Berea Stormwater Manual

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City of Berea, Kentucky

CDP Engineers, Inc.

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CHAPTER 1 – INTRODUCTION

1 GENERAL INFORMATION

1.1 Background and Purpose

The National Pollution Discharge Elimination System (NPDES) was created as part of the 1972 amendments made to the Clean Water Act. This program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. Over the years point discharges have been defined to include many types of discharges. Included in these discharge are construction runoff and runoff from storm drainage systems.

Under the program, states that meet certain criteria have the authority and responsibility to regulate discharges into these waters. In Kentucky this authority and responsibility lies with the Division of Water (DOW) in the Energy and Environment Cabinet, Department for Environmental Protection. The DOW regulates these discharges under Kentucky's version of the NPDES, the Kentucky Pollution Discharge Elimination System (KPDES).

The City of Berea operates under the requirements of KPDES general stormwater permit for small municipal separate storm sewer systems (MS4), issued to Berea in 2012. The City has six (6) minimum control measures that are required for implementation in order to be compliant with the MS4 stormwater permit. This manual is a compilation of stormwater and floodplain management resources for design and construction of stormwater facilities in the City of Berea.

The City of Berea Stormwater Ordinance and the Land Management and Development Ordinance, establish the legal framework for reviewing construction plans for stormwater management provisions and for requiring grading permits to control erosion and sedimentation. This manual provides stormwater management regulations and technical guidelines for developments built within the City of Berea to prevent excessive erosion, to control stormwater runoff quantity, and to reduce pollutants in stormwater runoff to the maximum extent practicable.

1.2 Current Edition

This is the first edition of the manual. Changes to this manual will be made by the city as necessary. A list of revisions will be maintained as addenda to the manual between manual updates.

1.3 Authorization and Title

As authorized by city of Berea Stormwater Ordinance ------------ and adopted by reference by the City Council (change to reflect how the city will accept this manual), the provisions of this document establish the regulations and technical guidelines developed by the Codes and Planning Department to enforce the terms of the development ordinance.

This manual shall be cited as the City of Berea "Stormwater Procedures Manual."

1.4 Scope

In accordance with the Stormwater Ordinance and the Development Ordinance, the provisions of this manual shall replace any previous regulations and shall apply to all land alteration and construction within the City of Berea.

1.5 Language

1.5.1 Rules

The following rules apply to the text of this manual as referenced:

1. The particular shall control the general.
2. In the case of any difference in meaning or implication between the text of this manual and the text of the Stormwater Ordinance or Land Management and Development Ordinance, the text of the Ordinances shall control.
3. The words "shall" and "should" are always mandatory and not discretionary. The word "may" is permissive.
4. The word "permitted" means permitted without meeting the requirements of these regulations.
5. Words used in the present tense include the future tense. The singular includes the plural, unless the context clearly indicates the contrary.
6. All public officials, bodies, and agencies to which reference is made are those of the City of Berea, Kentucky unless otherwise indicated.
7. The term "City" or "Berea" shall mean the area of jurisdiction of the City of Berea, Kentucky.
8. Reference to "Ordinance" is to either the Stormwater Ordinance or the Land Management and Development Ordinance, current revisions unless otherwise specified.
9. Reference to "Regulations" is to the regulations presented in the Berea Stormwater Procedures Manual unless otherwise specified.
10. Unless specifically or otherwise noted the term "development" shall include "redevelopment" and "significant redevelopment" as defined in Appendix A. Significant redevelopment shall be required to follow the same requirements as new developments.

1.5.2 Definitions

In general, all words used in these regulations shall have their common dictionary definitions. Definitions for certain specific terms as applied to these regulations are provided in the Berea Stormwater Ordinance and this Appendix.

1.6 Legal Considerations

1.6.1 Caveat

This manual neither replaces the need for professional engineering judgment nor precludes the use of information not presented in this manual. The user assumes full responsibility for determining the appropriateness of applying the information presented herein. Careful consideration should be given to site-specific conditions, project requirements, and engineering experience to ensure that criteria and procedures are properly applied and adapted.

1.6.2 Disclaimer of Liability

The degree of flood protection intended to be provided by the Floodplain Overlay District Ordinance, the Land Management and Development Ordinance, the Stormwater Ordinance, and this manual is considered reasonable for regulatory purposes, and is based on engineering and scientific methods of study. Larger floods may occur on occasion, or the flood height may be increased by man-made or natural causes, an example of which might be debris blocking a channel or clogging a culvert opening. These ordinances and regulations do not imply that land outside the areas of special flood hazard or uses permitted within such areas will be free from flooding or flood damages. These ordinances and regulations shall not create a liability on the part of, or a cause of action against, the City of Berea or any officer or employee thereof for any flood damages that result from reliance on these regulations or ordinances, or any administrative decision lawfully made thereunder.

The City of Berea is required under the NPDES Phase II regulations to develop a stormwater quality program that reduces stormwater pollutants in runoff from new development and redevelopment to the maximum extent practicable. The Stormwater Ordinance and this manual outline an approach to stormwater quality management that is reasonable and meets the maximum extent practicable, based upon the most current stormwater quality research. This Stormwater Procedures Manual shall not create a liability on the part of, or a cause of action against, the City of Berea or any officer or employee thereof for damages that result from reliance on these regulations or ordinance, or any administrative decision lawfully made thereunder.

1.6.3 Severability

If any section, subsection, sentence, clause, phrase, or portion of these regulations is for any reason held invalid or unconstitutional by any court of competent jurisdiction, such portion shall be deemed a separate, distinct, and independent provision, and such holding shall not affect the validity of the remaining portions of these regulations.

1.6.4 Compatibility

If any provisions of these regulations and any other provisions of law impose overlapping or contradictory requirements, or contain any restrictions covering any of the same subject matter, that provision which is more restrictive or imposes higher standards or requirements shall govern. These regulations do not relieve the applicant from provisions of any other applicable codes, ordinances, or regulations not explicitly repealed by these regulations.

1.6.5 Saving Provision

These regulations do not abate any enforcement actions in progress pursuant to violations committed under existing stormwater management regulations unless as expressly provided herein.

CHAPTER 2 – STORMWATER MANAGEMENT POLICY

2 OVERVIEW

2.1 Planning

To be truly effective, a stormwater management plan should consider the total scope of development (i.e., transportation, residential, commercial, industrial, and agricultural).

A basic level of planning should be undertaken before designing any project that would properly locate facilities and adequately address local concerns, permitting requirements, legal considerations, and other potential problems. In other words, the designer should become involved in the early stages of project development and not wait until the later design stages.

2.2 Water Quality and Quantity Issues

Stormwater management addresses water quality or water quantity issues. Water quality issues deal with the degradation of runoff, and the protection of environmental resources. Planning for drainage and stormwater management facilities should include a consideration of the potential problems associated with stormwater quality. The following general rules should be followed:

- Maximize stable open channels
- Maximize use of vegetated linings
- Minimize curb and gutter sections and their associated storm sewers
- Minimize culvert lengths

Determinations of stormwater quantity are primarily useful for evaluating and mitigating the impact of a project from a flooding perspective. Land development can increase peak runoff rates and volumes from storm events which can lead to higher flood elevations in the absence of detention ponds (basins, storage areas). Appropriate hydrologic and hydraulic calculations presented in various chapters of this manual should be made to determine the required conveyance.

2.3 General Goals of Drainage Facility Designs

Goals for drainage facility designs are established to protect the integrity of the design, the location and the surrounding watershed of the facility. Procedures contained in this manual should be used to evaluate the ability of a facility to accomplish the following goals:

1. To protect, maintain, and enhance the public health, safety, and general welfare of the City of Berea
2. Does not adversely affect adjoining or downstream properties
3. Reduce runoff rates
4. Reduce flood levels

5. Protect areas subject to flood damages
6. Keep flood plain encroachment outside the limits of regulated floodways
7. Minimize the degradation of water quality
8. Protect special environmental resources
9. Support designated uses for aquatic life; reduce fish kills
10. Restore aquatic habitat

2.4 Objectives of Drainage Facility Design

The objectives of these regulations are to:

1. Establish minimum requirements and procedures to control adverse effects of stormwater runoff and erosion associated with new and redevelopment development
2. Encourage the use of natural and aesthetically pleasing design practices
3. Reduce sediment loads from upland sources; improve riparian vegetation
4. Improve peak and volume controls on urban sources and retrofit inadequate road culverts
5. Increase infiltration; store precipitation and runoff where it falls, then release it slowly
6. Discourage intrusions or development in the floodplain to minimize property damage
7. Encourage the accurate dissemination of floodplain information to potential homebuyers and increase the public awareness of potential flooding problems.
8. Locate public facilities and utilities, such as water and gas mains; electric, telephone, and sewer lines; and streets and bridges, in flood prone areas to minimize damage to utility facilities and the floodplain
9. Ensure a functional stormwater management system that will not result in excessive maintenance costs
10. Guide the construction of stormwater management facilities by developing stormwater master plans to address stormwater runoff
11. Reduce pollutants in stormwater runoff to the maximum extent practicable.

2.5 Policy Statements

To implement the objectives presented above, the following general policy statements shall apply:

1. The Berea Stormwater Procedures Manual intends to establish guidelines, criteria, and procedures for stormwater management activities within the City. Key elements of this program include the Stormwater Procedures Manual, the Stormwater Ordinance, the Floodplain Overlay District Ordinance, the Land Management and Development Ordinance, and stormwater master plans.
2. Each individual project shall be evaluated for consistency with the stormwater master plan for the drainage system, or drainage basin(s), within which the project site is located. Individual project evaluation will determine if stormwater management practices can adequately serve the property and limit impacts to downstream public and private properties. The presence of a regional facility(s) will be considered in determining the extent to which stormwater controls will be necessary.
3. In the absence of a stormwater master plan, a system of uniform requirements shall be

applied to each individual project site. In general, these uniform requirements will be based on the criterion that post-development stormwater peak runoff must not exceed pre-development conditions. Additional requirements will be based on volume control for sites tributary to sinkholes or “drainage” wells.

4. No construction, whether by private or public action, shall be performed in a manner that will negatively impact stormwater runoff in its vicinity or in other areas whether by flow restrictions, increased runoff, increased pollutant loading, or by diminishing channel or overbank storage capacity.
5. New construction may not aggravate upstream or downstream flooding. Offsite improvements may be required in conjunction with new development to mitigate increases in peak flow or volume.
6. Unwarranted acceleration of erosion due to various land development activities must be controlled. Off-site sedimentation is not allowed.
7. New construction shall not be permitted until temporary or permanent erosion prevention and sedimentation control management practices have been placed or constructed and are operational to the City's satisfaction. The City reserves the right to stop construction on properties that do not have adequate erosion prevention and sedimentation control measures.
8. The City reserves the right to require more stringent erosion prevention and sedimentation control practices on properties that drain to impaired, exceptional or otherwise sensitive drainage ways or sinkholes as identified by the City.
9. The City reserves the right to require maintenance or modification of stormwater management practices that are not operating properly, as determined by the Codes and Planning Director.
10. The City encourages regional stormwater management detention, serving large tracts of land or multiple property owners that may be consistently and efficiently managed and maintained. These types of practices will be encouraged in order to replace or reduce the implementation of on-site stormwater management practices, as appropriate and supported technically by a stormwater master plan.
11. Pollutant loading from individual properties must be reduced to the maximum extent practicable.
12. Redevelopment of properties containing on-site stormwater management practices may be permitted by the City provided the property and downstream public and private properties, infrastructure or “Waters of the Commonwealth” are adequately protected by a regional facility(s) from stormwater impacts.
13. Construction in floodplains should be done in a way that protects or enhances stormwater quality and promotes land and tree conservation, greenways, floodplain preservation and hazard mitigation. Furthermore, development within a floodplain shall be consistent with the requirements of the Stormwater Ordinance, the Land Management and Development Ordinance, and the Floodplain Overlay District Ordinance. Land disturbance activities will not be allowed within the floodway except as permitted by these ordinances.
14. Homebuilders must comply with the approved grading, drainage, and erosion and stormwater quality plans for the development in which they are building and are responsible for erosion leaving their construction site (lot).
15. The City will be responsible for maintenance of large drainage systems that are of a size deemed too large for individual landowners to maintain. City maintenance activities will be limited to those necessary to maintain a functioning drainage system. Drainage system maintenance to improve aesthetics or address minor erosion problems will not be

performed by the City. Refer to Section 2.10 of the Stormwater Control Ordinance.

16. Maintenance on small drainage systems beyond the extent of City maintenance responsibility shall be the responsibility of individual landowners.
17. The minimum diameter for driveway culverts and private drainage systems will be 15 inches. The minimum diameter for all other culverts will be 18 inches.
18. Water quality buffers must be established and maintained in perpetuity along new developments or redevelopments.

2.6 Stormwater Management Systems

The regulated stormwater systems in the city of Berea lies on both public and private property. Portions of the stormwater infrastructure are constructed through the city capital improvement projects and portions are constructed through private residential, commercial, and industrial development. In many cases, the city of Berea may ultimately become the owner of the stormwater infrastructure constructed by private development. To responsibly regulate the stormwater infrastructure, a consistent quality of construction is necessary regardless of the entity financing and managing the construction.

The purpose of this manual is to provide standards to assure quality in the design and construction of stormwater infrastructure that becomes a part of that owned or regulated by the city by providing standard design criteria to the engineers who design the infrastructure. The manual establishes uniformity in design assumptions and general methods of design. The manual also sets policy regarding design standards and specifications and provides for uniform interpretation of the specifications. Finally, the manual outlines the required calculations and design details applicable to all stormwater infrastructure.

The manual includes requirements for the stormwater infrastructure that is routinely designed and constructed, including rational engineering principles and practices. However, more comprehensive methods of analysis and design may be required 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.

2.7 Stormwater Detention

Increased urbanization within Berea has caused radical changes to the topography, ground cover, and stormwater management systems. These changes have adverse effects on the environment, primarily through the subsequent increase in stormwater runoff quantity and nonpoint source pollution which impacts stormwater quality. In some areas, the combination of increased runoff and the location of property near a major drainage system causes frequent flooding (often several times per year). In these areas, upstream control of frequent as well as large flows may not provide adequate flood protection for residents and property downstream.

To minimize adverse stormwater impacts, on-site detention of stormwater is mandatory for all developments that are not served by an adequately sized regional stormwater management facility, subject to review and approval by the City. Because detention in downstream areas of a large basin can cause increased peak flows in downstream channels, the City reserves the right to alter the detention criteria or to prohibit it where it would cause adverse impacts. This decision shall be based on sound engineering judgment along with supporting data and studies as available. The City may also require or allow some type of in-stream mitigation measure in lieu of detention, where it can be shown that such measures are of equal or greater benefit.

Nevertheless, in all cases where detention facilities are required, the location and design must comply with any stormwater master plans that may have been adopted by the City.

This policy is primarily concerned with post-development drainage conditions being maintained at the pre-development conditions, for flood storage, flow and velocity; it should also be applied under certain conditions for the purpose of maintaining adequate capacity of an existing outfall or combining public and private efforts to correct existing deficiencies for flooding and erosion. In some cases controlling the total volume of runoff to predevelopment levels may also be required, such as areas tributary to sinkholes.

2.7.1 Ownership of Detention Basins

The City of Berea shall own and maintain the facilities listed below in single family residential and two family residential developments:

- Dry Detention Ponds
- Extended Detention Ponds
- Infiltration Basins
- Constructed Wetlands

These facilities shall be on a separate lot with adequate access for maintenance, and dedicated to the City of Berea. In multi-family residential developments, these facilities shall be owned and maintained by the City of Berea if they are on a separate lot with access to a public street.

The property owner shall own and maintain stormwater Best Management Practices (BMPs) in commercial and industrial developments. The BMPs shall not be subdivided into multiple lots. Furthermore, they shall be connected to at least one building lot, but no more than one building lot.

The purpose of these requirements is to ensure that:

- A citizen, group of citizens, or neighborhood association does not own or maintain a new detention pond or other BMP
- Only one corporation or business owns and maintains a detention pond or other BMP

2.8 Construction in the Waters of the Commonwealth inside the Berea Corp. Limit

In general, construction activities shall not be allowed in the waters or post-development floodplains of the city. Filling the floodplain to allow more land to be developed shall be prohibited. Excavation in the floodplain to lower flood levels shall not be permitted. Only the following activities shall be undertaken in the waters or post-development floodplains

- Temporary sediment ponds that will be converted to a permanent stormwater management pond
- Roadways and utilities that cross at angles within 10 degrees of being perpendicular to the stream or floodplain
- Sanitary sewers, constructed outside the horizontal limits of the 10-year post-development floodplain, with manhole covers set at an elevation one foot higher than the 100-year post-development floodplain, using the procedures described in Chapter 5 of this manual; surface fill may not be placed in the floodplain to cover a sanitary sewer; any excess material from excavation of the sewer must be removed from the post-development floodplain
- storm sewer pipe outlets where the outlet terminates at the edge of the post- development floodplain
- regional flood control or water quality control ponds constructed by the City of Berea
- other flood control practices that do not disturb below the normal top of bank of the stream
- water quality practices that do not disturb below the normal top of bank of the stream
- pedestrian crossings and trails

If situations arise where there are no feasible alternatives to construction in a water or floodplain, the construction will only be allowed if the water or floodplain can be enhanced in the area of construction or if enhancement work is done on another water as mitigation.

2.9 Mitigation

It is the intent of the City of Berea to ensure that impacts to streams and wetlands are mitigated. Some impacts are regulated by the U.S. Army Corps of Engineers (COE) and the Kentucky Division of Water (KDOW) and require mitigation plans to be approved by those agencies. In those cases, the mitigation plans approved by the COE and the KDOW will satisfy the requirements of this section if the mitigation takes place in the City of Berea.

In cases where neither the COE nor the KDOW regulate a stream or wetland impact, the following mitigation guidelines shall be followed:

Fills along a Stream > 200 Feet
Fill for road crossings and embankments shall be mitigated by establishing a riparian buffer zone on each side of the stream for a length equal to the width of the post-development floodplain.

Stream Relocations > 200 Feet
The relocated stream shall be designed to:

- restore the geomorphic function, including the meandering pattern
- include measures to enhance aquatic habitat
- use natural or bioengineering techniques to stabilize banks
- include a minimum 25 foot vegetative buffer strip on each side

Wetlands > 0.5 acre
Mitigation shall take the form of creating another wetland at a ratio of 1:1, or obtaining credits in a wetland bank.

2.10 Lot Drainage in Residential Development

Constructed channels shall be provided for drainage areas greater than 1 acre in residential developments. The channel shall be designed to carry the 100-year storm to the stream. 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.

Channels in back yards and side yards that receive runoff from a storm sewer or culvert shall have a paved (generally concrete) trickle channel designed to carry 50% of the 1 year storm. The design criteria for the trickle channel are contained in Chapter 6.

2.11 Maintenance of Drainage Easements

The City of Berea shall be responsible for maintaining the major structural items in the public drainage system easement. These items include pipes, paved channels, and headwalls. In residential areas, minor maintenance like mowing and trash/debris control, shall be the responsibility of the property owner. For commercial and industrial areas, the property owner shall be responsible for all maintenance.

Property owners shall not construct anything in the public drainage system, including the waters and post-development floodplains of Berea adjoining their property that will impede the flow of water.

2.12 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. The evaluation shall be based on fully developed conditions downstream of the structure in accordance with the Comprehensive Plan.

2.13 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 have to 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 3.

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 the City of Berea. Rather than improve the upstream structure, the Developer may choose to establish an easement to ensure that the impact area downstream of a failed impoundment is not developed.

2.14 Offsite Drainage Problems

Where offsite stormwater problems are known to exist, development projects shall consider these problems and integrate solutions determined through the Watershed Studies discussed above. Development projects shall help mitigate these existing problems. For example, in areas where downstream flooding is known to be a problem, the City of Berea may require that peak flows from a new development be less than pre-development peak flows.

2.15 Coordination with the National Flood Insurance Program

Construction within the FEMA Special Flood Hazard Area shall comply with the Land Management and Development 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 that contain the FEMA Special Flood Hazard Area, the Developer shall determine the 1% Annual Chance “Post-developed floodplain” (defined in Section 1.3.3) using the procedures in this manual. For developments containing the FEMA Special Flood Hazard Area, the following minimum requirements shall apply:

- The 1% Annual Chance Special Flood Hazard Area and the 1% Annual Chance Post- Development floodplain shall be shown on the 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) are permitted unless a 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 must obtain the final LOMR or LOMR-F from FEMA (44 CFR 72.1).
- Any other physical change which may affect flooding conditions must be submitted to FEMA for a Letter of Map Revision (LOMR) within six (6) months of the change being made (44 CFR 65.3).
- 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 the City of Berea.
- In the event of conflict between Local, State, and Federal regulations, the more stringent regulation shall govern.

2.16 Erosion Control Requirements

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

2.17 Water Quantity Criteria for New Development

2.17.1 Quantity Impacts

The runoff from impervious surfaces created by development can result in impacts to property and the aquatic community caused by increases in the rate of flow and volume of water. Aquatic community impacts are addressed in Section 2.18 Impacts to property may occur because of

- 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

2.17.2 Exemptions from Quantity Controls

Development sites that are part of a regional stormwater master plan are exempted from quantity controls. Other sites are exempted as described below.

1. In general, runoff controls shall not be required if it can be shown by a detailed watershed study that any of the following exists:

    - The construction of detention ponds would not increase downstream flood levels, or
    - Detention ponds are not needed to protect downstream property and the downstream drainage system has sufficient capacity to receive any increase in runoff for the 100- year storm, or
    - Detention ponds are not necessary to control runoff at the exit of a proposed development and constructing such detention ponds would increase flood levels at some point downstream, or
    - The City of Berea determines that detention ponds are not needed to control runoff and installing such facilities would not be in the best interest of the city

    Therefore, detention shall not be required for a site if the effect of uncontrolled runoff for the 100-year 1-hour and 100-year 6-hour storms can be shown to increase flood elevations by less than 0.1 foot on the receiving stream (solid or dashed blue line).

    To evaluate the effect on the receiving stream, the Engineer shall conduct a watershed study to determine the flood levels using the 100-year 1-hour and 100-year 6-hour storms. The study area of the receiving stream shall extend downstream to, but no more than, 10 times the area of the proposed development. This means that when the receiving stream combines with another stream, and the combined watershed is more than 10 times the development site area, then the study area shall stop immediately before the confluence with the other stream.

    The study area shall be based on fully developed conditions assuming no detention on any of the remaining parcels of land within the study area. If the cumulative effect of the additional runoff from the undeveloped sites within the study area, without detention, increases the water level less than 0.1 foot for each storm, then no detention shall be required on the development site in question. If the cumulative effect increases the water level greater than 0.1 foot for either storm within the study area, no detention shall be required on the site in question if all of the following apply:

- The increase in water level for each storm at the downstream end of the study area is less than 0.1 foot.
- The drainage system has sufficient capacity to carry the flow for both storms from the site in question to the receiving stream. Sufficient capacity for a pipe system shall be defined as no overflows at inlets or manholes. Sufficient capacity for an open channel system shall be defined as a drainage easement wide enough to carry the flow.

2. Small “bathtub” detention ponds for small drainage areas are generally ineffective at reducing peak flows because they clog easily. Therefore, small drainage areas shall not be required to have detention ponds if they meet the following conditions:

   a. The drainage area is residential, less than 5 acres in size, and the pipe/open channel drainage system from the site to the blue line stream has sufficient capacity, as defined above, to carry the 100-year storm.

   b. The drainage area is commercial or industrial, less than 1.0 acres in size, and the pipe/open channel drainage system from the site to the blue line stream has sufficient capacity, as defined above, to carry the 100-year storm.

2.17.3 Peak Flow Design Criteria

Stormwater BMPs shall be designed and constructed to maintain existing peak flows from new development projects. The design storms used for this analysis are contained in Chapter 5. BMPs for controlling peak flows are contained in Chapters 6-11. The BMPs that can be used for residential and commercial/industrial development are shown in Table 2-1.

2.17.4 Downstream Study Limits

Stormwater facilities for future development shall be designed so that the capacity of the existing and proposed pipes, culverts, channels, and other components of the drainage system are not exceeded. The study limits for a proposed development site shall extend downstream to a point where the drainage area is 10 times the area of the proposed development.

The Engineer shall determine the existing flow capacity of the downstream drainage system impacted by the proposed development if the City of Berea has not conducted such a study. Table 2-2 lists the flow criteria for these drainage system components.

2.17.5 Capacity of the Proposed Drainage System

Storm sewers, inlets, culverts, and constructed channels shall be designed to meet the design criteria in Table 2-2.

2.17.6 Flood Protection Elevation

All residential, commercial, and industrial structures shall be constructed at or above the Flood Protection Elevation. The Flood Protection Elevation (FPE) shall be determined by the Engineer and shall be all of the following:

- Two feet above the calculated 100-year-post development floodplain elevation, or two feet above the FEMA base flood (100-year) elevation, whichever is higher
- Two feet above the 100-year storm elevation in constructed channels
- Two feet above the 100-year storm elevation at low points in streets if there is no overflow channel
- Two feet above the 100-year, 24-hour storm elevation in detention ponds and wet ponds
- Two feet above the embankment crest of detention ponds and wet ponds

2.17.7 Buffers - Vegetated Buffer Strip, Floodplain and Floodplain Setback Requirements

All land 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 24-hour post-development floodplain.

No structure can be constructed within the 100-year floodplain. The width of this buffer varies depending on the width of the floodplain.

A 25-foot vegetative buffer shall be required from the top of bank on a perennial, or a blue-line, stream or from the center of an intermittent stream. These buffers are illustrated in Figure 2.1.

Buffers shall be required along all streams, ponds or wetlands.

Vegetated buffers and floodplain buffers must be protected during construction. Temporary fencing or other suitable alternatives must be placed at the outer edge of the buffer to prevent inadvertent disturbance. The method of buffer protection must be detailed in the SWPPP.

Buffers on private property shall be protected by individual lot easements. Maintenance of the buffers shall be the responsibility of the property owner or with a homeowner's association. Maintenance shall be limited to removing dead or diseased plant material, repairing erosion problems internal to the buffer, clean up after a storm, or removal of invasive plants. Woody vegetation shall be removed by hand. Vegetative root systems shall be left intact to maintain the integrity of the soil. Stumps shall remain where trees are cut.

TABLE 2 - 1, OPTIONS FOR STORMWATER MANAGEMENT

Options for Stormwater Management

Best Management Practice	**Residential Development**		**Commercial and Industrial Development**	
	Quantity	Quantity	Quantity	Quantity
Bioretention Systems				*
Infiltration Systems				
Downspouts to Grass		*		*
Modular Pavement				*
Swales Bermed		*		*
Swales		*		*
Biofiltration Swales				*
Terraforming				*
Infiltration Basins		*		*
Vegetated Filter Strips				*
Riparian Buffers		*		*
Sand/Organic Filters				*
Prefabricated Treatment Devices				*
Detention Ponds	*		*	
Extended Detention Ponds	*	*	*	*
Wet Ponds	*	*	*	*
Constructed Wetlands	*	*	*	*

TABLE 2 – 2, FLOW CRITERIA FOR STORMWATER FACILITIES

Stormwater Appurtenance	Design Storm Criteria	Manual Reference Section
Road Inlets on Grade	Spacing is based on allowable spread of water at a rainfall intensity of 4 inches per hour.	Chapter 5
Road Inlets in Sags	Top of Curb: 10-year Back of Sidewalk: 100-year	Chapter 5
Storm Sewers	10-year and 100-year	Chapter 5
Culverts	100-year	Chapter 5
Constructed Channels	100-year	Chapter 6

2.18 Water Quality Criteria for New Development

All development in The City of Berea shall be conducted in a manner that minimizes stormwater pollution to the maximum extent practicable. Both structural and non-structural measures shall be employed at sites to reduce the potential for stormwater pollution. Measures shall also be employed long-term, after development ceases, to reduce the potential for stormwater pollution. Direct connections of non-stormwater runoff to the stormwater system are not allowed. Discharging oils, paints, yard debris and other pollutants to the stormwater system shall be expressly prohibited.

2.18.1 Impairment of Uses

The runoff from impervious surfaces created by new development can result in impacts to the water quality. Impairment to aquatic life may occur because of the loss of aquatic habitat caused by:

- the destruction of riparian vegetation
- decreases in the base flow during non-runoff periods
- increases in stream bank erosion from higher stages caused by additional runoff volume
- bottom scour from higher velocities through culverts and other conveyance mechanisms
- increased toxicity from the increased chemical content
- the nuisance growth of algae and other aquatic plants resulting from the nutrients in runoff
- decreased light penetration from suspended material
- increases in the sediment deposited on the stream bottom

Impairment to secondary contact recreation uses may result from

- increases in bacteriological content due to small animal wastes
- increases 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

- increases in bacteriological content due to small animal wastes
- increases in the presence of petroleum products
- increases in suspended solids resulting in an increased cost of water treatment
- decreases in reservoir water storage capacity resulting from sedimentation

2.18.2 Exemptions from Quality Controls

Development sites that are part of a regional stormwater master plan are exempted from quality controls. Sites less than one acre are also exempted. Water quality BMPs are not required for sites with less than ten percent imperviousness.

2.18.3 Water Quality Volume Criteria

The impact of the increase in the volume of water that becomes runoff rather than infiltration from a development site shall be mitigated through the capture, storage, and release of a volume of water proportional to the amount of impervious area. This volume is referred to as the water quality volume. The procedures for calculating the water quality volume are contained in Chapter 8.

For commercial and industrial areas, at least fifty percent of the site shall be treated with bioretention or infiltration. The remaining area shall be treated using one of the options in Table 2-1.

2.18.4 Infiltration Credit for Floodplains

Proposed developments that contain a floodplain shall receive an infiltration credit of 0.5 acre-feet/acre of floodplain. The credit can be used against the required water quality volume.

2.18.5 Culvert Outlet Velocity Criteria

The design velocity at the culvert outlet shall be reduced to match the natural stream velocity in accordance with the design procedures in Chapter 5.

2.18.6 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.

2.19 Stormwater Standards for Redevelopment Projects

2.19.1 Objectives

The objectives of these standards are to (1) demonstrate compliance with federal stormwater quality regulations and (2) prevent causing new flooding problems.

Constructing water quality best management practices (BMPs) on redevelopment sites is typically more difficult and more expensive than on new development sites. To encourage redevelopment, the water quality requirements for redevelopment are less stringent than those for new development. Whereas new development sites must treat 100% of the runoff to meet the water quality requirements in this manual, redevelopment sites must treat a maximum of 20% of the runoff.

Redevelopment projects generally do not increase the impervious area; thus, water quantity BMPs are not required if the impervious area stays the same or is reduced.

2.19.2 Application

Stormwater standards for redevelopment shall apply to sites that previously contained structures or parking lots, where one acre or more of land (including buildings and parking lots) will be disturbed. Disturbance is defined as construction that exposes soil; it does not include remodeling or pavement surfacing. Proposed development of infill parcels that never contained buildings or parking lots shall be considered new development. Proposed development of parcels containing a residence where the land use is agricultural shall also be considered new development.

2.19.3 Water Quantity Criteria for Redevelopment

Water quantity BMPs are not required if the impervious area is not increased.

If the impervious area is increased less than 1 acre, water quantity BMPs are not required if the downstream drainage system (to a blue-line stream) has sufficient capacity to carry the 100-year 1-hour and 100-year 6-hour storms (this is intended to prevent the construction of small bathtub detention basins because they are usually ineffective). Sufficient capacity for a pipe system shall be defined as no overflows at inlets or manholes. Sufficient capacity for an open channel system shall be defined as a drainage easement wide enough to carry the flow. If a drainage easement does not exist, sufficient capacity shall be defined as an insignificant (<0.1’) rise in the water surface elevation for each storm.

Where required, BMPs shall be implemented to reduce peak flows. A fee in lieu may be allowed as described in Section 2.2.

2.19.4 Water Quality Criteria for Redevelopment

The water quality criteria shall require a 20% reduction in the impervious area that has existed on the site (based on historical maps or other documentation provided by the developer), or implement stormwater quality BMPs for 20% of the site impervious area, or a combination thereof.

A fee in lieu of constructing water quality BMPs may be allowed as described in Section 2.2. It is anticipated that sites less than five acres will pay the fee, and sites of 5 acres or more will construct on-site BMPs.

2.19.5 Erosion and Sediment Control

Erosion and sediment control BMPs shall be installed as described in Chapters 6-11.

2.20 Fee-In-Lieu for New Development and Redevelopment

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. The City of Berea recognizes that constructing on-site best management practices (BMPs) may not be the most effective method for controlling stormwater runoff. Therefore, the city has established a fee-in-lieu of constructing on-site BMPs in such a way to facilitate development and redevelopment, reduce costs for stormwater management, and avoid unnecessary delays for the developer. The fee-in-lieu program is described below:

1 Where water quantity or water quality BMPs are required by this manual, the City of Berea may allow the Developer to pay a fee instead of constructing on-site BMPs whenever the Codes and Planning Director (Director) determines that on-site BMPs are not the most effective method of controlling stormwater runoff. This includes, but is not limited to, the following situations:

   a. The Director has reviewed studies and evaluations conducted by the developer and determined that constructing on-site BMPs
      - will not effectively improve water quality
      - will not effectively reduce peak flows
      - is not feasible because of design constraints, such as the inability for a below ground structure to drain by gravity

   b. Existing downstream homes and businesses that experience structure flooding are being removed from the floodplain

   c. Flood control or water quality control BMPs are being planned or implemented in the watershed.

   d. Drainage improvements such as storm sewer replacement or enlargement in the watershed are funded.

2 The City of Berea will enter into an agreement with each developer participating in the fee-in-lieu program. Funds collected will be placed in a government account to be used for government water quality projects within or benefiting the watershed from which the funds originated.

3 The Director shall establish the fee for <u>water quantity</u> based on studies and evaluations conducted by the developer.

   The fee shall not be applied to the following because water quantity BMPs are not required as explained in previous sections of this manual:

- new development residential sites less than 5 acres if the downstream drainage system has the capacity to carry the 100-year storm
- new development commercial sites less than 1 acre if the downstream drainage system has the capacity to carry the 100-year storm
- redevelopment sites that do not increase the impervious area
- redevelopment sites that increase the impervious area less than 1 acre if the downstream drainage system has the capacity to carry the 100-year storm

4 The fee for water quality shall be based on the table below.

Disturbed Area (acres)	**Fee-in-Lieu of Constructing On-Site Water Quality BMPs**	
	New Development	**Redevelopment**
Less than 1.00	Not applicable because water quality BMPs are not required for sites that disturb less than 1 acre	Not applicable because water quality BMPs are not required for sites that disturb less than 1 acre
1.01- 5.00	Determined by the Director based on the developer's cost estimate for constructing BMPs to treat 100% of the impervious area, including land costs if applicable.	Determined by the Director based on the developer's cost estimate for constructing BMPs to treat 20% of the impervious area, including land costs if applicable.
Greater than 5.00	Generally not applicable. On-site BMPs will typically be required.	Generally not applicable. On-site BMPs will typically be required.

2.21 Allowable Uses in the Floodplain

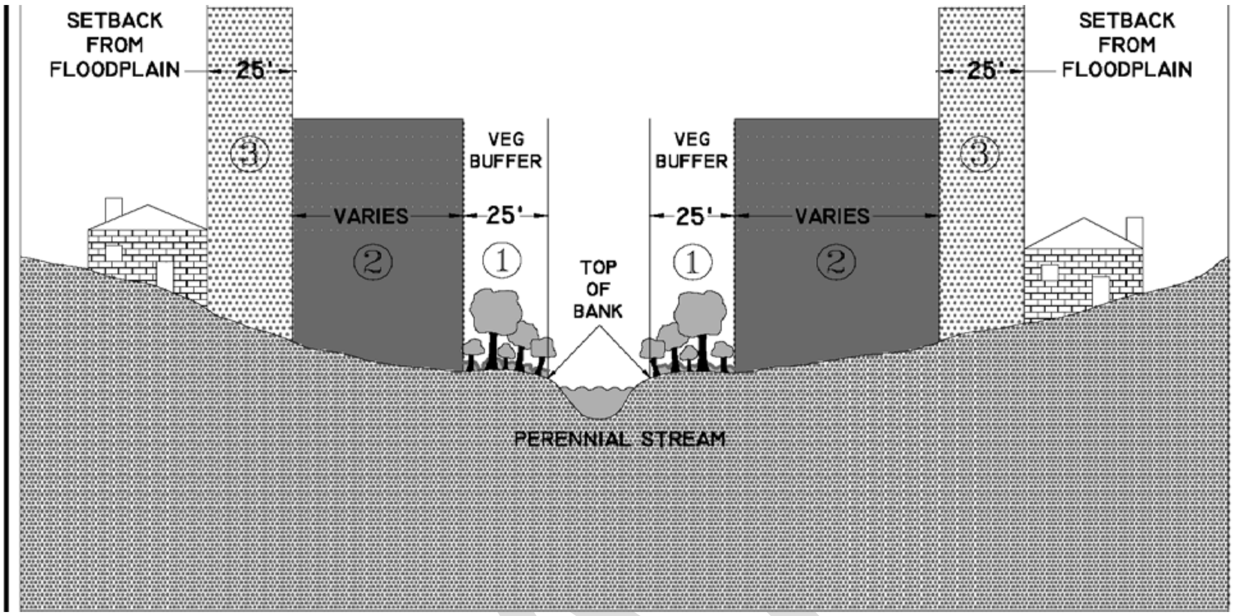
Development of property located within the floodplain must comply with guidelines established in the Stormwater Management Ordinance, Floodplain Overlay District Ordinance, and this manual. Wise use of the floodplain is encouraged to minimize adverse effects on flood heights and flow velocities, as well as maximize land conservation, greenways, floodplain preservation, and hazard mitigation.

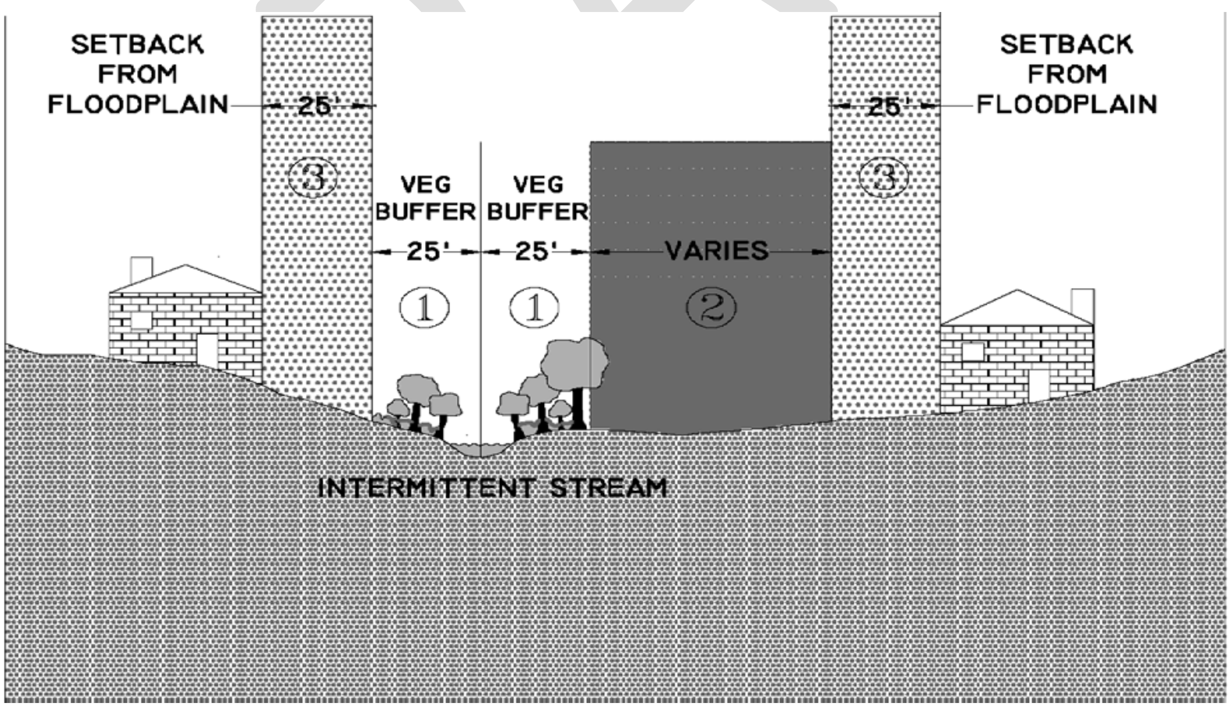
Table 2-3, along with Figure 2-1 shows the allowable uses in floodplains.

TABLE 2- 3, ALLOWABLE USES IN THE FLOODPLAIN

Activity or Use	Zone 1 Vegetative Buffer Strip	Zone 2 Floodplain	Zone 3 Floodplain Setback
Sediment Ponds	N	Y	Y
Detention Ponds along Perennial Streams	N	Y	Y
Detention Ponds along Intermittent Streams	Y	Y	Y
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	N	Y
Excavation to Lower Flood Levels	N	N	N/A
Principal Structures (Homes, Businesses)	N	N	N
Swimming Pools	N	N	Y
Detached garages and storage buildings	N	N	N
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”)	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 Decks	N	N	Y
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

Figure 2.1, Vegetated Buffer Strip, Floodplain and Floodplain Setback Requirements





2.22 Erosion and Sediment Control

All development shall be conducted in a manner that minimizes soil erosion and resulting sedimentation. No sediment shall leave a construction site, under any circumstances, due to inadequately installed or maintained erosion control features. Site-specific variables such as topography, soil erodibility, stormwater management features, and vegetation shall be considered when developing a grading, drainage and erosion control plan. The exposed area of any disturbed land shall be limited to the smallest practical area for the shortest possible period of time.

2.23 Construction Considerations

Many serious construction problems arise because important drainage and water-related factors were overlooked or neglected in the planning and location of the project. With proper planning, many problems can be avoided or cost effective solutions developed to prevent extended damages. Such problems include but are not limited to:

- Soil erosion,
- Sediment deposition,
- Drainage and landslide,
- Sinkholes and karst areas,
- Timing of project stages,
- Protection for aquatic habitat,
- Protection of streams, lakes, and rivers
- Protection of wetlands, , and
- Temporary drainage measures.

Analysis of available data, proper scheduling of work, and other aspects involved in the early planning and location studies can alleviate many problems encountered in the construction of drainage facilities.

2.24 Post Construction Best Management Practice (BMP)

The term Post Construction Best Management Practice is a term used to define a group of design and construction techniques that are intended to address water quality and quantity issues for several years after the construction of a project. Unlike the BMPs developed from the Erosion Control Plan, Post Construction BMPs will remain in place long after the construction of the project is complete. Maintenance of post construction BMPs is a significant issue. Long-term agreements with the property owner are required to maintain these structures.

CHAPTER 3 - STORMWATER MANAGEMENT ADMINISTRATION AND PERMITTING

3 General

3.1 Overview

This chapter summarizes the division of responsibilities for administering storm water management activities among public agencies. The requirements for permitting by the City of Berea Codes and Planning Department are delineated, for construction, land disturbance, and storm water quality. Procedures are established for enforcement of storm water regulations and inspection of affected sites. As-built certification requirements for detention ponds and storm water quality best management practices (BMPs), cut and fill, site grading and other construction are also addressed.

3.2 Organization

Administration of storm water management activities is carried out primarily by three local government agencies: the City of Berea Public Works Department, and the City of Berea Codes and Planning Department, and the City of Berea Planning Commission. Specific storm water management responsibilities of these three entities are briefly discussed below.

A list of addresses and phone numbers for these and other relevant agencies is presented later in this section.

3.2.1 City of Berea Codes and Planning Department

The Codes and Planning Department regulates building and planning in the City. This department is supervised directly by the Codes Administrator and works under the control, in part, of the Planning Commission. The department assures that the building code is consistently applied, provides building inspections for new construction, assures the directives of the Planning Commission are followed and assures that nuisance violations are cited and abated. The department adheres to the International Code, Kentucky Building Code, and the Kentucky residential Code in building design and construction inspection and it adheres to Chapter 5, 7 and 8, of the City of Berea Codes of Ordinances for city planning and additional construction regulations. Specific duties of this department are listed in the Berea Code of Ordinances.

Having principal responsibility for storm water management in the City of Berea, the Codes and Planning Department performs numerous functions:

1. Reviews development plans, land disturbance permit applications, and storm water quality plans for completeness and for technical compliance with the requirements of these storm water management regulations and other pertinent laws and ordinances and to assure that sites are reasonably safe from flooding;
2. Provides technical reviews of submittals for the Federal Emergency Management Agency (FEMA) no-rise certificates and Conditional Letters of Map Revisions (CLOMR);
3. Investigates drainage complaints and initiates corrective action where needed;
4. Inspects new development for proper application of erosion control measures,

installation of storm water drainage systems, and installation and maintenance of storm water BMPs;

5. Obtains and stores as-built certifications and permit applications to other storm water agencies;
6. Administers and enforces the provisions of the Storm Water Ordinance, the Land Management and Development Ordinance, and the Stormwater Procedures Manual;
7. Facilitates and coordinates compliance with NPDES regulations;

In order to carry out the duties set forth in this manual, the Storm Water Ordinance and the Land Management and Development Ordinance, the Codes and Planning Director has the authority to initiate the following actions:

1. Authorize designated employees of the Codes and Planning Department to act on behalf of the Director in carrying out the duties set forth in the Ordinance.
2. Develop erosion and sediment control practices, procedures, and requirements for land disturbing activities.
3. Establish and amend written regulations and technical guidelines to enforce the terms of the Storm Water Ordinance and the Land Management and Development Ordinance.
4. Prepare or have prepared storm water master plans and drainage studies for basins and such details as may be needed to implement the master plans.
5. Maintain records pertaining to the provisions of the Storm Water Ordinance, the Land Management and Development Ordinance and these regulations.
6. Inspect storm water management systems and stream alterations and order corrective actions as necessary to properly maintain storm water management systems and assure the flood carrying capacity of the watercourse is not diminished.
7. Take enforcement actions as necessary to ensure compliance with the provisions of the Storm Water Ordinance, the Land Management and Development Ordinance and these regulations.
8. Require the establishment and long-term maintenance of water quality buffers as required by the Storm Water Ordinance, the Land Management and Development Ordinance and this Storm Water Manual.

3.2.2 City of Berea Public Works Department

The Department of Public Works is an 18-person organization dedicated to maintenance of city streets, right of ways, public storm water drainage, creeks, manholes, catch basins, public detention and retention ponds, sidewalks, street signs, city vehicles and equipment, in a safe, efficient and professional manner to enhance the quality of life for citizens of Berea.

3.2.3 City of Berea Planning Commission

The Berea Planning Commission is responsible for the issuance and maintenance of the Subdivision Regulations for the City of Berea. These regulations include some provisions for the construction of storm water drainage systems.

The Planning Commission is responsible for receiving preliminary and final subdivision plats and planned unit development (PUD) plans for approval. Preliminary concept plans for PUDs and major subdivisions approved by the Planning Commission shall be conditioned such that no grading, excavating, stripping, filling, or other disturbance of the natural ground cover shall take place prior to the approval of a land disturbance, drainage, and erosion control plan, as appropriate. Depending on the potential impact of the proposed project, the Planning Commission may require that certain requirements of these regulations be included on the preliminary plan for review.

In order to receive approval for any plans, the Planning Commission will require submission of an appropriate number of plans to be submitted for review and approval. The Planning Commission's review will be to verify that the project complies with the requirements of subdivision regulations and general specifications. After the review an appropriate number of sets of plans shall be submitted for written approval. At least one set shall contain the original seal and signature of a registered professional engineer on each sheet. Construction shall not begin until the Planning Commission has issued a written approval of the plans. Upon completion of the construction the developer shall make a written request to the City of Berea for acceptance of the public facilities. The City of Berea reserves the right to reject any plan that would adversely affect adjoining or downstream properties.

The developers and/or property owner may make minor changes to the approved construction plans if written notifications of the change is given to the Codes Administrator if changes meet the requirements of the City's subdivision regulations and general specifications, and if the changes do not violate any city, county, state or federal regulations. Any changes from the approved plans that are not in compliance with the regulations must be approved by the Planning Commission prior to making the proposed changes.

The Planning Commission is the responsible authority in Berea for the FEMA National Flood Improvement Program (NFIP). As administrator of the NFIP, the Planning Commission maintains FEMA floodplain and floodway mapping and associated information.

3.2.4 Contact Information for Storm Water Agencies

Local Agencies	**Contact Purpose**
Berea Streets Department 200 Harrison Road Berea, Kentucky 40403 Phone: (859) 986-8792 Fax: (859) 986-1360 7:00 am – 3:30 pm Monday – Friday Email: mwalton@bereaky.gov.	Stormwater Drainage Drainage System Maintenance
Berea Codes and Planning Department City Hall 212 Chestnut Street Berea, Kentucky 40403 (859) 986-8528 8:00 am – 5:00 pm Monday – Friday Email: dvanwinkle@bereaky.gov.	Preliminary Plan Review Final Plan Review Land Disturbance Permits Building Permit Certificate of Occupancy Elevation Certificates

Berea Planning Commission City Hall 212 Chestnut Street Berea, Kentucky 40403 (859) 986-8528	Preliminary Plan Approval Final Plan Approval NFIP Program

State Agencies	**Contact Purpose**
Energy and Environment Cabinet Department for Environmental Protection Division of Water 200 Fair Oaks Lane, Fourth Floor Frankfort, KY 40601 502-564-3410 (Telephone) 502-564-0111 (Fax)	Water Quality Certification Program (401) Floodplain Construction Permit Dam Construction Permit 303(d) list Impaired Streams 305(b) list Assessed Waters General Permit for Stormwater Discharges Associated with Construction Activities (KYR100000)
Kentucky Transportation Cabinet Department of Highways District 7 763 West New Circle Road Lexington, KY 40511 Phone: (859) 246-2355 Fax: (859) 246-2354 Hours: Monday – Friday 8:00am – 4:30pm Email: KYTC.District7Info@ky.gov	Right of Way Encroachment Permit

Federal Agencies	**Contact Purpose**
Federal Emergency Management Agency (FEMA) Region IV - Mitigation Division Koger Center, Rutgers Building Atlanta, GA 30341 (770) 220-5200	Floodplain/floodway mapping Flood insurance information. Alteration of floodplains/floodways
US Army Corps of Engineers Romano Mazzoli Federal Building 600 Dr. Martin Luther King, Jr. Place Louisville, KY 40202 Mailing Address: U.S. Army Corps of Engineers, Louisville P.O. Box 59 Louisville, KY 40201-0059	Section 404 permit (alteration to navigable waterways and wetlands)

Regulatory & Permits - (502) 315-6733
Water Quality - (502) 315-7439

Natural Resources Conservation Service (NRCS) Kentucky NRCS State Office 771 Corporate Drive Suite 210 Lexington, KY 40503 Phone 859-224-7350 Fax 855-768-4251	Soils information. Hydrologic procedures (TR-55)

3.3 Permits Needed for New Development and Redevelopment

New development and redevelopment in the City of Berea is subject to various permit requirements. Table 3.1 below provides an "at-a-glance" overview of permits or major permit issues that must be addressed prior to beginning development. This table is provided as a guide and therefore does not cover every possible permitting issue. Sections of the manual addressing each permit or major permit issue are referenced in the table to provide more detailed information.

TABLE 3-1 - PERMITS AND MAJOR PERMIT ISSUES FOR NEW DEVELOPMENT AND REDEVELOPMENT

Activity	Preconstruction meeting	Land Disturbance Permit	SWPPP	Detention	BMP maintenance agreement	KDOW Floodplain Construction Permit	KDOW Water Quality Certification (401)	U.S. Army Corp of Engineers permit (404)	KYTC Encroachment Permit
Disturbing less than one acre		X	?		?	?	?	?	?
Disturbing one acre or more	X	X	X	?	?	?	?	?	?
"Hot Spot" development	X	X	X	X	X	?	?	?	?
Development has a stream	?	?	X	?	?	?	?	?	?
Development has a wetland	?	?	X	?	?	?	?	?	?
Development has a spring fed pond	?	?	X	?	?	?	?	?	?
Development within a stream	X	X	X	?	?	X	X	X	?
Stream crossing	X	X	X	?	?	X	X	X	?
Disturbing historic areas	?	?	?	?	?	?	?	?	?
Threatened or endangered species in the project area	?	?	?	?	?	?	?	?	?

X – Permits are needed, except where specifically exempted
? - Permits could be needed, based upon site conditions or the type of development

3.4 Land Disturbance Permit Requirements

Storm water management activities associated with development projects require land disturbance permits and storm water quality plans. These permits shall be in conformance with the provisions of these regulations and are required prior to the commencement of any development activities. Additional permits may be required by state or federal agencies. Copies of necessary permit applications and the corresponding notice of coverage for these agencies shall be submitted to the Department for record keeping.

See Section 3 of the Stormwater Ordinance for detailed procedures to obtain the Land Disturbance

Permit for a construction site.

3.4.1 Stormwater Hot Spots

Potential Stormwater Hotspots (PSHs) are defined as commercial, industrial, institutional, municipal, or transportation-related operations that produce or can produce relatively high levels of stormwater pollutants. PSHs include locations where there is a potential risk for spills, leaks or illicit discharges. It is important to note that designation as a PSH does not imply that a site is a hotspot, but rather that the land use and associated on-site activities have the potential to generate higher pollutant runoff loads compared to other land uses. Designation as a PSH serves as a useful reminder to designers and reviewers that more careful consideration of the site is warranted. Ultimately, a PSH site designation may dictate that certain practices and/or design criteria are promoted or discouraged.

A list of potential hot spots is included below as a more refined listing of hot spot considerations than listed in the Stormwater Ordinance, additional hot spots identified include:

- Commercial:
    - animal care services;
    - building material;
    - commercial vehicle wash facilities;
    - convenience stores;
    - laundries and dry cleaners;
    - lawn care companies;
    - automotive fueling stations;
    - nurseries and garden centers;
    - petroleum wholesalers;
    - restaurants;
    - outdoor materials storage areas;
    - shopping centers;
    - new/used car sales;
    - shopping centers;
    - hotel/motels;
    - vehicle maintenance and repair; and
    - wholesale food and beverage.

- Industrial:
    - auto recyclers;
    - boat building and repair facilities;
    - recycling centers and scrap yards; and
    - warehouses;
    - Industrial rooftops.

- Institutional:
    - cemeteries;
    - churches;
    - colleges;
    - corporate office parks;

  - hospitals;
  - private schools; and
  - private golf courses

- Municipal:
  - composting facilities;
  - fleet storage and school bus depots;
  - landfills/solid waste facilities;
  - local streets and storm drains;
  - pesticide use in rights-of-way;
  - public golf courses;
  - public schools;
  - public works yards;
  - maintenance depots;
  - solid waste facilities; and
  - wastewater treatment plants.

