing inlets, storm sewers, culverts, and channels.

5.3 Design Rainfall Event

5.3.1 Design Storms

Stormwater facilities shall be designed using the design storms in Table 5-1. The design storm distributions are contained in Appendix 5A.

TABLE 5- 1 – APPLICATION OF DESIGN STORMS

Design Storm	Flood-plains	Flood Control Structures ¹	Inlets	Storm Sewers	Culverts	Channels ²	Sediment Ponds ³	Channel Protection
Intensity of 4 inches per hour			•					
10-year and 100-year intensity				•		•		
10-year 6-hour		•					•	•
10-year 24-hour							•	
100-year 6-hour		•					•	
100-year 24-hour	•	•			•			
June 26, 1995		•						
September 23, 2006		•						

¹ Flood control structures (detention basins) shall be designed to reduce post-development peak flows to pre-development peak flows for the 10-year 6-hour, 100-year 6-hour, 1995, and 2006 storms. The emergency spillway shall be designed to pass the 100-year 24-hour storm.

² Constructed channels in back yards and side yards of residential areas shall be designed with a low flow channel to prevent erosion. See Section 8.2.

³ Sediment ponds shall be designed to:

- remove 80% of total suspended solids for the 10-year 24-hour storm (or achieve a detention time of 24-48 hours)
- reduce peak flows to pre-development levels for the 10-year 6-hour and 100-year 6-hour storms

5.4 HEC-HMS Model

5.4.1 *Input Parameters*

Runoff Volume

- The Green-Ampt method or Curve Number method may be used to determine the runoff volume.
- Green-Ampt soil parameters are shown in Table 5-2 for each soil group listed in the NRCS Soil Survey for Fayette County.
- Curve Numbers are based on the type of land use. Typical values are given in Table 5-3.

Unit Hydrograph

- The NRCS Unit Hydrograph Method shall be used. The time of concentration shall be determined using the method described in Technical Release No. 55 published by the U.S. Department of Agriculture, Natural Resources Conservation Service.

Storage Routing

- Use the stage-discharge-volume relationship for the structure.

Watershed Delineation

- Watersheds shall be subdivided into areas with homogenous land use. The subwatersheds shall have an average size of 10-50 acres, and a maximum size of 200 acres.

**TABLE 5- 2 – GREEN-AMPT INFILTRATION PARAMETERS
FOR FAYETTE COUNTY SOILS**

NRCS Soil Series	NRCS Hydrologic Soil Group	Saturated Hydraulic Conductivity (inches/hour)	Wetting Front Suction (inches)	Initial Moisture Deficit (in/in)
Armour	B	0.20	6.6	0.17
Braxton	C	0.10	8.6	0.14
Captina	C	0.10	8.6	0.14
Culleoka	B	0.20	6.6	0.17
Donerail	C	0.10	8.6	0.14
Egam	C	0.10	8.6	0.14
Fairmount	D	0.03	12.5	0.08
Huntington	B	0.20	6.6	0.17
Lanton	D	0.03	12.5	0.08
Lawrence	C	0.10	8.6	0.14
Lindside	C	0.10	8.6	0.14
Loradale	C	0.10	8.6	0.14
Loudon	C	0.10	8.6	0.14
Lowell	C	0.10	8.6	0.14
Maury	B	0.20	6.6	0.17
McAfee	C	0.10	8.6	0.14
Melvin	D	0.03	12.5	0.08
Mercer	C	0.10	8.6	0.14
Newark	C	0.10	8.6	0.14
Russellville	C	0.10	8.6	0.14
Salvisa	C	0.10	8.6	0.14

For areas where there is no detailed NRCS soil survey, use the following values:

- Saturated Hydraulic Conductivity – 0.15
- Wetting Front Suction – 7.6
- Initial Moisture Deficit – 0.155

TABLE 5- 3 – CURVE NUMBERS

Land Use	Percent Impervious	Hydrologic Soil Group			
		A	B	C	D
Urban Areas					
Parking Lots, Roofs, Driveways, and Streets	100	98	98	98	98
Commercial Development	85	89	92	94	95
Industrial Development	72	81	88	91	93
Residential Development:					
1/8 acre lots or less	65	77	85	90	92
1/6 acre lots	52	70	80	86	89
1/4 acre lots	38	61	75	83	87
1/3 acre lots	30	57	72	81	86
1/2 acre lots	25	54	70	80	85
1 acre lots	20	51	68	79	84
Pervious Areas					
Lawns, Parks, Golf Courses, Cemeteries, etc.	-	39	61	74	80
Pasture for Grazing (not mowed)	-	39	61	74	80
Meadows (mowed for hay)	-	30	58	71	78
Brushy Areas	-	30	48	65	73
Woods	-	30	55	70	77

1. For urban areas that have a different percent impervious than those shown above, calculate a composite Curve Number using a Curve Number of 98 for impervious areas and the associated Curve Number for the pervious area from the table above.
2. For areas where there is no detailed NRCS Soil Survey, assume the subwatershed is Hydrologic Soil Group C.
3. Hydrologic Soil Group A soils that are disturbed during construction shall be analyzed as Hydrologic Soil Group B soils for the post-developed condition.

5.5 Stormwater Management Model (SWMM)

5.5.1 *Input Parameters*

Infiltration

- Green-Ampt soil parameters are shown in Table 5-2 for each soil group listed in the NRCS Soil Survey.

Overland Flow

- Use the values in Table 5-4 for N.

Depression Storage

- Impervious depression storage = 0.02 inches
- Pervious depression storage = 0.10 inches

Monthly Evaporation

- Use the values in Table 5-5.

Storage Routing

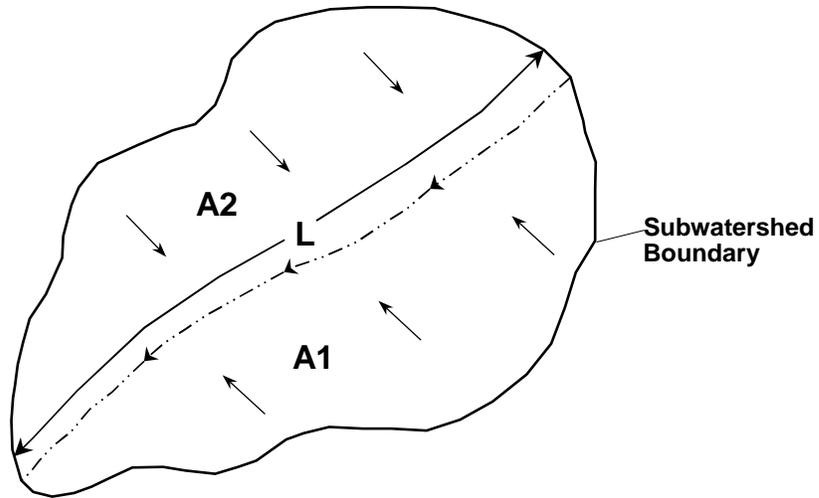
- Use the stage-discharge-volume relationship for the structure.

Watershed Delineation

- Watersheds shall be subdivided into areas with homogenous land use. The subwatersheds shall have an average size of 10-50 acres, and a maximum size of 200 acres.

5.5.2 *Subwatershed Width Calculation*

The following method shall be used to calculate the subwatershed width:



$$\text{Subwatershed Width} = W = (2 - S_k) \times L$$

Where

S_k = skew factor ($0 \leq S_k \leq 1$) = $(A_2 - A_1) / (A_1 + A_2)$

A1 = Area on one side of the channel

A2 = Area on the other side of the channel

L = Length of the channel

TABLE 5- 4 – MANNING’S n FOR OVERLAND FLOW

Surface	N
Asphalt or Concrete	0.015
Gravelled Surface	0.02
Short Grass Pasture	0.15
Dense Shrubbery and Forest Litter	0.40
Heavily Wooded	0.40
Bluegrass Sod	0.45

TABLE 5- 5 – MONTHLY EVAPORATION RATES FOR FAYETTE COUNTY

Month	Inches / Month
January	1.31
February	1.52
March	2.97
April	3.83
May	5.23
June	6.71
July	6.96
August	6.62
September	4.97
October	3.55
November	2.14
December	1.39

5.6 Rational Method

The following equation may be used for drainage areas less than or equal to 100 acres.

$$Q = CIA$$

where:

Q = peak flow in cubic feet per second

C = 0.95 for impervious areas

0.20 for pervious areas

A = drainage area

I = rainfall intensity

The rainfall intensity shall be determined based on Table 5-6:

TABLE 5- 6 – TIME OF CONCENTRATION VERSUS RAINFALL INTENSITY

Time of Concentration (minutes)	Intensity (inches/hour)	
	10 yr.	100 yr.
10	5.3	6.9
15	4.4	5.7
30	3.1	4.2
60	2.0	2.9

The time of concentration shall be determined using the method described in Technical Release No. 55 published by the U.S. Department of Agriculture, Natural Resources Conservation Service. The minimum time of concentration shall be 10 minutes.

**APPENDIX 5-A
DESIGN STORM DISTRIBUTIONS**

6-HOUR RAINFALL DISTRIBUTIONS

Minutes	Cumulative Rainfall (Inches)	
	10-year	100-year
0	0.00	0.00
20	0.10	0.16
40	0.24	0.36
60	0.37	0.57
80	0.59	0.90
100	0.86	1.32
120	1.15	1.76
140	1.47	2.26
160	1.81	2.79
180	2.09	3.22
200	2.32	3.58
220	2.51	3.87
240	2.65	4.08
260	2.76	4.25
280	2.85	4.38
300	2.93	4.51
320	2.97	4.58
340	3.01	4.63
360	3.07	4.73

10-YEAR – 24-HOUR RAINFALL DISTRIBUTION

Hours	10-year Cumulative Rainfall (Inches)	Hours	10-year Cumulative Rainfall (Inches)
0.0	0.00	12.5	3.21
0.5	0.02	13.0	3.38
1.0	0.05	13.5	3.49
1.5	0.07	14.0	3.58
2.0	0.10	14.5	3.66
2.5	0.12	15.0	3.73
3.0	0.15	15.5	3.79
3.5	0.18	16.0	3.85
4.0	0.21	16.5	3.90
4.5	0.24	17.0	3.94
5.0	0.28	17.5	3.98
5.5	0.31	18.0	4.02
6.0	0.35	18.5	4.06
6.5	0.39	19.0	4.10
7.0	0.43	19.5	4.13
7.5	0.48	20.0	4.16
8.0	0.53	20.5	4.19
8.5	0.58	21.0	4.22
9.0	0.64	21.5	4.25
9.5	0.71	22.0	4.27
10.0	0.79	22.5	4.30
10.5	0.89	23.0	4.32
11.0	1.03	23.5	4.35
11.5	1.24	24.0	4.37
12.0	2.90		

25-YEAR – 24-HOUR RAINFALL DISTRIBUTION

Hours	25-year Cumulative Rainfall (Inches)	Hours	25-year Cumulative Rainfall (Inches)
0.0	0.00	12.5	3.84
0.5	0.03	13.0	4.04
1.0	0.06	13.5	4.18
1.5	0.09	14.0	4.29
2.0	0.12	14.5	4.38
2.5	0.15	15.0	4.47
3.0	0.18	15.5	4.54
3.5	0.22	16.0	4.60
4.0	0.25	16.5	4.66
4.5	0.29	17.0	4.72
5.0	0.33	17.5	4.77
5.5	0.37	18.0	4.81
6.0	0.42	18.5	4.86
6.5	0.46	19.0	4.90
7.0	0.51	19.5	4.94
7.5	0.57	20.0	4.98
8.0	0.63	20.5	5.01
8.5	0.69	21.0	5.05
9.0	0.77	21.5	5.08
9.5	0.85	22.0	5.11
10.0	0.95	22.5	5.14
10.5	1.07	23.0	5.17
11.0	1.23	23.5	5.20
11.5	1.48	24.0	5.23
12.0	3.47		

100-YEAR – 24-HOUR RAINFALL DISTRIBUTION

Hours	100-year Cumulative Rainfall (Inches)	Hours	100-year Cumulative Rainfall (Inches)
0.0	0.00	12.5	5.01
0.5	0.04	13.0	5.26
1.0	0.07	13.5	5.44
1.5	0.11	14.0	5.58
2.0	0.15	14.5	5.71
2.5	0.19	15.0	5.81
3.0	0.24	15.5	5.91
3.5	0.28	16.0	5.99
4.0	0.33	16.5	6.07
4.5	0.38	17.0	6.14
5.0	0.43	17.5	6.21
5.5	0.48	18.0	6.27
6.0	0.54	18.5	6.33
6.5	0.60	19.0	6.38
7.0	0.67	19.5	6.43
7.5	0.74	20.0	6.48
8.0	0.82	20.5	6.53
8.5	0.90	21.0	6.57
9.0	1.00	21.5	6.62
9.5	1.11	22.0	6.66
10.0	1.23	22.5	6.70
10.5	1.39	23.0	6.74
11.0	1.60	23.5	6.77
11.5	1.93	24.0	6.81
12.0	4.52		

**HISTORIC RAINFALL DISTRIBUTION
JUNE 26, 1995**

Minutes	Cumulative Rainfall (Inches)
0	0.00
20	0.03
40	0.11
60	0.25
80	0.60
100	1.36
120	2.05
140	2.43
160	2.70
180	2.95
200	3.57
220	4.03
240	4.20
260	4.23
280	4.24
300	4.25

HISTORIC RAINFALL DISTRIBUTIONS

Minutes	Cumulative Rainfall (Inches)	Minutes	Cumulative Rainfall (Inches)
	September 23, 2006		September 23, 2006
0		940	2.86
20	0.01	960	3.74
40	0.02	980	4.73
60	0.08	1000	4.94
80	0.24	1020	5.55
100	0.31	1040	6.40
120	0.38	1060	6.48
140	0.49	1080	6.54
160	0.59	1100	6.74
180	0.77	1120	6.75
200	0.87	1140	6.75
220	0.94	1160	6.75
240	0.99	1180	6.76
260	1.09	1200	6.77
280	1.09	1220	6.80
300	1.10	1240	6.83
320	1.11	1260	6.84
340	1.13	1280	6.85
360	1.14	1300	6.86
380	1.15	1320	6.86
400	1.17	1340	6.86
420	1.17	1360	6.86
440	1.21	1380	6.86
460	1.21	1400	6.86
480	1.21	1420	6.86
500	1.22	1440	6.86
520	1.22		
540	1.22		
560	1.22		
580	1.22		
600	1.25		
620	1.26		
640	1.27		
660	1.27		
680	1.27		
700	1.27		
720	1.27		
740	1.27		
760	1.27		
780	1.27		
800	1.27		
820	1.27		
840	1.27		
860	1.63		
880	1.78		
900	2.35		
920	2.52		

CHAPTER 6
INLETS / STORM SEWERS / MANHOLES

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6.1 Design Criteria

6.1.1 General

The primary objective of street drainage design is to limit the amount of water flowing along the gutters or ponding at the low points to quantities that will not interfere with the passage of traffic for the design frequency. This is accomplished by placing inlets at such points and at such intervals to intercept flows and control spread.

6.1.2 Curb Inlets

Curb inlets used for street drainage shall be designed as follows:

General Requirements:

- Space inlets on grade to limit the spread of water as shown below, based on an intensity of 4 inches per hour. Note: A bike lane is not considered part of the driving lane.
 - Local streets – $\frac{3}{4}$ of the driving lane
 - Collector streets – $\frac{1}{2}$ of the driving lane
 - Arterial streets – 4 feet in the driving lane
- Space inlets to prevent concentrated water from flowing across the road
- Place inlets on the upstream side of intersection radii
- Design the inlet assuming flow only through the curb opening, if a grate is present
- The maximum distance between curb inlets shall be 600 feet
- Inlets shall not be placed in the radius of an intersection
- Curb inlets in residential subdivisions shall be located on the lot line

Curb Inlets at Sags

- The depth of water in a sag shall be limited to 6 inches at the gutter flow line using an intensity of 4 inches per hour
- Provide an overflow channel assuming that inlets in low points are 50% obstructed; the channel shall be designed to carry the portion of the 100-year storm that does not enter the inlets.
- If an overflow channel cannot be provided, flanking inlets shall be designed to receive all the flow assuming the inlet at the sag is clogged.

6.1.3 Surface Inlets

Surface inlets in grassed areas, parking lots, and roadside channels shall be designed as follows:

- Inlets in grass areas shall be constructed in a sump condition so that the top elevation of the berm around the inlet is at least 1 foot above the 100-year storm elevation
- Limit the depth of water for the 100-year storm to at least 2 feet below the elevation of the lowest opening of adjacent structures
- Provide a clear path for water to flow overland to a channel or the street assuming that inlets in low points are obstructed
- For roadside channels, limit the depth of water to the edge of pavement or sidewalk, whichever applies, for the 100-year storm

Surface inlets shall not be used within a roadway for street drainage.

6.1.4 Storm Sewers

Storm sewers shall be designed as follows:

- Size the pipes to flow under gravity (not under pressure) for the 10-year storm
- Size the pipes so that the hydraulic grade line is below the overflow elevation at inlets and manholes for the 100-year storm
- Use a minimum pipe size of 15 inches
- Use open channels for flows greater than 100 cfs for the 100-year storm

- Limit the cumulative discharge from storm sewers in a 200 feet section of channel to less than 100 cfs, calculated for the 100-year storm
- Provide a minimum slope of 0.5%.
- Provide a minimum velocity of 3 feet per second for the 10-year storm
- Provide a minimum cover of 18 inches

Storm sewer inlet headwalls shall be designed with a debris grate as follows:

- Grate shall be installed at a 45 degree vertical angle to the upstream flow line
- Provide a bottom opening of at least 8 inches
- Provide a flow area through the grate that is greater than the pipe/box opening

Outfalls shall be extended to the rear property line in residential developments where possible. Where this is not possible, a constructed channel shall be designed to carry the flow to the receiving stream or detention basin. The outfall elevation of the storm sewer shall be higher than the 10-year 6-hour water surface elevation in the receiving stream or detention basin.

Storm sewers shall not be used to convey flow from areas upstream of a development unless the 100-year peak flow is less than 100 cfs.

6.1.5 *Manholes*

- Place manholes at the following locations:
 - Where 2 storm sewers intersect
 - At changes in pipe size
 - Where the slope changes
 - Where horizontal alignment changes
- Space manholes no more than 300 feet apart for pipes 42-inch diameter or less, and no more than 400 feet apart for pipes 48-inch diameter and larger
- The crown line of the upstream pipe shall be at or above the crown line of the downstream pipe

6.1.6 *Passthrough Drainage*

Runoff from off-site areas shall be evaluated based on future land use as shown in the Comprehensive Plan. Pass through systems shall be designed for the 100-year storm. The upstream area shall be assumed to have detention unless it is exempted as described in Chapter 1.

6.2 Inlet Design Procedures

6.2.1 Curb Inlets on Grade

Use a software program based on the hydraulic methods used by the KYTC or FHWA for highway drainage. For more information, go to the FHWA Urban Drainage Design Manual (HEC22).

Following is the acceptable list of software:

- Hydraflow (AutoCAD Civil 3D)
- CivilStorm (Bentley)
- StormCAD (Bentley)
- HydroCAD

6.2.2 Curb Inlets in Low Points

Use the weir flow equation for depths less than or equal to the curb opening.

$$Q = CLd^{1.5}$$

where:

Q = flow in cfs

C = 3.0

L = curb opening length (ft)

d = depth of water at curb measured from the normal cross slope gutter flow line (ft)

Use the orifice equation for depths greater than the curb opening.

$$Q = CA(2gd)^{0.5}$$

where:

Q = flow (cfs)

C = 0.67

A = clear area of opening (ft²)

d = head on center of opening (ft)

g = 32.2 (ft/sec)

6.2.3 Surface Inlets

Use the weir flow and orifice flow equation to compute flow through the grate:

For $d \leq 0.4$ feet, use the weir flow equation:

$$Q = C Pd^{1.5}$$

where:

Q = flow in cfs

C = 3.0

d = depth of water in feet

P = perimeter of the grate in feet

For $d \geq 1.0$ feet, use the orifice flow equation:

$$Q = CA \sqrt{2gd}$$

where:

$$C = 0.67$$

A = clear opening area of the grate (ft²)

$$g = 32.2 \text{ ft/sec}$$

d = depth of water in feet

For $0.4 \text{ feet} < d < 1.0 \text{ feet}$, compute the flow using both the weir flow and orifice flow equations. Use the smallest flow for a given depth.

6.3 Storm Sewer Design Procedures

Use a software program based on the hydraulic methods used by KYTC or FHWA for highway drainage.

Following is the list of acceptable software:

- Hydraflow (AutoCAD Civil 3D)
- CivilStorm (Bentley)
- StormCAD (Bentley)
- HydroCAD

6.4 Construction Specifications

All public drainage system structures (see Section 1.4.1), including storm sewer pipe, curb box inlets, surface inlets, culvert pipe, and manholes, shall meet the specifications of the LFUCG Standard Drawings and the KYTC Standard Specifications for Road and Bridge Construction, latest edition.

Storm sewers shall be reinforced concrete pipe or corrugated plastic pipe (CPP). CPP shall meet the following requirements:

1. CPP shall have a smooth inner liner and shall be manufactured according to ASTM F2306 or ASTM F2562 for high density polyethylene pipe, or ASTM F2881 for polypropylene pipe.
2. CPP shall have an integral bell and spigot with an elastomeric seal meeting the requirements of ASTM F477 or ASTM D3212.
3. CPP may be used up to 36 inches in diameter in new development applications in easements and public right-of-ways.
4. Manufacturers of CPP shall be qualified participants of the National Transportation Product Evaluation Program (NTPEP).
5. Installation of CPP shall follow existing LFUCG standard drawing details and requirements as previously outlined for other pipe materials. Additional manufacturer guidelines shall be followed if necessary.
6. The minimum cover shall be 24 inches. Maximum depth for CPP shall be 16 feet. All necessary precautions shall be taken to avoid operating heavy equipment on top of the pipe until the required cover is attained. If stone size other than #9 is proposed, it must be in accordance with manufacturer’s recommendations. If no such recommendation exists, then the manufacturer shall submit approval to LFUCG in writing.
7. In new development, the developer’s engineer shall, 30 days after installation, certify that CPP pipe was installed in accordance with manufacturer’s recommendations and ASTM 2321 and that the pipe’s structural integrity and functionality is preserved. The Engineer shall conduct deflection testing of the pipe 30 days after installation. The deflection testing shall be done in accordance with KYTC specifications. The pipe shall be replaced if the deflection is greater than 5%. Allowable deflections on any axis are presented in the table below.

Base Pipe Diameter (inches)	AASHTO Nominal Diameter (inches)	Max. Deflection Limit		
		5.0% (inches)	7.5% (inches)	10.0% (inches)
15	14.76	14.02	13.65	13.28
18	17.72	16.83	16.39	15.95
24	23.62	22.44	21.85	21.26
30	29.53	28.05	27.32	26.58
36	35.43	33.66	32.77	31.89
48	47.24	44.88	43.70	42.52
54	53.15	50.49	49.16	47.84
60	59.06	56.11	54.63	53.15

From KYTC Kentucky Method (KM) 114-14

CHAPTER 7
CULVERTS AND BRIDGES

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7.1 Introduction

As used in this manual, bridges are defined as structures 20 feet wide or greater (support to support) that transport vehicles over streams or constructed channels. Culverts are structures narrower than 20 feet wide that transport vehicles over streams or constructed channels.

7.2 Culvert Design Criteria

7.2.1 General

Culverts shall be located and designed to present a minimum hazard to traffic and people.

7.2.2 Alignment and Slope

The culvert shall be designed to approximate the existing alignment and slope of the stream.

A culvert shall not be placed within 50 feet of a bend in a stream or channel greater than 20 degrees.

7.2.3 Allowable Headwater

The culvert shall be designed so that:

- HW/D (headwater/barrel height) is no greater than 1.2 for the 100-year storm for drainage areas less than or equal to one square mile
- HW/D is no greater than 1.0 for the 100-year storm for drainage areas greater than one square mile
- The headwater is at least 12 inches below the edge of pavement for the 100-year storm
- The 100-year water surface elevation is not increased on adjacent property.

7.2.4 Culvert Size and Shape

A minimum culvert diameter of 15 inches shall be used to avoid maintenance problems and clogging.

7.2.5 Multiple Barrels and Staged Culverts

Culverts with a drainage area of greater than 1.0 square miles shall be designed using multiple barrels at different elevations according to the following:

- Develop a stage-discharge curve for the existing floodplain to determine the discharge associated with bankfull flow and the flow distribution for events greater than bankfull flow.
- Design the culvert pipe within the main channel to pass bankfull flow as a minimum.
- Where practical, use additional barrels in the floodplain so that the flow distribution after construction of the culverts approximates the distribution prior to construction. For example, if 30 percent of the 100-year storm passes through the main channel cross-section with 35 percent passing in the floodplain on each side, use staged culverts to approximate that distribution.

7.2.6 Culvert Skew

A culvert shall be designed with a maximum skew of 45 degrees as measured from a line perpendicular to the roadway centerline.

7.2.7 End Treatments

All culverts shall be designed with inlet and outlet headwalls. The parapet wall shall be parallel to the road.

7.2.8 Outlet Protection

The outlet of culverts shall be protected with gabion mattresses or impact stilling basins in accordance with Chapter 11.

7.3 Culvert Design Procedures

7.3.1 *Acceptable Methods*

Culverts shall be designed in accordance with methods described in “Hydraulic Design of Highway Culverts” (Hydraulic Design Series (HDS) No. 5) of the Federal Highway Administration (FHWA).

7.4 Bridge Design Criteria

7.4.1 General

Bridges shall be designed to:

- Pass the 100-year flow with one foot of freeboard below the bottom of the bridge structure
- Not damage the road or increase damages to adjacent property because of high velocities
- Maintain existing flow distribution in the floodplain to the extent practicable
- Minimize flow disruption and potential scour from pier spacing, pier orientation, and abutment
- Avoid failure by scour
- Pass anticipated debris
- Provide measures to counteract the sometimes unstable or unpredictable nature of alluvial streambeds or demonstrate that the risk of damage is low
- Produce minimal disruption of ecosystems and values unique to the floodplain and stream
- Accommodate pedestrian access

7.4.2 Backwater Increases

Bridges shall be designed so that flooding to upstream properties is not increased over existing levels. Verify this by conducting a flow profile analysis for the waterway, using the 100-year storm flow, for conditions prior to and following construction of the bridge. Limit the allowable increase in backwater at the bridge to 1 foot during passage of the 100-year flow. The 100-year flood elevation may be increased only within the development site and shall not extend off site.

7.5 Bridge Design Procedures

Use HEC-RAS to evaluate the effects of the bridge.

7.6 Construction Specifications

7.6.1 Circular Culvert Pipe

Circular culvert pipe in the public drainage system (see Section 1.4.1) shall be reinforced concrete pipe or corrugated plastic pipe and shall meet the specifications of the LFUCG Standard Drawings and KYTC Standard Specifications for Road and Bridge Construction, latest edition.

Corrugated plastic pipe (CPP) shall meet the following requirements:

1. CPP shall have a smooth inner liner and shall be manufactured according to ASTM F2306 or ASTM F2562 for high density polyethylene pipe, or ASTM F2881 for polypropylene pipe.
2. CPP shall have an integral bell and spigot with an elastomeric seal meeting the requirements of ASTM F477 or ASTM D3212.
3. CPP may be used up to 36 inches in diameter in new development applications in easements and public right-of-ways.
4. Manufacturers of CPP shall be qualified participants of the National Transportation Product Evaluation Program (NTPEP).
5. Installation of CPP shall follow existing LFUCG standard drawing details and requirements as previously outlined for other pipe materials. Additional manufacturer guidelines shall be followed if necessary.
6. The minimum cover shall be 24 inches. Maximum depth for CPP shall be 16 feet. All necessary precautions shall be taken to avoid operating heavy equipment on top of the pipe until the required cover is attained. If stone size other than #9 is proposed, it must be in accordance with manufacturer’s recommendations. If no such recommendation exists, then the manufacturer shall submit approval to LFUCG in writing.
7. In new development, the developer’s engineer shall, 30 days after installation, certify that CPP pipe was installed in accordance with manufacturer’s recommendations and ASTM 2321 and that the pipe’s structural integrity and functionality is preserved. The Engineer shall conduct deflection testing of the pipe 30 days after installation. The deflection testing shall be done in accordance with KYTC specifications. The pipe shall be replaced if the deflection is greater than 5%. Allowable deflections on any axis are presented in the table below.

Base Pipe Diameter (inches)	AASHTO Nominal Diameter (inches)	Max. Deflection Limit		
		5.0% (inches)	7.5% (inches)	10.0% (inches)
15	14.76	14.02	13.65	13.28
18	17.72	16.83	16.39	15.95
24	23.62	22.44	21.85	21.26
30	29.53	28.05	27.32	26.58
36	35.43	33.66	32.77	31.89
48	47.24	44.88	43.70	42.52
54	53.15	50.49	49.16	47.84
60	59.06	56.11	54.63	53.15

From KYTC Kentucky Method (KM) 114-14

7.6.2 Box Culverts and Bridges

Box culverts and bridges shall be designed and constructed in accordance with the LFUCG Structures Manual.

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CONSTRUCTED CHANNELS

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8.1 Introduction

Constructed channels include permanent constructed channels and temporary diversions. Temporary diversions shall be designed in accordance with requirements of Chapter 11. This chapter describes permanent constructed channels, including paved channels.

8.2 Permanent Constructed Channels

Constructed channels include roadside channels and stormwater drainage channels with regular geometric cross-sections and lining of natural or synthetic materials to protect against erosion.

Safety of the general public shall be an important consideration in the selection of cross-sectional geometry of constructed channels.

The design of channels shall consider the frequency and type of maintenance expected and make allowance for access of maintenance equipment.

8.2.1 Design Criteria

Constructed channels shall be contained within a drainage easement wide enough to carry the 100-year storm.

Constructed channels shall be designed with stable side slopes. Vegetated channels shall have side slopes of 3:1 or flatter.

Constructed channels in residential areas that receive runoff from a storm sewer or culvert shall be designed with a low flow channel of turf reinforcement, permeable pavers, or articulated blocks to prevent erosion. Concrete low flow channels may only be used if the above methods are not sufficient to prevent erosion. The low flow channel shall be designed to carry 25% of the 10-year storm.

Channel freeboard shall be one foot or two velocity heads ($\text{velocity head} = V^2/2g$), whichever is larger.

Channels with bottom widths greater than 10 feet shall have a minimum bottom cross slope of 12:1 to the center of the channel. The flow line shall be at the center of the channel.

Maximum design depth shall be based on the 100-year storm.

The minimum slope of constructed channels receiving flow from a storm sewer shall be 2%.

8.2.2 Channel Protection

Use channel protection to stabilize the slopes and bottoms of constructed channels. Evaluate vegetative lining first. If a vegetated channel is not stable, other alternatives shall be considered in the order shown below:

- Vegetative with a turf reinforced mat (TRM)
- Permeable pavers or articulated blocks
- Concrete

Where there is a base flow and the channel does not have a natural rock bottom, the bottom of the channel shall have a non-vegetative lining.

8.2.3 Manning's Equation

Use the Manning Equation to design open channels.

$$Q = (1.49/n)AR^{2/3} S^{1/2}$$

Where:

- Q = discharge, cfs
- n = Manning's roughness coefficient
- A = cross-sectional area of flow, ft²
- R = hydraulic radius = A/P, ft

P = wetted perimeter, ft
S = channel slope, ft/ft

Select Manning's n from Tables 8-1 and 8-2.

8.2.4 *Tractive Force*

After sizing the channel and determining the normal flow depth corresponding to the design storm, check the suitability of the channel lining using the tractive force method. The maximum tractive force at normal flow depth, τ_d , is calculated as:

$$\tau_d \text{ (lbs/ft}^2\text{)} = 62.4yS$$

Where:

y = normal depth (ft)
S = channel slope.

The critical tractive force, τ_c , for many linings can be found in Table 8-3. If $\tau_d < \tau_c$, the lining is acceptable. Options for redesign include selecting a more resistant lining or decreasing the flow velocity by decreasing the channel bed slope or side slopes or increasing the width.

For linings not listed in Table 8-3, use the manufacturer's literature to determine the critical tractive force and submit documentation with the design. For mats, nets, or TRMs use the critical tractive force in the unvegetated condition.

8.2.5 *Construction Specifications*

All ditches or other depressions to be crossed shall be filled before construction begins or as part of construction, and the earth fill used to fill the depressions shall be compacted using the treads of the construction equipment. All old terraces, fencerows, or other obstructions that will interfere with the successful operation of the channel shall be removed.

The earth materials used to construct the earth fill portions of the channel shall be obtained from the excavated portion of the channel or other approved source.

The earth fill materials used to construct the channel shall be compacted by running the construction equipment over the fill in such a manner that the entire surface of the fill will be traversed by at least one tread track of the equipment.

The completed channel shall conform to the cross section and grade shown on the design plans.

**TABLE 8-1 –
MANNING’S n FOR CONSTRUCTED CHANNELS**

Lining Type	Manning’s n
Concrete	0.013
Grouted Stone	0.030
Stone Masonry	0.032
Bare Soil	0.020
Rock Cut	0.035
Jute Net	0.022
Straw with Net	0.033
Curled Wood Mat	0.035
6-inch D ₅₀ Riprap	0.050
12-inch D ₅₀ Riprap	0.060
Pavers and Articulated Blocks	0.020
Grass	0.045

**TABLE 8-2 –
MANNING’S n FOR STREAMS AND FLOODPLAINS**

	Manning’s n
Streams	0.045
Floodplains	
Pasture, no brush	0.035
Brush	0.10
Trees	0.120

**TABLE 8-3 –
SUMMARY OF CRITICAL TRACTIVE FORCES FOR VARIOUS PROTECTION MEASURES**

Protective Cover	τ_c(lbs/ft²)
Grass or Grass-legume Mixture Good Stand	1.0
Jute Net	0.45
Straw with Net	1.45
Curled Wood Mat	1.55
Turf Reinforcement Matting (TRM)	6-10
Riprap	
D ₅₀ = 6 inches	2.50
D ₅₀ = 12 inches	5.00

8.2.6 Maintenance

Channels shall be inspected regularly to check for points of scour or bank failure; rubbish or channel obstruction; rodent holes; breaching; and excessive wear from pedestrian or construction traffic.

Channels shall be repaired at the time damage is detected. Sediment deposits shall be removed from adjoining vegetative filter strips when they are visible.

Channels shall be reseeded and fertilized as needed to establish vegetative cover.

8.3 Paved Channels

A paved channel shall be used when the flow velocity at design capacity (using vegetative lining) exceeds 12 fps.

8.3.1 *Design Criteria*

Paved channels shall be designed to carry the peak flow from the 100-year storm.

The outlets of paved channels shall be protected from erosion using gabion mattresses. The length of the gabion mattress shall be one foot for each one fps of velocity. The width of the gabion mattress shall extend one foot in elevation beyond the top elevation of the paved channel.

Cutoff walls shall be constructed at the beginning and end of each channel except where the channel connects with a catch basin or inlet.

The minimum slope of paved channels shall be 2% for channels receiving flow from a storm sewer.

8.3.2 *Material Specifications*

Paved channels shall be constructed of concrete or interlocking concrete blocks.

8.3.3 *Construction Specifications*

The subgrade shall be constructed to the required elevations. All soft sections and unsuitable material shall be removed and replaced with suitable material. The subgrade shall be thoroughly compacted and shaped to a smooth, uniform surface. The subgrade shall be moist when pouring concrete.

8.3.4 *Maintenance*

Before permanent stabilization of the slope, the structure shall be inspected after each rainfall. Any damages to the channel or slope shall be repaired immediately.

CHAPTER 9
STREAM BANK STABILIZATION AND RESTORATION

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FIGURE 9-2 – OTHER RIPARIAN BUFFER ZONE WIDTHS

FIGURE 9-3 – CANOPY HEIGHT FOR WATER TEMPERATURE CONTROL

FIGURE 9-4 – DETAILS OF STAKES

FIGURE 9-5 – DETAIL OF ROOT WAD REVETMENT

FIGURE 9-6 – DETAIL OF STACKED COIR FIBER LOG REVETMENT

FIGURE 9-7 – DETAIL OF LIVE FASCINE

FIGURE 9-8 – DETAIL OF BRUSH MATTRESS

FIGURE 9-9 – DETAIL OF BRANCH PACKING

FIGURE 9-10 – DETAIL OF LIVE CRIBWALL

FIGURE 9-11 – DETAIL OF LOG CRIB REVETMENT

9.1 Introduction

The streams of Fayette County are part of the waters of Fayette County as discussed in Chapter 1. They are shown on the Fayette County GIS waters coverage. The streams of Fayette County are typically those shown on the USGS 7.5 minute quadrangle map with a solid or dashed blue line. However, in some instances streams not shown as blue lines have been found to exhibit the same characteristics as blue line streams and have been added to the Fayette County waters GIS coverage.

In general, streams are:

- Natural channels with their size and shape determined by natural forces
- Compound in cross section with a main channel for conveying low flows and a floodplain to transport flood flows
- Shaped geomorphologically by the long-term history of sediment load and water discharge which they experience

As indicated in Chapter 1, construction is only allowed in the floodplain and stream for certain activities.

The practices listed in this chapter are to be used for two purposes:

- Protecting the stream bank and floodplain from the construction that must occur
- Enhancing the stream and floodplain as part of the overall development or stream restoration plan

9.2 Vegetative Stream Bank Stabilization

9.2.1 General

In some instances, certain allowable construction will result in excavation into the stream bank. In those instances when the natural stream bank must be disturbed, first consider vegetative stream bank stabilization methods. If those methods are not applicable, use bioengineering techniques. Use structural stream bank stabilization techniques as a last resort for permanent stabilization except in instances where a small gabion mattress is needed for outlet protection. In no case will gabions be allowed within a stream unless bioengineering methods are not suitable.

In other instances, increased runoff may cause the deterioration of a natural stream bank. Similarly, a natural stream bank that has been previously degraded due to past impacts may be further deteriorated by new development. In these cases, the stream bank shall be restored to prevent further degradation using vegetative methods and/or bioengineering techniques.

9.2.2 Design Criteria

Planned protective measures shall be compatible with the adjacent land use and the improvements that will be carried out by others.

The selection of native vegetation to be established shall be based on the soil type and chemistry, land use, flooding periods, and stream velocity. A list of recommended species is provided in Table 9-1. Soil tests shall be conducted prior to land disturbance activity to determine if soil amendments and/or fertilizers are needed. If soil tests determine that fertilization is required, then application of recommended fertilizer shall not occur until after the vegetation has germinated and established growth.

Where necessary, erosion control matting or turf reinforcement matting shall be used along with the vegetative measures to stabilize the stream banks.

If traditional vegetative measures described in this section are not effective, bioengineering techniques shall be considered.

Special attention shall be given to maintaining or improving habitat for fish and wildlife.

On smaller streams where a good seedbed can be prepared, herbaceous plants may be used alone to stabilize the banks. On larger streams and more difficult sites, woody shrubs and trees with herbaceous plants shall be considered.

All requirements of state law and permit requirements of local, state, and federal agencies must be met.

9.2.3 Material Specifications

Vegetation shall consist of herbaceous ground cover and/or woody shrubs and trees. Installation methods shall include direct seeding and/or the planting of bare root seedlings, hardwood cuttings, and/or containerized plants.

Direct seeding shall only be conducted during March 1 to May 15 or August 1 to September 30. Bare root and cutting installation shall only be conducted during December 1 to March 15. Installation of containerized plants shall only be conducted during March 1 to May 15 and September 1 to December 31.

The surface shall be mulched with clean wheat straw at a rate of 2 tons per acre. Mulch shall be secured as described in the section on mulch. If mulch tackifiers or related methods are not applicable then erosion control matting or turf reinforcement matting (TRMs) shall be used. Many types of erosion control mats and TRMs are available from various manufacturers. Some are considered temporary because they are manufactured of organic materials that will degrade over time. Due to wildlife endangerment problems associated with the UV resistant mesh in some erosion control matting, only materials with fully degradable mesh shall be used as mulch blankets. Non-

degradable products (TRMs) are appropriate where turf reinforcement is necessary. The material shall be chosen based on calculated tractive forces in accordance with manufacturers' recommendations (See Chapter 8).

If nursery stock (bare root or containerized) is used, the species listed in Table 9-1 shall be used for establishing vegetation. Direct seeding of the herbaceous species listed below shall also be used. Selected species shall be based upon the native vegetation of the watershed where work is proposed and shall reflect the original stream bank species. Exotic or pest species shall not be used.

See Section 9.4.2 for recommended species and installation requirements of hardwood cuttings.

9.2.4 Construction Specifications

Prior to seeding or planting, only fallen trees, stumps, and other debris that may force stream flow into the stream bank shall be removed. Leaving other debris may be desirable for aquatic habitat.

Where feasible, the stream bank side slope shall be cut back to 3:1 slope or flatter and overhanging bank edges shall be removed.

Direct seeding areas shall be roughened with a rake or similar tool. Seeding rates shall be a minimum of 10 lbs. per 1000 square feet of disturbed area.

Erosion control matting or turf reinforcement matting shall be installed in accordance with manufacturers' requirements. Erosion control fabrics, blankets, mats and nettings shall be anchored at the top of stream banks by excavating a shallow trench. The material shall be laid in the bottom of trench with overlap. The trench shall be backfilled with excavated soil. The overlap material shall be laid on top of backfill and secured with dead stout stakes, metal staples, or according to manufacturer's specifications (see Figure 9-1).

Bare root or containerized stock shall be planted at the same depth as planted in the nursery. The stock shall be planted in a hole large enough to accommodate the root system when well spread. Trees and shrubs shall be planted to achieve a minimum density of 300 live stems per acre after three years.

9.2.5 Maintenance

Banks shall be checked after every high water event. Gaps in vegetative cover shall be repaired at once with new plants and mulched if necessary. Exotic and pest species that become established on the bank shall be removed.

TABLE 9-1 – SUGGESTED RIPARIAN SPECIES LIST

The species on the list are only suggestions. Native species that are appropriate for a given site may be proposed.

Common Name	Scientific Name
Tree Species:	
Pin Oak	<i>Quercus palustris</i>
Cherrybark Oak	<i>Quercus pagoda</i>
Bur Oak	<i>Quercus macrocarpa</i>
Swamp Chestnut Oak	<i>Quercus michauxii</i>
Shingle Oak	<i>Quercus imbricaria</i>
Northern Red Oak	<i>Quercus rubra</i>
Post Oak	<i>Quercus stellata</i>
Red Maple	<i>Acer rubrum</i>
Green Ash	<i>Fraxinus pennsylvanica</i>
Shellbark Hickory	<i>Carya laciniosa</i>
Blackgum	<i>Nyssa sylvatica</i>
American Elm	<i>Ulmus americana</i>
Eastern Cottonwood	<i>Populus deltoides</i>
Black Walnut	<i>Juglans nigra</i>
River Birch	<i>Betula nigra</i>
Yellow Poplar	<i>Liriodendron tulipifera</i>
Persimmon	<i>Diospyrus virginiana</i>
Black Walnut	<i>Juglans nigra</i>
Ohio Buckeye	<i>Aesculus glabra</i>
Sugar Maple	<i>Acer saccharum</i>
Sycamore	<i>Plantanus occidentalis</i>
Persimmon	<i>Diospyros virginiana</i>
Shrubs	
Arrow-wood	<i>Viburnum dentatum</i>
American Plum	<i>Prunus americana</i>
Deciduous Holly	<i>Ilex decidua</i>
Gray Dogwood	<i>Cornus racemosa</i>
Silky Dogwood	<i>Cornus amomun</i>
Spicebush	<i>Lindera benzoin</i>
Sassafras	<i>Sassafras albinum</i>
American Elder	<i>Sambucus canadensis</i>
Button Bush	<i>Cephalanthus occidentalis</i>
River Cane	<i>Arundinaria gigantea</i>
Coralberry	<i>Symphoricarpos orbiculatus</i>

Common Name	Scientific Name
Herbaceous Species	
Rice cutgrass	<i>Leersia oryzoides</i>
Managrass	<i>Glyceria striata</i>
Spangle grass	<i>Chasmanthium latifolium</i>
Barnyard grass	<i>Echinochloa crus-galli</i>
Switchgrass	<i>Panicum virgatum</i>
Annual rye	<i>Secale cereale</i>
Wild rye	<i>Elymus virginicus</i>
Deertongue grass	<i>Panicum clandestinum</i>
Panic grass	<i>Panicum microcarpon</i>
Giant Cane Bambo	<i>Arundinaria gigantea</i>
Boneset	<i>Eupatorium perfoliatum</i>
Big Bluestem	<i>Andropogon gerardii</i>
Prairie cordgrass	<i>Spartina pectinata</i>
Water Plantain	<i>Alisma subcordatum</i>
Common Milkweed	<i>Asclepias syriaca</i>
Beggar's Ticks	<i>Biden polyeps</i>
Canada Brome	<i>Bromus pubescens</i>
American Bellflower	<i>Campanula americana</i>
Frank's Sedge	<i>Carex frankii</i>
Sedge	<i>Carex granularis</i>
Shallow Sedge	<i>Carex lurida</i>
Hop Sedge	<i>Carex lupulina</i>
River Oats	<i>Chasmanthium latifolium</i>
Riverbank Wild rye	<i>Elymus riparius</i>
Downy Wild rye	<i>Elymus villosus</i>
Joe-pie Weed	<i>Eupatorium maculatum</i>
Fowl Manna Grass	<i>Glyceria striata</i>
Rush	<i>Juncus sp.</i>
Western Panic grass	<i>Panicum acuminatum</i>
Switchgrass	<i>Panicum virginica</i>
Foxglove Beardtongue	<i>Penstemon digitalis</i>
Leafcup	<i>Polymnia canadensis</i>
Brown-eyed Susan	<i>Rudbeckia triloba</i>
Dark Green Bulrush	<i>Scirpus cyprinus</i>
Yellow Wingstem	<i>Verbesina alternafolia</i>
White Wingstem	<i>Verbesina virginica</i>

9.3 Riparian Buffer Zones

9.3.1 General

Riparian buffer zones are areas of trees and/or shrubs located adjacent to and up-gradient from perennial or intermittent streams, lakes, ponds, wetlands, and areas with groundwater recharge. They may be constructed by Developers to satisfy some or all of the required water quality volume (see Chapter 10).

The purpose of riparian buffer zones are:

- To reduce excess amounts of sediment, organic material, nutrients, pesticides, and other pollutants in surface runoff and reduce excess nutrients and other chemicals in shallow groundwater flow
- Create shade to moderate water temperatures to improve habitat for fish and other aquatic organisms
- To provide a source of detritus and large woody debris for fish and other aquatic organisms
- To provide riparian habitat and corridors for wildlife

9.3.2 Design Criteria

The buffer shall consist of a zone (identified as Zone 1) that begins at the top of bank, and extends a minimum distance of 15 feet, measured horizontally on a line perpendicular to the water course or water body and planted with tree species selected from Table 9-1.

An additional strip or area of land (Zone 2) will begin at the edge and up-gradient of Zone 1 and extend a minimum distance of 20 feet, measured horizontally on a line perpendicular to the water course or water body. Zone 2 shall be planted with shrubs and herbaceous ground cover species selected from Table 9-1. The combined width of Zones 1 and 2 shall be 100 feet or 30 percent of the geomorphic floodplain, whichever is less. A geomorphic floodplain is defined as the area adjacent to a river or stream that is built of alluvial sediments that are associated with the present depositional activity.

Figures 9-1 and 9-2 illustrate examples of Zone 1 and 2 widths for water courses and water bodies. Zone 2 may need to be adjusted to include important resource features such as wetlands, steep slopes, or critical habitats.

Buffers shall be established or maintained from top of bank to waterline along water courses and bodies where practical. The buffer canopy shall be established to achieve at least 50 percent crown cover with average canopy heights equal to or greater than the width of the water course, or 30 feet for water bodies. (See Figure 9-3).

Dominant vegetation shall consist of existing or planted trees and shrubs suited to the site and the intended purpose. Selection of locally native species shall be a priority when feasible. Plantings shall consist of six or more species in an attempt to achieve greater diversity. Individual plants selected shall be suited to the seasonal variation of soil moisture status of individual planting sites. Plant types and species shall be selected based on their compatibility in growth rates and shade tolerance.

Necessary site preparation and planting for establishing new buffers shall be done at a time and manner to insure survival and growth of selected species. Refer to Section 9.2 for care, handling, and planting requirements for woody planting stock.

Only viable, high quality and adapted planting stock shall be used. The method of planting for new buffers shall include hand or machine planting techniques, suited to achieving proper depths and placement for intended purpose and function of the buffer.

Site preparation shall be sufficient for establishment and growth of selected species and be done in a manner that does not compromise the intended purpose. Refer to Section 9.2 for woody planting stock quality requirements and planting rate densities. Supplemental moisture shall be applied if and when necessary to assure early survival and establishment of selected species.

Livestock shall be controlled or excluded as necessary to achieve and maintain the intended purpose. Water course crossings and livestock watering shall be located and sized to minimize impact to buffer vegetation and function.

9.3.3 Maintenance

The riparian forest buffer shall be inspected periodically, protected, and restored as needed, to maintain the intended purpose and protect it from adverse impacts such as excessive vehicular and pedestrian traffic, pest infestations, pesticide use on adjacent lands, livestock damage, and fire.

Replacement of dead trees or shrubs and control of undesirable vegetative competition shall be continued until the buffer has reached, or will progress to, a fully functional condition.

To maintain buffer function, control of erosion and sedimentation shall be continued in the up-gradient area immediately adjacent to Zone 2 until the up-gradient area is permanently stabilized.

For purposes of moderating water temperatures and providing detritus and large woody debris, riparian forest buffer management must maintain a minimum of 50 percent canopy cover. To achieve benefits provided by large woody debris, natural mortality of trees and shrubs may need to be supplemented by periodically falling and placing selected stems or large limbs within water courses and water bodies

9.4 Bioengineering Techniques

Bioengineering techniques for stream bank protection utilize native vegetation in combination with inert structural materials to stabilize soils that are subject to erosion and shallow mass movement.

9.4.1 Design Criteria

Establishing permanent vegetation is the preferred method for stabilizing soils along stream banks. With proper installation and maintenance, the planting of rooted stock, cuttings and direct seeding of native vegetation, in combination with erosion control fabrics, will effectively stabilize soils on slopes of 3:1 or flatter along streams with low flows and no concentrated discharges over the face of the stream bank.

On stream bank slopes of 3:1 or steeper, the techniques described in the following sections (with exception of the Live Staking technique) shall be employed as needed. Each technique is discussed in order of increasing effectiveness of protection based upon the slope of the stream bank. The combined use of two or more techniques to accomplish stream bank stabilization and protection may be applicable for some sites.

When stream banks must be disturbed, slopes shall be regraded to match the adjoining upstream and downstream slopes, if they are stable. If the adjoining slopes are not stable, the disturbed portion shall be regraded to the least gradient possible.

Reinforcement shall be provided at the base or toe of the stream bank below the mean low waterline prior to implementing bioengineering techniques. Several techniques discussed are applicable for base reinforcement. All work shall begin at the base of the stream bank and continue up gradient.

For sites involving the discharge of concentrated flow through a stream bank and directly into a stream, protection shall be provided for the stream bank opposite of the concentrated discharge. Most of the techniques discussed below will be applicable for those sites and are duly noted.

9.4.2 Live Stake

Live stakes shall be used in limited situations for stream bank slopes of 3:1 or flatter with low flows and no surficial overbank discharge. This technique consists of inserting (tamping) fresh hardwood cuttings into the stream bank. This technique is more applicable as a preventive measure before severe erosion problems occur.

Live hardwood cuttings shall be collected and installed during the dormant season (November through March) from areas near the site. Drainage ditches, detention ponds, and construction sites can be good sources for materials. The following table provides recommended species for hardwood cuttings. Table 9-1 provides the recommended species for rooted seedlings.

TABLE 9-2 – NATIVE PLANT SPECIES SUITABLE FOR HARDWOOD CUTTING IN CENTRAL KENTUCKY

Common Name	Scientific Name
Primary Species:	
Black willow	<i>Salix nigra</i>
Sandbar willow	<i>Salix interior</i>
Heart-leaf willow	<i>Salix rigida</i>
Silky dogwood	<i>Cornus amomum</i>
Redosier dogwood	<i>Cornus sericea</i>
American elderberry	<i>Sambucus canadensis</i>
Secondary Species:	
Tall pussy willow	<i>Salix discolor</i>
Silky willow	<i>Salix sericea</i>
Dwarf willow	<i>Salix humilis var. macrophylla</i>
Alternate-leaf dogwood	<i>Cornus alternifolia</i>
Gray dogwood	<i>Cornus racemosa</i>
Rough-leaf dogwood	<i>Cornus drummondii</i>
Boxelder	<i>Acer negundo</i>
Nannyberry	<i>Viburnum lentago</i>
Swamp Haw	<i>Viburnum nudum</i>
Arrowwood	<i>Viburnum dentatum</i>

Other practices, in combination with live stakes, shall be used for stream banks that receive high flow fluctuations or consist of fill soils.

Stakes (cuttings) shall be 2 to 3 feet in length and 0.5 to 2 inches in diameter with all outer branches removed. Basal end (inserted into ground) shall be sawed clean at an angle. Blunt end (exposed end) shall be cut square. See Figure 9-4A for a live stake detail.

Stakes shall be installed within 24 hours of cutting. Temporary storage shall occur in a moist, cool location.

Stakes shall be installed at right angles to the slope with 20 percent (1/5) of the stake left exposed. Stakes shall be spaced at a minimum of 2 to 4 per square yard and in a random configuration.