- Transport-related:
  - airports;
  - bus depots;
  - rental car lots;
  - railroad stations and associated maintenance facilities;
  - ports;
  - highway maintenance facilities; and
  - trucking companies and distribution centers
  - large parking lots

Many of the municipal operations are regulated PSHs in MS4 communities. Municipal PSHs must prepare the same pollution prevention plans and implement source control practices as any other regulated PSHs. Many, but not all, transportation-related uses are regulated PSHs. This list is not all-inclusive, nor does mention here indicate that all such occurrences will be PSHs; rather, these are examples of typical land uses that could be PSHs.

3.4.2 Activities Requiring Land Disturbance Permits

Land disturbance permits are required for all land disturbing activities, as prescribed in the Stormwater Ordinance. Permit requirements for land disturbance activities on properties with less than one (1) acre of disturbance are less stringent than requirements for developments greater than one (1) acre.

For developments having greater than one (1) acre of land disturbance, a Stormwater Pollution Prevention Plan, a SWPPP, is required as part of documentation for the permit. The format of a SWPPP submittal is included in the Appendix of this manual.

The land disturbance permit for shall be submitted to the city and must include a:

a. Completed application request
b. Notice of Intent (NOI) with proof of public notice

c. A Perimeter Control Plan (PCP) and Erosion Protection and Sediment Control Plan (EPSC)
d. Storm Water Pollution Prevention Plan (SWPPP)
e. Post-Construction Stormwater Pollution Prevention Plan
f. Any required maintenance agreement, and
g. Any other necessary information or documentation required by the city.

Detailed explanations and descriptions of the formal process are included in the Stormwater Ordinance.

3.4.3 Sinkhole and Drainage Well Requirements

Sinkholes, drainage wells, and closed depression areas present a unique challenge to the management of storm water runoff. These drainage features are primarily dependent on the volume of storm water runoff, while the rate of runoff is a secondary concern. To minimize the impact of new developments on these downstream volume-sensitive systems, additional reporting requirements are required. The following information shall be provided with the land disturbance permit application if stormwater runoff from the proposed development drains to a sinkhole or drainage well.

a) Proposed onsite and offsite stormwater management channels that discharge to a sinkhole throat or drainage well inlet shall be delineated, along with appropriate hydraulic calculations to define the existing and altered (if appropriate) 100-year floodplain and to confirm that offsite flooding will not be increased. Such plans and hydraulic calculations are to be certified by a registered engineer.

b) It must be demonstrated that development (placement of habitable structures or structures that may cause a water quality concern) will not occur within the area flooded by the 100-year flood. Calculations shall be based on the 100-year, 24-hour storm.

c) The contributing drainage area for the sinkhole or drainage well shall be delineated on a map to show basin wide contours. Preferably, the City of Berea GIS base map data will be used to delineate and present the contributing drainage area.

d) For those sinkholes requiring an underground injection permit from the KDOW, provide supporting documentation verifying the permit requirements for water quality treatment. Long term maintenance requirements and responsibilities must also be provided.

When a sinkhole or drainage well is used to store stormwater drainage from the site, the hydrologic and hydraulic computations must assume that these features are blocked and do not actively convey runoff to the subsurface. No development will be allowed within the contributing drainage area of a sinkhole or drainage well if such development will lead to any additional increase in flood levels within that or adjacent drainage areas. Special care will be required during construction to prevent eroded soil or debris from being washed into the sinkhole.

3.4.4 Kentucky DOW Requirements

Complying with the provisions of this chapter and an issued Land Disturbance permit does not exempt the permittee from obtaining coverage from the Kentucky Division of Water (KDOW) under the KPDES stormwater general permit for storm discharges related to construction activities that disturb one acre or more (KYR20) and the water quality certification, 401 process, including floodplain construction. The permittee is still required to obtain coverage under the KPDES stormwater general permit and shall provide a copy of the notice of intent filed with KDOW to the issuing authority of the City of Berea.

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.

3.4.5 Federal and State Permits

The applicant must comply with all federal laws and obtain the necessary permits from any federal agency that has jurisdiction in the construction activity. This may include the U. S. Army Corps of Engineers, the U. S. Environmental Protection Agency, or other federal agency.

If work involves construction on a state or federal highway right of way, an encroachment permit from the Kentucky Transportation Cabinet may also be required.

The Codes and Planning Department may suspend or revoke a land disturbance permit immediately upon notification that state or federal permits were denied or applicable permit applications were not made.

3.5 Enforcement

3.5.1 Right-of-Entry

Right-of-entry to private property is granted by the Stormwater Ordinance.

3.5.2 Revocation of Approvals and Permits

The Codes and Planning Director may revoke any approval or permit issued under the provisions of these regulations when informed of any false statement or misrepresentation of facts in the application or plans on which the permit or approval was based. Additionally, approvals or permits issued under the provisions of these regulations may be revoked when errors or omissions to the permit application or design plans on which the permit approval was based are found.

3.5.3 Corrective Measures

Any non-permitted storm water management system, or construction, or fill shall be removed at the expense of the property owner upon written notice from the Codes and Planning Director.

3.5.4 Notice of Violation

When it is found that any provisions of these regulations are being violated, the Codes and Planning Director, or authorized representative, may issue a notice of violation stating the conditions that constitute a violation and a timeframe for correction of the objectionable conditions. Corrective actions taken to remove the objectionable conditions must be approved by the Codes and Planning Director.

3.5.5 Stop Work Order

The Codes and Planning Director, or authorized representative, may issue an order to stop work, as directed in the Stormwater Ordinance.

3.5.6 Penalties and Injunctions

Penalties and injunctions shall be issued as directed in the Stormwater Ordinance.

3.6 Inspections

The Codes and Planning Department may make, or cause to be made, inspections required by this section. Such inspections shall be permitted as directed in the Stormwater Ordinance.

3.6.1 Permitting

Before the Codes and Planning Department issues a permit, the Department may examine, or cause to be examined, any tract of land for which a permit application has been received.

3.6.2 Construction

The Codes and Planning Department shall inspect, or cause to be inspected, at various intervals all construction or grading for which or a land disturbance permit has been issued, and a final inspection or waiver thereof shall be made of the tract of land upon completion.

Inspection of construction activities is outlined in the SWPPP procedures, listed in the Appendix of this manual.

3.7 As-Built Certifications

For any development that requires a land disturbance permit, a registered professional (engineer, land surveyor, or landscape architect as appropriate) shall submit to the Codes and Planning Department certification that the storm water management system (both public and private) and the public road system is complete and functional in accordance with the plans approved by the Department. Any deviations from the approved plans shall be noted on as-built drawings submitted. To insure the adequacy of storm water detention facilities, storm water quality BMPs, and improved sinkholes, this certification shall, at a minimum include as-built drawings showing final topographic features of these facilities including invert elevations of outlet control structures. Hydrologic and hydraulic calculations may be required for as-built conditions.

Certifications are included for the Contractor and Subcontractor(s) in the SWPPP.

All procedures are required to comply with the Stormwater Ordinance, the Land Management and Development Ordinance and this manual.

3.8 Digital Submittal Requirements

The Department maintains and updates an inventory of the City's storm drain system, using Geographic Information Systems (GIS) and computer aided drawing (CAD) software. Digital plans for new developments and redevelopments can be submitted and incorporated into the GIS, allowing the City to maintain up-to-date mapping of the City's system as development occurs. The Department is requiring that all new development plans be submitted in both digital and hard copy formats. Hard copies are restricted to 24 x 36 plan sheet size. This section defines the standards and specifications that will apply to all digital submissions to the Department.

Standard specifications in this document pertain to the digital drawings for all new developments and redevelopments. Furthermore, the digital submissions and standard specifications shall not supersede the current requirements for hard copy drawing submittal; the digital submission of drawings shall be in addition to all existing plan submittal requirements.

All digital data submitted to the Department shall be formatted in accordance with the standards contained in these sections. Please submit a digital CAD file that has a coordinate system referenced to it, such as NAD State Plane 83. Digital submittals must have all proposed/As-built stormwater structures and pipes. All stormwater features must have at least the following attributes in a corresponding table, in the fields of the CAD database, or as annotations;

Pipes:

- Material
- Diameter
- Slope
- Shape
- Length
- Number of barrels if more than one

Structure:

- Type
- Material

- Number of grates
- Cast elevation
- Invert elevation

Digital submittals that contain incorrectly formatted data, unreadable data, or missing required information shall be returned to the responsible agency or person for corrections and resubmittal. Land disturbance permit approval shall be contingent upon the submission of correct and accurate digital data. Failure to provide the digital information in the format required may cause the plan to be rejected.

3.8.1 Acceptable Digital Submittal Formats

The Department will accept the following file formats for digital submittals:

TABLE 3-2, ACCEPTABLE FORMATS FOR DIGITAL FILES

File Format	Preliminary Submittals	Digital As-Built Certifications*
*.dwg (AutoCAD)	X	X
*.dxf (drawing interchange file)	X	X
*.shp (ArcView shapefile)	X	X
*.pdf (portable document format from Adobe)	X	

* All as-built submittals must be georeferenced.

Other formats will be reviewed by the City of Berea on a case-by-case basis to determine compatibility and use. A digital submittal not compatible with the formats listed above will be disapproved.

3.8.2 Transfer Media Requirements

Digital submittals must be presented to the City using the following media:

- CD-ROM, and DVD
- USB Drive
- Email attachment

Digital submittals presented to the Department using media other than those listed above will not be accepted.

CHAPTER 4 – Stormwater Technical Guidelines and Design Criteria

4 General

4.1 Adequate Stormwater Management Systems

Adequate stormwater management systems shall have the hydraulic capacity to accommodate the stormwater discharge for a specified tributary area and precipitation duration and intensity.

Adequate stormwater management systems shall be designed to accomplish the following:

- Account for both offsite and onsite stormwater
- Maintain natural topographic divides
- Convey stormwater to a stream, natural channel, or other existing facility
- Discharge stormwater into the natural channel by connecting the channel at natural elevations, or by discharging the stormwater into an existing facility of sufficient capacity to receive it, or by discharging into an approved drainage well
- Limit or control stormwater quality leaving the site to predevelopment levels through the use of appropriate stormwater quality BMPs

Determination of the size and capacity of an adequate stormwater management system shall take into account the future development in the watershed or affected portions thereof. The design must not adversely affect adjacent or neighboring properties.

It is the responsibility of the developer or property owner to pick up or acceptably handle the quantity of runoff as it flows onto their property from offsite, and conduct it through the property to an adequate outfall at property line or beyond. The outfall must be sufficient to receive the runoff without deterioration of the downstream channel. The discharge of the storm drainage facilities shall be into either a well-defined natural or manmade drainage way. For areas proposed to drain onto adjoining properties essentially undetained, then the drainage must sheet flow onto the downstream property. Point discharges onto adjoining property and public right of ways are prohibited unless the discharge point is into an actual, well defined drainage way. The design calculations shall confirm the adequacy of the downstream system.

4.2 Public Drainage System

The public drainage system for subdivided property shall begin at the point where the water from more than two lots combine, or where water from one lot combines with water from a public road or other public facility. The public drainage system may be located on either public or private property. This definition of the public drainage system applies to areas covered by infrastructure plans submitted after adoption of this manual.

The public drainage system is divided into two parts: the constructed part and the natural part. The constructed part includes those pipes, overland flow channels, swales, etc., which carry water from the beginning of the public drainage system to the portion of the drainage system that remains undisturbed, the natural portion. The natural portion of the public drainage system is referred to as the waters of the city as defined below.

An adequate drainage right of way shall be required for all of the public drainage system not already in a street right of way. The right of way shall be of sufficient width to allow cleaning, widening, deepening, replacing, and generally maintaining the public drainage system. For areas covered by plans reviewed before the effective date of these procedures, the city may assume equivalent rights of way by agreement or condemnation. In general, the government will add these older areas to the public drainage system if they meet the same standards required by this manual. The minimum width of the drainage right of way shall be 20 feet.

The drainage right of way shall be treated the same as the street right of way. Like the area between the curb and the back of the sidewalk, property owners adjacent to the drainage right- of way will have certain maintenance responsibilities such as mowing.

4.3 Waters of the City of Berea

The waters of the city of Berea are the natural portion of the public drainage system that shall remain undisturbed. The waters of the city are those shown on the Berea GIS waters coverage. These include:

- intermittent and perennial streams represented on the USGS 7.5 minute topographic maps as either solid or dashed blue line streams; channels that are not shown as a solid or dashed blue line shall be considered a stream if they have a drainage area of at least 50 acres
- other channels which may be added because they display a nature similar to those designated as a blue line on the USGS maps
- reservoirs, lakes, farm ponds, and other impoundments on the streams, or in many cases which are the beginning of the stream
- wetlands with areas of more than ½ acre according to the current wetland delineation criteria used by the U. S. Army Corps of Engineers and a buffer area of 25 feet around the wetland; known wetlands are shown on the Berea GIS wetlands coverage
- groundwater flowing in the soil and rock formations beneath Berea
- a vegetative buffer strip extending 25 feet horizontally from the top of bank elevation for perennial streams, and 25 feet from the centerline of intermittent streams
- post-development floodplains
- greenways along streams on the Berea Masterplan

4.4 Post Development Floodplain

The post-development floodplain for waters of the city of Berea is the portion of land adjacent to a stream (as defined above) covered with water during the 100-year, 24-hour storm. It shall be determined using the procedures outlined in Chapter 5 of this manual. The post-development floodplain shall be based on a fully developed watershed and shall be used to determine the flood protection elevation for structures.

4.5 Easement

An easement is a right of use by one party over the property of another party, sometimes for a specific purpose. For stormwater activity, easements are property interests which document the condition under which the city has permission to enter an easement area on private property to repair drainage issues and/or perform on-going maintenance activities. A storm drainage easement is a recorded, legal document which describes easement boundaries and any conditions and restrictions related to the permission granted by the property owner to the city. Under the easement, the property owner is the grantor and the city is the grantee.

4.5.1 Need for Easements

The city of Berea may address stormwater issues on private property when a storm drainage easement is granted for that reason. Until an easement has been executed and recorded, maintenance of any portion of a storm drainage system on private property remains the legal responsibility of the property owner. The city of Berea will provide limited maintenance on specific streams identified by ordinance, not covered by an easement, in special situations.

4.5.2 Purpose for Easements

An easement does not give or take away property. An easement is a property right granting permission by one party to another party for access to property for a specific reason. However, there are certain restrictions for drainage easements accepted by the city of Berea so that the area can function as it is designed. For example, in a storm drainage easement, the flow of water cannot be blocked by the property owner and buildings, swimming pools, dirt/rock fill, wall and other structures are not allowed within the easement area.

4.5.3 Items Allowed/Not Allowed in Easements

Items that are allowed in stormwater easements include fences that do not block the drainage way (but not stone, block or concrete), trees (as long as the root system is not a threat to the drainage system), shrubs, flowers. Items that are not allowed in easements include trees planted over stormwater pipes, tennis courts, swimming pools, dams or anything that might block flow of water, permanent structures not intended to be moved, such as walls, structures made of brick, block or concrete, sheds or other buildings.

4.5.4 City Services within Easements

Remove fallen trees and large debris from creeks when those obstructions create a qualifying drainage problem, clear storm drainage pipes, catch basins or culverts, repair or replace broken drainage pipes, control severe creek bank erosion when necessary to protect water quality and adjacent properties, and repair sinkholes that occur over drainage pipe systems.

4.5.5 City Services not provided within Easements

The City does not clean up sticks, leaves or debris on private property after heavy rain or flooding, repair or replace private property damaged by stormwater runoff or flooding; including but not limited to air conditioners, heating units, fences, gardens, lawns, shrubs, mail boxes, and dog houses; clear out incidental debris from creeks and drainage ditches such as trash, leaves, grass clippings or small tree branches; clear cut vegetation from creek banks as part of routine maintenance; mow a ditch or storm drainage easement on private property; or re-grade or re-seed a storm drainage easement after project warranty period.

4.6 Watershed Studies

4.6.1 Watershed studies shall be conducted to:

- determine the effects of a proposed development on the public drainage system
- establish the post-development 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

4.6.2 Data Collection

- Data Sources
  Chapter 3 lists numerous sources for obtaining mapping and other reference materials required as part of a watershed study.
- 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' contour maps with field checks to determine any significant changes in the contributing drainage area such as:
    - Lakes
    - Sinkholes
    - flood control structures
    - grade 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 (conventional and infrared)
  - Berea zoning maps and the most current Berea Comprehensive Plan
  - USGS and other maps
  - landsat (satellite) images
  - 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 Berea Codes and Planning Department.

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 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
- Use of the water resource (stock water, aquatic habitat, recreation, power, irrigation, municipal or industrial water supply, etc.)
- riparian rights and/or ownership(s)
- Applicable water quality standards
- 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 stormwater 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 Chapters 5-6.

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.

Acceptable Flood Levels

Determine the lowest opening elevation of structures where flooding is known to occur.

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
- U.S.G.S.
- Kentucky Division of Water
- City of Berea

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 the city of Berea. Collect field data in accordance with GIS requirements of the City of Berea.

4.7 Runoff Models

4.7.1 General

The Stormwater Management Model (SWMM) or models using NRCS methods like HEC- HMS shall be used for hydrologic modeling. More information is contained in Chapter 5.

4.7.2 Sub Basin 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 existing percent imperviousness from Table 4-1.
- Calculate overland slope from an average of at least three slope measurements of the subbasin terrain.

TABLE 4- 1, LAND USE IMPERVIOUSNESS

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

4.7.3 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

4.7.4 Structural Data

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

- Calculate the stage-discharge curve for each structure.

- Using the 2-foot contour lines and field information, calculate a stage-area-storage relationship for each structure in the model. Include storage below the permanent pools. The stage-area information will allow the model to account for evaporation during continuous simulation.

- Combine the stage-discharge curve with the stage-area-storage curve to make one table for input into the model.

4.7.5 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.

4.7.6 Calibration

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

4.8 Post-Development Floodplain Analysis

4.8.1 General

Once the runoff model is complete, post-development 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. This portion of the chapter details how to build the HEC-RAS input file for a watershed study.

4.8.2 Post-Development Floodplain Definition

The post-development floodplain shall be determined for streams shown as waters on city of Berea GIS waters coverage. The post-development watershed condition shall be based on future land use.

4.8.3 Cross-Sections

HEC-RAS determines floodplains based on cross-section data provided by the user. The following methodology shall be employed when developing cross-sections.

- Starting at the most downstream end of the study area, locate a cross-section at least every 200 feet until the upstream end of the study area is reached.
- Orient the cross section so that it is perpendicular to the contour lines.
- Using a 2' contour map, determine stations and elevations along each cross-section.

- Determine the station along the left side and the station along the right side of each cross-section that corresponds to the top of bank.
- Determine the downstream reach length from each cross-section to the preceding cross-section along the left bank, centerline, and right bank.

The data outlined above are required for each cross-section. If a cross-section happens to fall where a tributary intersects the channel, then employ one of the following two options.

- Delete the tributary-impacted cross-section from the analysis.
- Copy the stations and elevations from the downstream cross-section to the tributary-impacted cross-section, but increase all the elevations along the tributary-impacted cross-section by the difference in elevation of the centerline of the two cross-sections.

If tributaries are to be modeled, treat them similarly to the main stream by working from downstream to upstream and spacing cross-sections at 200' intervals.

4.8.4 Roughness Values and Coefficients

Working from downstream to upstream, specify the following roughness values and coefficients:

- left bank = Manning's n from Chapter 6
- right bank = Manning's n from Chapter 6
- stream channel = Manning's n from Chapter 6
- contraction coefficient = 0.10
- expansion coefficient = 0.30

If the entire stream reach has the same set of roughness values from downstream to upstream, then only specify these values at the beginning of the input file.

4.8.5 Flow and Water Surface Elevations

The results from SWMM or HEC-HMS will provide the flows and water surface elevations at flow control structures for each HEC-HMS run.

4.8.6 Rounding of Water Surface Elevations

The water surface elevations from HEC-RAS shall be rounded to the nearest 0.1'.

4.9 Design Documentation

4.9.1 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.

4.9.2 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.

4.9.3 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 Berea'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 (such proof should certainly not increase a potential court award and may decrease it by disproving claims of negligence by the plaintiff)
- 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 (this should further disprove negligence claims)
- 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

4.9.4 Improvement Plans

All preliminary and final design improvement plans shall be drawn and submitted to the City of Berea for review and acceptance. The plans shall be prepared according to the Stormwater Pollution Prevention Plan, (SWPPP), included in Appendix B of this manual. The format of improvement plans are also outlined in the Stormwater Ordinance, Sections 3 and 4, included in Appendix F of this manual.

CHAPTER 5 – Hydrology

5 General

One of the first steps in the analysis and design of a drainage system is to determine discharges for a range of storms used to analyze the system. These storms range from a channel forming storm to a maximum probable storm.

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 complex. There is not enough data available on the factors influencing the rainfall–runoff relationship to expect exact solutions. Compounding this problem is the significant variation in the amount of runoff from different surfaces. On some surfaces, such as paved areas, nearly all of the rainfall will translate to surface runoff. However on other surfaces such as forested areas, much of the rainfall will be absorbed, and a small percentage will be translated into runoff. Additionally, the moisture content of the soil at the time of rainfall is also a variable that must be taken into account.

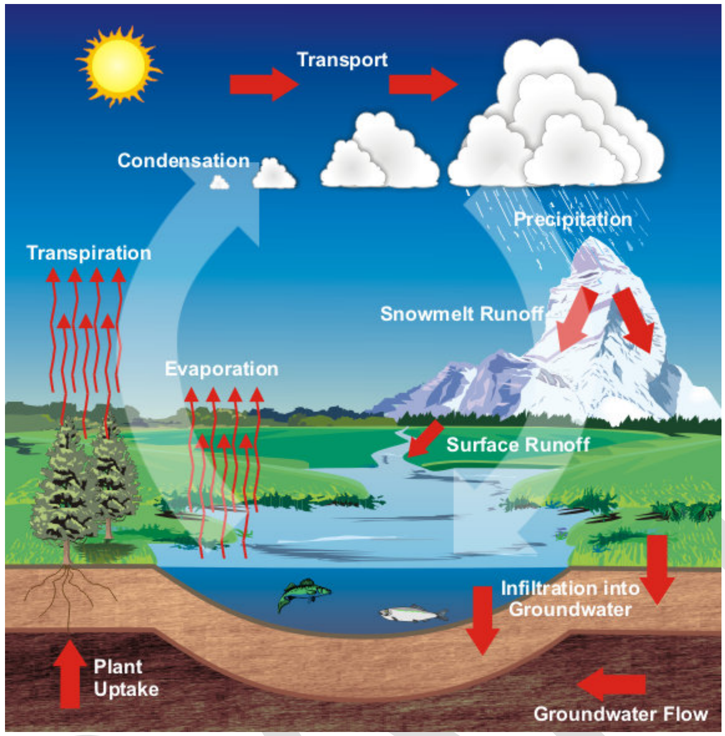
5.1 Hydrology

Hydrology is the science dealing with the occurrence and movement of water upon and beneath the land areas of the earth. It overlaps and includes portions of other sciences such as meteorology and geology. The sequence of events, called the "hydrologic cycle," describes the various movements of water as it relates to the earth. These processes of water movements are:

1. Precipitation
2. Infiltration
3. Evaporation, transpiration, interception
4. Surface runoff
5. Subsurface runoff and storage

The drainage engineer is concerned with surface runoff and relationships of rainfall to surface runoff. Total losses constitute the difference between total rainfall and the surface runoff available from that rainfall. Precipitation minus infiltration, evaporation, transpiration, interception, and groundwater storage equals surface runoff. Typically only total loss is considered in drainage investigations. In general, no attempt is made to evaluate separate losses. Surface runoff is sometimes called "excess rainfall."

The Hydrologic Cycle



Reference photo from The Ozone Hole Inc.

5.2 Surface Runoff

Runoff comprises the movement of water overland or through channels. Runoff is affected by variations in precipitation. These variations may be characterized by:

1. Seasonal fluctuations
2. Long term variations such as cycles of droughts and floods over periods of many years

Runoff rate is influenced by:

1. Topographic features
2. Geological formations
3. Soil
4. Vegetal cover
5. Land usage

Runoff from small drainage areas (less than ten square miles) is affected by factors of physiography usually differing from those used for river basins.

Factors affecting runoff from small drainage areas are:

1. Topography
2. Soil type and depth
3. Shape and slope of area
4. Land use
5. Vegetal cover
6. Condition and season of crops
7. Method of tillage
8. Antecedent soil moisture
9. Stream patterns
10. Pondage

Factors influencing runoff in river basins are:

1. Topography, geology, and soil provinces
2. Size and shape of basin
3. Size and shape of tributary watershed
4. General vegetal cover
5. Infiltration losses
6. Depression storage
7. Channel storage

The foregoing factors may have greater influence on runoff rates and volumes than rainfall intensity alone. Frequency of peak runoff is not always the same as recurrence of like rainfall intensities in an area. Peak rate of runoff produced by rainfall of given amounts, distribution, and intensities cannot be expected to occur as often as such rainfall recurrence.

5.3 Introduction to Modeling

5.3.1 Purpose

The analysis of the peak flow, volume of runoff, and time distribution of flow is fundamental to the design of storm water 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 complex, and too little data are available on the factors influencing the rural and urban rainfall-runoff relationship to expect exact solutions.

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

5.3.2 Continuous Simulation

Berea's approach to stormwater is to manage both water quantity and water quality in a manner consistent with the development of new, more scientific techniques that take advantage of the computing power now available through the use of personal computers. The available computing power allows the use of continuous simulation models using actual historical rainfall events rather than the synthetic single-event storms currently used. This chapter describes both currently approved single event models and continuous simulation models.

5.4 Approved Methods

5.4.1 Single Event Modeling

Two models are approved for single event hydrologic modeling. They are the Corps of Engineers HEC-HMS program and the U.S. Environmental Protection Agency's Stormwater Management Model (SWMM). More information is given later on these models.

Other computer programs may be used for designing storm sewers, open channels, culverts, inlets, and detention ponds if they use the methods in this chapter for determining runoff hydrographs and peak flows.

5.4.2 Continuous Simulation

SWMM shall be the model used when conducting continuous simulations. The city of Berea will provide the Lexington rainfall record for use in such a simulation.

5.4.3 Rational Method

The Rational Method may be used to compute peak flows for drainage areas less than or equal to 25 acres when designing inlets, storm sewers, culverts, and channels.

5.5 Design Rainfall Event

5.5.1 Single Event Modeling

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

5.5.2 Continuous Simulation

The City of Berea will provide the rainfall record for continuous simulation.

TABLE 5- 1, APPLICATION OF DESIGN STORMS

Design Storm	Stormwater Facility						
	Floodplains	Detention Ponds[1]	Inlets	Storm Sewers	Culverts	Constructed Channels	Sediment Ponds[4]
1-year 1-hour						X[2]	
10-year 1-hour			X	X			
10-year 6-hour	X	X					X
10-year 24-hour							X
100-year 1-hour			X	X	X[3]	X	
100-year 6-hour		X					X
100-year 24-hour	X	X			X[3]		

1. Detention ponds shall be designed to reduce post-development peak flows to pre-development peak flows for the 10-year 6-hour, 100-year 6-hour. 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 paved trickle channel. The trickle channel shall be designed to carry 50% of the 1-year 1-hour storm.

3. The storm producing the largest peak flow shall be used to design culverts.

4. 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

5.6 HEC-HMS Model

5.6.1 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 select soil groups listed in the NRCS Soil Survey for the Madison County.
- Curve Numbers are based on the type of land use. Typical values are 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 SELECT BEREA SOILS

NRCS Soil Series	NRCS Hydrologic Soil Group	Saturated Hydraulic Conductivity (inches/hour)	Wetting Front Suction (inches)	Initial Moisture Deficit (in/in)
Egam	C	0.10	8.6	0.14
Fairmount	D	0.03	12.5	0.08
Huntington	B	0.20	6.6	0.17
Lawrence	C	0.10	8.6	0.14
Lindside	C	0.10	8.6	0.14
Loudon	C	0.10	8.6	0.14
Lowell	C	0.10	8.6	0.14
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

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
1/4 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 50% Group B soils and 50% Group C soils.

5.7 Stormwater Management Model (SWMM)

5.7.1 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

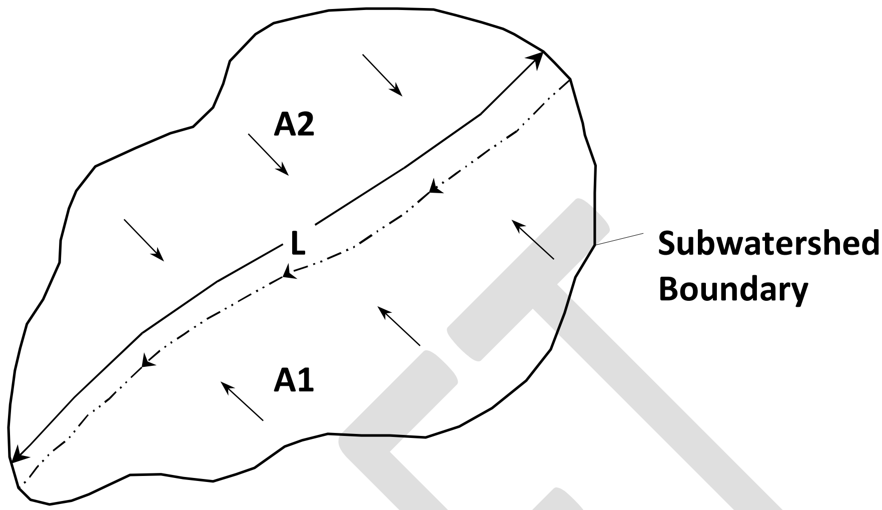
- Use the stage-discharge-volume relationship for the structure.

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.

5.7.2 Subwatershed Width Calculation

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



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

Where
S_k = skew factor $(0<S_k\leq1)$ = (A2 - A1) / (A1 + A2)
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, MANNINGS N FOR OVERLAND FLOW

Surface	N
Asphalt or Concrete	0.015
Graveled 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 MADISON 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

5.8 Rational Method

The following equation may be used for drainage areas less than or equal to 25 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)		
	1 yr.	**10 yr.**	**100 yr.**
10	3.2	5.3	6.9
15	2.8	4.4	5.7
30	1.9	3.1	4.2
60	1.2	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.

Table 5-7, Values of Runoff Coefficient (C) for Rational Formula

Land Use	C	Land Use	C
Business: Downtown areas Neighborhood areas	 0.70 - 0.95 0.50 - 0.70	***Lawns:*** Sandy soil, flat, 2% Sandy soil, avg., 2-7% Sandy soil, steep, 7% Heavy soil, flat, 2% Heavy soil, avg., 2-7% Heavy soil, steep, 7%	 0.05 - 0.10 0.10 - 0.15 0.15 - 0.20 0.13 - 0.17 0.18 - 0.22 0.25 - 0.35
Residential: Single-family areas Multi units, detached Munti units, attached Suburban	 0.30 - 0.50 0.40 - 0.60 0.60 - 0.75 0.25 - 0.40	***Agricultural land:*** *Bare packed soil* *Smooth *Rough *Cultivated rows* *Heavy soil, no crop *Heavy soil, with crop *Sandy soil, no crop *Sandy soil, with crop *Pasture* *Heavy soil *Sandy soil Woodlands	 0.30 - 0.60 0.20 - 0.50 0.30 - 0.60 0.20 - 0.50 0.20 - 0.40 0.10 - 0.25 0.15 - 0.45 0.05 - 0.25 0.05 - 0.25
Industrial: Light areas Heavy areas	 0.50 - 0.80 0.60 - 0.90	*Streets:* Asphaltic Concrete Brick	 0.70 - 0.95 0.80 - 0.95 0.70 - 0.85
Parks, cemeteries	0.10 - 0.25	Unimproved areas	0.10 - 0.30
Playgrounds	0.20 - 0.35	Drives and walks	0.75 - 0.85
Railroad yard areas	0.20 - 0.40	Roofs	0.75 - 0.95

Table 5-8, 1-Hour Rainfall Distributions

BEREA 1-HOUR RAINFALL DISTRIBUTIONS							
Minutes	Cumulative Rainfall (Inches)						
	1-year	2-year	10-year	25-year	50-year	100-year	500-year
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.14	0.16	0.24	0.28	0.31	0.34	0.43
6	0.25	0.30	0.43	0.51	0.57	0.63	0.79
9	0.39	0.46	0.64	0.76	0.85	0.95	1.18
12	0.50	0.60	0.84	0.99	1.11	1.24	1.55
15	0.63	0.75	1.05	1.24	1.39	1.55	1.94
18	0.73	0.88	1.23	1.45	1.63	1.81	2.27
21	0.82	0.98	1.39	1.64	1.83	2.03	2.54
24	0.89	1.07	1.50	1.77	1.98	2.21	2.76
27	0.94	1.12	1.58	1.86	2.09	2.33	2.91
30	0.98	1.17	1.63	1.93	2.16	2.41	3.01
33	1.01	1.20	1.69	2.00	2.25	2.50	3.12
36	1.03	1.24	1.73	2.04	2.30	2.56	3.20
39	1.06	1.27	1.79	2.11	2.37	2.64	3.30
42	1.09	1.31	1.82	2.15	2.43	2.70	3.38
45	1.11	1.33	1.87	2.21	2.48	2.76	3.45
48	1.12	1.34	1.89	2.23	2.50	2.78	3.48
51	1.14	1.37	1.91	2.25	2.53	2.81	3.51
54	1.15	1.38	1.93	2.28	2.55	2.84	3.55
57	1.15	1.38	1.93	2.28	2.55	2.84	3.55
60	1.16	1.39	1.95	2.30	2.58	2.87	3.59

Table 5-9, 6-Hour Rainfall Distributions

BEREA 6-HOUR RAINFALL DISTRIBUTIONS						
Minutes	Cumulative Rainfall (Inches)					
	2-year	10-year	25-year	50-year	100-year	500-year
0	0.00	0.00	0.00	0.00	0.00	0.00
20	0.07	0.10	0.12	0.13	0.15	0.19
40	0.16	0.23	0.26	0.30	0.33	0.43
60	0.25	0.35	0.42	0.47	0.53	0.67
80	0.40	0.57	0.66	0.75	0.84	1.07
100	0.59	0.82	0.97	1.09	1.23	1.56
120	0.79	1.10	1.29	1.46	1.63	2.08
140	1.01	1.41	1.66	1.87	2.10	2.68
160	1.24	1.73	2.05	2.31	2.59	3.30
180	1.44	2.00	2.37	2.67	2.99	3.81
200	1.60	2.22	2.63	2.97	3.32	4.24
220	1.73	2.40	2.85	3.21	3.59	4.58
240	1.82	2.54	3.00	3.38	3.79	4.83
260	1.90	2.64	3.13	3.52	3.94	5.03
280	1.95	2.73	3.22	3.63	4.07	5.19
300	2.01	2.81	3.32	3.74	4.19	5.34
320	2.04	2.84	3.37	3.80	4.25	5.42
340	2.07	2.88	3.41	3.84	4.30	5.48
360	2.11	2.94	3.48	3.92	4.39	5.60

Table 5-10, 24-Hour Rainfall Distributions

BEREA 24-HOUR RAINFALL DISTRIBUTIONS						
Hours	Cumulative Rainfall (Inches)					
	2-year	10-year	25-year	50-year	100-year	500-year
0.0	0.00	0.00	0.00	0.00	0.00	0.00
0.5	0.01	0.02	0.02	0.03	0.03	0.04
1.0	0.04	0.05	0.06	0.06	0.07	0.09
1.5	0.05	0.07	0.08	0.09	0.10	0.13
2.0	0.07	0.10	0.12	0.13	0.14	0.18
2.5	0.08	0.12	0.14	0.16	0.17	0.22
3.0	0.11	0.15	0.17	0.19	0.22	0.27
3.5	0.13	0.18	0.21	0.23	0.26	0.32
4.0	0.15	0.21	0.24	0.27	0.30	0.38
4.5	0.17	0.24	0.28	0.31	0.34	0.43
5.0	0.20	0.27	0.32	0.36	0.40	0.50
5.5	0.22	0.30	0.36	0.40	0.45	0.56
6.0	0.25	0.34	0.40	0.45	0.50	0.63
6.5	0.27	0.38	0.45	0.50	0.56	0.70
7.0	0.30	0.42	0.49	0.56	0.62	0.78
7.5	0.34	0.47	0.55	0.62	0.69	0.87
8.0	0.37	0.52	0.61	0.69	0.76	0.96
8.5	0.41	0.57	0.67	0.75	0.83	1.05
9.0	0.45	0.63	0.74	0.83	0.92	1.15
9.5	0.50	0.70	0.82	0.92	1.02	1.28
10.0	0.56	0.77	0.91	1.02	1.14	1.42
10.5	0.63	0.87	1.02	1.15	1.28	1.60
11.0	0.73	1.01	1.19	1.33	1.48	1.86
11.5	0.87	1.21	1.43	1.60	1.78	2.24
12.0	2.04	2.84	3.34	3.75	4.17	5.23
12.5	2.26	3.14	3.69	4.15	4.61	5.79
13.0	2.38	3.31	3.89	4.37	4.86	6.09
13.5	2.46	3.42	4.02	4.51	5.02	6.29
14.0	2.52	3.51	4.12	4.63	5.14	6.46
14.5	2.58	3.58	4.21	4.73	5.26	6.60
15.0	2.63	3.65	4.29	4.82	5.36	6.73
15.5	2.67	3.71	4.36	4.90	5.45	6.83
16.0	2.71	3.77	4.43	4.98	5.53	6.94
16.5	2.75	3.82	4.49	5.04	5.60	7.03
17.0	2.78	3.86	4.54	5.09	5.66	7.10
17.5	2.81	3.90	4.58	5.15	5.72	7.18
18.0	2.83	3.94	4.63	5.20	5.78	7.25
18.5	2.86	3.98	4.67	5.25	5.83	7.32
19.0	2.89	4.02	4.72	5.30	5.89	7.39
19.5	2.91	4.04	4.75	5.34	5.94	7.45
20.0	2.93	4.07	4.79	5.38	5.98	7.50
20.5	2.95	4.10	4.82	5.42	6.02	7.56
21.0	2.97	4.13	4.86	5.46	6.06	7.61

BEREA 24-HOUR RAINFALL DISTRIBUTIONS						
Hours	**Cumulative Rainfall (Inches)**					
	2-year	**10-year**	**25-year**	**50-year**	**100-year**	**500-year**
21.5	3.00	4.16	4.89	5.49	6.11	7.66
22.0	3.01	4.18	4.91	5.52	6.14	7.70
22.5	3.03	4.21	4.95	5.56	6.18	7.75
23.0	3.04	4.23	4.97	5.59	6.21	7.79
23.5	3.07	4.26	5.01	5.62	6.25	7.84
24.0	3.08	4.28	5.03	5.65	6.28	7.88

5.9 Inlets / Storm Sewers / Manholes / Headwalls / Existing Structures

5.9.1 Design Criteria

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.

5.9.2 Inlet Classification

City Of Berea drainage inlets are classified as curb inlets, drop inlets, and special purpose inlets. Curb inlets are further classified as curb opening, grated, or combination inlets. Drop inlets are primarily used in ditches, depressed medians, and as yard drains. Special purpose inlets are those such as bridge deck drains (scuppers), spring boxes, slotted drains and outlet structures for detention or retention ponds. City of Berea follows the KYTC Standard Drawing and Specifications on all new construction.

5.9.3 Curb Inlets

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

- Space inlets on grade to limit the spread of water as follows, based on an intensity of 4 inches per hour:
    - Local streets – ¾ of the driving lane
    - Collector streets – ½ of the driving lane
    - Arterial streets – 4 feet in the driving lane
- The depth of water in a sag shall be limited to the
    - Top of curb using an intensity of 4 inches per hour
    - Back of sidewalk using an intensity of 6.9 inches per hour (100 year storm with a 10 minute time of concentration)
- 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, even if a grate is present

- 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.

- Inlet pipe chambers should be designed such that the outside limits of a proposed pipe will fit entirely inside the chamber

- Inlets should be located at any point where side drainage enters streets and may overload gutter capacity. Where possible, these side drainage inlets should be located to intercept side drainage before it enters the street.

- Inlets shall be placed at all sag points in gutters, medians, and channels.

- Flanking inlets should be placed at major sag points where significant ponding may occur, and no other outlet exists except through the system.

- Inlets are used upstream of bridges to prevent pavement drainage from flowing onto the bridge decks and downstream of bridges to intercept drainage from the bridge.

- Inlets should not be located within driveway areas.

- Inlet structures can serve as access holes in storm sewer systems and should be used in lieu of manholes or junction boxes where the benefit of extra stormwater interception is achieved at minimal additional cost.

- Inlets should be placed immediately upstream of median breaks, and entrance/exit gore ramps.

- Inlets should be placed immediately upstream of crosswalks.

- Inlets shall conform to the City of Berea Standard Drawings or KYTC Standard Drawings.

5.9.4 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.

- Depth in channel becomes deep enough to exceed allowable shear stress criteria for the channel

- 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.

5.9.5 Inlet Design Procedures

5.9.6.1 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).

5.9.6.2 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 (ft^2)
d = head on center of opening (ft) g = 32.2 (ft/sec)

5.9.6.3 Surface Inlets

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

For d ≤ 0.4’, 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 ≥ 1.0’, use the orifice flow equation:

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

Where: C = 0.67
A = clear opening area of the grate (ft^2) g = 32.2 ft/sec
d = depth of water in feet

For 0.4’ < d < 1.0’, compute the flow using both the weir flow and orifice flow equations. Use the smallest flow for a given depth.

5.9.6 Storm Sewers

The City of Berea defines a storm sewer as two or more inlets, manholes or junction boxes connected by a series of pipes.

The function of a storm sewer system is to collect storm runoff, convey the water to an outlet point and discharge the flow in an environmentally acceptable manner. The design is, at a minimum, a four step process with some iteration until a final design is achieved.

1. Determine the location of inlets into the storm sewer. This involves spacing the inlets at locations that will limit the spread and provide access for maintaining the system. Based on roadway geometrics and traffic safety requirements, more inlets may be needed. Determine where existing systems or inlets will tie into the proposed and where the system outfall points will be.

2. Calculate the inflow into the system. This involves determining the peak runoffs of drainage areas draining toward the inlets and checking if the spread and interception capacity are acceptable. If not, additional inlets may be required or inlet locations may have to be adjusted to meet drainage requirements.

3. Determine the size of the storm sewer pipe required to convey the runoff for the design event and whether the system design criteria are met.

4. Evaluate the impacts of the discharge at the outfall on adjacent property owners and downstream receiving waters. Determine if energy dissipation or channel lining is required to protect the outlet from excessive erosion. Determine if the design meets the Post Construction BMP requirements from local agencies, such as MS4s, or the Division of Water.

5.9.6.1 Storm Sewer Design

Storm sewers shall be designed as follows:

- Provide inlets, junction boxes, or manholes at every break in horizontal or vertical alignment. This arrangement allows access to the ends of all sections of pipe in the system to clear potential obstructions.

- Size the pipes to flow under gravity (not under pressure) for the 10-year storm.
- Size the pipes so that overflows at inlets and manholes do not occur for the 100-year storm.
- Use a minimum pipe size of 15 inches. (Reason for size is driven by ability to maintain system, not capacity)
- 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 at full flow.
- Design the system to avoid transitions from steep to mild slopes.
- Avoid deep trenches unless no other alternative is available.
- Consider the location of other utilities, particularly those that cannot be changed or otherwise disturbed, such as sanitary sewers or fiberoptic cable.
- Provide a minimum cover of 18 inches.
- Construct storm sewers of reinforced concrete pipe, or smooth wall HDPE as approved by the engineer. No corrugated metal pipe allowed.

Outfalls shall be extended to the rear property line in residential developments where possible.

The design discharge at the outlet of storm water management systems shall not result in velocities that equal or exceed the erosive velocity of the receiving channel, unless energy dissipation and permanent erosion protection measures are placed at the outlet. Energy dissipation and erosion control devices shall have no overfall at the terminal end and shall discharge onto a stable section.

The terminal section shall be considered stable if the terminal section design velocity is less than the erosive velocity.

Streams that are part of the waters of Kentucky shall not be routed to flow through storm sewers.

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

5.9.6.2 Easements

Easements shall be dedicated to protect any storm drainage system. Width of a storm sewer easement shall be at a minimum 12’ wide. The table below is a minimum guideline. The City of Berea retains the right to require additional easement width based on site specific issues.

Table 5-11, Easements Widths

Utility in Easement	Minimum Easement Width Required (ft)
Storm Sewer <6’ deep	12
Storm Sewer 6’-10’ deep	15
Storm Sewer >10’ deep	20
Storm Sewer (any depth) with other utilities	20, other utility owners may require additional width to the amount listed.

5.9.6.3 Quality Assurance – Post Construction Inspection

All Storm Sewer lines shall be camera tested at the Developer’s expense and certified by the Design Engineer prior to acceptance by the City. When conducting a CCTV inspection of newly constructed storm sewer pipes, it is necessary to determine if pipe joints are less than or greater than manufacturer’s tolerances specified to maintain a watertight joint. All pipes installed in the field shall be installed per manufacturer requirements and will be “pushed home” to minimize open joints. Gap tolerances for reinforced concrete pipe are listed in the table below. Refer to manufacturer’s specifications for gap tolerances for other pipe products.

Table 5-12, Reinforced Concrete Pipe (RCP)

Pipe Diameter (in.)	Allowable Gap for RCP (in)
12-36	1/2
42	1 1/4
48	1 1/4
54	1 7/8
60	1 3/4
72	1 5/8

5.9.6.4 Deflection

Deflection shall be per current AASHTO Bridge Committee – LRFD Bridge Construction Specifications: Section 30:

- For locations where pipe deflection exceeds 5 percent of the inside diameter, an evaluation shall be conducted by the Contractor and submitted to the Engineer for review and approval considering the severity of the deflection, structural integrity, environmental conditions, and the design service life of the pipe. Pipe remediation or replacement shall be required for locations where the evaluation finds that the deflection could be problematic. For locations where pipe deflection exceeds 7.5 percent of the inside diameter, remediation or replacement of the pipe is required.

- Pipes shall be checked for deflection using a mandrel or any other device approved by the Engineer or "where direct measurements are made, a measurement shall be taken once every 10.0 ft. for the length of the pipe.

- At least 10 percent of the total project footage on the project shall be randomly selected by the Engineer and inspected for deflection.

- Pipe Connections with structures shall have a concrete collar poured from the outside of the structure and non-shrink grout formed on the inside of the structure.

5.9.7 Manholes and Junction Boxes

Manholes or junction boxes shall be provided at breaks in horizontal or vertical alignment where it is not feasible to construct an inlet. Another primary consideration in locating these structures is to provide access to the storm sewer for maintenance purposes. Refer to the access point spacing criteria set for the allowable maximum spacing of access points. It should be noted that some inlets provide manhole access as well. Ladder systems or Epoxy set Plastic coated steel rod steps shall be placed in structures for ease of maintenance

5.9.6.1 Maximum Access Point Spacing

The designer shall provide an inlet, manhole, or junction box at every break in horizontal or vertical alignment and at minimum distances along the storm sewer network to provide access for maintenance. Use Table 5-13 from AASHTO's "Model Drainage Manual" to determine the maximum spacing between access points in a storm sewer.

Table 5-13, Maximum Access Point Spacing

Pipe Size (in)	Suggested Maximum Spacing(ft.)
12 - 36	300
42 - 54	400
≥ 54	500

5.9.6.2 Place Manholes at the Following Locations

- where 2 storm sewers intersect
- at changes in pipe size
- where the slope changes
- where horizontal alignment changes
- Match the crown line of the upstream pipe to the crown line of the downstream pipe
- Ensure that pipes entering these structures fall within the ranges for the maximum and minimum pipe sizes listed on the Standard Drawings.
- Ensure that the heights of the inlets, junctions, and manholes meet the limitations noted on the Standard Drawings.
- Ensure that pipe chambers are large enough to intercept the incoming pipes
- When not noted otherwise in the Standard Drawings, set minimum heights for inlets as follows:
    - For cross drainage (pipe under pavement), the minimum height is the pipe diameter, plus the pipe thickness, plus 18” cover, plus pavement thickness (D + t + 1.5’ + pavement thickness).
    - For pipes outside cross drainage limits parallel to or leading away from the roadway, the minimum height is the pipe diameter, plus the pipe thickness, plus 18” cover, measured from the gutter line elevation to the top of the pipe (D + t + 1.5’).

5.9.8 Pass through 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 2.

5.9.9 *Construction Specifications*

All storm drainage structures, including storm sewer pipe, curb box inlets, surface inlets, culvert pipe, and manholes, shall be installed in accordance with the City of Berea Standard Drawings and the KYTC Standard Specifications for Road and Bridge Construction, latest edition.

5.10 Culverts and Bridges

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

5.10.1 Culvert Design Criteria

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

- **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.

- **Allowable Headwater**

The culvert shall be designed so that:

1. 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

2. HW/D is no greater than 1.0 for the 100-year storm for drainage areas greater than one square mile

3. The headwater is at least 12 inches below the edge of pavement for the 100-year storm

4. The headwater is at least 24 inches below the lowest opening of upstream structures for the 100-year storm

- **Culvert Size and Shape**

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

- **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:

1. Develop a stage-discharge curve for the existing floodplain to determine the discharge associated with bank full flow and the flow distribution for events greater than bank full flow.

2. Design the culvert pipe within the main channel to pass bankfull flow as a minimum.

3. 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.

- **Culvert Skew**

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

- **End Treatments**

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

- **Outlet Protection**

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

- **Culvert Design Procedures**

  - **Approved 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). HDS No. 5 is based on the concept of analyzing a culvert for both inlet and outlet control and designing for the control that produces the minimum performance.

    - **Inlet Control**

    Inlet control occurs when the culvert barrel is capable of conveying more flow than the inlet will accept. For inlet control, the control section is at the upstream end of the barrel (the inlet). The flow passes through critical depth near the inlet and becomes shallow, high velocity (supercritical) flow in the culvert barrel. Depending on the tailwater, a hydraulic jump may occur downstream of the inlet.

    Factors which affect the flowrate for a given headwater depth during inlet control are inlet area, inlet edge configuration and inlet shape. The following definitions are important for inlet control:

    1. The control section is the location where there is a unique relationship between the flow rate and the upstream water surface elevation.

    2. Headwater depth is measured from the inlet invert of the inlet control section to the surface of the upstream pool.

    3. Inlet area is the cross-sectional area of the face of the culvert. Generally, the inlet face area is the same as the barrel area.

    4. Inlet edge configuration describes the entrance type. Some typical inlet edge configurations are thin edge projecting, mitered, square edges in a headwall, and beveled edge.

    5. Inlet shape is usually the same as the shape of the culvert barrel. Typical shapes are rectangular, circular, elliptical, and arch.

    - **Outlet Control**

Outlet control occurs when the culvert barrel is not capable of conveying as much flow as the inlet opening will accept, and the downstream end of the culvert controls the flow. Outlet control has depth and velocity that are subcritical. The tailwater depth is either assumed to be critical depth near the culvert outlet or the downstream channel depth, whichever is higher. In addition to the inlet control factors, the following factors also affect outlet control flow:

Barrel Roughness

Barrel roughness is a function of the material used to fabricate the barrel. The roughness is represented by a hydraulic resistance coefficient such as the Manning n value.

Barrel Area and Shape

Barrel area is measured perpendicular to the flow. Barrel shape impacts the friction loss through the barrel.

Barrel Length

Barrel length is the total culvert length from the entrance to the exit of the culvert. Because the design height of the barrel and the slope influence the actual length, an approximation of barrel length is usually necessary to begin the design process.

Barrel Slope

Barrel slope is the actual slope of the culvert barrel, and is often the same as the natural stream slope. However, when the culvert inlet or outlet is raised or lowered, the barrel slope is different from the stream slope.

Tailwater Elevation

Tailwater is based on the downstream water surface elevation. Backwater calculations from a downstream control, a normal depth approximation, or field observations are used to define the tailwater elevation.

5.10.2 Bridge Design Criteria

Bridges shall be designed to:

- Pass the 100-year flow with one foot of freeboard below the bottom of the bridge structure
- The design flow shall consider runoff from the total tributary area and will require stream channel routing, as appropriate. Unless otherwise approved by the Director of Codes and Planning, bridges must be designed to result in no increase (no-rise) in water surface elevations for the 100-year flood event.

- 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

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-yr flow.

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

5.11 Headwalls

Headwalls are required for any pipe, culvert, bridges, or other structure, within the proposed storm drainage system. Headwalls are also required for any existing pipe within the proposed subdivision. Headwalls and outlet protection shall be provided at the outlet of all pipes and of a configuration to prevent erosion and to reduce velocity of stormwater. Minimum three foot (3”) high chain link fencing shall be required along the perimeter of the headwall if the distance from the pipe invert to the top of the headwall exceeds 3.5 feet. The fence shall consist of galvanized number 9-gauge wire with 2 ½“ diameter core posts. All headwall designed shall have prior approval of the City of Berea.

5.12 Existing Structures

The storm drainage system shall take into account adjoining subdivision and drainage areas to ensure that the effects of existing structures and or drainage ways have been considered. If existing structures are to be utilized within the storm drainage system, then each existing structure shall meet the design requirements as set forth in the specifications. Additionally, the existing structure shall meet the materials and construction requirements as set forth in the specifications.

CHAPTER 6 – BMP - Natural and Constructed Channels

6 General

6.1 Natural and Constructed Channels

Open-channel systems will often be used to collect and convey storm water. The open channels discussed in this chapter range from small manmade roadside channels that convey small local drainage areas to large natural channels that act as the primary storm water conveyance for a large geographic areas.

An open channel is defined as any conduit in which liquid flows with a free surface such as a stream, roadside ditch, depressed median, slope flume, or pipe flowing part full.

Although open channel hydraulic principles apply to both roadway ditches and stream channels, the analysis techniques and assumption are different for each of them.

The following general guidelines shall be considered in open channel design:

- Open channels shall be designed such that elevation of the water surfaces in the channel do not cause undue flooding of the proposed facility or damage to adjacent property.
- Open channels shall be designed to be stable against erosive forces of water.
- Use of grass lined channels shall be maximized as a drainage conveyance system due to their positive impacts on water quality. The use of turf reinforcing mats should be considered when natural vegetation alone will not withstand the expected erosive forces.
- 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.
- Channel design calculations must be submitted with the design plans and must include specifics on design discharges and corresponding velocities. If computer software programs are used to select appropriate geosynthetic erosion control materials based on flow and velocity, the software input and output data be submitted.
- Constructed channels include permanent constructed channels and temporary diversions. Temporary diversions shall be designed in accordance with requirements of Chapter 11.
- 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.

6.1.1 Channel Classification

- Natural stream channels include any drainage feature that is currently or ever has been a natural feature. They are naturally shaped channels that usually drain larger areas than constructed channels. Natural stream channels are generally larger than constructed channels and are usually associated with large hydraulic structures such as bridges and culverts. However, stream channels can include very small channels that are not wet year round. Stream channels are sometimes relocated or modified to accommodate development or construction of highways. Although there are cases where changes to stream channels will be necessary, this practice should be avoided if possible.

Characteristics of natural stream channels are:

- Usually natural channels with their size and shape determined by natural forces,
- Usually compound in cross section with a main channel for conveying low flows and a floodplain to transport flood flows, and
- Usually shaped in cross section and plan form by the long-term history of sediment load and water discharge that they experience
- Usually analyzed with step – backwater techniques.

- Constructed channels include the manmade channels used to convey local drainage to a larger drainage system.

  Characteristics of constructed channels are:

  - Constructed channels have regular geometric cross sections uniformly shaped
  - Grass-lined or may be lined with a protective material to prevent erosion
  - Used for conveying excess rainfall runoff in a controlled manner around and/or away from roads or development
  - Used to separate clean off site water from sediment laden construction runoff
  - Used to collect water at the top of cut slopes to prevent erosion of the slope
  - Used to divert water to a controlled outlet point
  - Generally designed and analyzed assuming steady, uniform flow assumptions

6.1.2 Natural Stream Types

Natural streams are classified into 3 different types. Although there are numerous definitions of these steam types, it is widely accepted that the 3 basic types of natural streams are Ephemeral, Intermittent, and Perennial. The United States Army Corps of Engineers (USACE) defines these streams as follows:

- Ephemeral stream: An ephemeral stream has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral stream beds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.
- Intermittent stream: An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.
- Perennial stream: A perennial stream has flowing water year-round during a typical year. The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.

Another common term used to describe steams is “blue line streams”. United States Geological Survey (USGS) maps show Intermittent and Perennial streams as blue lines, hence the term “blue line stream”. It should be noted that the determination of stream types as shown on USGS maps follows the USGS definition, which is different than the USACE definition presented above.

6.1.3 Constructed Channel Design Criteria

Open channels may be designed as hard-armored, geosynthetic or soil bioengineering lined channels. The use of geosynthetic erosion control materials are permitted and encouraged in lieu of semi-rigid or rigid linings. Approval of lining materials is subject to review by the Codes and Planning Department.

- Constructed channels shall be designed with stable side slopes. Vegetated channels shall have sideslopes of 3:1 or flatter.
- Constructed channels in residential areas that receive runoff from a storm sewer or culvert shall be constructed with a paved trickle channel. The trickle channel shall be designed to carry 50% of the 1-year storm. A detail is shown in Figure 6-1.
- Channel lining shall be required when the design velocity exceeds the allowable, non-erosive velocity for a given channel reach and no other erosion control measures provide adequate protection.
- The minimum slope for all channels shall be 0.5% and channels with a slope less than 1% must be concrete lined.
- Channel freeboard shall be one foot or two velocity heads (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 to 1.
- Maximum design depth shall be based on the 100-year storm.
- For channels running along the toe of a fill, provide adequate distance between the toe of fill and the channel. If the channel carries large amounts of runoff it is desirable to place the channel at least 10' from the toe of the fill.
- For channels located in close proximity to roadway pavements, make the channel deep enough to provide subgrade drainage for the pavement structure.
- Aggregate linings should follow thickness recommendations specified
- Avoid sharp bends and abrupt grade changes that could lead to erosion of the channel.
- Roadside safety should be considered when determining the geometry of ditches and channels.

6.1.4 Channel Lining

Channel lining materials fall into two classes: rigid or flexible channel linings. From an erosion control standpoint, the primary difference between rigid and flexible channel linings is their response to changes in channel shape (i.e. the width, depth and alignment). Flexible linings are able to adjust to some change in channel shape while rigid linings cannot. The ability to sustain some change in channel shape improves the overall integrity of the channel lining and reduces maintenance. Flexible linings also have several other advantages compared to rigid linings. They are generally less expensive, permit infiltration and exfiltration and can be vegetated to have a natural appearance. Flexible linings are preferred over rigid linings.

Rigid linings prevent infiltration and contribute to high velocities that often cause scour at the end. Despite the non-erodible nature of rigid linings, they are susceptible to failure from foundation instability. The high cost of this type of lining demands that the situation be analyzed adequately to ensure that this lining type will function as designed.

If a vegetated channel is not stable, other alternatives shall be considered in the order shown below:

- Flexible Linings
  - Grass
  - Vegetated with a Turf Reinforcing Mat (TRM)
  - Dry stone masonry
  - Aggregate Lining (discouraged and will only be permitted when vegetative linings are not feasible. One limited use of rock riprap that is acceptable is for bank stabilization at channel crossings and at outlets or outfalls to channels)
  - Mattress Units (Gabions)
  - Modular Block

- Rigid Linings
- Concrete Paving

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.

Temporary erosion control shall be utilized during non- growing seasons and during grass cover establishment. The engineer shall note on the drawings or in the specifications that **"All grassed channels must be in a well-stabilized condition and show no sign of erosion at the time of final acceptance by the City."**

Other considerations include:

- Grass lining is one of the most common long-term channel linings. Grass lining can be accomplished either by seeding or by sodding. Seeding provides a grass lining at a low cost but there is a transition period between seeding and vegetation establishment. Temporary protective methods such as hydroseeding or Erosion Control Blanket will hold the seeds in place. For seeded, grass lined channels Erosion Control Blanket is required to protect the seed.
- Sodding allows for an immediate application of grass lining at a higher cost than seeding. Sodding expands the use of grass lining and also serves to transition into more rigid linings. Composite linings using sodding are desirable in some applications and should be studied carefully. If sodding is able to withstand the expected flows, it is the preferred channel lining in urban applications when immediate establishment of vegetation is desired.
- The purpose of turf reinforcement is to provide a structure to the soil/vegetation matrix that will both assist in the establishment of vegetation and provide support to mature vegetation. To be effective, Turf Mats must be used where vegetation can establish itself. Although they are considered long term, mats do degrade over long periods of time.

  Turf Reinforcing Mats are preferred over aggregate lining in instances where vegetation can be established. When compared to aggregate linings, they offer similar levels of erosion protection and provide water quality benefits.

Turf Reinforcing Mats are not suitable for outlet protection. When rock outlet protection is needed at the end of a culvert and has to transition into a channel lined with Turf Reinforcing Mat, specify the extension of the outlet protection for a distance of 3' over the upstream edge of the Turf Reinforcing Mat.

6.1.5 Easement Width

All open channels shall be located within the right-of-way of a drainage easement. Minimum easement width shall be determined from Table 6.1. Easements must be dedicated to the City for all drainage systems downstream from the point where storm water runoff from two or more properties combine. It is the responsibility of property owners to maintain storm water drainage systems within drainage easements unless maintenance is accepted by the City in accordance with the Stormwater Ordinance (Appendix F).

Table 6.1--Minimum Easement Width for Open Channels.

Top Width of Channel	Minimum Easement Width
Less than 5 feet	10 feet
5-20 feet	10 feet greater than top width of channel with a minimum of 5 feet on both sides
Greater than 20 feet	15 feet greater than top width of channel with a minimum of 5 feet on both sides

6.1.6 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, ft^2

R = hydraulic radius = A/P, ft

P = wetted perimeter, ft

S = channel slope, ft/ft

Select Manning's n from Tables 6-2 and 6-3.

6.1.7 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 6-4. 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 6-4, 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.

6.1.8 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, fence rows, 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 6-2, 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 D50 Riprap	0.050
12-inch D50 Riprap	0.060
Grass	0.045

TABLE 6-3, 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 6-4, SUMMARY OF CRITICAL TRACTIVE FORCES FOR VARIOUS PROTECTION MEASURES

Protective Cover	τ_d (lbs/ft^2)
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 D50 = 6 inches D50 = 12 inches	 2.50 5.00

6.1.9 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.

6.2 Paved Channels

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

6.2.1 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.

6.2.2 Material Specifications

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

6.2.3 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.

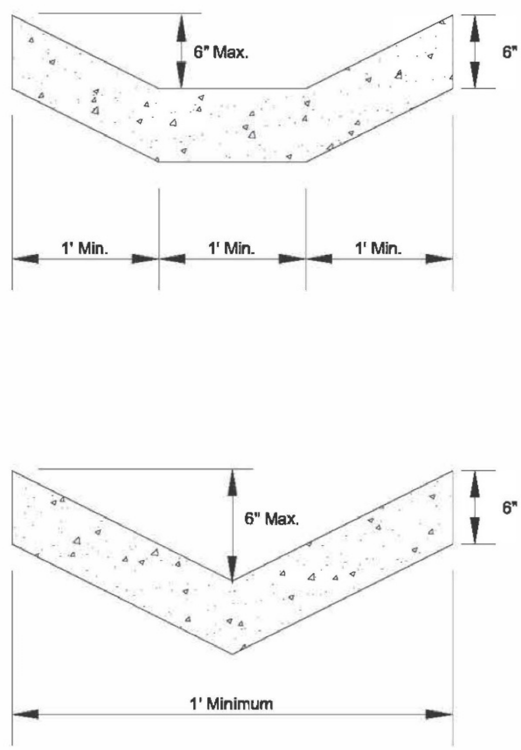
6.2.4 Maintenance

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.

STORMWATER MANUAL

FIGURE 6-1

TRICKLE CHANNELS



TRICKLE CHANNELS

Note: The trickle channel shall be designed to carry 50% of the 1-year storm.

CHAPTER 7 – BMP – Streambank Stabilization and Restoration

7.1 Introduction

The streams of the City of Berea 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 city 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 2, 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 streambank and floodplain from the construction that must occur
- enhancing the stream and floodplain as part of the overall development or stream restoration plan

7.2 Vegetative Streambank Stabilization

7.2.1 General

In some instances, certain allowable construction will result in excavation into the streambank. In those instances when the natural streambank must be disturbed, first consider vegetative streambank stabilization methods. If those methods are not applicable, use bioengineering techniques. Use structural streambank 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 streambank. Similarly, a natural streambank that has been previously degraded due to past impacts may be further deteriorated by new development. In these cases, the streambank shall be restored to prevent further degradation using vegetative methods and/or bioengineering techniques.

7.2.2 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 7-1. 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 streambanks.

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.

7.2.3 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 6).

If nursery stock (bare root or containerized) is used, the species listed in Table 7-1 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 7.4.2 for recommended species and installation requirements of hardwood cuttings.

7.2.4 Construction Specifications

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

Where feasible, the streambank 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 streambanks 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.

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.

7.2.5 *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 7- 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.

Tree Species

Pin Oak	*Quercus palustris*
Cherrybark Oak	*Quercus pagoda*
Bur Oak	*Quercus macrocarpa*
Swamp Chestnut Oak	*Quercus michauxii*
Shingle Oak	*Quercus imbricaria*
Northern Red Oak	*Quercus rubra*
Post Oak	*Quercus stellata*
Red Maple	*Acer rubrum*
Green Ash	*Fraxinus pennsylvanica*
Shellbark Hickory	*Carya laciniosa*
Blackgum	*Nyssa sylvatica*
American Elm	*Ulmus americana*
Eastern Cottonwood	*Populus deltoides*
Black Walnut	*Juglans nigra*
River Birch	*Betula nigra*
Yellow Poplar	*Liriodendron tulipifera*
Persimmon	*Diospyrus virginiana*
Black Walnut	*Juglans nigra*
Ohio Buckeye	*Aesculus glabra*
Sugar Maple	*Acer saccharum*
Sycamore	*Plantanus occidentalis*
Persimmon	*Diospyros virginiana*

Shrubs

Arrow-wood	Viburnum dentatum
American Plum	*Prunus americana*
Deciduous Holly	*Ilex decidua*
Gray Dogwood	*Cornus racemosa*
Silky Dogwood	*Cornus amomun*
Spicebush	*Lindera benzoin*
Sassafrass	*Sassafras albinum*
American Elder	*Sambucus canadensis*
Button Bush	*Cephalanthus occidentalis*
River Cane	*Arundinaria gigantea*
Coralberry	*Symphoricarpos orbiculatus*

Herbaceous Species

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

7.3 Riparian Buffer Zones

7.3.1 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 8).

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

7.3.2 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 7-1.

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 7-1. 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 7-1 and 7-2 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 7-3).

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 7.2 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 7.2 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.

7.3.3 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 upgradient area immediately adjacent to Zone 2 until the upgradient 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.

7.4 Bioengineering Techniques

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

7.4.1 Design Criteria

Establishing permanent vegetation is the preferred method for stabilizing soils along streambanks. 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 streambank.

On streambank 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 streambank. The combined use of two or more techniques to accomplish streambank stabilization and protection may be applicable for some sites.

When streambanks 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 streambank 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 streambank and continue up gradient.

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

7.4.2 Live Stake

Live stakes shall be used in limited situations for streambank 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 streambank. 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 7-1 provides the recommended species for rooted seedlings.

TABLE 7- 2, NATIVE PLANT SPECIES SUITABLE FOR HARDWOOD CUTTING IN CENTRAL KENTUCKY

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

Other practices, in combination with live stakes, shall be used for streambanks 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 7-4A 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 streambank 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 streambank.

7.4.3 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 streambanks.

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. Streambank above root wad shall be covered with erosion control fabrics and planted. Figure 7-5 shows the typical construction detail for root wad revetment.

7.4.4 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 streambanks 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 7-6 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 <u>untreated</u> lumber that have been cut diagonally across the 4 inch width with a 0.25 inch tip. Figure 7-4B shows in detail how the stakes are cut.

7.4.5 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 streambank. Live fascines can also be used to reinforce the toe of streambank slopes.

Fascines shall not be used when surficial concentrated flows are discharged over the face of the streambank 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 7-7 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 streambank. Parallel trenches shall be constructed along the face of the slope according to the following table:

TABLE 7- 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 7.4.1 shall be used.

7.4.6 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 streambank protection. This technique is limited to streambank 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 streambank.

Live fascines shall be installed in the trench as described in Section 7.4.5.

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 7-8 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 upgradient.

The stakes shall be tapped further into ground to secure the mattress to the bank face. Live stakes shall be inserted between dead stout stakes similar to Section 7.4.1.

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

7.4.7 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 streambank and high flow fluctuations in the stream channel. This technique can also be used for opposite streambank protection and in areas where severe erosion has resulted in shallow mass movement of the streambank.

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 7-9 for a detail on this technique.

Wooden poles (4 inches in diameter) shall be <u>untreated</u> 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 streambank slopes.

7.4.8 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 streambank.

This technique is limited in overall height of 6 feet and shall <u>not</u> be used where the adjoining streambed is subject to severe degradation. Figure 7-10 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 <u>untreated</u>. 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 streambank slope and the final layer shall reach to the top of the original streambank 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 7-11 for a construction detail.

7.4.9 Joint Planting

Joint planting is applicable to sites where the use of gabion mattresses or rubble stone to stabilize a streambank 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.

7.4.10 Maintenance and Monitoring

Streambanks 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 streambank 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.

7.5 Structural Streambank Stabilization

Structural stream-bank stabilization refers to the stabilization of banks of 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.

7.5.1 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.

Streambank 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.

7.5.2 Specifications

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

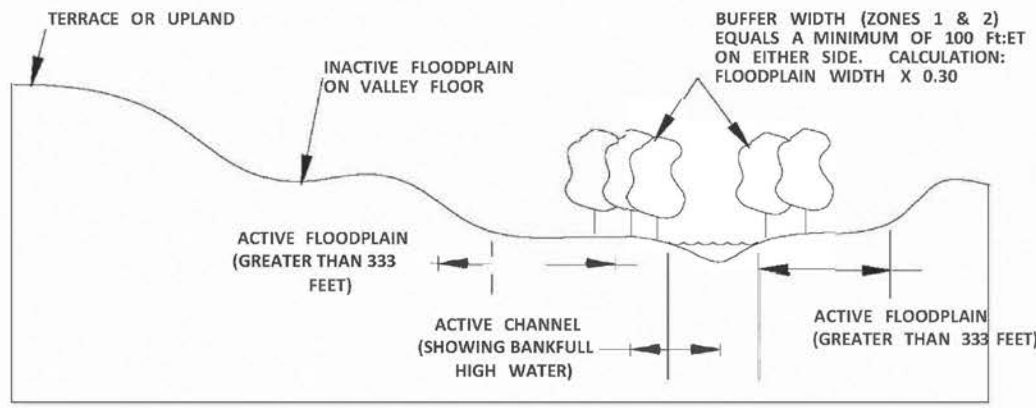
7.5.3 Maintenance

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 streambank.

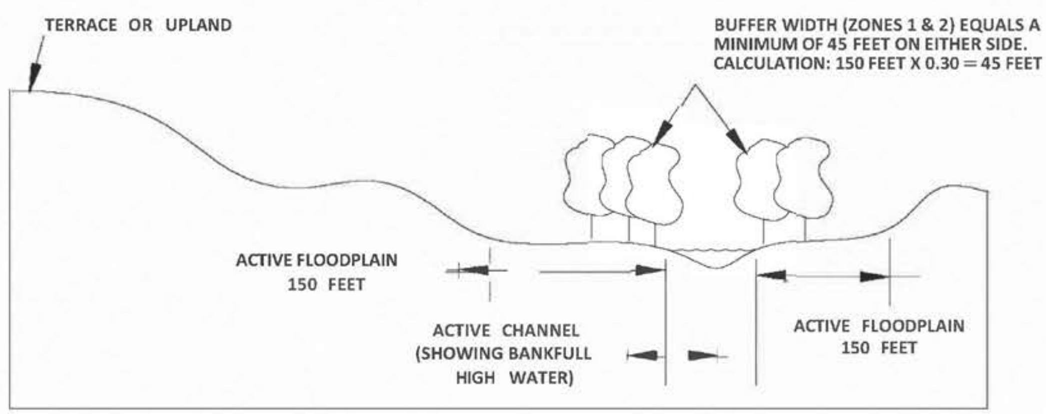
STORMWATER MANUAL

FIGURE 7-1

RIPARIAN BUFFER ZONE WIDTHS ACTIVE FLOODPLAIN ON BOTH SIDES OF CHANNEL



ACTIVE FLOODPLAINS GREATER THAN 333 FEET IN WIDTH

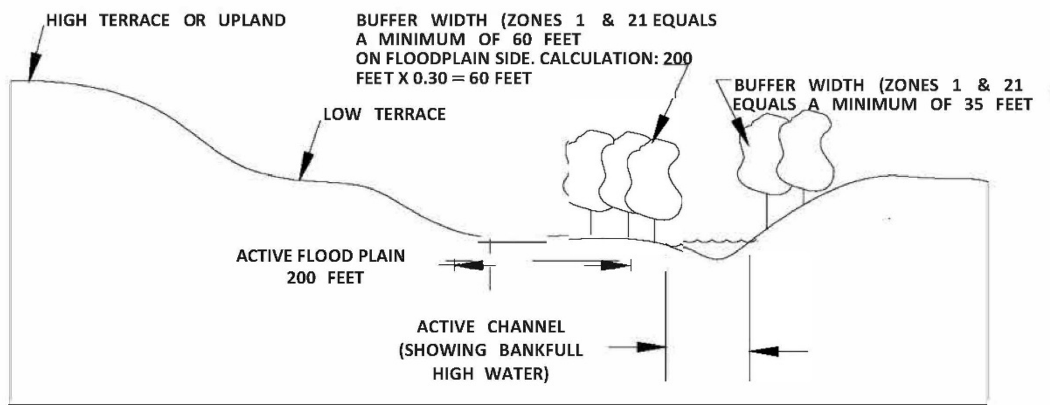


ACTIVE FLOODPLAINS LESS THAN 333 FEET IN WIDTH

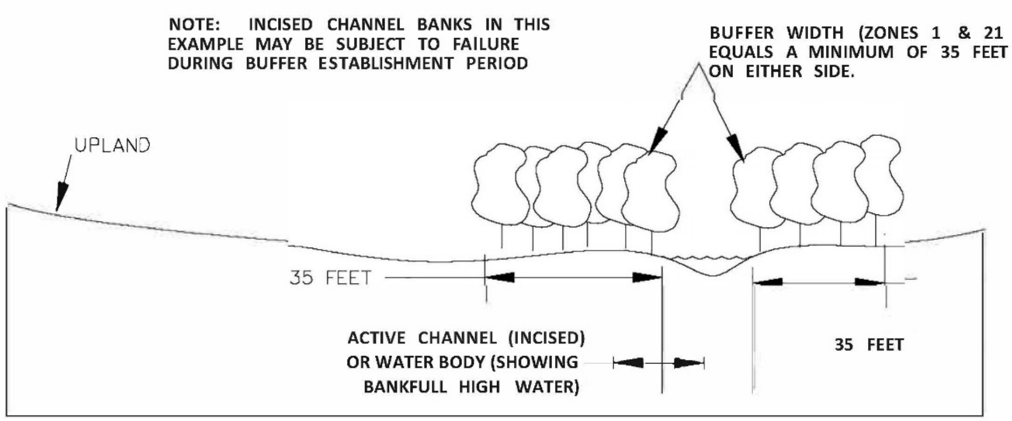
STORMWATER MANUAL

FIGURE 7-2

OTHER RIPARIAN BUFFER ZONE WIDTHS

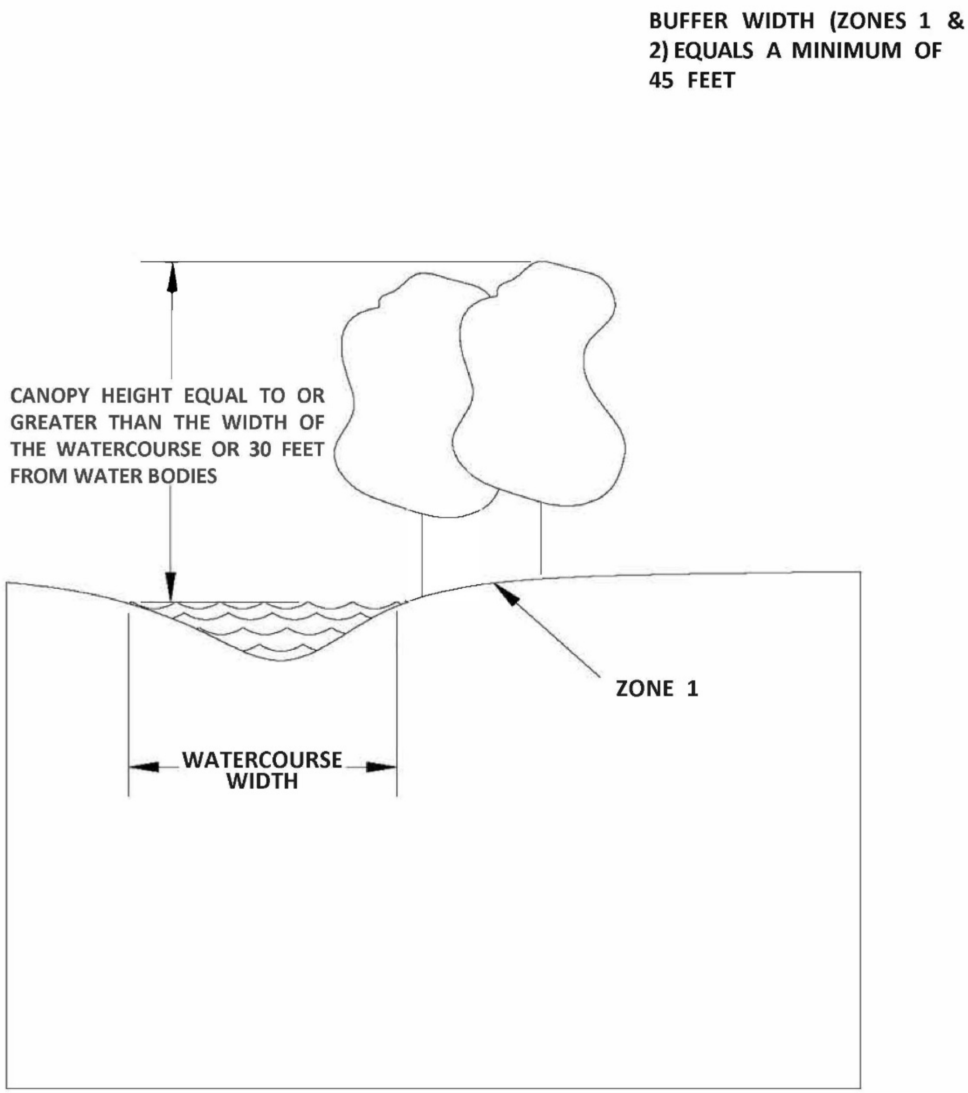


ACTIVE FLOODPLAIN ONLY ONE SIDE OF THE CHANNEL



INCISED CHANNEL WITHOUT FLOODPLAINS AND ALL WATER BODIES

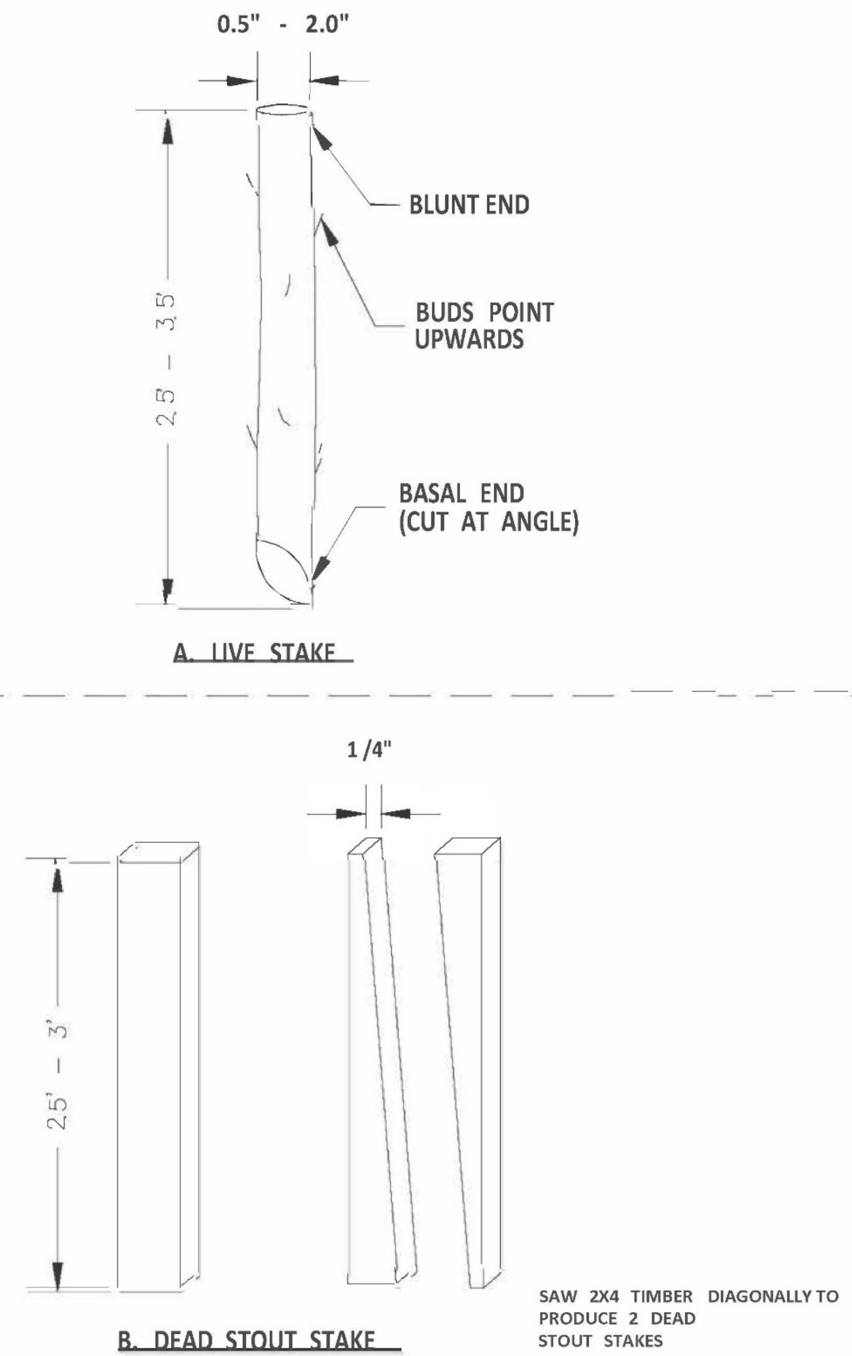
STORMWATER MANUAL	FIGURE 7-3 CANOPY HEIGHT FOR WATER TEMPERATURE CONTROL



STORMWATER MANUAL

FIGURE 7-4

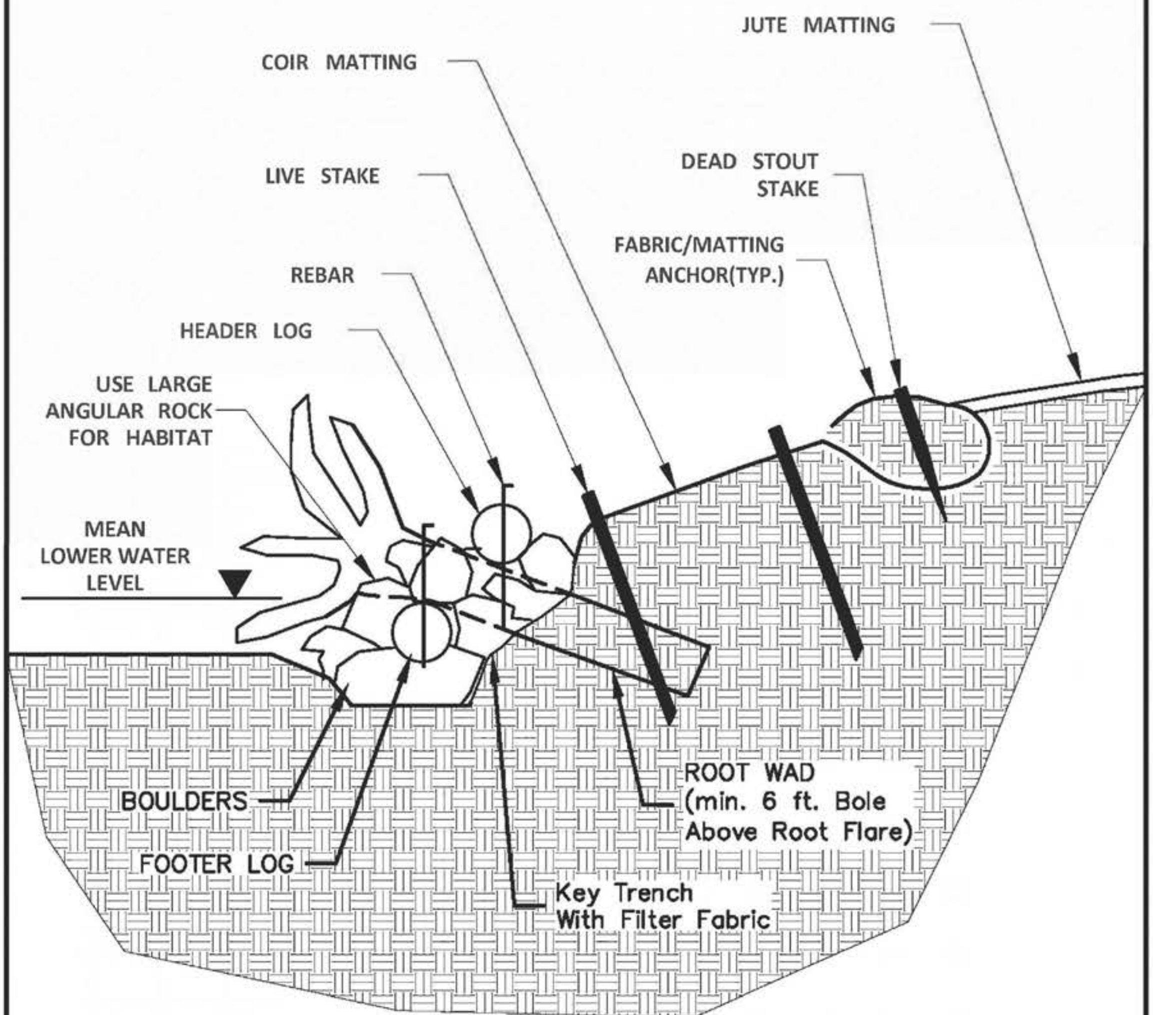
DETAILS OF STAKES



STORMWATER MANUAL

FIGURE 7-5

DETAIL OF ROOT WAD REVETMENT

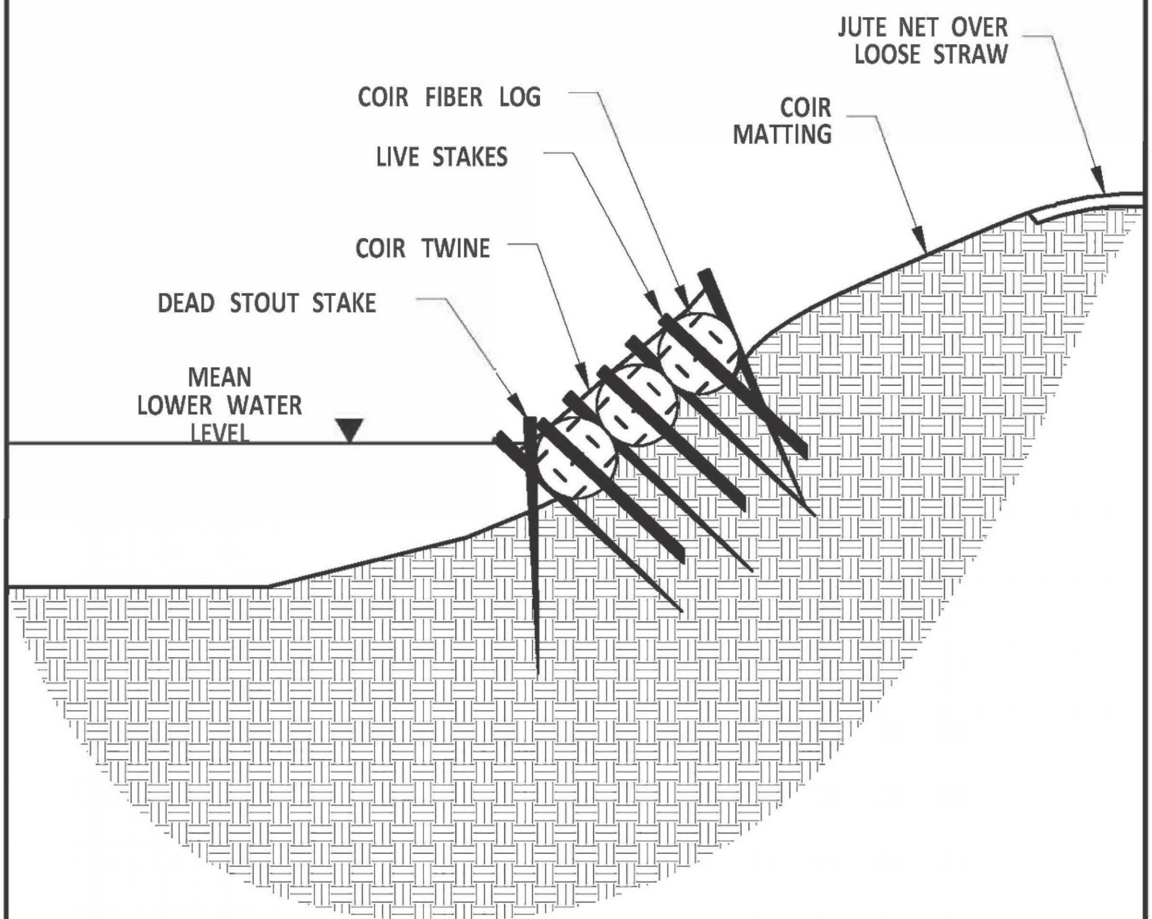


SECTION VIEW
N.T.S.

STORMWATER MANUAL

FIGURE 7-6

DETAIL OF STACKED COIR FIBER LOG REVETMENT

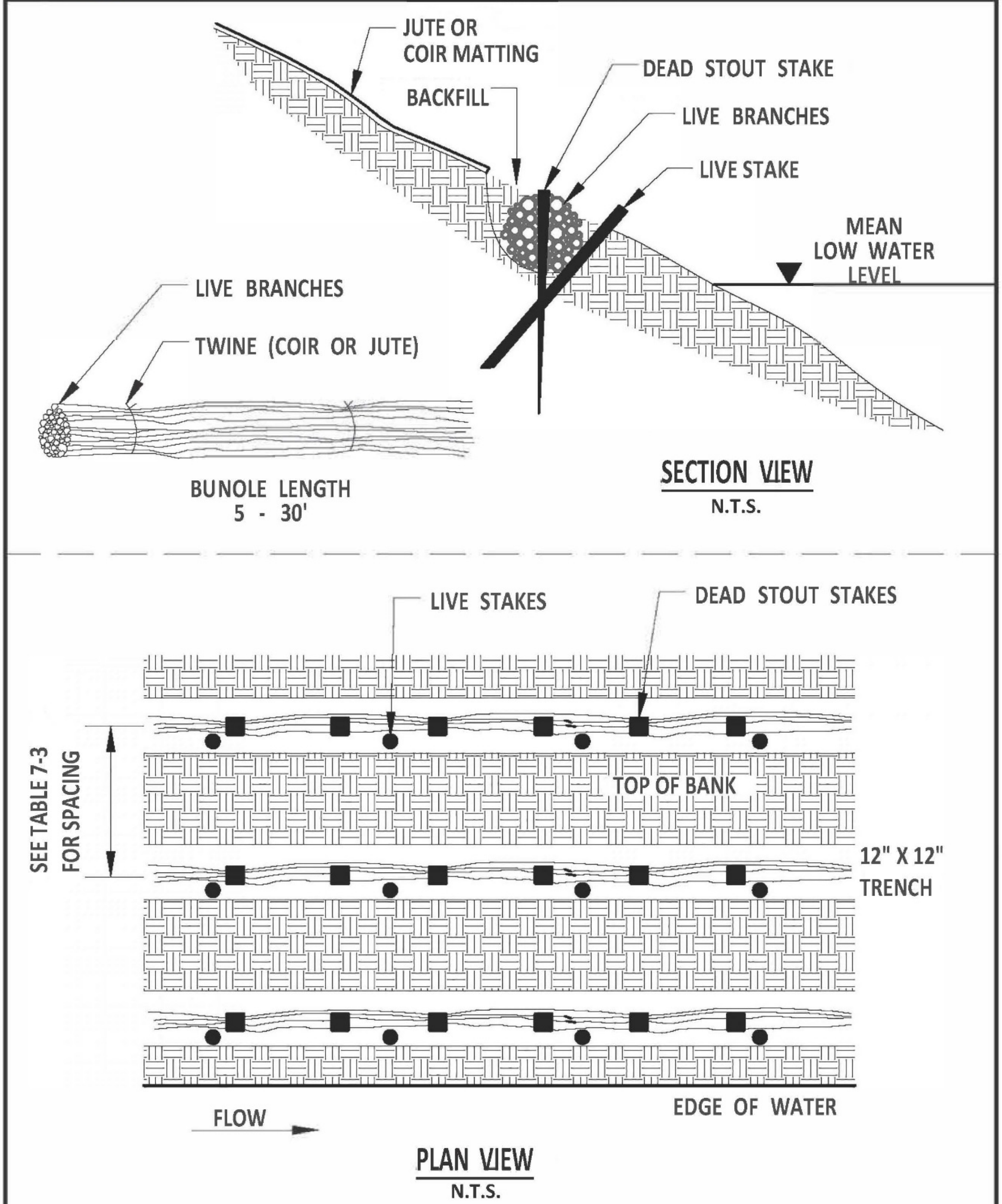


SECTION VIEW
N.T.S.

STORMWATER MANUAL

FIGURE 7-7

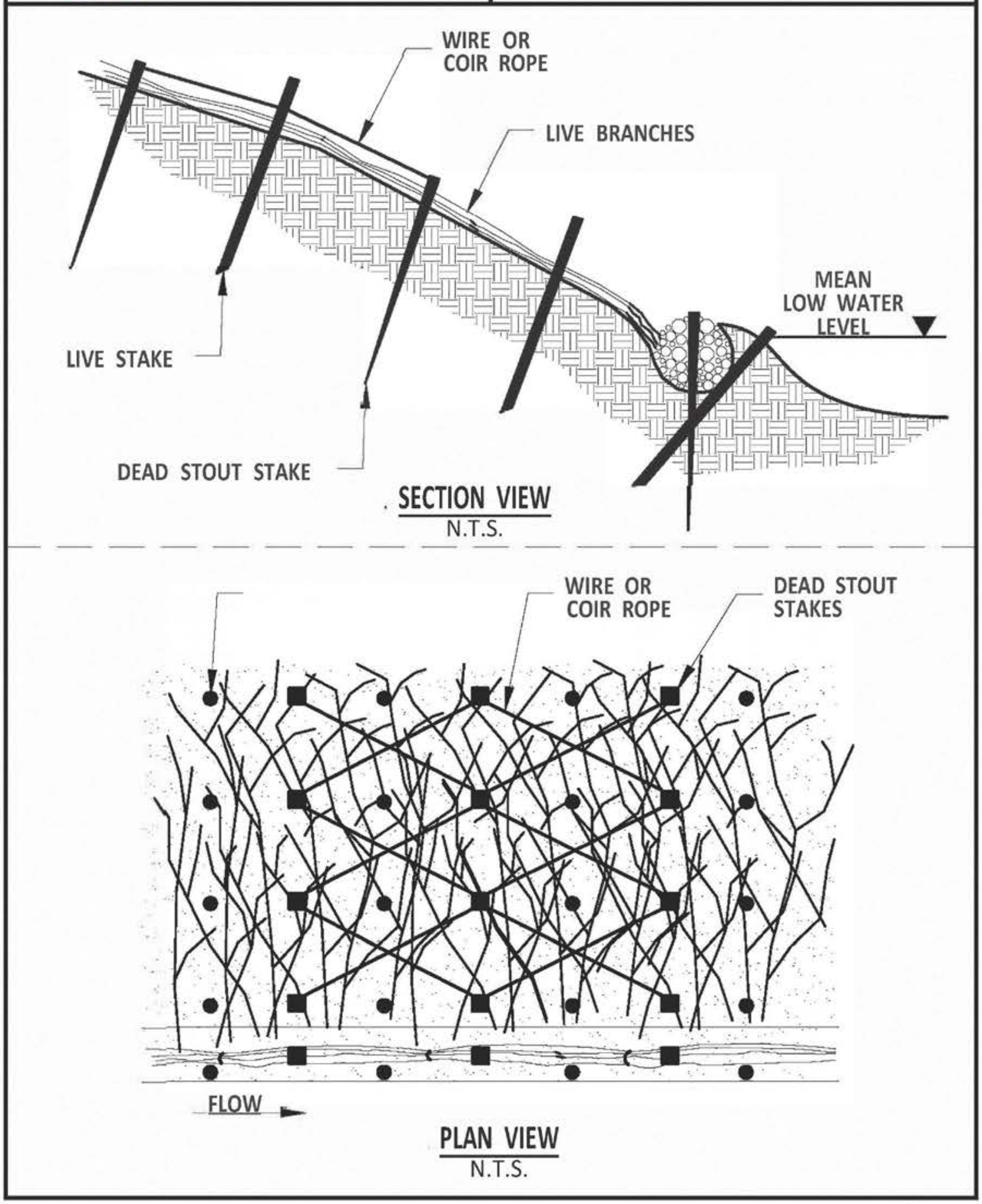
DETAIL OF LIVE FASCINE



STORMWATER MANUAL

FIGURE 7-8

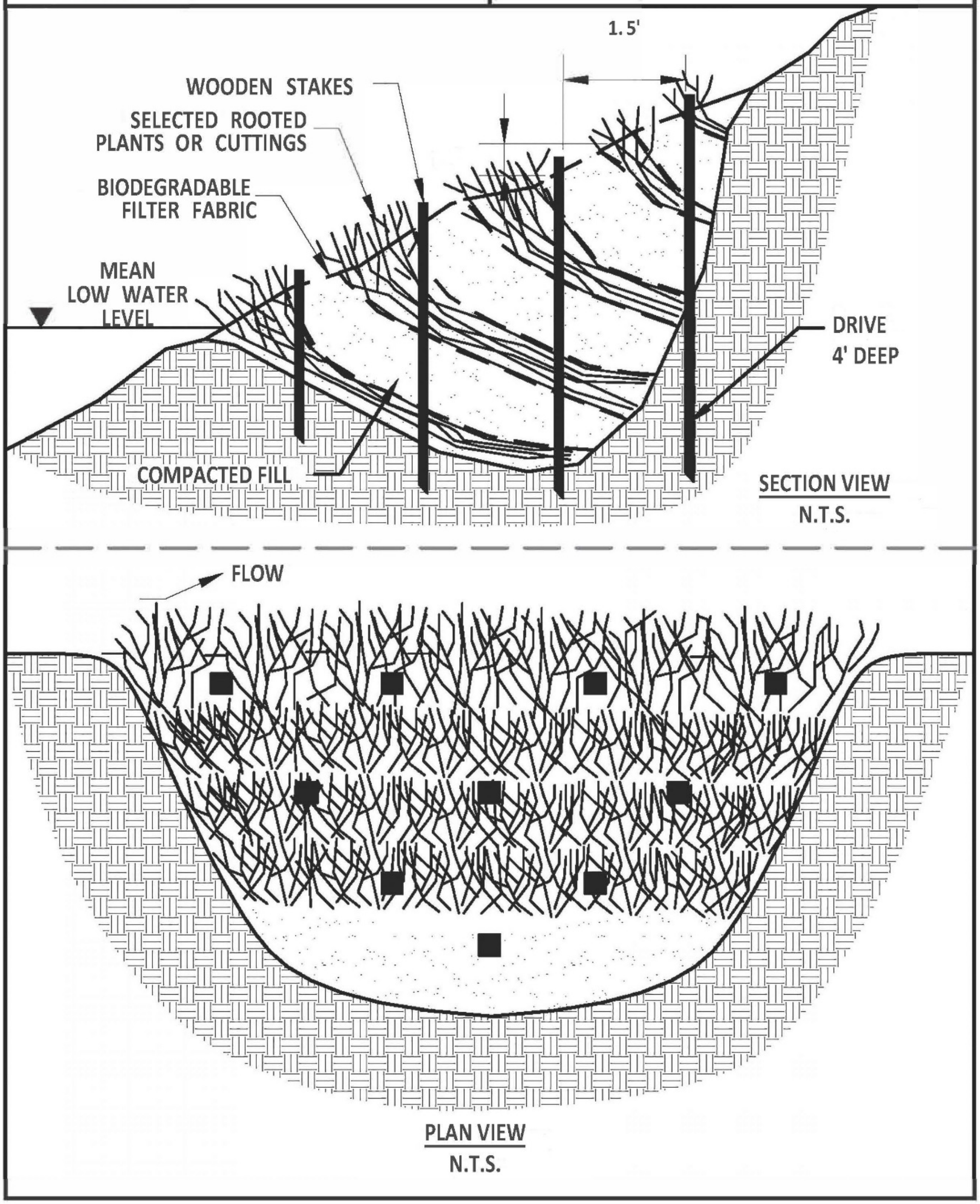
DETAIL OF BRUSH MATTRESS



STORMWATER MANUAL

FIGURE 7-9

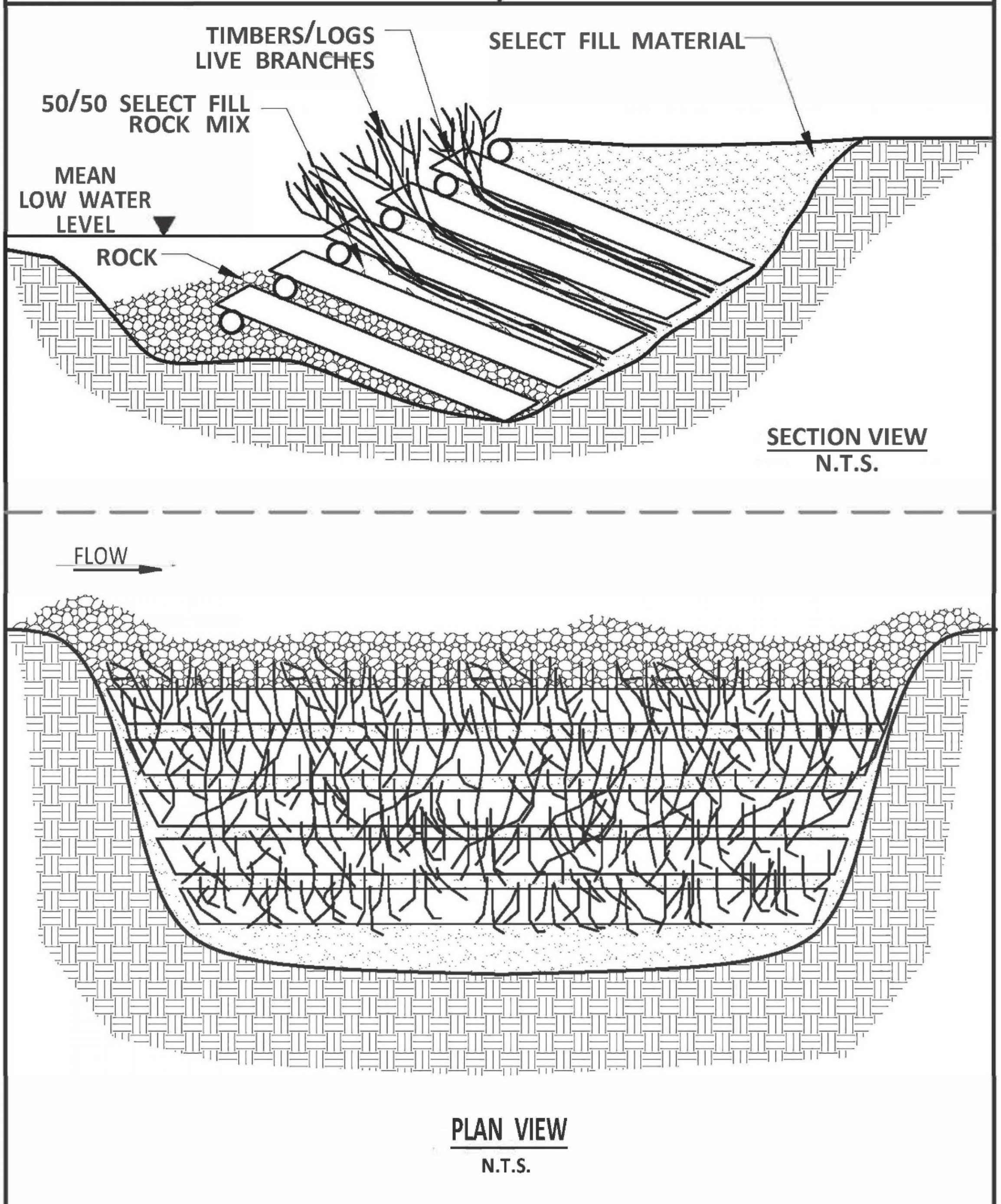
DETAIL OF BRANCH PACKING



STORMWATER MANUAL

FIGURE 7-10

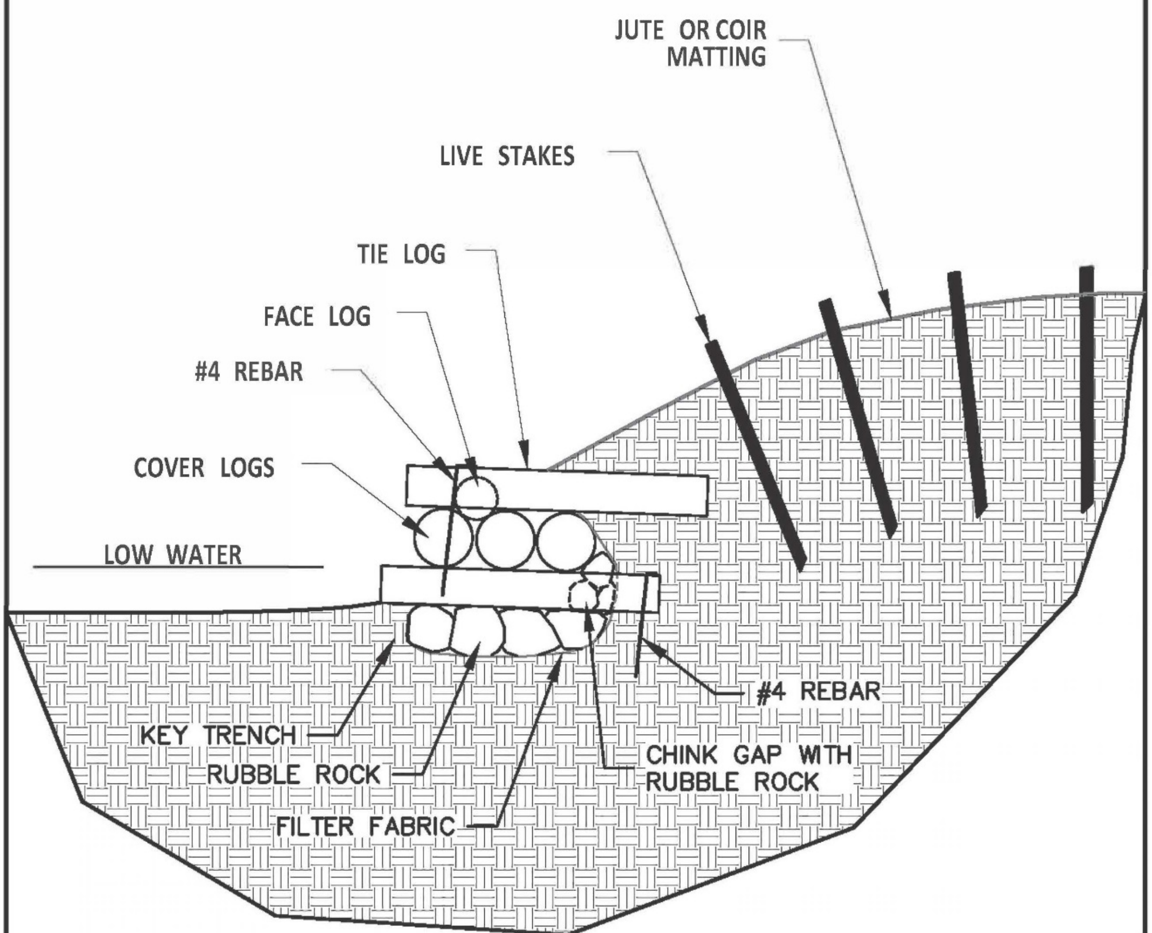
DETAIL OF LIVE CRIBWALL



STORMWATER MANUAL

FIGURE 7-11

DETAIL OF LOG CRIB REVETMENT



CHAPTER 8 – BMP – Water Quantity and Water Quality Control

8.1 Introduction

Non-point source pollution is now responsible for up to 80 percent of pollution in waters of the U.S., which include streams, lakes, rivers, and wetlands. This is true, in part, due to significant reductions in direct discharges of pollutants by industry that have been achieved since passage of the Clean Water Act (CWA) of 1972. In urban areas, non-point source pollution occurs because stormwater runoff collects impurities while passing over rooftops, streets, parking lots, landscaping and gutters. This polluted stormwater runoff typically enters a storm drain system and is rapidly conveyed to a stream, lake, or river. The percentage of impervious land cover in urban and suburban watersheds generally indicates the level of pollutant impact on receiving waters. In most cases, impervious cover in excess of 30 percent results in streams that are considered "degraded," while impervious cover between 10 and 30 percent causes "impacts" on the receiving streams. Typical residential development results in approximately 35 percent of a watershed being impervious, which is more than enough to degrade the receiving waters. Realization of this fact is important, because healthy (non-impacted) streams are important for a healthy ecosystem, and a healthy ecosystem is important for all living creatures including people.