Installation shall begin at the base of the stream bank working up gradient. Dead blow hammers work the best for installing stakes in soft soils. In cases where stiff soils exist, then pre-drilled holes must be used to accommodate cutting installation. The ground at the base of each stake shall be tamped firm.

When erosion control fabrics are necessary, the live stakes shall be used to help secure the material to the face of the stream bank.

9.4.3 Root Wad Revetment

Root wad revetment techniques can be used for opposite bank protection from concentrated flow discharge and as toe of slope reinforcement with a high flow fluctuation in the stream. This technique is excellent for restoring and improving fish habitats and, when used in combination with proper vegetative methods, is highly effective for stabilizing stream banks.

Root wads are tree stumps with a minimum of 6 feet of bole (trunk) above the root flare. The root wads shall be built on top of footer logs and secured with a header log. Footer and header logs shall be secured to the root wad

by iron rebar. The bole shall be inserted or placed in the bank at a 30 to 45 degree angle from the downstream line of streamflow, i.e. the root flare shall face upstream.

Placed stone shall be used to further secure the root wad system. Filter fabrics may be required in loamy silts or sandy soils.

Root wads shall be backfilled with soil and planted with live stakes. Stream bank above root wad shall be covered with erosion control fabrics and planted. Figure 9-5 shows the typical construction detail for root wad revetment.

9.4.4 Coir Log Revetment

Coir (coconut fiber) log revetments can be used for slope stabilization at the toe of slopes of 2:1 or flatter and as protection for stream banks opposite concentrated discharge points. Coir log revetments shall be used in combination with coir mats or jute netting, planted vegetation and/or live staking. Figure 9-6 provides a detail of staked coir log revetment.

Coir logs shall be secured with dead stout stakes inserted down gradient and against logs. Live stakes should be inserted directly into logs. Coir twine should be wrapped around dead stout stakes and over logs to hold them securely to the bank face.

Dead stout stakes are 2.5 feet long and 2 inches thick by 4 inches wide (2x4) of untreated lumber that have been cut diagonally across the 4 inch width with a 0.25 inch tip. Figure 9-4B shows in detail how the stakes are cut.

9.4.5 Live Fascine

The live fascine technique is applicable on slopes of 2:1 or flatter and utilizes cylindrical bundles of freshly cut willow (*Salix spp.*), or dogwood (*Cornus spp.*) branches placed in trenches excavated along the contours of the stream bank. Live fascines can also be used to reinforce the toe of stream bank slopes.

Fascines shall not be used when surficial concentrated flows are discharged over the face of the stream bank or where high flow fluctuations occur. When used in combination with coir mats or jute netting and planted vegetation, live fascines can be used on slopes of 2:1 or flatter.

Coir logs shall be used in place of live fascines when bundle materials are not available; however, the coir logs shall be planted with rooted willow, dogwood, or alder.

Live fascine bundles can be 5 to 30 feet in length by 7 to 10 inches in diameter and tied together with jute or bailing twine. The bundles are secured with both dead stout stakes and live stakes of fresh cut willow.

The cuttings are composed of branches 0.5 to 1 inch in diameter and must be arranged in the bundle with growing tips in the same direction and staggered to evenly distribute growth along the bundle. See Figure 9-7 for construction detail.

Small trenches (12 inch by 12 inch) shall be constructed starting at the base of the slope, parallel to the stream channel, and spanning the entire stream bank. Parallel trenches shall be constructed along the face of the slope according to the following table:

TABLE 9-3 – LIVE FASCINE TRENCH DISTANCES

Bank Slope	Slope Distance Between Trenches	Maximum Slope Length
2:1 to 2.5:1	5 to 6 feet	20 feet
2.5:1 to 3:1	6 to 7 feet	30 feet
3:1 to 3.5:1	7 to 8 feet	40 feet
3.5:1 to 4:1	8 to 9 feet	50 feet

Source: Wright, 1995.

Live fascines shall be placed end to end inside the trenches starting at the base of the slope and working up gradient. Dead stout stakes shall be tamped into bundles every 3 feet along the length and at bundle connections. Trenches shall be backfilled with soil and tamped firm around the fascine.

Live stakes shall be tamped in down gradient and against the bundles at right angles to the slope. The live stake procedures in Section 9.4.1 shall be used.

9.4.6 Brush Mattress

Brush mattresses are applicable for 1:1 slopes or flatter along streams subject to high flow fluctuations. They can also be used for opposite stream bank protection. This technique is limited to stream bank faces of 10 feet or less. Brush mattresses require substantial amounts of materials, which including live fascines, live stakes, dead stout stakes, and cut branches.

The slope face shall be prepared by smoothly grading the surface and constructing a small trench (12 inch by 12 inch) at the base of the slope, parallel to the stream channel, and spanning the entire stream bank.

Live fascines shall be installed in the trench as described in Section 9.4.4.

Dead stout stakes shall be installed 3 feet on center in rows parallel to the channel for the entire slope face. Six inches of stake shall be left exposed above the surface. Figure 9-8 shows in detail the layout of the trench and stakes.

Pieces of willow and/or dogwood cuttings 8 – 10 feet long shall be placed along the bank with basal ends towards the trench. Enough brush shall be used to create a 6-inch thick mattress.

The mattress shall be secured by wrapping wire or coir rope around dead stout stakes in a criss cross pattern between stakes. Work shall begin at bottom of the slope and proceed up-gradient.

The stakes shall be tamped further into ground to secure the mattress to the bank face. Live stakes shall be inserted between dead stout stakes similar to Section 9.4.1.

Cover area lightly with soil and tamp. Do not bury branches.

9.4.7 Branch Packing

Branch packing consists of alternating layers of live willow and/or dogwood cuttings and compacted soil secured with wooden poles along a trench. Branch packing is applicable for slopes of 1:1 or flatter that receive surficial discharge over the face of the stream bank and high flow fluctuations in the stream channel. This technique can also be used for opposite stream bank protection and in areas where severe erosion has resulted in shallow mass movement of the stream bank.

The trench dimensions for this technique are limited to 12 feet long by 5 feet high and 4 feet deep. Biodegradable filter fabrics shall be used to reinforce soil layers along streams with high flow fluctuations. Placed stone or log

cribs shall be used for toe of slope reinforcement at mean low waterline. See Figure 9-9 for a detail on this technique.

Wooden poles (4 inches in diameter) shall be untreated and cut at lengths to accommodate the specific depth of the site plus 4 feet. Branch cuttings shall be cut to lengths to accommodate the depth of trench plus 3 feet.

The trench shall be excavated clean and the bottom of the site sloped towards the bank from the stream channel. A stone or log crib shall be placed at the outer edge of the excavated area into and below mean low waterline.

Dead stout stakes shall be inserted 4 feet deep into the bottom of the trench on 1.5-foot centers. The first layer of brush shall be placed in the bottom of the trench with basal ends towards the bank in a criss-cross pattern 6 inches thick. The first brush layer shall be backfilled with 12 inches of equal parts soil and large gravel. The soil/gravel layer shall be compacted.

This process shall be repeated until the trench is filled. The amount of rock mixed with the soil can be reduced with each successive layer. The compacted bank face should correspond to the adjoining stream bank slopes.

9.4.8 Live Cribwall and Log Crib Revetment

Live cribwalls are rectangular frameworks of logs or timbers backfilled with soil, rock and live branch cuttings. They are applicable for a bank of any gradient that receives surficial discharge over the bank and high flow fluctuations and where space is limited to stabilize the stream bank.

This technique is limited in overall height of 6 feet and shall not be used where the adjoining streambed is subject to severe degradation. Figure 9-10 shows a detail for live cribwall.

Branch cuttings shall be 0.5 to 2 inches in diameter and 4 to 6 feet long. Logs or timbers shall be 4 to 6 feet long in varying lengths to accommodate site conditions. Timber shall be untreated. Stone shall be 2 to 4 inches in diameter.

The work area shall be over excavated 2 to 3 feet below the streambed or toe of bank and sloped back towards bank. Long log or timber shall be placed parallel to the channel and then short logs placed on top and perpendicular. Short logs shall extend to the back of the work area (bank). The logs shall be secured with rebar or spikes. This layer shall be backfilled, covered with 12 inches of rock, and compacted.

Build successive layers using rock as backfill until cribwall is above mean low waterline. Use soil backfill in layers above mean low waterline. Compact each soil layer.

The layer building process shall be repeated placing live brush cuttings on top of each compacted soil layer. The cuttings shall be placed with basal end towards the bank and the growth ends protruding out from the cribwall.

The slope of cribwall shall correspond to the adjoining stream bank slope and the final layer shall reach to the top of the original stream bank not to exceed 6 feet in overall height.

Log crib revetment techniques can be very effective for opposite bank protection or toe of bank reinforcement, especially where high concentrated discharges and high stream flow fluctuations occur. They are similar in construction to live cribwalls with the exception that they are lower in height and no vegetation is used. See Figure 9-11 for a construction detail.

9.4.9 Joint Planting

Joint planting is applicable to sites where the use of gabion mattresses or rubble stone to stabilize a stream bank has been determined to be the only practical method. This technique is accomplished by inserting live willow stakes between the placed stone. This technique is also applicable where stone is used for toe of bank reinforcement.

Willow tree species are the best for live cutting and shall be a minimum length of 3 to 3.5 feet and 1 to 2 inches in diameter. Planting time and storage specifications are similar to live staking.

The stakes shall be inserted in random configuration at a spacing of 3 to 6 stakes per square yard. At least two thirds of the stakes shall extend in to the soil below the stone layer.

9.4.10 Maintenance and Monitoring

Stream banks shall be checked after every high water event for six months after completion. Noticeable failures in bioengineering techniques shall be repaired as necessary. Vegetation growth shall be monitored for one year after completion to determine survival rates of planted vegetation. A minimum of 75 percent of designed density must be established by end of the first year after completion. Volunteer species will be considered towards the survival density. Areas of erosion or undermining of stream bank adjoining the stabilized portion of the stream shall be noted and monitored to assess whether retrofitting or repairs will be needed.

Signs shall be posted indicating a natural area that should not be mowed.

9.5 Structural Stream Bank Stabilization

Structural stream-bank stabilization refers to the stabilization of banks of live streams with permanent structural measures. Generally, the materials and processes are proprietary and include things like interlocking concrete blocks, gabions, gabion mattresses, crib walls, synthetic cellular confinement grids, and dry stone masonry.

9.5.1 Design Criteria

Structural stream-bank stabilization shall be used only in cases where vegetative stabilization in conjunction with turf reinforcement matting and vegetative bioengineering will not be effective.

Structural stabilization measures shall be planned and designed by an engineer and shall be used, only as necessary, in conjunction with vegetative techniques.

Rip-rap may be used if other measures are not feasible.

The protective measures shall be compatible with improvements planned or being carried out by others. The bottom scour shall be controlled before any permanent type of bank protection can be considered feasible unless the protection can be safely and economically constructed to a depth well below the anticipated lowest depth of bottom scour.

Stream bank protection shall start and end at a stabilized or controlled point on the stream.

Changes from a natural channel alignment shall not generally be made. Alignment changes in previously modified channels shall be made to take the channel to a more natural alignment and shall consider the effect upon land use, hydraulic characteristics, and the existing channel.

Special attention shall be given to maintaining and improving habitat for fish and wildlife.

Structural measures must be effective for the design flow and be capable of withstanding greater flows without serious damage.

All requirements of state law and permit requirements of local, state, and federal agencies must be met.

9.5.2 Specifications

All structural stream-bank protection measures shall be designed and installed in accordance with manufacturer's standards and specifications.

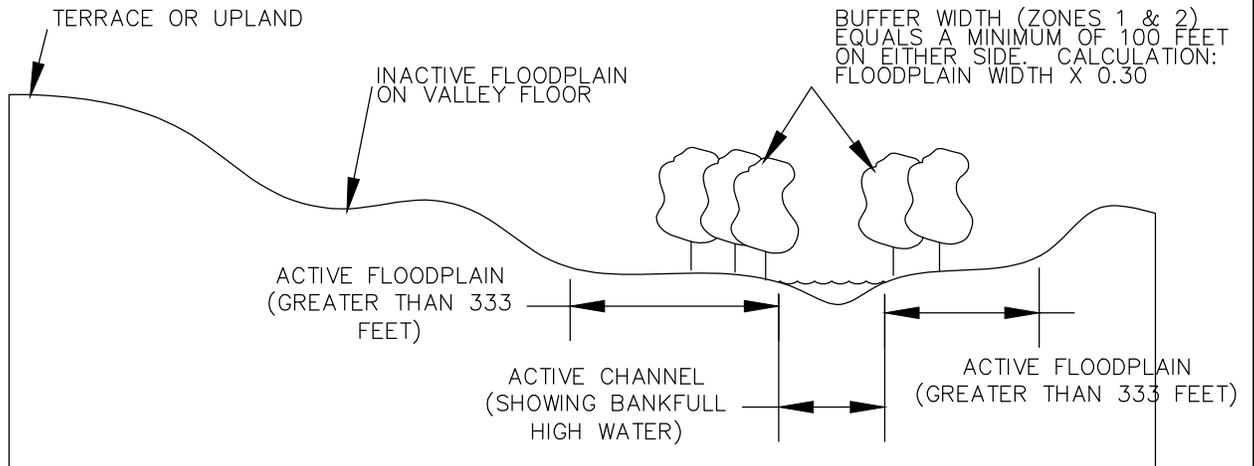
9.5.3 Maintenance

All structures shall be maintained in an "as built" condition. Inspection shall occur each month for the first 6 months after construction and at least every 6 months thereafter. Structural damage caused by storm events shall be repaired as soon as possible to prevent further damage to the structure or erosion of the stream bank.

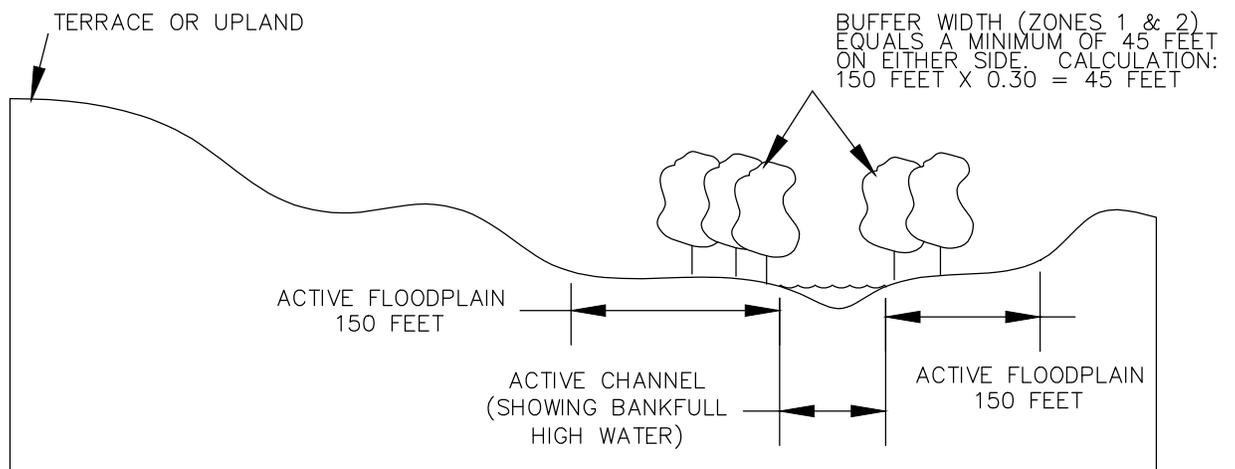


STORMWATER MANUAL

FIGURE 9-1
RIPARIAN BUFFER ZONE WIDTHS
ACTIVE FLOODPLAIN ON
BOTH SIDES OF CHANNEL
(OCTOBER 1, 2016)



ACTIVE FLOODPLAINS GREATER THAN 333 FEET IN WIDTH



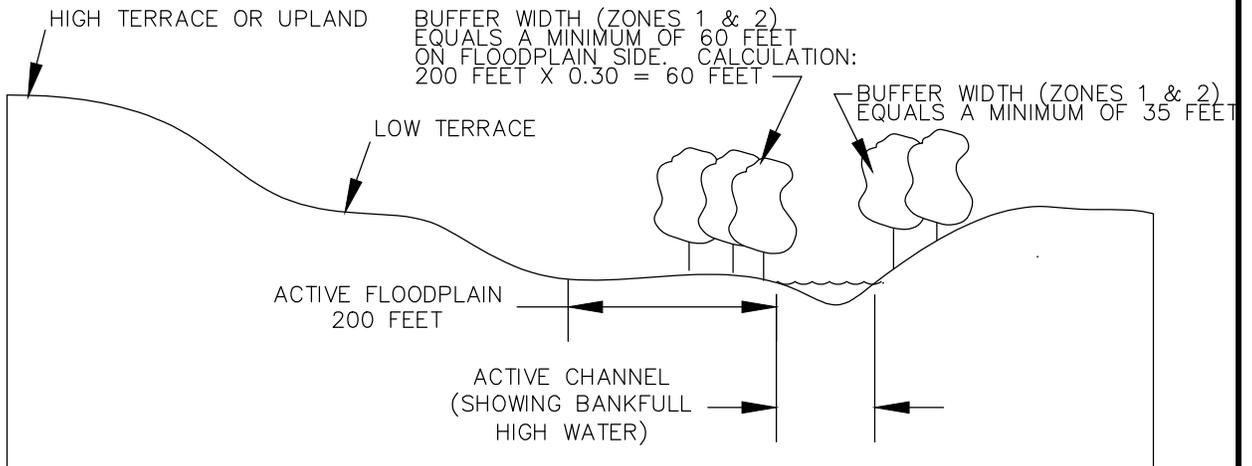
ACTIVE FLOODPLAINS LESS THAN 333 FEET IN WIDTH



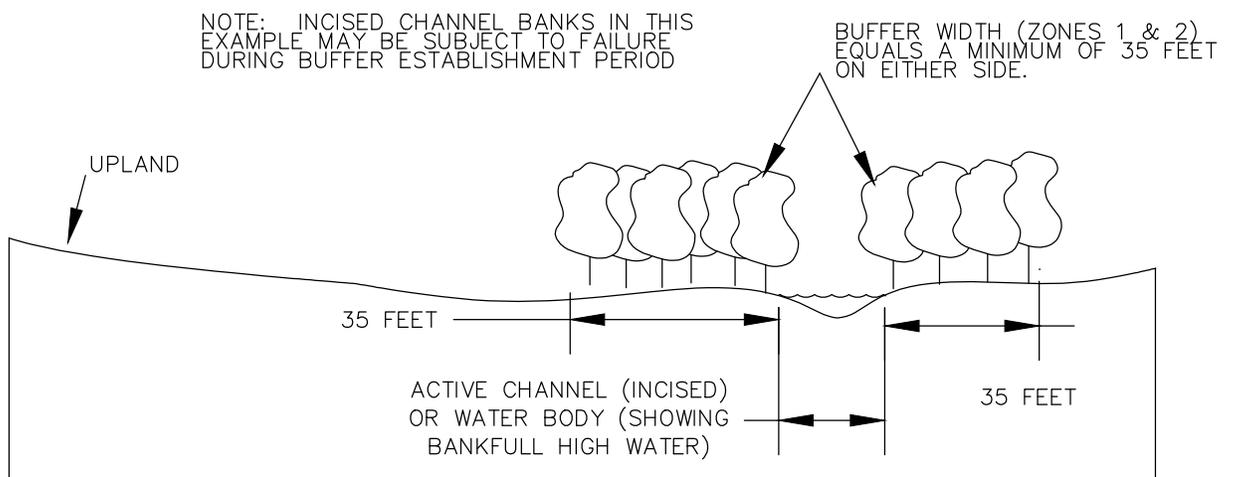
STORMWATER MANUAL

FIGURE 9-2 OTHER RIPARIAN BUFFER ZONE WIDTHS

(OCTOBER 1, 2016)



ACTIVE FLOODPLAIN ONLY ONE SIDE OF THE CHANNEL



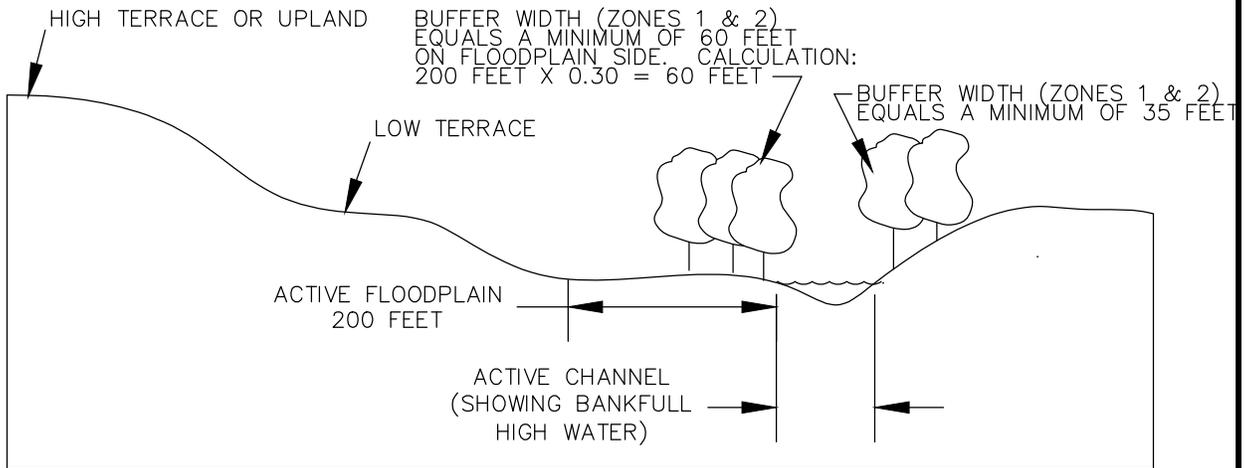
INCISED CHANNEL WITHOUT FLOODPLAINS AND ALL WATER BODIES



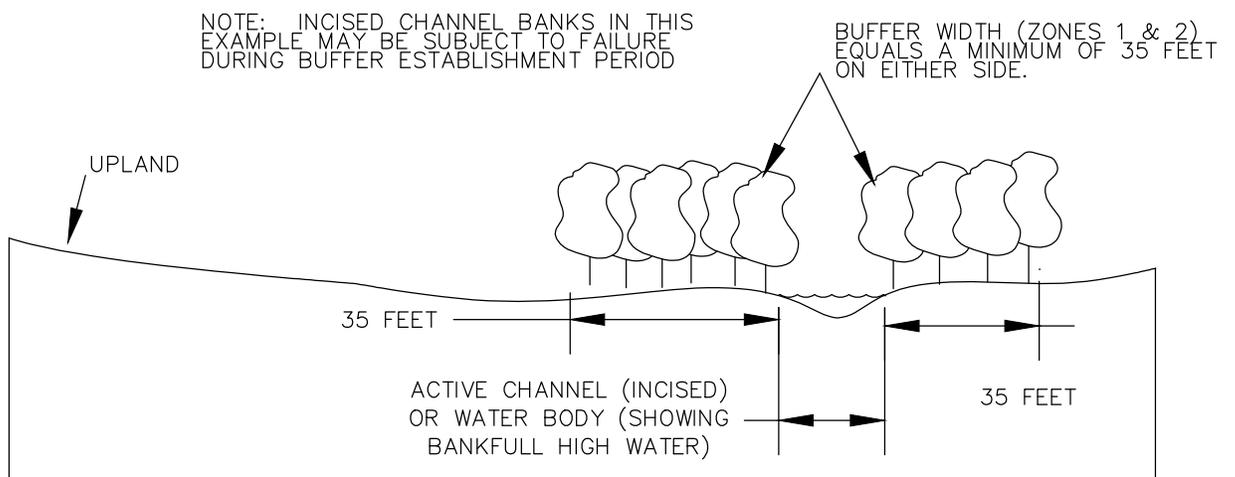
STORMWATER MANUAL

FIGURE 9-2 OTHER RIPARIAN BUFFER ZONE WIDTHS

(OCTOBER 1, 2016)



ACTIVE FLOODPLAIN ONLY ONE SIDE OF THE CHANNEL



INCISED CHANNEL WITHOUT FLOODPLAINS AND ALL WATER BODIES

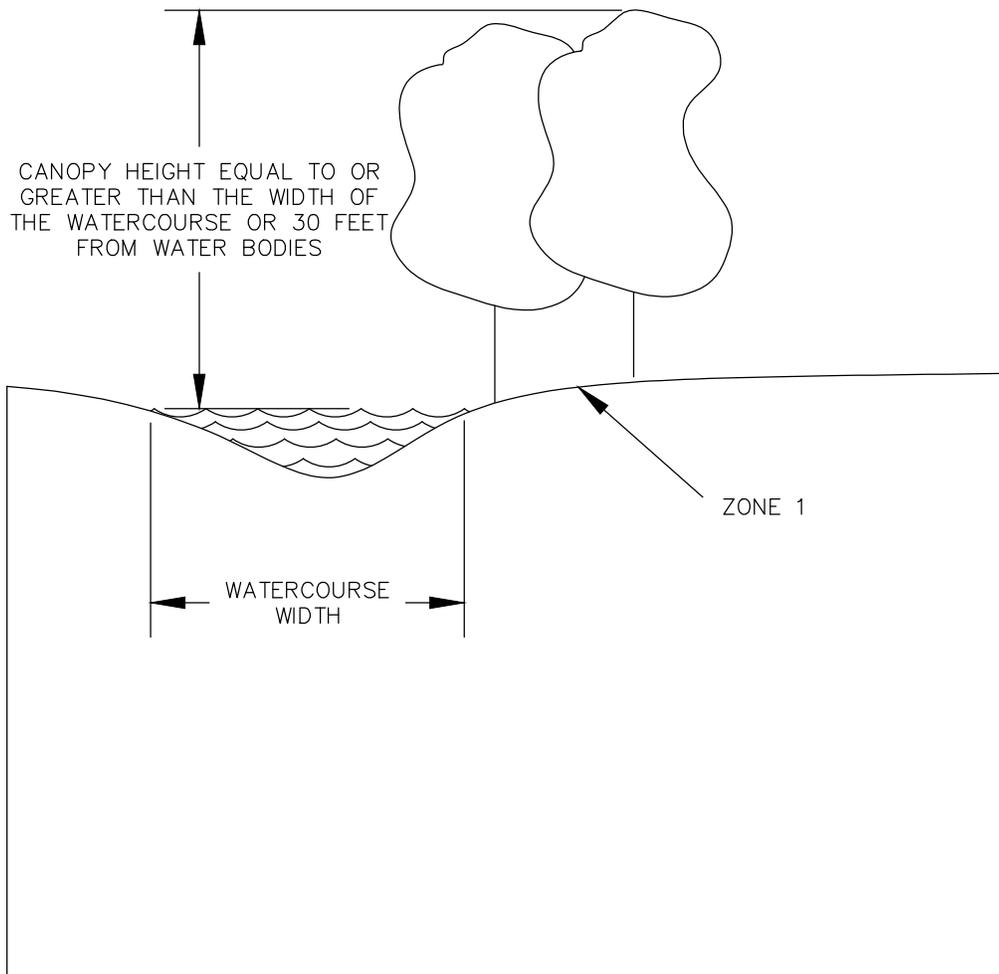


STORMWATER MANUAL

FIGURE 9-3

CANOPY HEIGHT
FOR WATER TEMPERATURE CONTROL
(OCTOBER 1, 2016)

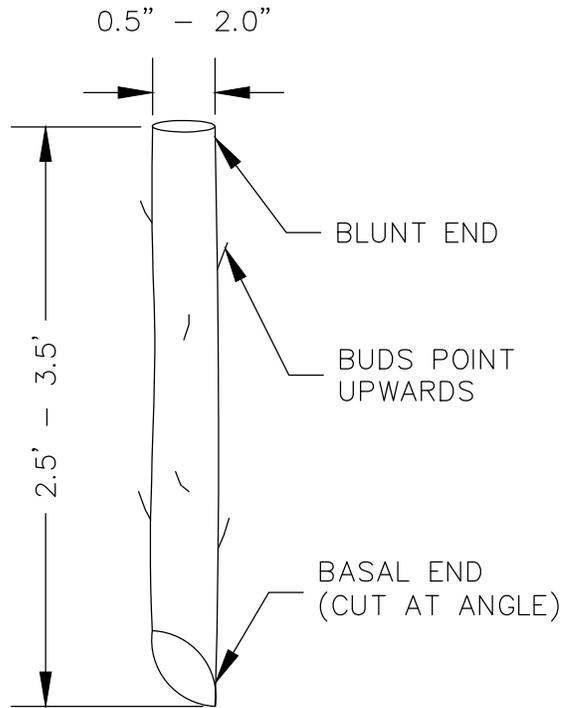
BUFFER WIDTH (ZONES 1 & 2)
EQUALS A MINIMUM OF 45 FEET



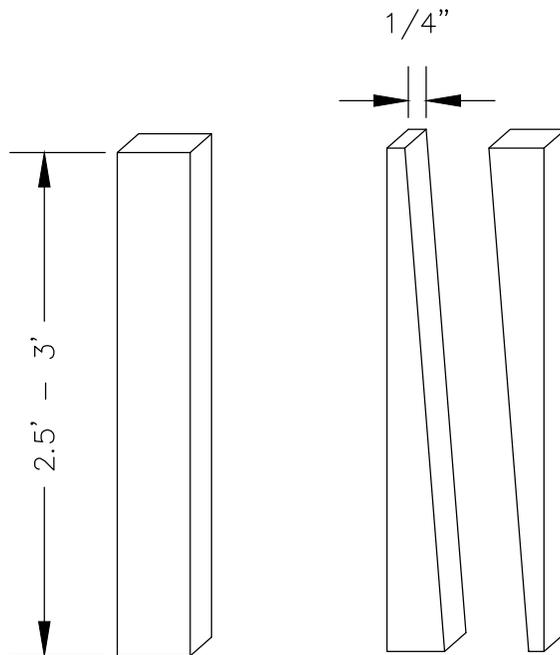


STORMWATER MANUAL

FIGURE 9-4
DETAILS OF STAKES
(OCTOBER 1, 2016)



A. LIVE STAKE



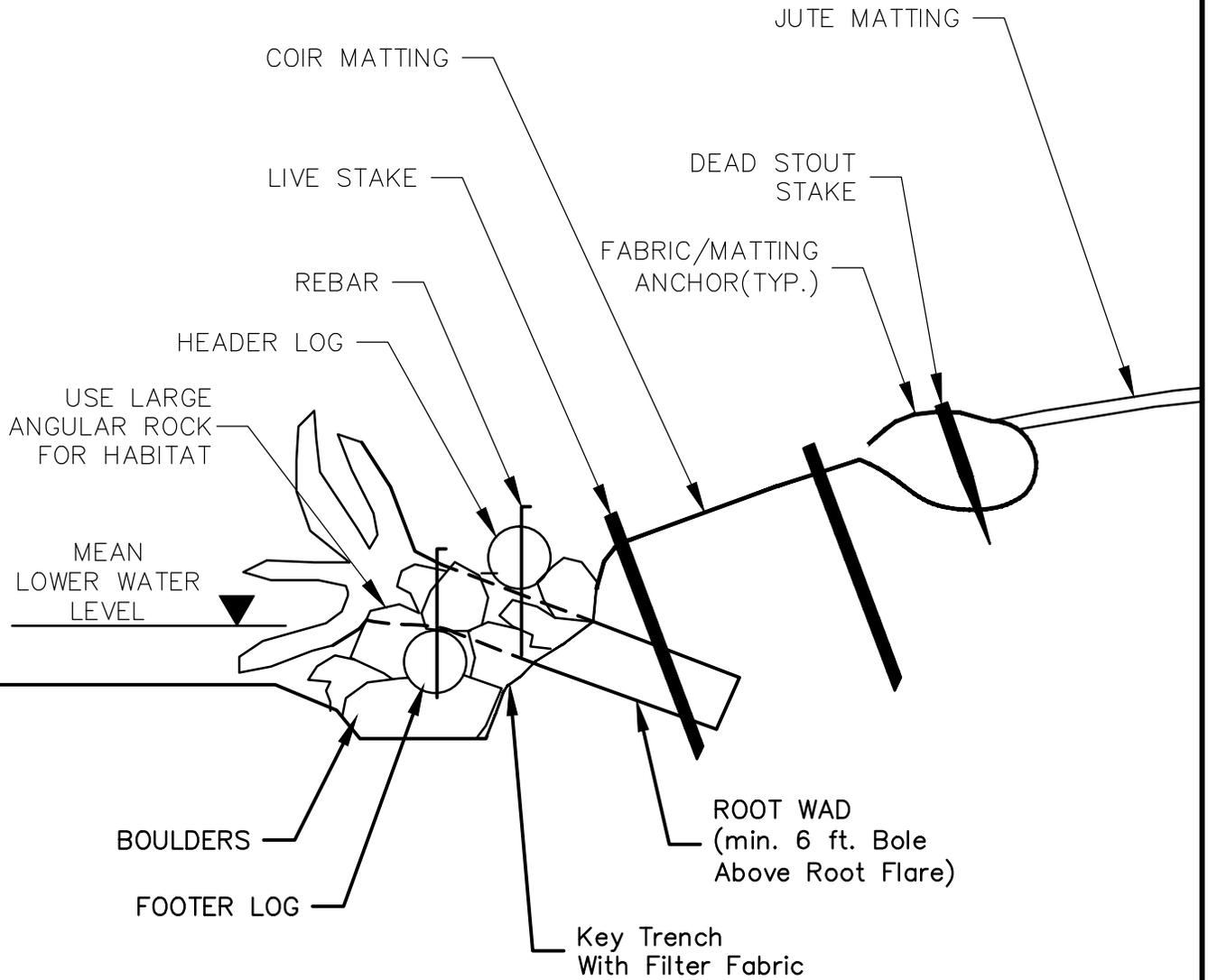
B. DEAD STOUT STAKE

SAW 2X4 TIMBER DIAGONALLY
TO PRODUCE 2 DEAD
STOUT STAKES



STORMWATER MANUAL

FIGURE 9-5
DETAIL OF ROOT WAD REVETMENT
(OCTOBER 1, 2016)



SECTION VIEW

N.T.S.

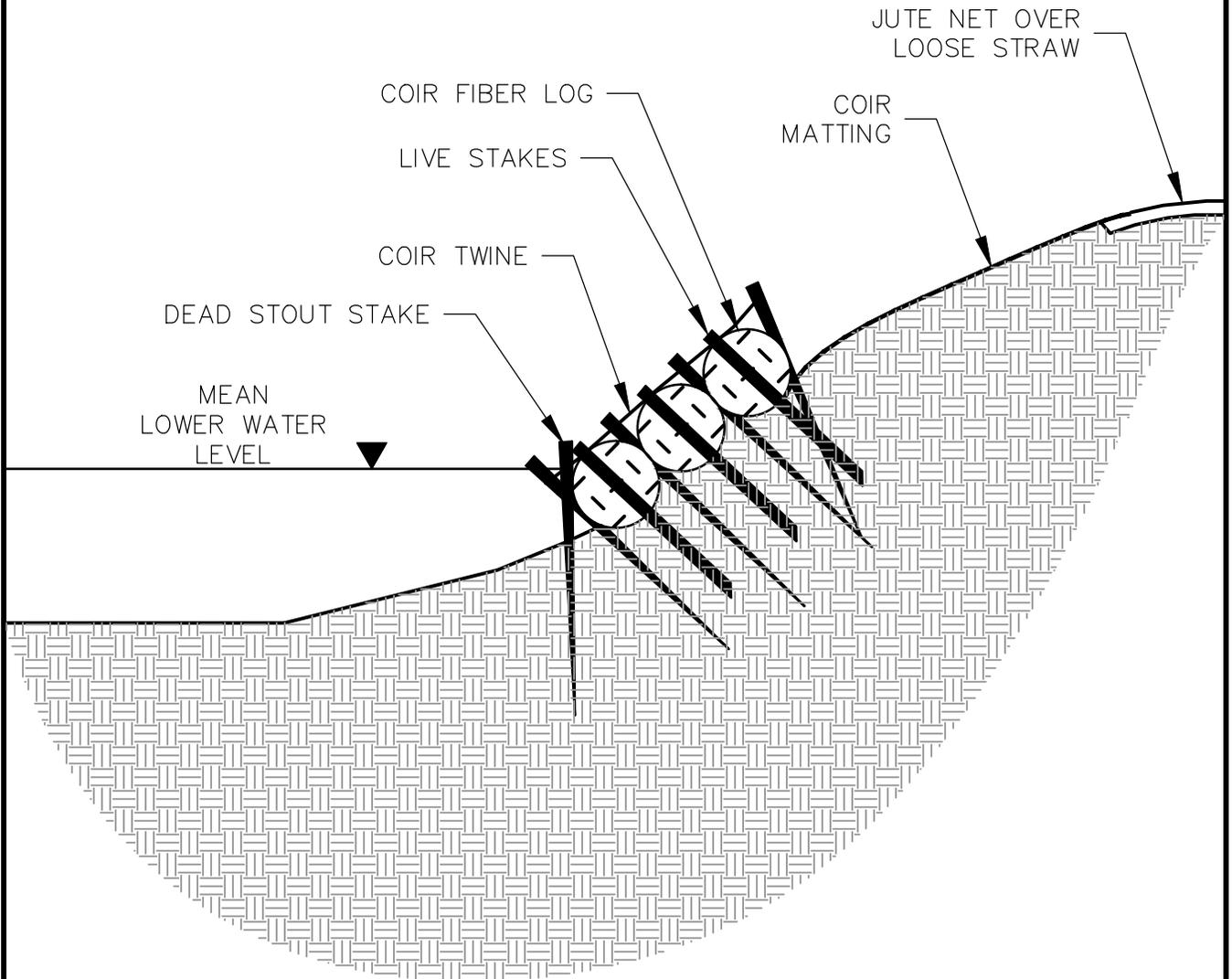


STORMWATER MANUAL

FIGURE 9-6

DETAIL OF STACKED COIR FIBER
LOG REVETMENT

(OCTOBER 1, 2016)

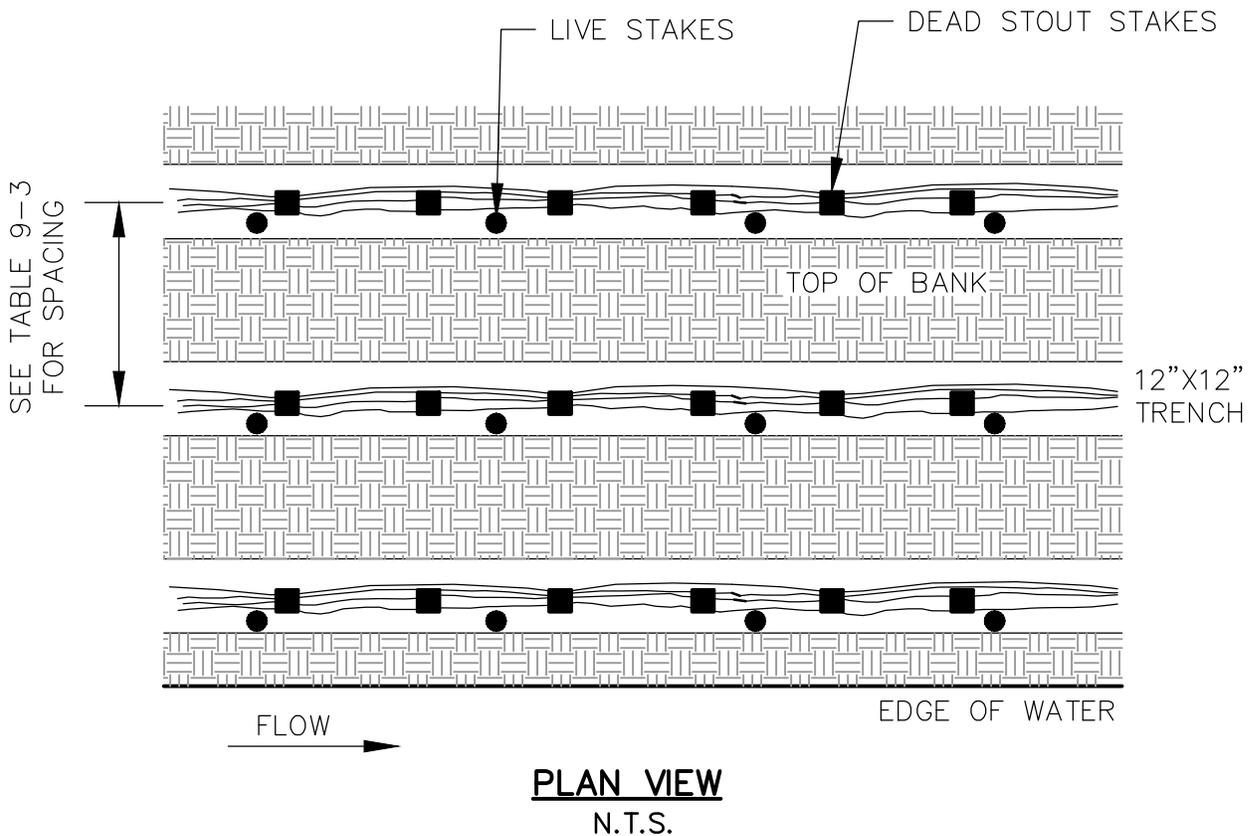
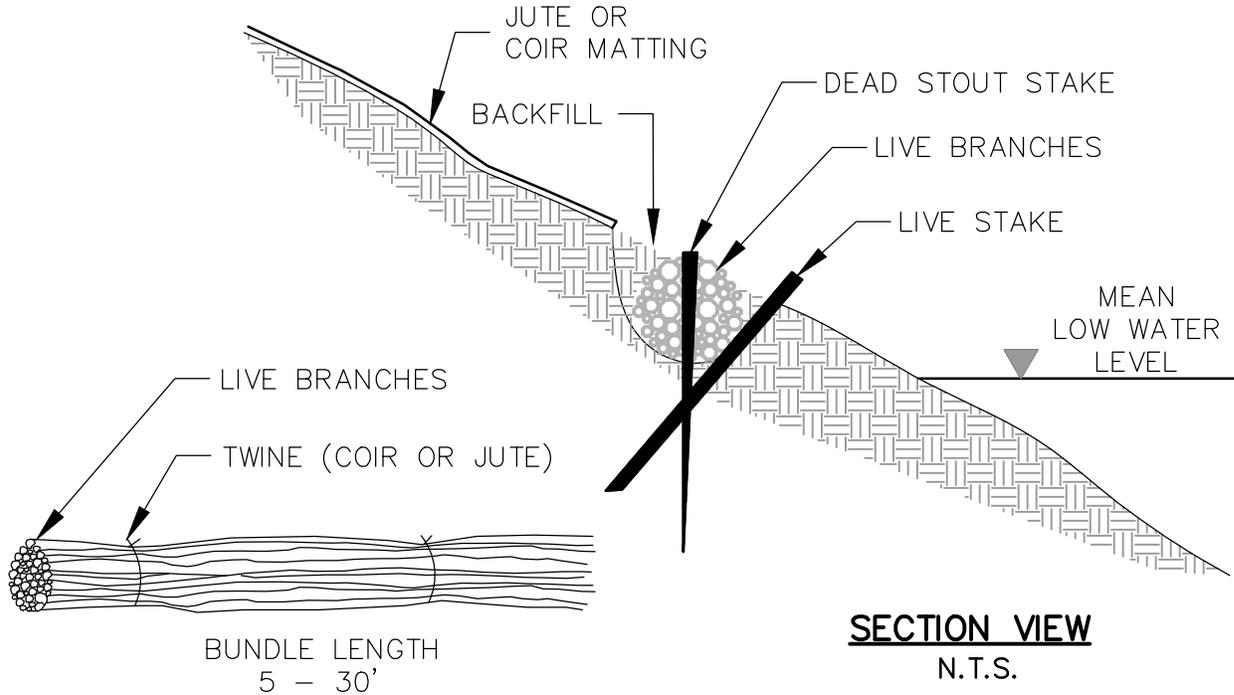


SECTION VIEW
N.T.S.



STORMWATER MANUAL

FIGURE 9-7
DETAIL OF LIVE FASCINE
(OCTOBER 1, 2016)

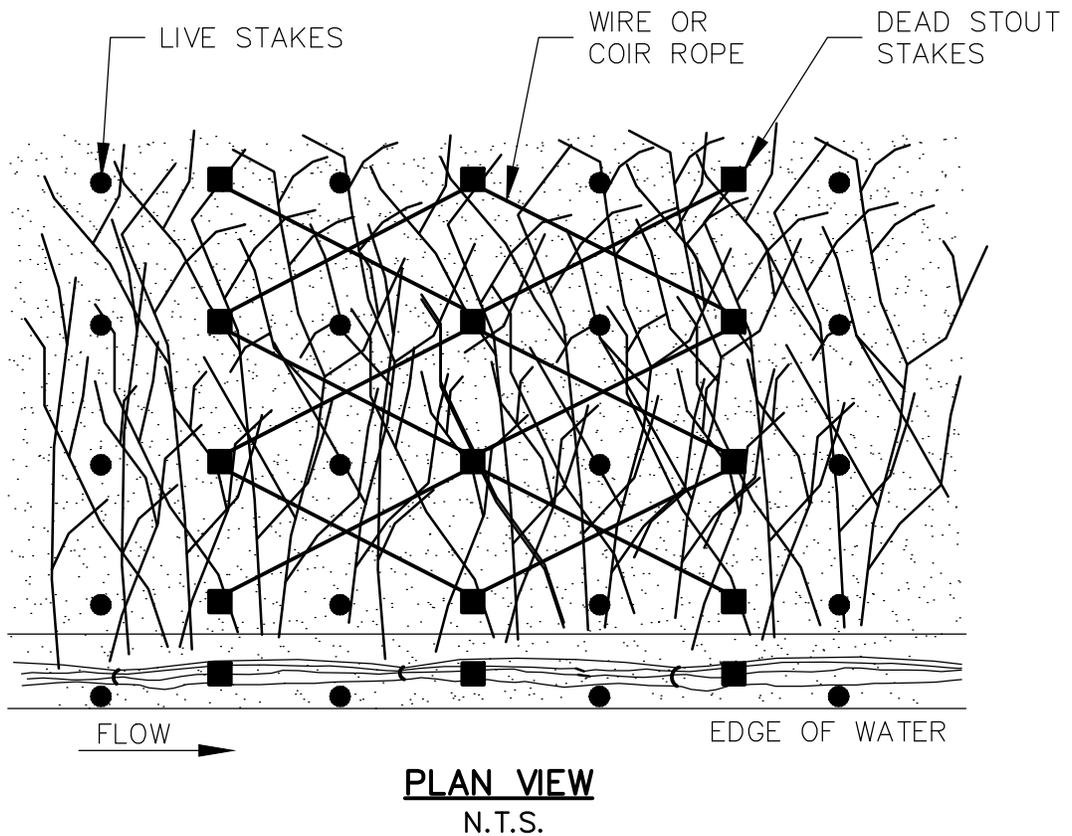
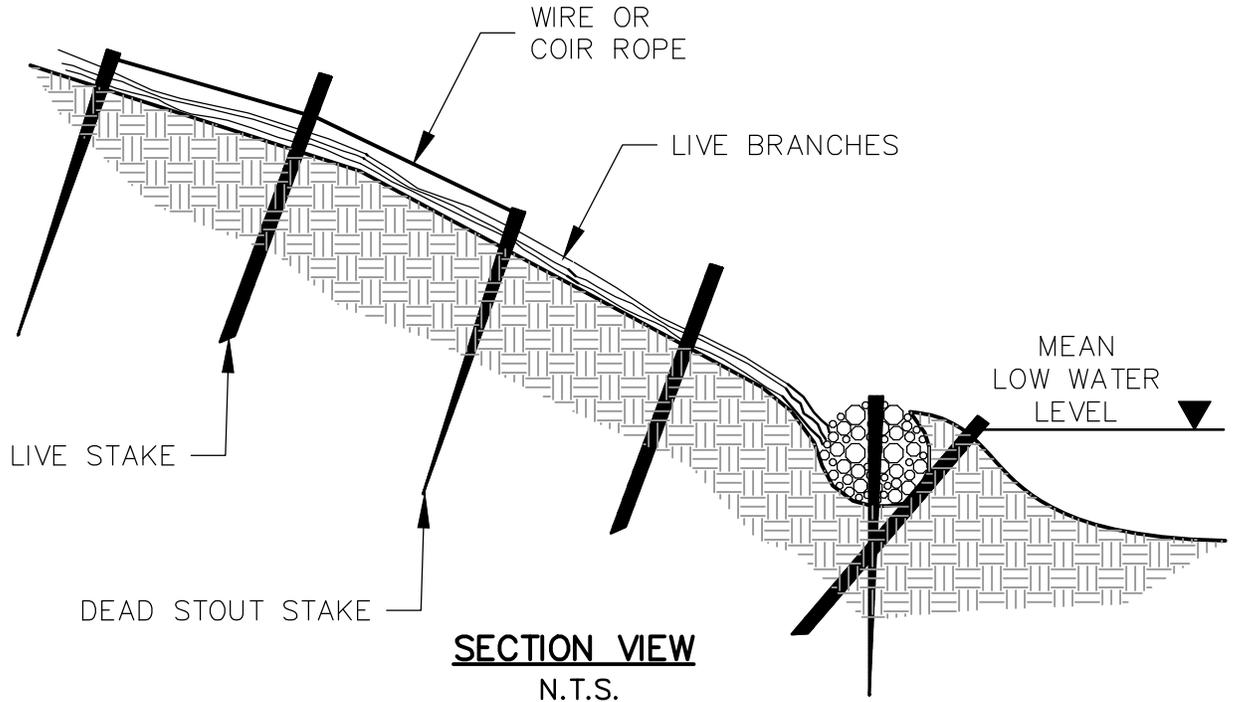




STORMWATER MANUAL

FIGURE 9-8
DETAIL OF BRUSH MATTRESS

(OCTOBER 1, 2016)

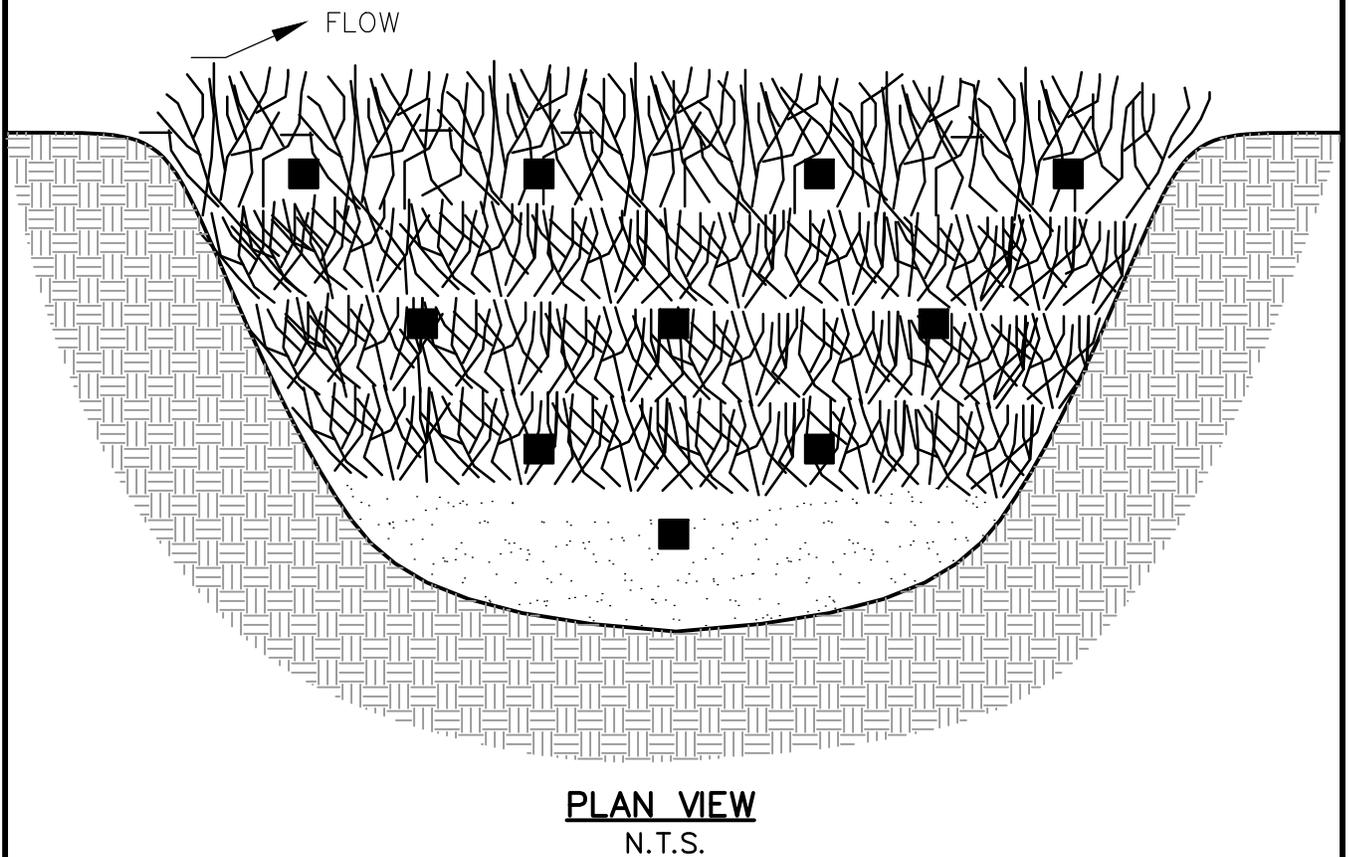
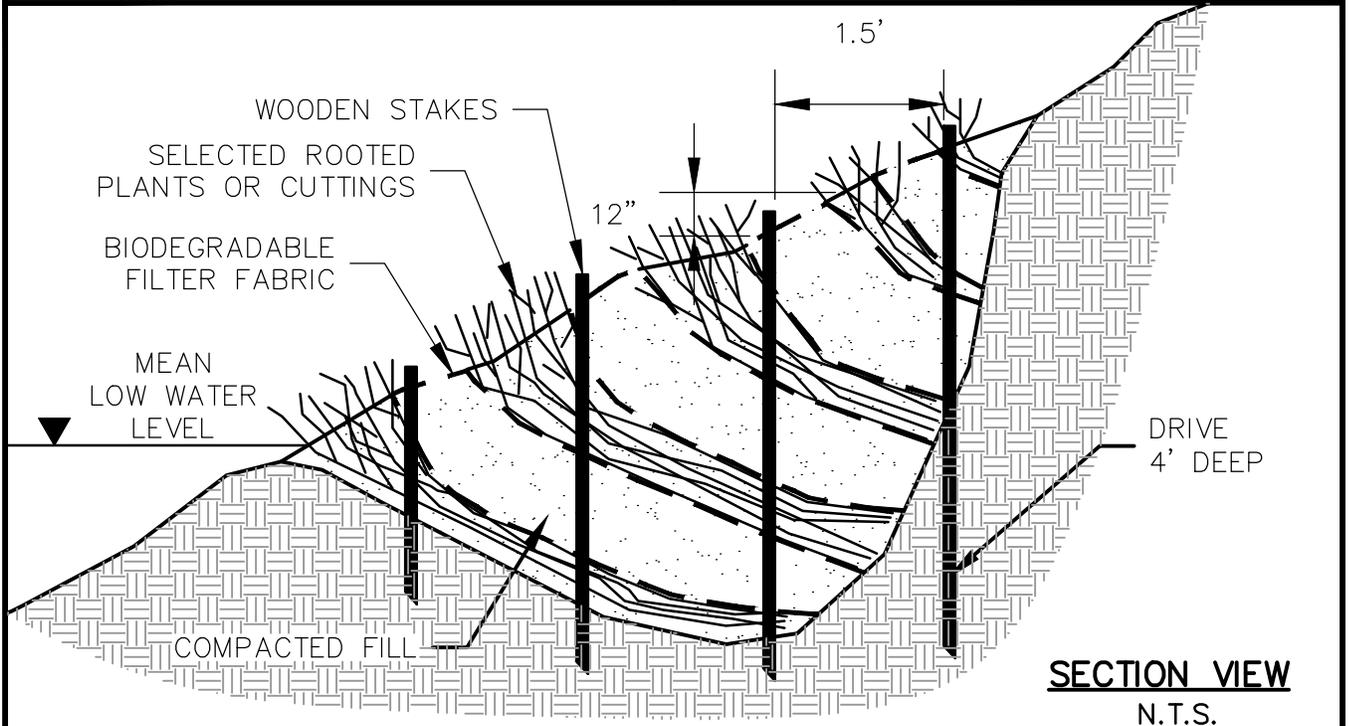