To protect our natural resources, the CWA of 1972, as amended in 1987, prohibits the discharge of pollutants to waters of the U.S. and mandates that stormwater not be discharged unless it is in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. The city of Berea is responsible for ensuring that discharges of stormwater from public stormwater systems into waters of the state comply with CWA requirements. The implementation of the requirements contained in this manual will be a primary mechanism for accomplishing this objective.

Stormwater management in the city of Berea shall include management for quality as well as quantity (flood protection). The general policies for control of quality and quantity were given in Chapter 1. This chapter gives detailed design information on the structural water quality and water quantity best management practices (BMPs) to implement these policies.

Permanent water quality treatment measures described in this chapter should not be confused with erosion and sediment controls required during construction, which are described in Chapter 11.

8.2 General Design Criteria

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

8.2.1 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.

8.2.2 Water Quality Control Treatment Standards

In urban areas the first flush of runoff pollutants carries a heavy load of pollutants from impervious areas such as streets and parking areas that can negatively impact receiving streams by altering the water chemistry and water quality. Capturing the "First Flush" of pollutants is one way to improve water quality leaving the MS4. The goal of this stormwater runoff quality treatment standard is to establish the water quality volume (WQV) metric and provide treatment for the WQV.

The term "water quality volume" is generally used to define the amount of storm water runoff from any given storm that should be captured and treated in order to remove a majority of storm water pollutants on an average annual basis. Therefore, daily precipitation records were retrieved from the UK Ag Weather Station website between 1971 and 2010 for the Lexington climatology station. The data was sorted by depth with zero or trace amounts removed and the total number of rainfall events was multiplied by 0.8 to determine the event depth at which 80% of the total number of events were equal to or less than. The resulting depth was 0.6 inches.

The water quality volume (WQV) can then be calculated using the formula below:

$$WQ_V = \left(\frac{A * d}{43560\, ft^2 * 12in} \right)$$

Where:

WQ_V = Ac•ft
A = Impervious area (ft^2)
d = 0.6 (in)

The calculated WQV shall be treated in combination or alone, by management measures that are designed, built, and maintained to treat, filter, flocculate, infiltrate, screen, evapotranspire, harvest and reuse stormwater runoff, or otherwise manage the stormwater runoff quality.

8.3 Bioretention Systems

Bioretention is a practice to treat stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with biological processes. The system consists of a structure to spread flow, a pretreatment filter strip or grass channel, a sand bed, pea gravel overflow curtain drain, a shallow ponding area, a surface organic layer of mulch, a planting soil bed, plant material, a gravel underdrain system, and an overflow system. Figure 8-1 shows a diagram of a bioretention system designed to receive runoff from a paved area.

8.3.1 Applicability

Bioretention systems are very effective for water quality treatment. Bioretention systems are particularly well suited for use in parking lot islands, roadside swales, and median strips.

8.3.2 Design Criteria

Size the area of the filter bed in accordance with the design WQV corresponding to the area draining to it. (See the next section for procedure).

Design the bioretention system to be on-line with an overflow catch basin, as shown in Figure 8-1, to handle volumes exceeding the design WQV.

Design the bioretention 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 8-1 are minimums. When flow into a bioretention system is parallel to its long dimension (i.e., from a drainage swale), omit the gravel diaphragm shown in Figure 8-1 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 bioretention 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.

Provide a pea gravel curtain drain, as shown in Figure 8-1. The minimum width of the curtain drain is 8 inches.

Provide a 2 to 3 inch thick mulch layer above the planting soil bed.

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.

8.3.3 Design Procedures

Size the filter bed using the following equation: $A_f = V^*(d_f)/[k^*(h_f + d_f)(t_f)]$
where:
A_f = surface area of the sand filter bed (ft^2)
V = treatment or infiltration volume (ft^3)
d_f = planting bed depth (ft)
k = coefficient of permeability for planting bed (ft/day)
h_f = average height of water above the planting bed (ft); $h_f = 0.5 * h_{max}$
t_f = time required for V to filter through the planting bed (days).

Note:
d_f = 4 feet (including sand filter) unless it is increased by designer
k = 0.5 feet/day (median value of a silt loam)
$h_f = 0.5 * h_{max}$ = 3 inches = 0.25 feet

t_f = 3 days.

Design the bioretention system to provide the minimum filter area required and to meet the design criteria.

8.3.4 Specifications

Provide planting soil with the following characteristics:

- pH of 5.2 to 7.0
- organic content of 1.5 to 4 percent
- magnesium of 35 pounds per acre minimum
- phosphorus (as P_2O_5) of 75 pounds per acre minimum
- potassium (as K_2O) at 85 pounds per acre minimum
- soluble salts less than 500 ppm
- clay content of 10 to 25 percent by volume
- silt content of 30 to 55 percent by volume
- sand content of 35 to 60 percent by volume
- free of stones, stumps, roots, or other woody material greater than 1 inch in diameter

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 ¼ inch.

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

Provide PVC piping for the underdrain satisfying AASHTO M-278 standard for rigid schedule 40 pipe. Provide 3/8 inch diameter perforations on 6-inch centers with four holes per row.

Plant base of bioretention system (planting soil bed) in herbaceous ground cover and shrubs. Plant side slopes of bioretention system in herbaceous ground covers, vines, and shrubs. Trees may also be used in the bioretention 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).

Select herbaceous species for the planting soil bed from the following list. 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 7-1 in Chapter 7. Also, select vines, shrubs, and trees from Table 7-1.

8.4 Infiltration Systems

Infiltration practices and/or bioretention systems reduce the adverse impacts on the receiving waters that result from increasing the impervious area. This chapter describes several infiltration practices that can be used in many different situations. Many of the practices cannot function as the sole water quality infiltration and treatment device, but will provide significant “credits” toward reducing the magnitude of the runoff that must be detained and treated.

Infiltration practices include a variety of practices such as directing downspouts to grassed areas and using modular pavement. Infiltration practices also include swales, terraforming, infiltration, and vegetative filters. Terraforming is a term for special grading practices such as terracing and berming that are intended to promote infiltration. This section presents infiltration practices and describes the minimum requirements that must be met to obtain credits to reduce water quality treatment volumes.

The infiltration volume credit listed for each practice can be used to satisfy an equal amount of water quality volume.

8.4.1 Downspouts to Grass

Discharging downspouts from roofs onto grassed yards encourages infiltration and reduces direct discharge to impervious areas such as driveways. The grass area shall be greater than or equal to the roof area.

Infiltration Credit
When downspouts are discharged onto grass, the infiltration credit is 0.225 acre-feet per acre of roof area.

Design Criteria
The lot must be graded so that the downspout discharge travels at least 30 feet over grass before reaching a driveway, roadway, paved ditch, or any other impervious conveyance.

8.4.2 Modular Pavement (bricks, pavers, etc.)

Modular pavement consists of strong structural materials, typically concrete, having regularly interspersed void spaces that are filled with pervious materials such as sand, gravel, or sod. These pavements can be used as driveways or as overflow parking in areas that are used less frequently than the main parking areas for civic, commercial, and industrial facilities.

Infiltration Credit
Any area that is paved using modular pavement can be treated as pervious for purposes of calculating WQV and post-development peak runoff, as long as appropriate design criteria and construction specifications are satisfied.

Design Criteria
Large void spaces in modular pavement shall represent at least 30 percent of the total surface area of the pavement.

Voids shall be filled with silty soil and vegetated with permanent grass. If vegetation is inappropriate, voids may be filled with sand or gravel, but the material shall be clean and uniform (poorly graded) to ensure high permeability.

Construction Specifications
Install all modular pavements following manufacturer's specifications.

To prevent premature clogging and/or failure, modular pavements shall not be placed into service until the entire contributing surface drainage area has been completely stabilized.

Clearly mark the planned area for modular pavement to prevent heavy equipment from compacting the underlying soils.

Excavate the subgrade soil using equipment with tracks or oversized tires to minimize compaction.

8.4.3 Swales

Swales are typically vegetated parabolic or trapezoidal channels with a large width to depth ratio that are used for conveying stormwater runoff. Swales can act both as vegetated filters and infiltration practices because they tend to slow runoff rates and allow for both particle settling and stormwater infiltration. Swales are encouraged wherever they can be used as an alternative to narrower, deeper channels that tend to convey flow at higher velocities. Swales are especially effective in reducing water quality impacts when used for roadside drainage instead of the traditional curb inlet/storm sewer system. In this application, curb cuts are used instead of drop inlets in the gutter. See Figure 8-2.

Swales can be even more effective when constructed using berms or infiltration beds to encourage additional ponding and infiltration. These cases are discussed in subsequent sections.

Infiltration Credits
When swales are used, the infiltration credit is 0.25 acre-feet per acre of swale. To obtain this

credit, the area draining to the swale must be at least three times the area of the swale considering that the swale itself is part of the drainage area.

To calculate the area of the swale, the width will be the average water surface width corresponding to the flowrate associated with the 100-year storm.

Design Criteria
To be considered a swale, a channel must have a width to depth ratio of at least 6:1, have a bed slope of not greater than 4 percent, and be vegetated. When swales are used for roadside drainage, curb cuts shall be provided no less frequently than one per each 100 feet of curb.

Drop inlets in swales shall be spaced no closer than once per each 300 feet in order to obtain the infiltration credit.

Grassed channels that do not satisfy the design criteria to be considered swales may be given an infiltration credit only for the channel bottom, if the bed slope does not exceed 4 percent.

8.4.4 Bermed Swales

A bermed swale or infiltration swale is a grassed swale constructed with berms or swale blocks across the swale to impound shallow pools of water, slowing flow and providing additional opportunities for particle settling and stormwater infiltration.

Infiltration Credit
Infiltration credit for a bermed swale is calculated in the same manner as the credit for a swale, except that the calculated infiltration credit can be increased by 50 percent of the water volume that can be impounded by the berms.

Design Criteria
Swale blocks or earthen berms built across the swale shall be constructed with a 2-inch diameter PVC pipe through the berm to prevent long-term ponding of water.

Berms shall be no taller than 8 inches and spaced no closer than 60 feet.

Drop inlets in swales shall be spaced no closer than once per each 300 feet in order to obtain the infiltration credit.

Grassed channels that do not satisfy the design criteria to be considered swales may be given an infiltration credit only for the channel bottom, if the bed slope does not exceed 4 percent.

8.4.5 Biofiltration Swales

A biofiltration swale is a version of a bioretention system without the pipe underdrain system. This practice encourages infiltration from the swale bottom, through a planting bed, to the underlying soil. See Figure 8-3.

Infiltration Credit
Infiltration credit for a biofiltration swale is 0.50 acre-feet per acre of swale plus 100 percent of the

volume of the ponded water, when designed according to the following criteria. If biofiltration swales are designed consistent with the procedures for bioretention systems, the infiltration credit equals the design treatment volume.

Design Criteria
Biofiltration swales shall be designed to have the following characteristics:

- trapezoidal or parabolic shape
- 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.

An alternative to the above criteria is to size the filter bed (i.e., planting soil bed) for a biofiltration swale consistent with a bioretention system. Then the infiltration credit would be calculated in the same manner as the credit for bioretention.

8.4.6 Terraforming

Terraforming is a term for special grading practices such as terracing and berming that are intended to promote infiltration. Bermed swales are a special case of terraforming. Terraforming can range from a small depression in permeable soil to an extensive series of bermed terraces. A simple example is given in Figure 8-4.

Infiltration Credit
The infiltration credit for terraforming is 0.25 acre-feet per acre of area terraformed plus 100 percent of the impounded water.

8.4.7 Infiltration Basins

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 pond 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 infiltration credit for an infiltration basin is simply the volume designed to be impounded before overflow or discharge to a spillway.

Design Criteria

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 the city of Berea 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 10 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.

8.4.8 Vegetated Filter Strips

A vegetated filter is a practice that relies upon the use of vegetation to filter out sediment and other pollutants from stormwater runoff. These filters also provide an opportunity for stormwater runoff to infiltrate. Vegetated filters can be used as water quality devices. Vegetated filters can be used for small subareas of a larger development in order to reduce the total volume to be treated by other devices in the development.

A filter strip is a practice that relies upon sheet flow across the entire width of the vegetated area. The vegetation is typically grass; however, other ground cover can be used if it provides for dense vegetation. Filter strips are typically used at the edge of a parking lot or other paved surface.

Design Criteria
Design a filter strip to have a width matching the width of the area draining to the filter.

Design a filter strip to have a smooth transition with the area draining to it so that sheet flow can be developed across the filter.

Design filter strips to have a minimum slope of 2 percent and a maximum slope of 6 percent. Provide

a dense turf or other comparable vegetated ground cover over the whole filter area.

When the contributing area draining to the filter strip is impervious, do not allow the overland flow length of the impervious surface to exceed 75 feet.

When the contributing area draining to the filter strip is pervious, do not allow the overland flow length of the contributing surface to exceed 150 feet.

Infiltration Credit
The infiltration credit for vegetated filters is 0.075 acre-feet per acre of filter.

8.4.9 Riparian Buffers

Riparian buffers are vegetated zones of trees and/or shrubs adjacent to and upgradient from perennial or intermittent streams, lakes, ponds, and wetlands. See Chapter 7 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 7.

In order to obtain infiltration credit for re-establishing a riparian buffer zone, the streambank must also be restored in accordance with Chapter 7.

Infiltration Credit

The infiltration credit for re-establishing a riparian buffer zone is 0.5 acre-feet per acre of buffer restored.

In order to obtain this credit, 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 upgradient drainage area is permanently stabilized.

8.5 Sand and Organic Filters

In general usage, stormwater filters are a diverse group of techniques for treating stormwater quality with each using some sort of filtering media such as sand, soil, gravel, peat, compost, or vegetation. Filters will include systems with a designed filter bed composed of sand, gravel, compost, or peat and an outlet to the stormwater drainage system or a receiving stream. Systems described in this section include surface sand filters, underground sand filters, perimeter sand filters, and organic filters.

8.5.1 Applicability

Filters can be used for water quality treatment, but are not appropriate for peak flow (quantity) control.

8.5.2 General Design Criteria

Design criteria in this section apply to all filtration devices in this section.

Provide a pretreatment cell to allow sedimentation prior to the filter bed and reduce clogging. Locate

inlet and outlet structures at extreme ends of the pretreatment cell.

Design the pretreatment or sedimentation cell to have a minimum depth of 3 feet to minimize resuspension and turbulence.

Design the bottom of the pretreatment cell to be nearly level to facilitate sedimentation.

Design the surface area of the pretreatment cell (in square feet) to be at least 0.0081 times the WQV (in cubic feet) for areas with 75 percent or more impervious surface. For areas with less than 75 percent impervious surface, design the surface area of the pretreatment cell (in square feet) to be at least 0.066 times the WQV (in cubic feet). The order of magnitude difference in the two factors derives from the fact that areas with higher percentages of impervious surface (i.e., 75 percent or more) tend to have a greater proportion of coarse- grained sediments, which have a higher settling velocity.

Size the pretreatment cell with a minimum length to width ratio of 2:1.

The length to width ratio of the pretreatment cell can be less than 2:1 if baffles are provided to obtain a flow length equivalent to or greater than would be obtained with a 2:1 ratio.

Design each filtering device for a capture or storage volume equal to or greater than ¾ times the WQV.

Design filtration systems to be off-line by using a flow-splitter or other device to divert flows in excess of the WQV around the filtration systems.

Provide sufficient access to the device for construction and maintenance. Provide an access ramp with a maximum slope of 10 percent for vegetated ramps, 15 percent, if the slope is stabilized with crushed stone, or 25 percent if paved.

Construct exposed piping and accessories out of durable, strong materials to avoid susceptibility to damage by vandalism.

Provide access manholes and/or grates to underground and below grade structures for each subsurface chamber. Provide manhole diameters of at least 30 inches to meet confined space access criteria. Place manhole steps to allow maintenance personnel easy access to structure bottoms. Provide a 5-foot minimum height clearance (from the top of the sand layer to the bottom of slab) for all fixed permanent underground structures. Provide lifting rings or other suitable elements to lift and replace structure top slabs.

Construct the underground sand filter with a dewatering gate valve located just above the top of the sand filter bed. Should the filter bed and/or underdrain system clog completely, the gate valve can be opened to dewater the filter chamber for needed maintenance.

8.5.3 Surface Sand Filter

A surface sand filter is shown in Figure 8-5. This system is constructed of reinforced concrete with a pretreatment (sedimentation) chamber and a filter bed chamber with a sand filter and underdrain system. Figure 8-5 also shows a flow diversion chamber at the inlet end of the structure. The filter bed has an 18-inch to 24-inch sand layer which traps or strains pollutants before runoff is collected in an underdrain system (gravel and perforated pipe) and conveyed to the receiving stream, channel or pipe. The filter bed surface may have a sand or grass cover.

Surface sand filters are open at the top, which provides easy access for maintenance, but renders these unsuitable in areas easily accessible to the general public, especially small children. Control access to surface sand filters by enclosing them in an eight-foot chain link fence. Such a configuration is most suitable to industrial and warehousing facilities rather than commercial/retail establishments where aesthetic impact is significant. Even for industrial sites, consider proximity to residential areas and other locations frequented by children. In some locations, an eight-foot fence may not provide adequate protection.

Design Procedures

Size the pretreatment chamber in accordance with design criteria in 8.5.2. Size the

area of the filter bed using the following equation:

$A_f = WQV*(d_f)/[k*(h_f + d_f)(t_f)]$ where:
A_f = surface area of the sand filter bed (ft^2)
WQV = water quality treatment volume (ft^3) d_f
= sand filter bed depth (ft)
k = coefficient of permeability for sand bed (ft/day)
h_f = average height of water above the sand bed (ft); $h_f = 0.5 * h_{max}$ t_f =
time required for the WQV to filter through the sand bed (days).

Note:

- set d_f such that 1.5 feet $\leq d_f \leq$ 2 feet
- h_f can vary depending on the site conditions, but six feet is the maximum value.
- Use 1.7 days (i.e., 40 hours) for the filter bed draw-down time (t_f).
- Use k = 3.5 ft/day.

Design the underdrain system beneath the filter bed to be at least six inches deep, with at least two inches of gravel over drain pipes and pipe slopes of at least 0.5 percent.

Design the underdrain system to ensure that the flow through rate of the filter bed is controlled by the filter media rather than the underdrain system.

Calculate the minimum volume which must be stored within the device as V_{min} = 0.75 (WQV).

Compute the water volume within the filter bed as $V_f = A_f * 0.35 * (d_f + d_u)$, where d_f is the depth of the sand bed and d_u is the depth of the gravel underdrain. The constant 0.35 represents the porosity of the sand and gravel. Figure 10-6 provides an illustration of the parameters used for calculating storage volume.

Compute the temporary storage volume above the filter bed as $V_{f-temp} = 2 * h_f * A_f$.

Compute the remaining volume required for the pretreatment chamber as $V_s = V_{min} - (V_f + V_{f-temp})$. Check that V_s is approximately 50 percent of V_{min}. If it is not, decrease h_f and recompute. Note that changing h_f will change the computed A_f.

Calculate the height in the pretreatment chamber, h_s, as $h_s = V_s/A_s$.

Check that h_s is greater than 2 * h_f and h_s is greater than 3 feet. If not, adjust h_f and repeat computation.

Design a junction box flow splitter with either a pipe or weir overflow to the stormwater system. Set the invert of the overflow to the elevation of the design water level in the pretreatment chamber. Design the overflow to convey the peak discharge anticipated from the 10-year storm.

Design the structural concrete components in accordance with design loads and site soil conditions.

Specifications

Select sand to meet AASHTO M-6 or ASTM C-33 requirements for medium aggregate concrete sand with size range of 0.02 to 0.04 inches.

Select underdrain gravel to meet AASHTO classification M-43 with size range of 0.5 to 2 inches.

Select geotextile fabric to have a minimum puncture strength of 125 pounds (ASTM D-751), minimum mullen burst strength of 400 psi (ASTM D-1117), and minimum tensile strength of 300 pounds (ASTM D-1682). Geotextile fabric shall have an opening size equivalent to U.S. sieve size #80 and shall provide a minimum flow rate of 125 gallons/minute per square foot.

Select underdrain piping to meet AASHTO M-278 requirements for Schedule 40 PVC pipe. Provide 3/8-inch perforations on 6-inch centers with four holes per row.

Construct the base of the sand filter structure on undisturbed soil or rock. If disturbed soil must be used as a base, recompact it to 95 percent of maximum standard dry density in 6- inch compacted lifts.

Do not allow runoff to enter the sand filter bed until the upstream drainage area is completely stabilized and site construction is completed. The sedimentation pond may serve as a temporary sediment control pond during site construction with the provision that overflows will bypass the filtration bed.

Construct the top of the filter bed completely level.

Store materials which might be damaged during construction (such as perforated PVC piping, geotextiles, etc.) in a safe location and handle carefully.

Construct overflow weirs, multiple orifices and flow distribution slots completely level to ensure adequate distribution of design flows.

Construct the main collector pipe for underdrain systems at a minimum slope of 0.5 percent. Provide observation and clean-out pipes for all underdrain piping.

8.5.4 Underground Sand Filter

Underground sand filters are suitable for intensely developed urban areas where space is at a premium. These systems are also suitable in locations that are easily accessible to the public. Figure 8-7 shows an underground sand filter. In this design, the sand filter is placed in a three chamber underground vault accessible by manholes or grate openings. The first chamber is a 3-feet deep sediment chamber used for pretreatment. It is connected to the second chamber (the sand filter bed) by an inverted elbow or submerged slot, which keeps the filter surface free from trash and oil. The filter bed is 18 to 24 inches in depth and has a protective screen of gravel over filter fabric to act as a pre-planned failure plane that can easily be replaced when the filter surface becomes clogged. During a storm, the water quality volume is temporarily stored in both the first and second chambers. Flows in excess of the filter's capacity are diverted through an overflow weir.

Design Procedures

Design procedures are consistent with those described previously for a surface sand filter with the following exceptions. See Figure 8-8 for an illustration of the volume parameters.

After computing the minimum volume which must be stored (V_{min}) and the volume in the filter bed (V_f), compute the minimum wet pool volume in the settling basin as $V_w = 3\ ft * A_s$.

Compute the temporary storage volume required within both chambers as $V_{temp} = V_{min} - (V_f + V_w)$.

Compute the total surface area of both chambers as $(A_f + A_s)$.

Calculate the height of temporary storage needed as $h_{temp} = V_{temp}/(A_f + A_s)$.

Check that h_{temp} is greater than or equal to $2h_f$. If not, decrease h_f and recalculate volume requirements.

Specifications

Specifications are consistent with those provided for surface sand filters with the following addition.

To help extend the design life of the sand filter bed for the underground sand filter, place a wide mesh geotextile screen on the surface of the filter bed to trap the large quantities of trash, litter, and organic detritus associated with highly urban areas. During maintenance operations the screen is rolled up, removed and cleaned, and reinstalled.

8.5.5 Perimeter Sand Filters

The perimeter sand filter consists of two parallel trench-like chambers that are typically installed along the perimeter of a parking lot. Figure 8-9 shows a perimeter sand filter. Parking lot runoff enters the first chamber that has a shallow permanent pool of water. The first trench provides pretreatment before the runoff spills into the second trench, which consists of an 18-inch deep sand layer over a gravel/perforated pipe underdrain system. During a storm event, runoff is temporarily ponded above the normal pool and sand layer, respectively. When both chambers fill up to capacity, excess parking lot runoff is routed to a bypass drop inlet.

Design Procedures

Design procedures are consistent with those described previously for a surface sand filter with the following exceptions. See Figure 8-10 for an illustration of the volume parameters.

After computing the minimum volume which must be stored (V_{min}) and the volume in the filter bed (V_f), calculate the minimum wet pool volume in the pretreatment basin as $V_w = A_s * 2$ ft.

Calculate the temporary storage volume required as $V_{temp} = V_{min} – (V_f + V_w)$.

Compute the total surface area of both chambers as ($A_f + A_s$).

Check that h_{temp} is greater than or equal to $2h_f$. If not, decrease h_f and recompute areas and volumes. Note that changing h_f will change the required A_f.

Specifications
Specifications are consistent with those given for a surface sand filter.

8.5.6 Organic Filters

Organic filters are designed consistent with surface or underground filters except that the sand filter bed is replaced or modified with organic media. There are two basic options for organic filters: a peat-sand system and a compost system.

In the peat-sand system, the filter bed is a minimum of 24 inches deep over the underdrain system. This 24-inch bed consists of a 6-inch sand layer overlain by an 18-inch layer of peat- sand mix.

The compost filter system consists of a fabricated leaf compost filtration bed overlying the underdrain system. The compost must be mature and humic so that the organic material is no longer rapidly decaying, and it must be locally available at a reasonable cost.

Design Procedures
Design procedures are consistent with those given previously for surface sand filters or underground sand filters except that the coefficient of permeability, k, for the organic filter is modified. For a peat-sand system, use k = 2.75 ft/day. For a compost system, use k = 8 ft/day.

Specifications
For peat-sand filter beds, select a fibric peat that is shredded, uniform, and clean.

For peat-sand filter beds, combine equal volumes of peat and sand and mix to obtain uniform distribution of peat and sand. Sand specifications are given in Section 8.5.3.

For peat-sand filter beds, place a 6-inch layer of sand over the gravel underdrain. Separate the sand layer from the gravel layer with geotextile fabric. Select sand and geotextile consistent with specifications in Section 8.5.3. Above the 6-inch sand layer, place 18 inches of the 50/50 peat-sand mixture. Construct the filter bed so that the surface of each layer is level. Provide nominal compaction of the gravel and sand layers using a mechanical tamper. Do not compact the sand-peat layer.

For a compost filter bed, select a compost that is mature and humic, composed of leaf medium rather than general yard waste compost.

For a compost filter bed, place a minimum of 18 inches above the geotextile overlying the underdrain system. Do not compact the compost filter bed.

8.6 Prefabricated Treatment Devices

Several manufacturers produce devices that are effective in removing suspended solids and floating oils from stormwater runoff. These devices are typically well-suited to sites that are relatively small and have a high percentage of impervious cover. These devices are not as effective in applications where a majority of the ground cover is pervious and a high percentage of the suspended solids are eroded fine soil particles. Contact the city of Berea for a list of approved products.

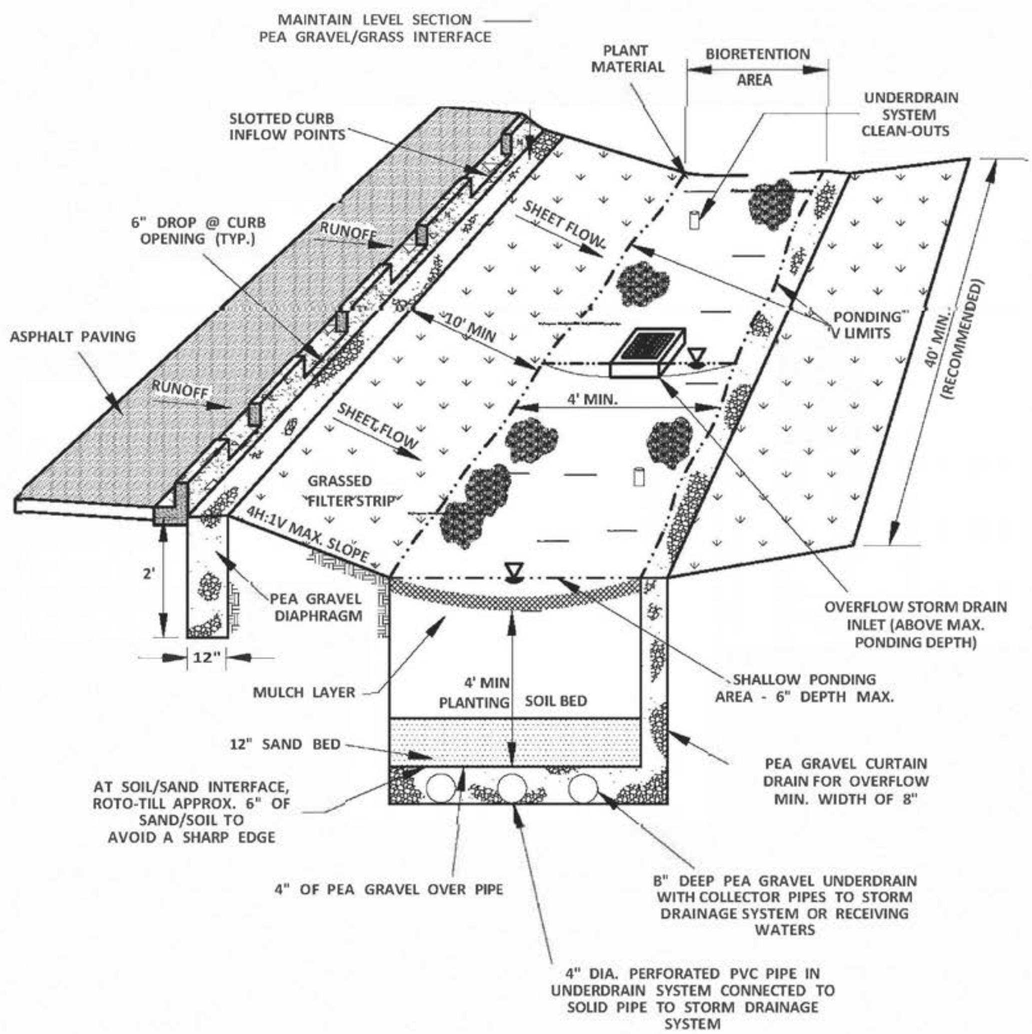
8.6.1 Design Criteria

The treatment devices shall be capable of demonstrating 80% capture of particles in a size range of 2 mm (very coarse sand) to 0.125 mm (very fine sand). The design storm shall have an intensity of 2.1 inches/hour (3-month frequency storm with a time of concentration of 10 minutes).

STORMWATER MANUAL

FIGURE 8-1

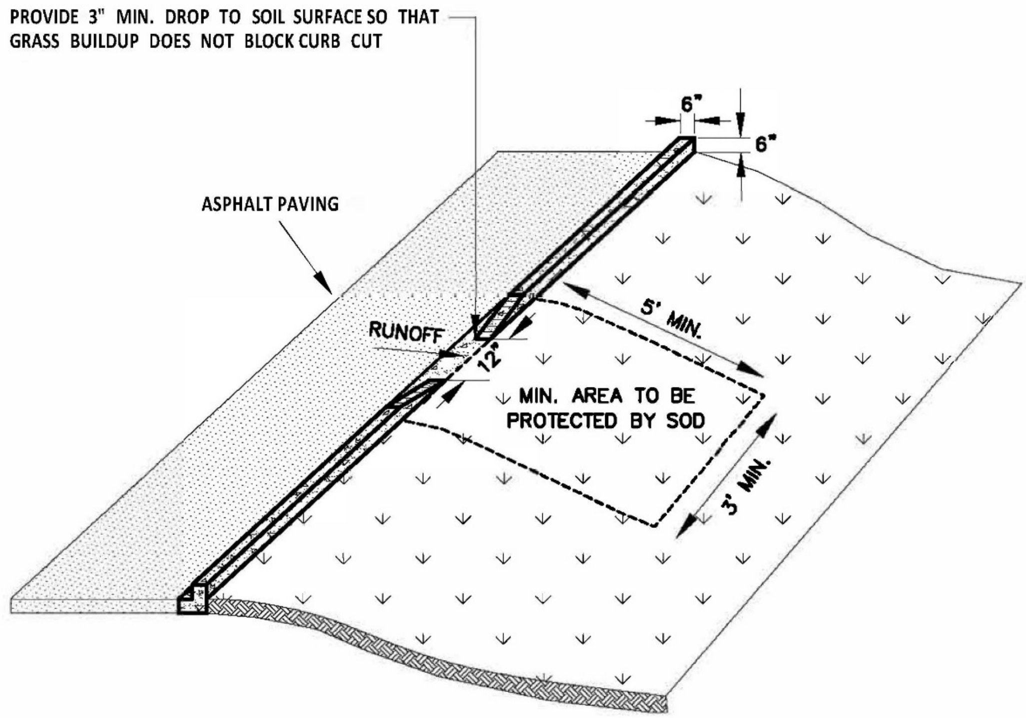
BIORETENTION SYSTEM



STORMWATER MANUAL

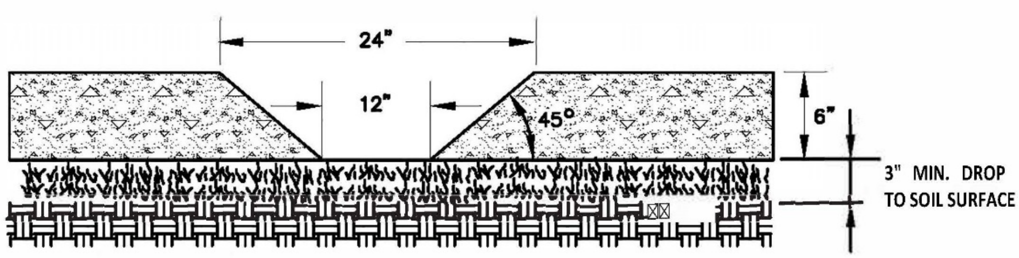
FIGURE 8-2

CURB CUT TO SWALE



ISOMETRIC VIEW

N.T.S.



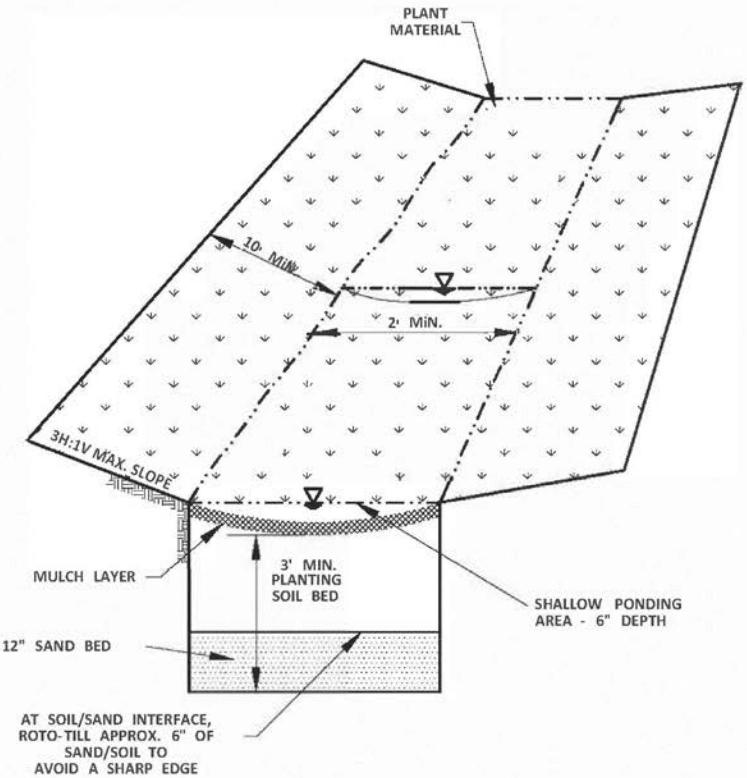
ELEVATION VIEW

N.T.S.

STORMWATER MANUAL

FIGURE 8-3

BIOFILTRATION SWALE

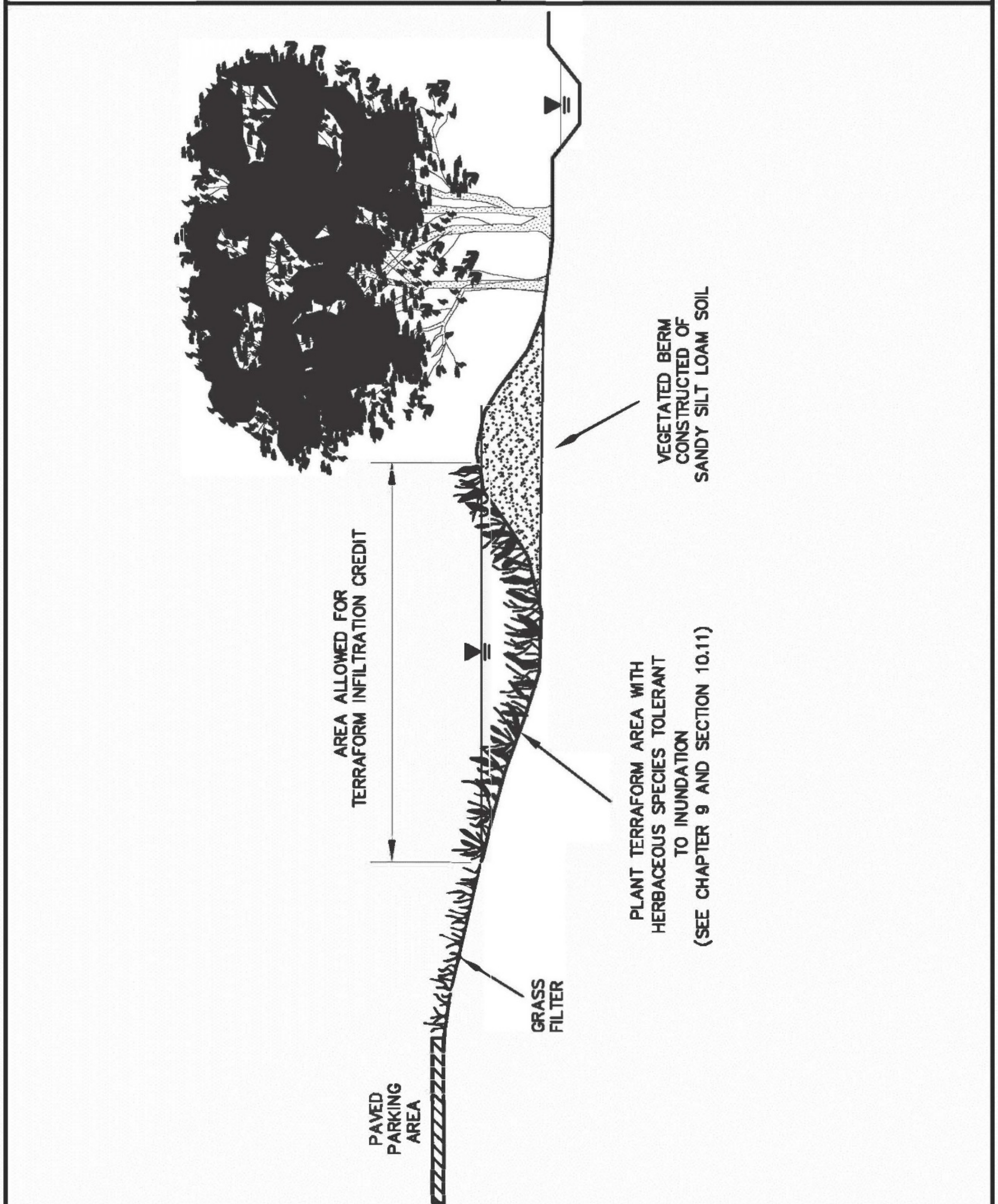


NOTE:
IF LONGITUDINAL SLOPE EXCEEDS 2 PERCENT, CONSTRUCT A BERM AT THE DOWNSTREAM END OF BIOFILTRATION SWALE. CONSTRUCT BERM SO THAT IT IS 12 TO 18 INCHES HIGH IN CENTER WITH A LEVEL TOP ACROSS THE PLANTING BED. CONSTRUCT THE BERM TO HAVE SIDE SLOPES NO GREATER THAN 2 HORIZONTAL TO 1 VERTICAL.

STORMWATER MANUAL

FIGURE 8-4

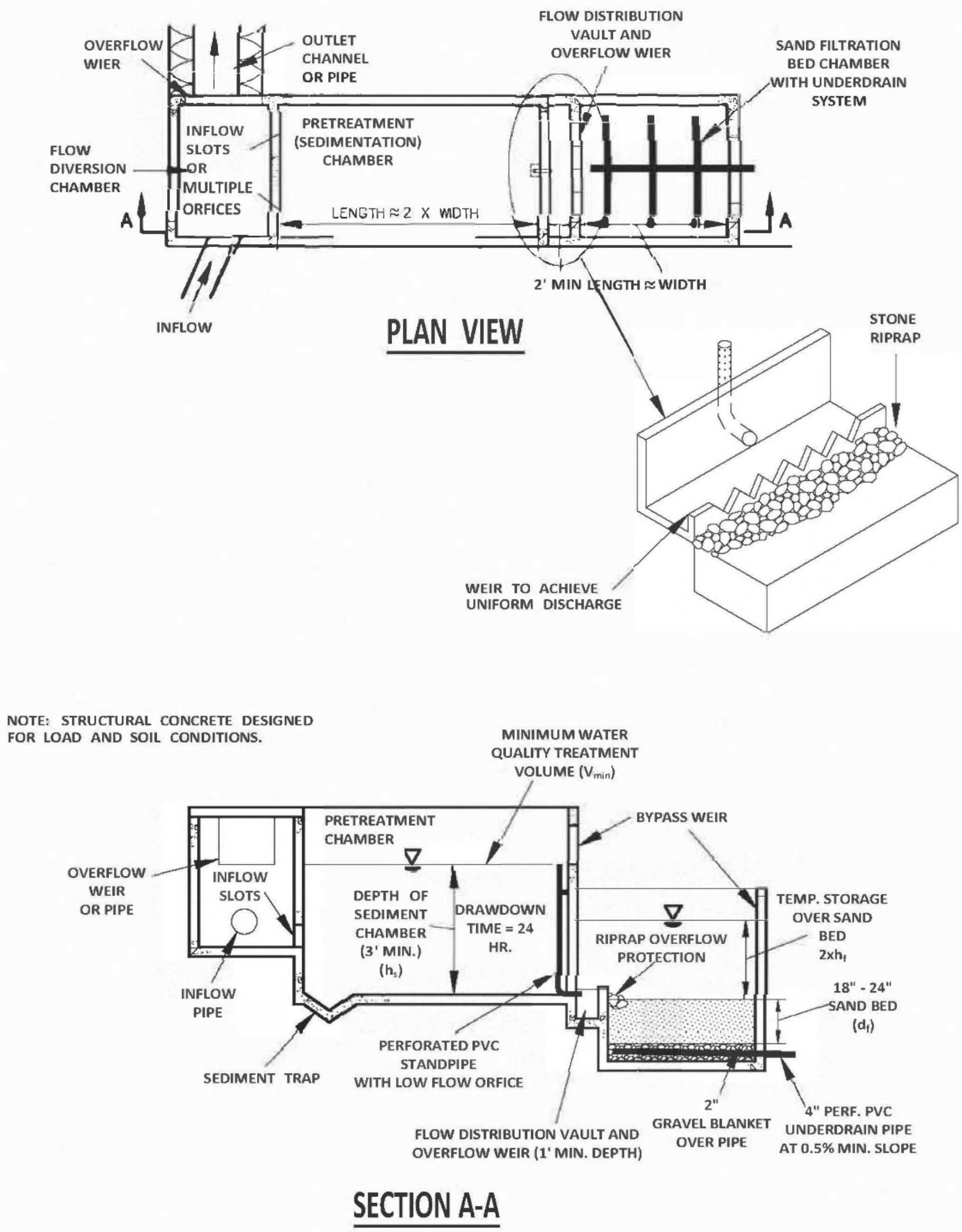
TERRAFORM BERM



STORMWATER MANUAL

FIGURE 8–5

SURFACE SAND FILTER

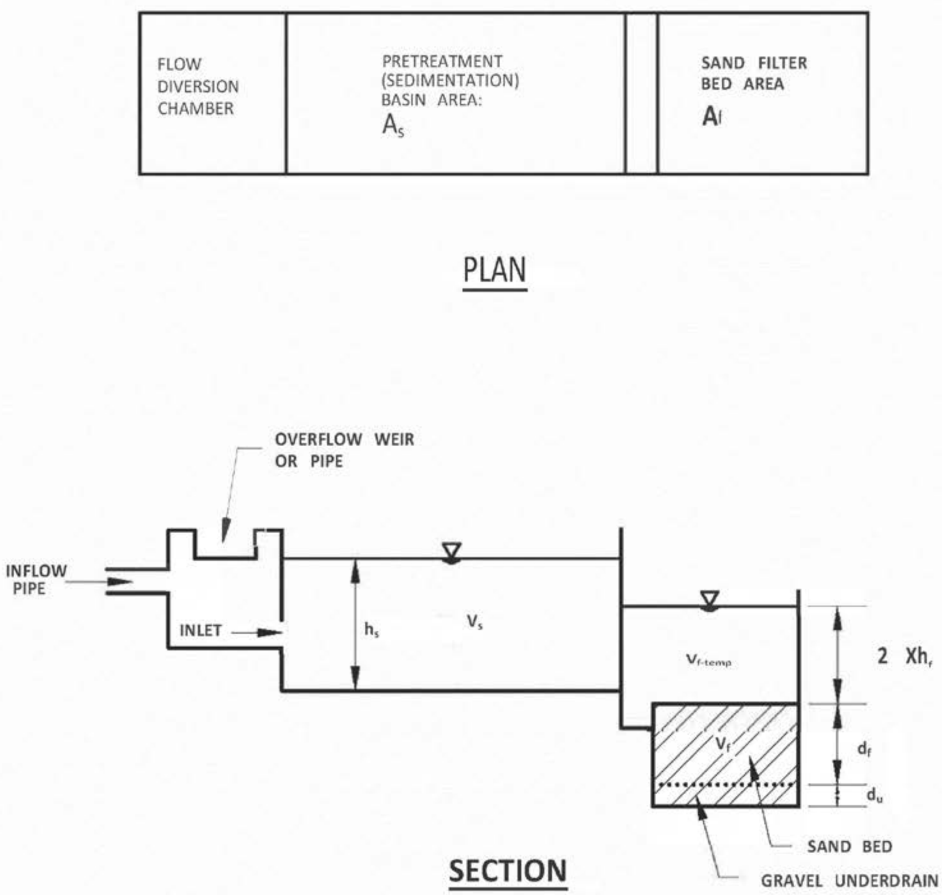


SOURCE: CLAYTOR AND SCHUELER, 1996

STORMWATER MANUAL

FIGURE 8-6

SURFACE SAND FILTER SCHEMATIC



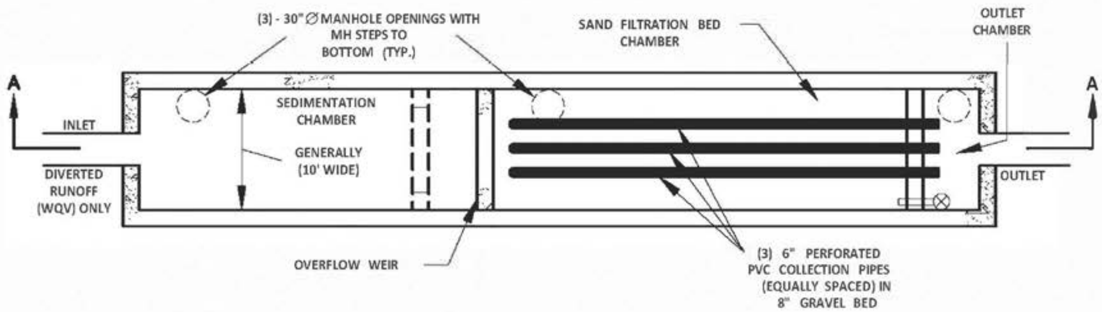
$$V_{TOTAL} = V_s + V_{f\text{-temp}} + V_f$$

CHECK THAT $V_{TOTAL} \geq V_{MIN} = 0.75 \times WQV$

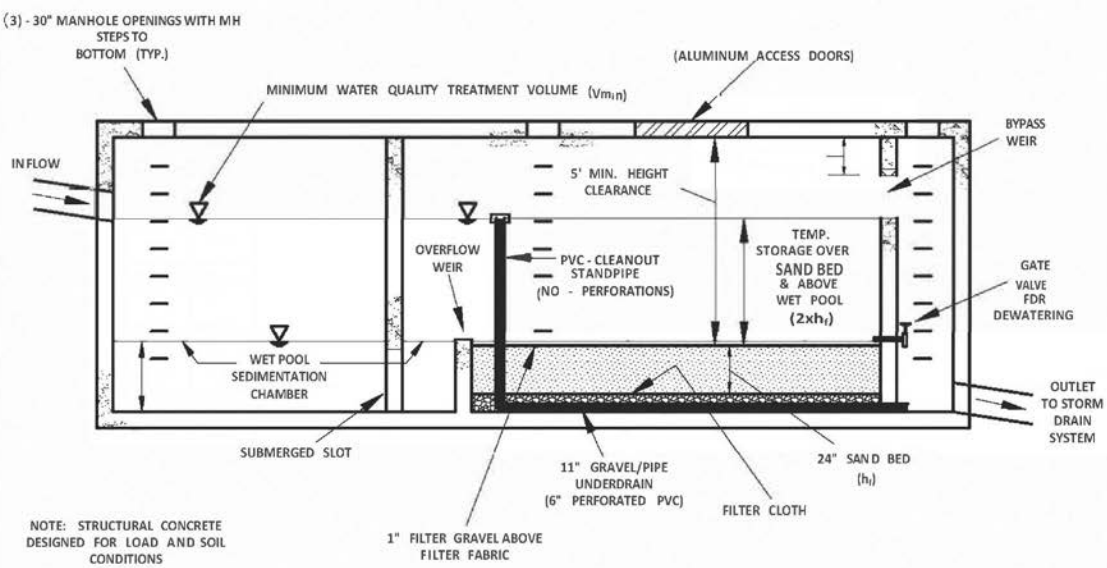
SOURCE: CLAYTOR AND SCHUELER, 1996

STORMWATER MANUAL

FIGURE 8-7
UNDERGROUND SAND FILTER



PLAN



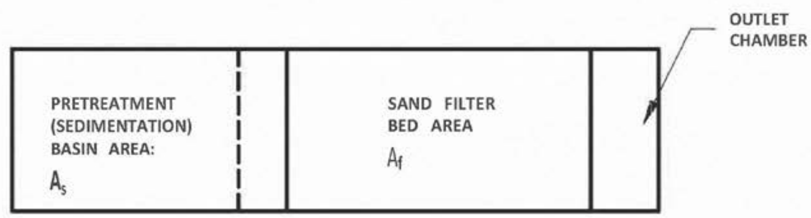
SECTION A-A

SOURCE: CLAYTOR AND SCHUELER, 1996

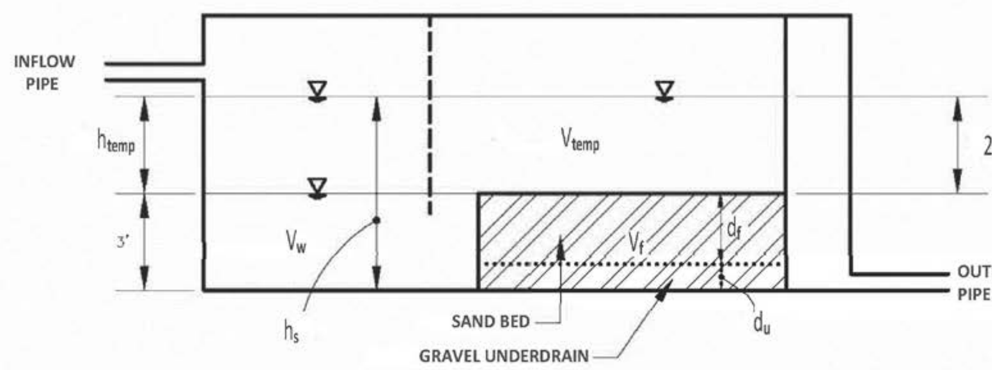
STORMWATER MANUAL

FIGURE 8-8

UNDERGROUND SAND FILTER SCHEMATIC



PLAN



SECTION

$$V_{TOTAL} = V_w + V_{temp} + V_f$$

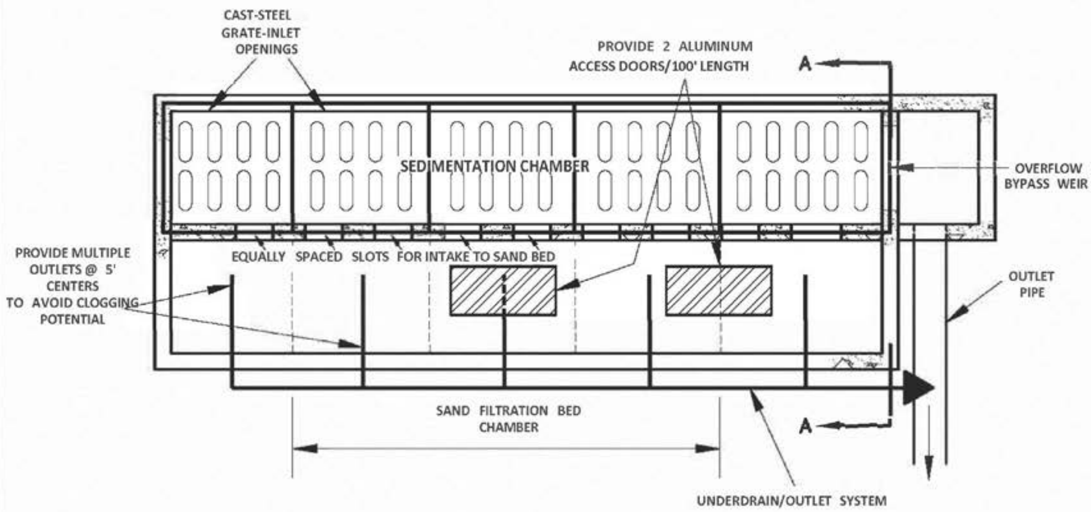
CHECK THAT $V_{TOTAL} \geq V_{MIN} = 0.75 \times WQV$

SOURCE: CLAYTOR AND SCHUELER, 1996

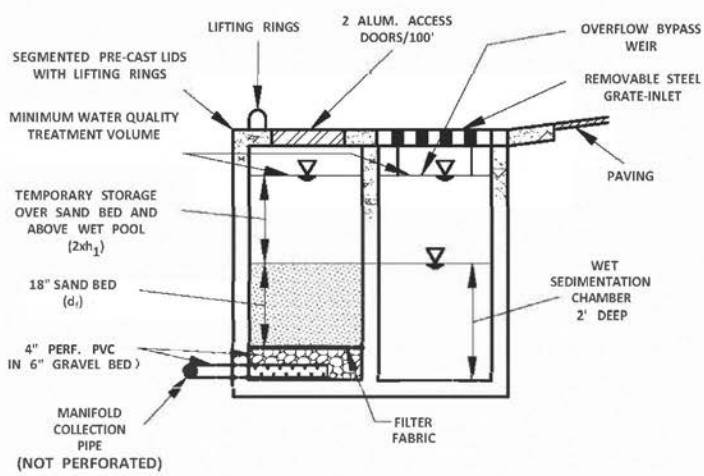
STORMWATER MANUAL

FIGURE 8-9

PERIMETER SAND FILTER



PLAN



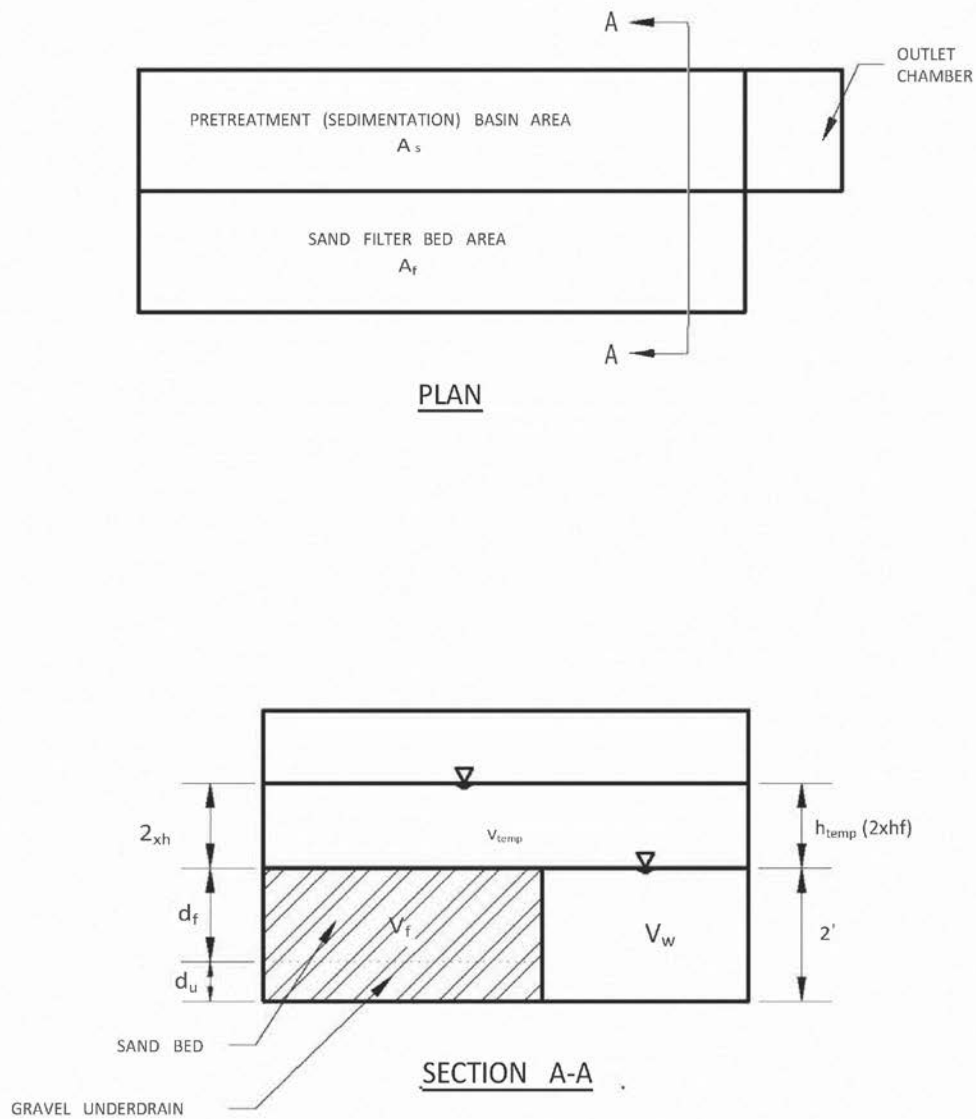
SECTION A-A

SOURCE: CLAYTOR AND SCHUELER, 1996

STORMWATER MANUAL

FIGURE 8-10

PERIMETER SAND FILTER SCHEMATIC



$$V_{TOTAL} = V_w + V_{temp} + V_f$$

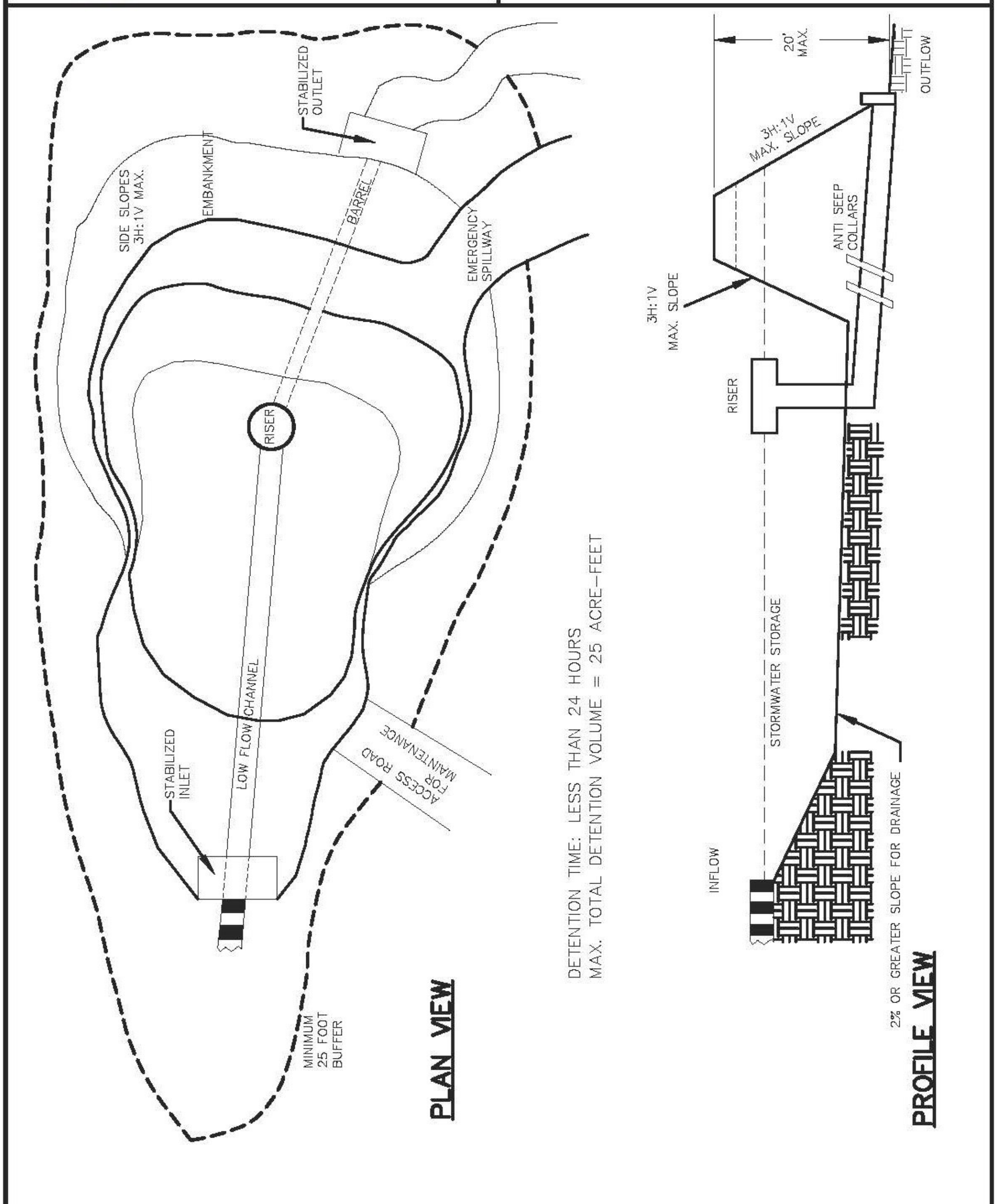
CHECK THAT $V_{TOTAL} \geq V_{MIN} = 0.75 \times WQV$

SOURCE: CLAYTOR AND SCHUELER, 1996

STORMWATER MANUAL

FIGURE 8 - 11

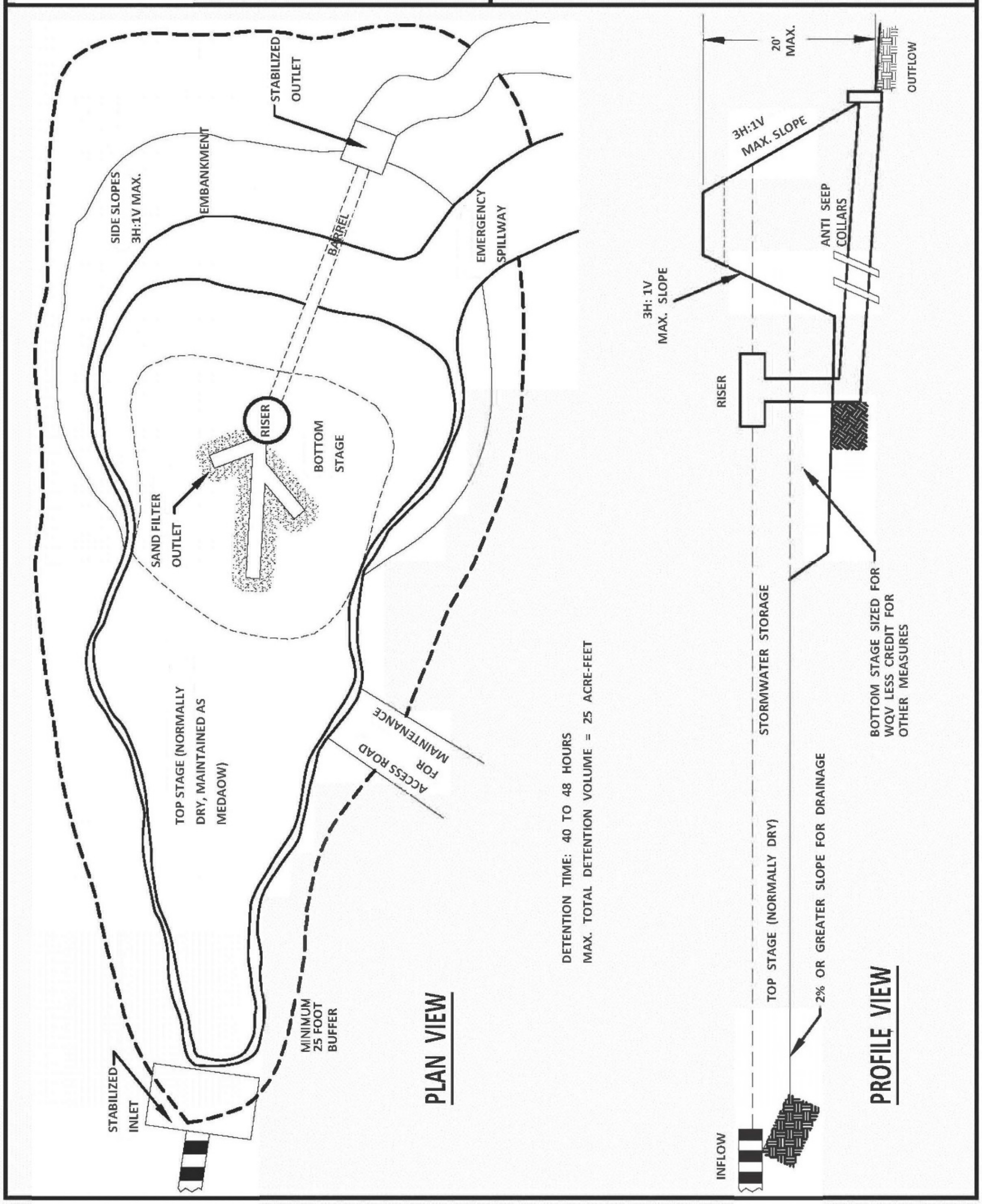
DETENTION POND



STORMWATER MANUAL

FIGURE 8 - 12

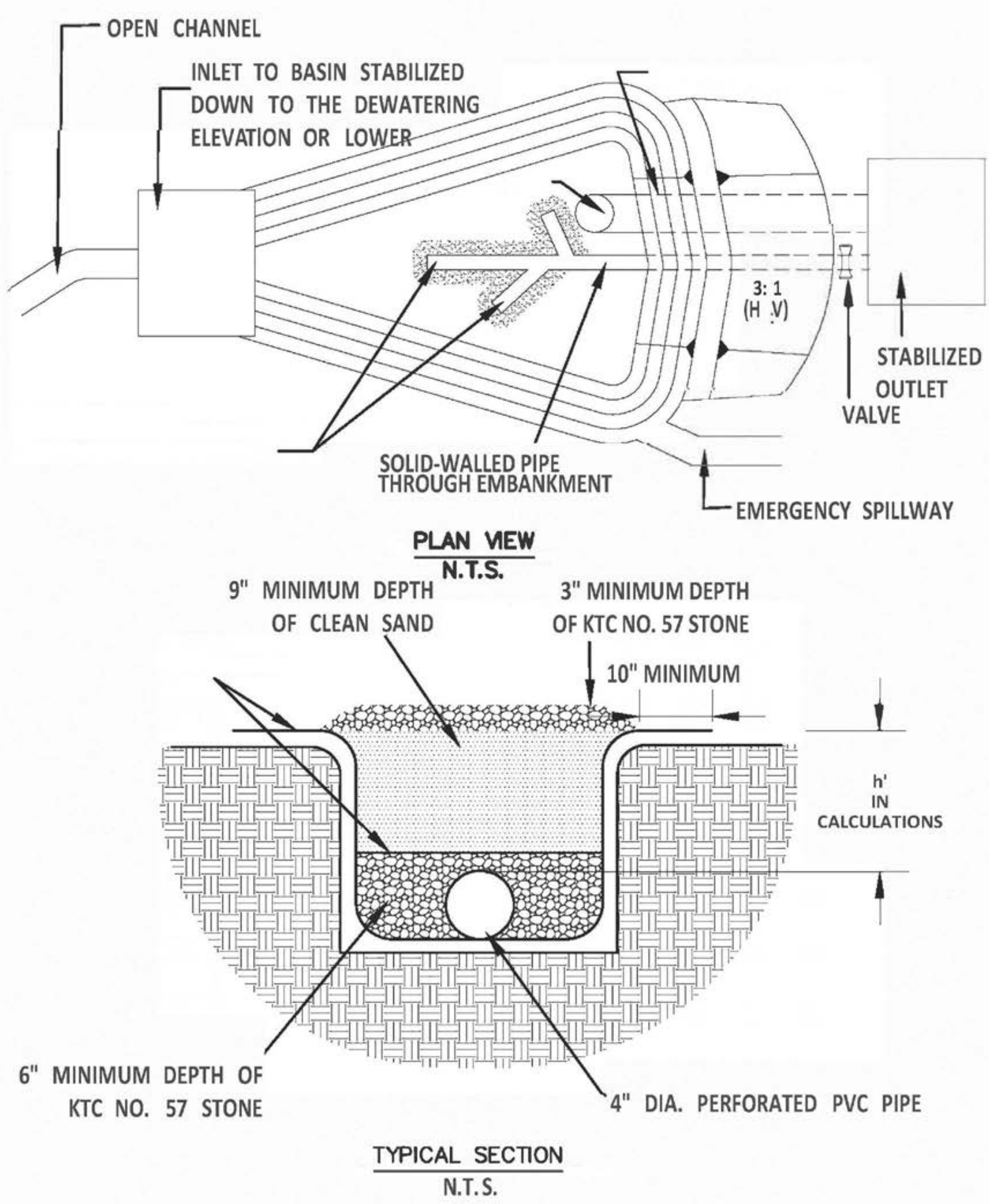
EXTENDED DETENTION POND



STORMWATER MANUAL

FIGURE 8-13

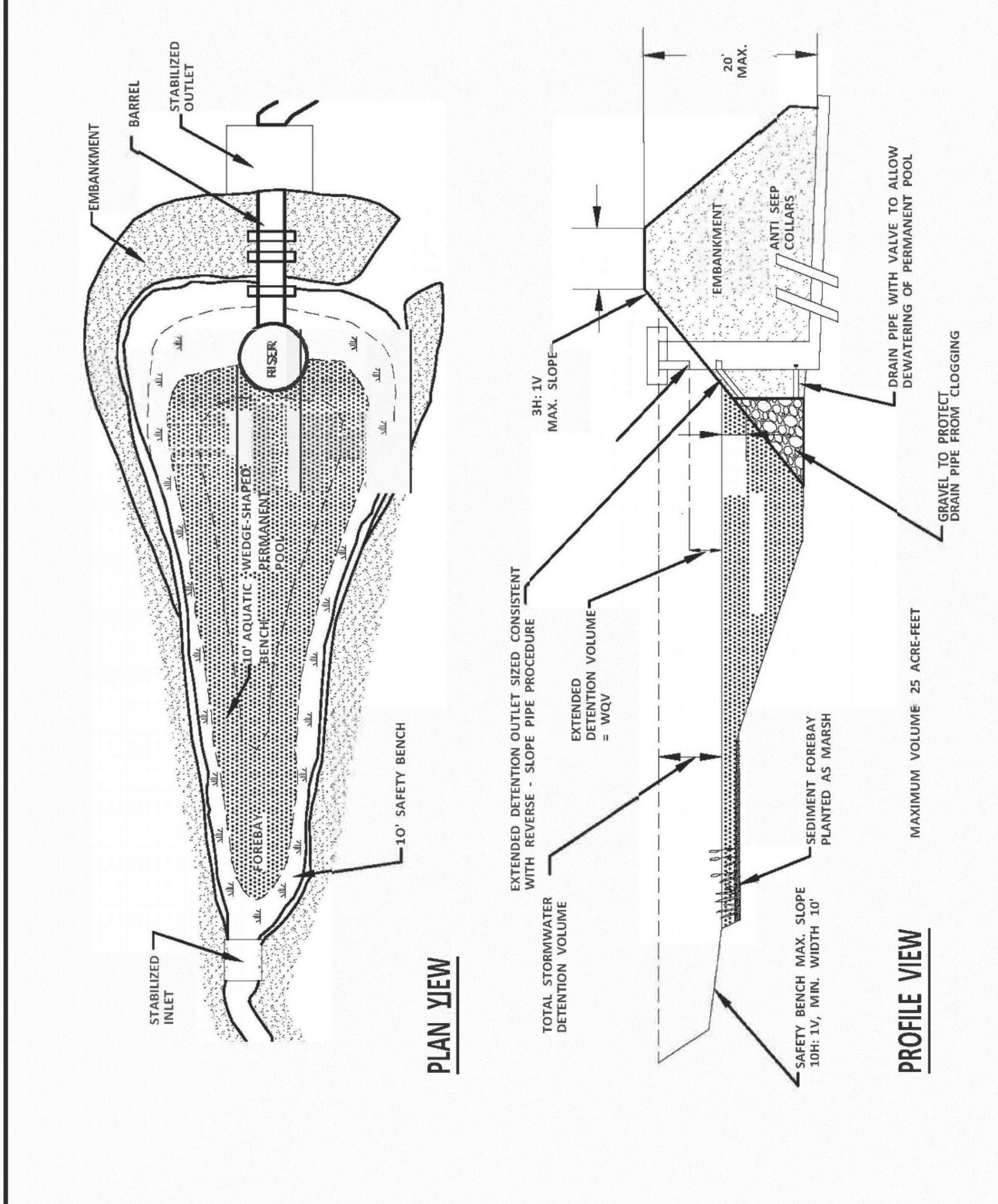
EXTENDED DETENTION OUTLET USING SAND FILTER



STORMWATER MANUAL

FIGURE 8 - 14

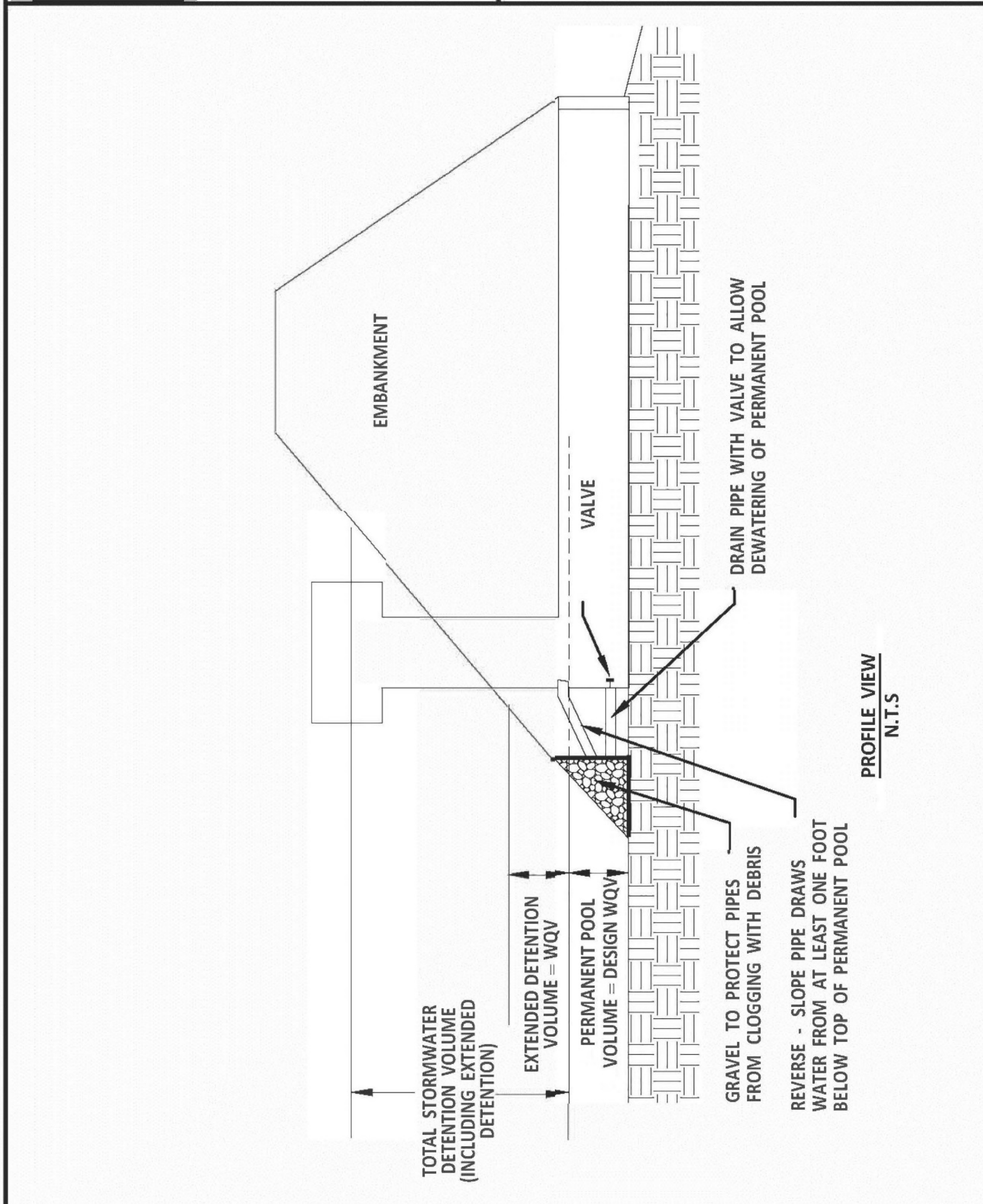
WET POND



STORMWATER MANUAL

FIGURE 8-15

EXTENDED DETENTION OUTLET FOR WET POND



CHAPTER 9 – BMP - Detention / Retention Pond Design

9 General

The purpose of this chapter is to summarize in one location the requirements for designing detention/retention ponds.

9.1 Hydrologic Design Criteria

Onsite storm water detention is mandatory for all developments that are not exempted or are not served by an adequately sized regional storm water management facility, subject to review and approval by the City. Because detention in downstream areas of a large basin can cause increased peak flows in downstream channels, the City reserves the right to alter the detention criteria or to prohibit it where it would cause adverse impacts. Nevertheless, in all cases where detention facilities are required, the location and design must comply with any storm water master plans or drainage studies that may have been adopted by the City.

9.1.1 Detention Pond Requirements

The detention requirement is mandatory for all new development and all significant redevelopment that are not otherwise exempted from the requirement. A detention pond is required for projects that:

- Create 5,000 square feet or more of effective impervious surfaces in a discharge area.
- Projects that through a combination of effective impervious surfaces and converted pervious surfaces, causes a 0.1 cubic feet per second increase in the 100-year recurrence interval flow frequency from a threshold discharge area.

Effective impervious surfaces are those impervious surfaces connected via sheet flow or discrete conveyance to a drainage system. If runoff from an impervious surface is infiltrated or dispersed into native vegetation or amended soils it is considered ineffective.

All land development activities that require a land disturbance permit shall employ storm water detention and related conveyance features to limit or mitigate any adverse impacts from increased runoff with the following exemptions:

1. Developments that do not disturb more than one (1) acre of land area in total
2. Developments located within areas where existing regional storm water detention already exists
3. Developments located within areas identified by storm water master plans as areas where storm water detention should not, or need not, be constructed
4. Other exemptions as deemed appropriate by the Codes and Planning Director and documented in the Stormwater Procedures Manual

The Codes and Planning Director may revoke these exemptions when, in his/her opinion, storm water runoff from the proposed land development activities will adversely affect adjacent property owners or will create an undue burden on storm water drainage systems.

A detention pond is a traditional stormwater quantity control device that is designed for peak discharge control. Detention ponds are designed to completely drain after the design storm passes. Figure 9-4 illustrates a detention pond.

Detention ponds are not effective as water quality treatment devices and can only be used for water quantity control (i.e., detention).

9.1.2 Special Requirements

If the detention pond includes a constructed berm above existing ground, a permit must be obtained from Kentucky Division of Water prior to construction. According to Kentucky Division of Water, a dam is defined as:

"*A dam is defined as any impounding structure that is either 25 feet in height, measured from the downstream toe to the crest, or has a maximum impounding capacity of 50 acre-feet of water. Structures that fail to meet these criteria but have the potential to cause significant property damage or pose a threat to life in the downstream area are regulated in the same manner as dams. All such structures except federal dams and those permitted by the Division of Mine Reclamation and Enforcement must be reviewed, and a stream construction permit must be issued by this office.*"

Detention ponds shall be located on separate tracts (not easements) with a minimum of 20-ft separation between the tract lines and any improvements (including fill or cut slopes) associated with the detention pond.

9.2 Detention Pond Design Process

9.2.1 Design Process

The following generalized design process is suggested for detention pond design:

- 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 pond.
- 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 pond 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.
- Evaluate project site for suitability including area available, depth to bedrock, presence of wetlands depth to water table, etc. If a detention pond is deemed suitable to the site proceed with the design process.
- Using a hydrologic model (HCS) input all contributing basin information and setup model to route contributing basin to a detention pond. Be sure to include the estimated area of the detention pond as an impervious area.
- Get preliminary pond dimensions--depth, volume, etc. and a preliminary control structure design.
- Locate pond to approximate dimensions on the site plan accounting for access roads, tract line setbacks, point of discharge, etc.
- Refine the preliminary calculations to finalize the pond dimensions. Be sure to account for the volume of any access ramps required, revise the original estimate of pond area assumed as impervious, and adjust the design accordingly.
- Make pond size and discharge structure modifications as necessary to meet discharge criteria. Adjust assumed impervious area of pond to match calculated area in finalizing design.
- Design emergency spillway and calculate maximum water surface elevation based on a plugged outlet structure. Add required freeboard to get top of berm elevations.
- Layout pond design and grading on drainage plans and be sure to address all applicable design details such as access roads, ramps, berm construction, fencing, control structure, inlets and outlets per detention pond design requirements. Show design and maximum water surface elevations on plan drawing.
- Show in drainage plans and construction drawings at least one pond cross-section through control structure. Indicate design and maximum water surface elevations.
- Provide details and specifications for control structures, inlet and outlet piping, slope treatments, emergency spillways, seeding or Sodding, berms, etc.
- Establish stormwater tract boundaries based on detention pond design. Boundary should be no closer than 5-feet to grading catch points or structures.
- Prepare a landscaping plan showing plantings within the stormwater tract which contains the detention pond.
- Include all design calculations, assumptions, modeling parameters, etc. in the Drainage Report for the project.

9.2.2 Detention Pond Design Criteria

Detention ponds shall be designed based on the following criteria:

- Post-development 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 not 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.
- Design ponds to be placed outside the receiving stream except when a pond is designed as a regional detention pond and the city has approved its use as a regional pond.
- Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 feet wide and not 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 not steeper than 5:1 (h:v).
- Provide a minimum 25-foot wide buffer strip between the pond and the nearest property line. 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.
- 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.
- Design ponds to have a minimum bottom slope of two percent (2%) with a pilot channel for low flow.
- Dissipate energy at inlet and outfall per design criteria
- A debris barrier (trash rack) may be installed on the pond outlet to the control structure. Debris barriers shall be installed on pond inlet pipes if directed by the Codes and Planning Director.
- Pond Berm Embankments:

    - Excavate “key” equal to 50% of the berm embankment cross-sectional height and width, or as determined by a geotechnical engineer.
    - Construct on suitable base soils either consolidated native soil or adequately compacted and stable fill soils as determined by a geotechnical engineer.
    - Place in 6-inch lifts and compact to 95% of maximum dry density as recommended by geotechnical engineer
    - Exposed earth on embankment shall be sodded or seeded. No trees or shrubs shall be planted on berms taller than 4 feet. Trees or shrubs planted on berms 4 feet or smaller shall not exceed 20 feet mature height and have a fibrous root system.
    - Minimum berm width is 15-feet where maintenance access is provided, otherwise minimum top width is 10-feet
    - Pond berm embankments greater than 25 ft. in height require design by a geotechnical engineer.

9.2.3 Access Roads and Ramps

These are guidelines for access roads and ramps for detention ponds. These include:

- A 15-foot wide access easement shall be provided from a public street or right-of-way to the detention pond. Access shall be surfaced with a 12-foot width of crushed rock or lattice block pavement or other acceptable surface.
- An access road shall be provided to the control structure and other drainage structures associated with the pond (e.g, inlet or bypass structures).
- If pond maintenance will be provided from the access road, the access road shall extend around the pond perimeter.
- Access road design criteria include:
  - 15% maximum grade. (12% maximum grade to control structure)
  - Outside turning radius of 40-feet minimum.
  - 12-feet width minimum.
  - Provide paved apron where access road connects to paved public roadway.
  - Provide asphalt, gravel, or modular grid pavement surface.
  - When length of road exceeds 75-feet a vehicle turnaround must be provided for a design vehicle with a 31 foot length and inside wheel path radius of 40-ft.
  - Vehicle access shall be limited by a locking gate or bollards. Gates are required if pond is fenced and must be located only on a straight section of road.
- Access ramps provide access to the bottom of a pond for maintenance, repair and sediment removal. They are required unless the pond is small enough that a trackhoe with a maximum reach of 20-ft can reach all areas of the pond from a perimeter access road.
- Access ramp design criteria include:
  - 12-feet width minimum.
  - 15% maximum grade if surfaced to access road standard.
  - 12% maximum grade for alternative ramp surface using geotextile over native soils, and 6 inches of crushed rock surface.
  - Extend ramp to bottom of pond if pond bottom is greater than 1,500 square feet, otherwise ramp may end 4 feet above the pond bottom.

9.2.4 Control Structure

The interior dimensions for a control structure must be a minimum of 4ft diameter manhole. The base of the structure must be a minimum of 8"thick concrete. The structure typically contacts multiple orifices to control the various storm events.

Most control structures include at least one restrictor orifice. Orifices shall meet the following requirements:

- Minimum orifice diameter is 4 inches. This may be too large to meet minimum target release rates.
- Orifices may be constructed on a tee section or on a baffle.
- If using multiple orifices, the top orifice may be located too high to be physically constructed, in which case a notch weir could be used to meet performance requirements.
- Consider backwater effects of water surface elevations downstream of the conveyance

system. High tailwater elevations may affect the restrictor system.
- At least one foot of separation between the invert elevation of the outlet pipe and the elevation of the lower orifice shall be provided

9.2.5 Overflow Protection

- A primary overflow must be provided to pass the 100-year developed peak flow over or around the restrictor system. (Typically a riser pipe within the control structure).
- A secondary inlet to the control structure must be provided. This may be a grated opening to the control structure or a “birdcage” overflow structure. A grated opening shall be designed to pass the 100-year developed peak flow. Vertical bars spaced 4- inches on center shall be provided within the window opening.
- Where an emergency overflow would discharge toward a steep slope, consider providing both an emergency overflow structure in addition to the spillway.
- Provide an emergency spillway sized to pass the 100-year developed peak flow for constructed berms over 2-feet in height. The emergency spillway shall meet the following design criteria:
  - The emergency spillway must be placed 6” above the 100yr-24hr storm.
  - Design the spillway as a broad-crested weir. The minimum side slopes of the weir must be more than 4h:1v
  - Establish the flow elevation through the emergency spillway. A minimum of one (1) foot of freeboard shall be provided above the maximum water surface elevation through the spillway.
  - Discharge directly to the downstream conveyance system or another acceptable discharge point.
  - Armored to full width, beginning at a point 2 ft. below the 100yr-24hr water elevation inside the pond and extending it across the berm embankment to downstream where the emergency overflow reenters the conveyance system.
  - Alternative armoring of 6” concrete pavement may be provided for spillways

9.2.6 Signage and Fencing

Signage and fencing shall be at the direction of the Codes and Planning Director. If required, the following criteria shall apply, unless directed by the Codes and Planning Director.

- Fence required where slopes greater than 3H:1V above the emergency overflow water surface elevation or higher or where there is a wall greater than 30-inches in height.
- Public stormwater pond tracts shall be fenced. Place fence 1-foot inside the tract boundary or a minimum of 5 feet from the top slope catch point.
- Public drainage ponds fence shall be 6-ft chain link.
- Wood fence allowed in subdivisions. Use pressure treated posts and cedar, pressure treated fir, or hemlock rails and fence boards.
- Pond shall have an information sign. Applicant shall submit sign design and proposed location.
- Easement shall be signed.
- Access easement shall be signed.

9.2.7 Planting and Landscaping

- All disturbed area of the project shall be landscaped to restore soil quality and depth.
- Seed should be at a rate of (KY 31- 85% at 350 lb/acre or Nexus Rye Grass 15% at 75 lb/acre)
- Pond interior side slopes and bottom shall be sodded or seeded with an appropriate seed mixture.
- All remaining areas of the tract should be planted with grass or landscaped
- Other than the above requirements, a specific landscape plan for ponds is not specified. However, if landscaping is provided, the following general criteria should be considered:
- Plant no trees or shrubs within 25-feet of inlet or outlet pipes or drainage structures. Species with roots that seek water such as willow or poplar shall be avoided within 50-ft of structures.
- Trees and shrubs should be planted in clumps to form “landscape islands.” Landscape islands should be a minimum of 6 feet apart and 6 feet from any fences or other barriers. The 6-feet allows a mower to pass between the landscape islands.

9.2.8 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 will be performed 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.

9.2.9 Construction Specifications

- Verify areas to be backfilled are free of debris, snow, ice, or water, and ground surfaces are not frozen.
- Remove all grass, topsoil or other organic material in the construction zone.
- 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 will 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.
- 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, 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).

9.2.10 Easements

Storm water detention facilities constructed on private property (private drainage systems) must be located within the right-of-way of a public utility and drainage easement. The dedicated easement must include the following areas:

1. The land area inundated by the detention pool elevation during a 100-year, 24-hour flood event,
2. A 25-foot wide strip of land area around the perimeter of the land area inundated by the detention pool elevation during a 100-year, 24-hour flood event, and
3. Sufficient area for ingress and egress to the facility from a public street or road.

9.3 Underground Detention

9.3.1 General

Underground detention is typically utilized on sites where developable surface area is at a minimum. Underground detention facilities can be either box-shaped facilities constructed with reinforced concrete, facilities constructed with large diameter plastic pipe or commercially-available proprietary underground systems. No Stone Pits or completely stone filled vaults of gabion baskets shall be allowed.

Underground detention facilities are not capable of significant pollutant removal. Therefore, because underground detention is not intended for water quality treatment, it must be used in a treatment train approach with other structural BMPs that provide treatment of the water quality volume. This will prevent the underground pipe systems or vaults from becoming clogged with trash or sediment and significantly reducing the maintenance requirements.

The following standards shall be considered minimum design standards for the design of underground detention. Underground detention that is not designed to these standards will not be approved. The city shall have the authority to require additional design conditions if deemed necessary.

9.3.2 Location and Siting

- The maximum contributing drainage area to be served by a single underground detention vault or tank is 25 acres.
- Flood protection controls should be designed as final controls for on-site stormwater. Therefore, underground detention will typically be located downstream of structural stormwater BMPs that are designed to provide treatment of the water quality volume (WQv)
- Underground detention shall be placed in an easement that is recorded with the deed and shown on the plan. Minimum setback requirements for the easement shall be as follows unless otherwise specified by Planning and Zoning:
    - From a private water system well – 50 feet; if the well is down gradient from a land use that must obtain a Special Pollution Abatement Permit, then the minimum setback is 250 feet
    - From a septic system tank/leach field – 50 feet
    - From a city owned sanitary sewer gravity line – 7.5 feet
    - From a city owned sanitary sewer force main – 10 feet
    - The easement boundary shall be located 15 feet from the outside limits of the underground detention structure.

- The first floor elevation (FFE) for any structure adjacent to underground detention shall have an elevation no lower than 2 feet above the emergency spillway elevation.

9.3.3 General Design

- Underground detention shall consist of the following elements, designed in accordance with the specifications provided in this section.
  - An outlet structure;
  - An emergency bypass; and
  - Maintenance access.

- Underground detention systems that are used to provide extended detention of the channel protection volume or water quality volume shall have watertight joints and piping.
- Routing calculations must be used to demonstrate that the storage volume is adequate.
- Adequate maintenance access must be provided for all underground detention systems. Access must be provided over the inlet pipe and outflow structure.
- Access openings can consist of a standard frame, grate and solid cover, or a removable panel. Vaults with widths of 10 feet or less should have removable lids.

9.3.4 Physical Specifications / Geometry

- Underground detention vaults and tanks must meet structural requirements for overburden support and traffic loading if appropriate.
- Detention Vaults: Minimum 3,000 psi structural reinforced concrete may be used for underground detention vaults. All construction joints must be provided with water stops. Cast-in-place wall sections must be designed as retaining walls. The maximum depth from finished grade to the vault invert should be 20 feet.
- Detention Pipes: The minimum pipe diameter for underground detention is 36 inches.

9.3.5 Inlet and Outlet Structures

- Additional outlets are sized for peak flow control (based upon hydrologic routing calculations) and can consist of weirs, orifices, outlet pipes, combination outlets, or other acceptable control structures.
- Water shall not be discharged from underground detention in an erosive manner. Riprap, plunge pools or pads, or other energy dissipaters are to be placed at the end of the outlet to prevent scouring and erosion. If a pond outlet discharges immediately to a channel that carries dry weather flow, care should be taken to minimize disturbance along the downstream channel and streambanks. If the downstream area is located in a vegetated buffer reestablish a forested riparian zone in the shortest possible distance.

9.3.6 Emergency Bypass

- A high flow bypass shall be included in the underground detention design to safely pass flows greater than the maximum storm used by the local jurisdiction or in the event of outlet structure blockage or mechanical failure. The bypass shall be located so that downstream structures will not be impacted by emergency discharges.

9.3.7 Maintenance Access

- A maintenance right-of-way or easement having a minimum width of 15 feet shall be provided from a driveway, public or private road. The maintenance access easement shall have a maximum slope of no more than 15% and shall have a minimum unobstructed drive path having a width of 12 feet, appropriately stabilized to withstand maintenance equipment and vehicles.
- The maintenance access shall extend to the forebay (if included) and outlet works, and, to the extent feasible, be designed to allow vehicles to turn around.
- No Rock Pits or completely rock filled vaults shall be allowed.

9.3.8 Design Procedures

- In general, engineers should perform the same design procedures when designing underground detention as typical above grade detention basins.

9.3.9 Maintenance Requirements and Inspection Checklist

- Regular inspection and maintenance is critical to the effective operation of underground detention as designed. It is the responsibility of the property owner to maintain all stormwater BMPs in accordance with the minimum design standards and other guidance provided in this manual. The local municipality has the authority to impose additional maintenance requirements where deemed necessary.

- This page provides guidance on maintenance activities that are typically required for underground detention, along with a suggested frequency for each activity. Individual underground detention locations may have more, or less, frequent maintenance needs, depending upon a variety of factors including the occurrence of large storm events, overly wet or dry (i.e., drought) regional hydrologic conditions, and any changes or redevelopment in the upstream land use. Each property owner shall perform the activities identified below at the frequency needed to maintain the pond in proper operating condition at all times.

  Use of the inspection checklist that is presented on the next page is encouraged to guide the property owner in the inspection and maintenance of underground detention facilities. The city can require the use of this checklist or other form(s) of maintenance documentation when and where deemed necessary in order to ensure the long-term proper operation of the underground detention facilities. Questions regarding stormwater facility inspection and maintenance should be referred to the City of Berea.

Inspection Activities	***Suggested Schedule***
After several storm events or an extreme storm event, inspect for: signs of clogging of the inlet or outlet structures and sediment accumulation.	*As Needed*
Inspect for: trash and debris; clogging of the outlet structures and any pilot channels; excessive erosion; sediment accumulation in the basin and inlet/outlet structures; tree growth on dam or embankment; the presence of burrowing animals; standing water where there should be none; vigor and density of the grass turf on the basin side slopes and floor; differential settlement; cracking; leakage; and slope stability.	*Semi-annually*
Inspect that the outlet structures, pipes, and downstream and pilot channels are free of debris and are operational. *Note signs of pollution, such as oil sheens, discolored water, or unpleasant odors.* • *Check for sediment accumulation in the facility.* • *Check for proper operation of control gates, valves or other mechanical devices.*	*Annually*
Maintenance Activities	***Suggested Schedule***
Perform structural repairs to inlet and outlets. Clean and remove debris from inlet and outlet structures.	*Monthly or as needed*
Repair damage to inlet or outlet structures, control gates, valves, or other mechanical devices, undercut or eroded areas.	*As Needed*
Monitor sediment accumulations, and remove sediment when the pond volume has become reduced significantly.	*As Needed*

INSPECTION CHECKLIST AND MAINTENANCE GUIDANCE
UNDERGROUND DETENTION INSPECTION CHECKLIST

Location: ____Owner Change since last inspection? Y N
Owner Name, Address, Phone: ________
____ Date: ________________Time:
_______________Site conditions: ____

If any of the above inspection items are **UNSATISFACTORY**, list corrective actions and the corresponding completion dates below:

Inspection Items	Satisfactory (S) or Unsatisfactory (U)	Comments/Corrective Action
Inlet/Outlet Structures		
Clear of debris / functional?		
Trash rack clear of debris / functional?		
Sediment accumulation?		
Condition of concrete/masonry?		
Pipes in good condition?		
Control valve operational?		
Pond drain valve operational?		
Outfall channels function, not eroding?		
Other (describe)?		
Pond Bottom		
Excessive sedimentation?		

Corrective Action Needed	Due Date

Inspector Signature: ____

Inspector Name (printed): ___________________________________

9.3.10 Example Schematics

Figure 9-1, Example Underground Detention Pipe System

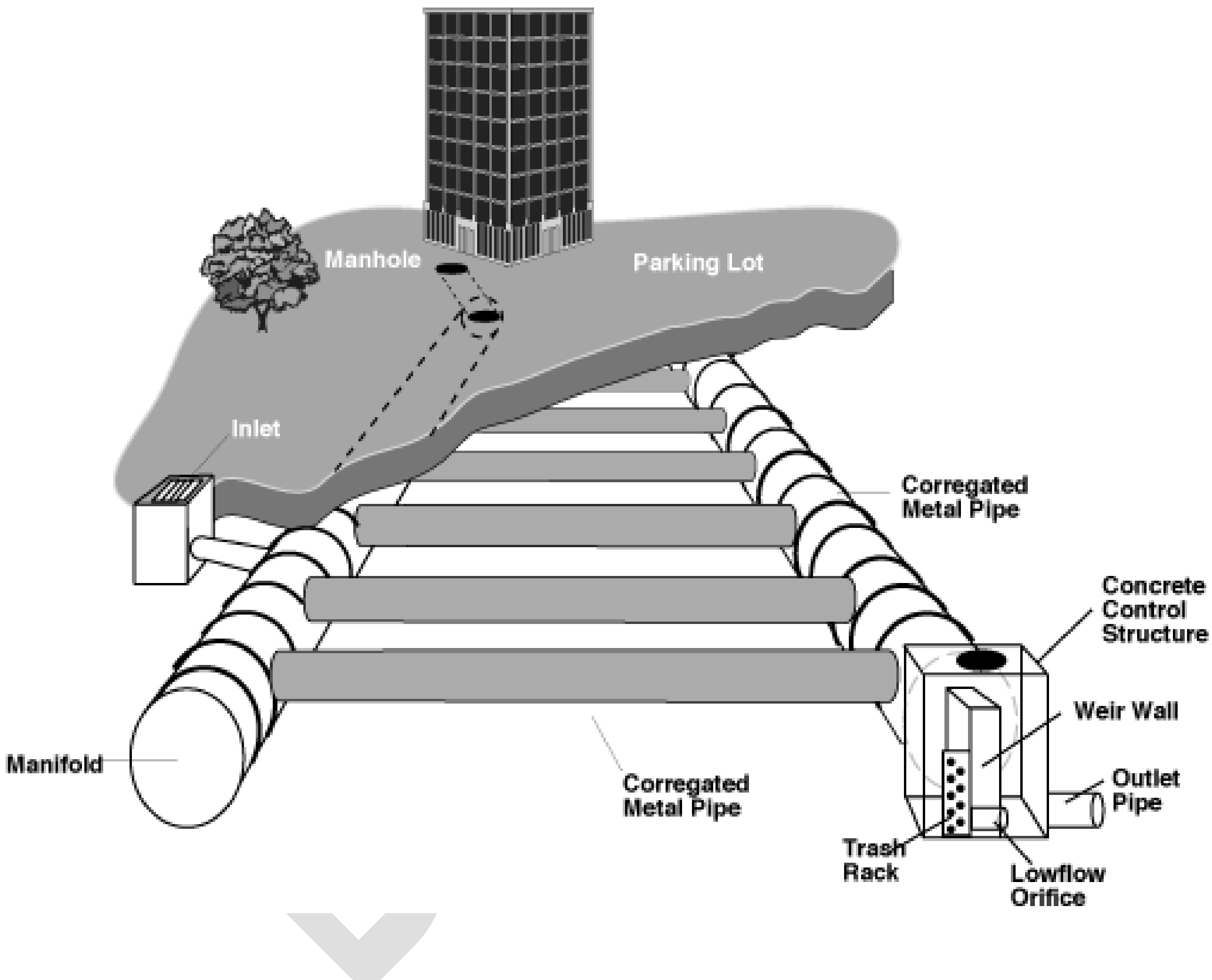


Figure 9-2, Schematic of a Typical Underground Detention Vault
(Source: WDE, 2000)

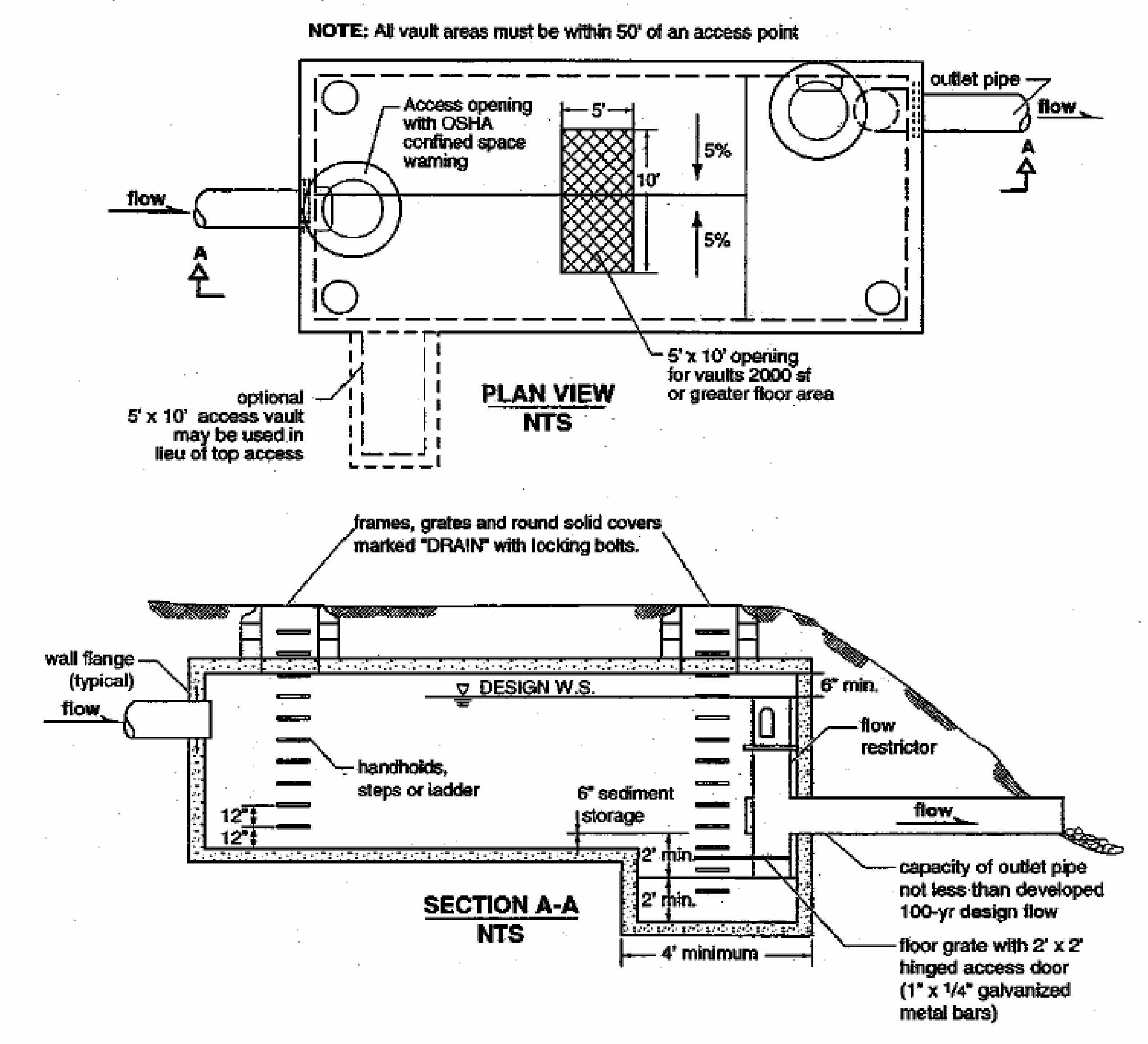
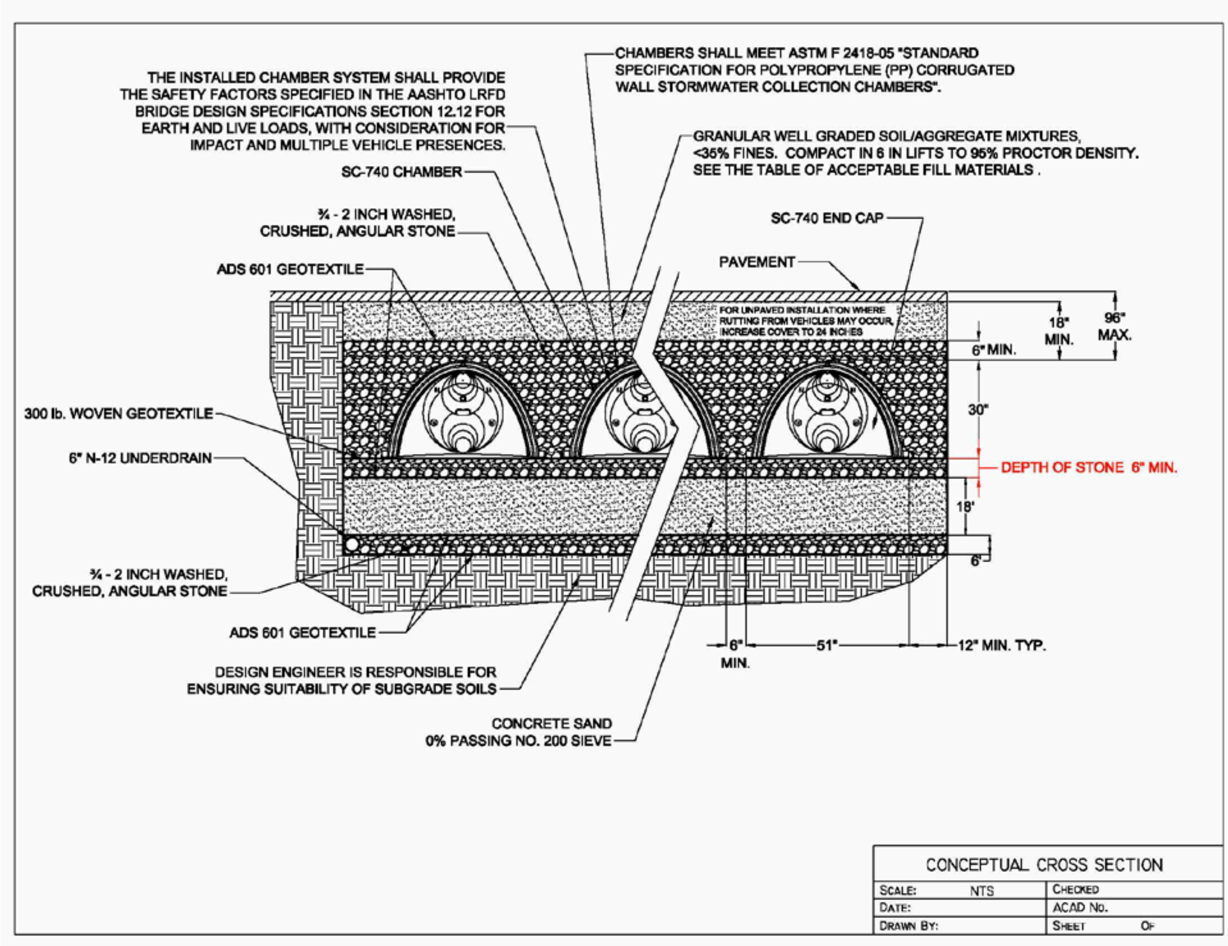


Figure 9-3, Schematic of a Typical Underground Arch System

(Source: ADS, Stormtech)



9.4 Extended Detention Ponds

9.4.1 General

An extended detention pond is a dry detention pond equipped with an outlet structure that provides extended detention time (typically 24 hours) for a specific water quality treatment volume. Figure 9-5 illustrates an extended detention pond.

9.4.2 Applicability

Extended detention ponds can be used for both water quality treatment and water quantity management. For water quality treatment, the extended detention volume is at least equal to the WQV derived from Table 10-2 less any credits for infiltration or bioretention.

In locations with continuous dry weather flow, an extended detention pond 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.

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

9.4.3 Design Criteria

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

Design the extended detention outlet so that the “design” WQV requires at least 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 ponds 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 pond 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 chapter 10 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 not 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 10 feet wide and not 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 not greater than 5:1 (h:v).

Provide a minimum 25-foot wide buffer strip between the pond and the nearest property line. 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.