STORMWATER MANUAL

FIGURE 9-9 DETAIL OF BRANCH PACKING

(OCTOBER 1, 2016)

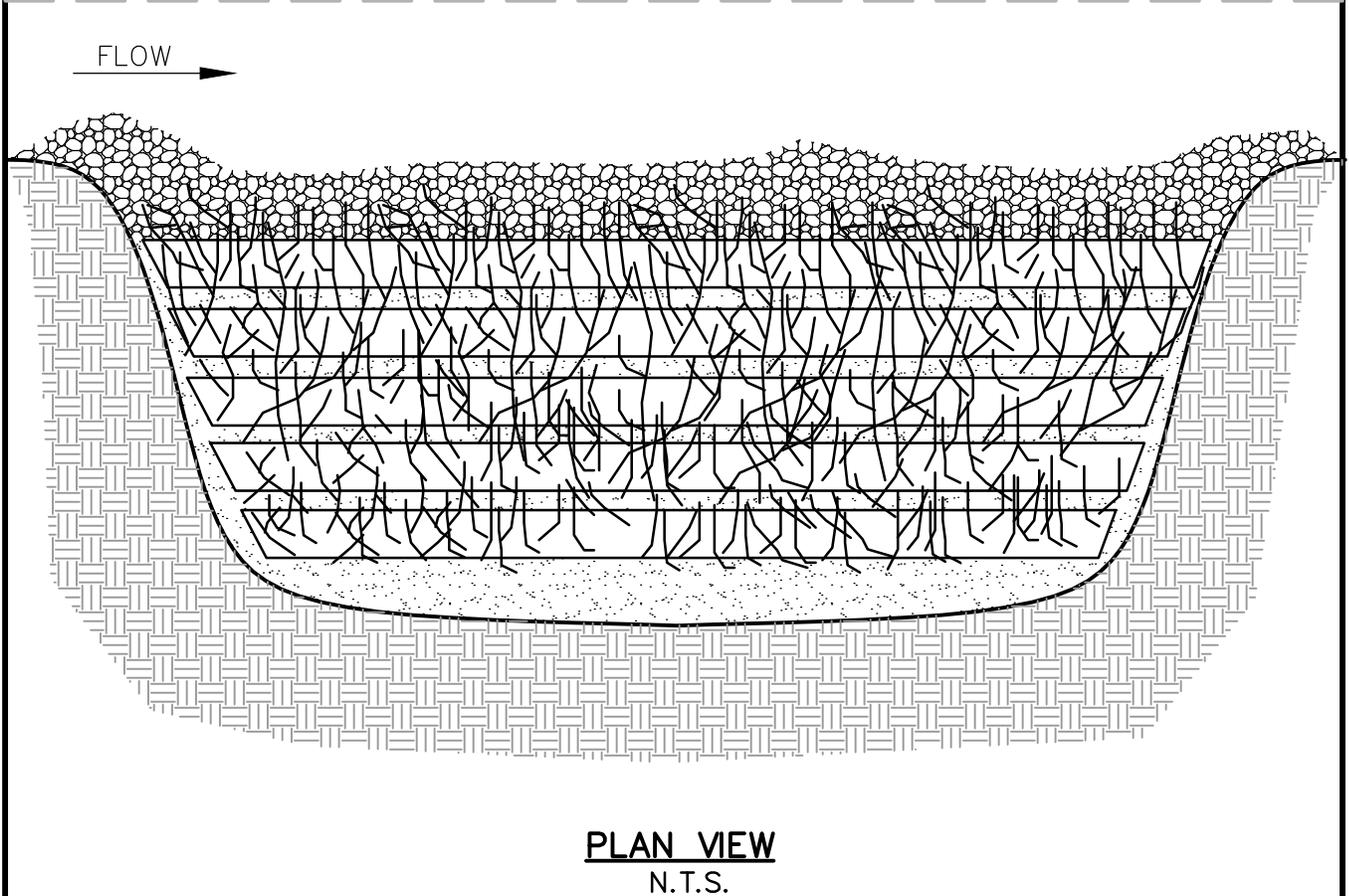
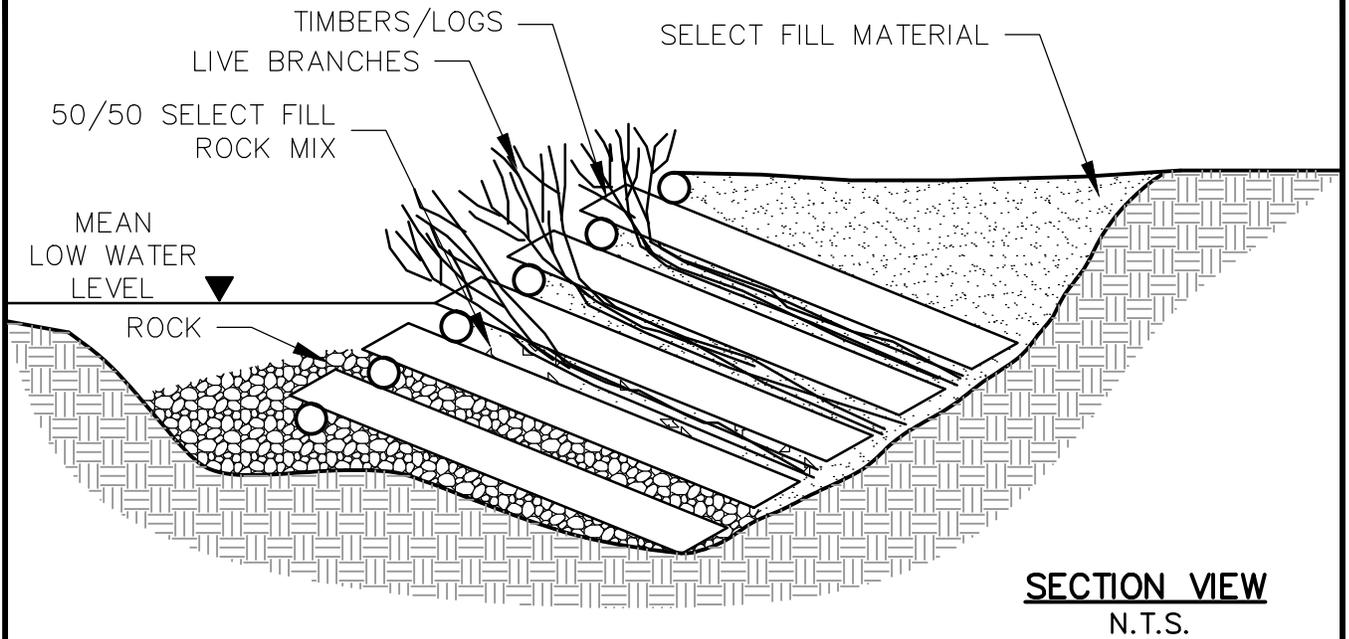




STORMWATER MANUAL

FIGURE 9-10
DETAIL OF LIVE CRIBWALL

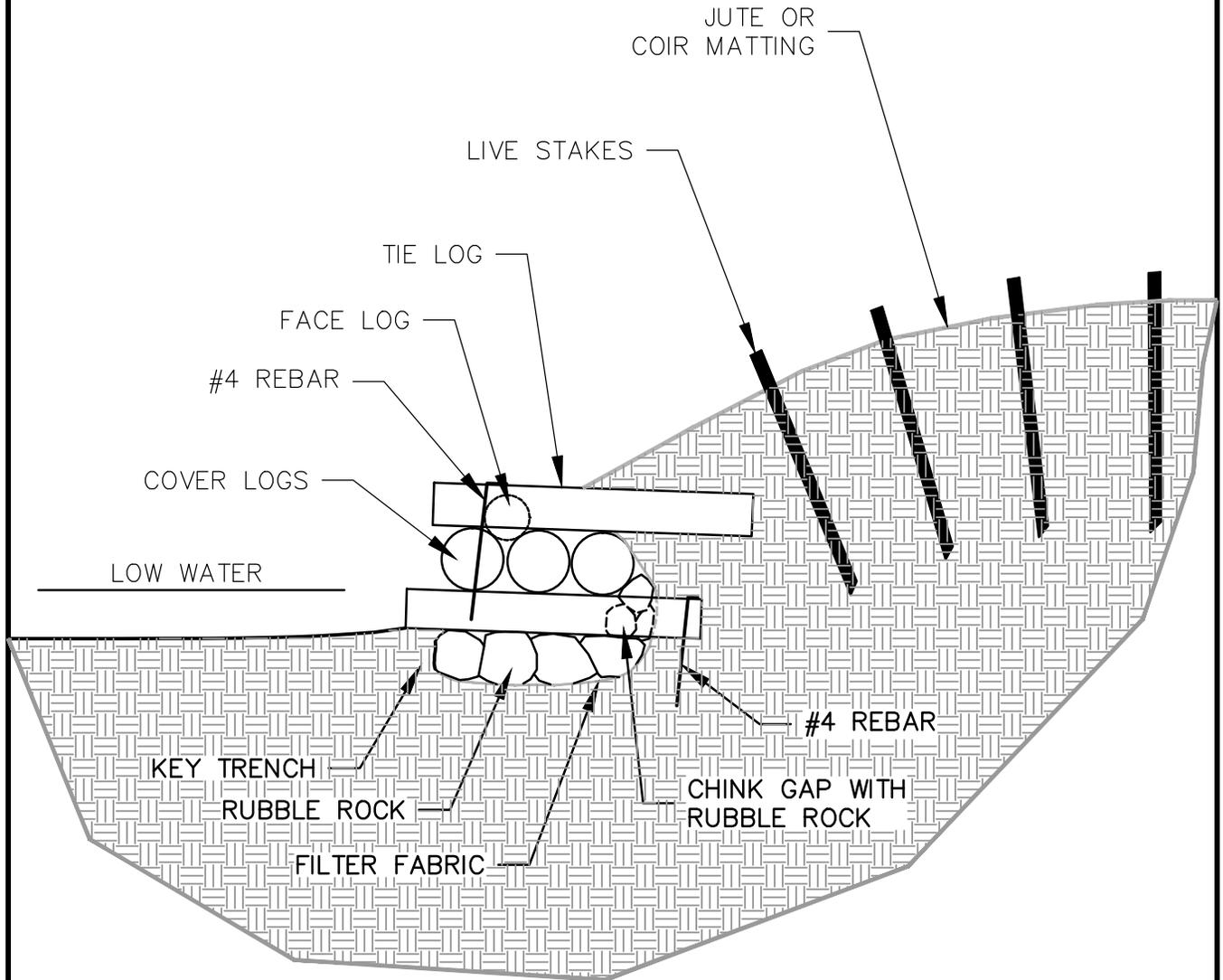
(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 9-11
DETAIL OF LOG CRIB REVETMENT
(OCTOBER 1, 2016)



CHAPTER 10
POST-CONSTRUCTION STORMWATER CONTROLS (BEST
MANAGEMENT PRACTICES)

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APPENDICES

APPENDIX A – PLANT LIST

10.1 Introduction

The MS4 permit requires LFUCG to implement post-construction stormwater controls for new development and redevelopment to minimize the discharge of pollutants to the MS4. LFUCG's stormwater management requirements for new development and redevelopment are contained in Chapter 1 of this manual. Chapter 10 sets forth the minimum design and construction standards for post-construction stormwater controls.

The results of LFUCG's water quality monitoring program indicate that the primary cause of stream impairment in Fayette County is lack of habitat and channel erosion due to sustained channel velocity caused by development. The construction of impervious surfaces in a watershed increases the stormwater runoff volume, peak flow, and the duration and frequency of bankfull flow. Thus, the stormwater controls in this chapter are intended to reduce the runoff volume and peak flow from developed sites as well as to maintain water quality.

10.2 General Design Criteria

Stormwater management in Fayette County shall include management for quality and quantity. This section provides the general design criteria for both.

10.2.1 Water Quantity Control

Water quantity controls shall be implemented so that post-development peak discharges do not exceed pre-development discharges for those storms listed in Table 5-1.

10.2.2 Water Quality Controls

EPA guidance indicates that an effective post-construction water quality standard is to manage the runoff from the 90th percentile storm, known as the water quality volume (WQV). The 90th percentile storm in Fayette County is 1.2 inches. The WQV is determined by multiplying 1.2 inches times the impervious area.

10.3 Green Infrastructure

This section contains the design and construction standards for green infrastructure to achieve the runoff reduction requirements in Section 1.7.4 of this manual. The acceptable plant list is contained in Appendix A.

10.3.1 Impervious Area Disconnection

Discharging impervious area runoff to grass reduces the runoff volume.

Design Criteria

The runoff from the impervious area shall be designed to flow as sheet flow across the grass.

10.3.2 Bio-retention and Rain Gardens

Description

A bio-retention facility is a stormwater management practice that promotes infiltration of stormwater in order to reduce its volume, improve its quality, and increase groundwater recharge. A bio-retention facility, commonly referred to as a rain garden, is a landscaped, shallow depression that receives stormwater from nearby impervious surfaces. Bio-retention detains runoff in a surface reservoir, filters it through plant roots and a biologically active soil mix, and then infiltrates it into the ground. Where native soils are less permeable, an underdrain conveys treated runoff to a storm drain or surface drainage. The facility typically consists of a structure to spread flow, a pretreatment filter strip or grass channel, a sand bed, a shallow ponding area, a surface organic layer of mulch, a planting soil bed, planting material, a gravel underdrain system, and an overflow system.



Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge
- Targeted pollutants: suspended solids, sediment, trash, bacteria, organics, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments, Private Streets
- LFUCG Roads and Rights-of-Way
- LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment
- Provides detention storage for **Water Quantity** (if designed with detention controls)
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area shall be less than 5 acres.

Proximity to Existing Features: Bio-retention facilities shall be located at least 10 feet from existing buildings and sanitary sewer lines. If known sanitary sewer or basement infiltration problems exist, a greater distance shall be used.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows into a storm drainage system.

Pretreatment: A minimum 10-foot grass border shall be provided.

Drain Time: Maximum drain time (i.e. ponding) is 24 hours. Total drawdown through the soil media is 3 days maximum.

Prohibited Areas: Bio-retention shall not be placed within 200 feet of a sinkhole area, in areas of soil contamination, or over existing utilities.

Design Guidance

The Runoff Reduction provided by bio-retention is equal to the surface storage volume plus the filter media storage volume. The surface storage is the volume of impounded water. The filter media storage is equal to the volume of the media multiplied by the porosity. Use the following values for media porosity:

- Stone porosity – 0.40
- Sand porosity – 0.30
- Soil porosity – 0.18

Maintenance

The property owner or Homeowner’s Association (HOA) shall maintain the bio-retention facility.

Easements

Areas of stormwater conveyance, including bio-retention, are typically demarcated with a “Storm Drainage Easement.” When a bio-retention area is being used to meet detention requirements, a “Detention and Storm Drainage Easement” shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the facility
2. Design calculations for bio-retention area, drawdown time, etc
3. Stage/Storage/Discharge (i.e. routing) calculations if it is being used for detention
4. Infiltration tests of the underlying in-situ soils in accordance with ASTM D3385
5. Landscaping plan showing the proposed plants, stamped by a licensed Landscape Architect or Professional Engineer
6. Construction drawings showing the plan, profile, and section views, and underdrain system.
7. As-built drawings with photos
8. Engineer's certification that the facility was constructed in accordance with the plans accepted by the Division of Engineering

Design Criteria

Design the bio-retention system to be on-line with an overflow catch basin, as shown in Figure 10-1, to handle volumes exceeding the design WQV.

Design the bio-retention system to have a longitudinal slope of 0 to 1 percent.

Provide a pretreatment system composed of a pea gravel diaphragm and a grassed filter strip. The pea gravel diaphragm also serves as a flow spreader. Dimensions of the gravel diaphragm and grass filter strip shown in Figure 10-1 are minimums. When flow into a bio-retention system is parallel to its long dimension (i.e., from a drainage swale), omit the gravel diaphragm shown in Figure 10-1 and provide a berm across the downstream end of the system to impede the flow. The top of the berm shall be level across the base of the bio-retention system and be 12 to 18 inches high in the center.

Provide a planting soil bed with a minimum width of 4 feet and a minimum depth of 4 feet (including a 12-inch sand bed). The planting soil bed can be as wide as 15 feet. The area of the system is determined by the required area of the filter bed. The minimum length is 15 feet.

For widths greater than 10 feet, maintain at least a 2:1 length to width ratio.

Grade the top of the planting soil bed to provide a shallow ponding area with a maximum depth of 6 inches.

Provide an underdrain system of gravel and perforated pipe. Design the gravel bed to be at least 8 inches deep. Connect the underdrain to the storm drainage system or design it to daylight to a suitable non-erosive outfall.

Specifications

The following specifications are provided as general guidance. The Engineer shall specify materials that ensure adequate drainage and that promote long term survivability of the plants.

The planting soil mix should be highly permeable and have the following characteristics:

- Approximately 70% sand, 15% organic compost, and 15% topsoil
- pH of 5.5-7.5
- Organic content of 4% to 8%

Place planting soil in lifts of 12 to 18 inches and loosely compact or tamp lightly with backhoe bucket.

Provide shredded hardwood mulch aged at least 2 months. Place mulch layer 2 to 3 inches deep.

Provide clean river pea gravel for the curtain drain and diaphragm sized to meet ASTM D-448 size no. 6 with diameter ranging from 1/8 to 1/4 inch.

Provide gravel for the underdrain sized to meet AASHTO M-43 with size range of ½ to 2 inches in diameter.

Provide PVC or HDPE underdrain pipe approved by KYTC. Provide ⅜ inch diameter perforations on 6-inch centers with four holes per row.

Plant base of bio-retention system (planting soil bed) in herbaceous ground cover and shrubs. Plant side slopes of bio-retention system in herbaceous ground covers, vines, and shrubs. Trees may also be used in the bio-retention system. Use direct seeding for herbaceous varieties and nursery stock for vines, shrubs, and trees.

Areas to be seeded with herbaceous varieties shall be roughened with a rake or similar tool. Seeding rates shall be minimum of 10 pounds of seed mix per 1000 square feet of area.

Bare root or containerized stock shall be planted at the same depth as planted in the nursery. The stock should be planted in a hole large enough to accommodate the root system when well spread. Shrubs and vines shall be planted at a minimum density of 1,700 stems per acre (one stem per 25 square feet at 5 feet on center).

Suggested herbaceous species for the planting soil bed are shown below. Use a minimum of two species.

Common Name	Scientific Name
Barnyard grass	Echinochloa crusgalli
Switch Grass	Panicum virgatum
Swamp Milkweed	Asclepias incarnata
Giant Cane	Arundinaria gigantea
Jewelweed	Impatiens capensis
River oats	Chasmanthium latifolia
Deertongue	Panicum clandestinum
Boneset	Eupatorium perfoliatum

Select herbaceous species for the side slopes from Table 9-1 in Chapter 9. Also, select vines, shrubs, and trees from Table 9-1.

10.3.3 Permeable Pavement

Description

Permeable pavements are alternatives to conventional pavements that may be used to reduce imperviousness. A wide variety of permeable pavements is available and can be classified into three basic types: porous (bituminous) asphalt, pervious concrete and permeable interlocking concrete paver stones (pavers). Permeable pavements are designed to infiltrate stormwater, thereby reducing runoff, promoting groundwater recharge, and filtering stormwater pollutants.

For new and redevelopment in Fayette County, permeable pavements are classified as an “**engineered pervious surface.**” Permeable pavements have a stone subgrade that is designed for structural strength required for the vehicular load, and contain the Water Quality Volume and optionally a Detention Volume within the voids in the stone. If permeable pavement is used to reduce site imperviousness or meet stormwater control requirements for new or redevelopment, and later becomes impervious for whatever reason, the site may become out of compliance with this manual. The surface could either be repaired/replaced or replacement stormwater controls may be required to offset the changes.



Environmental Benefits

- Reduces stormwater runoff volume and promotes infiltration and groundwater recharge
- Targeted pollutants: sediment, suspended solids, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartment, Private Streets
- LFUCG Roads and Rights-of-Way
- LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment if the underlying stone reservoir is sized to contain the WQV and release it slowly over the designed drain time.
- Provides detention storage for **Water Quantity** if the underlying stone reservoir and outlet structure is designed to reduce peak flows to predevelopment levels for the LFUCG design storms.
- Functions as a pervious surface for **Water Quantity** hydrologic calculations, unless the stone reservoir is being used for detention storage in which case the pervious surface area shall be considered impervious (e.g. functions as a pond with 100% of rainfall volume entering the storage reservoir).

LFUCG Site Design Requirements

Drainage Area: The area draining to permeable pavements should be free of loose dirt and grit. Stockpiled materials should not be placed on or adjacent to permeable pavements.

Proximity to Existing Features: Permeable pavements shall be located at least 10 feet from existing buildings and LFUCG sanitary sewer lines. If known sanitary sewer or basement infiltration problems exist, a greater distance shall be used.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Pretreatment: If upstream areas have potential sources for erosion/sediment, pretreatment shall be provided.

Drain Time: Based upon industry standard design.

Prohibited Areas: Permeable pavements shall not be placed within 200 feet of a sinkhole area, in areas of soil contamination, or over existing utilities.

Design Guidance

The storage volume for permeable pavement is equal to the storage volume in the stone media. Use a stone porosity of 0.4.

Porous asphalt shall be designed in accordance with **Plantmix Asphalt Industry of KY (PAIKY)** guidelines. Pervious concrete shall be designed in accordance with the **Portland Cement Association (PCA) and National Ready Mix Concrete Association** guidelines. Pavers shall be designed in accordance with **Interlocking Concrete Pavement Institute (ICPI)**. Note: All stone subgrade materials shall be washed with less than 1% passing No. 200 sieve. Stone materials should be certified as meeting this specification and proof of certification shall be provided as part of the Engineer's construction certification.

Maintenance

The property owner or HOA shall maintain the facility in accordance with PAIKY, PCS, and ICPI recommendations.

Special note on deicing agents: Consult industry professionals on the best type of surface appropriate for a given site. The property owner shall have control over snow removal operations to prevent possible damage to the surface. In particular, deicing agents should not be applied to pervious concrete surfaces less than one year old, and after only sparingly. Agents containing magnesium chloride or fertilizer agents (ammonium sulfate and ammonium nitrate) are prohibited. Surface damage that may occur from improper snow removal is the sole responsibility of the property owner and may require repair/replacement if being used to meet water quality or detention control criteria.

Easements

When this control is used to meet detention requirements a "Detention and Storm Drainage Easement" shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the facility.
2. Design calculations, including surface area, depth, drawdown time, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils in accordance with ASTM D3385.
5. Construction plans showing the plan, profile, section view, and underdrains.

10.3.4 Bio-infiltration Swales

Description

A bio-infiltration swale (or bio-swale), often referred to as linear bio-retention, is a shallow stormwater conveyance channel densely planted with a variety of grasses, shrubs, and trees designed to slow, filter, and infiltrate stormwater runoff. Bio-infiltration swales serve as an excellent alternative to traditional curb and gutter conveyance systems. Different design variations such as check dams, media type, and underdrains can be incorporated into bio-infiltration swales. As with bio-retention, a bio-infiltration swale is underlain with specialized planting soil media that promotes infiltration and plant growth. Bio-infiltration swales reduce stormwater runoff through infiltration and improve water quality by filtration through vegetation and media, sedimentation, adsorption and biological uptake through native plants. Unlike bio-retention, bio-infiltration swales serve dual purposes, and are designed both for stormwater conveyance and treatment. Therefore, the swale design must typically account for higher velocities and more concentrated flow than bio-retention.



Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge
- Targeted pollutants: suspended solids, sediment, trash, bacteria, organics, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments, Private Streets
- LFUCG Roads and Rights-of-Way
- LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment
- Provides detention storage for **Water Quantity** (if designed with detention controls)
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area for bio-infiltration swales is typically less than 2 acres. If concentrated flow is directed into a bio-swale, velocity dissipation measures are required to prevent scour.

Proximity to Existing Features: Bio-infiltration swales shall be located at least 10 feet from existing buildings and sanitary sewer lines. If known sanitary sewer or basement infiltration problems exist, a greater distance shall be used.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows from the swale into a storm drainage system.

Pretreatment: A minimum 10-foot grass border shall be provided.

Drain Time: Maximum drain time (i.e. ponding) for the swale is 24 hours. Total drawdown through the soil media is 3 days maximum.

Prohibited Areas: Bio-infiltration swales shall not be placed within 200 feet of a sinkhole area, in areas of soil contamination, or over existing utilities.

Design Guidance

The Runoff Reduction provided by bio-infiltration swales is equal to the surface storage volume plus the filter media storage volume. The surface storage is the volume of impounded water. The filter media storage is equal to the volume of the media multiplied by the porosity. Use the following values for media porosity:

- Stone porosity – 0.40
- Sand porosity – 0.30
- Soil porosity – 0.18

Maintenance

The property owner or HOA shall maintain the bio-infiltration swale.

Easements

Stormwater conveyance swales are typically demarcated with a “Drainage Easement.” When a bio-infiltration swale is being used to meet detention requirements, a “Detention and Storm Drainage Easement” shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the swale.
2. Design calculations for swale area, drawdown time, swale conveyance capacity, freeboard, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) of the swale if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils in accordance with ASTM D3385.
5. Landscaping plan showing the proposed plants.
6. Construction drawings showing the plan, profile, and section views, and underdrain system.

This practice encourages infiltration from the swale bottom, through a planting bed, to the underlying soil. See Figure 10-2.

Design Criteria

Bio-infiltration swales shall be designed to have the following characteristics:

- Trapezoidal or parabolic shape
- Minimum bottom width of 2 feet
- Side slopes no steeper than 3:1
- Longitudinal slope of 1 to 2 percent (up to 4 percent slope can be used with berms constructed as required for bermed swales)
- Length, width, depth, and slope necessary to provide surface storage of the design volume with a maximum ponded depth of 18 inches
- Vegetated in accordance with requirements for vegetated channels with grass lining
- Capacity to convey the 100-year design storm with at least 6 inches of freeboard
- A soil bed 36 inches deep having the width of the swale bottom

Plan the soil bed to consist of soils that have a permeability of at least 0.5 feet per day (USCS soils ML, SM, or SC). If native soils do not satisfy this criterion, a prepared soil bed can be designed.

Due to their use as a stormwater conveyance, mulch shall not be placed in the swale.

10.3.5 Infiltration Basins and Trenches

Description

Infiltration trenches are shallow excavations filled with stone, designed to capture sheet flow or piped inflow. Runoff is stored in the void space between the stones and infiltrates through the bottom and into the soil matrix. Infiltration trenches are used in conjunction with sediment removal practices so that most suspended solids are removed before runoff enters the infiltration trench. Pretreatment may include techniques like vegetated filter strips or grass swales. Infiltration trenches are very adaptable practices and the availability of practical configurations make them ideal for small urban drainage areas. Infiltration trenches improve water quality through treatment of runoff percolating through the soil, volume reduction, and some removal of sediments and pollutants.



Environmental Benefits

- Reduces stormwater runoff volume
- Targeted pollutants: suspended solids, sediment, trash, nutrients, metals, bacteria
- Promotes infiltration and groundwater recharge

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments, Private Streets
- LFUCG Roads and Rights-of-Way
- LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment
- Provides detention storage for **Water Quantity** (if designed with detention controls)
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area shall be less than 5 acres.

Proximity to Existing Features: Infiltration trenches shall be located at least 10 feet from existing buildings and sanitary sewer lines. If an adjacent building has a basement known to have seepage problems, a different type of control should be considered.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 0.5 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows into a storm drainage system.

Pretreatment: A minimum 10-foot grass border shall be provided.

Drain Time: Maximum drain time (i.e. ponding) is 24 hours.

Prohibited Areas: Infiltration trenches shall not be placed within 200 feet of a sinkhole area, in areas of soil contamination, or over existing utilities.

Configuration Restrictions: In order to avoid possible classification as a Class V Injection Well by the EPA, infiltration trench width should be greater than its depth. Use of perforated plastic chambers is often used for this type of facility, but may be more likely to be classified as a Class V Injection Well. (EPA Memorandum, June 13, 2008, Linda Boornazian and Steve Heare, *Clarification on which stormwater infiltration practices/technologies have the potential to be regulated as “Class V” wells by the Underground Injection Control Program*)

Design Guidance

The Runoff Reduction provided by infiltration trenches is equal to the surface storage volume plus the filter media storage volume. The surface storage is the volume of impounded water. The filter media storage is equal to the volume of the media multiplied by the porosity. Use the following values for media porosity:

- Stone porosity – 0.40
- Sand porosity – 0.30
- Soil porosity – 0.18

Maintenance

The property owner or HOA shall maintain the Infiltration Trench.

Easements

Areas of stormwater conveyance, including infiltration trenches, are typically demarcated with a “Drainage Easement.” When this BMP is being used to meet detention requirements, a “Detention and Storm Drainage Easement” shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the facility.
2. Design calculations for infiltration trench, including surface area, depth, volume of the trench and the porosity of the stone, drawdown time, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils in accordance with ASTM D3385.
5. Construction drawings showing the plan, profile, and section views, and underdrain system.

Design Criteria

Infiltration basins may be used in locations that have at least 5 feet of soil, with a permeability of at least 0.5 inches/hour underlying the device. The underlying 5 feet of soil must also be above the seasonal high water table.

If soils do not meet the permeability requirement, they can be modified by mixing sand and gravel in the top 5 feet of the soil underlying the device. If native soils are to be modified with sand or gravel, provide a design that shows the depth of soil to be modified and the total quantity of gravel or soil to be added. Include soil test data documenting the permeability of the soils before and after modification.

If desired, large infiltration basins can be designed much like an extended detention basin for storm peak control. The outlet structure and detention storage volumes are designed to be above the level needed to store the design WQV. The difference is that an infiltration basin does not have an extended detention outlet. Instead, the WQV is allowed to infiltrate into the soils underlying the basin. If the infiltration basin is not intended for peak flow control, it shall be designed so that volumes exceeding the WQV can discharge through an overflow weir or pipe. For small excavated basins of less than one-fourth acre, volumes exceeding the WQV may be allowed to overflow onto the ground surface without use of an overflow structure, if proper erosion control measures are implemented.

The flood protection elevation shall be two feet above the overflow elevation of the basin.

Test soils prior to designing an infiltration basin to ensure that the site is capable of infiltration. Obtain a minimum of three soil test borings or test pits to verify that the soil is at least 5 feet deep below the base elevation and has a permeability of at least 0.5 inch/hour.

Design the floor of the basin to be as flat as possible to promote infiltration. Provide side slopes not greater than 3:1 (h:v).

Provide a sediment forebay at the inlet to the basin with a depth of at least 4 feet and a volume of at least 10 percent of the WQV.

Size the basin to store the design WQV before discharging through the peak flow control outlet. If the basin is intended only for water quality treatment, design an outlet that allows volumes in excess of the WQV to discharge to a surface water conveyance.

If a base flow will be discharged into the infiltration basin, design a low flow orifice to allow base flow to pass through.

Adjust the storage depth so that the basin will completely drain the WQV in 72 hours.

When using an infiltration basin for peak flow control, provide a minimum of 1 foot of freeboard above the 100-year design storm high water elevation.

Impoundment depths shall not exceed 15 feet and storage volumes shall not exceed 25 acre-feet.

Design earthen embankments with side slopes not steeper than 3:1 (horizontal to vertical).

Design basins to be placed outside the receiving stream except when a basin is designed as a regional detention basin and LFUCG has approved its use as a regional basin.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 15 feet wide, with a slope not greater than 5:1 (h:v). Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope not greater than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the basin and the nearest lot. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the basin and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

Specifications

Embankment, outlet, and emergency spillway specifications are consistent with those for detention basins.

Excavate the basin with light equipment having tracks or over-sized tires to minimize compaction of the underlying soils. After the basin is excavated to the final design depth, deeply till the basin floor with a rotary tiller or disc harrow to restore infiltration rates. After tilling, apply a leveling drag.

Establish vegetation immediately after achieving final grade and preparing the infiltration bed. Stabilize the floor of the basin with a dense cover of water-tolerant herbaceous species consistent with requirements of bioretention systems.

10.3.6 Groundcover for Vehicular Parking

Description

Groundcover for vehicular parking is an alternative to conventional pavements and may be used to reduce imperviousness. Unlike permeable pavements, which provide substantial subsurface storage using an aggregate layer, groundcover for vehicular parking is focused on a pervious grid system underlain by a few inches of bedding material. The groundcover is a manufactured concrete or plastic grid system with topsoil and grass or aggregate used to fill the voids. Some systems are 2-dimensional geotextiles and some are 3-dimensional grids. Grid systems can be specified to handle heavier, although fairly static loads, appropriate for areas where utility trucks may need access. These surfaces may only be used for temporary and overflow parking locations.

For new and re-development in Fayette County, these types of ground covers are classified as an “**engineered pervious surface**.” They are not classified as a water quality control, but can serve to decrease existing site imperviousness or minimize site imperviousness for new development. If used for this purpose and later replaced with an impervious surface, replacement stormwater controls may be required to offset the increase in impervious area.



Environmental Benefits

- Reduces stormwater runoff volume and pollutant discharge

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments, Private Streets
- LFUCG Roads and Rights-of-Way
- LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment

- Provides detention storage for **Water Quantity**
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: N/A

Proximity to Existing Features: N/A

Soil Type: N/A

Pretreatment: N/A

Drain Time: N/A

Prohibited Areas: N/A

Design Guidance

Groundcover shall be designed and installed in accordance with manufacturer’s recommendations. Be sure to consider vehicular loading uses when selecting an appropriate surface. Check with LFUCG’s Department of Planning and the Division of Engineering to ensure compliance with the LFUCG Zoning Ordinance and Land Subdivision Regulations when proposing to use alternative ground cover.

Maintenance

The property owner shall maintain the groundcover in accordance with manufacturer’s recommendations. If an engineered pervious surface is used to lower site imperviousness for new development or redevelopment, and it later becomes impervious for whatever reason, the site may become out of compliance with this manual. The surface could either be replaced with new material to restore its original condition or replacement stormwater controls may be required to offset the increase in impervious area. In addition, Groundcover for Vehicular Parking areas classified as an “engineered pervious surface” that are found to have become impervious shall be noted on LFUCG’s Impervious Area GIS coverage for inclusion in the Water Quality Management Fee billing.

Easements

N/A

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Plan sheet showing the proposed locations of the groundcover.
2. Manufacturer’s specifications and installation/maintenance manual.

10.3.7 Tree Trenches and Planter Boxes

Description

Planter boxes and tree trenches, as similar to bio-retention facilities, are designed to infiltrate and/or temporarily store stormwater runoff. Tree trenches are a system of trees that are connected by an underground infiltration structure, and are designed to capture runoff from adjacent impervious areas. On the surface, a stormwater tree trench looks just like a series of street tree pits; however, under the sidewalk there is an engineered system to manage the incoming runoff. This system commonly consists of a trench dug along the sidewalk that is lined with a permeable geotextile fabric, filled with gravel or stone, and topped off with engineered soil and trees. Tree trenches are applicable in linear areas with limited space such as along streets and in pedestrian areas. Planter boxes receive runoff from multiple impervious surfaces, including roadways, sidewalks, and buildings. Planter

boxes can be used as a traffic calming device. Planter boxes can be designed adjacent to buildings to directly receive roof gutter flow. When well designed, installed, and maintained, planter boxes are extremely attractive additions to commercial businesses and office buildings.



Environmental Benefits

- Reduces stormwater runoff volume
- Promotes infiltration and groundwater recharge
- Enhances tree health and longevity
- Targeted pollutants: suspended solids, sediment, trash, bacteria, organics, nutrients, metals, oil & grease

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments, Private Streets
- LFUCG Roads and Rights-of-Way (**must obtain LFUCG approval if proposed for public infrastructure**)
- LFUCG Parking Lots

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment
- Provides detention storage for **Water Quantity** (if designed with detention controls)
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: The contributing drainage area shall be less than 15,000 square feet.

Proximity to Existing Features: Tree trenches shall be located at least 5 feet from existing buildings without basements, and 10 feet from sanitary sewer lines or buildings with basements. If an adjacent building has a basement known to have seepage problems, a different type of treatment BMP should be considered.

Soil Type: An underdrain shall be provided if the underlying soils have an infiltration rate of less than 2 inches per hour. Underdrains must freely discharge into a swale or be connected to a receiving storm drainage system.

Overflow: Design shall account for safe bypass of high flows from the BMP into a storm drainage system.

Pretreatment: None

Drain Time: Maximum drain time (i.e. ponding) is 4 hours in pedestrian areas, 24 hours in other areas. Maximum Ponding depth should not exceed 6 inches in pedestrian areas, 9 inches in other areas.

Prohibited Areas: Tree trenches/planter boxes shall not be placed within 200 feet of a sinkhole area, in areas of soil contamination, or over existing utilities. They shall not be used for water quantity control (i.e. detention) when placed in the right-of-way or pedestrian areas.

Design Guidance

Tree Trenches/Planter Boxes shall be designed similarly to a bio-retention facility.

Maintenance

The property owner or HOA shall maintain the facility in a manner similar to a bio-retention facility.

Easements

When used as a stormwater control and outside of the right-of-way, Tree Trenches/Planter Boxes are typically demarcated with a “Storm Drainage Easement.” When this control is being used to meet detention requirements a “Detention and Storm Drainage Easement” shall be used.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the BMP.
2. Design calculations, including surface area, depth, drawdown time, etc.
3. Stage/Storage/Discharge calculations (i.e. routing) if it is being used for detention.
4. Infiltration tests of the underlying in-situ soils in accordance with ASTM D3385.
5. Landscaping plan showing the proposed plants.
6. Construction plans showing the plan, profile, section view, underdrains and overflow system.

10.3.8 Rainwater Harvesting

Description

Rainwater harvesting is the practice of capturing, storing, and re-using rainfall or stormwater runoff. Potential uses include landscape irrigation, toilet flushing, cooling water, and wash or process water. Storage can be interior or exterior, and above ground or below ground. Typically, structures are designed to intercept and store runoff from rooftops although units can be designed to collect runoff from parking lots and other surfaces. In either case, the intent for the captured runoff is to be used following the rain event, thus preventing the runoff from leaving the site. The most common variations of rainwater harvesting are cisterns (both underground and above ground) and rain barrels. For new and redevelopment in Fayette County, rainwater harvesting systems can be designed to capture all, or a portion of, the Water Quality Volume. In order to be eligible to meet the water quality treatment requirement, a water balance model is required to determine tank size, as well as an operation plan to document expected water usage. Cisterns and rain barrels can be a useful method of reducing stormwater runoff volumes in urban areas where site constraints limit the use of other BMPs.



Environmental Benefits

- Reduces stormwater runoff volume and peak flow
- Roofwater capture removes pollutants from atmospheric deposition and roof/gutter metal sources
- Filtering of stormwater runoff can remove suspended solids, trash, bacteria, nutrients, oil & grease, etc.

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments
- LFUCG Roads and Rights-of-Way
- LFUCG Buildings

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment
- Provides detention storage for **Water Quantity**
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: Typically impervious areas only (e.g. rooftop, parking lots).

Proximity to Existing Features: Can be located indoors or outdoors.

Pretreatment: Filters are required to filter larger debris and grit from entering the tank. A screen filter, as well as a first flush diverter, are typical elements.

Overflow: Once the storage tank is full, design shall account for safe bypass of conveyed water into a storm drainage receiving system.

Drain Time: A water balance simulation is typically used to design the tank size. Rainwater harvesting models include variables such as daily runoff, daily stormwater captured, daily overflow, daily demand, and daily ending balance of the cistern. Simulations are typically 10 to 20 years of historical rainfall data.

When using rainwater harvesting to meet Water Quality Volume capture requirements, the volume shall equal, but not exceed, the average 2-week usage volume from the demand calculations, or the tank size, whichever is smaller.

Design Guidance

Full-year operation is expected for stormwater controls meeting the water quality treatment requirements of this manual. Consider winter conditions in tank designs to minimize potential shutdown.

Various system vendors provide runoff reduction calculators. Recommended references for design guidance, including tank size, configuration, pump requirements, water treatment, etc. include:

- American Rainwater Catchment Systems Association (ARCSA)
- Virginia Rainwater Harvesting Manual

Maintenance

When this stormwater control is used to meet the water quality requirements of this manual, an Operations Plan is required documenting the facility's water usage for the intended re-use purpose(s) meeting or exceeding that shown in the calculations for daily demand. An operations log of system use, including shutdowns, is required. The property owner shall maintain the facility in accordance with a Maintenance Plan. Extended periods of system shutdown may result in the site being out of compliance with this manual.

Easements

Storm Drainage Easements can be used to denote the area of the tank if external to a building. Underground systems should be denoted in a similar manner to Underground Detention systems.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Calculation of the WQV draining to the facility.
2. Design calculations, including water balance simulation, tank sizing, pump sizing, plumbing, etc.
3. Construction plans showing the plan, plumbing, details of pump, tank, filters, bypass etc.
4. Operations Plan and Maintenance Plan for the facility.

10.3.9 Vegetated Roofs

Description

Vegetative roofs (or green roofs) are alternatives to conventional rooftops that provide a protective covering of plant media and vegetation. Vegetative roofs may be used in traditional flat or pitched roofs to reduce impervious cover and absorb less heat than conventional systems. Vegetative roofs consist of vegetative cover, growing media, a drainage layer, and a waterproof membrane. There are two basic vegetative roof designs distinguished by media thickness: extensive vegetative roofs and intensive vegetative roofs. Extensive vegetative roofs are lightweight systems where the media layer ranges from 2 to 6 inches thick and are limited to herbs, grasses, and mosses. Intensive vegetative roofs have greater soil depths of 8 inches or more and include a variety of grasses, shrubs, and trees. Vegetative roofs reduce the rate and runoff volume released during storm events. The water retention and detention properties of vegetative roof covers can be enhanced through proper selection of engineered media and plants.

For new and redevelopment in Fayette County, vegetated roofs are classified as an “**engineered pervious surface**.” They are not classified as a water quality control, but can serve to decrease site imperviousness. If used for this purpose and later removed, replacement stormwater controls may be required to offset the increased imperviousness.



Environmental Benefits

- Reduces stormwater runoff volume and peak flow
- Removes pollutants from atmospheric deposition

Allowable Locations in New Development and Redevelopment

- Single-Family Residential
- Commercial, Industrial, Apartments
- LFUCG Buildings

Meeting LFUCG Design Criteria for New Development and Redevelopment

- Provides **Water Quality Volume** capture and treatment
- Provides detention storage for **Water Quantity** (if designed with detention controls)
- Functions as a pervious surface for **Water Quantity** hydrologic calculations

LFUCG Site Design Requirements

Drainage Area: Typically the rooftop only.

Building Structure: If retrofitting an existing building, a structural analysis is required to determine if the structure can hold the weight of the proposed roof. If installing on a new building, the structural design shall include the additional weight in the design.

Proximity to Existing Features: N/A

Soil Type: Special media specified for vegetated roof plant species (e.g. sedum, etc.)

Pretreatment: N/A

Drain Time: N/A

Design Guidance

Vegetated roofs shall be designed in accordance with industry standards (e.g., <http://www.greenroofs.org/index.php/resources/designstandards>)

When designing and constructing vegetated roofs, the following issues are of special concern:

- Fire, wind, and root penetration protection
- Flashing design and installation for watertight seal
- Gutters to handle runoff during heavy rain events
- Building code
- Access and future Operation & Maintenance Plan

Maintenance

The property owner shall maintain the vegetated roof in accordance with an Operation and Maintenance plan submitted to LFUCG. If an engineered pervious surface is used to lower site imperviousness for a new development or redevelopment, and it later becomes impervious for whatever reason, the site may become out of compliance with this manual. The surface could either be replaced with new material to restore its original condition or replacement stormwater controls may be required to offset the increase in impervious area. In addition, Vegetated Roofs classified as an “engineered pervious surface” that are found to have become impervious shall be noted on LFUCG’s Impervious Area GIS coverage for inclusion in the Water Quality Management Fee billing.

Easements

Easements are not required for vegetated roofs.

Submittal Requirements

The following items shall be submitted to the LFUCG Division of Engineering:

1. Roof design report by a structural engineer.
2. Operation and Maintenance plan prepared by a structural engineer and landscape specialist.
3. Roof design plan showing cross-section, drainage, plumbing, flashing detail, landscaping plan, etc.

10.3.10 Riparian Buffer Restoration

Riparian buffers are vegetated zones of trees and/or shrubs adjacent to and up-gradient from perennial or intermittent streams, lakes, ponds, and wetlands. See Chapter 9 for more information. In the ideal scenario, native riparian buffers would exist adjacent to all receiving waters. However, in many agricultural areas the native riparian buffer has been partially or fully removed to create pasture or cropland right up to the top of streambank. Existing riparian buffers cannot be used for infiltration or water quality credit, but restoration or reforestation of riparian buffers can be used to provide infiltration credit.



Design Criteria

Design a plan for riparian buffer reforestation/revegetation in accordance with requirements of Chapter 9.

In order to obtain infiltration credit for re-establishing a riparian buffer zone, the streambank must also be restored in accordance with Chapter 9.

A buffer zone planting plan must be included with the improvement plans. The plan shall also provide for maintenance of the buffer zone until such time as trees and shrubs are established and the up-gradient drainage area is permanently stabilized.

10.4 Manufactured Treatment Devices

Stormwater manufactured treatment devices (MTDs) remove pollutants from stormwater runoff. MTDs may be used as the sole stormwater quality control **only** in the following situations:

- redevelopment projects, or
- infill development projects, or
- new development projects where Green Infrastructure is not feasible

10.4.1 Design Criteria

MTDs acceptable for use in Fayette County shall be those verified by the New Jersey Corporation for Advanced Technology (NJCAT) and certified by the New Jersey Department of Environmental Protection (NJDEP), per the 2013 laboratory protocol, for removing 50% of the total suspended solids using the water quality design storm in the New Jersey Stormwater Manual. Pretreatment MTDs shall meet the same requirements.

The MTD shall be sized based on the peak flow using the Rational Method and the sizing shall be done in accordance with each MTD’s published verification report. The design rainfall intensity for the Rational Method shall be determined based on Table 10-1.

TABLE 10-1 – RAINFALL INTENSITY FOR MANUFACTURED TREATMENT DEVICES

Time of Concentration	Rainfall Intensity (inches per hour)
10	3.20
15	2.60
20	2.20
25	1.90
30	1.70
35	1.50
40	1.40
45	1.30
50	1.20
55	1.10
60	1.05

Source: Figure 5-3, New Jersey Stormwater Best Management Practices Manual, 2004

10.5 Detention Basins

A detention basin is a traditional stormwater quantity control device that is designed for peak discharge control. Detention basins are designed to completely drain after the design storm passes. Figure 10-3 illustrates a detention basin. Figure 10-4 illustrates a trash rack with a low flow orifice.



10.5.1 Applicability

Detention basins are primarily used for flood control.

10.5.2 Design Criteria

Design detention basins so that discharge rates do not exceed calculated pre-development peak runoff rates for the storms given in Chapter 5.

Design outlet structures so that detention volume is released within 24 hours.

Provide an emergency spillway sized to discharge the peak runoff from the 100-year storm assuming the principal spillway is clogged, without overtopping the crest.

Provide a minimum of 1 foot of freeboard above the calculated high water elevation for the 100-year storm.

Embankment heights shall not exceed 20 feet (measured from the downstream toe) and storage volumes shall not exceed 25 acre-feet and shall not be less than 0.3-acre feet. Regional facilities may exceed these limits, but they must comply with the applicable requirements of the Kentucky Division of Water.

Design earthen embankments with side slopes no steeper than 3:1 (horizontal to vertical).

Provide anti-seep collars where the spillway barrel passes through the embankment. Stabilize earthen embankments immediately with temporary or permanent vegetation in accordance with requirements of Chapter 11.

Detention basins shall be placed outside the receiving stream except when a basin is designed as a regional detention basin and LFUCG has approved its use as a regional basin.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 15 feet wide and no steeper than 5:1 (h:v). Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope no steeper than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the basin and the nearest property line. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the basin and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

Outlet works may be a combination of pipes, weirs, orifices and drop inlets, but design any outlet pipes to be at least 15 inches in diameter to facilitate maintenance. The minimum opening size of an orifice shall be 4 inches.

Design basins to have a minimum bottom slope of two percent.

10.5.3 Design Procedures

Compute the inflow hydrographs for both pre- and post-developed conditions for the 10-year and 100-year storms given in Chapter 5.

Size the outlet structure for the maximum allowable peak discharge at the estimated peak stage.

Develop a stage-storage curve for the proposed basin.

Develop a stage-discharge curve for all outlet control structures.

Perform flood routing calculations using the post-development hydrographs determined for the design storms.

If the routed post-development peak discharge(s) from the design storm(s) exceeds the pre-development discharge, or the peak stage varies significantly from the estimated peak stage, revise the basin volume and/or outlet structure design. Develop a revised stage-storage curve and a revised stage-discharge curve and rerun the flood routing.

Design the emergency spillway to handle the 100-year peak discharge from the post-development hydrograph with no conveyance through the primary outlet structure.

Evaluate the downstream effects of detention outflow to ensure that the routed hydrograph does not cause downstream flooding problems.

Evaluate the control structure outlet velocity and provide channel and bank stabilization if the velocities are greater than the natural stream velocities.

10.5.4 Material Specifications

Construct embankments of ML, CL, MH, or CH soils as determined in accordance with the Unified Soil Classification System (USCS).

Determine the maximum standard dry density (ASTM D698) of at least two distinct samples of the soils to be used for embankment construction.

All conduits used for principal spillways shall be reinforced concrete pipe (RCP). The conduits shall be sealed with rubber gaskets to form a flexible watertight seal under all conditions of service. All pipes shall meet the requirements set forth in the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction, latest edition. The design engineer shall be responsible for determining the size and grade of pipe to be used.

Anti-seep collars shall be provided on all conduits through earthen embankments, foundations, and abutments. The number and size of anti-seep collars shall be determined based on guidance set forth in the Kentucky

Department for Environmental Protection, Division of Water's Engineering Memorandum No. 5, Design Criteria for Dams and Associated Structures.

All stone shall meet the requirements set forth in the Kentucky Transportation Cabinet's Standard Specifications for Road and Bridge Construction, latest edition.

Gradation of stone material shall be in accordance with ASTM C-33. Tests shall be performed on every 5 tons of stone installed or at least once per installation location in locations where less than 5 tons are placed.

All geotextiles shall meet the requirements for performance and strength as set forth by the design engineer. Any alternative material used on the project shall be approved by the design engineer.

The following tests shall be performed and included in the manufacturer's certifications for each shipment of geotextile or every 500 square yards (or once per lot if manufacturer's records show multiple rolls came from same lot), whichever is less:

- Mass per unit area per ASTM D-5261
- Grab tensile strength per ASTM D-4632
- Trapezoidal tear strength per ASTM D-4533
- Burst Strength per ASTM D-3786
- Puncture strength per ASTM D-4833
- Thickness per ASTM D-5199
- Apparent opening size per ASTM D-4751
- Permittivity per ASTM D-4491
- Ultraviolet light resistance per ASTM D-4355

In the case that a more recent testing standard has been released, then that standard shall be used in lieu of the listed testing standards.

10.5.5 Construction Specifications

Verify areas to be backfilled are free of debris, snow, ice, or water, and ground surfaces are not frozen.

When necessary, compact subgrade surfaces to density requirements for the backfill material and prepare subgrade or previous layer of compacted fill prior to placement of additional fill by scarifying or disking.

Cut out soft areas of subgrade not readily capable of in situ compaction. Backfill with subsoil and compact to density equal to requirements for subsequent backfill material.

Backfill areas to contours and elevations. Use materials that are not frozen. The Contractor shall keep the foundation and subgrade free from water or unacceptable materials after the fill operations have started.

Backfill systematically, as early as possible, to allow minimum time for natural settlement. Do not backfill over porous, wet, or spongy subgrade surfaces.

Place and compact soil fill materials in continuous layers not exceeding eight (8) inches loose depth. Compact soil fill materials to 95 percent of maximum dry density. Field density tests shall be performed on each lift. Areas that fail to meet the requirements shall be reworked as necessary to meet the requirements and then tested again. This process shall be repeated until the compaction requirements are met.

Tests shall be performed on each 400 square feet of surface area and on each lift of the surface area.

Maintain optimum moisture content of backfill material to attain required compaction density as specified. Material deposited on the fill that is too wet shall be removed or spread and permitted to dry, assisted by disking or blading, if necessary, until the moisture content is reduced to the specified limits.

All crushed stone fill and crushed stone backfill under structures and pavements adjacent to structures shall be DGA crushed stone per Kentucky Highway Department Standard Specifications for Road and Bridge Construction, unless indicated otherwise. Stone fill and backfill materials shall be placed in layers not exceeding six (6) inches in thickness and compacted to 95 percent of maximum dry density.

Backfill shall not be placed against or on structures until they have attained sufficient strength to support all loads to which subjected without distortion, cracking, or damage. Deposit soil evenly around the structure.

Slope grade away from structures minimum two (2) inches in ten (10) feet, unless noted otherwise.

Make changes in grade gradual. Blend slopes into level areas.

Remove surplus excavation materials to designated areas.

Pipe bedding shall meet the requirements set forth in the Kentucky Highway Department Standard Specifications for Road and Bridge Construction, latest edition, and the LFUCG Standard Drawings, latest edition.

The pipe trench shall be overexcavated six (6) inches and properly backfilled prior to laying pipe. In no case shall pipe be laid on solid or blasted rock.

Pipe bedding material shall be placed in six (6) inch loose lifts and compacted to 95 percent maximum dry density at ± 2 percent of the optimum moisture content.

When the subgrade is found to be unstable or to include ashes, cinders, refuse, organic material, or other unsuitable material, such material shall be removed to the depth ordered by the design engineer and replaced under the directions of the design engineer with clean, stable backfill material. When the bottom of the trench or the subgrade is found to consist of material that is unstable to such a degree that, in the judgment of the design engineer it cannot be removed, a foundation for the pipe and/or other appurtenance shall be constructed using piling, timber, concrete, or other materials as the direction of the design engineer.

All pipe shall be laid with ends abutting and true to the lines and grades indicated on the Drawings. The pipe shall be laid straight between changes in alignment and at uniform grade between changes in grade. Pipe shall be fitted and matched so that when laid to grade, it will provide a smooth and uniform invert.

The pipe shall be thoroughly cleaned prior to placement. Any piece of pipe or fitting which is known to be defective shall not be laid. If any defective pipe or fitting shall be discovered after the pipe is laid, it shall be removed and replaced with a satisfactory pipe or fitting.

The interior of the pipe, as the work progresses, shall be cleaned of dirt, jointing materials, and superfluous materials of every description. When laying of pipe is stopped for any reason, the exposed end of such pipe shall be closed with a plug fitted into the pipe bell so as to exclude earth or other material. Other precautions shall be taken to prevent flotation of pipe by runoff into trench.

All pipe shall be laid starting at the lowest point and installed so that the spigot ends point in the direction of flow.

All joint surfaces shall be cleaned immediately before jointing the pipe. The bell or groove shall be lubricated in accordance with the manufacturer's recommendation. Each pipe unit shall then be carefully pushed into place without damage to pipe or gasket. All pipes shall be provided with home marks to insure proper gasket seating. Details of gasket installation and joint assembly shall follow the direction of the manufacturers of the joint material and of the pipe. The resulting joints shall be watertight and flexible. No solvent cement joints shall be allowed.

After the embankment has been built to final grade, scarify or till the top and side slopes to a depth of 6 inches to prepare a seed bed. Immediately seed and mulch with temporary or permanent seed according to the season (see Chapter 11).

10.6 Extended Detention Basins

In this manual, an extended detention basin is a dry detention basin equipped with an outlet structure that provides extended detention time (maximum of 24 hours) for a specific water quality treatment volume. Figure 10-5 illustrates an extended detention basin.



10.6.1 Applicability

Extended detention basins can be used for both water quality treatment and water quantity management.

In locations with continuous dry weather flow, an extended detention basin will tend to be continuously wet. In this instance, quantify the base flow so that the peak flow and water quality control structures can be designed accordingly.

Extended detention basins shall be located outside the receiving stream except when a basin is designed as a regional detention basin.

10.6.2 Design Criteria

The minimum drainage area for extended detention basins shall be 10 acres.

Design the extended detention outlet so that the “design” WQV requires a maximum of 24 hours to discharge.

To calculate the design WQV, take the full WQV for the site, minus any credits allowed for bioretention and infiltration practices.

Design extended detention basins with two stages. The lower stage would be the extended detention pool sized for the design WQV. The upper stage would be larger in area and sized for storm peak control.

Design the bottom slopes with a two percent minimum slope to promote drainage.

When a base flow into the basin exists, design the lower stage as a wetland marsh. In this case, provide a permanent pool of 6 to 12 inches below the design WQV. See section 10.9 for a list of wetland plants.

Provide an emergency spillway sized to discharge the peak runoff from the 100-year storm assuming the principal spillway is clogged, without overtopping the crest.

Provide a minimum of 1 foot of freeboard above the calculated high water elevation for the 100-year storm.

Embankment heights shall not exceed 20 feet (measured from the downstream toe) and storage volumes shall not exceed 25 acre-feet. The minimum storage volume shall be 0.3 acre-feet. Regional facilities may exceed these limits, but they must comply with the applicable requirements of the Kentucky Division of Water.

Design earthen embankments with side slopes no steeper than 3:1 (horizontal to vertical).

Provide anti-seep collars where the spillway barrel passes through the embankment. Stabilize earthen embankments immediately with temporary or permanent vegetation in accordance with requirements of Chapter 11.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 15 feet wide and no steeper than 5:1 (h:v) or less. Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope no greater than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the basin and the nearest property line. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the basin and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

10.6.3 Design Procedures

Design procedures for stormwater quantity and peak discharge control are the same for extended detention basins and traditional dry detention basins, except that the design WQV will be retained longer in the extended detention basin. To design the storm detention volume and peak control structure for an extended detention basin, follow the procedures given in section 10.5.3 and assume for design purposes that the elevation of the dry basin bottom corresponds to the elevation of the surface of the design WQV (i.e., the top of the extended detention pool).

Sand Filter Outlet

Figure 10-6 illustrates an outlet configuration that may be used to regulate discharge of the extended detention pool. A perforated riser may also be used.

To size this device pick a preliminary configuration and check it using the falling head permeability equation. Set t equal to 24 hours and calculate k . If the calculated k varies significantly from 3.5 ft/hr, adjust the filter dimensions and recalculate.

The falling head equation is:

$$k = 2.303 * (aL/At) * \log (H/h)$$

where:

k = coefficient of permeability (ft/hr) for sand,

a = average surface area of extended detention pool (ft²),

L = depth of sand (ft),

A = surface area of filter = width of sand layer * length of sand layer (ft²),

t = time (hr),

H = height of water over the perforated pipe with full extended detention pool (ft), and

h = height of filter from the top of the perforated pipe to the top of the sand (ft).

Size the sand filter trenches relative to the underdrain pipe such that the sand filter controls the discharge rate rather than the drain pipe. Provide calculations demonstrating that the underdrain pipe will convey the design flow rate under gravity flow conditions.

10.6.4 Specifications

Specifications are consistent with those provided in section 10.5.

10.7 Wet Ponds

In this manual, wet pond refers to a basin designed for both water quality and water quantity management and which has a permanent pool. Figure 10-7 illustrates a wet pond.



10.7.1 Applicability

Wet ponds can be used for water quantity management and water quality treatment. .

Design ponds to be placed outside the receiving stream except when a pond is designed as a regional detention basin.

10.7.2 Design Criteria

Design retention ponds to have a contributing drainage area of at least 10 acres and a surface area of at least one-fourth of an acre.

When using a wet pond with a permanent pool for water quality control, size the permanent pool to at least equal the design WQV.

To calculate the design WQV, take the full WQV for the site, minus any credits allowed for infiltration and bioretention.

Design the permanent pool to have an average depth between 3 feet and 6 feet and a maximum depth of no more than 8 feet.

Design wet ponds to be wedge-shaped with the narrow end at the inlet and the wide end at the embankment.

Provide a minimum length to width ratio of 3:1 or provide gabion baffles to extend the flow path to a length that meets or exceeds the path that would be achieved using a 3:1 length to width ratio.

Provide irregular shorelines so that the permanent pool has a natural appearance.

Provide a 10-foot wide, 12-inch deep, underwater bench around the perimeter except at the embankment.

Provide safety benches at least 10 feet wide around the perimeter above the permanent pool. Design these benches to have a slope no greater than 10:1 (h:v).

Design a liner for the permanent pool using on-site soils or other materials. Document that the proposed soils are suitable for use as a liner by providing soil classification data (Unified Soil Classification System) and standard moisture-density data (proctor density test). Design soil liners to be at least 6 inches thick.

Provide an emergency spillway sized to discharge the peak runoff from the 100-year storm, assuming the principal spillway is clogged.

Provide a minimum of 1 foot of freeboard above the calculated high water elevation for the 100-year storm.

Embankment heights shall not exceed 20 feet (measured from the downstream toe) and storage volumes shall not exceed 25 acre-feet. Regional facilities may exceed these limits, but they must comply with the applicable requirements of the Kentucky Division of Water.

Design earthen embankments with side slopes no steeper than 3:1 (horizontal to vertical).

Provide anti-seep collars where the spillway barrel passes through the embankment. Stabilize earthen embankments immediately with temporary or permanent vegetation in accordance with requirements of Chapter 11.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 15 feet wide and no steeper than 5:1 (h:v). Design the access way to connect to the embankment so that equipment can access the top of the embankment on a slope no steeper than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the pond and the nearest lot. Landscape the buffer strip with low-maintenance native grasses, shrubs, and trees. Provide a landscaping plan for the pond and the buffer. Objectives of landscaping include improving the appearance for adjacent residents and providing wildlife habitat.

10.7.3 Design Procedures

Design of the stormwater detention volume and peak control structure for a wet pond is similar to procedures given for a traditional dry detention basin. The permanent pool is sized to match the design WQV, which allows for effective water quality treatment. For quantity control, the pond must have capacity to hold the stormwater detention volume above the permanent pool. That portion of the stormwater detention volume equal to the design WQV is called the extended detention volume. That volume must be discharged slowly to protect the receiving stream from increased flood frequency. See Figure 10-8.

Reverse Slope Pipe

This section describes the design procedure for sizing a reverse slope pipe to discharge that portion of the stormwater detention volume equal to the design WQV. Figure 10-8 illustrates a reverse slope pipe.

Select a pipe diameter, length, and material and use the energy equation to calculate the discharge. The energy equation can be written as:

$$Q = A (2gH)^{0.5} / (1 + K_e + K_b + K_c L)^{0.5}$$

where:

Q = discharge (ft³/s)

A = cross-sectional area of pipe (ft²)

g = 32.2 ft/s²

H = head above discharge end of pipe (ft²)

K_e = entrance loss coefficient

K_b = bend loss coefficient (0 for no bends)

K_c = head loss coefficient for pipe

L = pipe length (ft)

Assume that the design WQV is placed above the permanent pool and calculate the corresponding height above the permanent pool. This is the head value, H , corresponding to the WQV.

Calculate the discharge (Q) at 0.25-foot intervals from the top of the design WQV (extended detention pool) to the bottom of the extended detention pool (i.e., top of permanent pool).

Calculate the average discharge for each 0.25-foot increment by averaging the Q calculated at the top and bottom of each increment.

Use the stage-storage curve for the ponds to determine the storage volume in cubic feet corresponding to each 0.25-foot increment of depth.

Divide each incremental storage volume by its corresponding average discharge to calculate the time required for each incremental volume to be discharged through the selected pipe.

Sum the incremental discharge durations to determine if the total design WQV required 24 hours to discharge. If not, adjust the pipe size and recalculate.

10.7.4 Specifications

Specifications are consistent with those provided in section 10.5.

10.8 Underground Detention

Underground stormwater controls may be used to meet the water quantity and/or water quality requirements. They may consist of tanks, chambers, compartments, or pipes designed to store and release stormwater. To meet the water quantity requirements, they shall be designed to reduce peak flows to pre-development levels. To meet the water quality requirements, they shall be designed to provide infiltration or extended detention of the water quality volume.



Minimum Requirements

1. Underground controls are not allowed in single-family residential developments. They are allowed in commercial, industrial, and multifamily development (condominiums, townhomes, and apartments). The property owner shall be responsible for all maintenance and annual inspection reports as required by Chapter 16 Article X Division 2 of the Code of Ordinances.
2. The maximum drainage area shall be 5 acres.
3. The plans shall be stamped by an engineer licensed in Kentucky.
4. The engineer shall provide inspection during construction and shall provide a final inspection report with construction photographs that demonstrate the facility will function as designed. The report shall include a certification statement from the engineer that the facility was constructed in accordance with the plans accepted by the Division of Engineering. The engineer shall also provide as-built drawings of the facility.
5. Facilities that use the stone porosity for the required volume shall use stone that has been washed. Filter fabric shall be placed at any stone/soil interface.
6. The design volume shall be based on the required water quantity volume and the water quality volume, plus 10%, to account for sediment accumulation prior to maintenance. The available sediment volume shall not be used in routing calculations.
7. Pretreatment shall be provided to remove debris, sediment, floatables, oil, and grease prior to stormwater entering the underground facility. Pretreatment options include in-line systems and bioretention. For permeable pavement systems, pretreatment is provided by the pavement itself. Isolator rows may be used for pretreatment only if they can be inspected from the surface without the need to use cameras.
8. The outer edge of the facility shall be at least 10 feet from building foundations and at least 10 feet from the property line. The bottom elevation of the structure shall be at least 1.0 foot lower than the lowest floor (including basements) of the nearest structure.
9. To enable long term inspection of the facility by the owner and LFUCG, visual inspection ports and access shall be located at the inlets and outlets of the facility. At least 1 access port shall be provided at 100-foot intervals to each chamber, row, pipe, and separate components or for each 1000 square feet of underground facility surface area.

10. The location of the underground facility shall be permanently marked “Underground Stormwater Control” on the site using signs, stenciling, stamped concrete, pavers, or manhole lid marking.
11. In order to avoid possible classification as a Class V injection well by the EPA, the width of the facility should be greater than its depth.
12. To meet the water quantity and water quality criteria of Chapter 1, underground facilities shall be designed as follows:
 - For water quantity, the facility shall be designed to reduce peak flows to pre-development levels for the design storms in Chapter 5
 - For water quality, the facility shall be designed to contain the WQV and release it slowly over the designed drain time

10.9 Constructed Wetlands

Constructed wetlands can provide a very effective management measure for mitigation of pollution from runoff, because they have the ability to assimilate large quantities of suspended and dissolved materials from inflow. The term “constructed wetland” can apply to a wetland which is constructed to mitigate impacts to a natural wetland (per a Corps of Engineers permit), or a wetland which is constructed as part of a wastewater treatment system. In this manual, a constructed wetland is a device constructed in accordance with the following criteria and procedures to treat and control stormwater.



10.9.1 Applicability

Constructed wetlands can be used for both water quality and water quantity management or for water quality only. For management of water quantity, a wetland would be constructed much like a wet pond with a 6 to 12 inch deep permanent pool. The most important criterion in determining whether a constructed wetland is applicable is the existence of a base flow that can be used to supply the permanent pool.

10.9.2 Design Criteria

For water quality control, size the extended detention pool above the permanent pool equal to the design WQV.

Design the extended detention outlet so that at maximum of 24 hours would be required to release the design WQV.

To calculate the design WQV, take the full WQV for the site, minus any credits allowed for infiltration and bioretention.

For stormwater quantity control, determine the necessary detention volume, and design the peak control outlet consistent with the design criteria and design procedures for detention basins in Section 10.5. The extended detention volume is a portion of the total detention volume rather than being an addition to it.

Size the surface area of the wetland according to procedures described in the following section.

Provide a sediment forebay. Design the forebay to be 4 to 6 feet deep and have a volume of at least 10 percent of the design WQV at the inlet to the constructed wetland.

Use a reverse slope pipe as the extended detention outlet and protect it from blockage using aggregate as shown in Figure 10-8.

Provide a micropool at the extended detention outlet so that the reverse slope outlet pipe can be placed 1 foot below the permanent pool surface. Design the micropool to be 4 to 6 feet deep with a volume of at least 10 percent of the WQV.

Provide a drain with a valve at the base of the micropool.

Design the permanent pool, with the exception of the sediment forebay and the outlet micropool, to be 3 to 12 inches deep with an average depth of 6 to 9 inches.

Design the grades in the constructed wetland so that the wetland will drain to the micropool at the outlet if the micropool is drained. Providing the ability to drain the wetland will facilitate maintenance and revegetation if necessary.

Design the wetland to have low marsh and high marsh in the permanent pool. Low marsh refers to a zone with 6 to 12 inches of permanent pool, while high marsh refers to a zone with zero to 6 inches of permanent pool. Design the wetland so that low marsh and high marsh each represent 35 to 45 percent of the total surface area. Design so that the total deep pool (i.e., the micropool plus the sediment forebay) represent 10 to 20 percent of the surface area.

Design the wetland to have a length-to-width ratio of at least 2:1.

Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 15 feet wide and no steeper than 5:1 (h:v). Design the easement to provide access to the sediment forebay and the outlet micropool.

Check the velocity of design storm flows at the inlet to the wetland and provide a stable entrance to prevent erosion.

Design a planting plan that shows 40 to 50 percent of the shallow (12 inches or less) wetland planted with wetland vegetation. A list of suitable species is available from the KY Division of Water. Plan to include a minimum of three emergent wetlands species as the majority planting with at least three additional emergent species comprising the remaining planting.

10.9.3 Design Procedures

Use Table 10-2 to determine the minimum surface area required based upon the size of the watershed draining to the wetland. Values in Table 10-2 are based upon expected nitrogen and phosphorus loading rates in urban areas and the maximum loading per acre that a constructed wetland can effectively treat.

Procedures for sizing the reverse slope pipe outlet at the micropool are consistent with procedures for wet retention ponds given in Section 10.7.

TABLE 10-1 – WETLAND SURFACE AREA

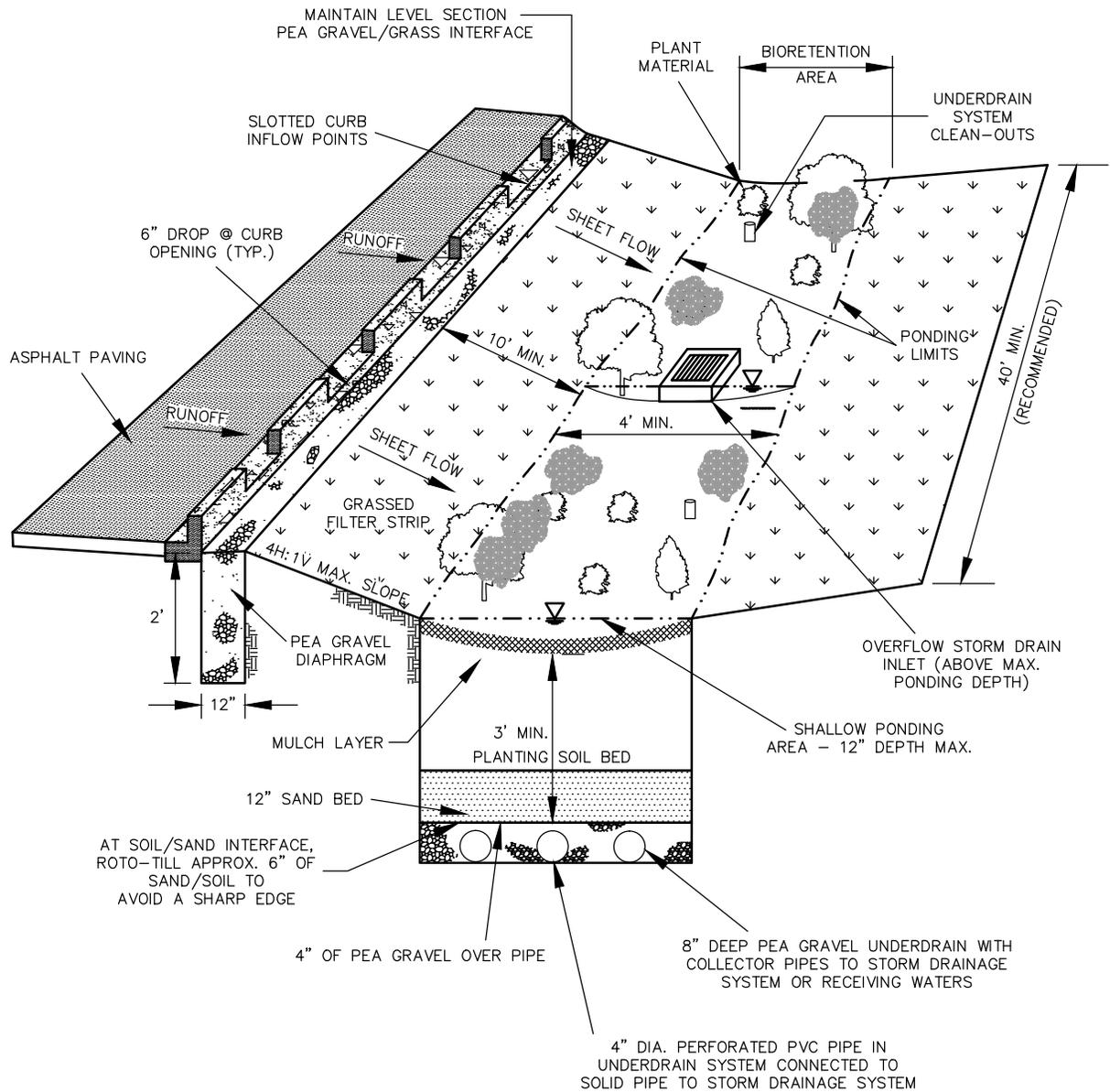
<p>% Impervious Surface</p>	<p>Surface Area in Acres per Acre of Watershed</p>
10	0.025
20	0.031
30	0.037
40	0.042
50	0.049
60	0.055
70	0.060
80	0.066
90	0.072
100	0.078

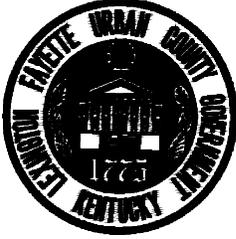
Note: Use linear interpolation for percent impervious values between those given in the table.



STORMWATER MANUAL

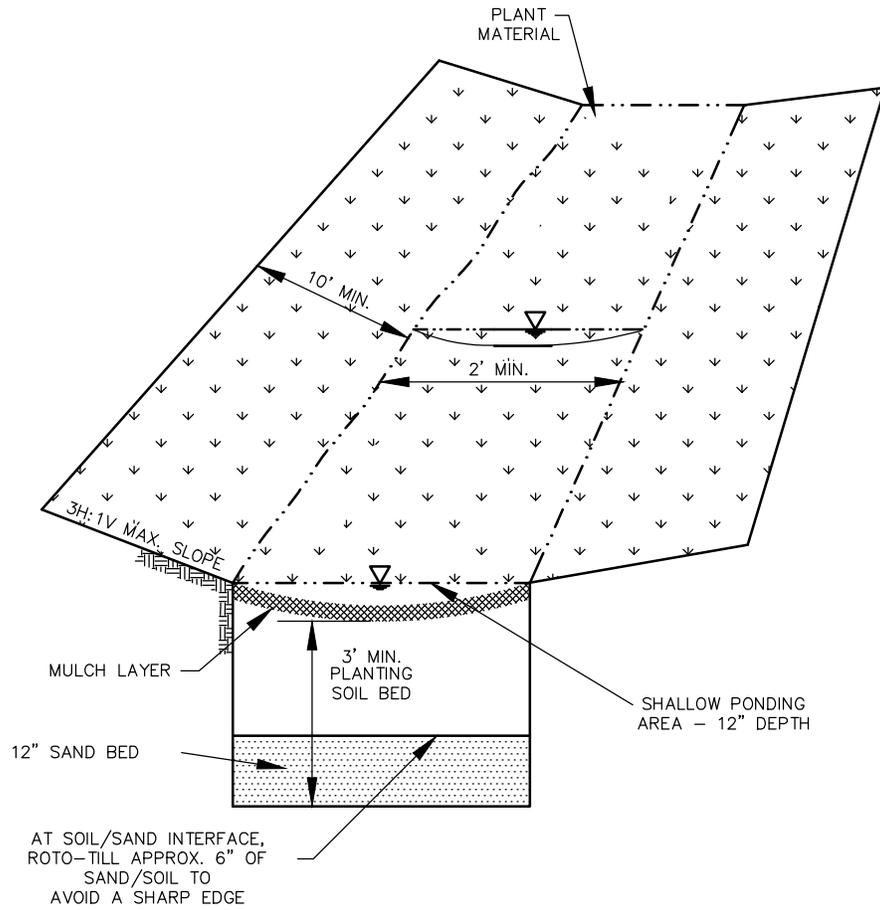
FIGURE 10-1
BIORETENTION SYSTEM
(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 10-2
BIOFILTRATION SWALE
(OCTOBER 1, 2016)



NOTE:
IF LONGITUDINAL SLOPE EXCEEDS 2 PERCENT, CONSTRUCT A BERM AT THE DOWNSTREAM END OF BIOFILTRATION SWALE. CONSTRUCT BERM SO THAT IT IS 12 TO 18 INCHES HIGH IN CENTER WITH A LEVEL TOP ACROSS THE PLANTING BED. CONSTRUCT THE BERM TO HAVE SIDE SLOPES NO GREATER THAN 2 HORIZONTAL TO 1 VERTICAL.

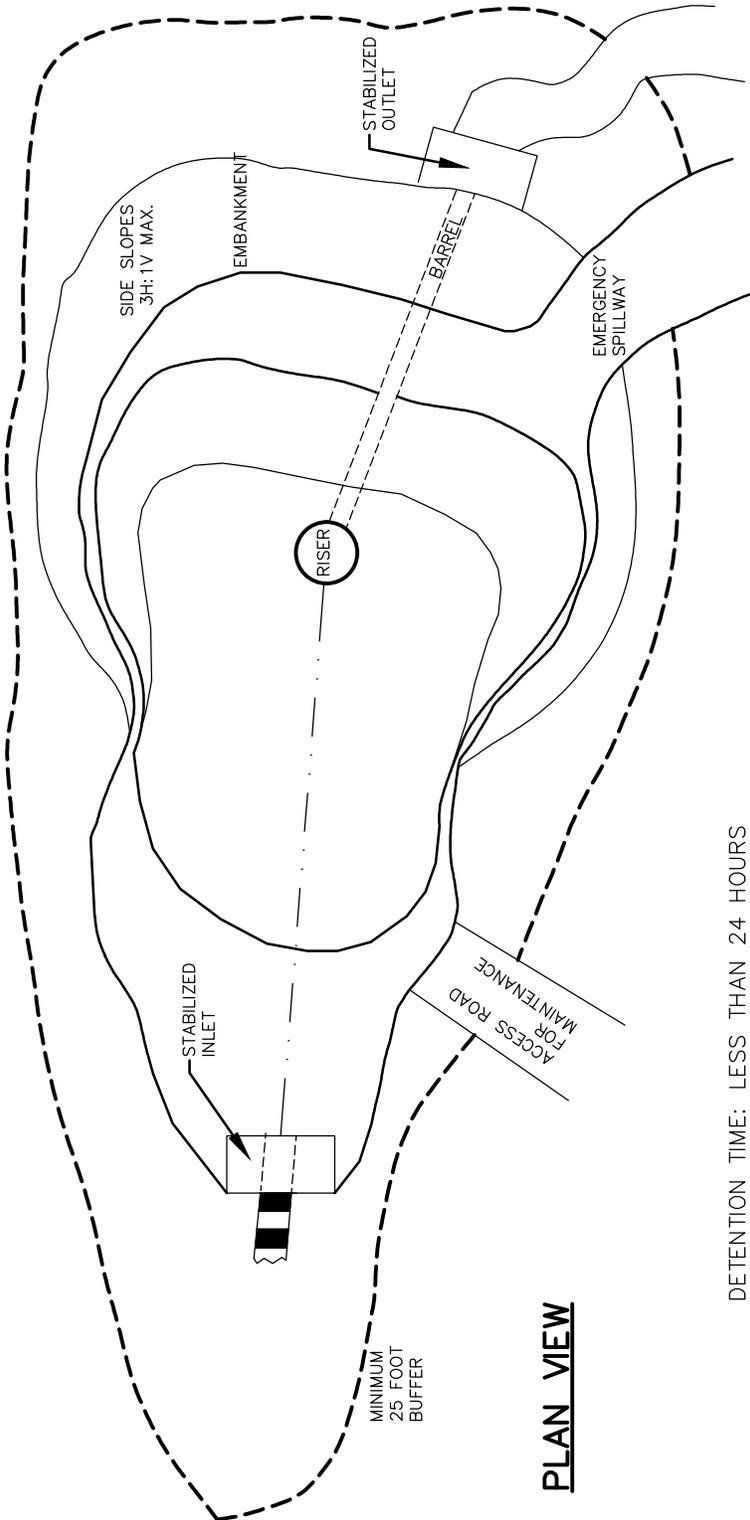


STORMWATER MANUAL

FIGURE 10-3

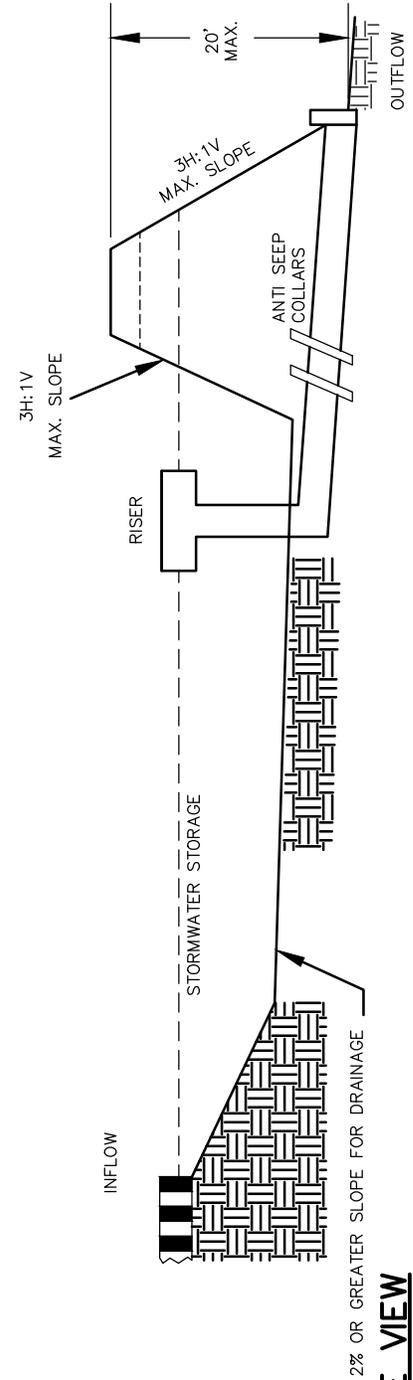
DETENTION BASIN

(OCTOBER 1, 2016)



PLAN VIEW

DETENTION TIME: LESS THAN 24 HOURS
MAX. TOTAL DETENTION VOLUME = 25 ACRE-FEET



PROFILE VIEW

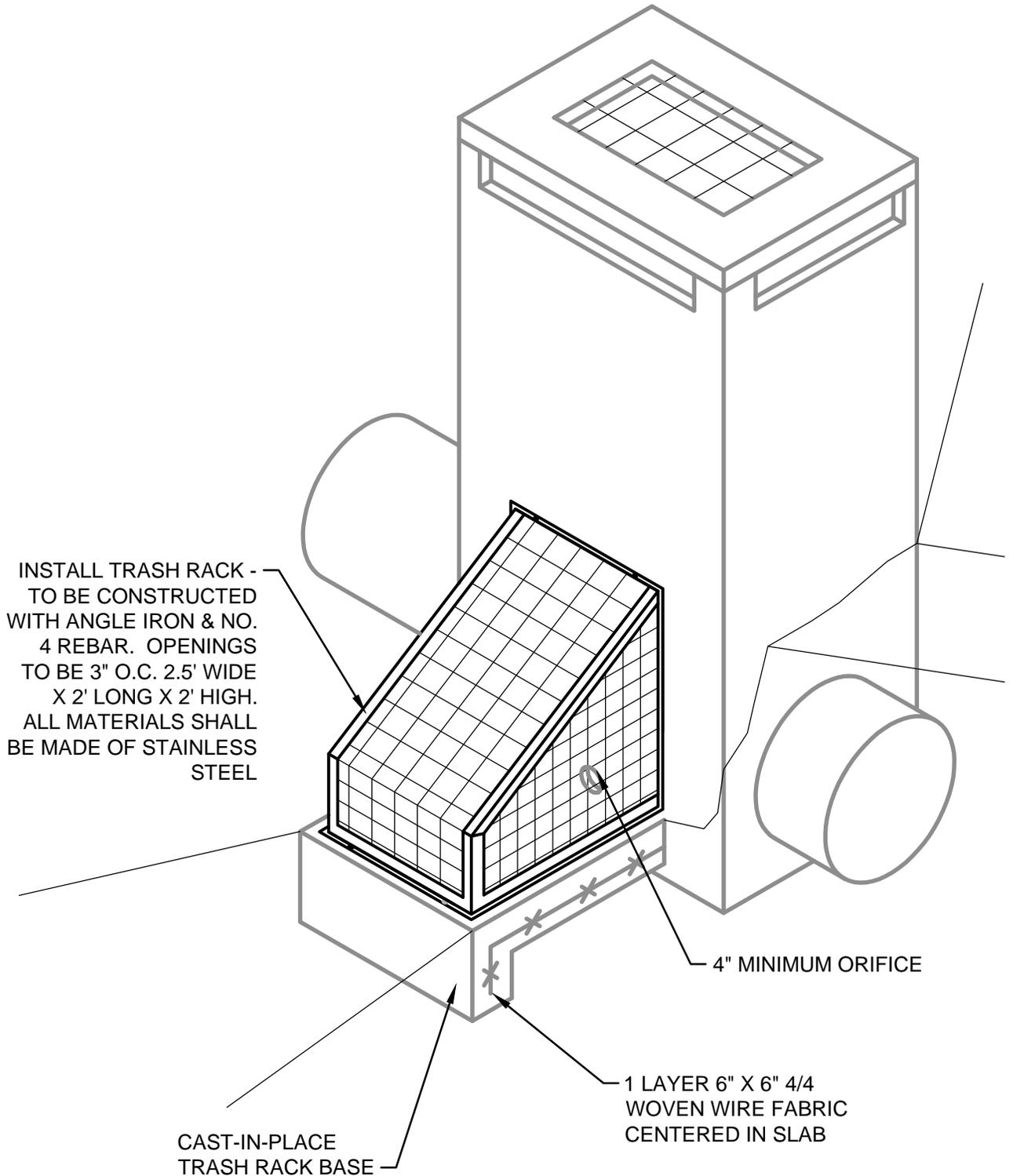


STORMWATER MANUAL

FIGURE 10-4

TRASH RACK PROTECTION
FOR LOW FLOW ORIFICE

(OCTOBER 1, 2016)



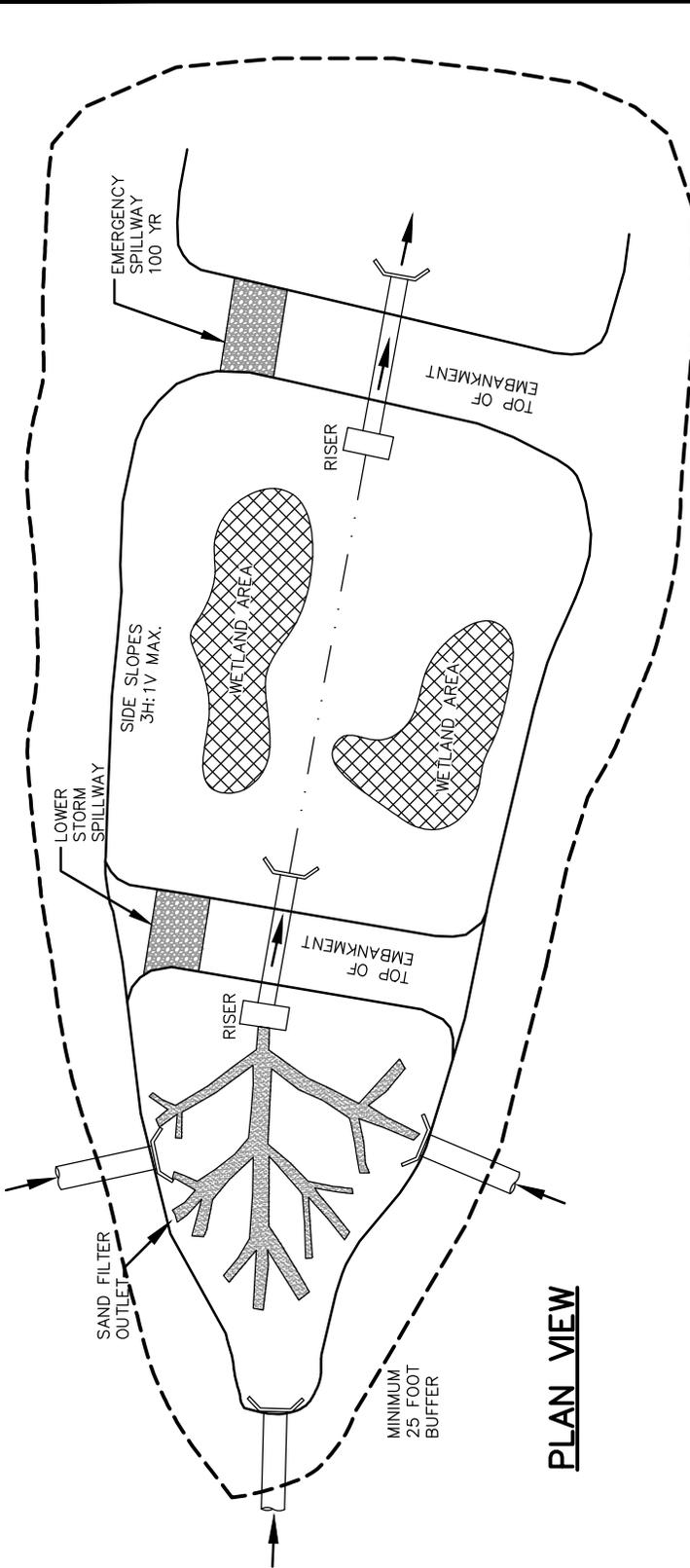


STORMWATER MANUAL

FIGURE 10-5

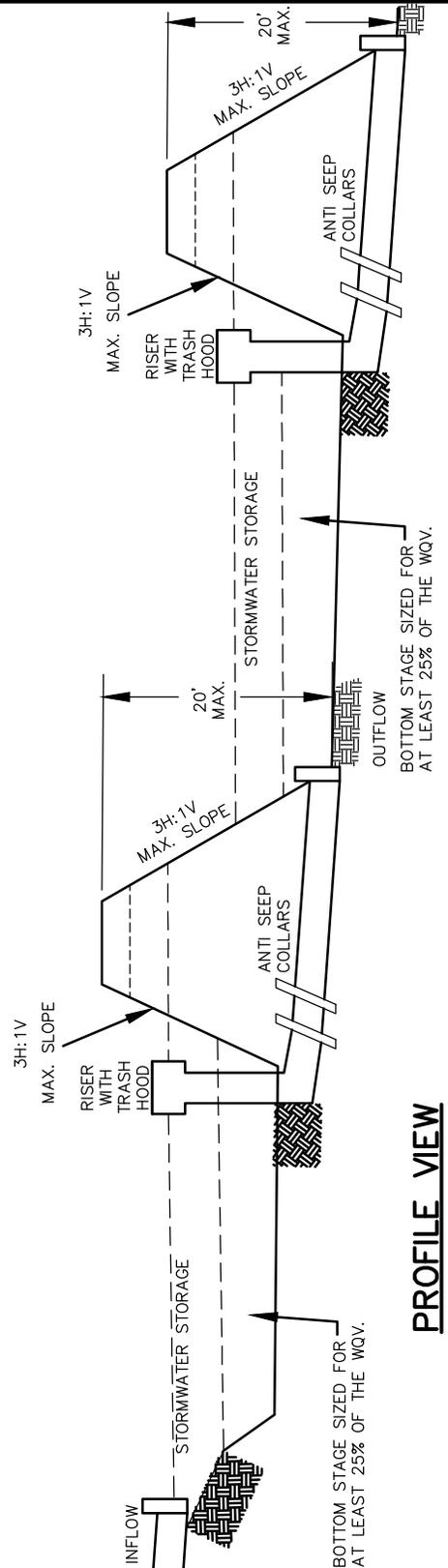
EXTENDED DETENTION BASIN

(OCTOBER 1, 2016)



PLAN VIEW

DETENTION TIME: 24 TO 48 HOURS
MAX. TOTAL DETENTION VOLUME = 25 ACRE-FEET

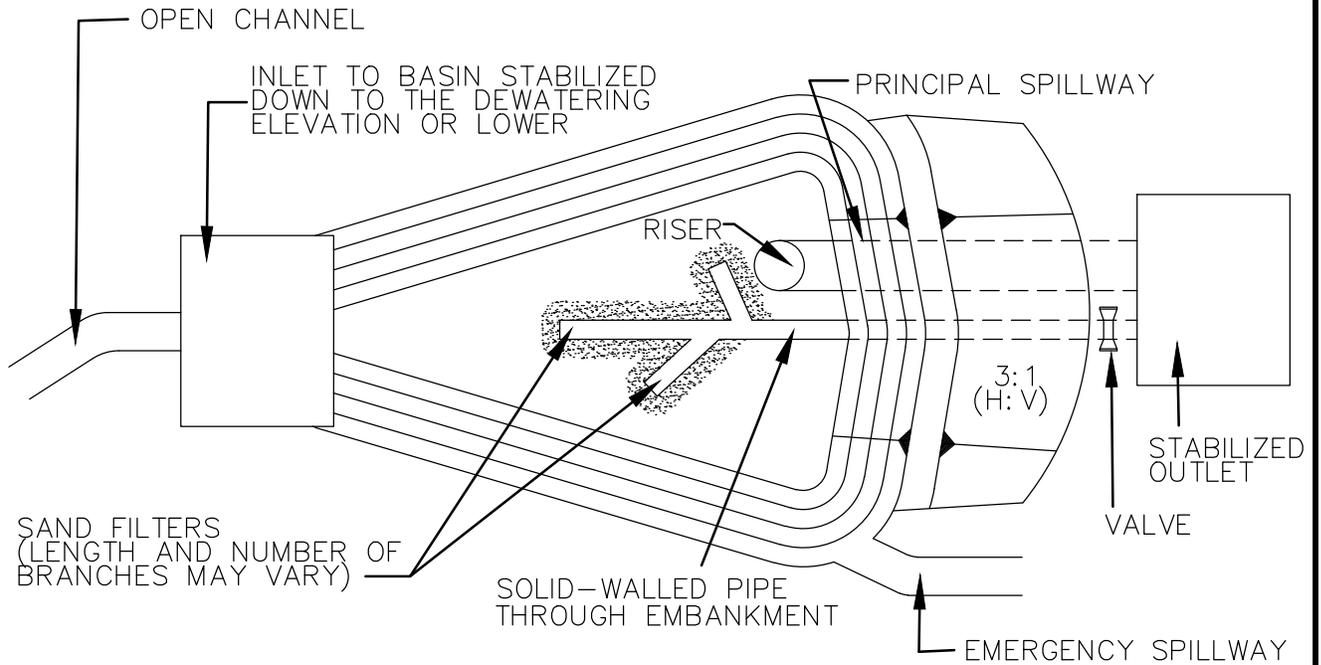


PROFILE VIEW

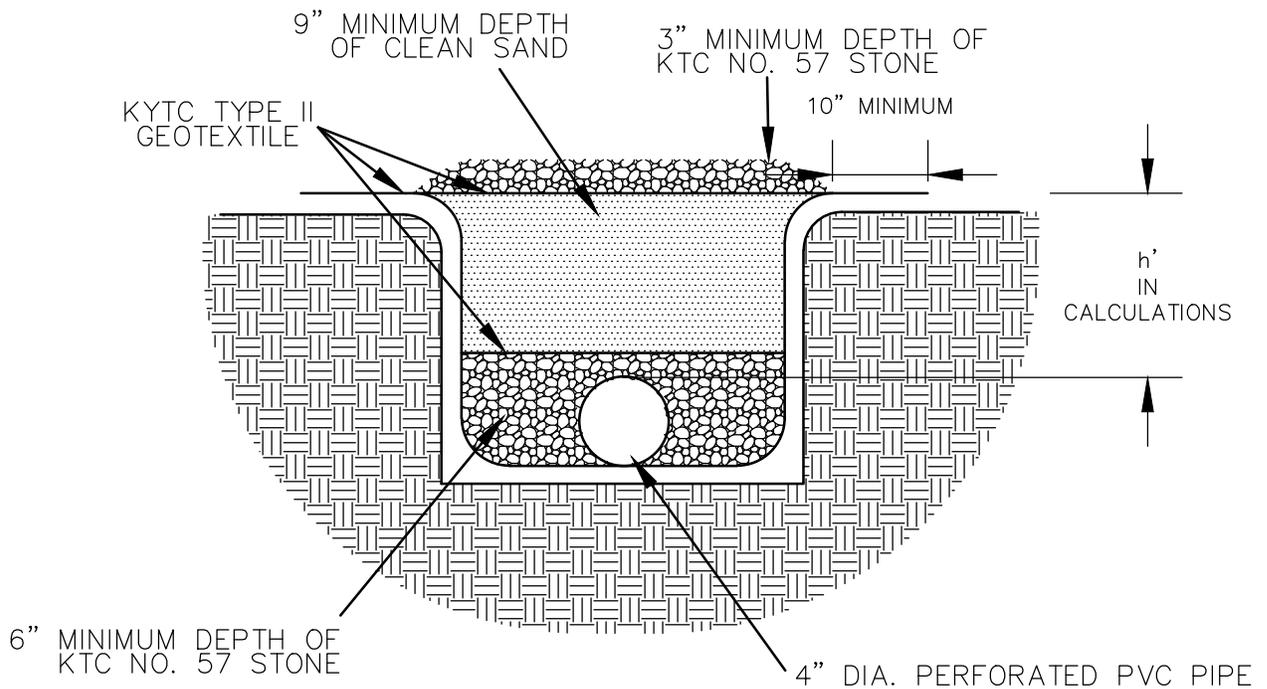


STORMWATER MANUAL

FIGURE 10-6
EXTENDED DETENTION OUTLET
USING SAND FILTER
(OCTOBER 1, 2016)



PLAN VIEW
N.T.S.



TYPICAL SECTION
N.T.S.

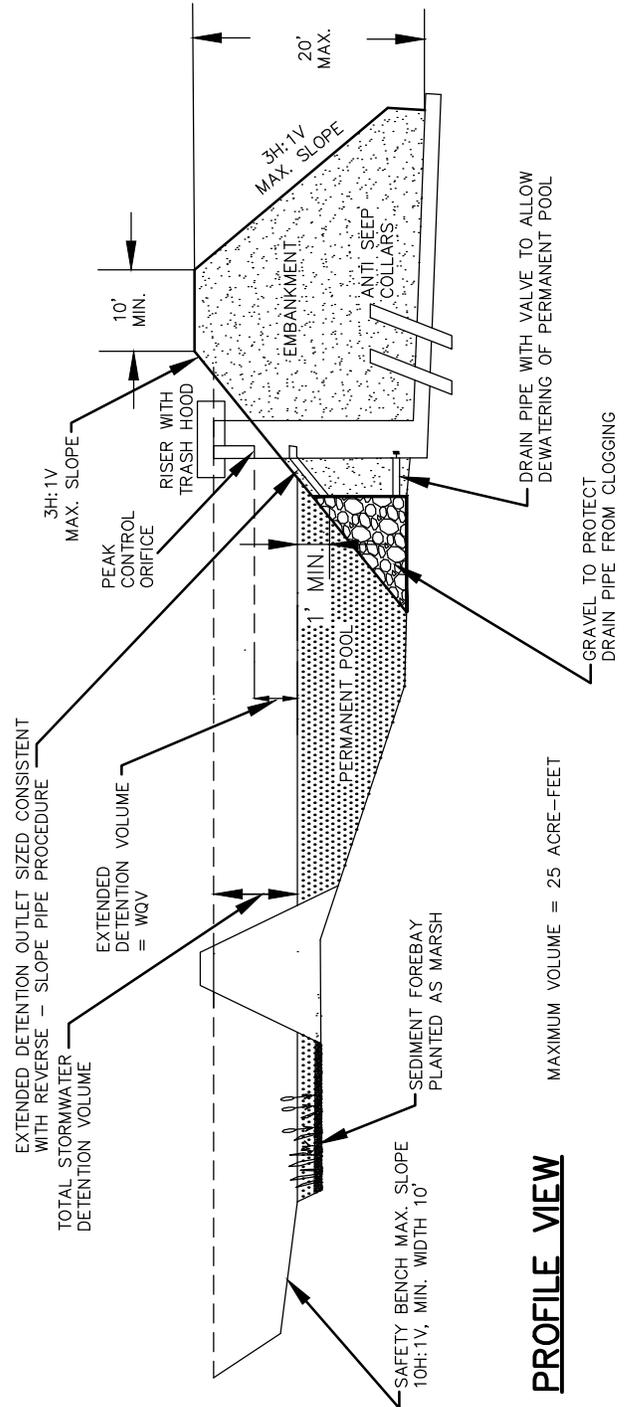
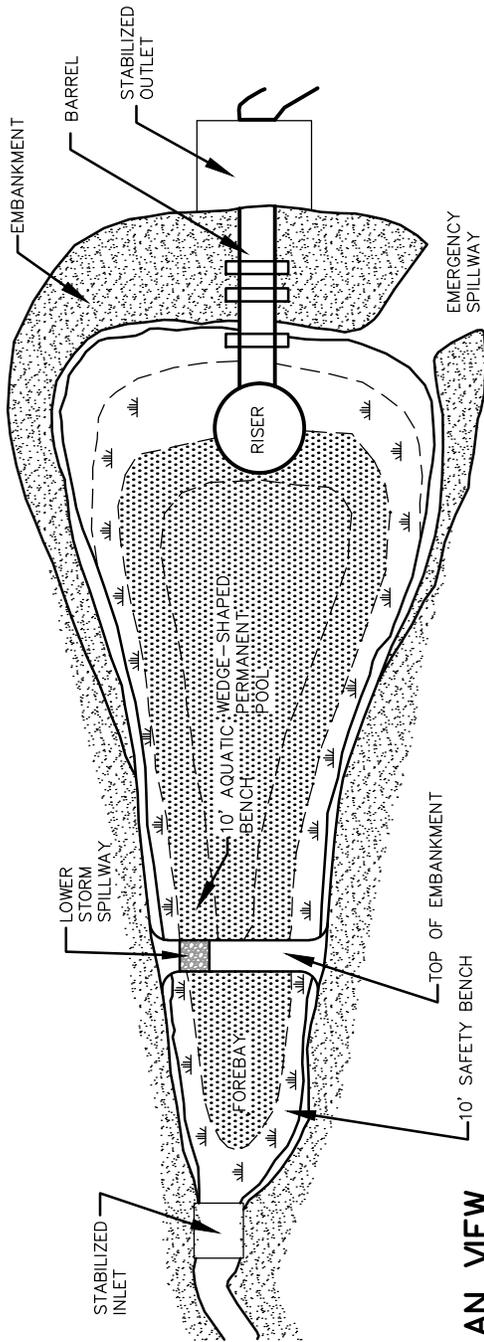


STORMWATER MANUAL

FIGURE 10-7

WET POND

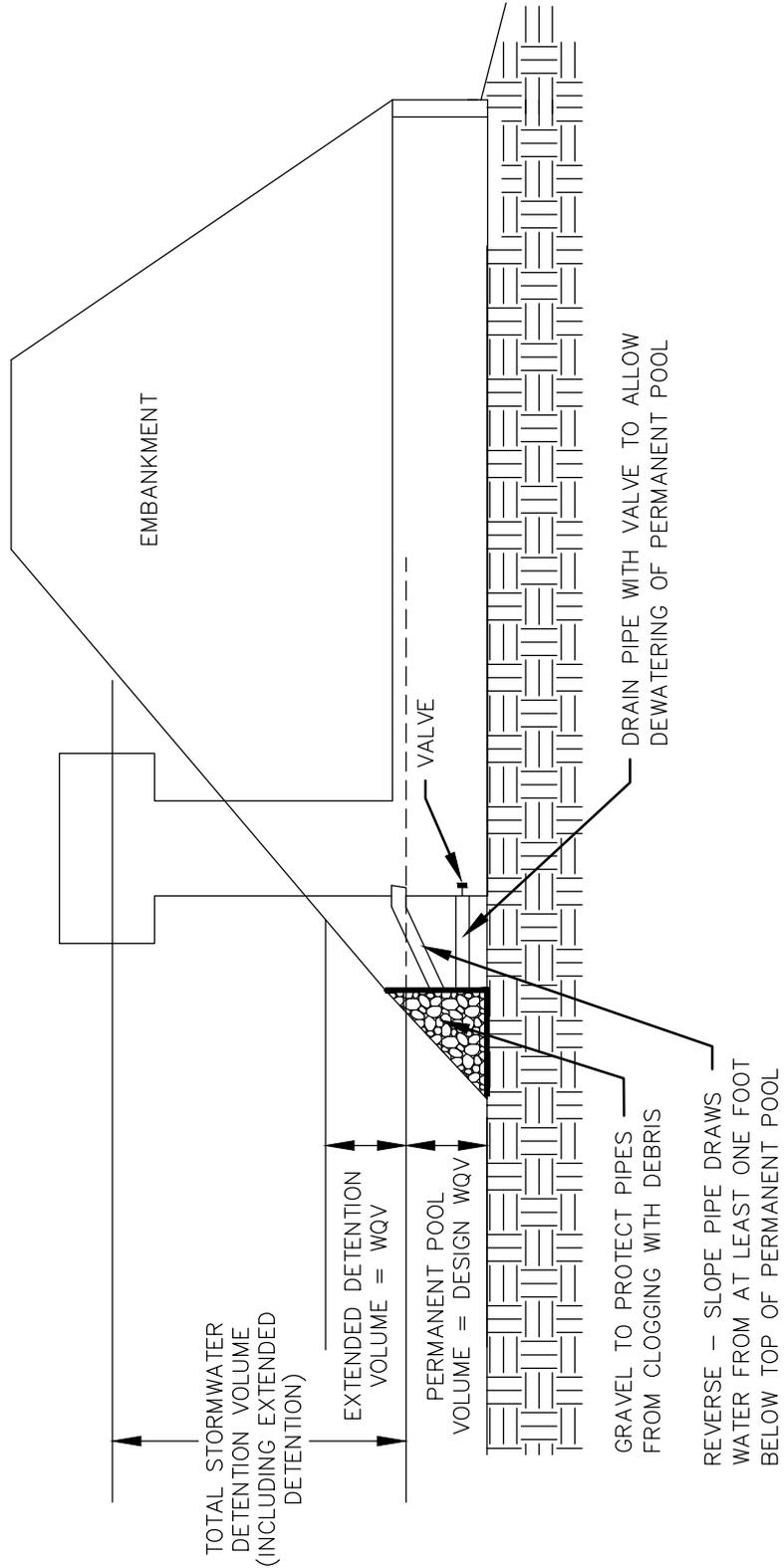
(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 10-8
EXTENDED DETENTION OUTLET FOR
WET POND
(OCTOBER 1, 2016)



PROFILE VIEW
N.T.S

APPENDIX A: PLANT LIST

Eight plant lists are included, one for each of the Best Management Practices (BMPs) that use vegetation as part of the treatment system. Some plants may appear on a number of the lists, others only on a single list. The vegetated roof list, for example, is almost totally different from any of the others.