9.4.4 Design Procedures

Design procedures for stormwater quantity and peak discharge control are the same for extended detention ponds and traditional dry detention ponds, except that the design WQV will be retained longer in the extended detention pond. To design the storm detention volume and peak control structure for an extended detention pond, follow the procedures given in section 9.2.2 and assume for design purposes that the elevation of the dry pond 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 8-13 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 3.54 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),
a = average surface area of extended detention pool (ft^2), L = depth of sand (ft),
A = surface area of filter = width of sand layer * length of sand layer (ft^2), 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.

9.4.5 Specifications

Specifications are consistent with those provided in section 9.2.9.

9.5 Wet Ponds

Wet ponds refer to basins designed for both water quality and water quantity management and which has a permanent pool. Figure 8-14 illustrates a wet pond.

9.5.1 Applicability

Wet ponds can be used for water quantity management and water quality treatment. For water quality treatment, the WQV is at least equal to the WQV derived from Table 10-2, less any credits earned from bioretention and infiltration.

Design ponds to be placed outside the receiving stream except when a pond is designed as a regional detention pond. The capacity to properly construct a wet pond shall also be considered including the following criteria:

1. Sufficient data on the underlying soils (existing and proposed) of the facility is provided along with documentation demonstrating that the facility can sustain a permanent pool,
2. Sufficient data and analysis is provided that describe the impacts the facility will have on local karst topography as found through a geological investigation of the site,
3. Sufficient flood storage is provided above the permanent pool in compliance with requirements for the site,
4. The facility must be able to bypass all storms up to a 100-year event with a discharge rate equivalent to or less than pre-development conditions without causing flooding above or below the site.

9.5.2 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 not 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 not 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 10 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.

9.5.3 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 pond. 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 Figures 8-14 & 8-15.

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 8-15 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:

$Q = A\,(2gH)^{0.5}/(1 + K_e + K_b + K_cL)^{0.5}$

where:

Q = discharge (ft^3/s)

A = cross-sectional area of pipe (ft^2) g = 32.2 ft/s^2

H = head above discharge end of pipe (ft^2) 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.

9.5.4 Specifications

Specifications are consistent with those provided in section 9.2.9.

9.6 Sinkholes and Drainage Wells

The City will review and accept storm water quality BMPs approved by the Kentucky Division of Water for underground injection wells if the water quality BMPs meet the City's standards.

Sinkholes and drainage wells used as part of a storm water management system shall be analyzed using the 100-year, 24-hour storm event. Design and analysis of sinkholes and drainage wells shall be done using engineering methods that develop and route hydrographs. The rational method or any derivative of this method will not be accepted for the design or analysis of sinkholes and drainage wells.

An engineering report and supporting data is required for sinkholes and drainage wells. It shall also be demonstrated on the design plans that development will not occur within the area flooded by the 100-year, 24-hour storm and that flooding will not be increased on any existing structure.

Dedicated easements required for sinkholes and drainage wells are consistent with those required for detention facilities.

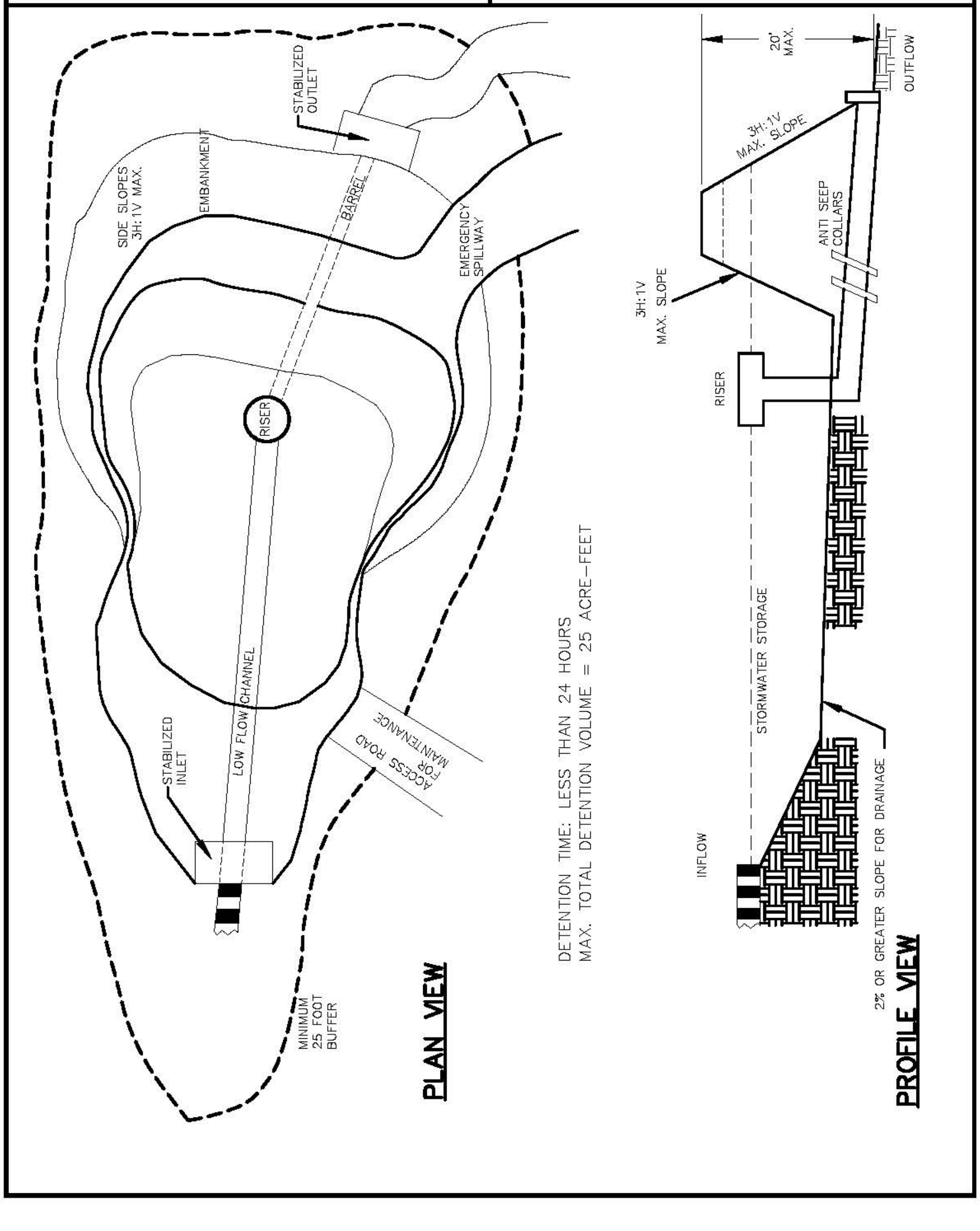
An injection well must be installed in sinkholes that are to be maintained by the city. Injection wells are not required in sinkholes that will be maintained by the landowner or private organization.

Sinkholes are not to be used as water quality BMPs in commercial or hotspot areas.

STORMWATER MANUAL

FIGURE 9 - 4

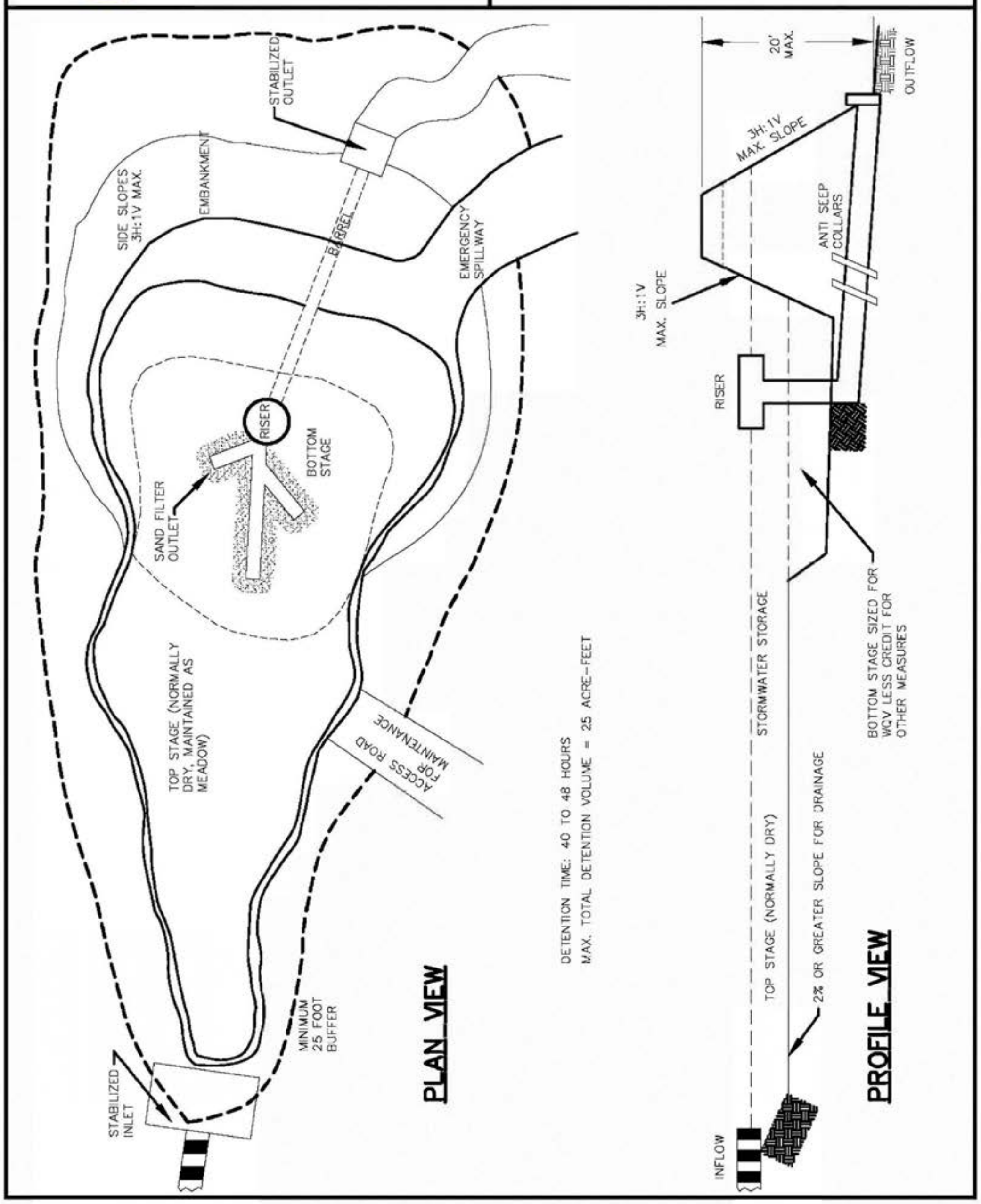
DETENTION POND



STORMWATER MANUAL

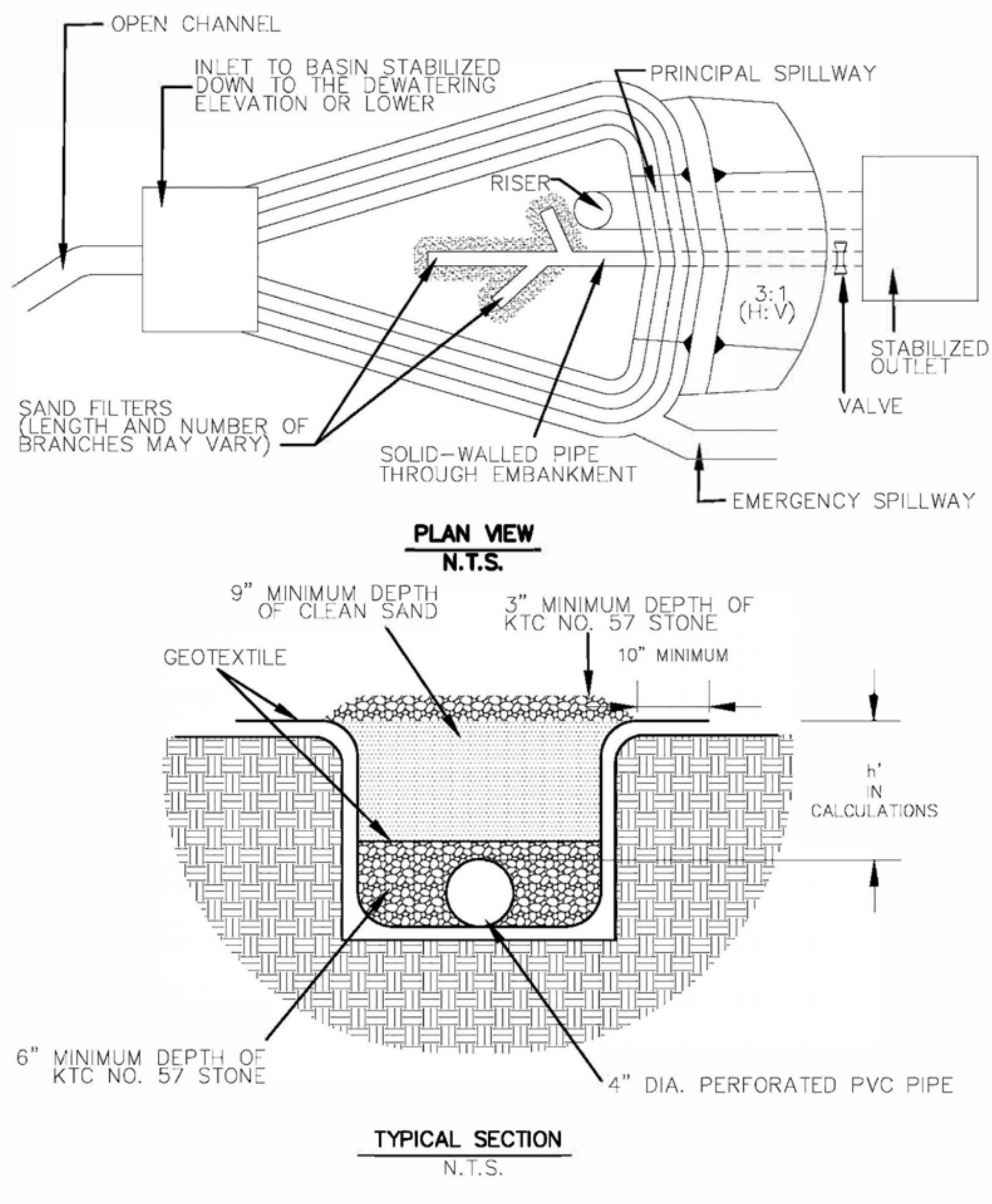
FIGURE 9 - 5

EXTENDED DETENTION POND



STORMWATER MANUAL

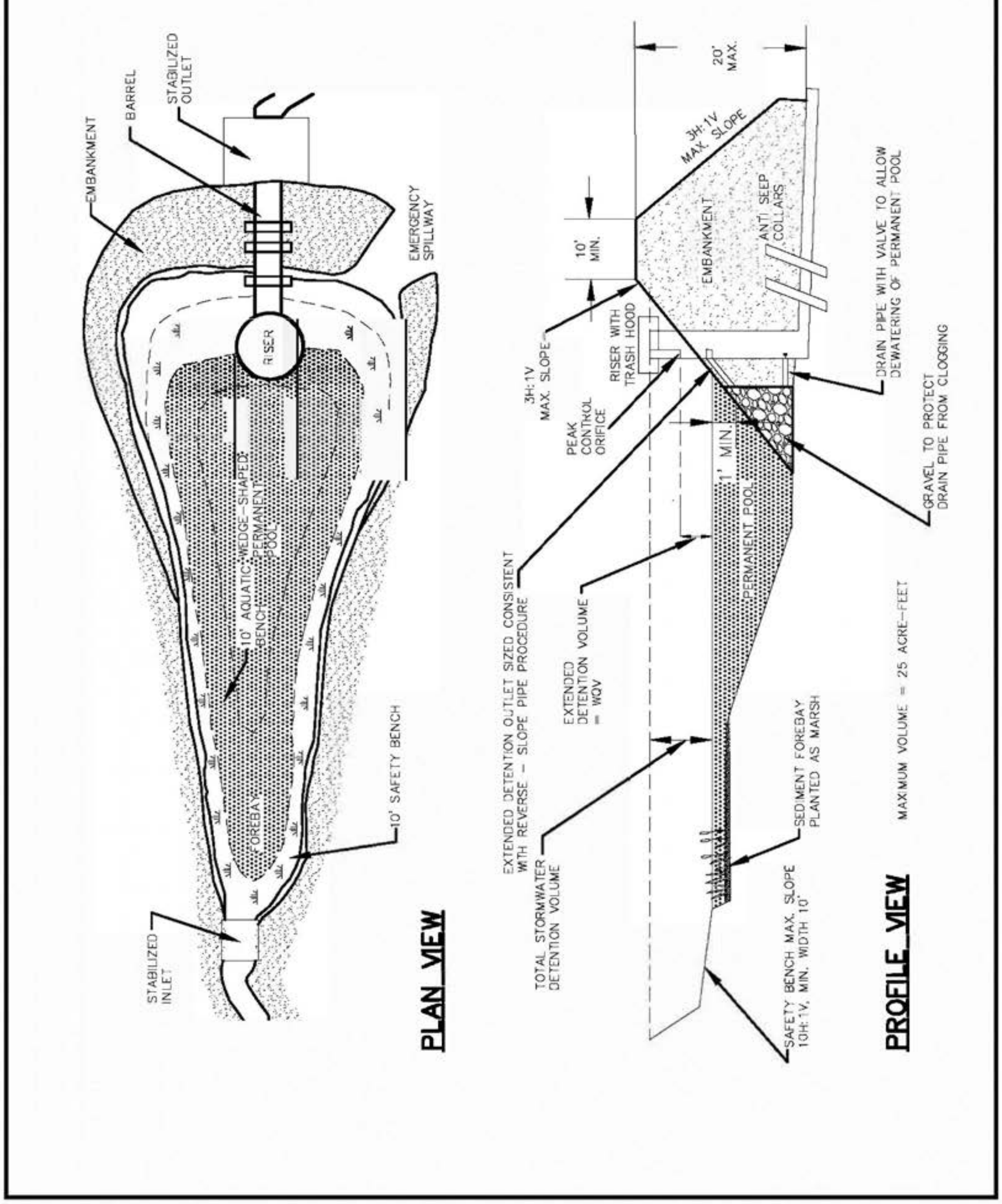
FIGURE 9-6
EXTENDED DETENTION OUTLET USING SAND FILTER



STORMWATER MANUAL

FIGURE 9 - 7

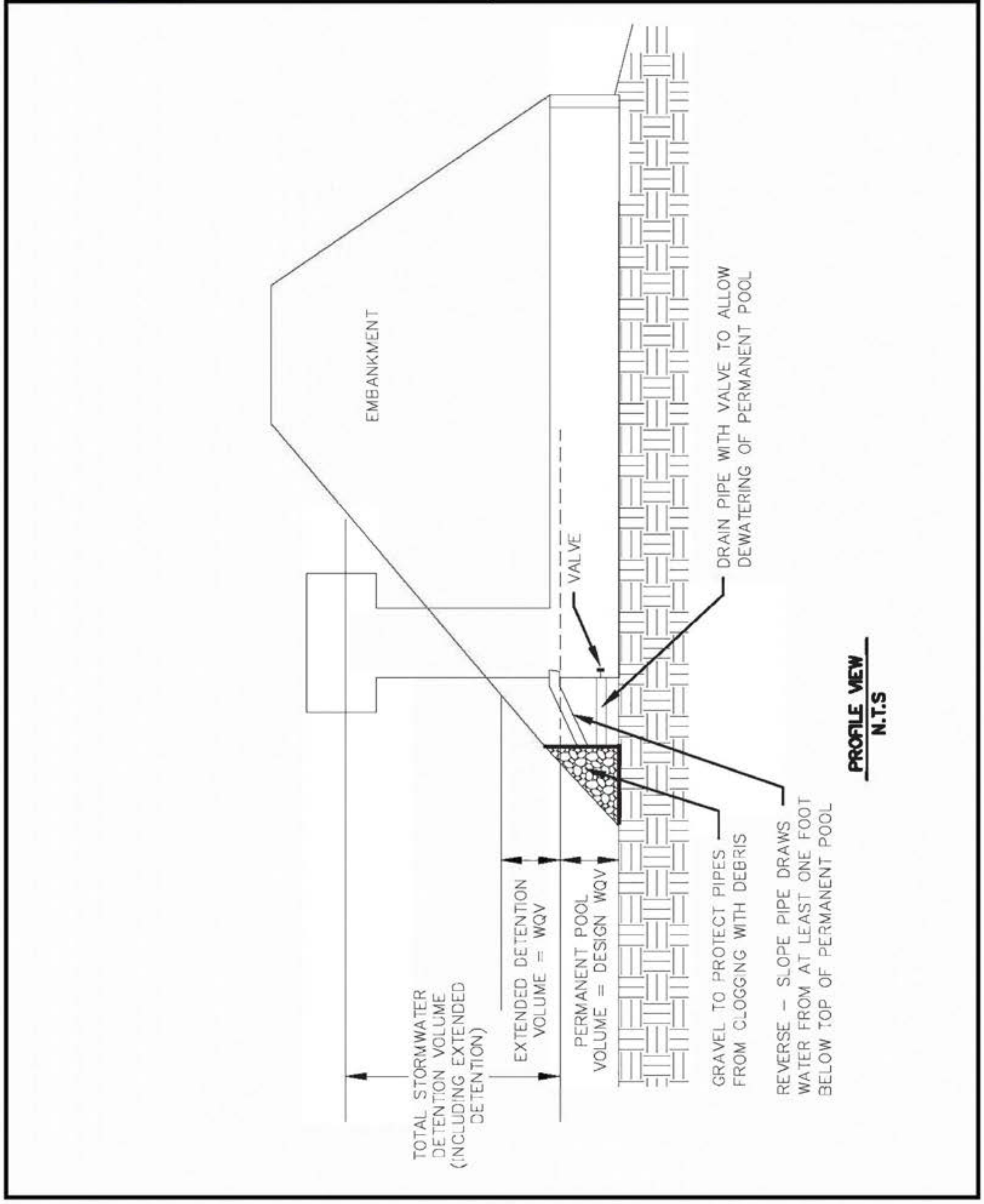
WET POND



STORMWATER MANUAL

FIGURE 9-8

EXTENDED DETENTION OUTLET FOR WET POND



CHAPTER 10 – BMP - Constructed Wetlands

10. Constructed Wetlands

Constructed wetlands are artificial wetlands created for the purposes of storm water pollutant removal and quantity control. They 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.

10.1 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.

10.2 Design Criteria

- For water quality control, size the extended detention pool above the permanent pool equal to the design WQV.
- Permanent sediment depth markers must be provided.
- Site preparation: Soil types conducive to wetland vegetation should be used during construction. The wetland must be designed to allow slow percolation of the runoff through the substrate (add a layer of clay for porous substrates). Ensure that the substrate, once flooded, is soft enough to permit relatively easy insertion of the plants.
- Design the extended detention outlet so that at least 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 ponds in Chapter 9. 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 8-15.

- 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.
- Storm water wetlands must be designed with the recommended proportion of depths noted in Table 10.1. The four basic depths and descriptions are:

    - *Deepwater:* 1.5 – 6 feet below normal pool elevation. Includes the outlet micropool and deep water channels through the wetland. This zone supports little emergent wetland vegetation but may support floating or submerged vegetation.
    - *Low marsh:* 6-18 inches below normal pool elevation or water surface elevation. This zone is suitable for the growth of several emergent wetland species.
    - *High marsh:* 6 inches or less below normal pool elevation. This zone will support a greater density and diversity of wetland vegetation than the low marsh. The high marsh area should have a greater surface area to volume ration than the low marsh area.
    - *Semi-wet zone:* Areas above normal pool elevation inundated by larger storm events. This area supports vegetation that can survive periodic flooding.

- Design the wetland to have a length-to-width ratio of at least 2:1. The design must incorporate long flow paths through the wetland, as appropriate.
- Reserve adequate access from public or private right-of-way by establishing a maintenance easement. Design the access to be at least 10 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.

    The designer must maximize use of existing- and post-grading pondscaping design to create both horizontal and vertical diversity and habitat. The optimal depth requirements for several common species of emergent wetland plants are often six inches of water or less. Approximately 50 individuals of each secondary species must be planted per acre; set out in 10 clumps of approximately 5 individuals and planted within 6 feet of the edge of the pond in the shallow area leading up to the ponds edge; spaced as far apart as possible, but no need to segregate species to different areas of the wetland. Wetland mulch, if used, shall be spread over the high marsh area and adjacent wet zones (-6 to +6 inches of depth) to depths of 3 to 6 inches.

- A minimum 25-foot buffer, for all but pocket wetlands, must be established and planted with riparian and upland vegetation (50-foot buffer if wildlife habitat value required in design). In addition, the wetland must be located within a minimum 40-foot wide easement.

- Surrounding slopes must be stabilized by planting to aid in trapping pollutants and preventing them from entering the wetland.
- Maintain the wetland to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
- The wetland and buffer must be located in a permanent easement. The easement must include access to the BMP for maintenance. A copy of the easement must be included with the as-built BMP certification.
- Construction debris cannot be disposed of in the facility or used as fill in the embankment.
- If the wetland area or sediment forebay is used as a sediment control measure during active construction, sediment must be cleaned out of the wetland or forebay and elevations and grades reestablished as noted in the approved storm water management plan for post-construction runoff control.

10.3 Wetland Surface Area Design Procedures

Use Table 10-2 to determine the minimum surface area required based upon the size of the watershed draining to the wetland.

Procedures for sizing the reverse slope pipe outlet at the micropool are consistent with procedures for wet retention ponds given Chapter 9.

Table 10-1, Minimum Required Design Configuration for Storm Water Wetlands

Design Criteria	Shallow Wetland	Pond/Wetland	Pocket Wetland
Length to width ratio (min)	2:1	2:1	2:1
Allocation of WQv (pool/marsh) in %	25/75	70/30 (includes pond volume)	25/70
Allocation of surface area (deepwater/low marsh/high marsh/semi-wet) in %	20/35/40/5	45/25/25/5 (includes pond surface area)	10/45/40/5
Forebay	Required	Required	Optional
Micropool	Required	Required	Required
Outlet configuration	Reverse-slope pipe or hooded broad crest weir	Reverse-slope pipe or hooded broad crest weir	Hooded broad crest weir

Modified from Massachusetts DEP, 1997; Schueler, 1992

TABLE 10- 2 WETLAND SURFACE AREA

% Impervious Surface	Surface Area in Acres per Acre of Watershed
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.

10.4 As-built Certification Considerations

After the BMP has been installed, the developer must have an as-built certification of the storm water wetland conducted by a registered Professional Engineer. The as-built certification verifies that the BMP was installed as designed and approved.

The following components are key to a properly working storm water wetland and must be documented in the as-built certification:

a. Properly designed, constructed and maintained sediment forebay.
b. Healthy vegetation.
c. Varying water depths.
d. Long flow paths through the BMP.
e. Storage volumes and flow depths as designed.

10.5 Maintenance

Each BMP must have an Operations and Maintenance plan submitted to the City for approval and maintained and updated by the BMP owner. Refer to Appendix C for the Operation and Maintenance (O&M) Agreement for storm water wetlands, as well as a BMP inspection checklist. The O&M Agreement must be completed and submitted to the City with the as-built certification. The O&M agreement is for the use of the BMP owner in performing routine inspections. The City will perform annual inspections of BMPs, using a similar checklist. The developer/owner is responsible for the cost of maintenance and annual inspections, unless the pond is located in a residential subdivision or receives public water. The BMP owner must maintain and update the BMP operations and maintenance plan. At a minimum, the operations and maintenance plan must address:

1. Remove debris from inlet and outlet structures.

2. Remove invasive vegetation from all side slopes.
3. Harvest overgrown vegetation within the wetlands.
4. Ongoing inspection and maintenance, with more intense inspection and maintenance activities for the first three years after construction.
5. The wetland must be maintained to prevent loss of area of ponded water available for emergent vegetation due to sedimentation and/or accumulation of plant material.
6. Sediment forebays must be cleaned when 50% full. Pocket wetlands without forebays must be cleaned after a six-inch accumulation of sediment.
7. The ponded water area may be maintained by raising the elevation of the water level in the permanent pond, by raising the height of the orifice in the outlet structure, or by removing accumulated solids by excavation. Such a change may constitute a major revision to the storm water management plan and may require approval from the City.
8. Water levels may need to be supplemented or drained periodically until vegetation is fully established.
9. It may be desirable to remove contaminated sediment bottoms or to harvest above ground biomass and remove it from the site to permanently remove pollutants from the wetland.

Figure 10.1 - Storm water Wetlands
(Source: Controlling Urban Runoff)

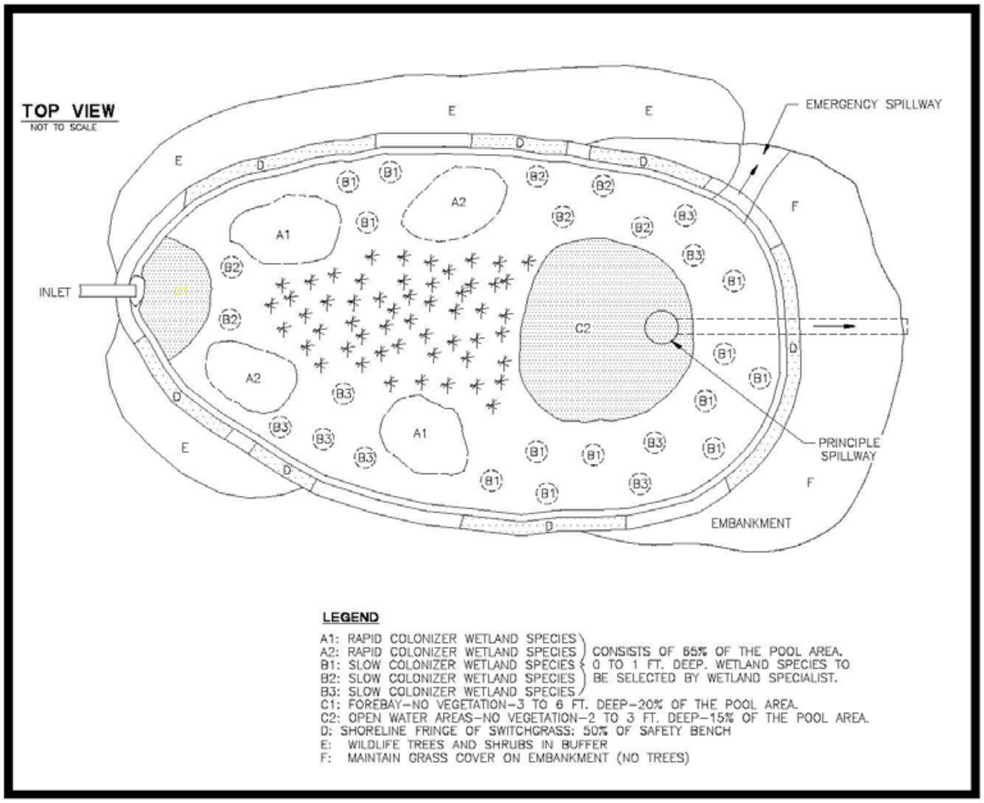


Figure 10.2 - Shallow Wetland
(Courtesy of the Center for Watershed Protection)

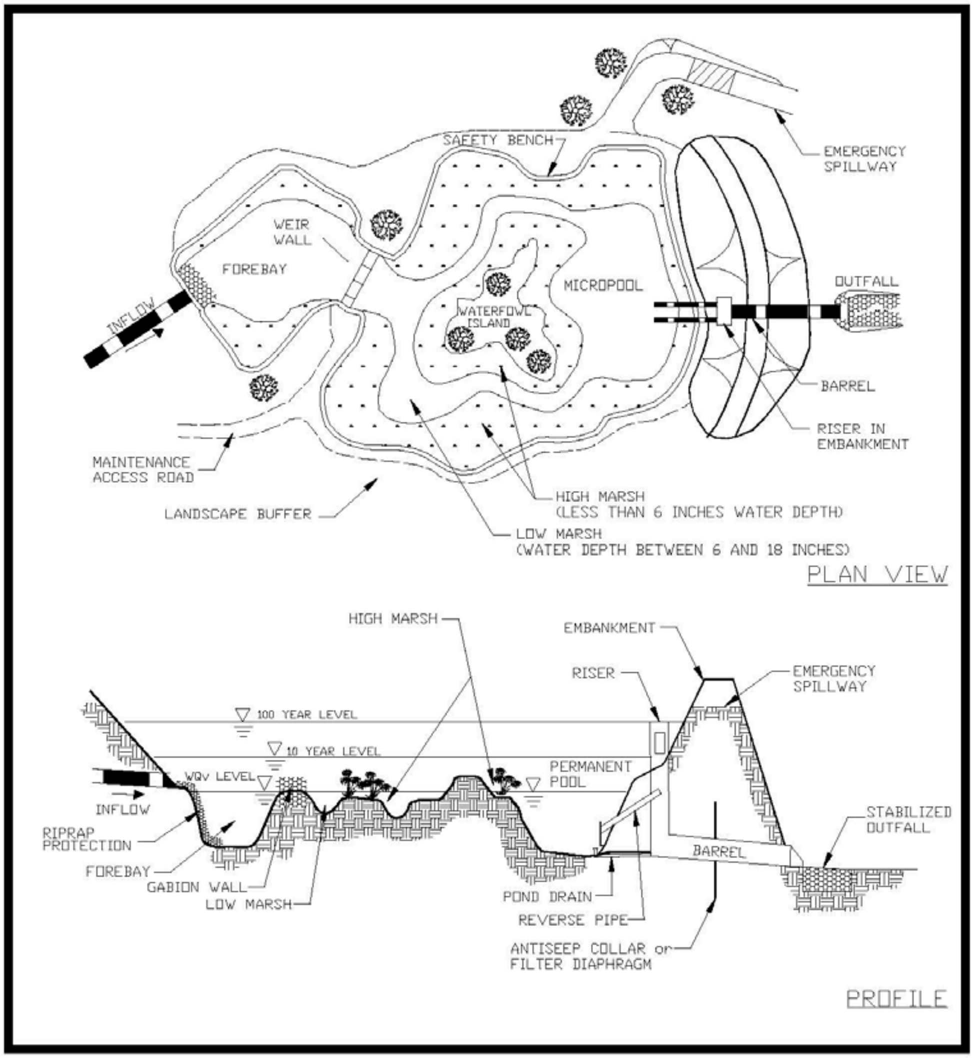


Figure 10.3- Schematic for a Pond/Wetland System
(Courtesy of the Center for Watershed Protection)

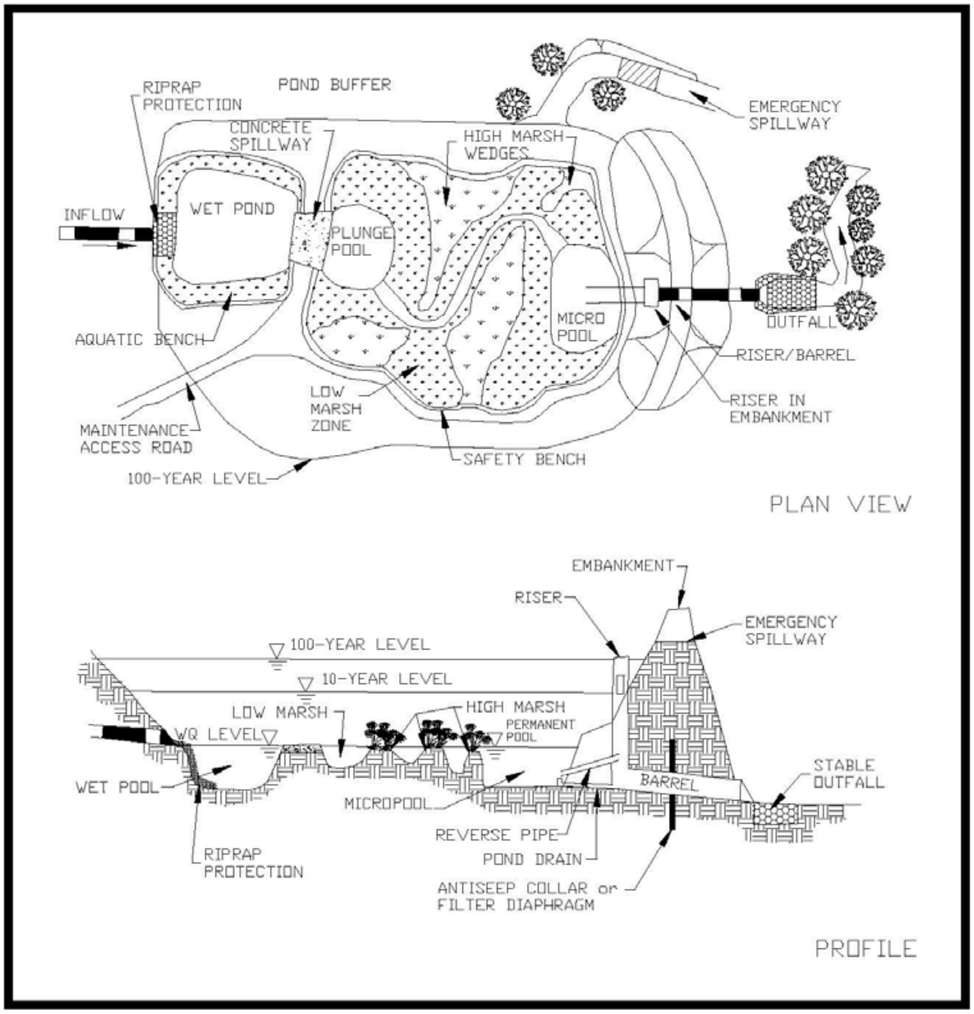


Figure 10.4 - Schematic of a Pocket Wetland
(Courtesy of the Center for Watershed Protection)

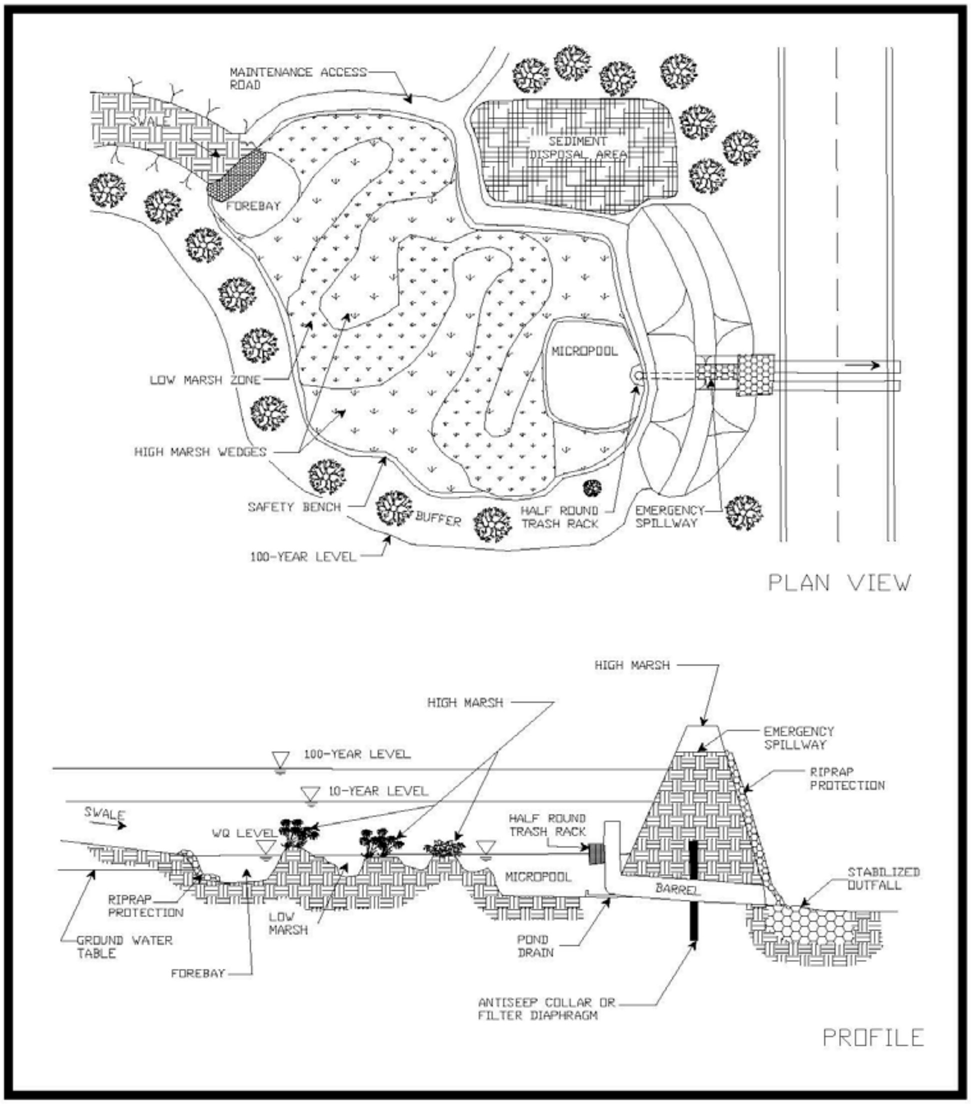
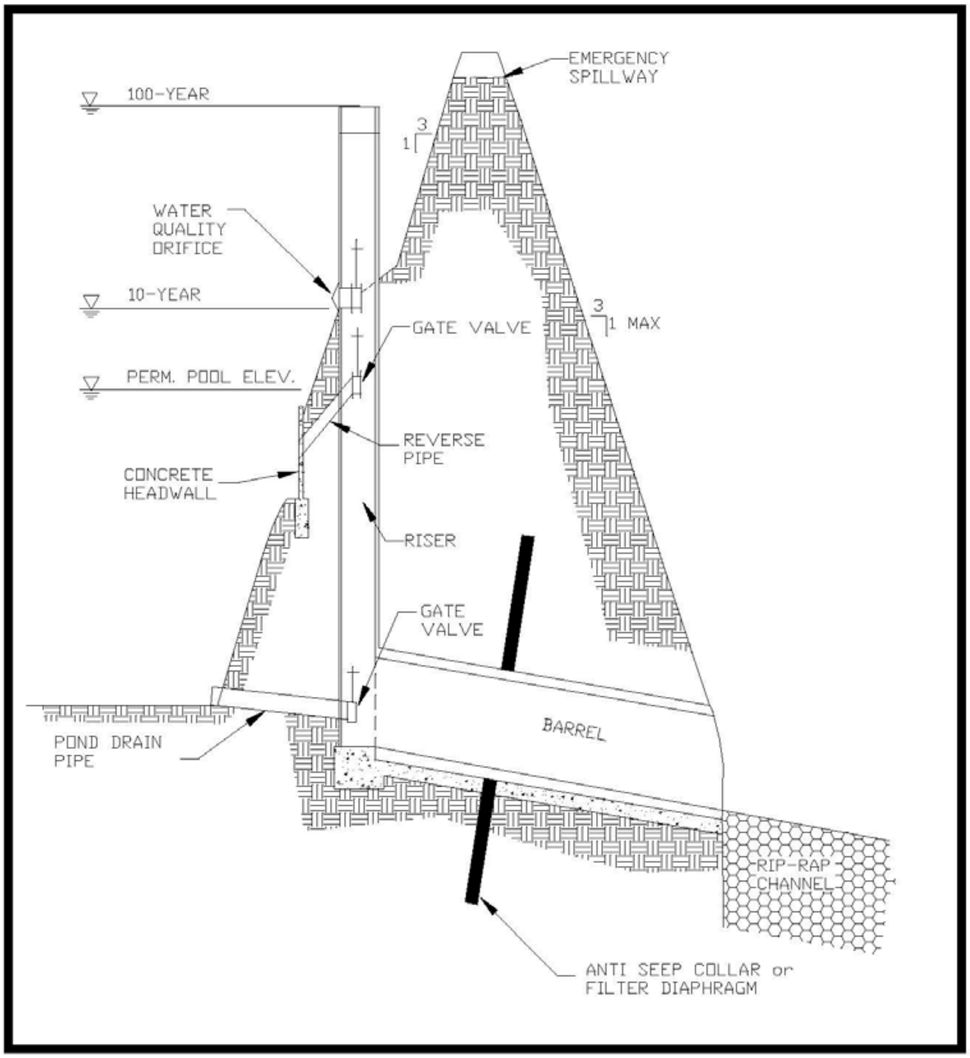


Figure 10.5 - Schematic of Outlet System



CHAPTER 11 – BMPs - Erosion and Sediment Control

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 during construction activities in Berea, Kentucky. 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

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.

11.2 Regulatory Requirements

This section lists the erosion and sediment control requirements.

11.2.1 Permitting Process

Land disturbance activity is regulated as described in the Berea Stormwater Ordinance, Sections 34.3.2, 34.3.3, and 34.3.4. Following is an updated summary of the permitting process for construction sites.

a) <u>34.3.2 LAND DISTURBANCE PERMIT</u>

Land Disturbance Permits (LDP) are required for all site construction projects and/or land disturbance activities, depending on the amount of disturbed areas.

(A) The Land Disturbance Permit alone does not authorize or grant permission to begin development or redevelopment on the property. It does not supersede other permits required by the City, State or federal government.

(B) Project site owners shall submit an application for an LDP on forms provided by the city.

(C) Applications for a Land Disturbance Permit shall be submitted to the city and must include a:

a. Completed application request
b. Notice of Intent (NOI), with proof of public notice
c. a perimeter control plan (PCP) and Erosion Protection and Sediment Control Plan (EPSC),
d. Storm Water Pollution Prevention Plan (SWPPP),
e. Post-Construction Stormwater Pollution Prevention Plan,
f. Any required maintenance agreement, and
g. Any other necessary information or documentation requested by the city.

(D) The PCP is a component of the Erosion Protection and Sediment Control Plan (EPSC). While both plans may be approved simultaneously, **the provisions of a PCP shall be implemented, inspected and accepted by the City before any other construction proceeds.**

(E) The landowner must notify the City and the Kentucky Division of Water (KDOW) within 7-days prior to the commencement of construction activities through the submittal of an updated NOI.

(F) Upon completion of construction activities, stabilization of the project site and removal of all temporary erosion protection and sediment control measures, the applicant shall submit a Notice of Termination (NOT) as required by the KDOW. The City, or its designated representative, shall inspect the project site to verify that the requirements of the NOT have been met.

(G) The City reserves the right to require a checklist of necessary items to be completed and included with the Land Disturbance Permit application submittal. Upon submittal, the LDP application shall be rejected in its entirety should any item on the checklist be incomplete.

(H) The City reserves the right to collect fees associated with LDP application, plan review, and inspections from the applicant.

b) 34.3.3 EXEMPTIONS

The following activities are exempt from the provisions of this ordinance:

A) Clearing or grading activities that are subject exclusively to State approval and enforcement under State law and regulations.

B) Emergencies posing an immediate danger to life or property, substantial flood or fire hazards, or natural resources;

C) Underground utility repairs in paved areas, home gardens, minor repairs, maintenance work, sign, telephone, and electric poles and other kinds of posts or poles;

D) Agricultural operations required to adopt and implement an individual agricultural water quality plan pursuant to the requirements set forth in the Kentucky Agriculture Water Quality Act (KRS 224);

E) Usual operations required to adopt and implement an individual agricultural water quality plan pursuant to the requirements set forth in the Kentucky Agriculture Water Quality Act (KRS 224);

F) Building improvements on existing residential dwellings (garages, additions, porches, etc.).

c) *34.*3.4 LAND DISTURBANCE ACTIVITY

(A) Land Disturbance Activity less than one (1) acre on individual lot(s) or parcel(s) that are part of a larger common plan of development that disturbs one (1) acre or more of soil, and currently covered by KPDES NOI, is not exempt from this Section or Land Disturbance Permit. In this situation, the landowner and/or developer of the larger development, and the individual lot owner(s) or homebuilder(s), will be issued a separate Land Disturbance Permit and will be responsible for complying with the provisions of this section. The landowner and/or developer of the larger development will remain jointly responsible for said lot(s) until such time that the larger common plan of development reaches 80% build-out.

(B) Land Disturbance Activity less than one (1) acre on individual lot(s) or parcel(s) that are not part of a larger common plan of development is not exempt from this Section or Land Disturbance Permit. The following information is required for submittal of the Land Disturbance Permit:

1 Land Disturbance Permit Application
2 Completed EPSC Land Disturbance Form
3 All fees for said permit shall be paid according to the established Permitting Fee Schedule.

(C) The City of Berea may on a project-by-project basis exempt other minor land disturbance activities not specifically identified in the exemptions above.

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

Floodplain Avoidance
No construction or grading activities are permitted in the post-development floodplains, as defined in Chapter 2 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 post-development floodplain. Temporary sediment control in a permanent pond shall be allowed in the post-development floodplain but not in a stream.

Vegetative Buffer Strips
Buffer strips are required adjacent to all streams and wetlands in Berea. The buffer strip width shall be 25 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 Stormwater Pollution Prevention Plan (SWPPP) 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.

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
- Sod
- Road/parking stabilization
- Construction entrance
- Dust control
- Nets 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 and Mats

Mulch netting, erosion control 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 6.

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 practices include:

- Check dam
- Sediment trap
- Sediment pond
- Silt fence
- Storm drain inlet protection
- Filter strip
- Stream crossing
- Pump-around flow diversion
- Construction dewatering

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 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.

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 post development 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 3 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 offsite.

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.

11.3 Structural Soil Stabilization BMPs

11.3.1 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 hydro seeder 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 hydro mulches 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 hydro seeder 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 hydro seeder 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.

11.3.2 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 hydro seeder (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 hydro seeder 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.

11.3.3 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 the city 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 hydro seeder (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:

- <u>Mechanical</u> – Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil.
- <u>Mulch</u> 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.
- <u>Wood Fiber</u> – Wood fiber hydro seeder 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.

11.3.4 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.

11.3.5 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.

11.3.6 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 50 feet, and where practical, shall be extended to 100 feet. 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 0.2 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.

11.3.7 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 the city 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.

11.3.8 Nets and Mats

Mulch netting, erosion control 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 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 6 for additional information on stabilizing vegetated channels.

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.

11.3.9 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 % 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.

11.3.10 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 6. Diversions can be constructed for various purposes including to:

- Divert storm runoff away from unprotected slopes to a stabilized outlet
- Divert sediment-laden runoff from a disturbed area to a sediment pond,
- 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.

11.3.11 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.

11.3.12 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., non-perforated, 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.

11.3.13 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 Berea Standard Drawings.

Construction Specifications

Construction specifications for impact stilling basins are provided in the Standard Drawings. An examples of an impact stilling basin is shown in Figure 11- 28.

11.4 Structural Sediment Control BMPs

11.4.1 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.

11.4.2 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.

11.4.3 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 ponds or storage structures for runoff control, if they are designed and constructed in accordance with applicable requirements of storage structures given in Chapter 9.

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 24-48 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.

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),
a = average surface area of sediment pond at the elevation of the principal spillway (ft^2),
L = depth of sand (ft),
A = surface area of filter = width of sand layer * length of sand layer (ft^2),
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 24-48 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-hourstorm 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.

11.4.4 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.

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:

PHYSICAL PROPERTY	REQUIREMENTS
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 10 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.

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 to the existing grade, prepared, and seeded.

Silt fences shall be replaced every 6 months.

11.4.5 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

For gravel curb inlet protection (shown in Figure 11-24), the following specifications apply:

- Wire mesh with ½-inch openings shall be placed over the curb inlet opening so that at least 12 inches of wire extends across the concrete gutter from the inlet opening.
- KYTC No. 2 Coarse Aggregate shall be piled against the wire so as to anchor it against the gutter and inlet cover and to cover the inlet opening completely.
- A gravel filtering device has no overflow mechanism, therefore, ponding is likely. This type of device must never be used where overflow may endanger an exposed fill slope. Consideration should also be given to the possible effects of ponding on traffic movement, nearby structures, working areas, and adjacent property.
- For block and gravel curb inlet protection (illustrated in Figure 11-25), the following specifications apply:
- Two concrete blocks shall be placed on their sides abutting the curb at either side of the inlet opening to act as spacer blocks.
- A 2-inch by 4-inch stud shall be cut and placed through the outer holes of each spacer block to help keep the front blocks in place.
- Concrete blocks shall be placed on their sides across the front of the inlet and abutting the spacer blocks.

- Wire mesh shall be placed over the outside of the concrete blocks to prevent stone from being washed through the holes in the blocks. Wire with ½-inch openings shall be used.
- KYTC No. 2 Coarse Aggregate shall be piled against the wire to the top of the barrier.

Maintenance
The structure shall be inspected after each rain, and repairs made as needed.

Sediment shall be removed and the device restored to its original dimensions when the sediment has accumulated to one-third the design depth of the filter. Removed sediment shall be deposited in a suitable area and in such a manner that it will not erode.

If a stone filter becomes clogged with sediment so that it no longer adequately performs its function, the stone must be pulled away from the blocks, cleaned, and replaced.
Structures shall be removed after the drainage area has been properly stabilized.

11.4.6 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 11-26.

Where a post development 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	10	
	or Red Clover	10	
	Plus		Well Drained
	Timothy	4	
	or Orchardgrass	6	
	or Bromegrass	6	
2.	Landino Clover	½	
	Plus		
	Timothy	4	Wet or Well Drained
	or Orchardgrass	6	
	or Bromegrass	6	

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.

11.4.7 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.

11.4.8 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

11-27 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.

11.4.9 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.

11.4.10 Concrete Washout Pits

Concrete washout pits shall be constructed to minimize the discharge of pollutants into streams and storm sewers. A minimum of one washout pit per 40 lots shall be constructed.

Design Criteria

The washout pits shall be sized approximately 20'x20'x5'. Alternative designs shall be submitted to the city of Berea for review and acceptance.

Construction Specifications

The pits shall be lined with a 10 mil plastic linter and located outside of the road right-of-way. A #2 stone rock entrance to the pit shall also be constructed. Manufactured signage directing the drivers to the pits shall be installed and maintained by the Developer.

Maintenance

The pits shall be maintained in good working order by the Developer throughout the home- building phase of the project. The pits shall be cleaned when they reach approximately 75% of their volume.

11.5 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.

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.

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.