Selecting plants from the list for any particular BMP should be based on a number of considerations: whether the site is in full sun, partially, or totally shaded; available soil moisture; the location and its aesthetics; the ultimate size of the plant; whether the plant is an annual or perennial; is shallow or deeply rooted; and its cost and availability, to mention just a few.

Some plants are more shade tolerant than others, some only do well in full sun, and others require full shade to survive. If the planting site is open to full sun, pick a group of plants that are compatible. A mix of sun requiring and shade requiring plants will result in the former out competing the latter and the shade requiring plants will soon be eliminated.

Moisture availability is one of the most important factors to consider. Bioretention facilities, more commonly called rain gardens, imply wet conditions but the opposite is generally true. These facilities may have standing water for 24 hours but may subsequently be very dry for the next 10 days.

Aesthetic considerations could differ considerably if a bioretention facility (rain garden) is located on a downtown street as opposed to the edge of greenway, where it is rarely seen. Spring and summer blooms or good fall color are important to the former, less so to the latter. Time of flowering is also a consideration, such that at least one species is blooming throughout the growing season. Several of the grasses listed are ornamental and should not be mowed during the growing season so that they can achieve their full height.

Plant size is important where tall plants may hide or shade shorter species. Both may be used but their location to each other, the sun, and the view should be considered. Size is particularly important when picking trees and shrubs - will the BMP have enough soil space to support the pencil thin seedling when it is 10 years old and 25 feet tall? Are there overhead utilities that would limit the height of trees but not be a problem for lower growing shrubs or under-story trees?

Annuals are plants that die each year but return from seed dropped by the parent plant. Some annuals do a better job of re-seeding themselves than others. The tops of herbaceous perennials die back each year but come back from the living root. Woody perennials do not die back but continue to gain size for years.

Rooting depth and type is important in several ways. BMPs with underdrains should not receive trees or shrubs with deep roots that could clog the drains in a few years. For that reason, willows are not recommended. Shallow soil may not adequately support trees that will reach considerable height unless they have an extensive lateral root system. Annuals are almost always shallow rooted, while perennials tend to be deeper rooted.

The large majority of plants listed are not expensive, particularly in relation to the cost of the entire BMP. Most should also be readily available at local or regional suppliers. Plants for a green roof may be the exception and may be obtainable from a limited number of sources.

Last but certainly not least, the decision whether to use seed or plants or a mixture of the two. Small plugs or container grown plants are initially more expensive than seed but may be cheaper in the long run. Establishing many species by seed can be a slow or difficult process. Where plants will be inundated for hours to days, seedlings would be much more vulnerable to anoxic conditions than larger plants of the same species. Planting healthy plugs, root cuttings, or larger container grown plants can result in better establishment and quicker BMP functioning. For some species, however, such as black-eyed Susan or grasses, seeding is the best option. Whatever species or mix of types is chosen,

they will all require some maintenance to become well established. At minimum, watering and weeding will likely be necessary during the first growing season.

TABLE B-1 – BIORETENTION SPECIES

Bioretention Species			
Common Name	Scientific Name	Height (Feet)	Notes
Grasses and Sedges			
Beaked Panicgrass	<i>Panicum anceps</i>	2-3	Can Be Mowed
Bluegrass	<i>Poa pratensis</i>	1-2	Full Sun; Can be Mowed; Non-native
Bottlebrush Grass	<i>Elymus hystrix</i>	2-3	Full Sun to Partial Shade; Dry, Well-Drained Soils; Do Not Mow
Canada Wild Rye	<i>Elymus canadensis</i>	2-4	Full Sun to Shade; Do Not Mow
Drooping Sedge	<i>Carex crinita</i>		
Fox Sedge	<i>Carex vulpinoidea</i>		
Indian Grass	<i>Sorghastrum nutans</i>	4-6	Open Sun; Do Not Mow
Little Bluestem	<i>Schizachyrium scoparium</i>	2-4	Full Sun; Can Be Mowed
Orchard Grass	<i>Dactylis glomerata</i>	2-3	Bunchgrass; Non-native; Can Be Mowed
Purpletop	<i>Tridens flavus</i>	2-3	Full Sun; Can Be Mowed
Redtop	<i>Agrostis alba</i>	1-3	Full Sun; Can Be Mowed
River Oats	<i>Chasmanthium latifolia</i>	2-4	Full Sun to Shade; Wet to Dry Soils; Do Not Mow
Switchgrass	<i>Panicum virgatum</i>	3-7	Open Sun; Deep Rooted; Late Spring Planting
Virginia Wild Rye	<i>Elymus virginicus</i>	2-4	Full Sun to Shade; Do Not Mow
Woolgrass	<i>Scirpus cyperinus</i>	3-5	Open Sun; Wet to Dry Soils; Do Not Mow
Forbs			
Bee Balm	<i>Monarda didyma</i>	2-4	Full Sun; Attracts Butterflies; May Spread
Black-eyed Susan	<i>Rudbeckia hirta</i>	2	Full Sun
Blazing Star	<i>Liatris spicata</i>	1-2	Full Sun
Blue False Indigo	<i>Baptisia australis</i>	3-4	Full Sun; Drought Tolerant; Blue Leaf Clusters
Blue Lobelia	<i>Lobelia siphilitica</i>	3-5	Full Sun
Bluestar	<i>Amsonia tabernaemontana</i>	1-2	Sun to Partial Shade
Bundleflower	<i>Desmanthus illinoensis</i>	2-3	Full Sun; Drought Tolerant
Butterfly Milkweed	<i>Asclepia tuberosa</i>	2	Full Sun
Cardinal Flower	<i>Lobelia cardinalis</i>	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Cream Indigo	<i>Baptisia leucophaea</i>	2-4	Full Sun; Slow Growing
Culvers Root	<i>Veronicastrum virginicum</i>	3-6	Full Sun to Partial Shade; Moist Soil
Downy Sunflower	<i>Helianthus mollis</i>	2-4	Full Sun; Drought Tolerant
Dwarf Larkspur	<i>Delphinium tricornis</i>	1	Full Sun
Gray Headed Coneflower	<i>Ratibida pinnata</i>	3-4	Full Sun; Drought Tolerant
Joe-Pye Weeds	<i>Eupatorium fistulosum purpureum</i>	5-8	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Marsh Milkweed	<i>Asclepias incarnata</i>	2-5	Sun; Moist Soil; Not Drought Tolerant
Mist Flower	<i>Conoclinium coelestinum</i>	2-3	Sun to Partial Shade; Moist Soil

Bioretention Species			
Common Name	Scientific Name	Height (Feet)	Notes
Monkey Flower	<i>Mimulus ringens</i>	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
New England Aster	<i>Aster novae-angliae</i>	2-4	Sun to Light Shade; Moist to Moderately Well-Drained
Obedient Plant	<i>Physostegia virginiana</i>	2-3	Sun to Light Shade; Moist Soil; May Spread
Orange Coneflower	<i>Rudbeckia fulgida</i>	2-3	Full Sun; May Spread
Prairie Dock	<i>Silphium terebinthenaceum</i>	3-10	Full Sun; Slow Growing; Drought Tolerant
Purple Coneflower	<i>Echinacea purpurea</i>	2-4	Full Sun; Large Flower; Drought Tolerant
Rattlesnake Master	<i>Eryngium yuccifolium</i>	2-5	Full Sun; Does Not Tolerate Standing Water; Unusual Appearance
Sneezeweed	<i>Helenium autumnale</i>	2-4	Full Sun; Moist Soil
Wild Bergamot	<i>Monarda fistulosa</i>	2-3	Full Sun; May Spread
Wild Blue Phlox	<i>Phlox divaricata</i>	1-2	Partial to Full Shade; Not Drought Tolerant

TABLE B-2 – BIO-INFILTRATION SPECIES

Bio-infiltration Species			
Common Name	Scientific Name	Height (Feet)	Notes
Grasses and Sedges			
Beaked Panicgrass	<i>Panicum anceps</i>	2-3	Can Be Mowed
Bluegrass	<i>Poa pratensis</i>	1-2	Full Sun; Can be Mowed; Non-native
Bottlebrush Grass	<i>Elymus hystrix</i>	2-3	Full Sun to Partial Shade; Dry, Well-Drained Soils; Do Not Mow
Canada Wild Rye	<i>Elymus canadensis</i>	2-4	Full Sun to Shade; Do Not Mow
Drooping Sedge	<i>Carex crinita</i>		
Fox Sedge	<i>Carex vulpinoidea</i>		
Indian Grass	<i>Sorghastrum nutans</i>	4-6	Open Sun; Do Not Mow
Little Bluestem	<i>Schizachyrium scoparium</i>	2-4	Full Sun; Can Be Mowed
Orchard Grass	<i>Dactylis glomerata</i>	2-3	Bunchgrass; Non-native; Can Be Mowed
Purpletop	<i>Tridens flavus</i>	2-3	Full Sun; Can Be Mowed
Redtop	<i>Agrostis alba</i>	1-3	Full Sun; Can Be Mowed
River Oats	<i>Chasmanthium latifolia</i>	2-4	Full Sun to Shade; Wet to Dry Soils; Do Not Mow
Switchgrass	<i>Panicum virgatum</i>	3-7	Open Sun; Deep Rooted; Late Spring Planting
Virginia Wild Rye	<i>Elymus virginicus</i>	2-4	Full Sun to Shade; Do Not Mow
Woolgrass	<i>Scirpus cyperinus</i>	3-5	Open Sun; Wet to Dry Soils; Do Not Mow
Forbs			
Bee Balm	<i>Monarda didyma</i>	2-4	Full Sun; Attracts Butterflies; May Spread
Black-eyed Susan	<i>Rudbeckia hirta</i>	2	Full Sun

Bio-infiltration Species			
Common Name	Scientific Name	Height (Feet)	Notes
Blazing Star	<i>Liatris spicata</i>	1-2	Full Sun
Blue False Indigo	<i>Baptisia australis</i>	3-4	Full Sun; Drought Tolerant; Blue Leaf Clusters
Blue Lobelia	<i>Lobelia siphilitica</i>	3-5	Full Sun
Bluestar	<i>Amsonia tabernaemontana</i>	1-2	Sun to Partial Shade
Bundleflower	<i>Desmanthus illinoensis</i>	2-3	Full Sun; Drought Tolerant
Butterfly Milkweed	<i>Asclepia tuberosa</i>	2	Full Sun
Cardinal Flower	<i>Lobelia cardinalis</i>	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Cream Indigo	<i>Baptisia leucophaea</i>	2-4	Full Sun; Slow Growing
Culvers Root	<i>Veronicastrum virginicum</i>	3-6	Full Sun to Partial Shade; Moist Soil
Downy Sunflower	<i>Helianthus mollis</i>	2-4	Full Sun; Drought Tolerant
Dwarf Larkspur	<i>Delphinium tricorne</i>	1	Full Sun
Gray Headed Coneflower	<i>Ratibida pinnata</i>	3-4	Full Sun; Drought Tolerant
Joe-Pye Weeds	<i>Eupatorium fistulosum purpureum</i>	5-8	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Marsh Milkweed	<i>Asclepias incarnata</i>	2-5	Sun; Moist Soil; Not Drought Tolerant
Mist Flower	<i>Conoclinium coelestinum</i>	2-3	Sun to Partial Shade; Moist Soil
Monkey Flower	<i>Mimulus ringens</i>	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
New England Aster	<i>Aster novae-angliae</i>	2-4	Sun to Light Shade; Moist to Moderately Well-Drained
Obedient Plant	<i>Physostegia virginiana</i>	2-3	Sun to Light Shade; Moist Soil; May Spread
Orange Coneflower	<i>Rudbeckia fulgida</i>	2-3	Full Sun; May Spread
Prairie Dock	<i>Silphium terebinthenaceum</i>	3-10	Full Sun; Slow Growing; Drought Tolerant
Purple Coneflower	<i>Echinacea purpurea</i>	2-4	Full Sun; Large Flower; Drought Tolerant
Rattlesnake Master	<i>Eryngium yuccifolium</i>	2-5	Full Sun; Does Not Tolerate Standing Water; Unusual Appearance
Sneezeweed	<i>Helenium autumnale</i>	2-4	Full Sun; Moist Soil
Wild Bergamot	<i>Monarda fistulosa</i>	2-3	Full Sun; May Spread
Wild Blue Phlox	<i>Phlox divaricata</i>	1-2	Partial to Full Shade; Not Drought Tolerant
Shrubs and Trees			
American Plum	<i>Prunus americana</i>	8-10	Full Sun to Partial Shade; Early White Flowers; Spreads
Azalea sp.	<i>Azalea sp.</i>	5-8	Open to Shade; Several Kentucky Species
Blackgum	<i>Nyssa sylvatica</i>	30-80	Full Sun to Shade; Great Fall Color
Blackhaw	<i>Viburnum prunifolium</i>	10-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color Varies
Bladdernut	<i>Staphylea trifolia</i>	5-20	Partial to Full Shade; Average to Moist Soil
Carolina Buckthorn	<i>Frangula caroliniana</i>	12-15	Best in Partial Shade
Black and Red Chokeberry	<i>Aronia sp.</i>	3-10	Full Sun to Partial Shade; Fall Color; Fruit

Bio-infiltration Species			
Common Name	Scientific Name	Height (Feet)	Notes
Elderberry	<i>Sambucus canadensis</i>	8-12	Open to Partial Shade; Clusters of White Flowers; Black Fruit
Ironwood	<i>Carpinus carolina</i>	20-30	Full Sun to Shade; Moist, Acidic Soil
Ninebark	<i>Physocarpus opulifolius</i>	5-8	Full Sun to Partial Shade; White Flowers
Roughleaf Dogwood	<i>Cornus drummondii</i>	5-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color
Rusty Blackhaw	<i>Viburnum rifidulum</i>	10-30	Full Sun to Partial Shade; White Flowers and Fall Color
Smooth Sumac	<i>Rhus glabra</i>	5-15	Full Sun; Brilliant Red Fall Color; Plant in Clusters
Spicebush	<i>Lindera benzoin</i>	5-15	Partial to Full Shade; Red Berries
Winged Sumac	<i>Rhus copallina</i>	10-25	Full Sun to Partial Shade

TABLE B-3 – GREEN ROOF SPECIES

Green Roof Species			
Common Name	Scientific Name	Height (Feet)	Notes
Pussytoes	<i>Antennaria plantaginifolia</i>	1	Common in Kentucky; Drought Tolerant
Butterfly Milkweed	<i>Asclepias tuberosa</i>	1-2	Drought Tolerant
Side Oats Grama	<i>Bouteloua curtipendula</i>	1-2	
Purple Prairie Clover	<i>Dalea purpurea</i>	2-3	
Poverty Grass	<i>Danthonia spicata</i>	1	
Bottlebrush Grass	<i>Elymus hystrix</i>	2-3	
Rattlesnake Master	<i>Eryngium yuccifolium</i>	3-4	
Alumroot	<i>Heuchera americana</i>	1-2	
Blazing Star	<i>Liatris sp.</i>	1-3	Several Native Species
Beardstongue	<i>Penstemon hirstutus and laevigatus</i>	2	
Cinquefoil	<i>Potentilla simplex</i>	1	Sprawling
Black-eyed Susan	<i>Rudbeckia hirta</i>	1-2	
Wild Petunia	<i>Ruellia humilis</i>	1-2	
Stonecrop	<i>Sedum sp.</i>	0.5	A Number of Kentucky Species are Available; Two Kentucky Species include <i>S. pulchellum</i> and <i>S. ternatum</i> .
Fameflower	<i>Talinum calycium</i>	0.5-1	
Spiderwort	<i>Tradescantea ohioensis</i>	2	
Birdsfoot Violet	<i>Viola pedata</i>	1	
Glade Violet	<i>Viola eglestonii</i>	0.5	A "Special Concern" Species in Kentucky

TABLE B-4 – PLANTER BOX SPECIES

Planter Box Species			
Common Name	Scientific Name	Height (Feet)	Notes
Forbs			
Bee Balm	<i>Monarda didyma</i>	2-4	Full Sun; Attracts Butterflies; May Spread
Black-eyed Susan	<i>Rudbeckia hirta</i>	2	Full Sun
Blazing Star	<i>Liatris spicata</i>	1-2	Full Sun
Blue False Indigo	<i>Baptisia australis</i>	3-4	Full Sun; Drought Tolerant; Blue Leaf Clusters
Blue Lobelia	<i>Lobelia siphilitica</i>	3-5	Full Sun
Bluestar	<i>Amsonia tabernaemontana</i>	1-2	Sun to Partial Shade
Bundleflower	<i>Desmanthus illinoensis</i>	2-3	Full Sun; Drought Tolerant
Butterfly Milkweed	<i>Asclepia tuberosa</i>	2	Full Sun
Cardinal Flower	<i>Lobelia cardinalis</i>	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
Cream Indigo	<i>Baptisia leucophaea</i>	2-4	Full Sun; Slow Growing
Culvers Root	<i>Veronicastrum virginicum</i>	3-6	Full Sun to Partial Shade; Moist Soil
Downy Sunflower	<i>Helianthus mollis</i>	2-4	Full Sun; Drought Tolerant
Dwarf Larkspur	<i>Delphinium tricorne</i>	1	Full Sun
Gray Headed Coneflower	<i>Ratibida pinnata</i>	3-4	Full Sun; Drought Tolerant
Marsh Milkweed	<i>Asclepias incarnata</i>	2-5	Sun; Moist Soil; Not Drought Tolerant
Mist Flower	<i>Conoclinium coelestinum</i>	2-3	Sun to Partial Shade; Moist Soil
Monkey Flower	<i>Mimulus ringens</i>	1-3	Sun to Partial Shade; Moist Soil; Not Drought Tolerant
New England Aster	<i>Aster novae-angliae</i>	2-4	Sun to Light Shade; Moist to Moderately Well-Drained
Obedient Plant	<i>Physostegia virginiana</i>	2-3	Sun to Light Shade; Moist Soil; May Spread
Orange Coneflower	<i>Rudbeckia fulgida</i>	2-3	Full Sun; May Spread
Prairie Dock	<i>Silphium terebinthenaceum</i>	3-10	Full Sun; Slow Growing; Drought Tolerant
Purple Coneflower	<i>Echinacea purpurea</i>	2-4	Full Sun; Large Flower; Drought Tolerant
Rattlesnake Master	<i>Eryngium yuccifolium</i>	2-5	Full Sun; Does Not Tolerate Standing Water; Unusual Appearance
Sneezeweed	<i>Helenium autumnale</i>	2-4	Full Sun; Moist Soil
Wild Bergamot	<i>Monarda fistulosa</i>	2-3	Full Sun; May Spread
Wild Blue Phlox	<i>Phlox divaricata</i>	1-2	Partial to Full Shade; Not Drought Tolerant
Shrubs and Trees			
American Plum	<i>Prunus americana</i>	8-10	Full Sun to Partial Shade; Early White Flowers; Spreads
Azalea sp.	<i>Azalea sp.</i>	5-8	Open to Shade; Several Kentucky Species
Blackgum	<i>Nyssa sylvatica</i>	30-80	Full Sun to Shade; Great Fall Color
Blackhaw	<i>Viburnum prunifolium</i>	10-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color Varies

Planter Box Species			
Common Name	Scientific Name	Height (Feet)	Notes
Bladdernut	<i>Staphylea trifolia</i>	5-20	Partial to Full Shade; Average to Moist Soil
Bottlebrush Buckeye	<i>Aesculus parviflora</i>	6-12	Open Sun; Large White Blooms
Carolina Buckthorn	<i>Frangula caroliniana</i>	12-15	Best in Partial Shade
Black and Red Chokeberry	<i>Aronia sp.</i>	3-10	Full Sun to Partial Shade; Fall Color; Fruit
Dwarf Red Buckeye	<i>Aesculus pavia</i>	6-8	Open Sun; Red Flowers
Elderberry	<i>Sambucus canadensis</i>	8-12	Open to Partial Shade; Clusters of White Flowers; Black Fruit
Flowering Dogwood	<i>Cornus florida</i>	20-30	Full Sun to Shade but Partial Shade Optimal; Shallow Roots; Early White Flower
Ironwood	<i>Carpinus carolina</i>	20-30	Full Sun to Shade; Moist, Acidic Soil
Ninebark	<i>Physocarpus opulifolius</i>	5-8	Full Sun to Partial Shade; White Flowers
Redbud	<i>Cercis canadensis</i>	20-30	Full Sun to Partial Shade; Early Spring Blooms
Roughleaf Dogwood	<i>Cornus drummondii</i>	5-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color
Rusty Blackhaw	<i>Viburnum rifidulum</i>	10-30	Full Sun to Partial Shade; White Flowers and Fall Color
Smooth Sumac	<i>Rhus glabra</i>	5-15	Full Sun; Brilliant Red Fall Color; Plant in Clusters
Spicebush	<i>Lindera benzoin</i>	5-15	Partial to Full Shade; Red Berries
Winged Sumac	<i>Rhus copallina</i>	10-25	Full Sun to Partial Shade
Yellow-wood	<i>Cladastris lutea</i>	25-50	Full Sun to Partial Shade; Large Clusters of White Flowers

TABLE B-5 – TREE TRENCH SPECIES

Tree Trench Species			
Common Name	Scientific Name	Height (Feet)	Notes
Shrubs and Trees			
American Plum	<i>Prunus americana</i>	8-10	Full Sun to Partial Shade; Early White Flowers; Spreads
Azalea sp.	<i>Azalea sp.</i>	5-8	Open to Shade; Several Kentucky Species
Blackhaw	<i>Viburnum prunifolium</i>	10-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color Varies
Bladdernut	<i>Staphylea trifolia</i>	5-20	Partial to Full Shade; Average to Moist Soil
Bottlebrush Buckeye	<i>Aesculus parviflora</i>	6-12	Open Sun; Large White Blooms
Carolina Buckthorn	<i>Frangula caroliniana</i>	12-15	Best in Partial Shade
Black and Red Chokeberry	<i>Aronia sp.</i>	3-10	Full Sun to Partial Shade; Fall Color; Fruit
Dwarf Red Buckeye	<i>Aesculus pavia</i>	6-8	Open Sun; Red Flowers
Elderberry	<i>Sambucus canadensis</i>	8-12	Open to Partial Shade; Clusters of White Flowers; Black Fruit

Tree Trench Species			
Common Name	Scientific Name	Height (Feet)	Notes
Flowering Dogwood	<i>Cornus florida</i>	20-30	Full Sun to Shade but Partial Shade Optimal; Shallow Roots; Early White Flower
Ironwood	<i>Carpinus carolina</i>	20-30	Full Sun to Shade; Moist, Acidic Soil
Ninebark	<i>Physocarpus opulifolius</i>	5-8	Full Sun to Partial Shade; White Flowers
Redbud	<i>Cercis canadensis</i>	20-30	Full Sun to Partial Shade; Early Spring Blooms
Roughleaf Dogwood	<i>Cornus drummondii</i>	5-15	Full Sun to Partial Shade; Clusters of White Flowers; Fall Color
Rusty Blackhaw	<i>Viburnum rifidulum</i>	10-30	Full Sun to Partial Shade; White Flowers and Fall Color
Smooth Sumac	<i>Rhus glabra</i>	5-15	Full Sun; Brilliant Red Fall Color; Plant in Clusters
Spicebush	<i>Lindera benzoin</i>	5-15	Partial to Full Shade; Red Berries
Winged Sumac	<i>Rhus copallina</i>	10-25	Full Sun to Partial Shade
Yellow-wood	<i>Cladastris lutea</i>	25-50	Full Sun to Partial Shade; Large Clusters of White Flowers

CHAPTER 11
EROSION AND SEDIMENT CONTROL

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11.1 Purpose

This chapter describes requirements for the planning and implementation of non-structural and structural best management practices (BMPs) to be used for erosion and sediment control and good housekeeping during construction activities in Fayette County, Kentucky. Good housekeeping refers to the storage, handling, and use of pollutants in a manner that minimizes or eliminates the potential for discharges into the MS4. Erosion control refers to efforts to maintain soil on a construction site. Sediment control refers to keeping the material that erodes from leaving the site.

Sediment leaving a construction site results in the following adverse impacts to the stream environment:

- Loss of habitat due to decreased light penetration
- Decreases in channel capacity
- Decreases in reservoir storage capacity

Erosion and sediment controls are required to minimize the above impacts. Non-structural practices, which are primarily avoidance practices, and structural practices, which require construction, are described in this chapter. A construction site will require the implementation of both types of practices. Details on the structural practices are given in Sections 11.4 and 11.5 of this manual.

11.1.1 Regulatory Basis

Erosion and sediment control on a construction site is regulated by Chapter 16, Article X, Division 5 of the LFUCG Code of Ordinances. Checklists and other information can be found on the LFUCG stormwater webpage.

Construction sites that disturb one or more acres of land are required to obtain a Commonwealth of Kentucky General Permit for Stormwater Discharges Associated with Construction Activities (KYR10).

11.2 Requirements

This section lists the erosion and sediment control and good housekeeping practice requirements.

11.2.1 Permitting Process

Following is a summary of the permitting process for construction sites as described in the LFUCG Code of Ordinances, Chapter 16, Article X, Division 5.

Site Disturbance less than 5000 square feet

A Land Disturbance Permit is not required for site disturbances less than 5,000 square feet, but the site operator must take reasonable measures to minimize soil erosion. A ten-foot vegetated buffer shall be maintained between the land disturbance activities and the edge of any perennial or intermittent stream, wetland, sinkhole, or municipal storm sewer inlet. If a ten-foot vegetated buffer is not feasible due to the nature or purpose of the activity, a protective alternate erosion control or management practice shall be used.

A Land Disturbance Permit is required for new residential or commercial buildings of any size that are not covered under the KYR10 general permit for the common plan of development. The permit application must be submitted to the Division of Engineering. The permit application is on the LFUCG website.

Site Disturbance between 5,000 square feet and One Acre

A Land Disturbance Permit application must be submitted to the Division of Engineering along with an erosion and sediment control plan for site disturbances between 5,000 square feet and one acre. The permit application and a checklist for preparing the erosion and sediment control plan are on the LFUCG web site. A 50-foot vegetated buffer shall be maintained between the land disturbance activities and the edge of any perennial or intermittent stream, wetland, open throat sinkhole, or municipal storm sewer inlet. Where a 50-foot vegetated buffer is not feasible due to the nature or purpose of the activity, a protective alternate erosion control shall be used as described in the erosion and sediment control plan. In such cases, the permittee shall minimize disturbances in buffer zone areas.

In addition, a Land Disturbance Permit is required for new residential or commercial buildings of any size that are not covered under the KYR10 general permit for the common plan of development. The permit application must be submitted to the Division of Engineering. The permit application is on the LFUCG website.

Site Disturbance of One Acre and Larger

At least 30 days prior to the proposed date of starting construction, the KYR10 Land Disturbance Permit application must be submitted to the Division of Engineering along with a stormwater pollution prevention plan (SWPPP) prepared in accordance with KYR10. The permit application and a checklist for preparing the SWPPP are on the LFUCG website. LFUCG's permit requirements for sites one acre and larger are the same as the state's KYR10 general permit with the following exceptions:

1. The limitations on coverage set out in Part I.C. of KYR10 are not applicable. LFUCG will allow permit coverage under KYR10 for all activities subject to Section 16-104 without regard to whether the Kentucky Division of Water requires coverage under an individual KPDES permit in lieu of KYR10. Alternatively, LFUCG will allow permit coverage to be established under an individual permit issued by the Kentucky Division of Water in lieu of KYR10.
2. A SWPPP shall, in addition to satisfying the requirements of KYR10, contain best management practices ("BMPs") and erosion controls consistent with those described in this manual and LFUCG's Engineering Standard Drawings.
3. Inspection reports prepared for all inspections are not required to be certified by a responsible corporate officer. Inspection reports may be signed by the site operator or the qualified person who conducts the inspection on behalf of the site operator.
4. The requirements for critical areas and buffer zones under KYR10 shall also apply to any municipal storm sewer inlet.
5. The term "as soon as practicable" as used in KYR10 shall mean, for purposes of Section 16-104 and this manual, at the earliest practicable time when external factors beyond the control of the permittee, such as inclement weather, would not prevent completion of the task.

6. Any proposed variances or alternative practices from specific standards that are authorized by KYR10 shall be described in the SWPPP and are subject to review by the Division of Engineering.
7. A SWPPP shall identify any structural water quality control measures that will be retained as part of the post-construction development land use.
8. A SWPPP shall include any special conditions or BMPs required by LFUCG to specifically address streams identified as impaired by sedimentation and/or siltation under Section 303(d) of the Clean Water Act to assure that the discharge is effectively treated to minimize pollution to such impaired water body.
9. A SWPPP shall include any special conditions or BMPs required by the Kentucky Division of Water as KPDES permit conditions to address antidegradation requirements for high quality or exceptional waters.

Linear Utility Line Projects

Utility companies that individually disturb less than one acre of land on a regular basis (more than ten times in a year) must submit an Operational Linear Utility Line erosion control plan to the Division of Engineering. Once approved, the Division of Engineering will issue a Linear Utility Line Land Disturbance General Permit with a duration of 24 months.

In addition, the following shall apply:

- A Land Disturbance Permit application must be submitted to the Division of Engineering along with an erosion and sediment control plan for an individual project that disturbs 500 linear feet or more of unpaved land surface, but less than one acre, if the project is not covered under an Operational Linear Utility Line erosion control plan.
- Individual projects that disturb one or more acres of land must submit a Land Disturbance Permit application to the Division of Engineering.
- Utility work that is part of a new development or redevelopment project that disturbs one or more acres of land will be covered by the developer's KYR10 permit instead of the Linear Utility Line Land Disturbance General Permit.
- An erosion control plan is not required for projects that involve the disturbance of 500 linear feet or more of paved land surface and that immediately places all excavated materials into a truck or other transportable soil containment device.
- A 50-foot vegetated buffer shall be maintained between the land disturbance activities and the edge of any perennial or intermittent stream, wetland, open throat sinkhole, or municipal storm sewer inlet. Where a 50-foot vegetated buffer is not feasible due to the nature or purpose of the activity, a protective alternate erosion control shall be used as described in the linear utility line erosion control plan. In such cases, the permittee shall minimize disturbances in buffer zone areas.

Inspection and Notification Requirements

The permittee shall make regular inspections of all control measures. Regular inspections means at least once every seven calendar days, or at least once every fourteen calendar days and within twenty-four hours after any storm event of one-half-inch or greater. The purpose of such inspections will be to determine the overall effectiveness of the erosion control plan and the need for maintenance and/or additional control measures. Records shall be maintained of each inspection that include:

- The date of the inspection
- The name of the inspector
- The findings from the inspection
- Any actions taken as a result of the inspection

Records shall be kept on site during construction and retained for 180 days following termination of the permit after project completion and shall be available for inspection consistent with subsection 16-207(c).

For Land Disturbance Permits, the permittee shall notify the Division of Engineering and the Division of Water Quality in writing (email, fax, or letter) at least two working days before the start of construction and at least two working days before the completion of soil stabilization.

For utility line projects, the permittee shall notify the Division of Engineering and the Division of Water Quality in writing (email, fax, or letter) at least two working days prior to commencing construction on a project that will result in a disturbance of 500 linear feet or more of existing land surface.

11.2.2 Non-Structural Practices

This section describes the planning and implementation of the required non-structural BMPs to minimize erosion and off-site sedimentation.

These BMPs include:

- Floodplain avoidance
- Stream buffer zones
- Reduced exposure time
- Limits on maximum disturbed area
- Embankment slope minimization
- Good housekeeping measures

Floodplain Avoidance

No construction or grading activities are permitted in the floodplains, as defined in Chapter 1 of this manual, except for road and utility crossings and permanent stormwater management facilities. Therefore, only erosion and sediment control practices related to allowable construction activities shall be permitted in the floodplain. Temporary sediment control in a permanent pond shall be allowed in the floodplain but not in a stream.

Vegetative Buffer Strips

Buffer strips are required adjacent to all streams and wetlands in Fayette County. The buffer strip width shall be 50 feet from the top of each bank and from the edge of a wetland. No grading or land clearing is allowed within the buffer zone, and native vegetation must be preserved.

Reduced Exposure Time

All on-site measures required by the Erosion and Sediment Control Plan shall be made functional before other land disturbance takes place. Permanent or temporary soil stabilization, as described under structural practices, shall be applied to disturbed or constructed areas within 14 days after final grade is reached. Soil stabilization shall also be applied to all disturbed areas not at final grade, including soil stockpiles, dams, dikes, and diversions, which have been inactive for 14 days.

Limits on Maximum Disturbed Area

The maximum area that may be disturbed at any time during construction, without soil stabilization, is 25 acres. For sites over 25 acres in size, additional land can be disturbed only when an equal amount of land is stabilized. A construction site shall not be broken into individual permits to avoid this requirement.

Embankment Slope Minimization

Steep embankment slopes present increased opportunities for erosion and sediment production due to high runoff velocities. To minimize adverse effects of steep embankment slopes, constructed fill slopes and cut slopes shall not be steeper than 3H:1V. For slopes of 4H:1V or steeper with slope lengths of greater than 100 feet, temporary diversion ditches shall be constructed at the top of the slope and every 100 feet horizontally down the slope.

Good Housekeeping Measures

Good housekeeping measures include practices that prevent or minimize the potential for pollutant discharges to the MS4 during construction. Such measures include concrete washouts, waste handling and disposal practices, proper storage of materials (e.g., fuel, oil, paint, fertilizer, other pollutants), spill prevention and cleanup, and other practices to keep pollutants out of the MS4 and surface/ground water.

11.2.3 Structural Practices for Soil Stabilization

This section describes the planning and implementation of the required structural BMPs to minimize erosion and off-site sedimentation through the stabilization of soil materials.

The BMPs include:

- Mulch
- Temporary seed
- Permanent seed
- Sod
- Road/parking stabilization
- Construction entrance
- Dust control
- Nets, Blankets, and Mats
- Gabion mattress
- Temporary diversion ditch
- Level spreader
- Permanent constructed waterway
- Pipe slope drain
- Impact stilling basin

Mulch

Mulch shall be used as a soil stabilization measure for any disturbed area inactive for 14 days or longer. Areas requiring stabilization during December through February shall receive only mulch held in place with bituminous material. Mulching shall be used whenever permanent or temporary seeding is used. The anchoring of mulch shall be in accordance with Figure 11-1 except all mulch placed in December through February shall be anchored with bituminous materials regardless of the slope.

Permanent mulches shall be used in conjunction with planting trees, shrubs, and other ground covers that do not provide adequate soil stabilization.

Temporary Seed

Temporary seeding shall be used for soil stabilization when grades are not ready for permanent seeding, except during December through February. The seed shall be applied within 14 days after grading has stopped. Only rye grain or annual rye grass seed shall be used for temporary seeding. The use of mulch and erosion matting and netting with temporary seeding shall be in accordance with Figure 11-1.

Permanent Seed

Permanent seeding shall be applied within 14 days after final grade has been reached, except during December through February. Permanent seeding shall also be applied on any areas that will not be disturbed again for a year even if final grades have not been reached. The use of mulch and erosion matting and netting with permanent seeding shall be in accordance with Figure 11-1. “Seed mats” may be used for permanent seeding in accordance with manufacturers’ recommendations.

Sod

Sod shall be used for disturbed areas that require immediate vegetative cover, e.g. the area surrounding a drop inlet in a grassed waterway, the design flow perimeter of a grassed waterway that will convey flow before vegetation can be established, and the inlet of a culvert. Sod may be installed throughout the year. “Seed mats” and seed with geotextiles may be used in place of sod when done in accordance with manufacturers’ recommendations.

Road/Parking Stabilization

Gravel or paved material shall be used to stabilize permanent roads or parking areas or roads or parking areas used repeatedly by construction traffic. Stabilization shall be accomplished within 14 days of grading or initiation of use for construction traffic. Unstabilized roads are not acceptable except in instances where the road will be used less than one month.

Construction Entrance

A stabilized construction entrance shall be constructed wherever vehicles are leaving a construction site to enter a public road or at any unpaved entrance/exit location where there is a risk of transporting mud or sediment onto paved roads. A construction entrance shall be constructed at the beginning of the project before construction traffic begins to enter and exit the site.

Dust Control

Dust control measures shall be implemented on all sites.

Nets, Blankets, and Mats

Mulch netting, erosion control blankets and matting, or turf reinforcement matting (TRM) shall be used on sloping areas as indicated in Figure 11-1. Mats or nets and permanent seeding may be used as an alternate to sod for culvert entrances and grassed waterways. TRMs shall be used at the water line to control wave action in wet ponds. TRMs shall be used in accordance with manufacturer's recommendations.

Gabion Mattress

Gabion mattresses shall be used at the outlets of all culverts and storm drains with an exit velocity greater than 5 feet per second when flowing full, except where there are paved ditches. Gabion mattresses shall also be used at the outlet of impact stilling basins.

Temporary Diversion Ditch

Temporary diversion ditches shall be used to collect sediment-laden runoff from disturbed areas and direct it to a sediment pond where applicable. Temporary ditches are those expected to be in use for less than one year. Temporary diversion ditches do not require stabilization.

Level Spreader

Level spreaders shall be constructed at the outlets of temporary diversion ditches. Level spreaders shall also be constructed at outlets of permanent constructed waterways where they terminate on undisturbed areas.

Permanent Constructed Waterway

Permanent constructed waterways shall be used to divert stormwater runoff from upland undisturbed areas around or away from areas to be disturbed during construction. A waterway expected to be in place for at least one year shall be considered permanent. Permanent waterways shall be lined with sod or permanent seeding and nets, mats, or TRMs. Design permanent constructed waterways in accordance with procedures and criteria given in Chapter 8.

Pipe Slope Drain

Pipe slope drains shall be used whenever it is necessary to convey water down a steep slope, which is not stabilized or which is prone to erosion, unless paved ditch (flume) is installed.

Impact Stilling Basin

Impact stilling basins shall be used at the outlet of culverts and storm sewers with calculated exit velocities greater than 15 feet per second when flowing full.

11.2.4 Structural Practices for Sediment Control

This section describes when and where specific structural sediment control practices are required. The design storm for sediment control shall be the 2-year 24-hour storm. The practices include:

- Check dam
- Sediment trap
- Sediment pond
- Silt fence
- Storm drain inlet protection
- Filter strip
- Stream crossing

- Pump-around flow diversion
- Construction dewatering
- Concrete Washout Pits

Check Dam

Check dams shall be installed in newly-constructed, vegetated, open channels, which drain 10 acres or less. Check dams shall be constructed prior to the establishment of vegetation.

Sediment Trap

Sediment traps shall be installed below all disturbed areas of less than 5 acres that do not drain to a sediment pond.

Sediment Pond

A sediment pond shall be installed at the outlet of a disturbed area of 5 acres or more. The maximum drainage area for a single pond is 100 acres. The pond shall be designed to reduce peak discharges during construction to pre-development levels for the 10-year and 100-year storms.

Silt Fence

Silt fence shall be installed down-slope of areas to be disturbed prior to clearing and grading. Silt fence must be situated such that the total area draining to the fence is not greater than one-fourth acre per 100 feet of fence. Silt fence shall be used for storm drain drop inlet protection and around soil stockpiles. Silt fence adjacent to greenways, floodplains, tree protection areas, retention ponds, and streams shall be wire-reinforced silt fence.

Storm Drain Inlet Protection

Storm drain inlet protection shall only be used around drop inlets when the up-slope area draining to the inlet has no other sediment control.

Filter Strip

Filter strips shall be used on each side of permanent constructed channels. The buffer strips described in Section 11.2.2 satisfy the filter strip requirement for streams and wetlands.

Stream Crossing

Stream crossings shall be used in cases where construction traffic, permanent traffic, or utilities must cross existing floodplains. If the drainage area exceeds 1 square mile and a structure is necessary, the structure must be designed by a professional engineer licensed in Kentucky. If applicable, U.S. Army Corps of Engineers and the Kentucky Division of Water permits, as indicated in Chapter 2 of this manual, may be required.

Pump-Around Flow Diversion

A pump-around flow diversion shall be used to divert flow around construction activities occurring in a stream when those activities are reasonably expected to cause the erosion or deposition of sediment in the stream.

Construction Dewatering

Sediment-laden water must be pumped to a dewatering structure before it is discharged off site.

Concrete Washout Pits

Concrete washout pits shall be constructed and maintained by the Developer throughout the home building phase of residential development projects. A minimum of one pit per 40 lots shall be constructed prior to plat recording. The location of washout pits shall be shown on the Stormwater Pollution Prevention Plan and the Erosion and Sediment Control Plan.

11.3 Erosion and Sediment Control Plans (for sites less than one acre)

An erosion and sediment control plan shall be submitted to the Division of Engineering along with a Land Disturbance Permit application for any proposed land disturbance greater than 5,000 square feet and less than 1 acre. In addition, an erosion and sediment control plan shall be submitted to the Division of Engineering along with a Land Disturbance Permit application for a proposed residential or commercial building if the site is not covered under KYR10 as part of the larger common plan of development. For sites one acre and larger, a Stormwater Pollution Prevention Plan must be prepared in accordance with KYR10. The erosion and sediment control plan shall include the items described in the following sub-sections.

11.3.1 Written Description

The erosion and sediment control plan must contain a written description that shall include, at a minimum:

1. A discussion of the land disturbing project including the purpose, location, and size of the area to be disturbed
2. A discussion of the topography, land cover conditions, soils, percent of impervious areas, and drainage patterns both before and after land disturbance
3. An identification of land use and cover conditions of adjacent property
4. A schedule of the work to be conducted including the projected beginning and completion dates of construction activities, and construction sequencing, including clearing, grading, and revegetation activities, as well as any winter shut-downs
5. A listing of erosion and sediment control best management practices, along with location, installation schedule, and the rationale for each use, such as silt fences, diversion ditches, earthen berms, grass strips, or other methods installed in conformance with this manual to prevent, to the maximum extent practicable, sediment from washing into streets, catch basins, storm sewers, grassed open channels, or adjacent seeded or sodded lots
6. A listing of stormwater pollution control and best management practices to minimize pollution during construction (other than erosion) that might result from construction activities
7. A discussion of the permittee's inspection and maintenance activities for erosion and sediment control best management practices

11.3.2 Site Map

The erosion and sediment control plan must contain a site map showing:

- Areas of proposed disturbance
- Locations of proposed controls, utilities, paved areas, and construction entrances
- All perennial or intermittent streams, wetlands, sinkholes, retention basins, retention ponds, culverts, and storm sewer inlets within one hundred feet of the site
- Current topography from field surveys or aerial photography at a scale of 1 inch=50 feet with 2-foot contours showing pre-construction topography, property lines, utilities, limits of construction, and trees to be preserved
- Finished grades, building locations, paved areas, construction entrances, access or haul roads, stockpile areas, and equipment storage areas overlaid on the site topographic map
- Riparian areas and karst features
- All planned BMPs overlaid on the other features
- Areas that are not to be disturbed

11.3.3 Drawings and Specifications

Drawings and specifications of the BMPs shall be included in the BMP plan. For residential subdivision projects, the plans shall include a minimum of four phases of construction: mass grading, pipe installation, roadway construction, and final grade/plat recording.

11.3.4 Design Calculations

All hydrologic, hydraulic, structural, and geotechnical design calculations shall be included in the plan.

11.3.5 O&M Plan

An operation and maintenance (O & M) plan shall be developed which provides a schedule for inspection, maintenance, and repair of BMPs during construction activities. A maintenance schedule shall also be provided to ensure that permanent measures such as vegetation are properly established after construction is complete.

11.3.6 Responsible Parties/Construction Supervisor

The name, address, and telephone number of the parties responsible for implementing the plan shall be included in the plan. The name of the construction supervisor who will be on-site during construction shall be included in the plan.

An on-site construction progress meeting to review erosion prevention and sediment control measures shall be held once the pipe crews have installed the pipe work. The meeting shall be attended by appropriate LFUCG staff, the Engineer, and Contractor.

The construction supervisor shall ensure that orange safety fence is placed around each storm sewer manhole and sanitary sewer manhole prior to plat recording to minimize the risk of accidental damage to the manholes. The safety fence may be removed after permanent seeding and sodding has been completed.

11.3.7 Education/Training

The education and training requirements for implementation of the plan shall be accomplished by the Engineer, who shall provide for initial training and continuing education for all construction employees and subcontractors of the contractor to inform them of the plan requirements. As work progresses and various subcontractors and/or new employees are brought onto the work site, each should be familiarized by the Engineer with the plan. At the beginning of each workweek, scheduled items of the plan to be implemented during that week should be brought to the attention of the impacted work force.

11.4 Structural Soil Stabilization BMPs

11.4.1 *Mulch*

Spreading mulch is a temporary soil stabilization or erosion control practice where materials such as straw, wood chips, wood fibers, or rock are placed on the soil surface. Mulching prevents erosion by protecting the soil surface from raindrop impact and by reducing the velocity of overland flow. Mulch can also be used for dust control.

When used with temporary or permanent seeding, mulch can aid in plant growth by holding the seeds, fertilizers, and topsoil in place, by helping to retain moisture, and by insulating against extreme temperatures. Mulch can also improve the aesthetics of the site. Organic mulch materials such as straw, wood chips, bark, recycled paper, and wood fiber are the most effective mulches.

Design Criteria

Straw is the mulch most commonly used in conjunction with seeding. The recommended straw should come from wheat, rye, or barley and may be spread by hand or machine. Straw shall be anchored.

Wood chips are suitable for areas that will not be closely mowed, and around ornamental plantings. Chips decompose slowly and do not require tacking. Wood chips should be treated with 12 pounds slow-release nitrogen per ton to prevent nutrient deficiency in plants.

Bark chips and shredded bark are used in landscaped plantings. Bark is also suitable mulch for areas planted to grasses and not closely mowed. Bark is not usually toxic to grasses or legumes, and additional nitrogen fertilizer is not required.

Manufactured wood fiber and recycled paper sold as mulch materials are usually marketed to apply in a hydroseeder slurry with binder/tackifiers. Manufacturer's recommendations shall be followed during application.

A wide range of synthetic, spray-on materials is marketed to stabilize and protect the soil surface. These are emulsions or dispersions of vinyl compounds, asphalt, rubber, or other substances that are mixed with water and applied to the soil. They may be used to tack wood fiber hydromulches or straw, and they usually decompose in 60 to 90 days.

A variety of mulch nets and mats are available to use as mulching or to hold mulch in place. Netting and mats shall be used in critical areas such as waterways where concentrated flows are expected. Netting can help retain soil moisture or modify temperature. It stabilizes the soil surface while grasses are being established and is particularly useful in grassed waterways and on slopes. Lightweight netting may also be used to hold other mulches in place. Netting and erosion control mats shall be used in accordance with Figure 11-1.

Gravel or crushed stone can be used to provide a long-term protection against erosion, particularly on short slopes. Before the gravel or crushed stone is applied, it should be washed. Aggregate cover shall only be used in relatively small areas and shall be incorporated into an overall landscaping plan.

Material Specifications

Straw shall be applied at two tons per acre or 90 pounds per 1,000 square feet. Straw shall be free from weeds and coarse matter.

Wood chips shall be applied at 40 cubic yards per acre or 1 cubic yard per 1,000 square feet and approximately 2 inches deep. Wood chips shall be treated with 20 pounds of nitrogen per acre.

Recycled paper (newsprint) or wood fiber shall be mixed at 50 pounds per 100 gallons of water and applied according to manufacturer's recommendations and model of hydroseeder in use.

Bark chips or shredded bark shall be applied at 70 cubic yards per acre or 1.5 to 2 cubic yards per 1,000 square feet and about one-half inch thick.

Liquid mulch binders/tackifiers may be asphalt, synthetic, or wood fiber slurries applied according to manufacturer's recommendations.

Chemical soil stabilizers or soil binders/tackifiers/emulsions shall not be used alone. These materials are useful to bind organic mulches together.

Construction Specifications

Seed shall be applied prior to mulching except where seed is to be applied as part of a hydroseeder slurry containing mulch.

Lime and fertilizer shall be incorporated and surface roughening accomplished as needed prior to mulching in accordance with applicable sections of this manual.

Mulch materials shall be spread uniformly by hand or machine.

Mulch shall be anchored during or immediately after spreading to prevent being blown by the wind. Mulch may be anchored using a mulch anchoring tool, a liquid binder/tackifier, or mulch nettings. Nets and mats shall be installed to obtain firm, continuous contact between the material and the soil. Without such contact, the material is useless and erosion occurs.

A mulch anchoring tool is a tractor-drawn implement that is typically used for anchoring straw and is designed to punch mulch approximately two inches into the soil surface. Machinery shall be operated on the contour and shall not be used on slopes steeper than 3H:1V.

When using liquid mulch binders and tackifiers, application shall be heaviest around edges of areas and at crests of ridges and banks to prevent wind blow. Remainder of area shall have binders/tackifiers spread uniformly in accordance with manufacturer's recommendations.

When using a mulch net, it shall be used in conjunction with an organic mulch and shall be installed immediately after the application and spreading of the mulch. Mulch net shall be installed over the mulch except when the mulch manufacturer recommends otherwise.

Excelsior blankets and mats with mulch are considered protective mulches and may be used alone on erodible soils and during all times of year. Erosion control mats shall be installed in accordance with manufacturer's recommendations.

Maintenance

Mulched areas shall be inspected at least weekly and after every rainfall of one-half inch or more. When mulch material is found to be loosened or removed, the mulch cover shall be replaced within 48 hours.

11.4.2 *Temporary Seed*

Temporary seeding stabilizes disturbed areas by the establishment of a temporary vegetative cover of rapidly growing plants on disturbed areas that are not at final grade. Temporary seeding reduces problems associated with mud or dust from bare soil surfaces during construction, reduces erosion and sediment runoff to downstream areas and/or groundwater basins, and improves the visual appearance of the construction area.

Seed, fertilizer, and mulch specifications are listed in the KY Erosion Prevention and Sediment Control Field Guide.

Construction Specifications

The site shall be graded as needed to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and anchoring.

The needed erosion control practices shall be installed prior to seeding such as diversions, temporary waterways for diversion outlets, and sediment ponds.

Prior to seeding, work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or similar tools to a depth of two inches. On sloping areas, the final operation shall be on the contour.

The seed shall be applied uniformly with a cyclone seeder, drill, cultipacker, seeder, or hydroseeder (slurry may include seed and fertilizer) preferably on a firm, moist seedbed. Seed no deeper than one-fourth inch to one-half inch.

When feasible, except where a cultipacker type seeder is used, the seedbed shall be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land, seeding operations shall be on the contour wherever possible.

Mulch shall be applied, in the amounts described in the mulch practice in this chapter, to protect the soil and provide a better environment for plant growth.

The mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. Following application, the mulch shall be anchored or otherwise secured to the ground according to one of the following methods:

- Mechanical – Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil.
- Mulch Tackifiers/Nettings/Emulsions – Use according to the manufacturer’s recommendations. This is a superior method in areas of water concentration to hold mulch in place.
- Wood Fiber – Wood fiber hydroseeder slurries may be used to tack straw mulch. This combination treatment is well suited to steep slopes and critical areas, and severe climate conditions.

For more information on mulch application see Section 11.4.1– Mulch.

Maintenance

New seed shall have adequate water for growth, through either natural means or irrigation, until plants are firmly established.

Seeded areas shall be inspected every two weeks after planting and after each rainfall of 0.5 inches or more. Areas requiring additional seed and mulch shall be repaired within 48 hours. If vegetative cover is not established within 21 days, the area shall be reseeded.

11.4.3 Permanent Seed

Permanent seeding is the stabilization of disturbed areas with the establishment of permanent vegetation by planting seed. The primary purpose of permanent seeding is to permanently stabilize disturbed areas in a manner that is economical, adaptable to site conditions, and allows selection of the most appropriate plant materials. Permanent seeding also reduces the erosion and sediment yield from disturbed areas while the vegetation is becoming established.

Design Criteria

Permanent seeding shall be used on disturbed areas where permanent, long-lived vegetative cover is needed to stabilize the soil and on rough graded areas that will not be brought to final grade for one year or more.

The area to be seeded shall be protected from excess runoff as necessary with diversions, grassed waterways, terraces, or sediment ponds.

Plant species shall be selected on the basis of timing of establishment, planned use of the area, and the amount or degree of maintenance that can be devoted to the area in the future.

Vegetative cover alone shall not be used to provide erosion control cover and prevent soil slippage on a soil that is not stable due to its structure, water movement, or excessive slope.

Material Specifications

Seed shall be applied in a mixture based upon the season and ultimate use of the site. Erosion and sediment control plans submitted to LFUCG shall include seed mixtures, rates, and planting dates selected for permanent seeding. Permanent seeding may be done at any time except December through February. Seed, fertilizer, and mulch specifications are listed in the KY Erosion Prevention and Sediment Control Field Guide.

Soil material shall be capable of supporting permanent vegetation and have at least 25 percent silt and clay to provide an adequate amount of moisture holding capacity. An excessive amount of sand will not consistently provide sufficient moisture for good growth regardless of other soil factors.

Construction Specifications

During site preparation, topsoil shall be stockpiled for use in establishing permanent vegetation.

The site shall be graded as needed to permit the use of conventional equipment for seedbed preparation, seeding, mulch application, and anchoring.

The needed erosion control practices shall be installed prior to seeding such as diversions, temporary waterways for diversion outlets, and sediment ponds.

Prior to seeding, work the lime and fertilizer into the soil with a disk harrow, springtooth harrow, or similar tools to a depth of four inches. On sloping areas, the final operation shall be on the contour.

Where compacted soils occur, they should be broken up sufficiently to create a favorable rooting depth of six to eight inches.

The seed shall be applied uniformly with a cyclone seeder, drill, cultipacker, seeder, or hydroseeder (slurry may include seed and fertilizer) preferably on a firm, moist seedbed. Seed no deeper than one-fourth inch to one-half inch.

When feasible, except where a cultipacker type seeder is used, the seedbed shall be firmed following seeding operations with a cultipacker, roller, or light drag.

On sloping land, seeding operations shall be on the contour wherever possible.

Mulch shall be applied to protect the soil and provide a better environment for plant growth.

The mulch shall be spread uniformly by hand or mechanically so the soil surface is covered. Following application, the mulch shall be anchored or otherwise secured to the ground according to one of the following methods:

- **Mechanical** – Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil.
- **Mulch** Tackifiers/Nettings/Emulsions – Use according to the manufacturer’s recommendations. This is a superior method in areas of water concentration to hold mulch in place.
- **Wood Fiber** – Wood fiber hydroseeder slurries may be used to tack straw mulch. This combination treatment is well suited to steep slopes and critical areas, and severe climate conditions.

For more detailed information on mulch application, see Section 11.4.1- Mulch.

Maintenance

New seed shall have adequate water for growth, through either natural means or irrigation, until plants are firmly established.

Seeded areas shall be inspected every two weeks after planting and after each rainfall of 0.5 inches or more. Areas requiring additional seed and mulch shall be repaired within 48 hours. If vegetative cover is not established within 21 days, the area shall be reseeded. If less than 70 percent groundcover is established, seed and fertilize, using half of rates originally applied, and mulch. If less than 40 percent groundcover occurs, follow original seedbed

preparation methods, seeding and mulching recommendations, and apply lime and fertilizer as needed according to soil tests.

11.4.4 Sod

Sod is used to stabilize fine-graded disturbed areas by establishing permanent grass stands. Sod has several purposes or applications including:

- Establishment of permanent turf immediately
- Prevention of erosion and damage from sediment and runoff by stabilization of the soil surface
- Reduction of dust and mud associated with bare soil surfaces
- Stabilization of drainageways where concentrated overland flow will occur

Design Criteria

Sodding shall be used for disturbed areas that require immediate vegetative cover. Locations particularly suited to stabilization with sod include waterways carrying intermittent flow and the area around drop inlets in grassed waterways.

The species of sod selected shall be based on soil type, planned use of the area, and the amount of maintenance that can be devoted to the area in the future.

Sod shall not be used to provide erosion control and prevent soil slippage on a soil that is not stable due to its structure, water movement, or excessive slope.

Sod shall be installed within 36 hours of digging and removal from the field. Sod should not be used on slopes steeper than 2H:1V. If it is to be mowed, installation should be on slopes no greater than 3H:1V.

Material Specifications

Soil material shall be capable of supporting permanent vegetation and shall consist of at least 25 percent silt and clay to provide an adequate amount of moisture holding capacity. An excessive amount of sand will not consistently provide sufficient moisture for the sod regardless of other soil factors.

Fertilizer shall be applied at a rate of 1,000 pounds per acre of 10-10-10 analysis or equivalent, unless soil test results indicate a different rate is appropriate. Lime shall be applied at a rate of 100 pounds per 1,000 square feet or two tons per acre of agricultural ground limestone, unless soil test results indicate differently.

The sod shall consist of strips of live, vigorously growing grasses. The sod shall be free of noxious and secondary noxious weeds and shall be obtained from good, solid, thick-growing stands. The sod shall be cut and transferred to the job in the largest continuous pieces that will hold together and are practical to handle.

The sod shall be cut with smooth clean edges and square ends to facilitate laying and fitting. The sod shall be cut to a uniform thickness of not less than three-fourth inch measured from the crown of the plants to the bottom of the sod strips for all grasses except bluegrass. Bluegrass sod shall be cut to a uniform thickness of not less than one and one-half inches.

The sod shall be mowed to a height of not less than two inches and no more than four inches prior to cutting.

The sod shall be kept moist and covered during hauling and preparation for placement on the sodbed.

Construction Specifications

The area to be sodded shall be protected from excess runoff, as necessary, with appropriate BMPs.

Lime and fertilizer shall be worked into the soil with a disk harrow, springtooth harrow, or other suitable field equipment to a depth of four inches.

Prior to sodding, the soil surface shall be cleared of all trash, debris, and stones larger than one and one-half inches in diameter, and of all roots, brush, wire, and other objects that would interfere with the placing of the sod.

Compacted soils must be broken up sufficiently to create a favorable rooting depth of six to eight inches.

After the lime and fertilizer have been applied and just prior to the laying of the sod, the soil in the area to be sodded shall be loosened to a depth of one inch. The soil shall be thoroughly dampened immediately after the sod is laid if it is not already in a moist condition.

No sod shall be placed when the temperature is below 32°F. No frozen sod shall be placed nor shall any sod be placed on frozen soil.

When sod is placed during the periods of June 15 to September 1 or October 15 to March 1, it shall be covered immediately with a uniform layer of straw mulch approximately one-half inch thick or so the green sod is barely visible through the mulch.

Sod shall be carefully placed and pressed together so it will be continuous without any voids between the pieces. Joints between the ends of strips shall be staggered.

On gutter and channel sodding, the sod should be carefully placed on rows or strips at right angles to the centerline of the channel (i.e., at right angles to the direction of flow). The edge of the sod at the outer edges of all gutters shall be sufficiently deep so that surface water will flow over onto the top of the sod.

On steep graded channels, each strip of sod shall be staked with at least two stakes not more than 18 inches apart.

Sod shall be tamped or rolled after placing and then watered. Watering shall consist of a thorough soaking of the sod and of the sodbed to a depth of at least 4 inches. The sod should be maintained in a moist condition by watering for a period of 30 days.

On slopes 3H:1V or steeper, or where drainage into a sod gutter or channel is one-half acre or larger, the sod shall be rolled or tamped and then chicken wire, jute, or other netting pegged over the sod for protection in the critical areas. The netting and sod shall be staked with at least two stakes not more than 18 inches apart. The netting shall be stapled on the side of each stake within two inches of the top of the stake. The stake should then be driven flush with the top of the sod.

When stakes are required, the stakes shall be wood and shall be approximately ½ inch by ¾ inch by 12 inches. They shall be driven flush with the top of the sod with the flat side against the slope and on an angle toward the slope.

Maintenance

In the absence of adequate rainfall, watering shall be performed daily or as often as necessary during the first week to maintain moist soil to a depth of 4 inches. Watering shall be done during the heat of the day to prevent wilting. After the first week, sod shall be watered as necessary to maintain adequate moisture content.

The first mowing of sod shall not be attempted until the sod is firmly rooted. No more than one-third of the grass leaf shall be removed by the initial and subsequent cuttings. Grass height shall be maintained between 2 inches and 3 inches.

Where sod does not establish properly, the sod should be replaced immediately. Areas requiring resodding should be prepared in the same manner as the original installation.

11.4.5 Road/Parking Stabilization

Road/parking stabilization refers to the stabilization of access roads, subdivision roads, parking areas, and other on-site vehicle routes with stone immediately after grading. The primary purpose of road/parking stabilization is to reduce erosion from roadbeds caused by construction traffic during wet weather. Stabilization also reduces regrading needed for permanent roadbeds by reducing erosion between the time of initial grading and final stabilization.

Design Criteria

Road/parking stabilization shall be used wherever roads or parking areas are constructed, whether permanent or temporary, for use by construction traffic.

Stabilization shall be accomplished with a minimum depth of six inches of crushed stone. Stabilized construction roadbeds shall be at least 14 feet wide for one-way traffic and at least 20 feet wide for two-way traffic. Figure 11-2 illustrates road/parking stabilization.

Temporary roads shall follow the contour of the natural terrain to the extent possible. Slopes shall not exceed 10 percent.

Temporary parking areas shall be located on naturally flat areas to minimize grading. Grades shall be sufficient to provide drainage but shall not exceed 4 percent.

All cuts and fills shall be 2H:1V or flatter.

Drainage ditches shall be provided as needed.

Material Specifications

Crushed stone shall be KYTC aggregate No. 2 (1.5 to 3 inches in diameter), or equivalent.

Construction Specifications

The roadbed or parking surface shall be cleared of all vegetation, roots, and other objectionable material.

All roadside ditches, cuts, fills, and disturbed areas adjacent to parking areas and roads shall be stabilized with appropriate temporary or permanent vegetation according to the applicable standards and specifications contained in this manual.

Geotextile filter fabric may be applied beneath the stone for additional stability in accordance with fabric manufacturer's specifications.

Both temporary and permanent roads and parking areas may require periodic top dressing with new gravel. Seeded areas adjacent to the roads and parking areas shall be checked regularly to ensure that a vigorous stand of vegetation is maintained. Roadside ditches and other drainage structures shall be checked once each week to ensure that they do not have silt or other debris that reduces their effectiveness.

11.4.6 Construction Entrance

A stabilized construction entrance is a portion of the construction road that is constructed with filter fabric and large stone. The primary purpose of a stabilized construction entrance is to reduce the amount of soil tracked off of the construction site by vehicles leaving the site. The stabilized entrance will also reduce erosion and rutting on that portion of the road where it is installed.

Design Criteria

A stabilized construction entrance shall be constructed in the following locations:

- Wherever vehicles are leaving a construction site and enter onto a public road
- At any unpaved entrance/exit location where there is risk of transporting mud or sediment onto paved roads

A stabilized construction entrance shall be constructed of crushed stone a minimum of 6 inches thick laid over geotextile (filter fabric).

The width shall be at least 20 feet and as wide as the entire width of the access. At sites where traffic volume is high, the entrance shall be wide enough for two vehicles to pass safely. The length shall be at least 100 feet, but may be reduced to 50 feet where site conditions do not allow a longer length. The entrance shall be flared where

it meets the existing road to provide a turning radius. A standard drawing for a stabilized construction entrance is provided in Figure 11-3, with notes provided in Figure 11-4.

Stormwater and wash water runoff from a stabilized construction entrance shall drain to a sediment trap or sediment pond. If conditions on the site are such that the majority of the mud is not removed by the vehicles traveling over the gravel, then the tires of the vehicles shall be washed before entering a public road.

Pipe placed under the entrance to handle runoff shall be protected with a mountable berm.

Dust control shall be provided in accordance with Section 11.2.3 and 11.4.7.

Material Specifications

Crushed stone shall be KYTC aggregate No. 2 (1.5 to 3 inches in diameter), or equivalent.

Geotextile filter fabric shall be KYTC Type III.

Construction Specifications

Vegetation, roots, and all other obstructions shall be cleared in preparation for grading. Prior to placing geotextile (filter fabric), the entrance shall be graded and compacted to 80% of standard proctor density.

To reduce maintenance and loss of aggregate, the geotextile shall be placed over the existing ground before placing the stone for the entrance. Stone shall be placed to depth of 6 inches or greater for the entire width and length of the stabilized construction entrance.

If wash racks are used, they shall be installed according to manufacturer's specifications.

Maintenance

The stabilized construction entrance shall be inspected once each week and after there has been a high volume of traffic or a storm event greater than 0.5 inches.

The entrance shall be maintained in a condition that will prevent tracking or flow of sediments onto public rights-of-way. This may require periodic top dressing with additional stone, as conditions demand, and repair and/or cleanout of any structures used to trap sediment.

All materials spilled, dropped, washed, or tracked from vehicles onto roadways or into storm drains must be removed immediately.

11.4.7 Dust Control

Dust control is the reducing of surface and air movement of dust during land disturbing, demolition and other construction activities. The purpose of dust control is to prevent the air movement of sediments to off-site areas or other on-site areas without sediment control where they could subsequently be washed into surface waters. Dust control shall be planned in association with earthmoving/site grading activities and areas with frequent construction traffic.

Design Criteria

Construction activities shall be phased to minimize the total area unstabilized at any given time, thereby reducing erosion due to air and water movement. Plans submitted to LFUCG shall illustrate construction phasing and describe dust and erosion control measures to be implemented at each phase.

Construction roads shall be watered as needed to minimize dust.

Existing trees, shrubs, and ground cover shall be retained as long as possible during the construction. Initial land clearing should be conducted only in those areas to be regraded or where construction is to occur. Areas to be cleared only for new vegetation or landscaping shall be stabilized with seed and mulch immediately following clearing.

Vegetative cover is the most effective means of dust and erosion control, when appropriate. See sections on Temporary Seed, Permanent Seed, Mulch, and Sod in this manual.

When areas have been regraded and brought to final grade, they shall be stabilized using temporary or permanent seed and mulch or other measures.

Mulch with mulch binders may be used as an interim dust control measure in areas where vegetation may not be appropriate.

Material Specifications

See sections on Temporary Seed, Permanent Seed, Sod, Mulch, Construction Road/Parking Stabilization, and Construction Entrance.

Construction Specifications

See sections referenced in Material Specifications above.

When construction is active on the site, dust control shall be implemented as needed.

When using tillage as a dust control measure, begin plowing on windward side of area. Chisel-type plows spaced about 12 inches apart, spring-toothed harrow, and similar plows are examples of equipment that may produce the desired effect.

Maintenance

The site shall be observed daily for evidence of windblown dust and reasonable steps shall be taken to reduce dust whenever possible. When construction on a site is inactive for a period, the site shall be inspected at least weekly for evidence of dust emissions or previously windblown sediments. Dust control measures must be implemented or upgraded if the site inspection shows evidence of wind erosion.

11.4.8 *Nets, Blankets, and Mats*

Mulch netting, erosion control blankets and matting, and turf reinforcement matting (TRM) make up a group of materials that are used to stabilize mulch and soil in order to prevent erosion and aid in the establishment of vegetative cover.

Some mats and TRMs are manufactured by weaving or bonding fibers made from synthetic materials such as polypropylene, polyester, polyethylene, nylon, polyvinyl chloride, glass, and various mixtures of these. These materials are intended to be longer lasting or even permanent in certain applications.

Some nets and mats are formed of biodegradable materials such as jute, coconut, or other wood fibers that have been formed into sheets of mulch that are more stable than loose mulch. Netting is typically made from jute, other wood fiber, plastic, paper, or cotton and can be used to hold the mulching and matting to the ground. Netting can also be used alone to stabilize soils while the plants are growing; however, it does not retain moisture or temperature well.

Design Criteria

Erosion control blankets and matting can be used to stabilize channels and swales and on recently planted slopes to protect seedlings until they become established. Refer to Figure 11-1 for guidance on using matting on slopes. See Chapter 8 for additional information on stabilizing vegetated channels. Additional guidance on the use of nets, mats, and blankets can be found in the Kentucky Construction BMP Technical Manual.

Effective netting and matting require firm, continuous contact between the materials and the soil. If there is no contact, the material will not hold the soil and erosion will occur underneath the material.

Material Specifications

Nets and mats shall be suitable for their intended purpose. With the wide variety of materials available, the product used should be determined by the designer according to its application.

Construction Specifications

Nets and mats shall be installed according to the manufacturer's recommendations. In the event that the manufacturer's recommendations conflict with any requirement of this manual, the most conservative requirement, in terms of protection of public health and the environment, shall govern. See Figure 11-5 for details on placement of straw or mats. See Figures 11-6 and 11-7 for details regarding placement of TRMs.

11.4.9 Gabion Mattress

Gabion mattresses are acceptable when used as water energy dissipating devices placed at the outlets of pipes or paved channel sections. Gabion mattresses are also known as reno mattresses. The purpose of gabion mattresses is to prevent scour at stormwater outlets and to minimize the potential for downstream erosion by reducing the velocity of concentrated stormwater flows.

Design Criteria

Gabion mattresses shall be used at the outlets of all pipes, box culverts, stilling basins, and paved ditch sections.

For outlets of 36 inches (width or diameter) or less, the length of the gabion mattress shall be 12 feet. For outlets greater than 36 inches, the gabion mattress length shall be 4 times the width or height of the outlet, whichever is greater. See Figure 11-8.

If the pipe discharges directly into a well-defined channel, the mattress shall extend across the channel bottom and up the channel banks to an elevation 1 foot above the maximum tailwater depth or to the top of the bank (whichever is less). See Figure 11-9. The side slopes of the channel shall not be steeper than 2:1 (Horizontal:Vertical).

If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be in accordance with Figures 11-10 and 11-11.

The mattress shall be constructed with no slope along its length (0.0 percent grade). The invert elevation of the downstream end of the mattress shall be equal to the invert elevation of the receiving channel. There shall be no overfall at the end of the mattress.

Where the outlet structure is supported by a concrete foundation, the first 3 feet of the mattress shall extend the depth of the foundation. See Figure 11-8.

For calculated outlet velocities of 5 to 10 feet per second when flowing full, the depth of the gabion mattress shall be at least 12 inches.

For calculated outlet velocities of greater than 10 feet per second when flowing full, the depth of the gabion mattress shall be at least 18 inches, except when an impact stilling basin is used. In that instance, a minimum depth of 12 inches is required.

When the mattress is placed on grades of 5% or greater, #8 reinforcing bar anchors at 18 inches on centers shall be installed.

Gabion mattresses shall be secured together in accordance with manufacturer's recommendations.

The mattress shall be located so that there are no bends in the horizontal alignment.

For paved channel outlets, the end of the paved channel shall merge smoothly with the gabion mattress in the receiving channel section. There shall be no overfall at the end of the paved section.

Where the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a paved transition section shall be provided.

Material Specifications

The gabion mattress shall be manufactured from galvanized wire with a minimum tensile strength of 40,000 psi.

The stone to be used shall be quarry run crushed limestone 3-6 inches in size.

Filter fabric placed below the gabion mattress shall have the minimum material specifications of the geotextile described in the material specifications for a construction entrance.

Construction Specifications

The subgrade for the mattress shall be prepared to the required lines and grades. Any fill required in the subgrade shall be compacted to a density approximately that of the surrounding undisturbed material. Brush, trees, stumps, and other objectionable material shall be removed.

Placement of the mattress and the fill rock shall follow immediately after subgrade preparation and be in accordance with methods recommended by the manufacturer.

The anchors shall be 3 feet long and driven or pushed into the subgrade. Where rock is encountered, the anchors shall be cut off even with the mattress.

Filter fabric shall be placed between the mattress and the subgrade.

Maintenance

Outlets shall be inspected at least weekly during the construction process and after every storm of one-half inch or more. If the mattress is damaged or displaced, it shall be repaired immediately.

11.4.10 Temporary Diversion Ditch

A temporary diversion ditch is an earth channel with a supporting ridge or berm on the lower side constructed across the slope. See Figure 11-12 for an illustration. Temporary diversion ditches usually have a life expectancy of one year or less with a low failure hazard. Permanent diversions are called permanent constructed waterways and shall be designed in accordance with requirements in Chapter 8. Diversions can be constructed for various purposes including:

- To divert storm runoff away from unprotected slopes to a stabilized outlet
- To divert sediment-laden runoff from a disturbed area to a sediment pond,
- To shorten the flow length within a long, sloping drainage area

Design Criteria

Temporary diversion ditches must have stable outlets. The combination of conditions of site, slopes, and soils should be so that the ditch can be maintained throughout its planned life.

Temporary diversion ditches shall not be constructed below high sediment-producing areas unless land treatment practices or structural measures, designed to prevent damaging accumulations of sediment in the channels, are installed with or before the diversion.

Temporary diversion ditches shall be designed for the 10-year, 24-hour storm in accordance with methods given in the next section for permanent constructed channels.

A typical diversion cross section consists of a channel and a supporting ridge. In the case of an excavated-type diversion, the natural ground serves as the diversion ridge. Diversion cross sections must be adapted to the equipment that will be used for their construction and maintenance.

The channel may be parabolic or trapezoidal in shape. V-shaped ditches shall not be constructed.

A diversion's location will be dictated by outlet condition, topography, land use, soil type, and length of slope. Diversions must be located so that water will empty onto an established area such as a stable watercourse, waterway, or structure.

The channel grade for diversions may be uniform or variable. The permissible velocity for the soil type and vegetative cover will determine the maximum grade. The grade should be such as to minimize standing water and wetness problems.

Level diversions with blocked ends may be used when an adequate underground outlet is provided.

Any high sediment-producing area above a diversion should be controlled by good land use management or by structural measures to prevent excessive sediment accumulation in the diversion channel. If movement of sediment into the diversion channel cannot be controlled, one of the following measures should be used:

Design the channel to include extra capacity for the storage of sediment, keep the velocity of flow for the design storm greater than 1.5 feet per second, and provide for clean out of the diversion channel when the sediment storage capacity has been depleted.

Provide a minimum 15-foot wide filter strip of close-growing sod adjacent to the diversion channel and remove excessive accumulations of sediment to maintain a vigorous growth.

Temporary diversions above steep slopes or across graded rights-of-way shall have a berm with a minimum top width of 2 feet, side slopes of 2:1 or flatter and a minimum height of 18 inches measured from the channel bottom.

Diversions installed to intercept flow on graded rights-of-way shall be spaced 200 to 300 feet apart.

A level lip spreader shall be used at diversion outlets discharging onto areas already stabilized by vegetation.

Construction Specifications

All dead furrows, ditches or other depressions to be crossed shall be filled before construction begins or as part of construction, and the earth fill used to fill the depressions will be compacted using the treads of the construction equipment. All old terraces, fencerows, or other obstructions that will interfere with the successful operation of the diversion shall be removed.

The base for the diversion ridge is to be prepared so that a good bond is obtained between the original ground and the fill material. Vegetation is to be removed and the base thoroughly disked prior to placement of fill.

The earth materials used to construct the earth fill portions of the diversions shall be obtained from the diversion channel or other approved source.

The earth fill materials used to construct diversions shall be compacted by running the construction equipment over the fill in such a manner that the entire surface of the fill will be traversed by not less than one tread track of the equipment.

When an excess of earth material results from cutting the channel cross section and grade, it shall be deposited adjacent to the supporting ridge unless otherwise directed.

The completed diversion shall conform to the cross section and grade shown on the design.

Temporary or permanent seeding and mulch must be applied to the berm or ditch immediately following its construction. Triple-seed areas below the flow line, and use erosion control blankets or turf reinforcement mats as needed.

Maintenance

Bare and vegetated diversion channels shall be inspected regularly to check for points of scour or bank failure; rubbish or channel obstruction; rodent holes, breaching, or settling of the ridge; and excessive wear from pedestrian or construction traffic.

Damaged channels or ridges shall be repaired at the time damage is detected. Sediment deposits shall be removed from diversion channels and adjoining vegetative filter strips regularly.

Diversions shall be reseeded and fertilized as needed to establish vegetative cover.

11.4.11 Level Spreader

Level spreaders are storm flow outlet devices constructed at zero grade across the slope whereby concentrated runoff may be discharged at non-erosive velocities onto undisturbed areas stabilized by existing vegetation. A level spreader is illustrated in Figure 11-13.

Level spreaders dissipate storm flow energy at the outlet by converting storm runoff into sheet flow and discharging it onto areas stabilized by existing vegetation without causing erosion.

Level spreaders are used at diversion outlets and other locations where sediment free storm runoff is intercepted and diverted from graded areas onto undisturbed stabilized areas. The practice applies only in those situations where the spreader can be constructed on undisturbed soil and where the area directly below the level spreader is stabilized by existing vegetation. The water must not be allowed to reconcentrate below the point of discharge.

Design Criteria

The length of the level spreader shall be based on the peak flow from the 100-year storm in accordance with the following table.

100-year Peak Flow (cfs)	Minimum Length (ft)
Up to 10	15
11 to 20	20
21 to 30	30
31 to 40	40
41 to 50	50

Construction Specifications

The minimum acceptable width shall be 6 feet. The depth of the level spreader as measured from the lip shall be at least 6 inches and the depth shall be uniform across the entire length of the measure.

The grade of the channel for the last 15 feet entering the level spreader shall be less than or equal to 1%.

The level lip of the spreader shall be constructed on zero percent grade to insure uniform conversion of channel flow to sheet flow.

Level spreaders shall be constructed on undisturbed soil.

The entrance to the spreader shall be graded in a manner to insure that runoff enters directly onto the zero percent graded channel.

Storm runoff converted to sheet flow shall discharge onto undisturbed areas stabilized with vegetation. All disturbed areas shall be stabilized immediately after construction is completed in accordance with the mulching and vegetation requirements of this manual.

Maintenance

The level spreader shall be inspected after each storm event and at least once each week. Any observed damage shall be repaired immediately.

11.4.12 Pipe Slope Drains

Pipe slope drains are made of flexible pipe and reduce the risk of erosion on slopes by discharging runoff to stabilized areas. See Figures 11-14 and 11-15. They carry concentrated runoff from the top to the bottom of a slope that has already been damaged by erosion or is at high risk for erosion. They are also used to drain saturated slopes that have the potential for soil slides. Pipe slope drains can be either temporary or permanent depending on the method of installation and material used.

Pipe slope drains shall be used whenever it is necessary to convey water down a slope that is steep or otherwise prone to erosion. Pipe slope drains may be used with other devices, including diversion dikes or swales, sediment traps, and level spreaders (used to spread out stormwater runoff uniformly over the surface of the ground).

Design Criteria

Use a 10-inch diameter pipe or larger to convey runoff from areas up to one-third acre; 12-inch or larger pipe for up to half-acre drainage areas, and 18-inch pipe for areas up to one acre. Multiple pipes are often required for large areas, spaced as needed.

The pipe slope drain shall be designed to handle the peak runoff for the 10-year, 24-hour storm.

Material Specifications

The pipe shall be heavy duty flexible tubing designed for this purpose, e.g., nonperforated, corrugated plastic pipe, or specially designed flexible tubing.

A standard flared end section or a standard T-section fitting secured with a watertight fitting shall be used for the inlet.

Extension collars shall be 12-inch long sections of corrugated pipe. All fittings shall be watertight.

Construction Specifications

The pipe slope drain shall be placed on undisturbed or well-compacted soil.

Soil around and under the entrance section shall be hand-tamped in 4-inch to 8-inch lifts to the top of the dike to prevent piping failure around the inlet.

Filter cloth shall be placed under the inlet and extended 5 feet in front of the inlet and be keyed in 6 inches on all sides to prevent erosion.

Backfilling around and under the pipe with stable soil material hand compacted in lifts of 4 inches to 8 inches shall be done to ensure firm contact between the pipe and the soil at all points.

The pipe slope drain shall be securely staked to the slope using grommets provided for this purpose at intervals of 10 feet or less.

All slope drain sections shall be securely fastened together and have watertight fittings.

The pipe shall be extended beyond the toe of the slope and discharged at a non-erosive velocity into a stabilized area (e.g., gabion mattress) or to a sediment trap or pond.

The pipe slope drain shall have a minimum slope of 3 percent or steeper.

The height at the centerline of the earth dike shall range from a minimum of 1.0 foot over the pipe to twice the diameter of the pipe measured from the invert of the pipe. It shall also be at least 6 inches higher than the adjoining

ridge on either side. At no point along the dike will the elevation of the top of the dike be less than 6 inches higher than the top of the pipe.

All areas disturbed by installation or removal of the pipe slope drain shall be immediately stabilized.

Maintenance

The pipe slope drain shall be inspected after every rainfall and at least weekly. Any necessary repairs shall be made immediately.

Check to see that water is not bypassing the inlet and undercutting the inlet or pipe. If necessary, install headwall or sandbags.

Check for erosion at the outlet point and check the pipe for breaks or clogs. Install additional outlet protection if needed and immediately repair the breaks and clean any clogs.

Do not allow construction traffic to cross the pipe slope drain and do not place any material on it.

If a sediment trap has been provided, it shall be cleaned out when the sediment level reaches 1/3 the design volume.

The pipe slope drain shall remain in place until the slope has been completely stabilized or up to 30 days after permanent slope stabilization.

11.4.13 *Impact Stilling Basin*

Impact stilling basins are concrete structures placed at the outlets of culverts and storm sewer pipes with calculated exit velocities greater than 15 feet per second. The purpose of an impact stilling basin is to dissipate energy at a high velocity outlet to protect the receiving channel.

Design Criteria

Impact stilling basins shall be designed in accordance with LFUCG Division of Engineering Standard Drawings.

Construction Specifications

Construction specifications for impact stilling basins are provided in the Standard Drawings

11.5 Structural Sediment Control BMPs

11.5.1 Check Dam

A check dam is a small temporary dam constructed across a swale or drainage ditch. The purpose of a check dam is to reduce the velocity of concentrated stormwater flows, thereby reducing erosion of the swale or ditch. This practice also traps small amounts of sediment generated in the ditch itself. However, this is not a sediment-trapping practice and should not be used as such.

Design Criteria

Check dams shall be limited to use in small, open channels that drain 10 acres or less.

Check dams shall not be used in streams.

Check dams are especially applicable where the gradient of waterways is close to the maximum for a grass lining.

Check dams can be constructed of stones, coir logs, or wood fiber logs. See Figures 11-16 and 11-17.

The maximum height of a check dam shall be three feet above the ground on which the rock is placed.

The center of the portion of the check dam above the flat portion of the channel shall be at least 1 foot lower than the outer edges. The outer edges of the check dam shall extend up the side slopes of the channel to a point 3 feet in elevation above the center portion of the check dam or to the top of the side slopes.

The maximum spacing between rock check dams in a ditch should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.

The spacing of coir and wood fiber check dams is one log every 100 feet for velocities of 5 fps, 50 feet for velocities between 5 and 7.5 fps, and 25 feet for velocities greater than 10 fps.

Material Specifications

Stone check dams shall be constructed of KYTC Class II channel lining.

Coir log or wood fiber log check dams shall be constructed of a single log with a diameter of at least 20 inches.

Construction Specifications

Stone shall be placed by hand or mechanically as necessary to achieve complete coverage of the ditch and to ensure that the center of the dam is at least 1 foot lower than the outer edges. Stone shall also be placed to extend 3 feet in elevation above the center portion of the check dam or to the top of the channel side slopes.

Coir and wood fiber logs shall be laid on the channel bottom.

Check dams must be removed when their useful life has been completed. In temporary ditches and swales, check dams shall be removed and the ditch filled in when it is no longer needed. In permanent channels, check dams shall be removed when a permanent lining can be installed. In the case of grass-lined ditches, check dams shall be removed when the grass has matured sufficiently to protect the ditch or swale. The area beneath the check dams shall be seeded and mulched or sodded (depending upon velocity) immediately after check dams are removed.

If stone check dams are used in grass-lined channels that will be mowed, care shall be taken to remove all stone from the channel when the dam is removed. This shall include any stone that has washed downstream.

Maintenance

Regular inspections shall be made to ensure that the measure is in good working order and the center of the dam is lower than the edges. Erosion caused by high flows around the edges of the dam shall be corrected immediately, and the dam shall be extended beyond the repaired area.

Check dams shall be checked for sediment accumulation after each rainfall. Sediment shall be removed when it reaches one-third of the original height or before.

Check dams shall remain in place and operational until the drainage area and channel are completely stabilized or up to 30 days after the permanent site stabilization is achieved.

11.5.2 Sediment Trap

A sediment trap is formed by an excavation of an area in a suitable location to retain sediment and other waterborne debris. Sediment traps are considered temporary structures.

This standard establishes minimum acceptable criteria for the design and construction of sediment traps formed by excavation. This standard is limited to sites where the drainage area is less than 5 acres.

Sediment traps shall be used where physical site conditions or other restrictions prevent other erosion control measures from adequately controlling erosion and sedimentation. Sediment traps may be used down slope from construction operations that expose areas to erosion. Sediment traps shall be removed after the exposed areas are adequately protected against erosion by vegetative or mechanical means.

General Design Criteria

Erosion control practices such as seeding, mulching, sodding, diversion dikes, etc., shall be used in conjunction with sediment traps to reduce the amount of sediment flowing into the trap.

The amount of sediment entering a trap can be reduced by the use of stabilized diversion dikes and ditches. The trap shall not be located in a stream. It shall be located to trap sediment-laden runoff before it enters the stream.

The minimum capacity of the sediment trap to the elevation of the crest of the spillway shall be the runoff volume from the 2-year, 24-hour storm of 3.0 inches.

The trap dimensions necessary to determine the designed sediment volume shall be clearly shown on the plans to facilitate plan review, construction, operation, and maintenance. Trap depth shall be at least 2 feet at the inlet and 4 feet at the outlet. Effective trap width shall be at least 10 feet and trap length shall be at least 30 feet. See Figure 11-18.

The erosion and sediment control plan shall indicate the final disposition of the sediment trap after the upstream drainage area is stabilized. The plans shall indicate methods for the removal of excess water lying over the sediment, stabilization of the pond site, and the disposal of any excess material.

Construction Specifications

The area to be excavated shall be cleared of all trees, stumps, roots, brush boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. All topsoil containing excessive amounts of organic matter shall be removed.

Seeding, fertilizing, and mulching of the material taken from the excavation shall comply with the applicable soil stabilization sections of this manual.

Any material excavated from the trap shall be placed in one of the following ways so that it will not be washed back into the pond by rainfall:

- Uniformly spread to a depth not exceeding 3 feet and graded to a continuous slope away from the trap
- Uniformly placed or shaped reasonably well with side slopes assuming the natural angle of repose for the excavated material behind a berm width not less than 12 feet

Maintenance

Sediment shall be removed from the trap when the capacity is reduced to one third of the design volume. Plans for the sediment trap shall indicate the methods for disposing of sediment removed from the pond.

11.5.3 *Sediment Pond*

A sediment pond is formed by a barrier or dam constructed across a drainage way or other suitable location to retain sediment and other waterborne debris. Sediment ponds are considered temporary structures. They can be converted to permanent detention basins or storage structures for runoff control, if they are designed and constructed in accordance with applicable requirements of storage structures given in Chapter 10.

This standard establishes minimum acceptable criteria for the design and construction of sediment ponds formed by an embankment, excavation, or a combination of embankment and excavation. This standard is limited to sites where:

- Failure of the structure would not result in loss of life; damage to homes; damage to commercial or industrial buildings; damage to highways or railroads; or interruption of public or private utility service (hazard class “A” only)
- The height of the dam is 20 feet or less, as measured from the natural streambed at the downstream toe of the dam to the top of the dam
- The drainage area is more than 5 acres but less than 120 acres
- The pond will be removed within a three-year period after construction

Sediment ponds are appropriate where physical site conditions or other restrictions prevent other erosion control measures from adequately controlling erosion and sedimentation. Sediment ponds may be used down slope from construction operations that expose areas to erosion. Sediment ponds shall be removed after the exposed areas are adequately protected against erosion by vegetative or mechanical means.

General Design Criteria

Sediment ponds shall be designed to meet one of the following design criteria:

- Remove 80% of the total suspended solids for the 10-year 24-hour storm; a computer program such as SEDCAD may be used
- A detention time of 24 hours for the 10 year, 24-hour storm

Design and construction shall comply with all federal, state, and local laws, ordinances, rules, and regulations regarding dams.

Erosion control practices such as seeding, mulching, sodding, diversion dikes, etc., shall be used in conjunction with sediment ponds to reduce the amount of sediment flowing into the pond.

The amount of sediment entering a pond can be reduced by the use of stabilized diversion dikes and ditches. The pond shall not be located in a stream. It shall be located to trap sediment-laden runoff before it enters the stream.

A sand filter outlet may be used in the bottom of the pond. See Figure 11-19. A perforated riser may also be used.

Permanent ponds designed for stormwater detention or water quality treatment may serve as temporary sediment ponds if site conditions make the use of these structures desirable. At the time of conversion from a sediment pond to a permanent stormwater management pond, excess sediment shall be cleaned from the pond. If the pond is converted to a water quality basin, the sand in the sand filter outlet shall be replaced with clean sand unless it is shown to be clean.

The minimum capacity of the sediment pond to the elevation of the crest of the pipe spillway shall be equal to the runoff volume from the 2-year, 24-hour storm of 3.0 inches.

Detention storage shall be provided above the sediment storage volume to reduce peak discharges for the 10-year, 6-hour and 100-year, 6-hour storms during construction to pre-development levels. The Division of Engineering may waive this requirement if all of the following conditions apply:

- There is an existing detention basin downstream of the proposed sediment pond, and the existing detention basin is sized to control the runoff from the new development project

- There are no existing roads or structures at risk of flooding in the area between the proposed sediment pond and existing detention basin
- No roads or structures at risk of flooding will be constructed in the area between the proposed sediment pond and the existing detention basin

Pond dimensions necessary to determine the designed sediment volume shall be clearly shown on the plans to facilitate plan review, construction, operation, and maintenance.

The pond configuration shall be such that the effective flow length through the pond is at least two times the average width of the pond. Baffles will be used when necessary to prevent short-circuiting by increasing the effective flow length.

The minimum freeboard for the maximum applicable design storm shall be 1.0 foot.

For embankments of 5 feet or less, the minimum top width shall be 5 feet. For embankments of over 5 feet, the minimum top width shall be 12 feet.

Embankment side slopes shall be no steeper than 3H:1V.

Sediment pond plans shall indicate the final disposition of the sediment pond after the upstream drainage area is stabilized. The plans shall indicate methods for the removal of excess water lying over the sediment, stabilization of the pond site, and the disposal of any excess material.

Vegetation shall be established upon completion of construction of the embankment, emergency spillway and other areas disturbed by construction.

Sand Filter Outlet Design Criteria

Figure 11-19 illustrates an outlet that may be used to regulate discharge from the sediment pond. To size this device, pick a preliminary configuration and check it using the falling head permeability equation. Set t equal to 24 hours and calculate k . The calculated k should not be greater than 0.146 ft/hr. If necessary, adjust the filter dimensions and recalculate.

The falling head equation is:

$$k = 2.303 * (aL/At) * \log (H/h)$$

where:

k = coefficient of permeability (ft/hr) for sand,

a = average surface area of sediment pond at the elevation of the principal spillway (ft²),

L = depth of sand (ft),

A = surface area of filter = width of sand layer * length of sand layer (ft²),

t = time (hr),

H = height of water over the perforated pipe with top of pool at principal spillway (ft), and

h = height of filter from the top of the perforated pipe to the top of the sand (ft).

Pipe Spillway Design Criteria

The capacity of a pipe spillway shall be sufficient to pass the runoff of a 10-year, 24-hour storm with a detention time of 24 hours. The minimum diameter of the conduit shall be 12 inches.

The crest elevation of the principal spillway shall be at the elevation of the designed sediment volume. See Figure 11-20.

The trickle tube shall discharge at approximately the lowest elevation of the valley cross section at the downstream toe of the dam. Protection using gabion mattresses, concrete aprons, or other acceptable materials will be used to convey pipe discharge to a stable channel or a level spreader in an erosion free manner.

Anti-seep collars shall be installed around the pipe barrel for all installations where the height of earth fill over the top of pipe is 5 feet or greater. The combination of the number of collars and the collar projections must increase the length of the line of seepage by at least 15 percent. Where more than one collar is used, they shall be spaced approximately 25 feet apart.

Emergency Spillway Design Criteria

For embankments of 5 feet or less in height, the embankment shall be used as an emergency spillway and the downstream slope shall be 5H:1V or flatter. In addition, the downstream slope of the embankment shall be immediately protected with rock riprap.

Emergency spillways shall be constructed for all sediment ponds having an embankment height greater than 5 feet. The spillway cross section shall be trapezoidal with a minimum bottom width of 8 feet and side slopes of 2H:1V or flatter.

For embankments greater than 5 feet in height, the emergency spillway channel shall be located so that it will not be constructed over fill material. The channel shall be located so there are no sharp turns or bends. The channel shall return the flow of water to a defined channel downstream from the embankment.

The crest of the emergency spillway shall be set at the elevation required to pass the 10-year, 24-hour storm through the pipe spillway. In no case shall the difference in elevation between the crests of the pipe spillway and the emergency spillway be less than 1.0 foot.

The minimum capacity of the emergency spillway shall be that required to pass the peak-rate of runoff from the 100-year, 24-hour storm with one foot of freeboard, assuming the pipe spillway is blocked.

The maximum allowable velocity of flow in the exit section of vegetated emergency spillways shall be 6 feet per second. For spillways with erosion protection other than vegetation, velocities or critical shear forces shall be in the safe range for the type of protection used.

The emergency spillway shall have a control section at least 20 feet in length. The control section is a level portion of the spillway channel at the highest elevation in the channel.

Construction Specifications

The foundation area shall be cleared of all trees, stumps, roots, brush boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. All topsoil containing excessive amounts of organic matter shall be removed. The surface of the foundation area shall be thoroughly scarified before placement of the embankment material.

A cutoff trench shall be backfilled with suitable material. The trench shall be kept free of standing water during backfill operations.

The pipe conduit barrel shall be placed on a firm foundation. Selected backfill material shall be placed around the conduit in layers, and each layer shall be compacted to at least the same density as the adjacent embankment. All compaction within 2 feet of the pipe spillway shall be accomplished with hand-operated tamping equipment.

All borrow areas outside the pond and in the drainage area shall be graded and left in such a manner that water will not be ponded.

The material placed in the fill shall be free of all sod, roots, frozen soil, stones more than 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall occur in approximately 6-inch horizontal layers or of such thickness that the required compaction can be obtained with the equipment used. Each layer shall be compacted in a way that will result in achieving 95 percent of the maximum standard dry density.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, stakes, or layers of material differing substantially in texture or gradation from the surrounding material. Where it

is necessary to use materials of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

The moisture content of fill material shall be such that the required degree of compaction can be obtained with the equipment used.

Fill shall not be placed on frozen, slick, or saturated soil.

The topsoil material saved in the site preparation shall be placed as a top dressing on the surface of the emergency spillways, embankments, and borrow areas. It shall be evenly spread.

A protective cover of herbaceous vegetation shall be established on all exposed surfaces of the embankment, spillway, and borrow areas to the extent practical under prevailing soil and climatic conditions.

Seedbed preparation, seeding, fertilizing, and mulching shall comply with the applicable sections of this manual.

Any material excavated from the pond shall be placed in one of the following ways so that its weight will not endanger the stability of the side slopes and where it will not be washed back into the pond by rainfall:

- Uniformly spread to a depth not exceeding 3 feet and graded to a continuous slope away from the pond
- Uniformly placed or shaped reasonably well with side slopes assuming the natural angle of repose for the excavated material behind a berm width not less than 12 feet

Maintenance

Sediment shall be removed from the pond when the capacity is reduced to one third of the design volume. Plans for the sediment pond shall indicate the methods for disposing of sediment removed from the pond.

11.5.4 Silt Fence

Silt fence is a temporary barrier to trap sediment that consists of a filter fabric stretched between supporting posts, with the bottom entrenched in the soil and with a wire support fence. The purpose of a silt fence is to intercept and detain water allowing the settling of small amounts of sediment from disturbed areas during construction operations to prevent sediment from leaving the site and entering streams or sinkholes.

Design Criteria

Silt fences are appropriate where the size of the drainage area is no more than one-fourth acre per 100 feet of silt fence length; the maximum slope length behind the barrier is 100 feet; and the maximum gradient behind the barrier is 50 percent (2H:1V). Silt fences can be used at the toe of stockpiles where the slope exceeds 2H:1V, but in that case, the slope length should not exceed 20 feet.

Silt fences can be used in minor swales or ditch lines where the maximum contributing drainage area is no greater than 2 acres

Under no circumstances shall silt fences be constructed in streams or in swales or ditch lines where flows are likely to exceed 1 cubic foot per second (cfs).

Silt fences composed of synthetic fabric have an expected usable life of 6 months.

Wire reinforced silt fence shall be used adjacent to greenways, floodplains, tree protection areas, retention ponds, and streams.

Material Specifications

Synthetic filter fabric shall be a pervious sheet of propylene, nylon, and polyester or ethylene yarn and shall be certified by the manufacturer or supplier as conforming to the following requirements:

<u>PHYSICAL PROPERTY</u>	<u>REQUIREMENTS</u>
Filtering Efficiency	80% (minimum)
Tensile Strength at 20%	50 lbs./linear inch (minimum)
Flow Rate	0.3 gal./ sq. ft/ min. (minimum)

Synthetic filter fabric shall contain ultraviolet ray inhibitors and stabilizers to provide a minimum of 6 months of expected usable construction life at a temperature range of 0°F to 120°F.

Posts for synthetic fabric silt fences shall be either 2-inch by 2-inch wood or 1.33 pounds per linear foot steel with a minimum length of 5 feet. Steel posts shall have projections for fastening wire to them.

Wire fence reinforcement for silt fences shall be a minimum of 36 inches in height, a minimum of 14 gauge and shall have a mesh spacing of no greater than 6 inches.

Construction Specifications

This section provides construction specifications for silt fences using synthetic fabric. See Figure 11-21 for an illustration and Figure 11-22 for general notes.

Posts shall be spaced a maximum of 6 feet apart at the barrier location and driven securely into the ground (minimum of 12 inches). When necessary because of rapid runoff, post spacing shall not exceed 6 feet.

A trench shall be excavated at least 6 inches wide and 6 inches deep along the line of posts and upslope from the barrier.

Where applicable, a wire mesh support fence shall be fastened securely to the upslope side of the posts using heavy-duty wire staples at least 1 inch long, tie wires or hog rings. The wire shall extend into the trench a minimum of 2 inches and shall not extend more than 36 inches above the original ground surface.

The filter fabric shall be stapled or wired to the fence, and 12 inches of the fabric shall be extended into the trench. The fabric shall not extend more than 30 inches above the original ground surface. Filter fabric shall not be stapled to existing trees.

At joints, filter fabric should be lapped with terminating posts with a minimum overlap of 3 feet.

The trench shall be backfilled and soil compacted over the filter fabric.

Silt fences shall be removed when they have served their useful purpose, but not before the upslope area has been permanently stabilized.

Maintenance

Silt fences and filter barriers shall be inspected immediately after each rainfall and at least daily during prolonged rainfall. Any required repairs shall be made immediately. Knocked down fences shall be repaired at the end of each day.

Should the fabric on a silt fence or filter barrier decompose or become ineffective prior to the end of the expected usable life and the barrier is still necessary, the fabric shall be replaced promptly.

Sediment deposits shall be removed after each storm event or when deposits reach approximately one-third the height of the barrier.

Any sediment deposits remaining in place after the silt fence or filter barrier is no longer required shall be dressed to conform with the existing grade, prepared, and seeded.

Silt fences shall be replaced every 12 months.

11.5.5 Storm Drain Inlet Protection

A sediment filter installed around a storm drain drop inlet or curb inlet is referred to as storm drain inlet protection. Its purpose is to prevent sediment from entering storm drainage systems prior to permanent stabilization of the disturbed area. This practice should be used when storm drain inlets are to be operational before permanent stabilization of disturbed areas in the watershed. Curb inlet protection is not required if other soil stabilization and sediment control measures are in place to prevent sediment from entering the street.

Design Criteria

The drainage area shall be no greater than 1 acre.

The inlet protection device shall be constructed in a manner that will facilitate cleanout and disposal of trapped sediment and minimize interference with construction activities.

Inlet protection devices shall be constructed in such a manner that any resultant ponding of stormwater will not cause excessive inconvenience or damage to adjacent areas or structures.

Specifications-Drop Inlet Filters

For silt fence inlet protection (illustrated in Figure 11-23), the following specifications apply:

- For stakes, use 2 x 4-inch wood (preferred) or equivalent metal with a minimum length of 3 feet.
- Space stakes evenly around the perimeter of the inlet a maximum of 3 feet apart, and securely drive them into the ground, approximately 18 inches deep.
- To provide needed stability to the installation, frame with 2 x 4-inch wood strips around the crest of the overflow area at a maximum of 1.5 feet above the drop inlet crest and brace diagonally.
- Place the bottom 12 inches of the fabric in a trench and backfill the trench with at least 4 inches of crushed stone or 12 inches of compacted soil.
- Fasten fabric securely to the stakes and frame. Joints must be overlapped to the next stake.

For sod drop inlet protection, sod shall be placed to form a turf mat covering the soil for a distance of 4 feet from each side of the inlet structure. Soil preparation and sod placement shall be in accordance with the section entitled Sodding.

Specifications-Curb Inlet Filters

The specifications for curb inlet filters are listed in Figure 11-24.

Maintenance

The structure shall be inspected after each rain, and repairs made as needed.

Sediment shall be removed as necessary to ensure the filter functions properly. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

Structures shall be removed after the drainage area has been properly stabilized.

Curb inlet filters shall be replaced every six months.

11.5.6 Filter Strips

A filter strip is a strip of vegetation for removing sediment and related pollutants from runoff. Filter strips are also called vegetative filters. This practice uses infiltration, deposition, absorption, and decomposition to reduce pollution in runoff. Filter strips are applicable to land undergoing development where this practice can reduce sediment damage to adjacent property, streams, wetlands, or sinkholes.

Design Criteria

Filter strips shall only be used to remove sediment from overland flow. Filter strips are not effective in removing sediment from concentrated flows.

Vegetative filters cannot be expected to remove all sediment or adequately protect adjacent areas from sediment damage when used alone. Vegetative filters should only be considered as one component of the erosion and sediment control system.

If vegetative filters are proposed as a sediment control device and they do not already exist, they shall be planned and established prior to initiating land disturbing activities.

Minimum filter strip width shall be 50 feet for streams, wetlands, and sinkholes. The minimum filter strip width shall be ten feet for constructed waterways. See Figure 11-25.

Where a floodplain or wet weather conveyance is being protected, filter strips shall be provided on each side. When a wetland or sinkhole is being protected, filter strips shall be provided around the perimeter.

Plans shall show the location, width, and length of filter strips. The type of vegetation and specifications for soil preparation and seeding shall be included. If existing vegetation is to be used, plans for protecting or improving it shall be provided.