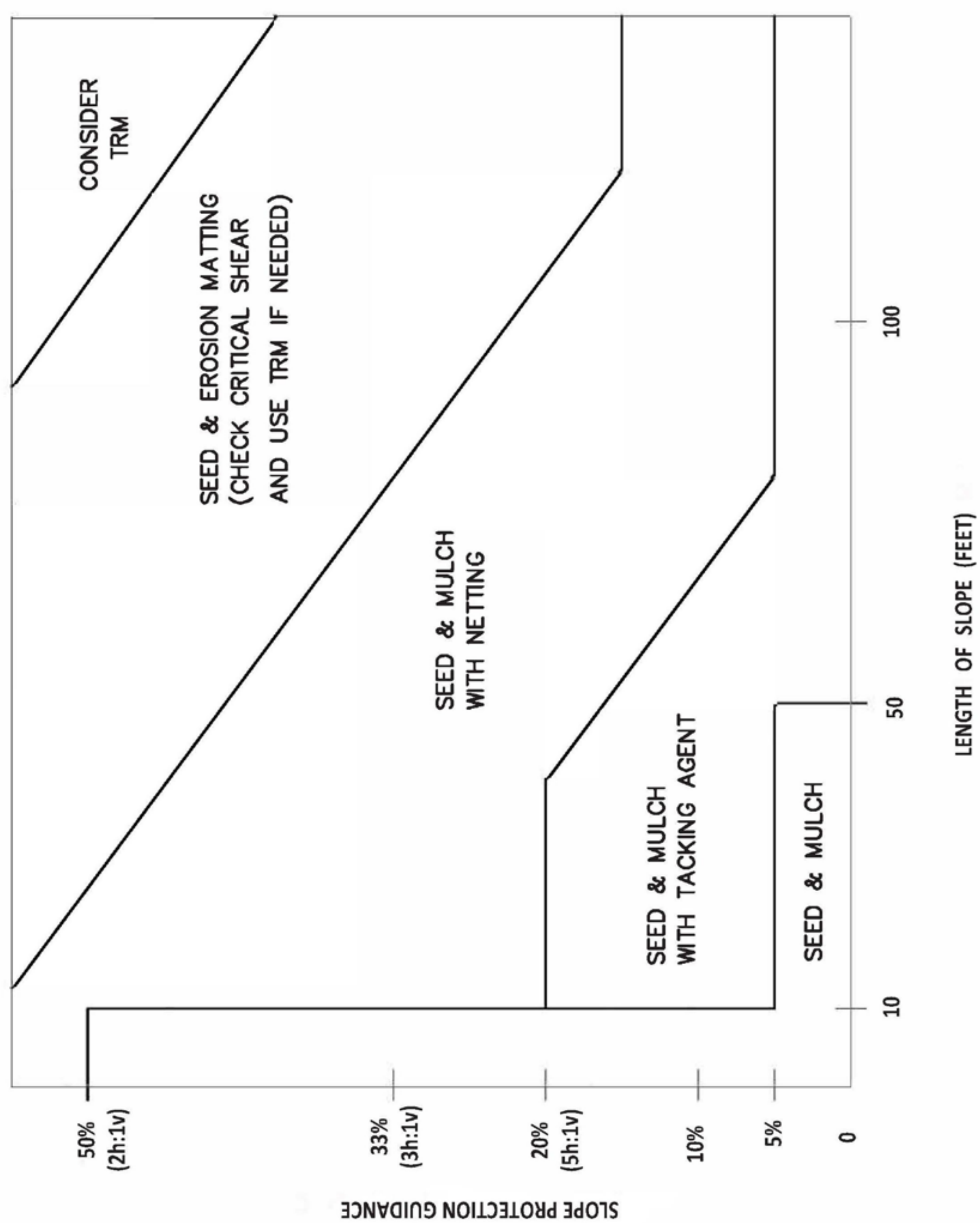
Alteration of Drainage System
The home builder shall not regrade the lot to move a swale, channel, or stream. The home builder shall not fill in a floodplain, detention/retention pond, swale, channel, or stream.

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

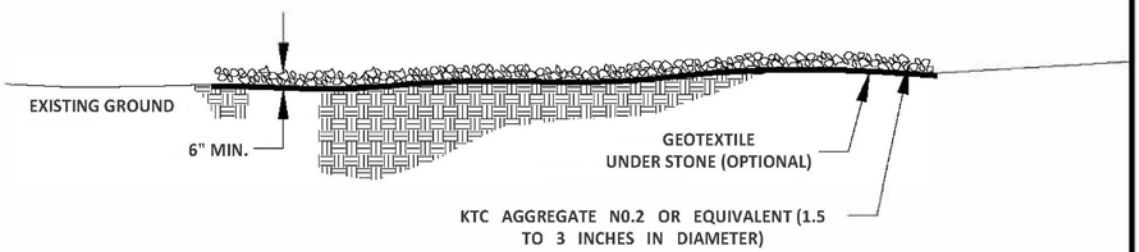
SLOPE PROTECTION GUIDANCE



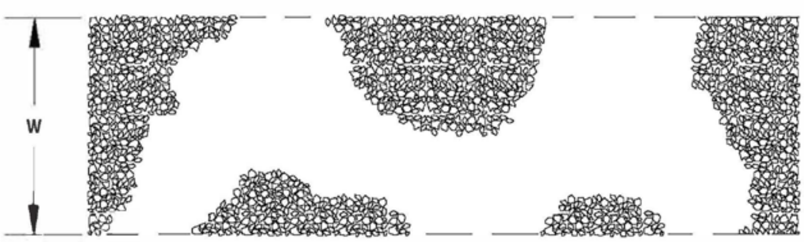
STORMWATER MANUAL

FIGURE 11-2

ROAD\PARKING STABILIZATION



CROSS SECTION

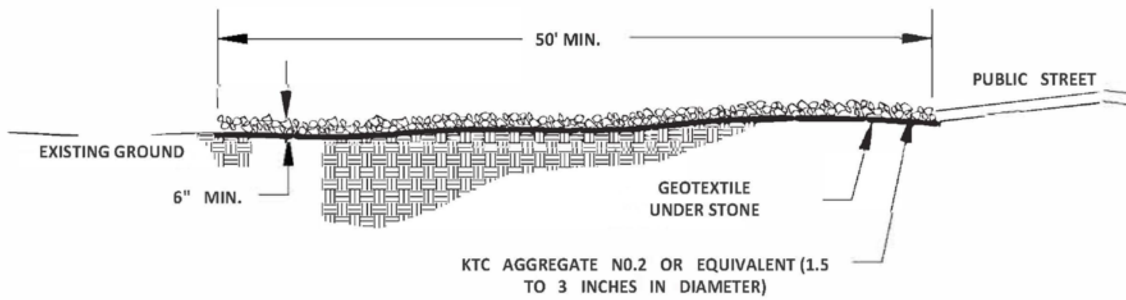


PLAN VIEW

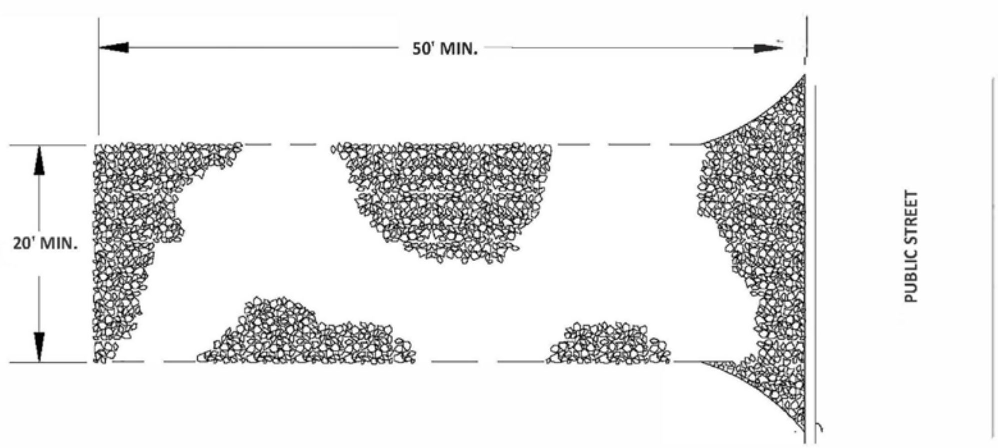
W = 14' MIN. FOR ONE WAY TRAFFIC 20' MIN. FOR TWO WAY TRAFFIC

STORMWATER MANUAL

FIGURE 11-3
CONSTRUCTION ENTRANCE



CROSS SECTION



PLAN VIEW

STORMWATER MANUAL

FIGURE 11-4

CONSTRUCTION ENTRANCE NOTES AND SPECIFICATIONS

SPECIFICATIONS FOR GEOJEXTILE FABRIC

GRAB TENSILE STRENGTH	220 LBS. (MIN.) (ASTM 01682)
ELONGATION FAILURE	60% (MIN.) (ASTM 01682)
MULLEN BURST STRENGTH	430 LBS. (MIN.) (ASTM 03768)
PUNCTURE STRENGTH	125 LBS. (MIN.) (ASTM 0751) (MODIFIED)
EQUIVALENT OPENING	SIZE 40-80 (us STD SIEVE) (CW-02215)

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

SLOPES UP TO 1.5H:1V

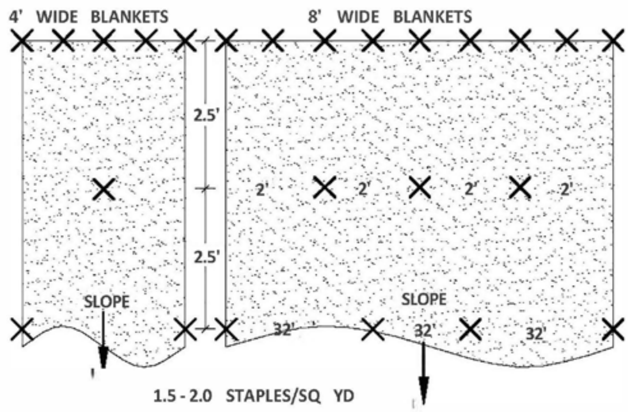
- INSTALL BLANKET VERTICALLY OR HORIZONTALLY
- USE 12" STAPLE SPACING ON STARTER ROW.

COHESIVE SOILS:

- NO OVERLAP REQUIRED ON SIDE SEAMS USE 6" STAPLE LENGTH

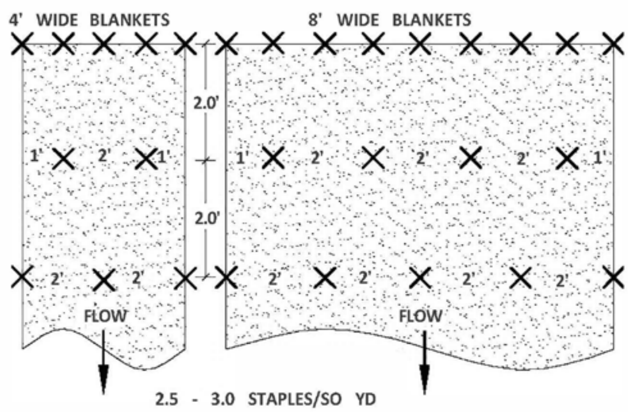
NON-COHESIVE SOILS:

- USE 6" SIDE SEAM OVERLAP
- USE 8" STAPLE LENGTH
- USE 6" ANCHOR TRENCH AT TOP OF SLOPE



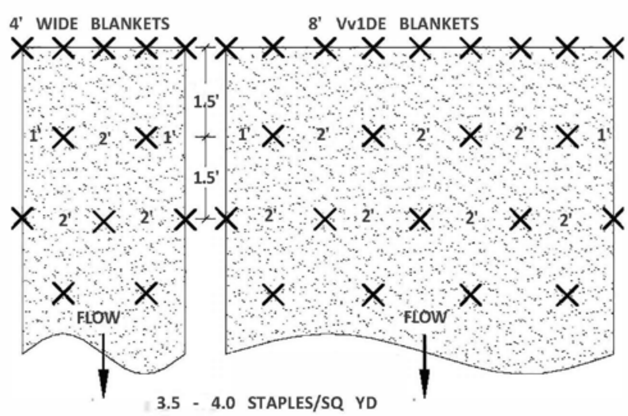
CHANNELS IN COHESIVE SOILS

- 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".



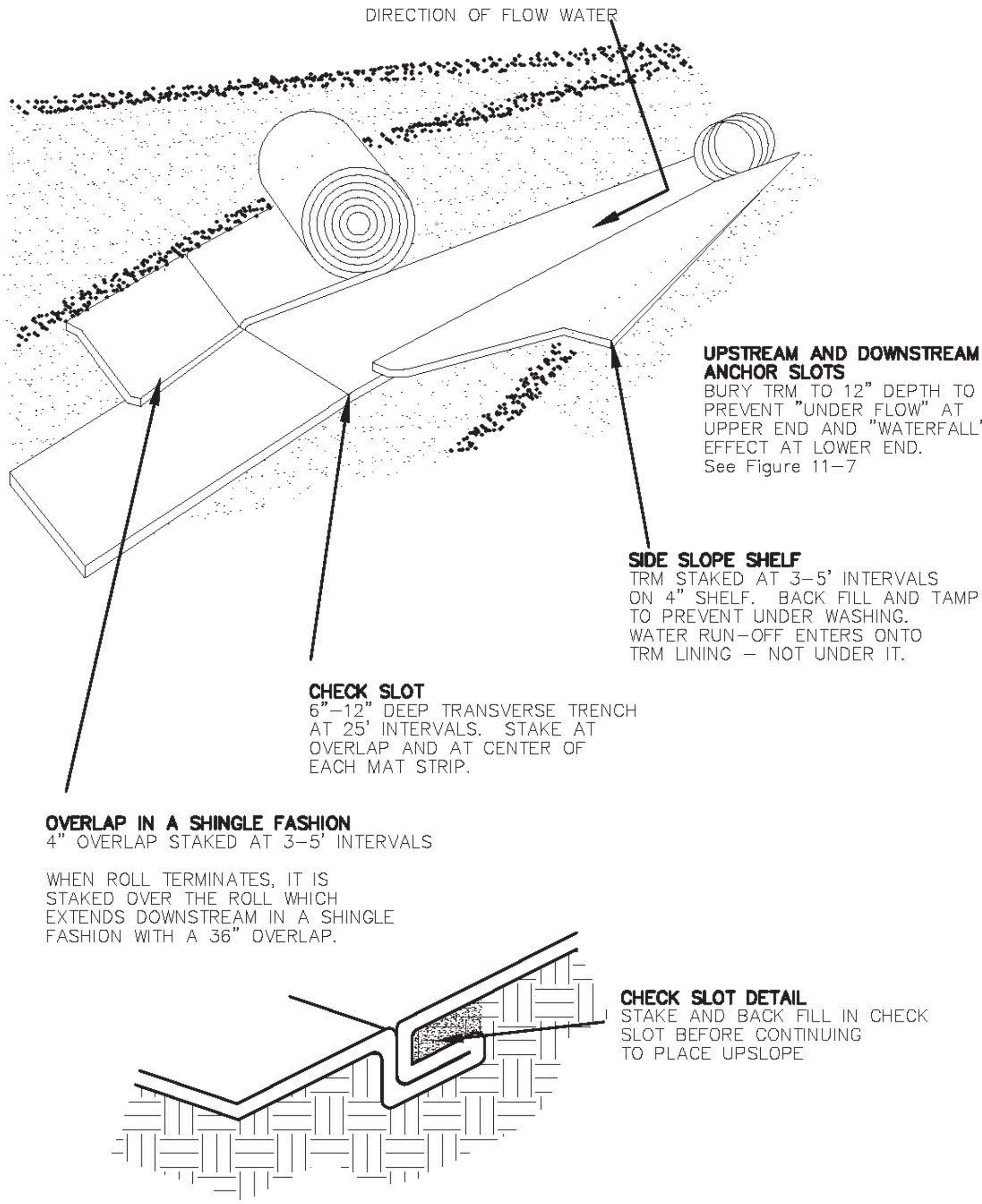
CHANNELS IN NON-COHESIVE SOILS

- 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

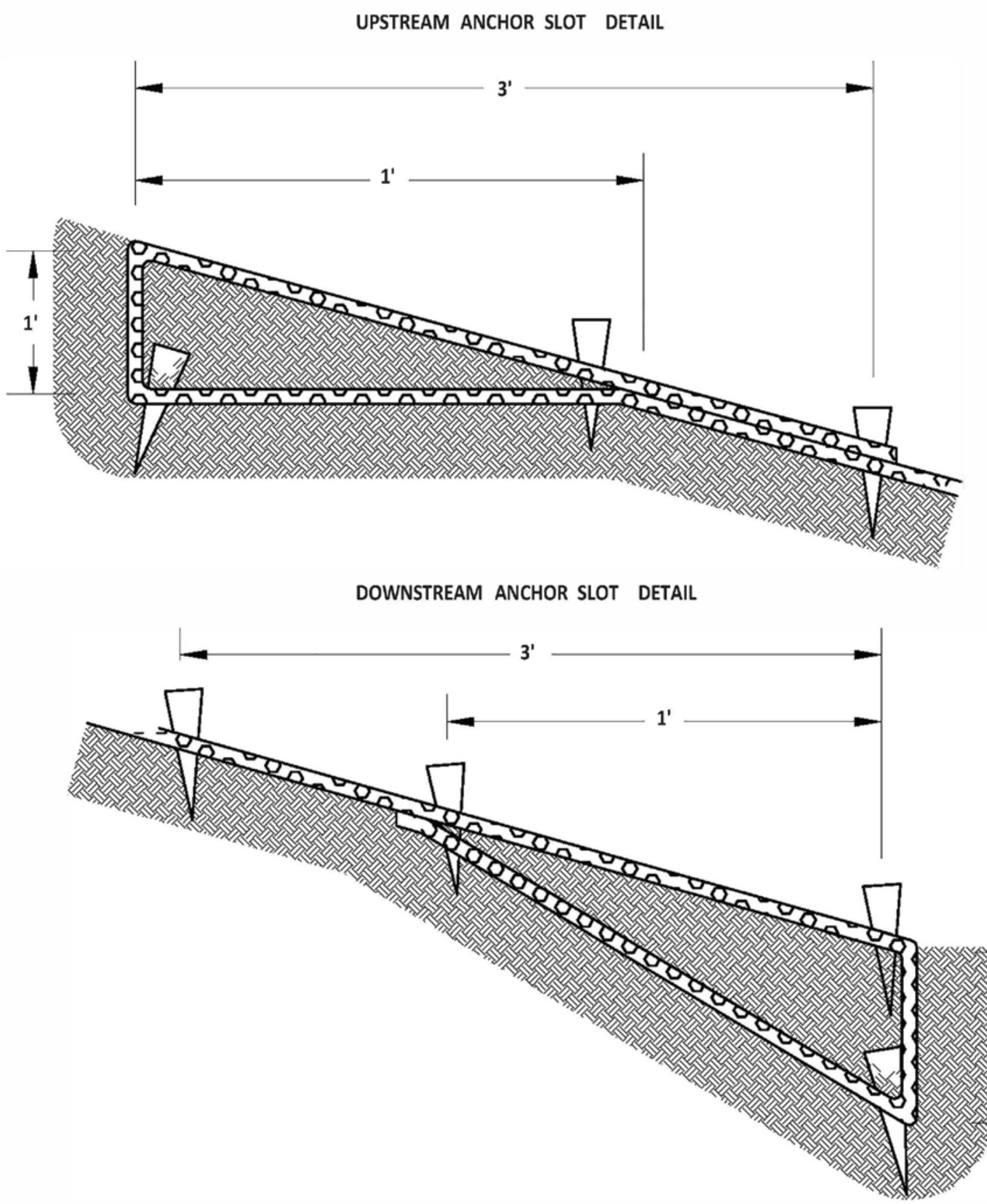
FIGURE 11-6
PLACEMENT OF TRM IN CHANNEL



STORMWATER MANUAL

FIGURE 11-7

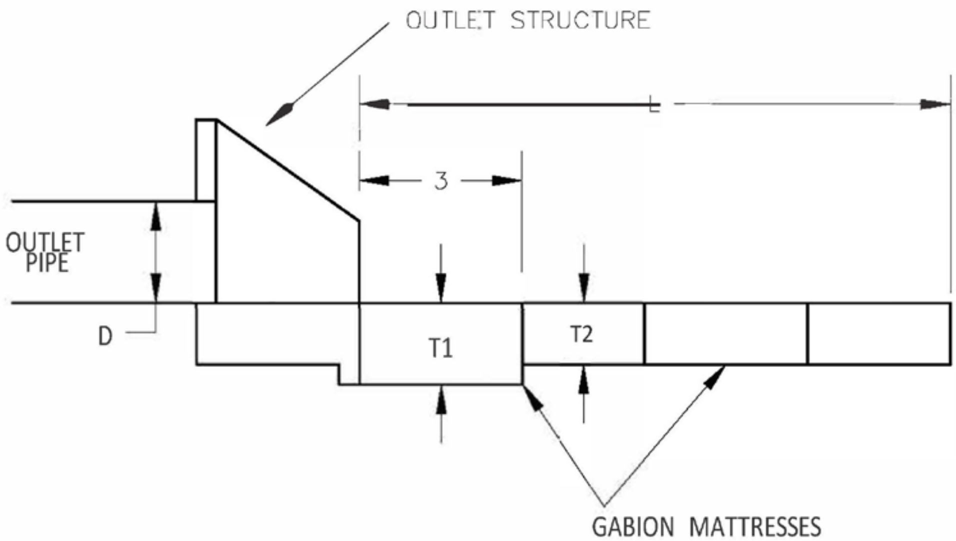
ANCHOR SLOT DETAILS FOR TRM



STORMWATER MANUAL

FIGURE 11-8

CROSS SECTION AT
GABION MATTRESS OUTLET PROTECTION



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

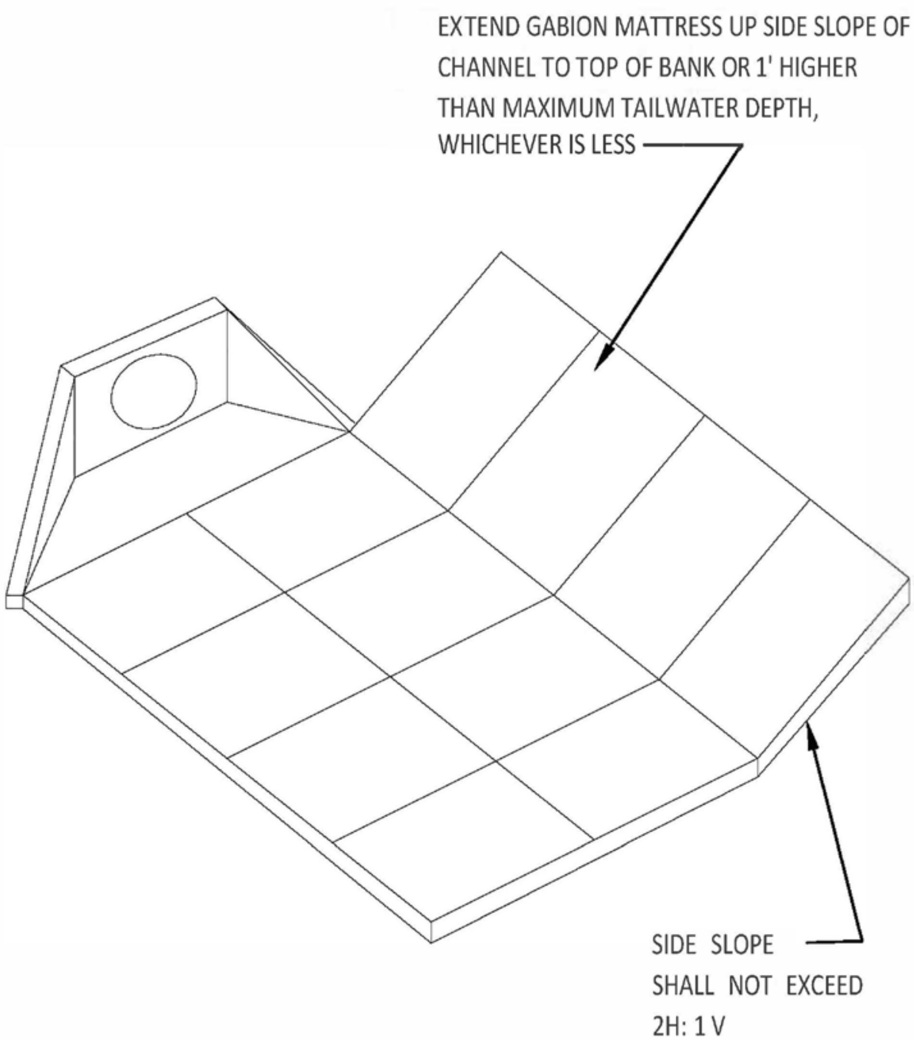
FOR D > 36 INCHES, L = 4 x D FEET

D = HEIGHT OR WIDTH OF OUTLET, WHICHEVER IS GREATER

STORMWATER MANUAL

FIGURE 11-9

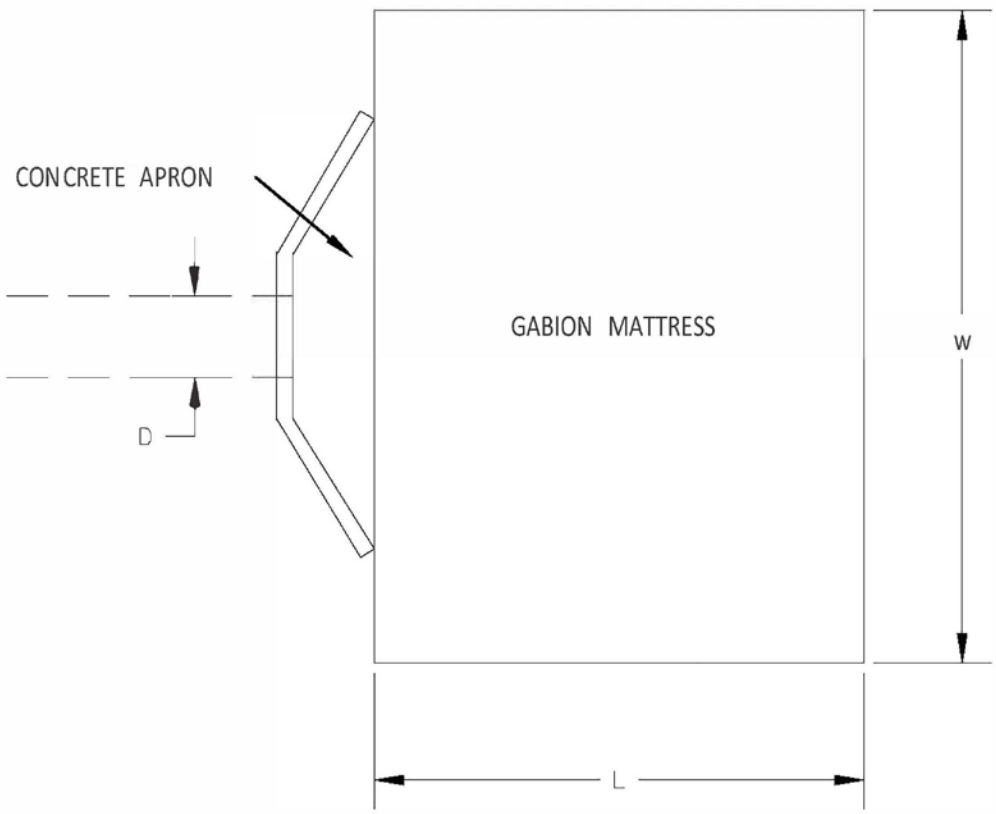
GABION MATTRESS AT OUTLET INTO WELL-DEFINED CHANNEL



STORMWATER MANUAL

FIGURE 11-10

PLAN VIEW OF GABION MATTRESS AT OUTLET INTO FLAT AREA



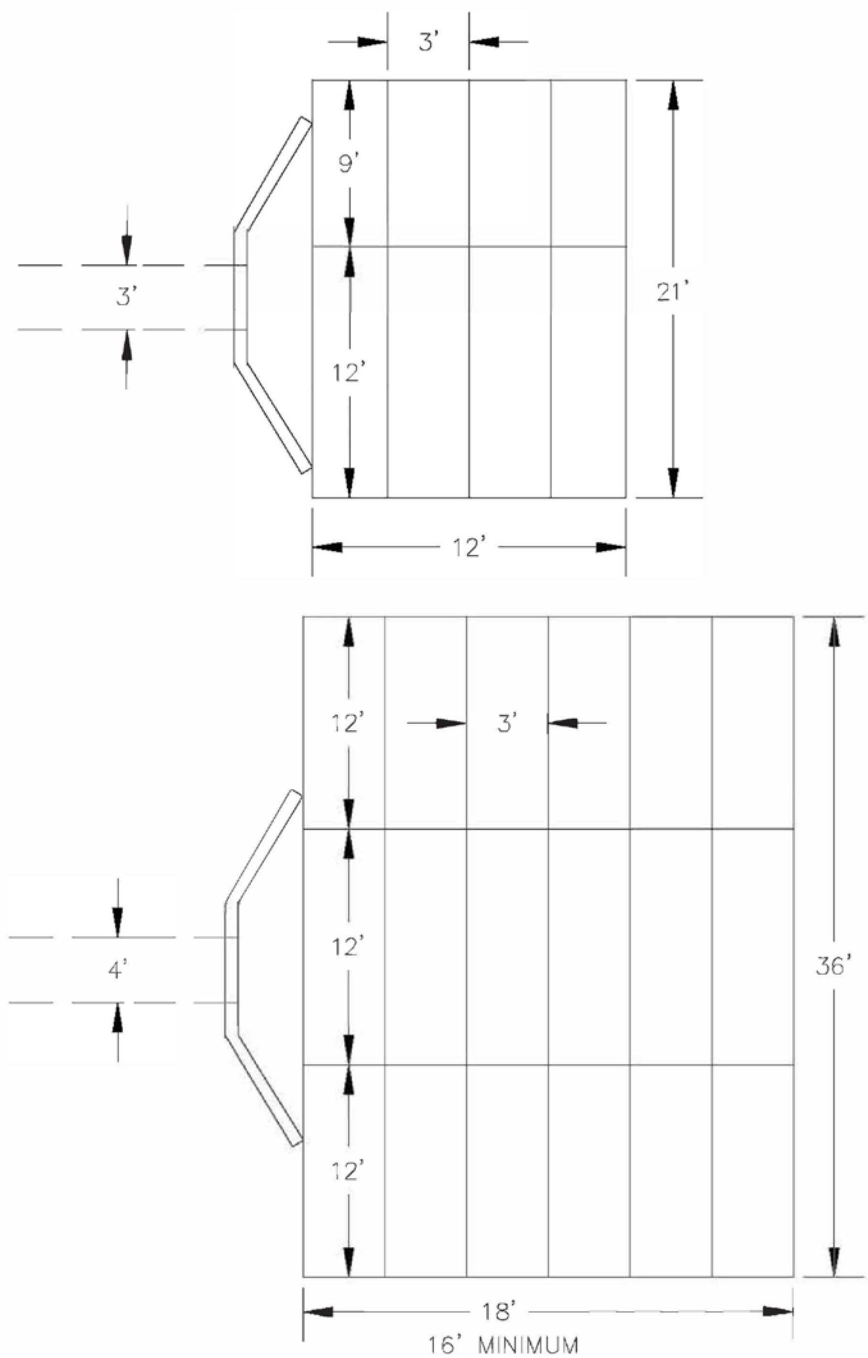
D = HEIGHT OR WIDTH OF OUTLET, WHICHEVER IS GREATER FOR
O <= 36 INCHES:
L = 12 FEET MINIMUM
W = (18 + D) FEET MINIMUM

FOR O > 36 INCHES:
L = 4 x D FEET MINIMUM
W = (2 L + D) FEET MINIMUM

STORMWATER MANUAL

FIGURE 11-11

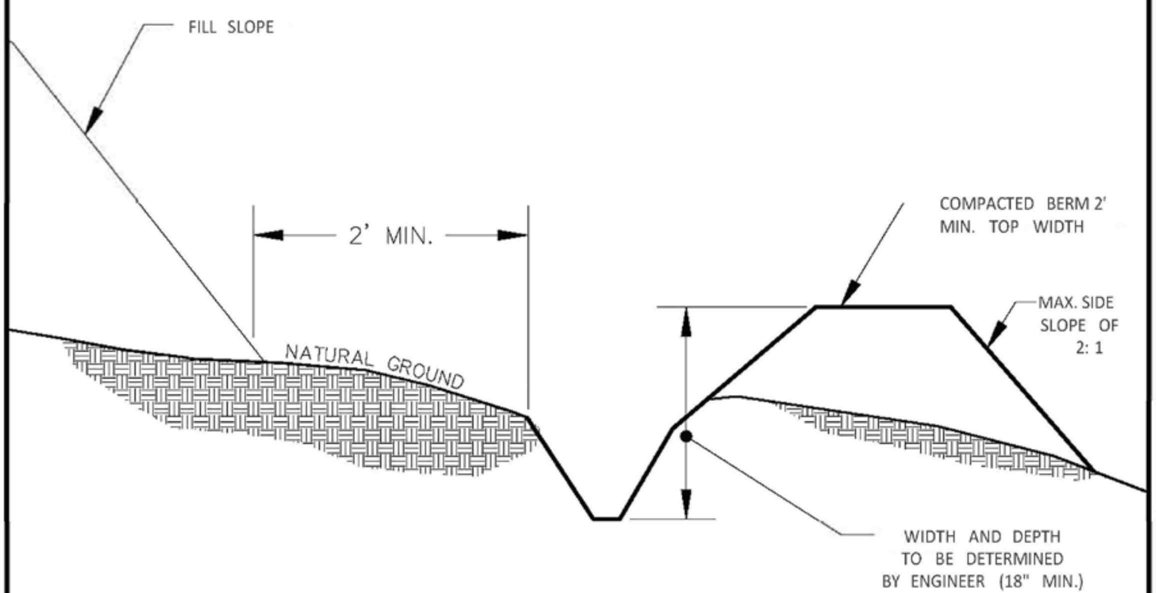
EXAMPLE PLAN VIEW LAYOUTS OF GABION MATTRESS FOR OUTLET ONTO FLAT AREAS



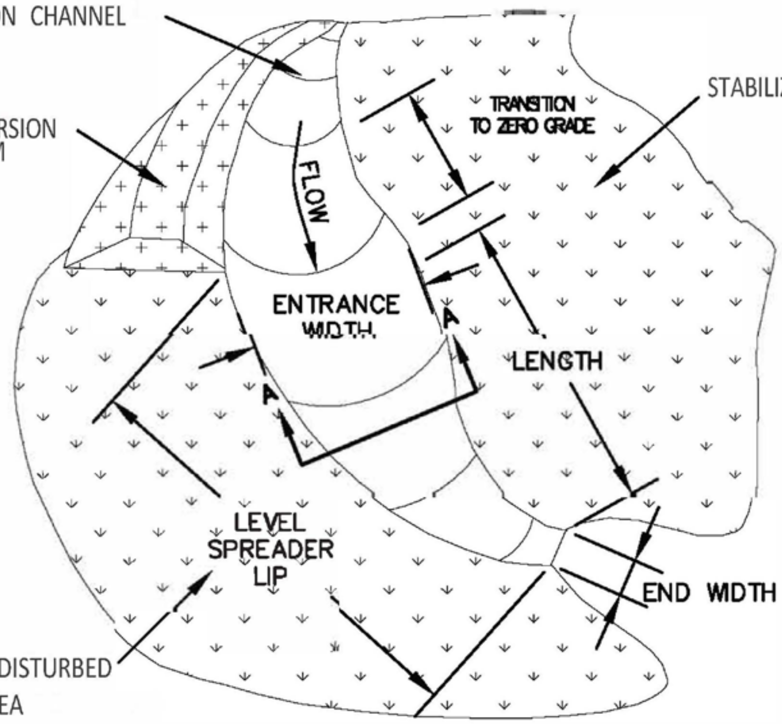
STORMWATER MANUAL

FIGURE 11-12

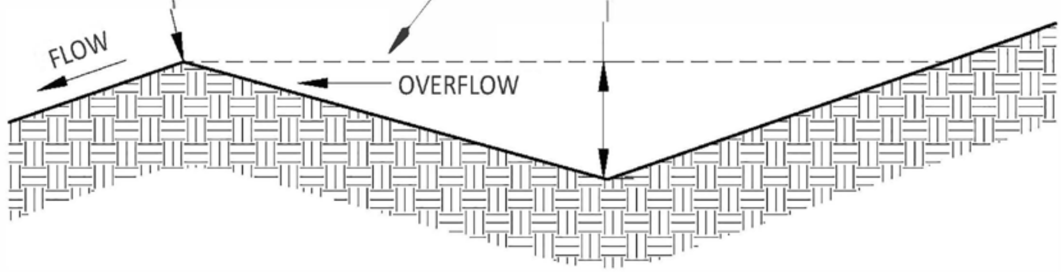
TEMPORARY DIVERSION DITCH



STORMWATER MANUAL	FIGURE 11-13 LEVEL SPREADER

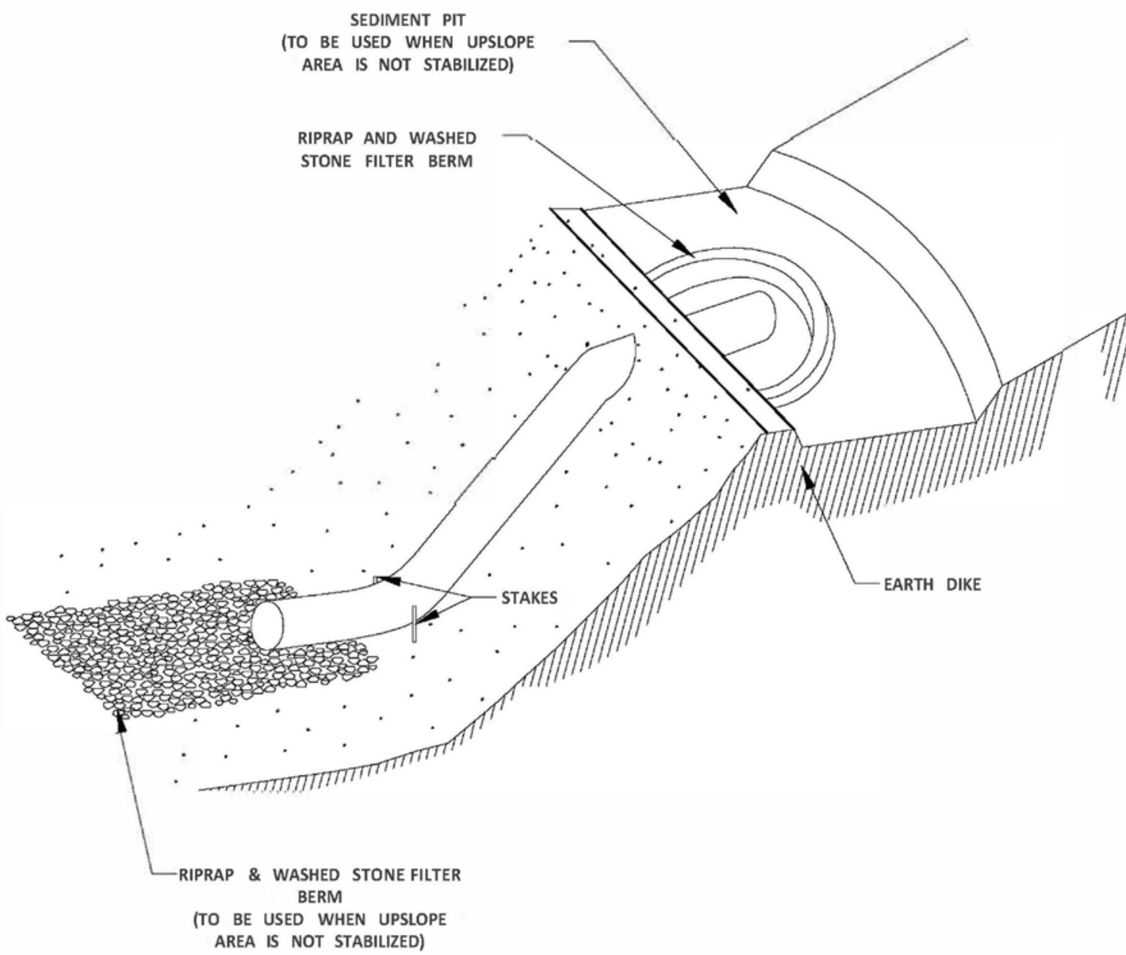


PERSPECTIVE



SECTION A-A

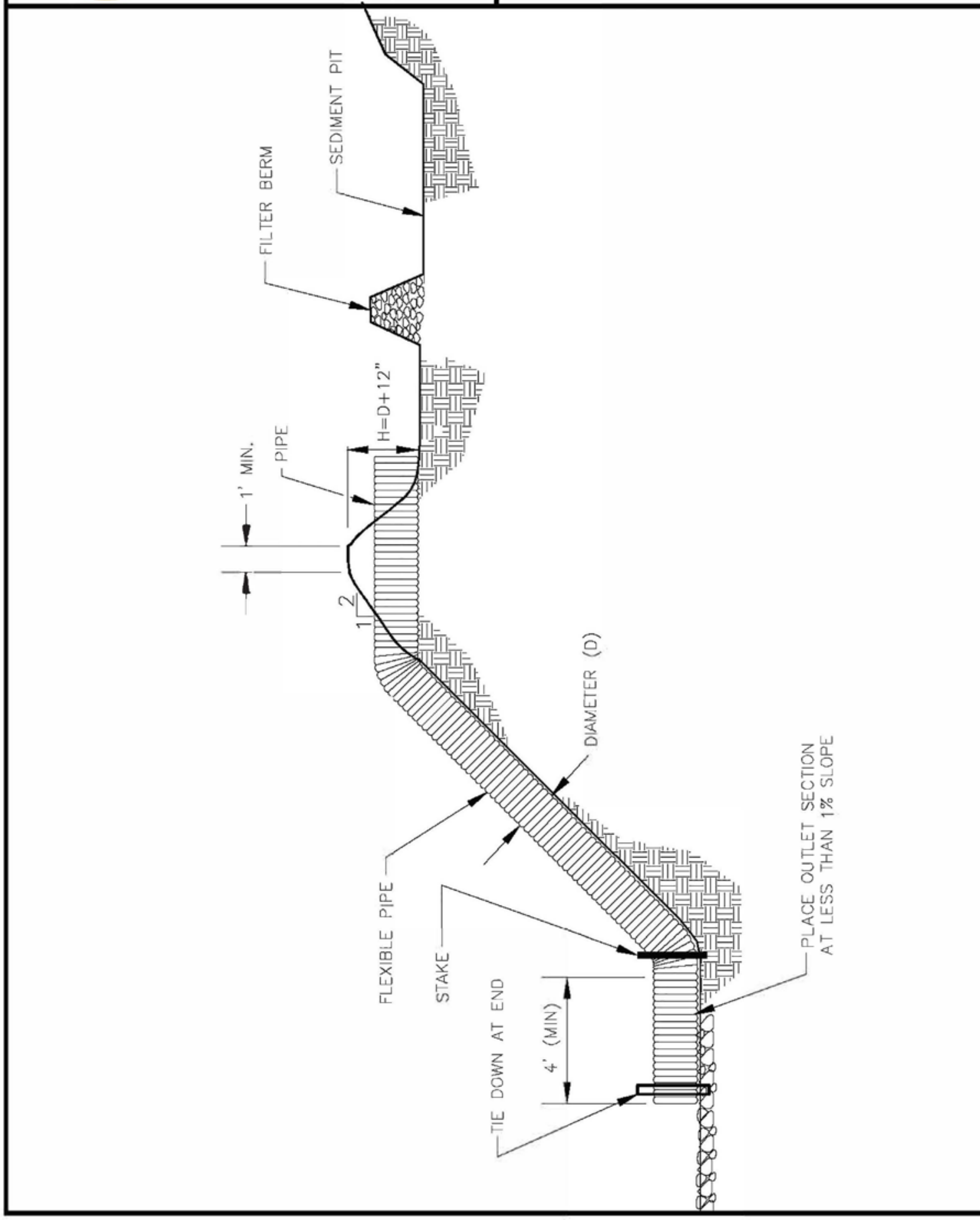
STORMWATER MANUAL	FIGURE 11-14 FLEXIBLE PIPE SLOPE DRAIN



STORMWATER MANUAL

FIGURE 11-15

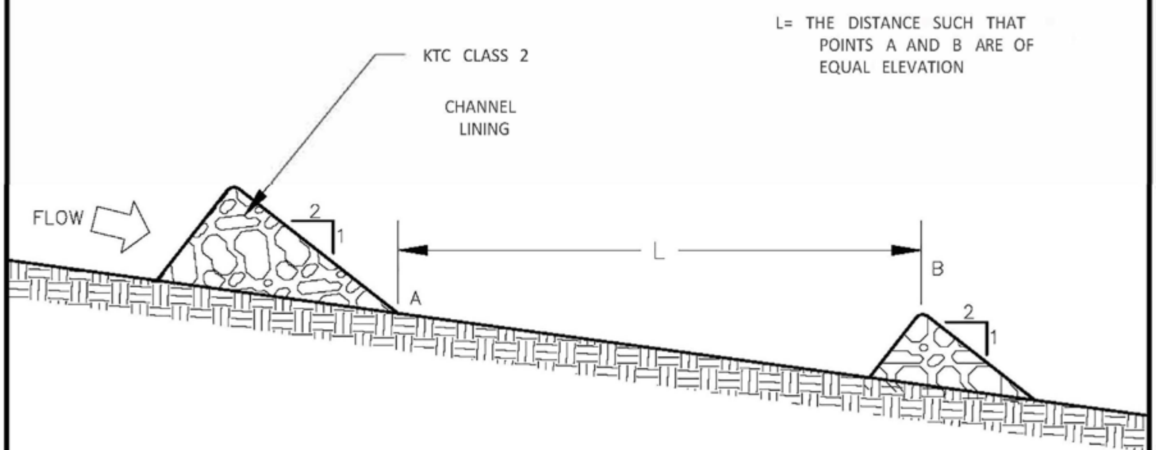
SLOPE DRAIN - PROFILE



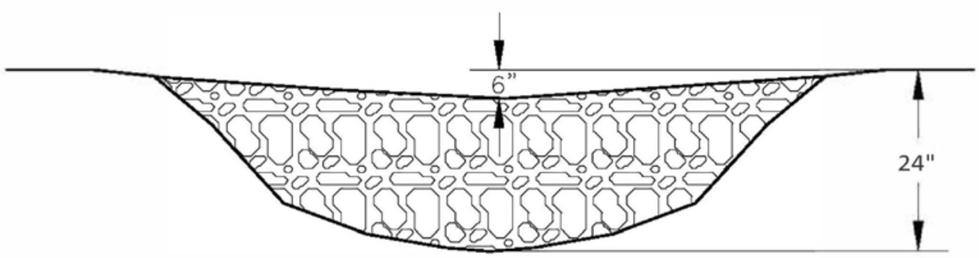
STORMWATER MANUAL

FIGURE 11-16

ROCK CHECK DAM



LONGITUDINAL SECTION SHOWING SPACING BETWEEN CHECK DAMS

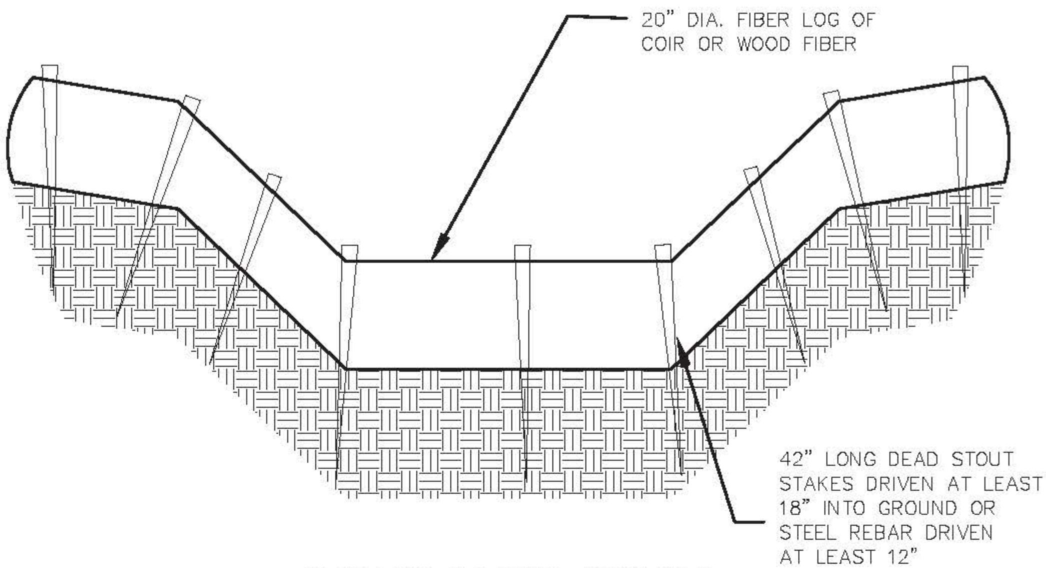


SECTION ACROSS CHANNEL

STORMWATER MANUAL

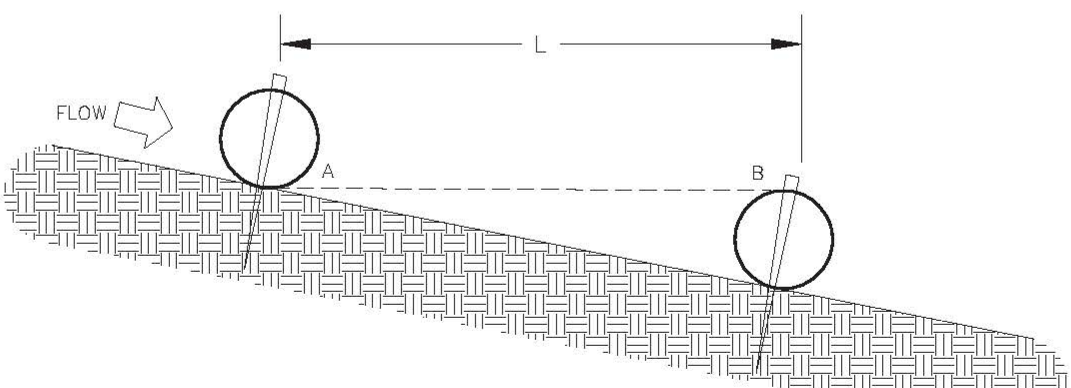
FIGURE 11-17

FIBER LOG CHECK DAM



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.