Material Specifications

Existing grass or grass/legume mixtures used as filter strips shall be dense and well established, with no bare spots. When establishing new seeding, consideration shall be given to wildlife needs and soil conditions on the site. The following chart provides a list of alternative grass and grass/legume mixtures:

SEEDING MIXTURE AND SITE SUITABILITY CHART

Seeding Mixture	Rate Lbs./Acre	Soil Suitability
1. Alfalfa or Red Clover Plus Timothy or Orchardgrass or Bromegrass	10 10 4 6 6	Well Drained
2. Landino Clover Plus Timothy or Orchardgrass or Bromegrass	½ 4 6 8	Wet or Well Drained

Notes:

1. All seeding shall be in accordance with the seeding sections of this manual
2. Well drained sites include sites that are drained with tile as well as naturally well drained and droughty sites. Wet sites include sites that are excessively wet only a portion of the growing season.

Construction Specifications

When planting filter strips, prepare seedbed, incorporate fertilizer, and apply mulch consistent with the seeding sections of this manual. Filter strips using areas of existing vegetation shall be over seeded, as necessary, with the above mixtures to obtain an equivalent density of vegetation. The over seeding shall be accomplished prior to the land disturbing activity.

Maintenance

Filter strips shall be inspected regularly to ensure that a healthy vegetative growth is maintained. Any bare spots or spots where sediment deposition could lead to the destruction of vegetation shall be repaired.

Filter strips shall be fertilized once each year in the fall. Irrigation shall be used as necessary to maintain the growth of the vegetation in the filter strip.

Sediment shall be removed when it becomes visible in the filter.

Construction traffic shall not be permitted to drive upon filter strips.

11.5.7 Temporary Stream Crossing

A temporary stream crossing is a temporary structural span installed across a flowing water course for use by construction traffic. Structures may include bridges, round pipes, or pipe arches. The purpose of a temporary stream crossing is to provide a means for construction traffic to cross flowing streams without damaging the channel or banks and to keep sediment generated by construction traffic out of the stream.

Design Criteria

Temporary stream crossings are applicable to flowing streams with drainage areas less than one square mile. Structures that must handle flow from larger drainage areas shall be designed as permanent structures by a professional engineer.

Temporary stream crossings shall be planned to be in service for the shortest practical period of time and to be removed as soon as their function is completed.

Such structures are subject to the rules and regulations of the U.S. Army Corps of Engineers for in-stream modifications (404 permits) and the Kentucky Natural Resources and Environmental Protection Cabinet, Division of Water (401 certification).

The span shall be designed to withstand the expected loads from heavy construction equipment that will cross the structure.

The structure shall be large enough to convey the peak flow expected from a 2-year storm without appreciably altering the stream flow characteristics. The structure may be a span, a culvert, or multiple culverts.

The minimum-sized culvert shall be 18 inches.

Where culverts are installed, compacted soil or rock shall be used to form the crossing. The depth of soil or rock cover over the culvert shall be equal to one-half the diameter of the culvert or 12 inches, whichever is greater. The sides of the fill shall be protected from erosion using the mulching and seeding erosion control measures specified in this manual.

The slope of the culvert shall be at least 0.25 inches per foot.

Material Specifications

When using a culvert crossing, the top of a compacted earth fill shall be covered with six inches of KTC No. 57 stone.

No. 57 stone shall also be used for the stone pads forming the crossing approaches.

Construction Specifications

Clearing and excavation of the streambed and banks shall be kept to a minimum.

The structure shall be removed as soon as it is no longer necessary for project construction.

Upon removal of the structure, the stream shall immediately be reshaped to its original cross section and properly stabilized.

The approaches to the structure shall consist of stone pads with a minimum thickness of 6 inches, a minimum width equal to the width of the structure, and a minimum approach length of 25 feet on each side.

Maintenance

The structure shall be inspected after every rainfall and at least once a week and all damages repaired immediately.

11.5.8 Pump-Around Flow Diversion

Pump-around flow diversions must be used to divert flow during excavation operations in streams. Pump-around flow diversions provide dry working conditions during construction in streams. Diverting stream flow around the work area prevents suspension of sediment in stream flow by construction activities. See Figure 11-26 for an illustration of a pump-around flow diversion.

Design Criteria

Size the diversion pump based on normal stream flow. Dewatering pump should be sized based on the size of the work area, the time allowed for dewatering, and the expected rate of groundwater flow into the excavation.

The check dams to form the diversion shall span the banks of the stream. Maintain 1-foot freeboard (minimum) on the upstream and downstream checks.

Check dams may be constructed of sandbags or may be a water-filled bladder such as an Aqua-Barrier.

The dewatering flow from the work area must be treated in a sediment-trapping device prior to discharge to the stream.

Material Specifications

Sandbags shall be woven polypropylene bags with approximate dimensions of 18-1/2 inches by 28 inches. Tie the ends of filled bags closed using either draw strings or wire ties.

Construction Procedures and Specifications

Schedule operations such that diversion installation, in-stream excavation, in-stream construction, stream restoration, and diversion removal are completed as quickly as possible. Do not construct in a stream when rainfall is expected during the time excavation will be occurring in the stream.

Install check dams across the stream during low flow conditions.

Pump stream flow around the check dams. Install outlet protection as required at the discharge.

Dewater the work area and pump into a sediment trapping device.

Complete construction activities across the stream.

Restore the streambed and banks.

Remove sandbags and shut down pumping operation. (Salvage sandbags for future use if multiple stream crossings are required on the project.) Remove all sandbags from the stream, including damaged and empty bags.

Pumps shall be manned around-the-clock when the pump-around diversion is in the stream.

Maintenance

This control provides short-term diversion of stream flow (typically 1 day to 3 days). Additional sandbags or pumps may be required to maintain 1-foot freeboard on the sandbag checks if flow conditions change.

Add sandbags as required to seal leaks in checks.

11.5.9 Construction Dewatering

Dewatering is the pumping of stormwater or groundwater from excavation pits or trenches. The sediment-laden water must be pumped to a dewatering structure before it is discharged offsite. The purpose of a dewatering structure is to remove sediment from the water before it is discharged.

Design Criteria

There are several types of dewatering structures that may be used. A well-stabilized vegetated area may serve as a filtering structure if it can withstand the velocity of the discharged water. The minimum filter length must be at least 75 feet.

Other methods that may be used include a sediment trap/basin, portable sediment tank, a straw bale/silt fence pit, or a commercial sediment filter bag. The structure must be sized to allow pumped water to flow through the structure without overtopping.

Construction Specifications

See the specifications in this manual for sediment traps and basins. The manufacturer's recommendations should be followed for commercial products.

Maintenance

The dewatering structure should be inspected frequently to ensure it is functioning properly and not overtopping. Accumulated sediment should be spread out on site and stabilized, or disposed of offsite.

11.5.10 Concrete Washout Pits

Concrete washout facilities shall be used to minimize the discharge of pollutants into streams, groundwater, and storm sewers. All concrete waste and washout material shall be captured and contained in an approved prefabricated or constructed washout facility. The location of washout pits shall be shown on the Stormwater Pollution Prevention Plan and the Erosion and Sediment Control Plan.

Design Criteria

Washout facilities shall be leakproof, and sized to fully contain wash water and concrete waste. Where used, plastic liners must be at least 10 mils thick (one-hundredth of an inch, or about three sheets of paper). Design volume shall be at least 50 cubic feet (375 gallons) per active residential lot, or a minimum of one 20-foot x 20-foot x 5-foot washout for every 40 active lots. The type, location, and dimensions of each washout to be used throughout the project shall be included in the Erosion Control Plan. All designs must be approved by the Division of Engineering. Additional washouts may be required at the discretion of the Division of Engineering or Division of Water Quality during Erosion Control Plan review or the active construction period.

Construction Specifications

Prefabricated washouts may be used as long as they meet the volume and other requirements above. Non-prefabricated washout facilities can be constructed of straw bales, wood, or earthen pits/berms with plastic liner(s) totaling at least 10 mils thickness. Where multiple liners are used to meet the 10 mil thickness requirement, all seams within the basin must be folded and joined with an appropriate sealer. Non-inflatable plastic pools meeting the 10 mil thickness and volume requirements (e.g., 8 feet diameter x 1.5 feet deep) may be used for short term single-lot applications where centralized washouts are not appropriate. Washout facilities must be sited outside of the right-of-way in a location convenient to the pour site, at least 25 feet from storm drains and 50 feet from water bodies. Each washout shall have a minimum 6 inches thick, 15 feet wide #2 stone construction entrance leading up to each washout facility. Manufactured signage must be installed and maintained throughout the construction site directing concrete truck drivers to the location of the washout area(s).

Maintenance

Washout facilities and signage shall be maintained by the Land Disturbance Permittee in good working order while in use. No discharges shall be made to them 1) if they are compromised structurally; 2) if they are leaking; or 3) when less than 10 percent of the total containment depth remains (e.g., no discharges after a 30-inch deep structure is filled to within 3 inches of the top). Leaks and overflows must be cleaned up within 3 calendar days. Concrete trucks that are leaking waste, oil, or water shall not be operated on paved public roads. Washouts may be broken up and disposed of after all liquids have evaporated or solidified. Washouts that are no longer functional or have reached full capacity must be removed and properly disposed of within 14 calendar days of termination of use. All washouts must be removed prior to the permit closeout or other final site / lot approvals.

11.6 Erosion Control Requirements for Home Builders

The home builder shall install the erosion and sediment controls described below to minimize the sediment washing into streets, inlets, stormwater pipes, open channels, and adjacent lots. Builders who own multiple adjoining lots may treat them as a single project. Erosion and sediment control on vacant lots is the responsibility of the property owner.

Enforcement

Home builders who fail to install the erosion and sediment controls will be issued a notice of violation. Failure to correct the problem may lead to additional enforcement action.

Silt Fence

A silt fence shall be properly installed prior to clearing and grading the lot. The silt fence is not required around the entire perimeter of the lot but must be installed down-slope of all disturbed areas.

The silt fence shall be firmly entrenched and attached to wood or steel posts spaced 6 feet apart. The trench is typically 6"x6". The posts go on the downhill side of the fence. The posts are typically 2"x2"x36" wood and shall be driven firmly into the ground. The silt fence fabric should be at least 18" in height above the ground.

Construction Entrance

A construction entrance of No. 2 stone, 6" thick, shall be installed where the driveway will be constructed. The stone should not be placed in the gutter. If a box curb is present, it should be cut and removed.

Seed, Sod, and Mulch

The lot shall be seeded and mulched, or sodded, within 14 days after final grading. Areas that have not reached final grade, but will remain inactive for more than 21 days, shall be seeded and mulched. Sod shall be used for channels that require immediate vegetative cover. Mulch without seed may be applied during December, January, and February, but seeding shall occur as soon as possible in the spring.

Disposal of Trash

Each day, all scrap building materials and litter that could be carried away by wind or water must be hauled off-site or placed in an on-site dumpster. This includes food packages, cans, bottles, paper, and scrap building materials such as wood, drywall, shingles, etc.

Curb Inlet Protection

Rock bags or other devices shall be used to keep sediment from washing into curb inlets. Do not completely block the curb opening because that could lead to flooding during heavy rain. Pollutants shall be kept out of curb inlets and surface waters.

Surface Inlet Protection

A silt fence or other device shall be used to keep sediment from washing into surface inlets.

Inspection of Sediment Controls

The home builder shall inspect the sediment controls each working day and repair them as necessary. In addition, sediment shall be removed from behind silt fences and other sediment controls to keep them functioning properly.

Street Cleaning

The home builder shall clean sediment off the street to prevent it from becoming muddy and slick.

Alteration of Drainage System

The home builder shall not regrade the lot to move a swale, channel, or stream. The home builder shall not fill in a floodplain, detention basin/retention pond, swale, channel, or stream.

Snow Fence

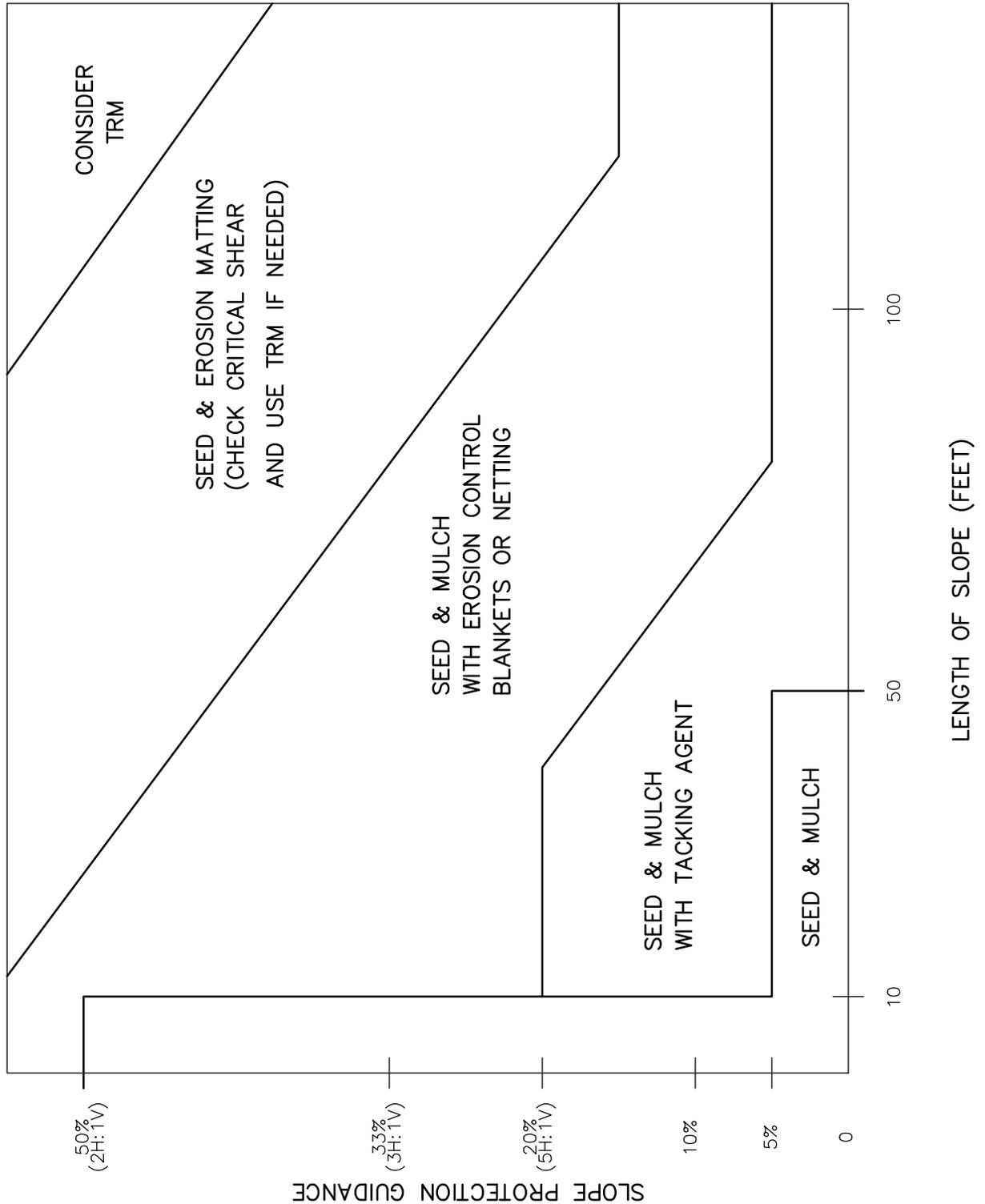
Snow fence shall be used to keep vehicles off the lot along the street frontage if silt fence is not necessary for sediment control at that location.



STORMWATER MANUAL

FIGURE 11-1
SLOPE PROTECTION GUIDANCE

(OCTOBER 1, 2016)

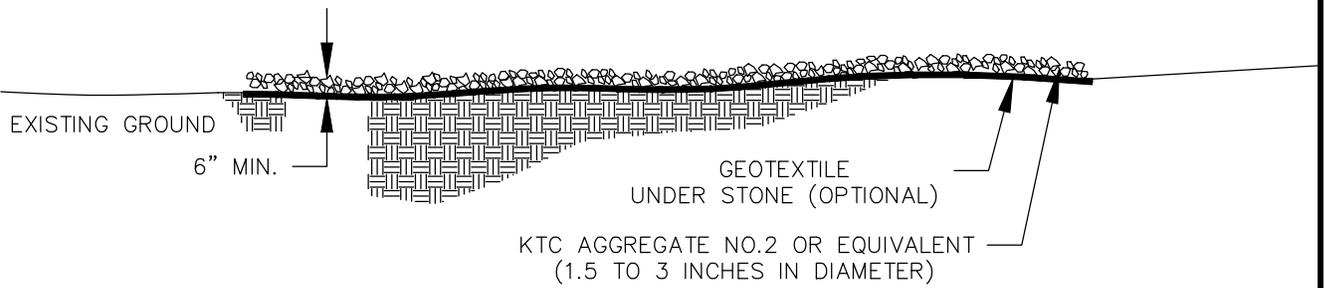




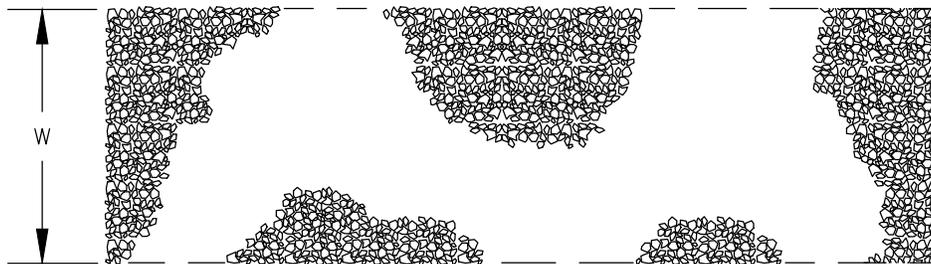
STORMWATER MANUAL

FIGURE 11-2 ROAD\ PARKING STABILIZATION

(OCTOBER 1, 2016)



CROSS SECTION



PLAN VIEW

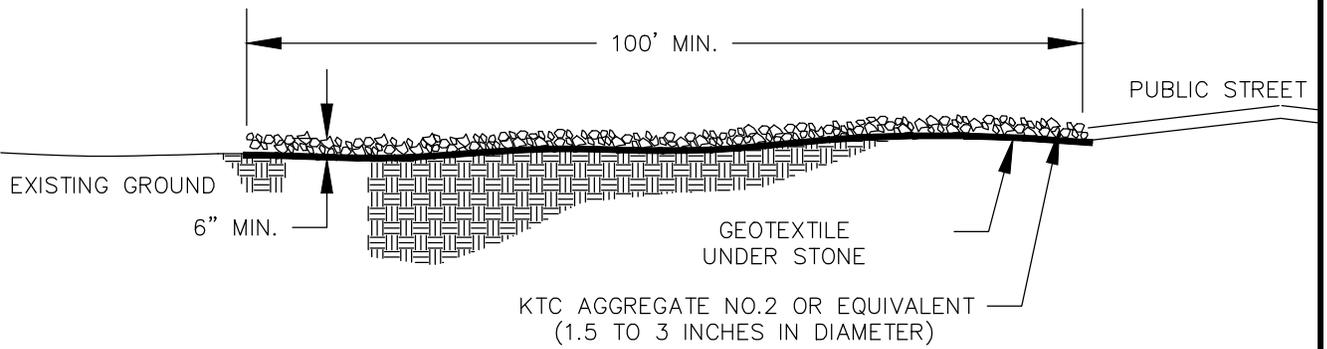
W = 14' MIN. FOR ONE WAY TRAFFIC
20' MIN. FOR TWO WAY TRAFFIC



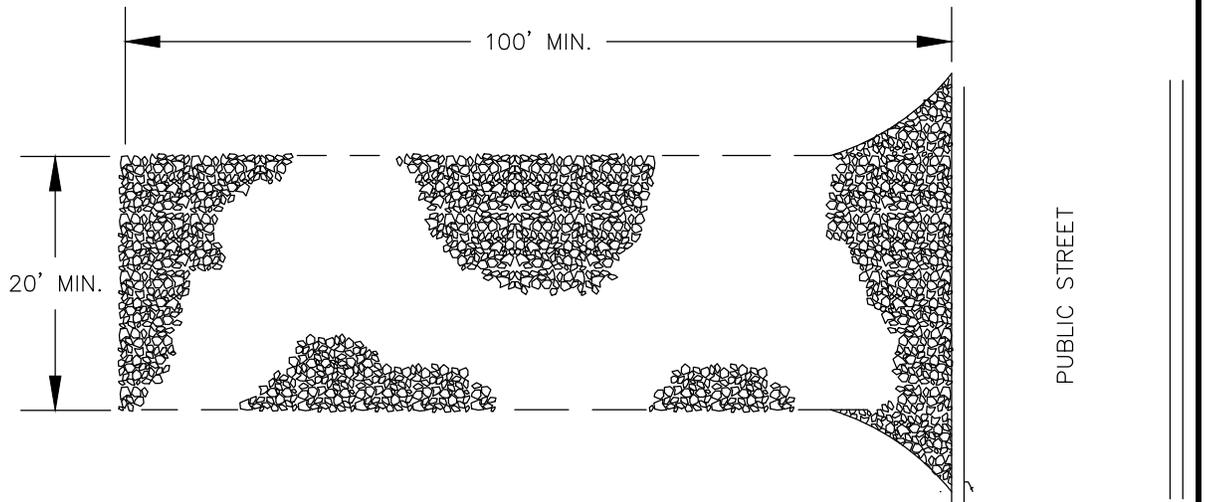
STORMWATER MANUAL

FIGURE 11-3
CONSTRUCTION ENTRANCE

(OCTOBER 1, 2016)



CROSS SECTION



PLAN VIEW



STORMWATER MANUAL

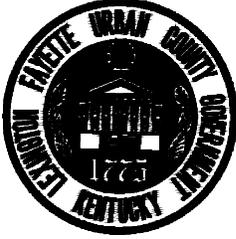
FIGURE 11-4 CONSTRUCTION ENTRANCE NOTES AND SPECIFICATIONS (OCTOBER 1, 2016)

SPECIFICATIONS FOR GEOTEXTILE FABRIC

GRAB TENSILE STRENGTH	220 LBS. (MIN.) (ASTM D1682)
ELONGATION FAILURE	60% (MIN.) (ASTM D1682)
MULLEN BURST STRENGTH	430 LBS. (MIN.) (ASTM D3768)
PUNCTURE STRENGTH	125 LBS. (MIN.) (ASTM D751) (MODIFIED)
EQUIVALENT OPENING	SIZE 40-80 (US STD SIEVE) (CW-02215)

NOTES

1. A STABILIZED ENTRANCE PAD OF CRUSHED STONE SHALL BE LOCATED WHERE TRAFFIC WILL ENTER OR LEAVE THE CONSTRUCTION SITE ONTO A PUBLIC STREET.
2. SOIL STABILIZATION FABRIC SHALL BE USED AS A BASE FOR THE CONSTRUCTION ENTRANCE.
3. THE ENTRANCE SHALL BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR FLOWING OF SEDIMENT ONTO PUBLIC STREETS OR EXISTING PAVEMENT. THIS MAY REQUIRE PERIODIC TOP DRESSING WITH ADDITIONAL STONE AS CONDITIONS WARRANT AND REPAIR OR CLEAN OUT OF ANY MEASURES USED TO TRAP SEDIMENT.
4. ANY SEDIMENT SPILLED, DROPPED, WASHED, OR TRACKED ONTO PUBLIC STREETS OR INTO STORM DRAINS MUST BE REMOVED IMMEDIATELY.
5. WHEN APPROPRIATE, WHEELS MUST BE CLEANED TO REMOVE SEDIMENT PRIOR TO ENTERING A PUBLIC STREET. WHEN WASHING IS REQUIRED, IT SHALL BE DONE IN AN AREA STABILIZED WITH CRUSHED STONE WHICH DRAINS INTO AN APPROVED SEDIMENT BASIN.



STORMWATER MANUAL

FIGURE 11-5
STAPLE PATTERN FOR STRAW
OR EXCELSIOR MATS
(OCTOBER 1, 2016)

SLOPES UP TO 1.5H:1V

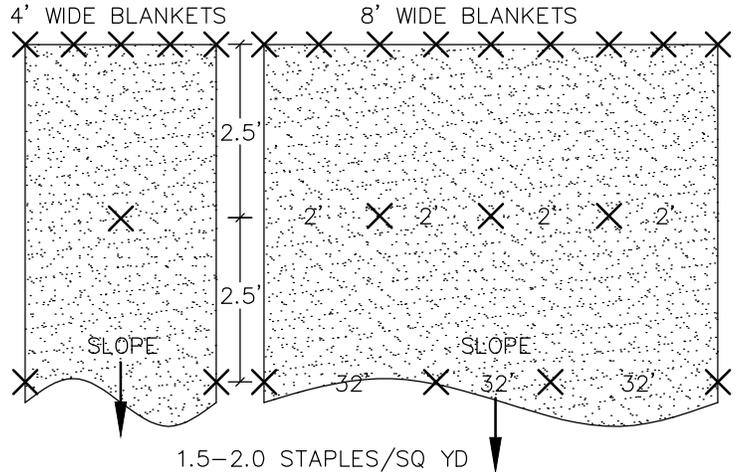
- INSTALL BLANKET VERTICALLY OR HORIZONTALLY
- USE 12" STAPLE SPACING ON STARTER ROW.

COHESIVE SOILS:

- NO OVERLAP REQUIRED ON SIDE SEAMS
- USE 6" STAPLE LENGTH

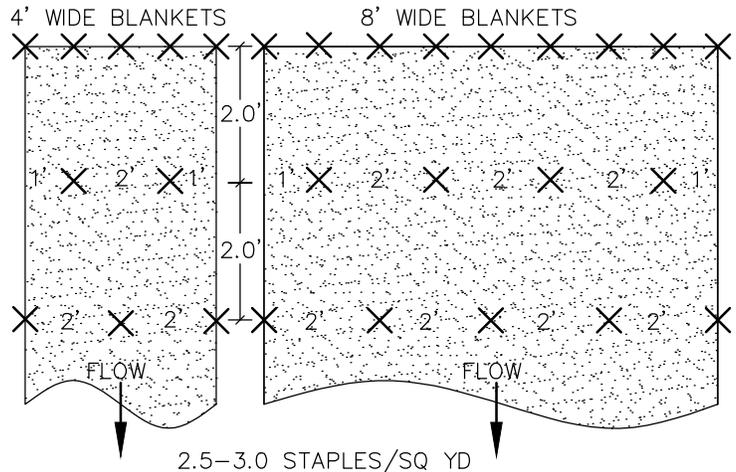
NON-COHESIVE SOILS:

- USE 6" SIDE SEAM OVERLAP
- USE 8" STAPLE LENGTH
- USE 6" ANCHOR TRENCH AT TOP OF SLOPE



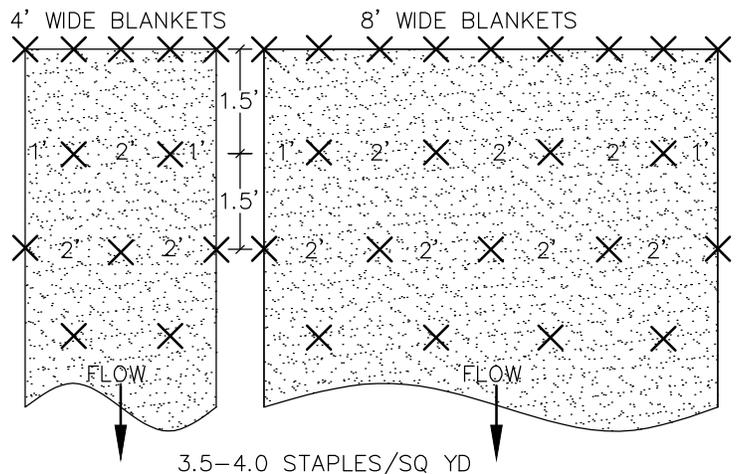
CHANNELS IN COHESIVE SOILS

- USE 6" SIDE SEAM OVERLAP
- USE 6" STAPLE LENGTH
- USE 6" TRANSVERSE ANCHOR TRENCH AT 100-FT. INTERVALS
- USE 12" STAPLE SPACING ON STARTER ROW.
- UPSTREAM BLANKET SHOULD OVERLAP DOWNSTREAM BLANKET A DISTANCE OF 12" IN A "SHINGLE" FASHION AND BURY THE FINISHED TOE AT LEAST 6".



CHANNELS IN NON-COHESIVE SOILS

- USE 6" SIDE SEAM OVERLAP
- USE 8" STAPLE LENGTH
- USE 6" TRANSVERSE ANCHOR TRENCH AT 50-FT. INTERVALS
- USE 12" STAPLE SPACING ON STARTER ROW.
- UPSTREAM BLANKET SHOULD OVERLAP DOWNSTREAM BLANKET A DISTANCE OF 12" IN A "SHINGLE" FASHION AND BURY THE FINISHED TOE AT LEAST 6".

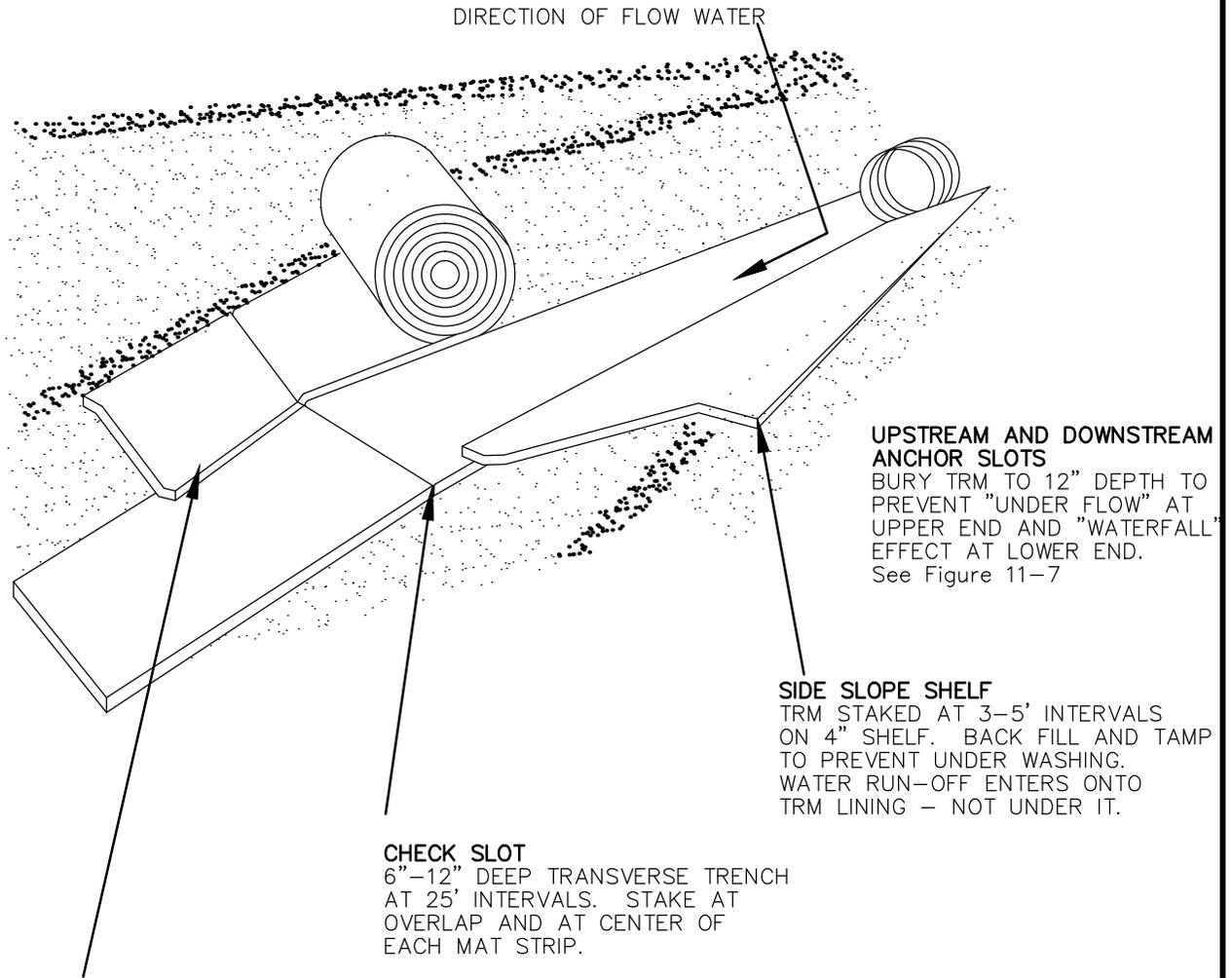




STORMWATER MANUAL

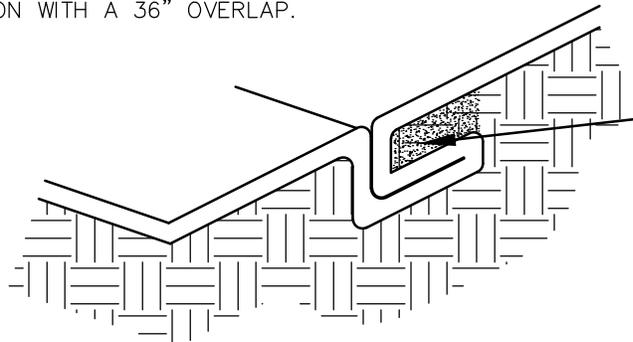
FIGURE 11-6
PLACEMENT OF TRM IN CHANNEL

(OCTOBER 1, 2016)



OVERLAP IN A SHINGLE FASHION
4" OVERLAP STAKED AT 3-5' INTERVALS

WHEN ROLL TERMINATES, IT IS STAKED OVER THE ROLL WHICH EXTENDS DOWNSTREAM IN A SHINGLE FASHION WITH A 36" OVERLAP.



CHECK SLOT DETAIL
STAKE AND BACK FILL IN CHECK SLOT BEFORE CONTINUING TO PLACE UPSLOPE

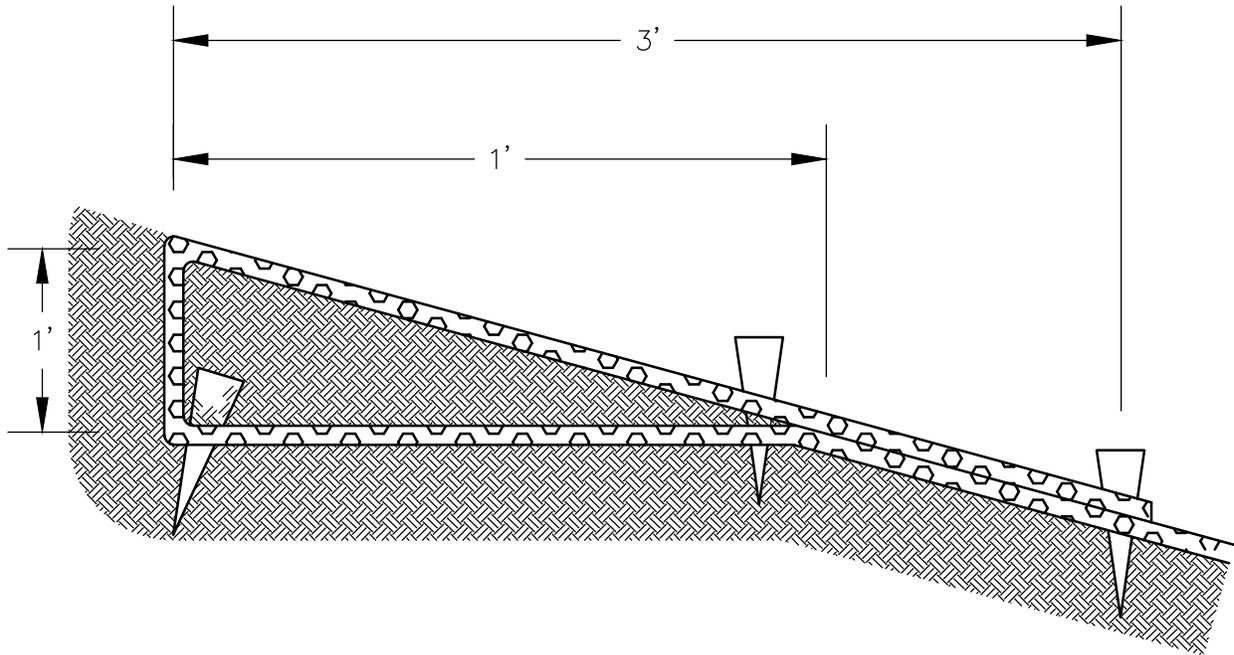


STORMWATER MANUAL

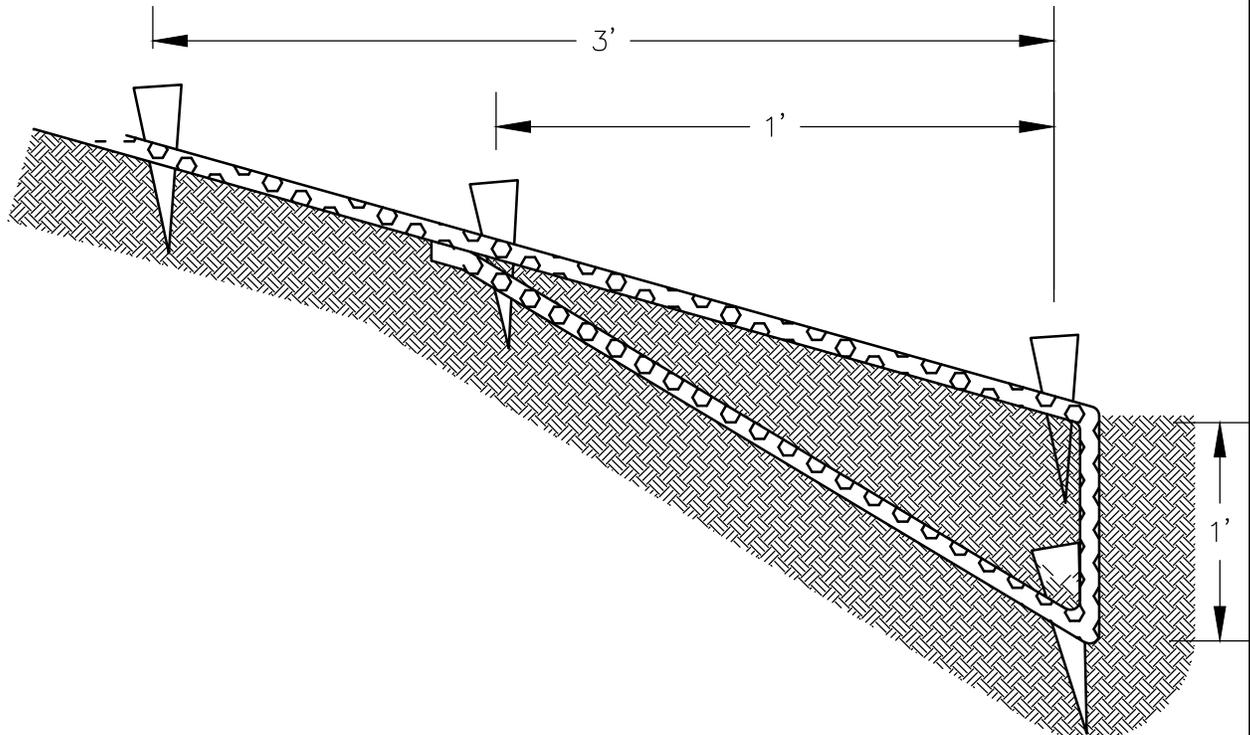
FIGURE 11-7
ANCHOR SLOT DETAILS FOR TRM

(OCTOBER 1, 2016)

UPSTREAM ANCHOR SLOT DETAIL



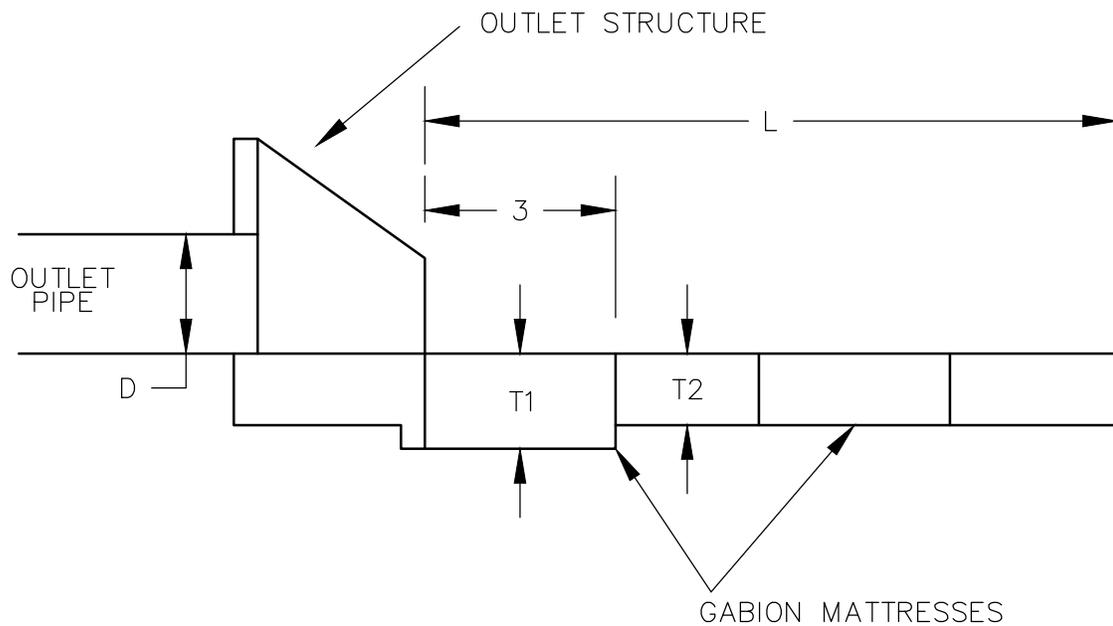
DOWNSTREAM ANCHOR SLOT DETAIL





STORMWATER MANUAL

FIGURE 11-8
CROSS SECTION AT
GABION MATTRESS OUTLET PROTECTION
(OCTOBER 1, 2016)



- T1** = THICKNESS OF FIRST 3 FEET OF GABION MATTRESS TO MATCH DEPTH OF OUTLET STRUCTURE FOUNDATION
- T2** = THICKNESS OF REMAINING GABION MATTRESS, 12 INCHES MINIMUM AND 18 INCHES MINIMUM FOR CALCULATED OUTLET VELOCITIES OF 10 TO 15 FEET PER SECOND.

FOR $D < 36$ INCHES, $L = 12$ FEET

FOR $D > 36$ INCHES, $L = 4 \times D$ FEET

D = HEIGHT OR WIDTH OF OUTLET, WHICHEVER IS GREATER



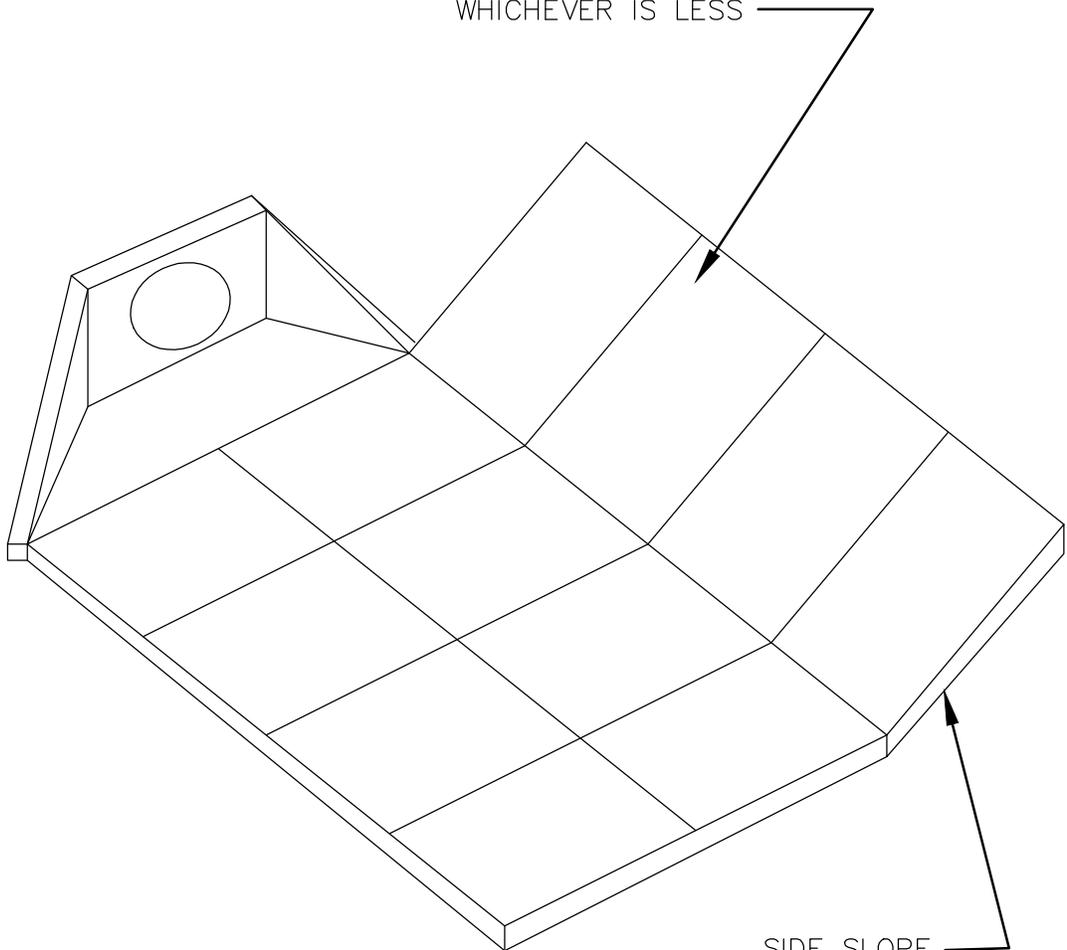
STORMWATER MANUAL

FIGURE 11-9

GABION MATTRESS AT OUTLET
INTO WELL-DEFINED CHANNEL

(OCTOBER 1, 2016)

EXTEND GABION MATTRESS UP SIDE SLOPE
OF CHANNEL TO TOP OF BANK OR 1' HIGHER
THAN MAXIMUM TAILWATER DEPTH,
WHICHEVER IS LESS



SIDE SLOPE
SHALL NOT EXCEED
2H:1V

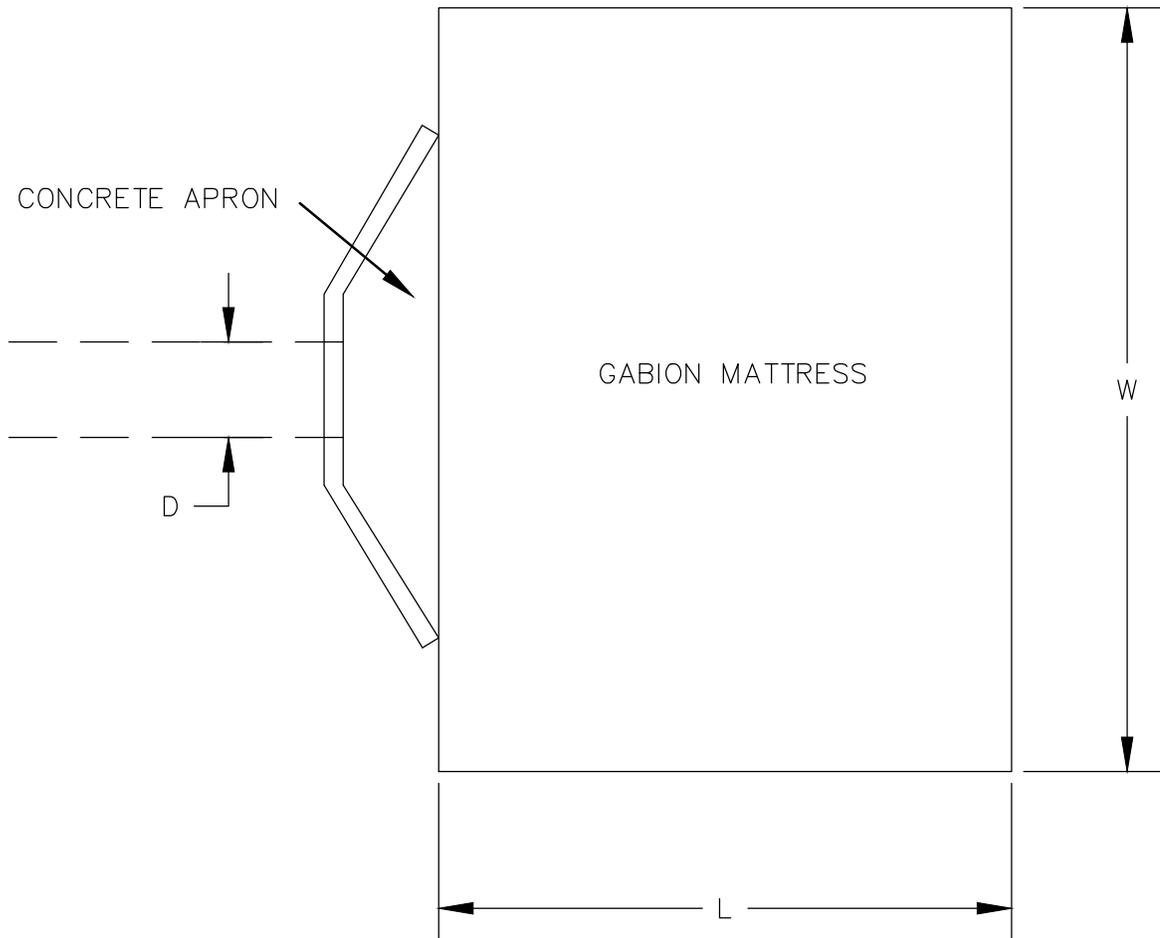


STORMWATER MANUAL

FIGURE 11-10

PLAN VIEW OF GABION MATTRESS
AT OUTLET INTO FLAT AREA

(OCTOBER 1, 2016)



D = HEIGHT OR WIDTH OF OUTLET, WHICHEVER IS GREATER

FOR $D \leq 36$ INCHES:

L = 12 FEET MINIMUM

W = (18 + D) FEET MINIMUM

FOR $D > 36$ INCHES:

L = 4 × D FEET MINIMUM

W = (2 L + D) FEET MINIMUM

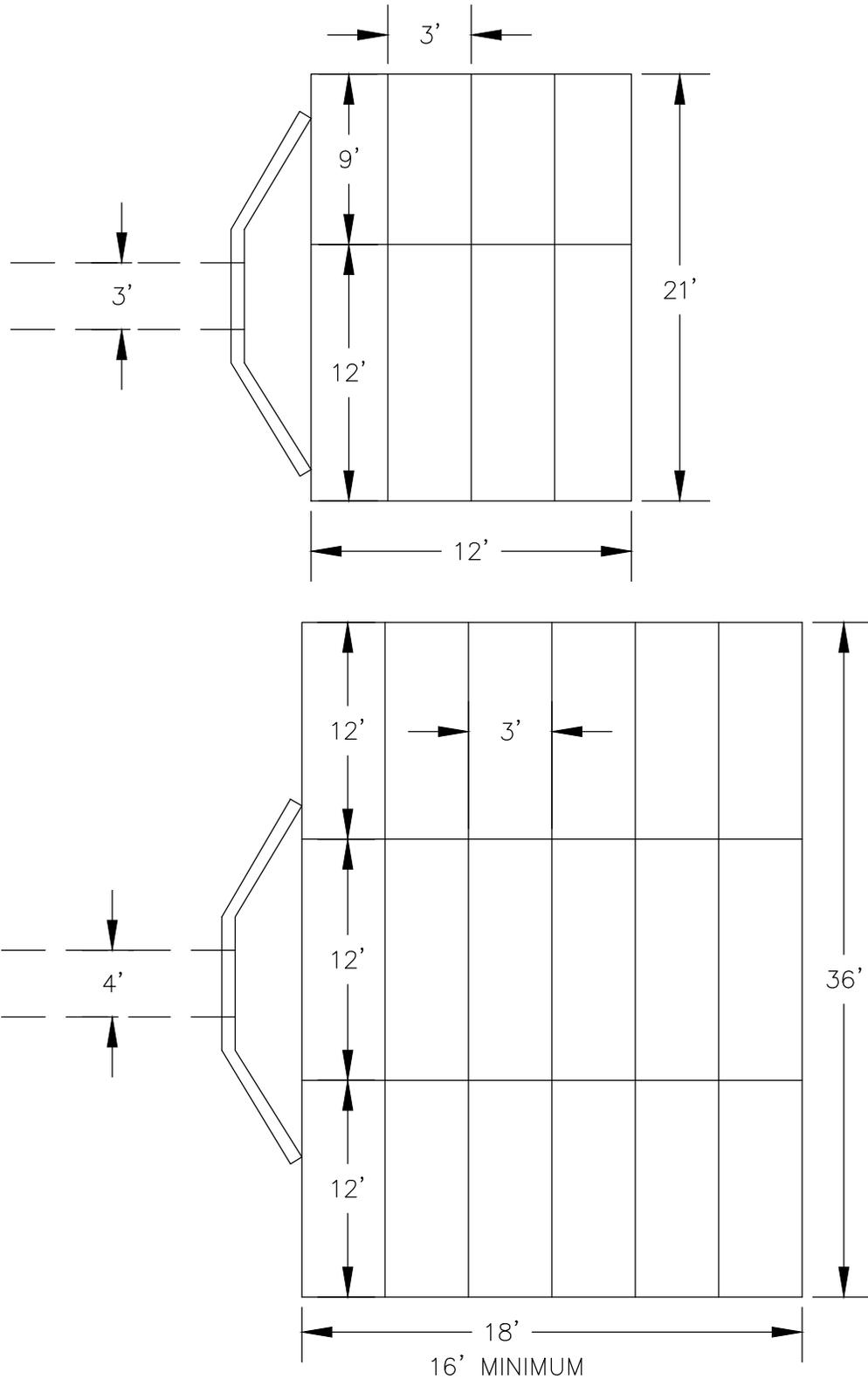


STORMWATER MANUAL

FIGURE 11-11

EXAMPLE PLAN VIEW LAYOUTS OF GABION
MATTRESS FOR OUTLET ONTO FLAT AREAS

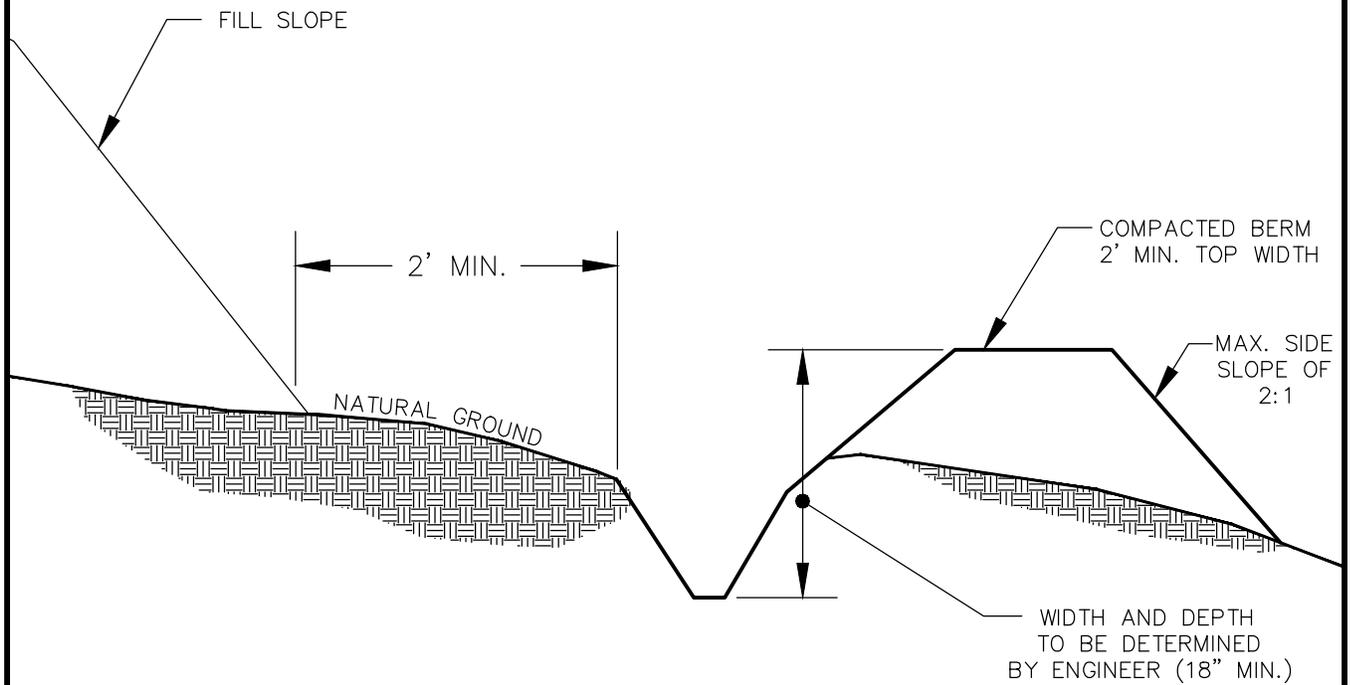
(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 11-12
TEMPORARY DIVERSION DITCH
(OCTOBER 1, 2016)



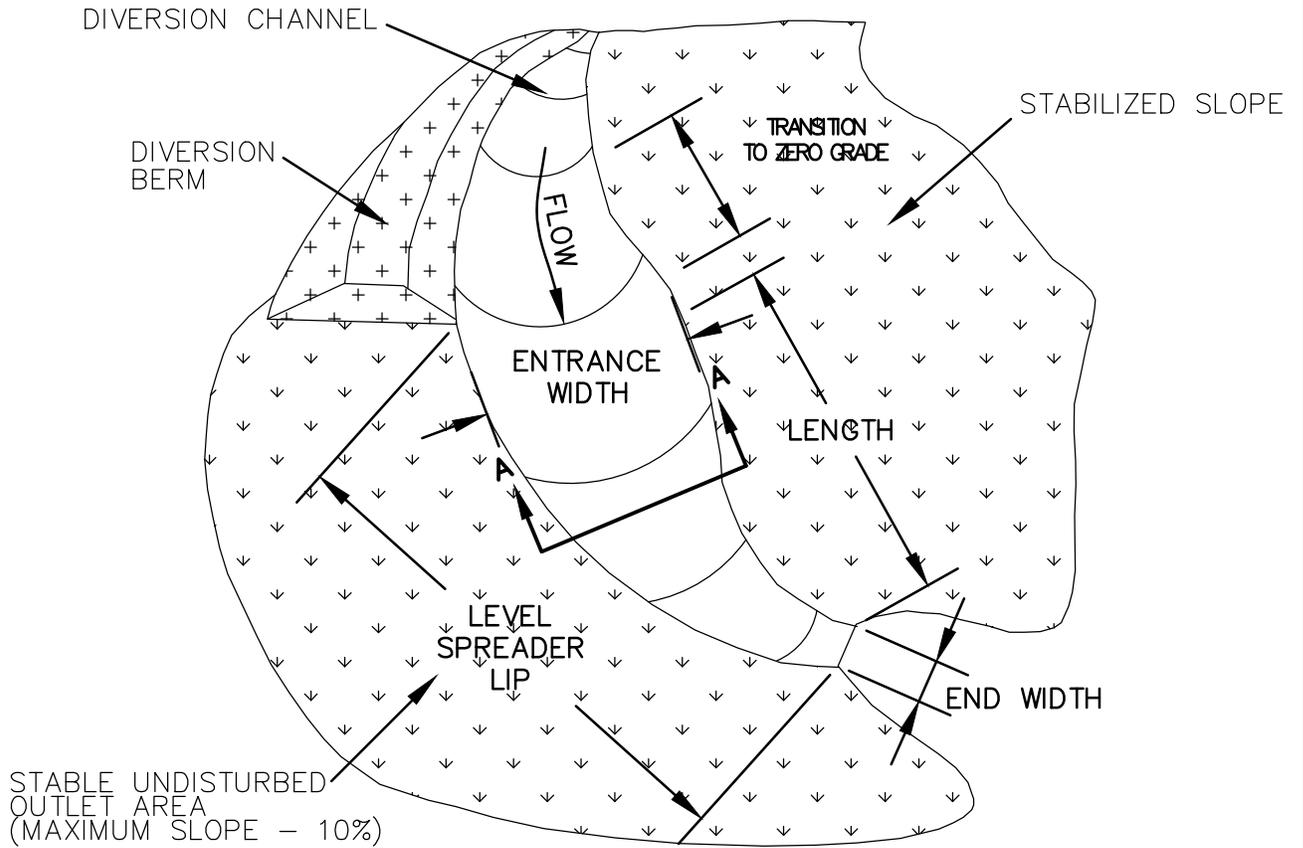


STORMWATER MANUAL

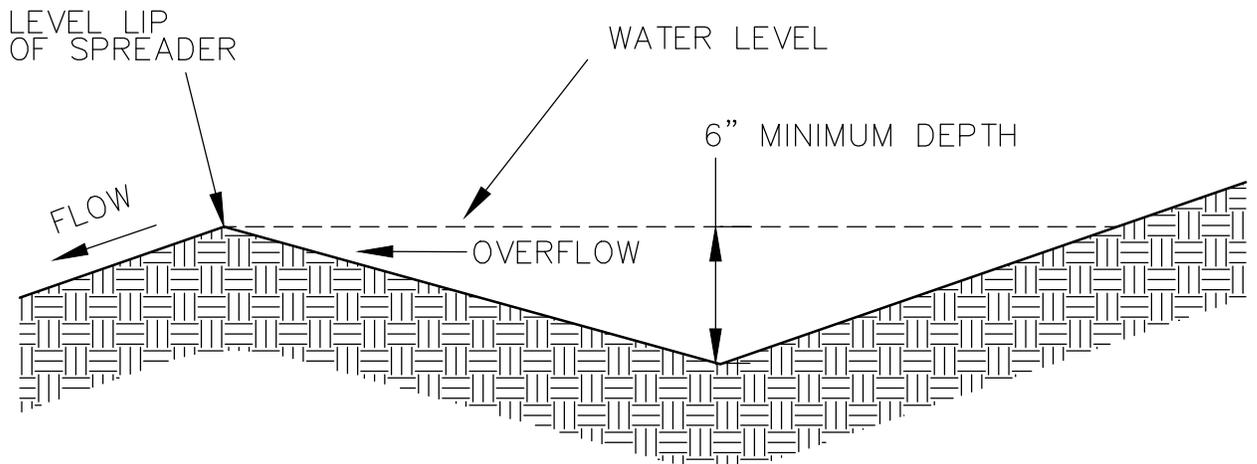
FIGURE 11-13

LEVEL SPREADER

(OCTOBER 1, 2016)



PERSPECTIVE



SECTION A-A

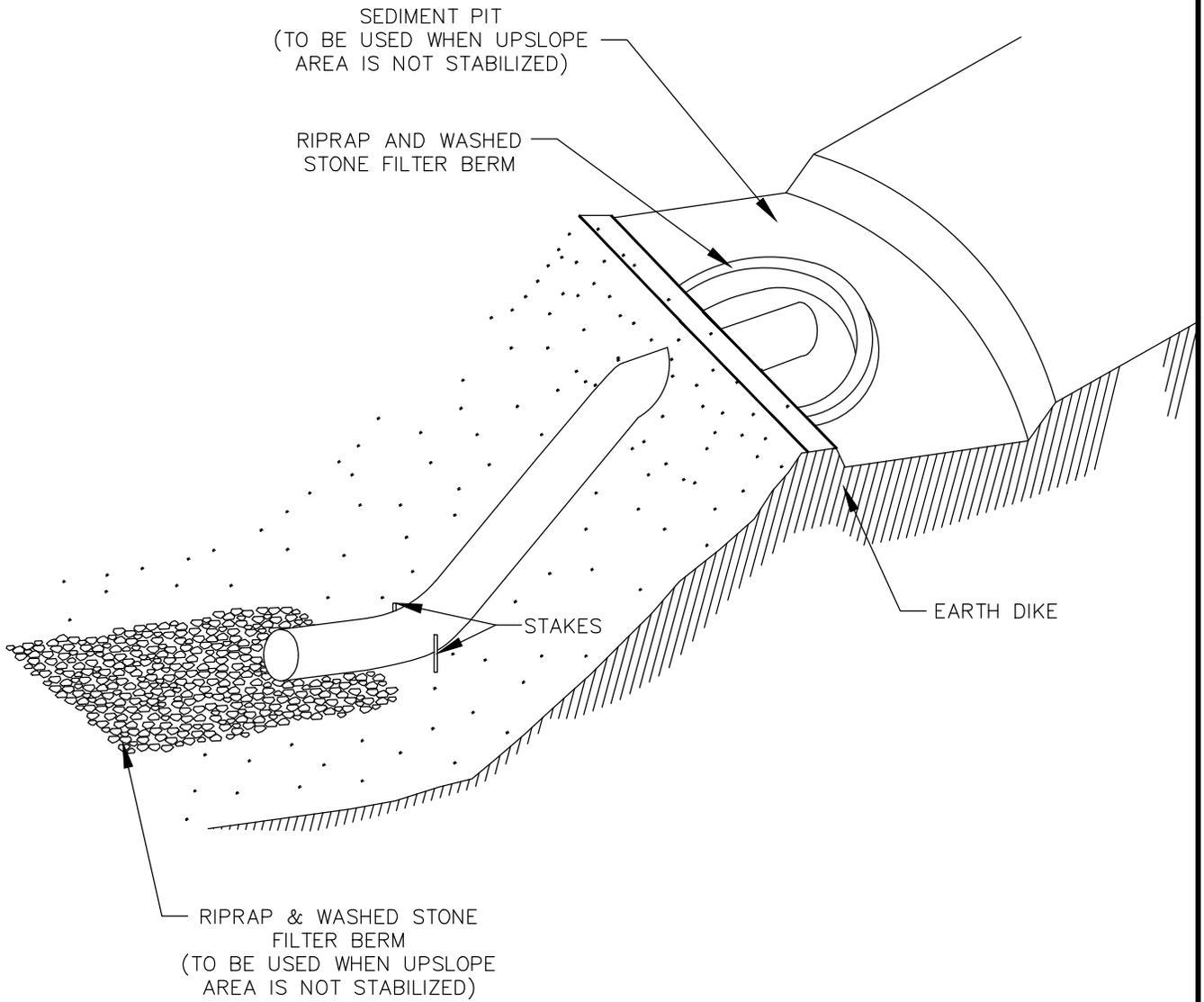


STORMWATER MANUAL

FIGURE 11-14

FLEXIBLE PIPE SLOPE DRAIN

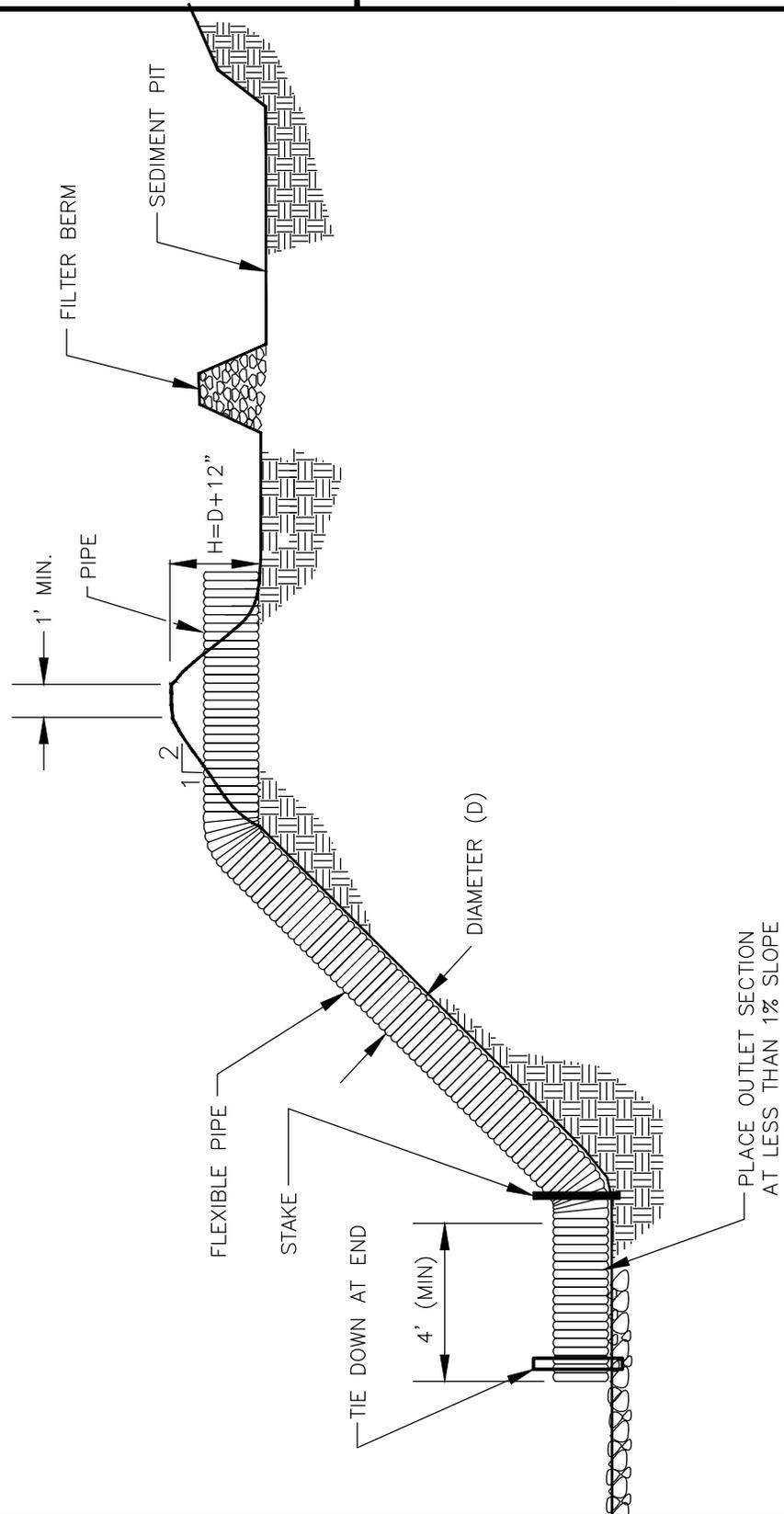
(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 11-15
SLOPE DRAIN - PROFILE
(OCTOBER 1, 2016)



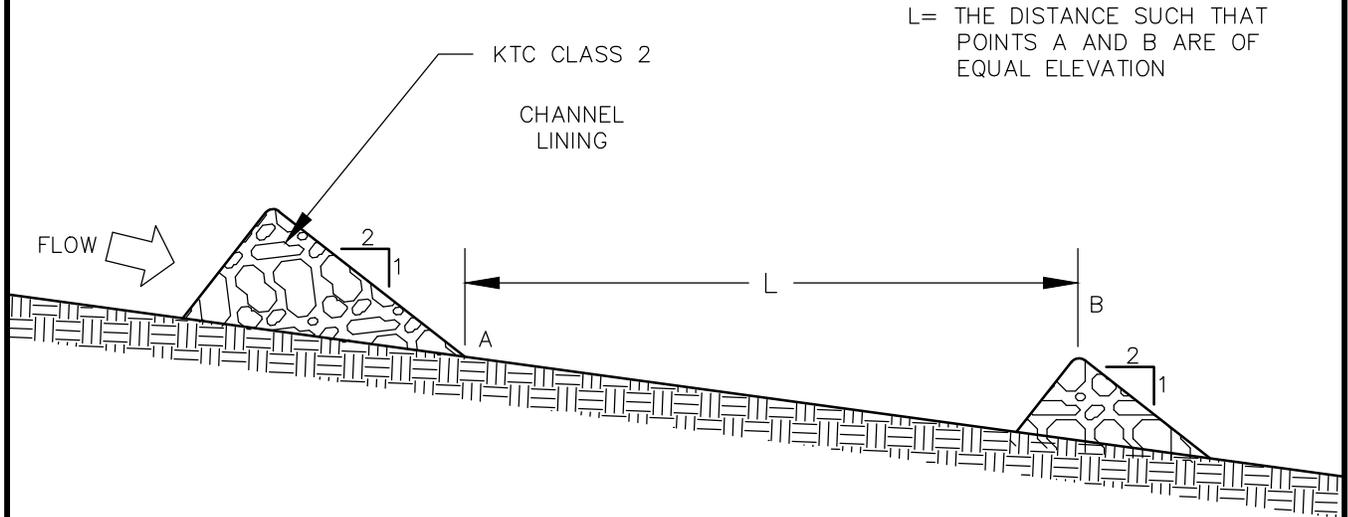


STORMWATER MANUAL

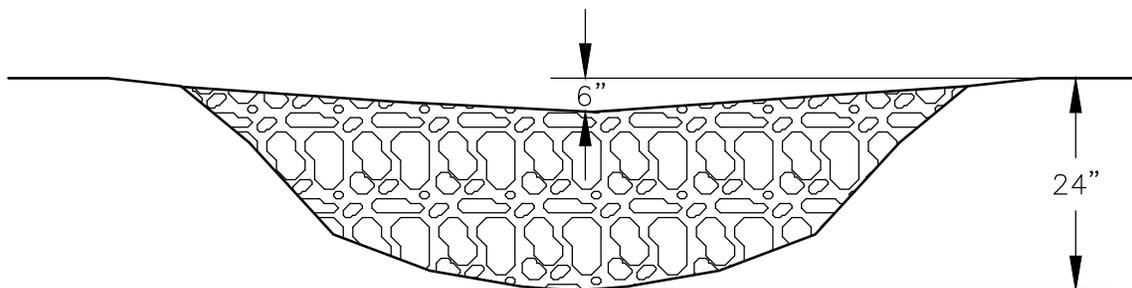
FIGURE 11-16

ROCK CHECK DAM

(OCTOBER 1, 2016)



LONGITUDINAL SECTION SHOWING
SPACING BETWEEN CHECK DAMS



SECTION ACROSS CHANNEL

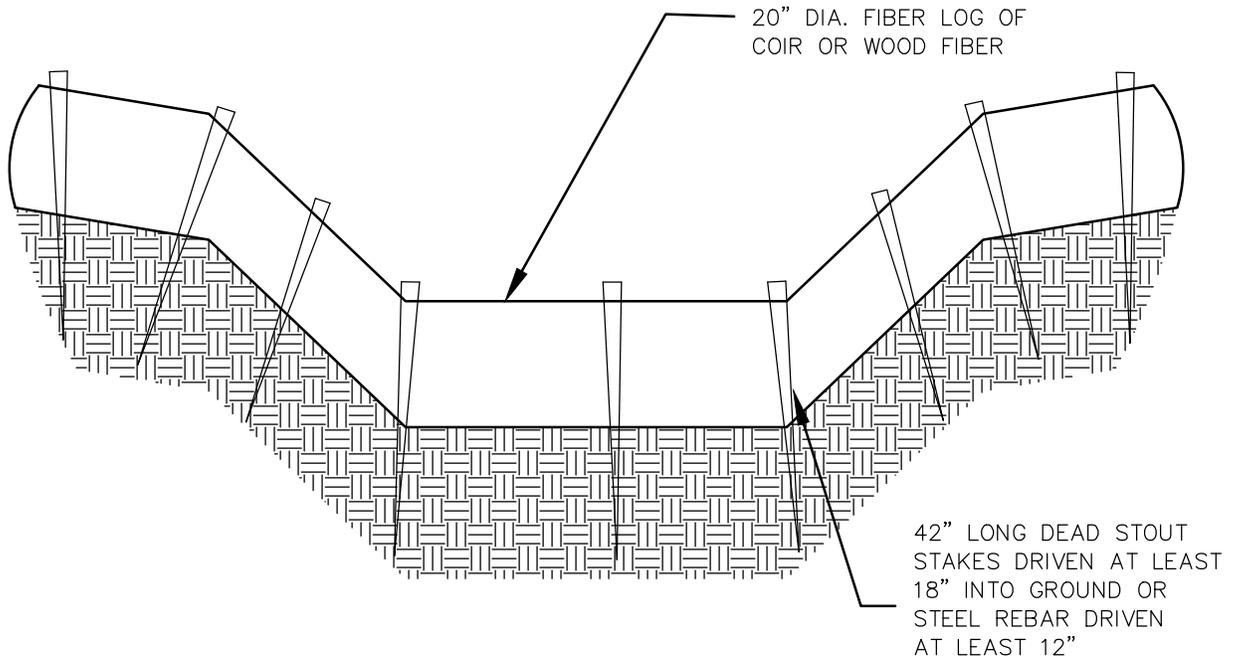


STORMWATER MANUAL

FIGURE 11-17

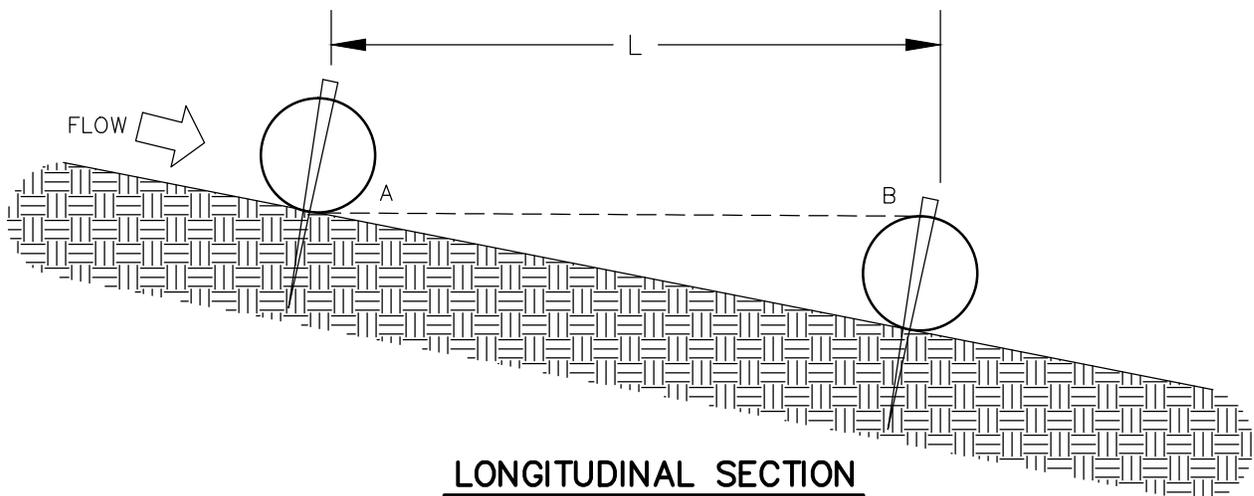
FIBER LOG CHECK DAM

(OCTOBER 1, 2016)



SECTION ACROSS CHANNEL

STAKES SHALL BE SPACED NO FURTHER
THAN 24" AND SHALL BE DRIVEN AT EACH
SIGNIFICANT SLOPE BREAK AND WITHIN 6" OF EACH END.



LONGITUDINAL SECTION

L = DISTANCE SUCH THAT POINTS A AND B ARE OF EQUAL ELEVATION

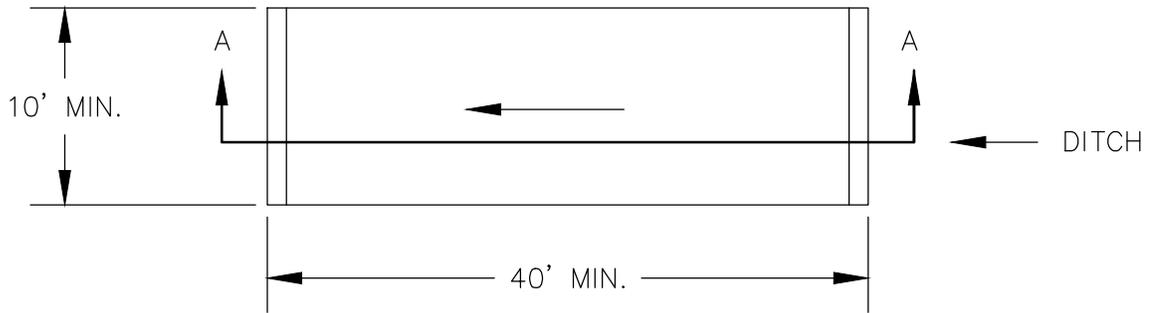


STORMWATER MANUAL

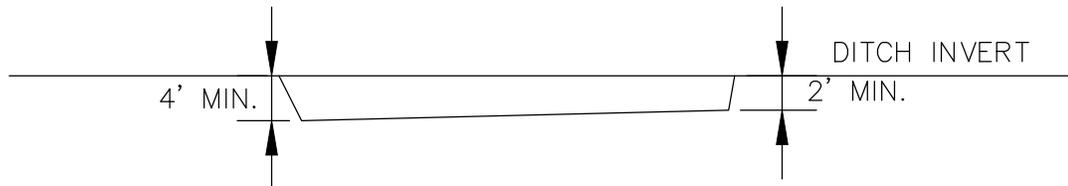
FIGURE 11-18

SEDIMENT TRAP

(OCTOBER 1, 2016)



PLAN VIEW



SECTION A-A

NOTES:

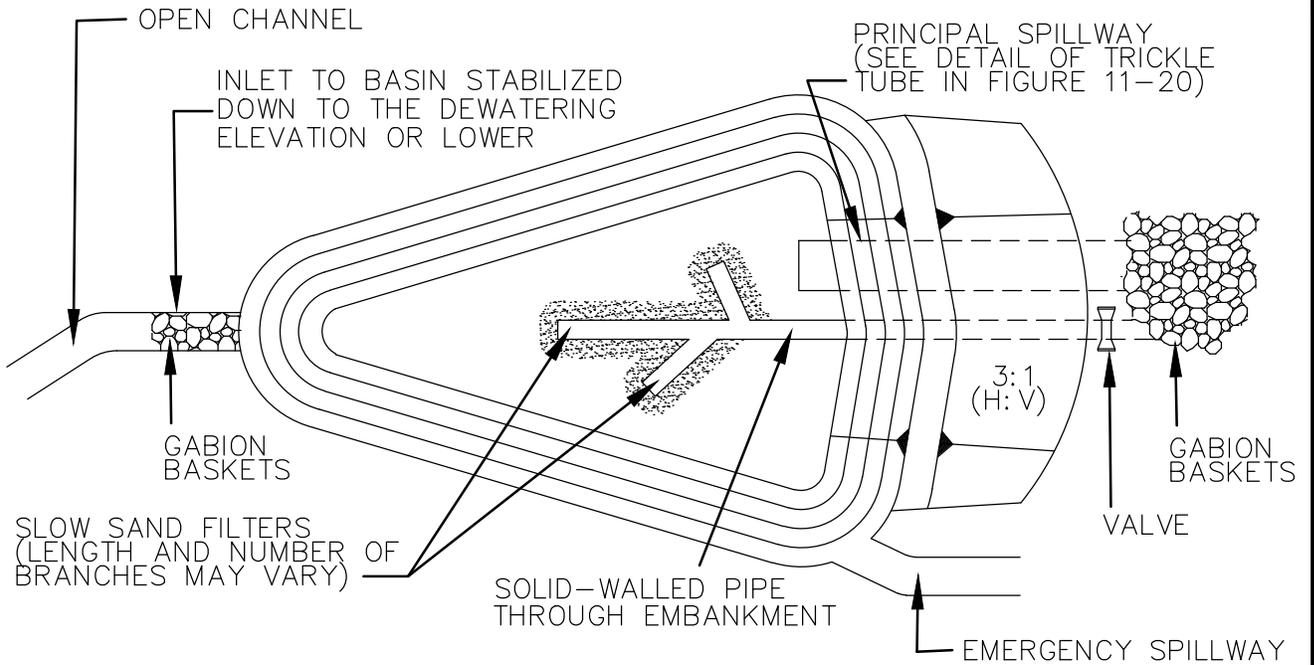
- 1) THE SIZE, SHAPE AND LOCATION OF TRAP MAY BE ADJUSTED FROM THAT SHOWN IN THE CONSTRUCTION PLANS, AS DIRECTED BY THE ENGINEER.
- 2) THE SEDIMENT TRAP MAY BE CONSTRUCTED AS DIRECTED BY THE ENGINEER AS LONG AS THE AREA AND DEPTH IS AT LEAST AS THAT INDICATED ON THE PLANS.
- 3) SEDIMENT TRAP SHALL BE CONSTRUCTED BY EXCAVATING THE BASIN IN NATURAL OR EXCAVATED CHANNELS. SEDIMENT DEPOSITS IN TRAP SHALL BE REMOVED EACH TIME THE TRAP IS APPROXIMATELY 50 PERCENT FILLED. WHEN THEIR USEFULNESS HAS ENDED, THE TRAPS SHALL BE REMOVED, SURPLUS MATERIAL DISPOSED OF AND THE ENTIRE DISTURBED AREA SHALL BE SEEDED AND PROTECTED, OR SODDED, AS DIRECTED. SEDIMENT TRAPS MAY REMAIN IN PLACE UPON COMPLETION OF THE PROJECT ONLY WHEN PERMITTED BY THE ENGINEER OR THE PLANS.



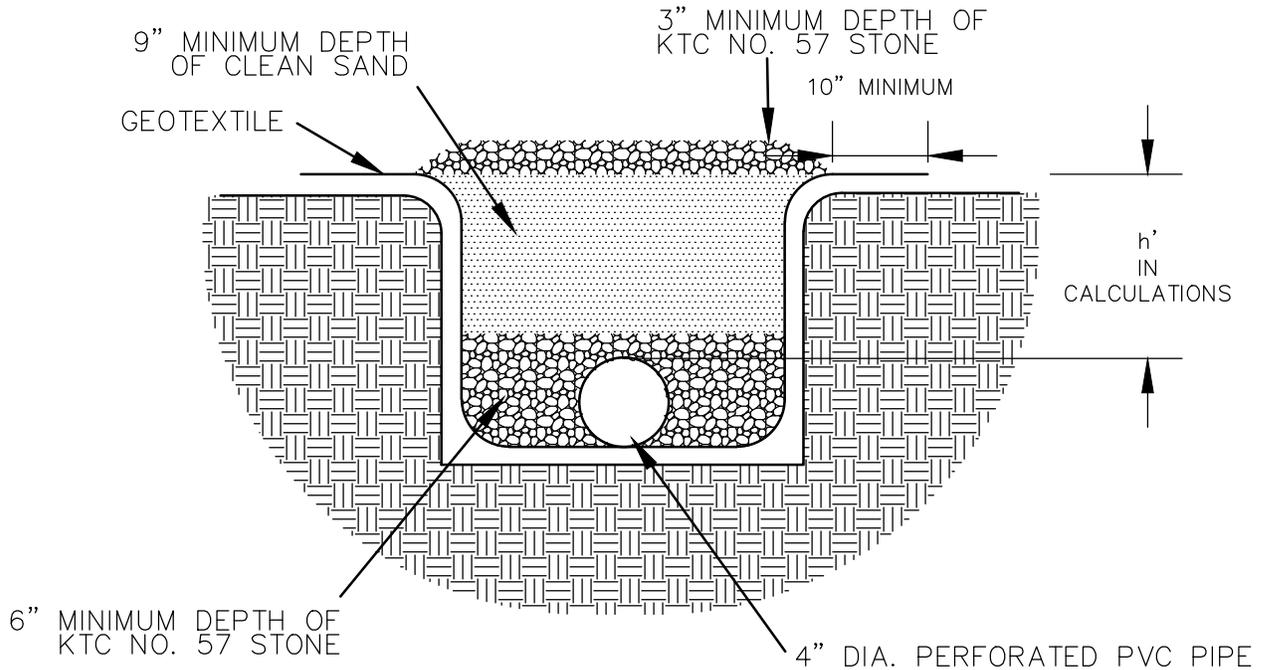
STORMWATER MANUAL

FIGURE 11-19

SEDIMENT POND WITH
SAND FILTER OUTLET
(OCTOBER 1, 2016)



PLAN VIEW
N.T.S.

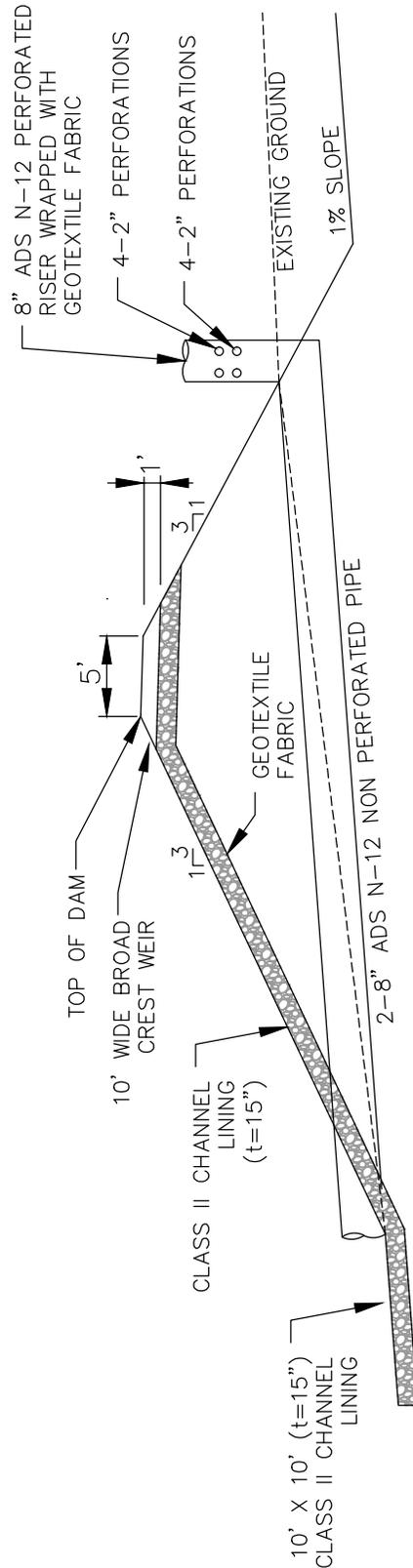


TYPICAL SECTION
N.T.S.



STORMWATER MANUAL

FIGURE 11-20
TEMPORARY SEDIMENTATION BASIN
OUTLET STRUCTURE / SPILLWAY
DETAIL
(OCTOBER 1, 2016)



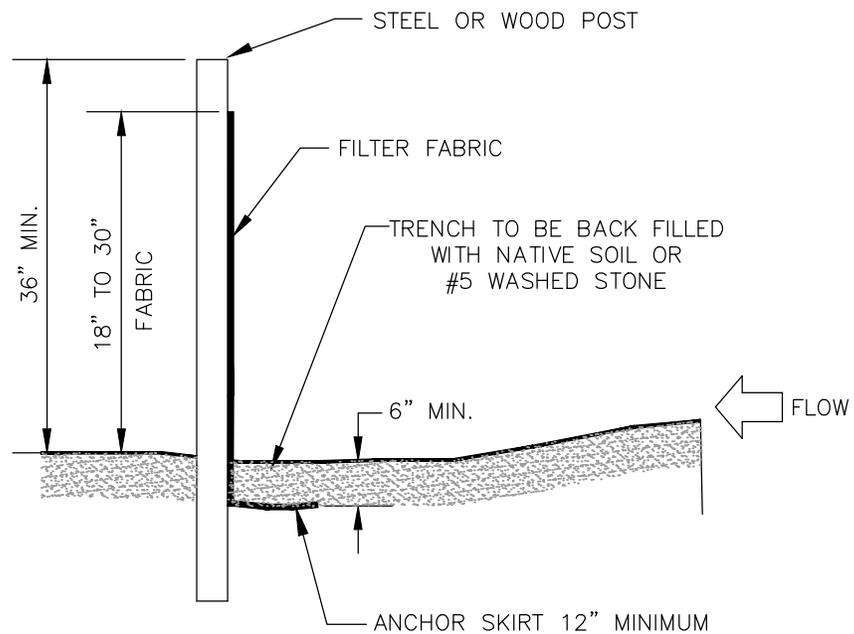
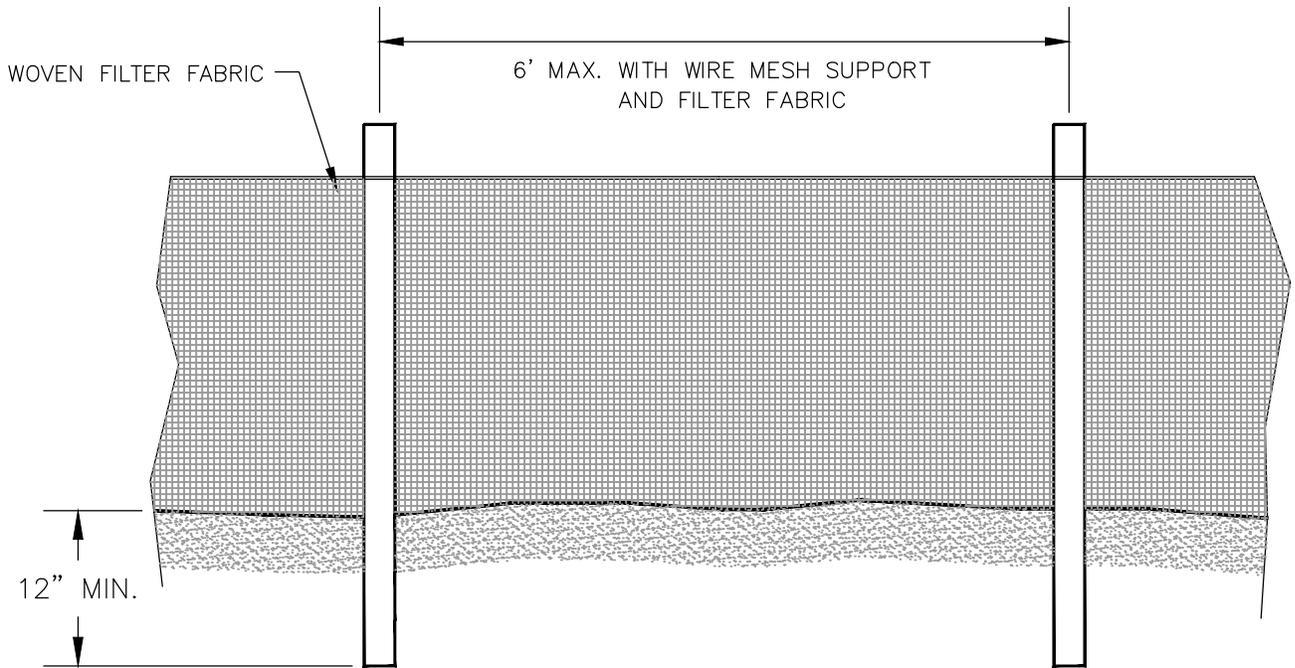
TEMPORARY SEDIMENTATION BASIN
OUTLET STRUCTURE / SPILLWAY
N.T.S.



STORMWATER MANUAL

FIGURE 11-21
TEMPORARY SILT FENCE

(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 11-22

TEMPORARY SILT FENCE GENERAL NOTES

(OCTOBER 1, 2016)

GENERAL NOTES

1. FILTER FABRIC SHALL BE PURCHASED IN A CONTINUOUS ROLL AND CUT TO THE LENGTH OF THE BARRIER. WHEN JOINTS CANNOT BE AVOIDED, FILTER FABRIC SHALL BE SPLICED TOGETHER ONLY AT A POST WITH 3 FOOT MIN. OVERLAP, AND SECURELY SEALED.
2. POSTS SHALL BE SPACED AT 6 FOOT INTERVALS IN AREAS OF RAPID RUNOFF.
3. POSTS SHALL BE AT LEAST 5 FEET IN LENGTH.
4. STEEL POSTS SHALL HAVE PROJECTIONS FOR FASTENING WIRE AND FABRIC.
5. WOOD POSTS SHALL BE 2 INCHES BY 2 INCHES OR EQUIVALENT. STEEL POSTS SHALL BE 1.33 LBS PER LINEAR FOOT.
6. A WIRE MESH SUPPORT FENCE SHALL BE FASTENED SECURELY TO THE UPSLOPE SIDE OF THE POSTS USING HEAVY DUTY WIRE STAPLES AT LEAST 1 INCH IN LENGTH, WIRE TIES OR HOG RINGS. THE WIRE SHALL EXTEND INTO THE TRENCH A MINIMUM OF 2 INCHES AND SHALL NOT EXTEND MORE THAN 36 INCHES ABOVE THE ORIGINAL GROUND SURFACE.
7. WASHED STONE SHALL BE USED TO BURY SKIRT WHEN SILT FENCE IS USED ADJACENT TO A CHANNEL, CREEK, OR POND.
8. TURN SILT FENCE UP SLOPE AT ENDS.

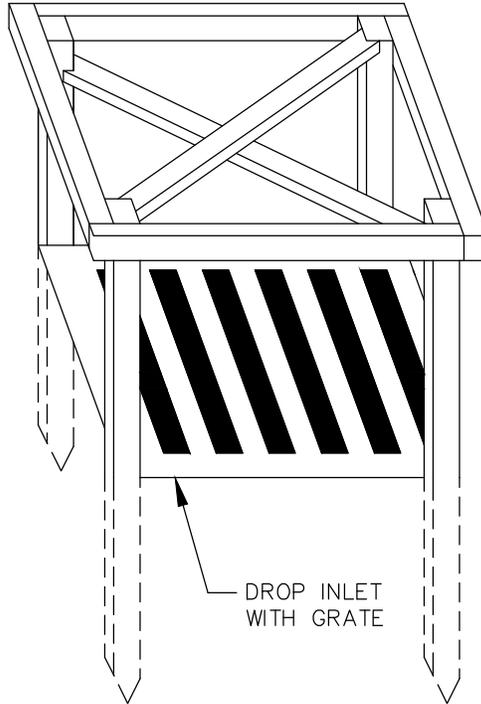


STORMWATER MANUAL

FIGURE 11-23

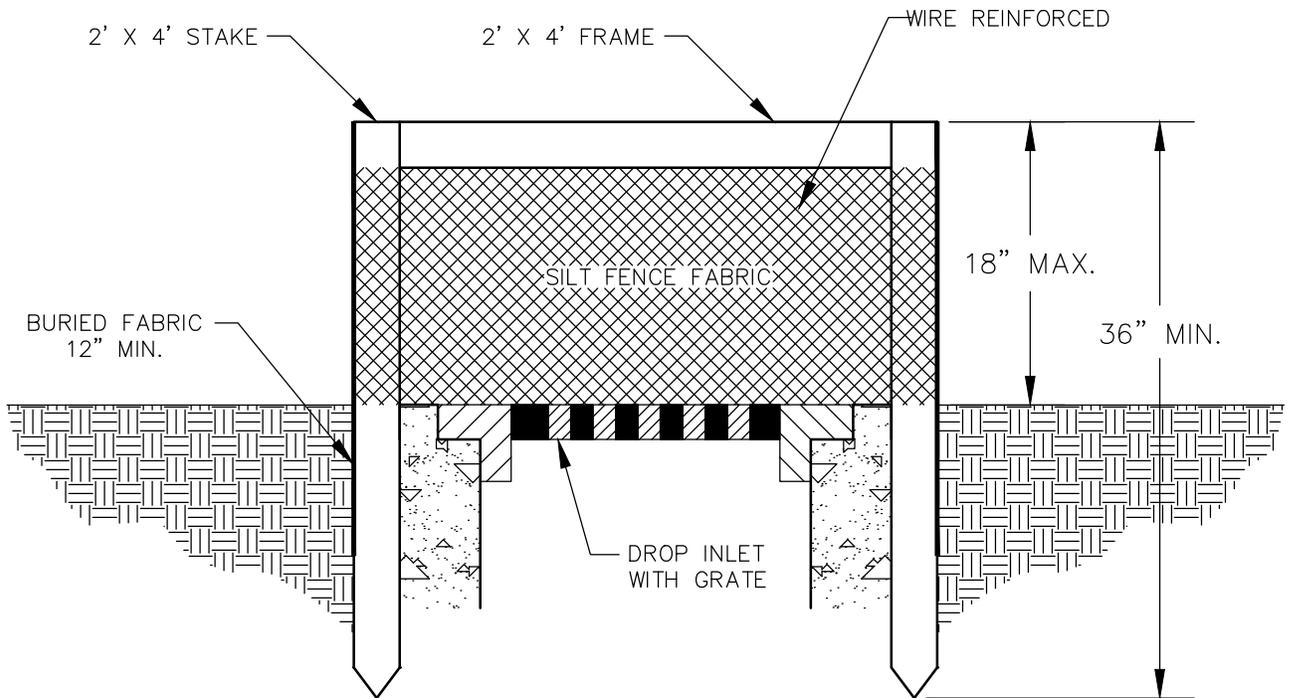
DROP INLET PROTECTION
USING SILT FENCE

(OCTOBER 1, 2016)



DROP INLET
WITH GRATE

**ISOMETRIC VIEW OF
2 X 4 WOOD FRAME**



2' X 4' STAKE

2' X 4' FRAME

WIRE REINFORCED

SILT FENCE FABRIC

18" MAX.

BURIED FABRIC
12" MIN.

36" MIN.

DROP INLET
WITH GRATE

CROSS SECTION VIEW

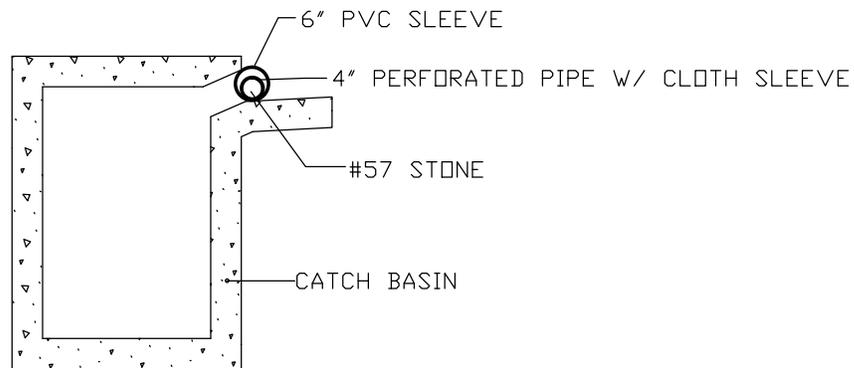
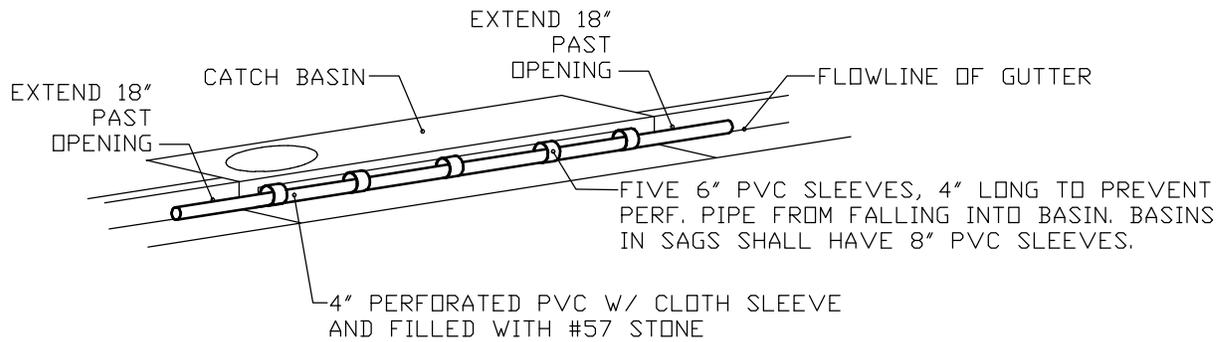


STORMWATER MANUAL

FIGURE 11-24

CATCH BASIN INLET PROTECTION DETAIL

(OCTOBER 1, 2016)



SIDE VIEW

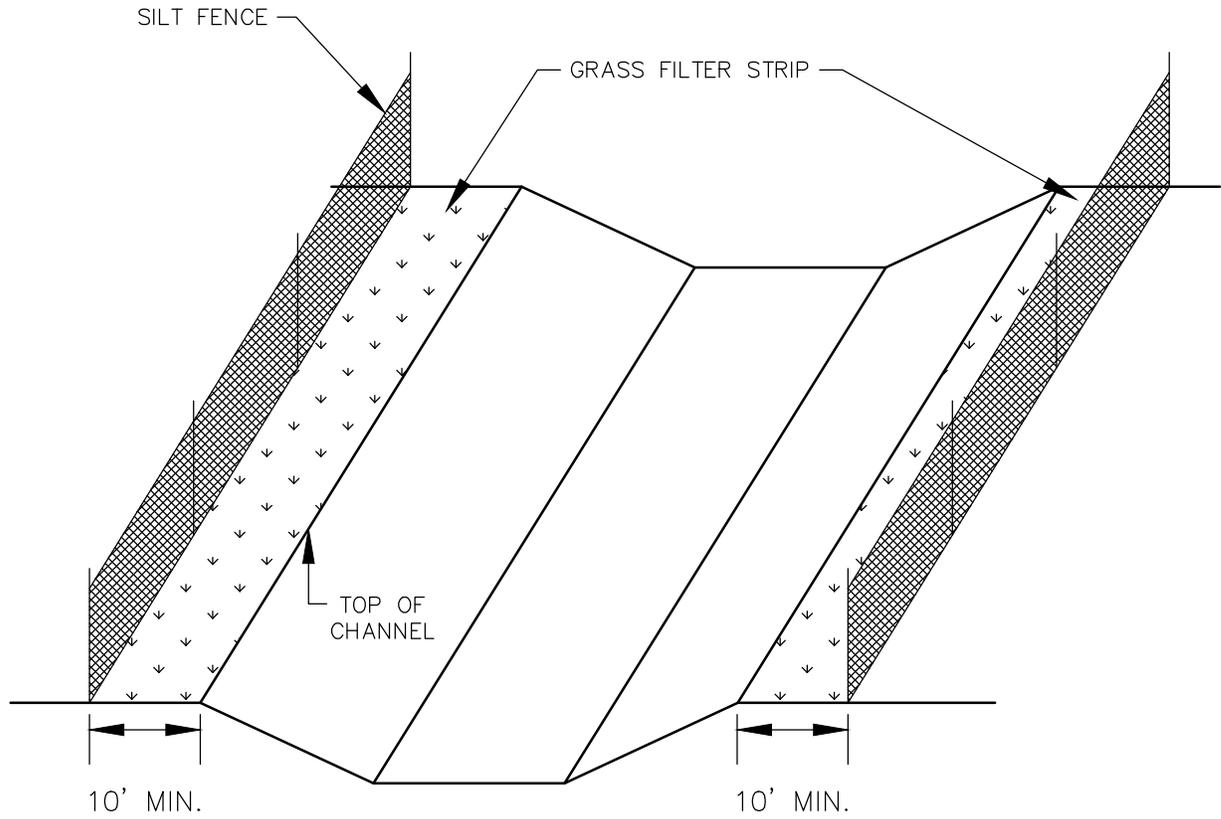
CATCH BASIN INLET PROTECTION DETAIL

N.T.S.



STORMWATER MANUAL

FIGURE 11-25
FILTER STRIP FOR
CONSTRUCTED CHANNEL
(OCTOBER 1, 2016)





STORMWATER MANUAL

FIGURE 11-26

PUMP-AROUND FLOW DIVERSION

(OCTOBER 1, 2016)