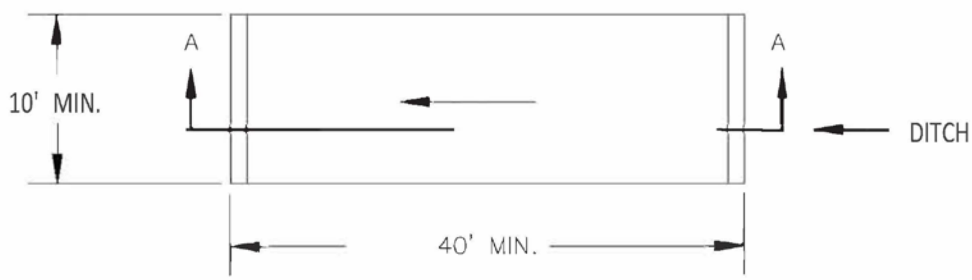
LONGITUDINAL SECTION

L = DISTANCE SUCH THAT POINTS A AND B ARE OF EQUAL ELEVATION

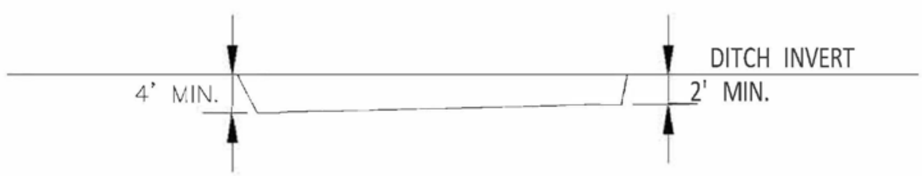
STORMWATER MANUAL

FIGURE 11-18

SEDIMENT TRAP



PLAN VIEW



SECTION A–A

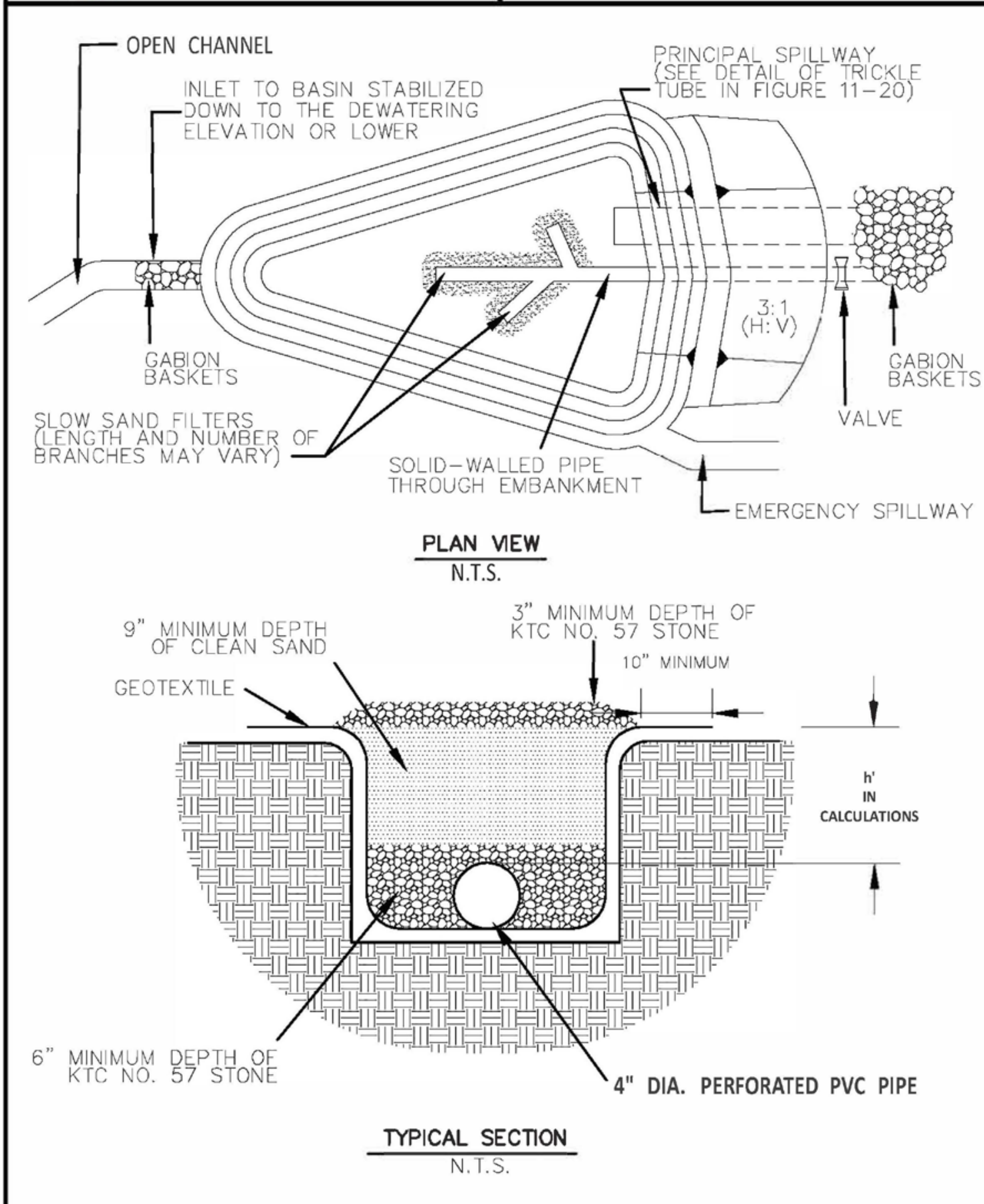
NOTES:

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

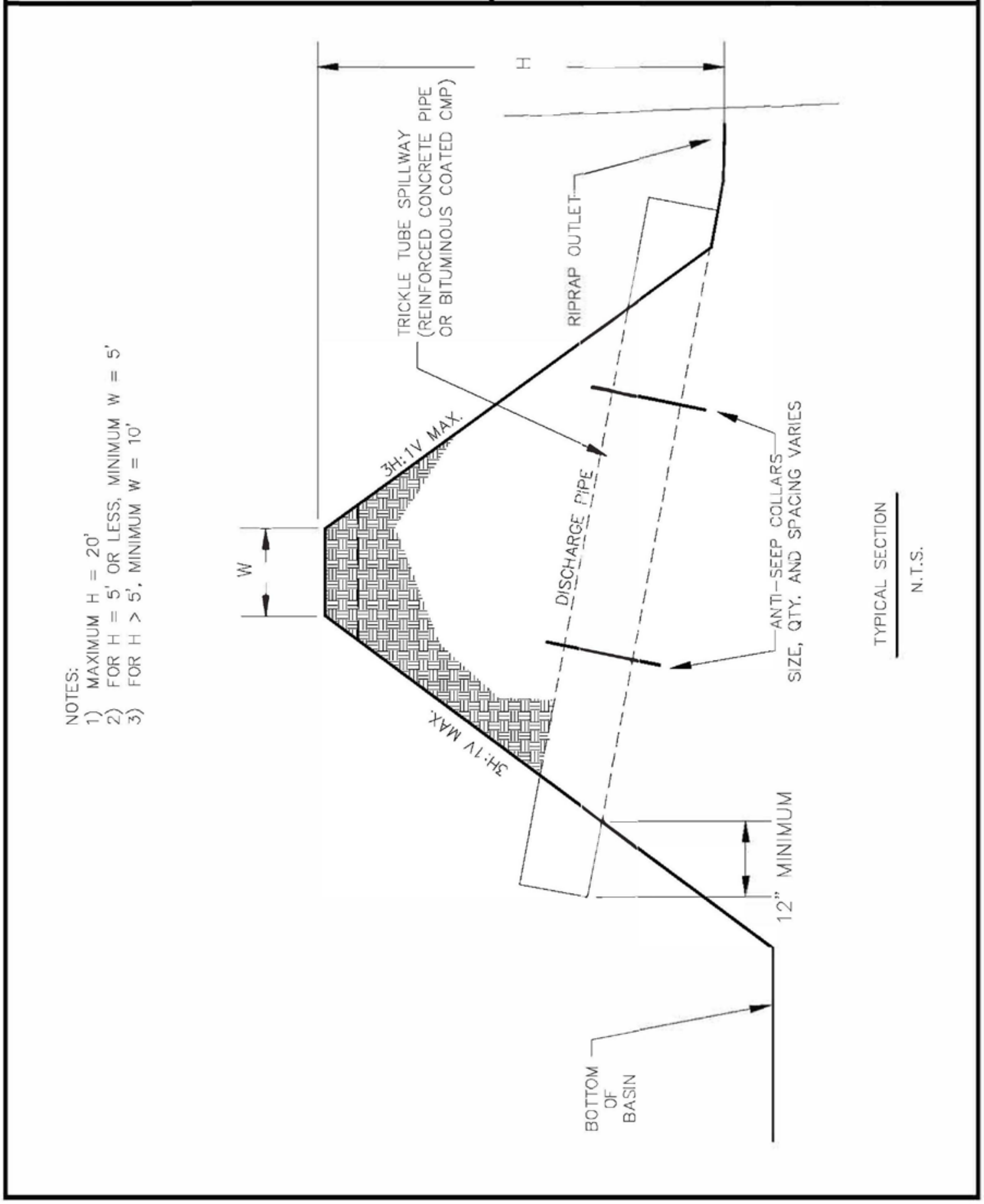
FIGURE 11-19

SEDIMENT POND WITH SAND FILTER OUTLET



STORMWATER MANUAL

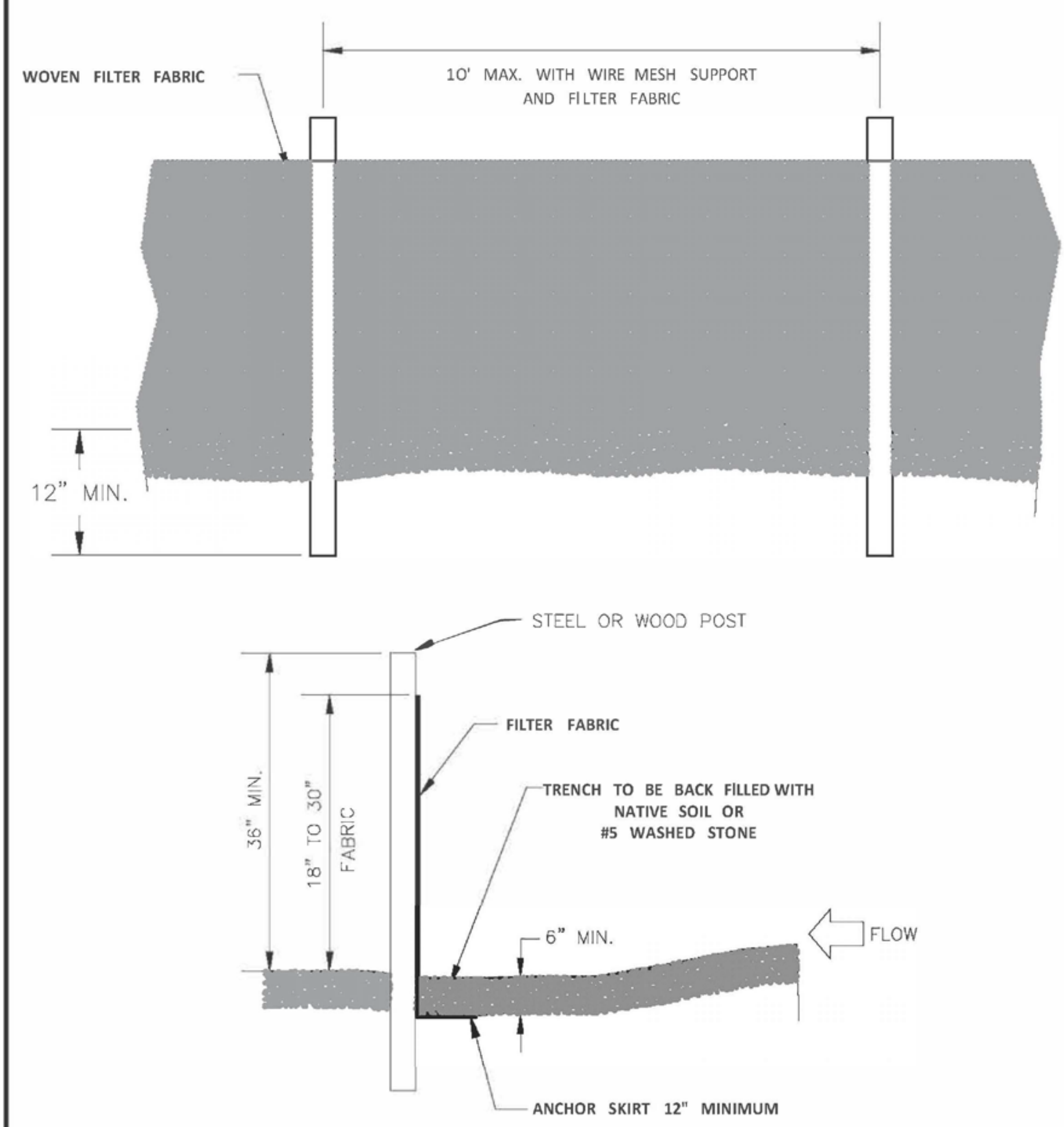
FIGURE 11-20
SEDIMENT POND PRINCIPAL SPILLWAY DETAIL



STORMWATER MANUAL

FIGURE 11-21

TEMPORARY SILT FENCE



STORMWATER MANUAL

FIGURE 11-22

TEMPORARY SILT FENCE
GENERAL NOTES

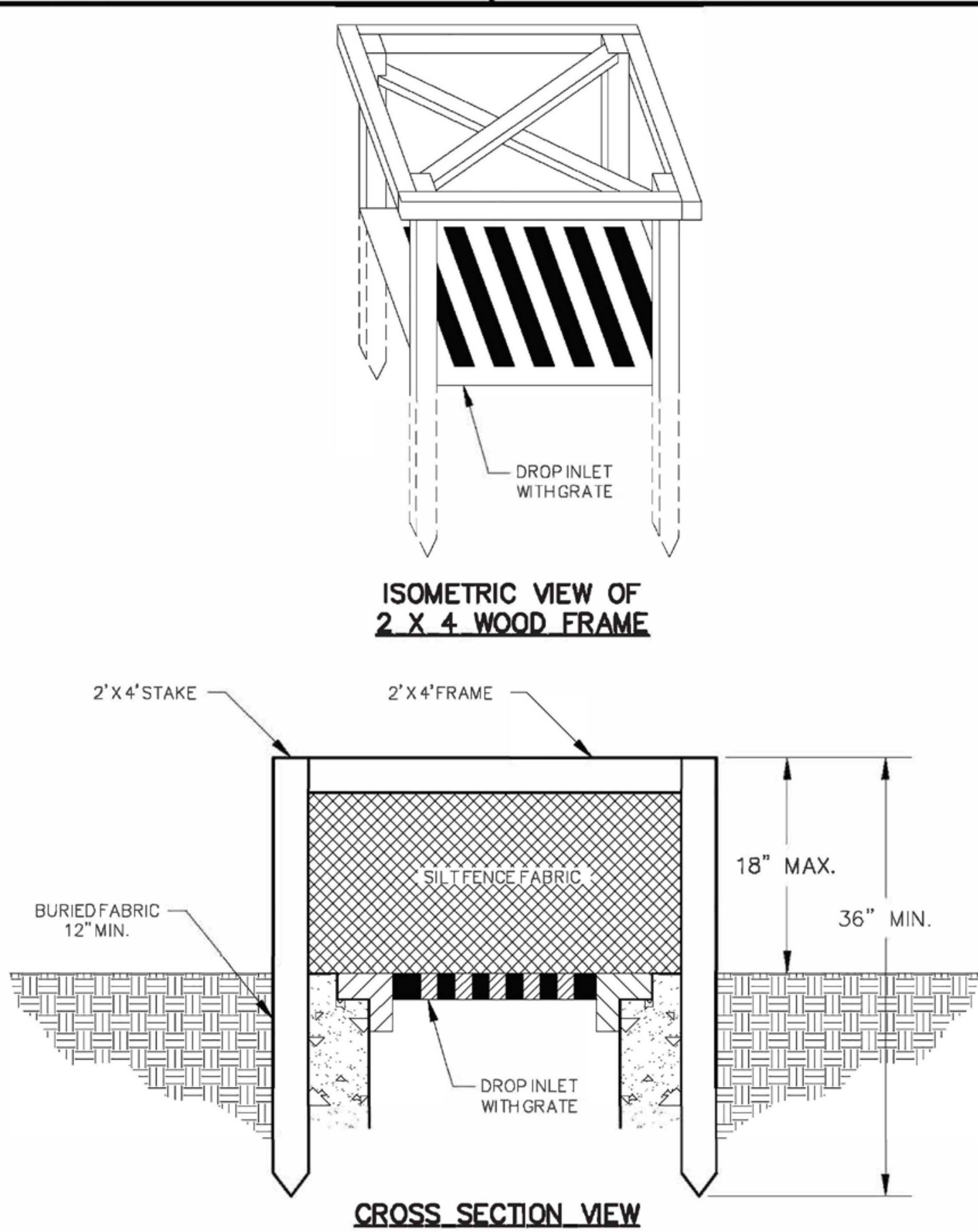
GENERAL NOTES

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

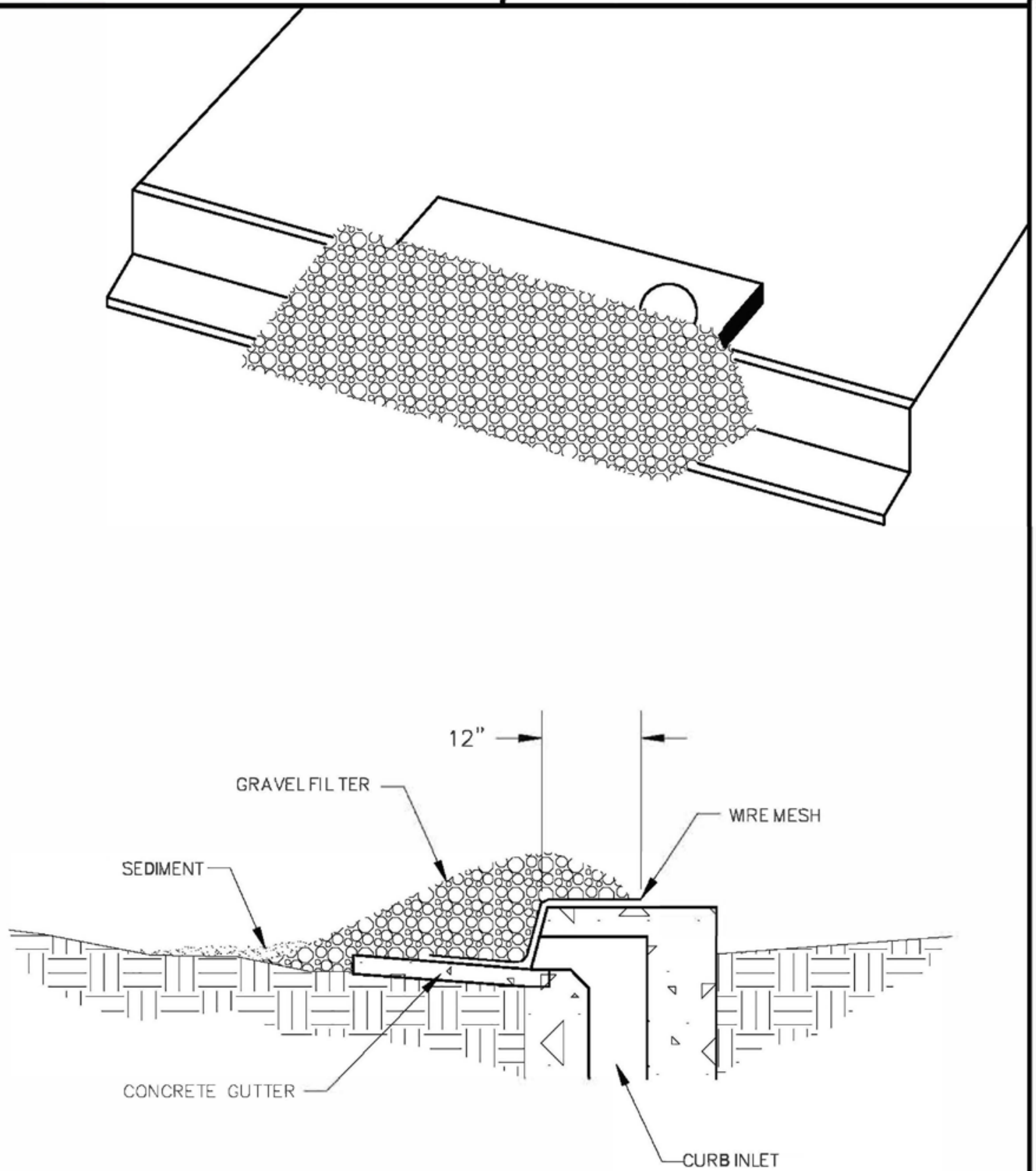
FIGURE 11-23

DROP INLET PROTECTION USING SILT FENCE



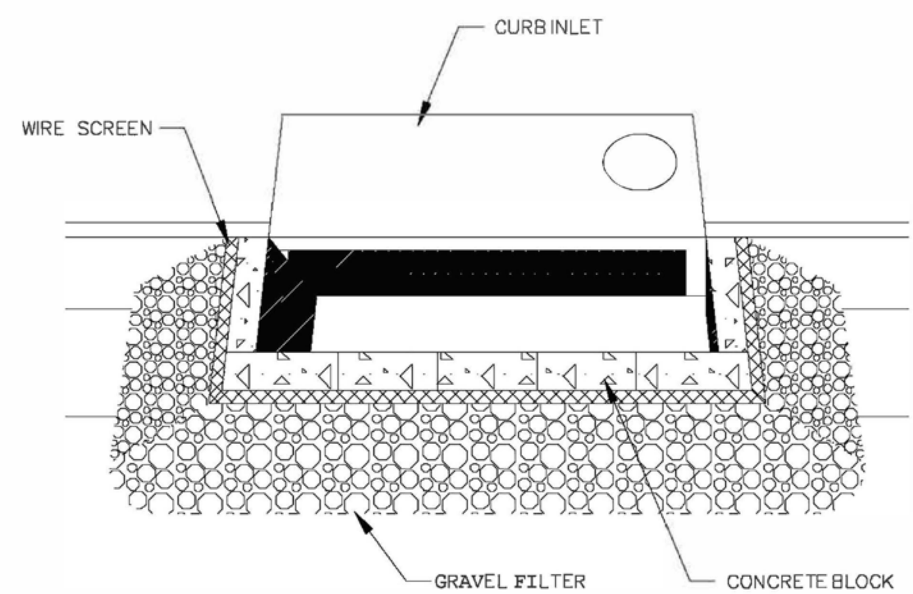
STORMWATER MANUAL

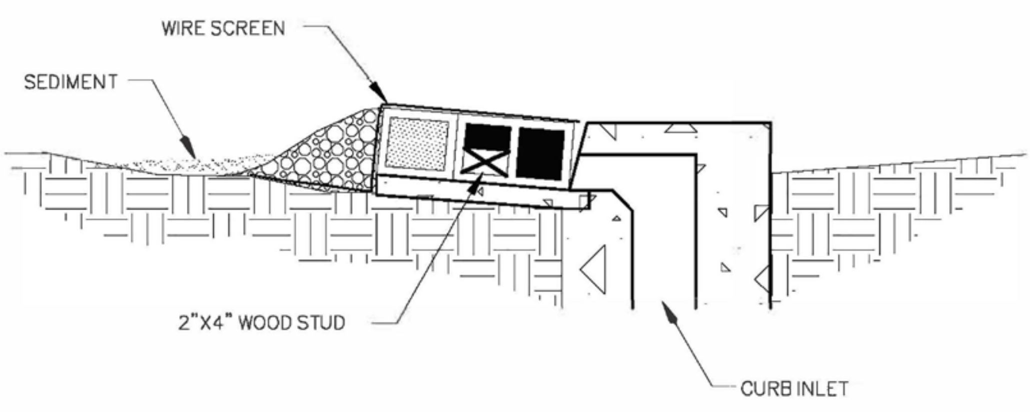
FIGURE 11-24
GRAVEL CURB INLET SEDIMENT FILTER



STORMWATER MANUAL

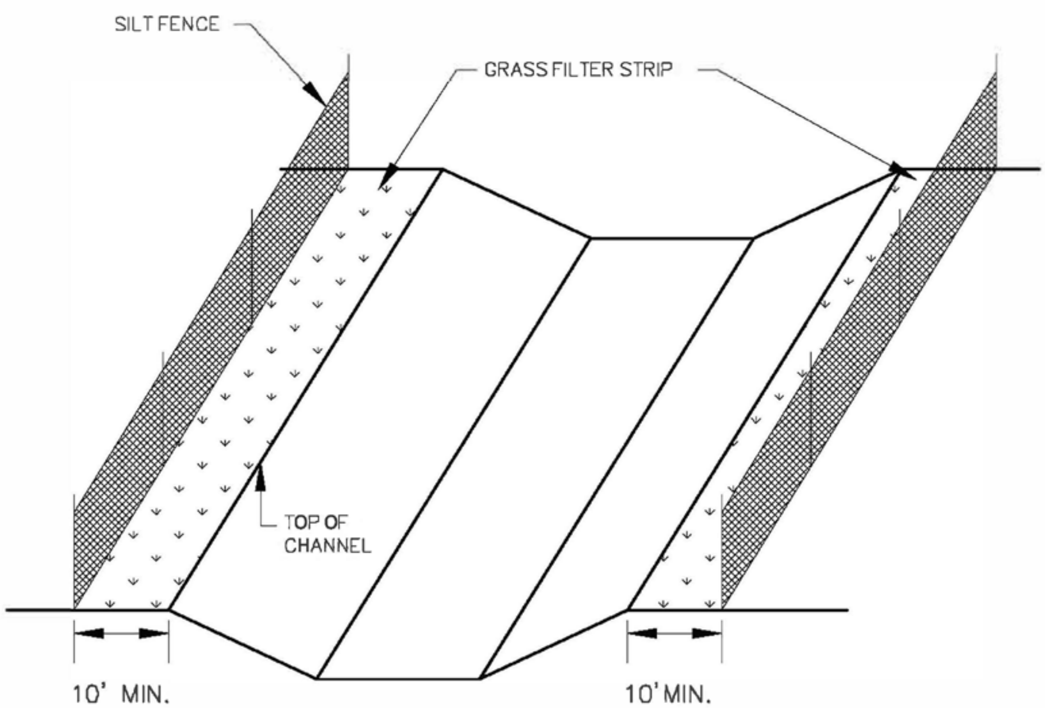
FIGURE 11-25
BLOCK AND GRAVEL CURB INLET SEDIMENT FILTER





STORMWATER MANUAL

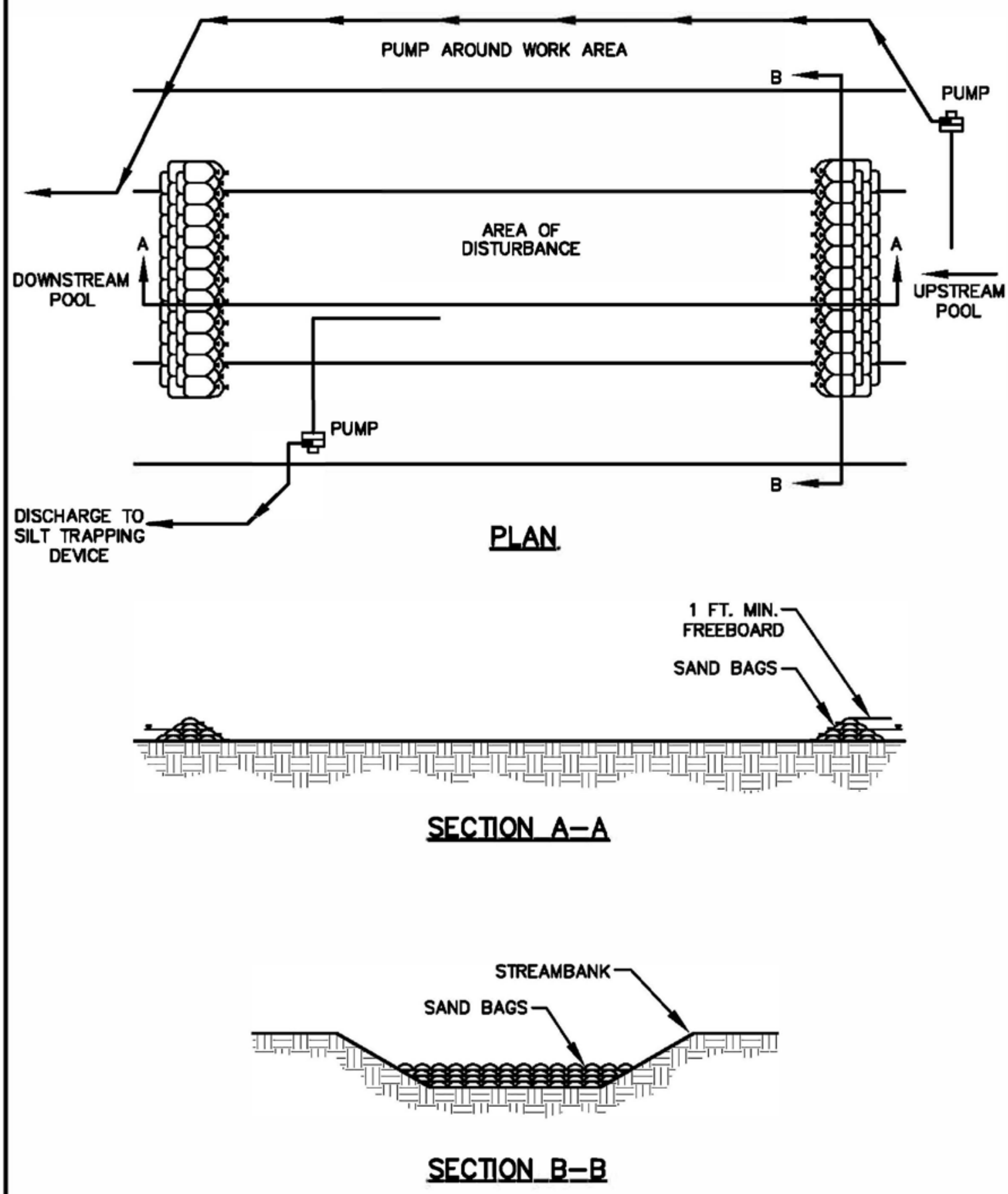
FIGURE 11-26
FILTER STRIP FOR CONSTRUCTED CHANNEL

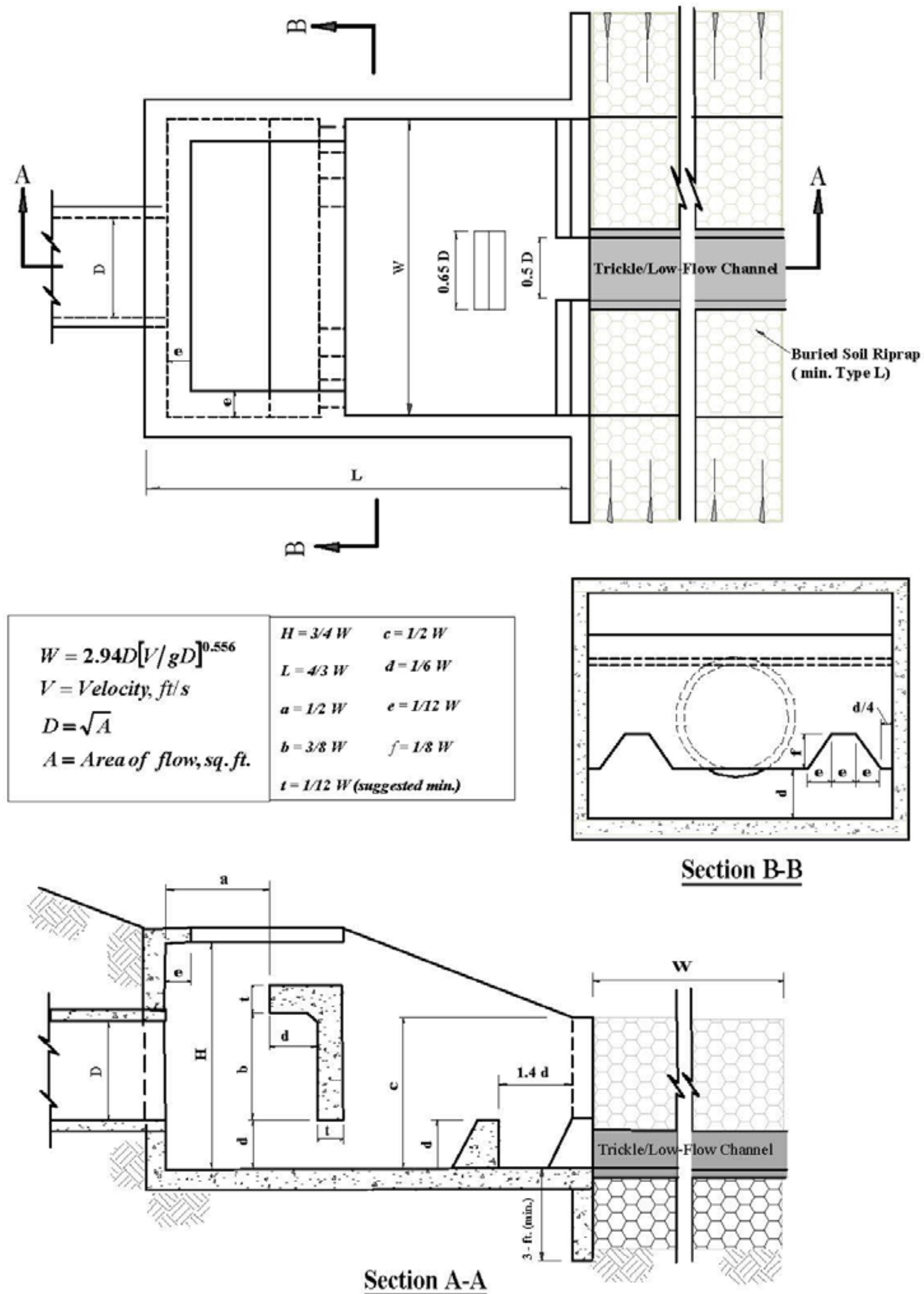


STORMWATER MANUAL

FIGURE 11-27

PUMP-AROUND FLOW DIVERSION





USGS Impact Stilling Basin Modified by UDFCD February 2004

Figure 11-28—General Design Dimensions for a USBR Type VI Impact Stilling Basin

CHAPTER 12 – Maintenance Manual for Stormwater BMPs

12.1 Introduction

As Berea urbanizes, the impact of urbanization on the water resources of its watersheds becomes more apparent. Development has altered stormwater drainage patterns and characteristics, sometimes resulting in flooding. The developed uses of land in the city have resulted in the introduction to the waters of non-desirable substances. These substances are known as nonpoint source pollution and include sediment, nutrients such as phosphorous, motor oil, lawn and garden care products, and anything else that washes from streets and developed property into the area's streams.

Stormwater management efforts in Berea have focused on reducing the risks of downstream flooding. An important tool has been the detention basin, which temporarily stores runoff during large storms and releases it slowly so that peak flows are reduced.

In some instances, these detention basins have been combined with amenity ponds or water quality ponds to produce multi-functional ponds. In other instances, water quality ponds with no storage for flood protection have been constructed. In some instances, practices other than ponds have been constructed to mitigate flooding and/or protect water quality. All of these practices are generally referred to as BMPs – Best Management Practices.

The City of Berea is transitioning from a stormwater management program that has only considered flooding to one that considers both flooding and water quality. This transition mandates that more complicated BMPs be installed to control the small storms that occur frequently and impact water quality as opposed to larger, less frequent storms that cause flooding. These BMPs include infiltration areas, wet ponds, sand filters, vegetative swales, oil and grease removal facilities, and constructed wetlands.

The water quality practices are inherently more complex, not only in their function and operations, but also in the numbers and types of materials used to construct them. They commonly include natural materials like aquatic vegetation and microorganisms. The increased complexity demands a greater level of maintenance and management to assure safe and effective operation. No two BMPs are the same and their maintenance needs are as different as the BMPs themselves. This requires expertise and judgment to be involved in the BMP maintenance process, thereby requiring a higher level of skill for the majority of the maintenance.

This manual for maintaining BMPs has been developed as a part of Berea's watershed management program. The manual includes:

- A brief discussion of each BMP
- A listing of the mechanisms used to protect water quality
- A listing of the maintenance required
- A listing of the inspection required
- The assignment of responsibility for maintenance between the property owner and the city of Berea.

The manual also includes a checklist for use in inspection of each practice or type of practice.

12.2 Dry Detention Pond

12.2.1 Description

An area used to detain stormwater for a relatively short period of time to reduce downstream peak discharge rates. The area should go dry between storms. This is the traditional type of detention system used in "drainage" programs for many years to help provide flood protection. Any sediment that collects in the bottom of the basin reduces the capacity for flood control.

12.2.2 Pollutant Removal Mechanisms

Settling or sedimentation of larger, heavier particles is the primary mechanism. In some systems, limited infiltration may occur.

12.2.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on maintaining the storage volume, the discharge rate, and, in many cases, the system's infiltration capability.

Maintenance
Activities necessary to maintain the functioning of a dry detention system include:

- Frequent removal of accumulated solids, debris, and litter from the detention area, especially from the low flow channel; sediments should be removed when they are dry and have cracked, separating from the bottom and vegetation
- Removal of debris from vegetated area to prevent damage to vegetation and to maintain visual appearance
- Removal of debris from the bottom of the pond to reduce clogging of outlet structures, trash racks, and other mechanical components
- Mowing
- Removal of vegetation, such as small trees, which can damage the embankment
- Vegetative stabilization of eroding sides or bottom

Inspection
Inspections are necessary to assure proper discharge, prevention of soggy bottoms, assure healthy vegetative growth, and to monitor accumulation of sediments. Inspections should include the following:

- Obstructions of the inlet or outlet devices by trash and debris
- Excessive erosion or sedimentation
- Cracking or settling of the dam
- Deterioration of pipes

- Condition of the emergency spillway
- Stability of the side-slopes
- Up and downstream channel conditions
- Signs of vandalism

12.2.4 Responsibility for Maintenance

Maintenance responsibilities are spelled out in the Stormwater Ordinance.

12.3 Dry Extended Detention Pond

12.3.1 Description

A dry detention system with a discharge structure that is modified to extend the detention time of runoff, typically up to 24 to 48 hours. The modified discharge may also include some type of filtering device (i.e., gravel or sand envelope) to improve the removal of particulate pollutants.

Dry extended detention systems may be designed as either on-line or off-line facilities. A dry extended detention pond detains runoff from small, frequent storms and the “first flush” from larger storms in a lower second stage, with a normally dry upper stage for detention of larger storms for flood control. To improve stormwater treatment, the second stage can be designed and managed as a shallow marsh.

12.3.2 Pollutant Removal Mechanisms

- Settling or sedimentation
- Plant uptake and bacterial activity in two-stage systems with a shallow marsh
- In some systems, limited infiltration may occur.

12.3.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on maintaining the storage volume, the discharge rate, and, in many cases, the system’s infiltration capability.

Maintenance
Activities necessary to maintain the functioning of a dry extended detention system include:

- Frequent removal of accumulated solids, debris, and litter from the detention area, especially the low flow channel if included. Sediments should be removed when they are dry and have cracked, separating from the bottom and vegetation.
- Removal of debris from the control device since it typically will have a small orifice.
- Mowing and removal of vegetation. The use of low growing, native grasses is recommended to minimize mowing frequency and the need for irrigation and fertilizers, which should only be used when necessary.

- Vegetative stabilization of eroding sides or bottom.
- Management of aquatic plants if portions of the basin have been designed as a constructed wetland.

Inspection

Inspections are necessary monthly and after large storms to assure proper discharge, prevention of soggy bottoms, assure healthy vegetative growth, and to monitor accumulation of sediments. Inspections should include the following:

- Obstructions of the inlet or outlet devices by trash and debris
- Excessive erosion or sedimentation
- Cracking or settling of the dam
- Low spots in the bottom of an extended detention facility
- Deterioration of pipes
- Condition of the emergency spillway
- Stability of the side-slopes
- Up and downstream channel conditions
- Signs of vandalism

12.3.4 Responsibility for Maintenance

Maintenance responsibilities are spelled out in the Stormwater Ordinance.

12.4 Wet Detention Pond

12.4.1 Description

A detention system with a permanent pool of water that is completely or partially displaced by stormwater from the contributing drainage area. Water is temporarily stored before it is slowly released. A wet detention system is essentially a small lake with rooted wetland vegetation in the littoral zone.

12.4.2 Pollutant Removal Mechanisms

- Settling or sedimentation
- Chemical flocculation, which occurs when heavier sediment particles overtake and coalesce with smaller, lighter particles to form a still larger particle
- Dissolved stormwater pollutants are reduced by a variety of biological processes including filtering, adsorption onto bottom sediments, uptake by aquatic plants including algae, and metabolism by microorganisms inhabiting bottom sediments and aquatic plants
- Removal of stormwater pollutants primarily occurs during the relatively long quiescent period between storms

12.4.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on good design, construction, and maintenance, especially of the discharge structure and littoral zone vegetation.

Maintenance
Activities necessary to maintain the functioning of wet detention system can be broken down into two categories, routine and corrective.

Specific routine maintenance activities include:

- Grass mowing and removal from side slopes and the embankment
- Removal of trees, brush, and animal burrows from the embankment
- Vegetative cover stabilization to prevent erosion of side slopes and the embankment
- Removal and disposal of trash and debris, especially from inlet or outlet structures
- Monitoring and periodic removal of nuisance species in the littoral zone
- Thinning and transplanting of thriving littoral zone plants as needed to maintain good growth throughout the littoral zone
- Monitoring for mosquitoes and introduction of natural predators as needed
- Monitoring of sediment accumulations in forebays or in the pond bottom
- Monitoring of channel erosion in downstream conveyances

Specific corrective maintenance activities include:

- Pond dewatering and removal of accumulated sediments. The frequency will depend on a variety of factors including use of pretreatment BMPs or forebays, contributing drainage area, land use, sediment loading, etc. A good rule of thumb is to remove sediment when 10 to 20 % of the system's storage volume has been lost.
- Structural repairs to inlets, outlets, or discharge structure, including the emergency spillway.
- Repairs to the dam, embankment, or slopes to prevent erosion or piping.
- Repairs to fences, if applicable.

Inspection
Inspections are necessary monthly and after large storms to assure proper discharge, monitor accumulations of trash and debris, monitor sediment accumulations in forebays or inlets, and determine mowing or vegetation removal needs, and determine health of littoral zone vegetation. Inspections should include the following:

- Obstructions of the inlet or outlet devices by trash and debris
- Excessive erosion or sedimentation
- Cracking or settling of the dam
- Low spots in the bottom of an extended detention facility
- Deterioration of pipes
- Condition of the emergency spillway
- Stability of the side-slopes

- Up and downstream channel conditions
- Signs of vandalism

Monitor pond sediment accumulations annually. This can be done by coring, installation of a permanent measuring device such as a "yardstick," or even by mapping the pond bathymetry in larger ponds.

12.4.4 Responsibility for Maintenance

Maintenance responsibilities are spelled out in the Stormwater Ordinance.

12.5 Constructed Wetlands

12.5.1 Description

A runoff storage and treatment area constructed in uplands that is vegetated with aquatic macrophyte plants native to the area. These systems attempt to incorporate properties of natural wetlands such as shallow, sheet flow through dense, diverse assemblage of wetland plants that also serve as habitat for microorganisms.

12.5.2 Pollutant Removal Mechanisms

- Settling or sedimentation
- Adsorption to sediments, vegetation, or detritus
- Filtration by plants
- Microbial uptake and/or transformations
- Uptake by wetland plants or algae
- Extended detention
- Removal of stormwater pollutants primarily occurs during the relatively long quiescent period between storms

12.5.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on good design, construction, and maintenance, especially of the sediment forebays, wetland vegetation, and the discharge structure.

Maintenance
Activities necessary to maintain the long term functioning of a constructed wetland system include the following:

- Grass mowing and removal from side slopes and the embankment
- Removal of trees, brush, and animal burrows from the embankment
- Vegetative cover stabilization to prevent erosion of side slopes and the embankment
- Removal and disposal of trash and debris, especially from inlet or outlet structures
- Monitoring and periodic removal of nuisance plant and animal species

- Thinning and transplanting of thriving wetland plants as needed to maintain good growth throughout the constructed wetland
- Monitoring for mosquitoes
- Monitoring and removal of sediment accumulations in forebays or within the constructed wetland

Inspection

- Inspect quarterly and after large storms to assure proper discharge, monitor accumulations of trash and debris, monitor sediment accumulations in forebays or inlets, determine mowing or vegetation removal needs, and determine health of wetland vegetation.
- Closely monitor the wetland plant community, both during the growing season and, if needed, during the dry season, to assure healthy growth of desired plants. Remove exotic or nuisance species as soon as they appear to limit their establishment and areal extent. Thin or transplant plants from areas where they are growing densely and use them to further establishment or growth in areas with less vigorous plant growth.
- Monitor sediment accumulations in forebays semiannually. Sediments should be removed when 25% of the storage volume of the forebay has been lost.

12.5.4 Responsibility for Maintenance

Maintenance responsibilities are spelled out in the Stormwater Ordinance.

12.6 Biofiltration Practices

12.6.1 Description

Biofiltration is a term used to describe the generally simultaneous processes of filtration, infiltration, adsorption, ion exchange, and biological uptake of pollutants from runoff as it flows through a vegetated stormwater management system. Biofiltration practices include vegetated swales, filter strips, and bioretention areas. Swales are conveyances where the flow passes through vegetation at some specified depth. Filter strips are broad surfaces that receive flow as a well distributed thin sheet. Bioretention practices capture sheet flow from impervious surfaces and treats it by infiltration, filtration, plant uptake, and microbial processes as the runoff flows through native forest or landscaped areas.

12.6.2 Pollutant Removal Mechanisms

- Infiltration, ion exchange, and adsorption
- Settling
- Vegetative filtration and uptake
- Microbial action
- The degree to which the various pollutant removal mechanisms operate depends on soil properties, condition and types of plants, depth, water velocity, slope, and residence time.

12.6.3 Operation, Maintenance, and Inspection

Operation

Successful operation depends on proper design, especially estimation of hydraulic resistance times and infiltration rates, proper construction and regular maintenance.

Maintenance

Activities necessary to maintain the functioning of biofiltration practices include:

- Vegetation removal to maintain adequate hydraulic functioning. Biofilter turf grass height should not exceed six inches nor be less than two inches. Excessively long grass can flatten when water flows over it, preventing sedimentation. Additionally, if not removed, decaying vegetation could release captured nutrients and other pollutants.
- Frequent removal of accumulated solids, debris, and litter. Sediments should be removed when they reach 20% of the design depth in any spot, cover or hinder the growth of vegetation, or otherwise interfere with the operation. Maintenance workers should give special attention to sediment accumulation in the upper portion of swales after major storm events. Sediment and large debris should be removed from biofilters at least twice annually and more frequently if needed.
- Vegetative stabilization of eroding sides or bottom or of bare areas created when removing sediments. Fertilizer use should be minimized. Vegetation should be maintained and replanted early enough in the growing season so that it is well established before the rainy season or before the prime growing period ends.
- If swale blocks are used to promote infiltration or sedimentation, special attention needs to be paid to their maintenance. Sediments need to be carefully removed without damaging the swale block or its associated vegetation.
- If curb cuts are used as inflows to biofilters, sediments and vegetation growths should be removed from the curb cut when they begin to interfere with the inflow.
- Roadside shoulder scraping and ditch cleaning should be based on hydraulic necessity, not simply a timed schedule. When these operations are performed, only the amount of sediment to restore hydraulic capacity should be removed. More importantly, the shoulder and swale should be revegetated immediately to minimize erosion and restore treatment effectiveness. Operations should be done in the dry season.

Inspection

- Inspect semiannually and after large storms to assure proper flow, vegetative growth, and to monitor accumulation of sediments, trash, and debris.

12.6.4 *Responsibility for Maintenance*

Maintenance responsibilities are spelled out in the Stormwater Ordinance.

12.7 Infiltration Practices

12.7.1 Description

A family of practices in which the “treatment volume” is infiltrated into the soil rather than discharged off-site. Infiltration practices include basins and dry wells.

12.7.2 Pollutant Removal Mechanisms

The primary “treatment” mechanism is the infiltration and evaporation of runoff. This reduces the total volume of stormwater leaving the site, thereby reducing the total pollutant loading. Ancillary benefits of reducing stormwater volume include a decrease in stream channel erosion and loss of stream habitat.

Pollutant removal occurs as runoff passes through the soil profile and/or the vegetation root mass. Pollutants are trapped, bound, or decomposed in the vegetation, its roots, and in the pore spaces between the soil particles, while runoff passes into the ground. Soils must have an appropriate infiltration rate, contain sufficient organic matter, and maintain aerobic conditions to minimize migration of pollutants into the ground water.

12.7.3 Operation, Maintenance, and Inspection

Operation
Infiltration practices all depend on the ability of stormwater to pass through the vegetation and soil into the ground. Therefore, long term operation of the practice depends on maintaining its permeability.

Maintenance
Maintenance activities shall include:

- Removal of accumulated solids
- Mowing and removal of vegetation
- Vegetative stabilization of eroding sides or bottom
- Rototilling, disking, or aerating the bottom or bottom vegetation
- Clearing materials that have accumulated in the discharge structure
- Cleaning pretreatment BMPs (i.e., swales, sediment sumps) so they can continue to protect the infiltration practice

Inspection
- Inspect the facility semiannually (just before the wet season and at the end of it) and after large storms. If there is still water in the BMP after 72 hours (or after 24-36 hours for vegetated systems), it is time to clean it and restore its percolation capacity. Cleanout frequency will depend on whether the practice is on-line or off-line, vegetated or not vegetated, its design storage capacity, sediment loading, and use of pretreatment BMPs.
- Eroding sides or bottoms shall be revegetated as soon as possible
- Revegetate the contributing area where needed to stabilize and reduce generation of particulates

12.7.4 Responsibility for Maintenance

Maintenance responsibilities are spelled out in the Stormwater Ordinance.

12.8 Modular Pavement

12.8.1 Description

Pavement consisting of strong structural materials having regularly interspersed void areas that are filled with pervious materials such as sand, gravel, or sod. Generally used in low- volume traffic areas such as the outer parts of parking lots or in parking lots serving parks or recreational areas.

12.8.2 Pollutant Removal Mechanisms

- Percolation of rainfall and runoff through the voids into the underlying permeable base and then into the soil
- Filtration of rainfall and runoff by the vegetation that can grow in the voids

12.8.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on maintaining the percolation rate of the void spaces and the underlying base and soils. Keys to assuring long-term performance are accurate estimation of the soil's percolation rate, proper construction, and regular maintenance.

Maintenance
Activities necessary to maintain the performance of modular pavements include:

- "Good housekeeping" practices by the users to minimize the production and transport of sediment onto the modular pavement. This includes vegetative stabilization of adjacent areas that may erode and become a source of sediments.
- Replacement of base and underlying soils if they become clogged and water ponding persists.
- When turf is incorporated into the installation, normal turf maintenance will be necessary. However, mowing is seldom required in areas of frequent traffic and fertilizers and pesticides should be used sparingly since this may adversely affect concrete products and groundwater.

Inspection
- All modular pavements should be inspected several times in the first few months after construction to assure that they are working correctly and were installed properly. Inspections should be conducted after storms to check for long duration surface ponding that may indicate local or widespread clogging.

12.8.4 Responsibility of Private Property Owner

- Conduct all required maintenance.

12.9 Stormwater Filters

12.9.1 Description

A family of stormwater treatment practices which typically consist of a storage BMP in conjunction with a filtering device. The most common filter media is sand, but filters have been made of peat/sand mixtures and even from leaf compost.

12.9.2 Pollutant Removal Mechanisms

- Settling or sedimentation
- Filtration by sand or other filter media
- Microbial uptake and/or transformations

12.9.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on good design, construction, and most importantly, on regular maintenance, especially of the filter media to prevent clogging.

Maintenance
Activities necessary to maintain the long term functioning of stormwater filtrations systems include:

- Grass mowing and removal from side slopes and the embankment
- Removal of trees, brush, and animal burrows from the embankment
- Vegetative cover stabilization to prevent erosion of side slopes and the embankment
- Removal and disposal of trash and debris, especially from inlet or outlet structures
- Removal of sediments and other materials that accumulate in pretreatment practices, such as sediment traps and forebays
- Periodic scraping and aeration of the filter media, with partial removal

Inspection
- Inspect monthly and after large storms to assure proper discharge, monitor accumulations of trash and debris, monitor sediment, accumulations in forebays or inlets, and determine mowing or vegetation removal needs, and determine whether the filter media is clogging.
- Closely monitor clogging of the filter media to determine when maintenance is needed.
- Monitor sediment accumulations in sediment traps semiannually. Sediments should be removed when 25% of the storage volume has been lost.

12.9.4 Responsibility of Commercial Property Owner

- Conduct all required maintenance.

12.10 Prefabricated Treatment Devices

12.10.1 Description

These BMPs consist of flow-through concrete structures with a settling or separation unit.

12.10.2 Pollutant Removal Mechanisms

- Swirl action
- Indirect filtration

12.10.3 Operation, Maintenance, and Inspection

Operation
Successful operation depends on good design, construction, and, most importantly, on regular cleaning.

Maintenance
Activities necessary to maintain the long-term functioning of stormwater filtration systems include:

- Removal of sediments and other materials that accumulate in the device

Inspection
Inspect monthly and after large storms to assure proper operation.

Inspection Checklists

City of Berea, Kentucky

Operation and Maintenance Inspection Report for Stormwater Management Ponds

BMP Name/GIS Number______________________________ Subdivision ____________________________________
Inspection Name____________________________________ Address ____________________________________
Inspection Date ____________________________________ ____________________________________
Stormwater Pond____________________________________ ____________________________________
Normal Pool________________________ ____________________________________
Normally Dry________________________ Watershed ____________________________________

Items Inspected	Checked Yes	Checked No	Maintenance Needed Yes	Maintenance Needed No	Inspection Frequency	Remarks
I, Pond Components						
A. Embankment and emergency spillway					A,S	
1. Vegetation and ground cover adequate						
2. Embankment erosion						
3. Animal burrows						
4. Unauthorized plantings						
5. Cracking, bulging, or sliding of dam a. Upstream face						
b. Downstream face						
c. At or beyond toe Upstream						
Downstream						
d. Emergency spillway						
6. Pond, toe & chimney drains clear and functioning						
7. Seeps/leaks on downstream face						
8. Slope protection or riprap failures						
9. Vertical and horizontal alignment of top of dam as per "As-Built" plans						
10. Emergency spillway clear of obstructions and debris						
11. Other (specify)						
B. Riser and principal spillway Type: Reinforced concrete _____ Corrugated pipe _____ Masonry _____ 1. Low flow orifice obstructed					A	
2. Low flow trash rack a. Debris removal necessary						
b. Corrosion control						
3. Weir trash rack maintenance						
a. Debris removal necessary						
b. Corrosion control						
4. Excessive sediment accumulation inside riser						
5. Concrete/masonry condition riser and barrels a. Cracks or displacement						

Inspection Frequency Key: A = Annual, M = Monthly, S = After major storm

City of Berea, Kentucky
Operation and Maintenance Inspection Report for Stormwater Management Ponds (continued)

Items Inspected	Checked Yes	Checked No	Maintenance Needed Yes	Maintenance Needed No	Inspection Frequency	Remarks
I, Pond Components						
b. Minor spalling (< 1")						
c. Major spalling (rebars exposed)						
d. Joint failures						
e. Water tightness						
6. Metal pipe condition						
7. Control valve a. Operational/exercised						
b. Chained and locked						
8. Pond drain valve a. Operational/exercised						
b. Chained and locked						
9. Outfall channels functioning						
10. Other (specify)						
C. Permanent pool (wet pond)					M	
1. Undesirable vegetative growth						
2. Floating or floatable debris removal required						
3. Visible pollution						
4. Shoreline problems						
5. Other (specify)						
D. Sediment forebays						
1. Sedimentation noted						
2. Sediment cleanout when depth < 50% design depth						
E. Dry pond areas					M	
1. Vegetation adequate						
2. Undesirable vegetative growth						
3. Undesirable woody vegetation						
4. Low flow channels clear of obstructions						
5. Standing water or wet spots						
6. Sediment and/or trash accumulation						
7. Other (specify)						
F. Condition of outfalls into pond					A,S	
1. Riprap failures						
2. Slope erosion						
3. Storm drain pipes						
4. Endwalls/headwalls						
5. Other (specify)						
G. Other					M	
1. Encroachments on pond or easement area						

Inspection Frequency Key: A = Annual, M = Monthly, S = After major storm

Infiltration Basin Maintenance Inspection Report

Date________________________ Time ________________________

Project ____

Location____Individual

Conducting the Inspection_____“As Built” Plans available____________Y/N___________

Inspection frequency shown in parentheses after item being considered

Item	Frequency	Satisfactory	Unsatisfactory
1. Debris cleanout	(Monthly)		
Basin bottom clear of debris			
Inlet clear of debris			
Outlet clear of debris			
Emergency spillway clear of debris			
2. Sediment traps or forebays	(Annual)		
Obviously trapping sediment greater than 50% of storage volume remaining			
3. Vegetation	(Monthly)		
Mowing done when needed			
Fertilized per specifications			
No evidence of erosion			
4. Dewatering	(Monthly)		
Basin dewaters between storms			
5. Sediment cleanout of basin	(Annual)		
No evidence of sedimentation in basin			
Sediment accumulation does not yet require cleanout			
6. Inlets	(Annual)		
Good condition No			
evidence of erosion			
7. Outlets/overflow spillway	(Annual, After Major Storm)		
Good condition, no need for repair			
No evidence of erosion			
8. Structural repairs	(Annual, After Major Storm)		
Embankment in good repair			
Side slopes are stable			
No evidence of erosion			
9. Fences/access repairs	(Annual)		
Fences in good condition			
No damage which would allow undesired entry			
Access point in good condition			
Locks and gate function adequate			

Inspection Frequency Key Annual, Monthly, After Major Storm

Action to be taken:

If any of the answers to the above items are checked unsatisfactory, a time frame shall be established for their correction or repair

No action necessary. Continue routine inspections ___________________
Correct noted facility deficiencies by _________________________

Facility repairs were indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection accomplished on ___________________________________

Site reinspection was satisfactory. Next routine inspection is scheduled for approximately:

____

____
Signature of Inspector

Infiltration Swale Maintenance Inspection Report

Date________________________ Time ________________________

Project ____

Location____Individual

Conducting the Inspection_____"As Built" Plans available____________Y/N___________

9. Inspection frequency shown in parentheses after item being considered

		Satisfactory	Unsatisfactory
1. Debris cleanout	(Monthly)		
Swales and contributing areas clean of debris			
2. Vegetation	(Monthly)		
Mowing done when needed			
Fertilized per specifications			
No evidence of erosion			
Minimum mowing depth not exceeded			
3. Dewatering	(Monthly)		
Swale dewaters between storms			
4. Check dams or energy dissipators	(Annual, After Major Storm)		
No evidence of flow going around structures			
No evidence of erosion at downstream toe			
5. Sediment deposition	(Annual)		
Swale clean of sediments			
6. Outlets/overflow spillway	(Annual, After Major Storm)		
Good condition, no need for repair			
No evidence of erosion			
Inspection Frequency Key	Annual, Monthly, After Major Storm		

Action to be taken:

If any of the answers to the above items are checked unsatisfactory, a time frame shall be established for their correction or repair

No action necessary. Continue routine inspections __________________
Correct noted facility deficiencies by ________________________

Facility repairs were indicated and completed. Site reinspection is necessary to verify corrections.

Site reinspection accomplished on _________________________________

Site reinspection was satisfactory. Next routine inspection is scheduled for approximately:

____

____
Signature of Inspector

Biofiltration Facility Maintenance Inspection Report

Date________________________ Time ________________________

Project ____

Location____Individual

Conducting the Inspection_____“As Built” Plans available_____________Y/N___________

10. Inspection frequency shown in parentheses after item being considered

		Satisfactory	Unsatisfactory
1. Debris cleanout	(Monthly)		
Biofilters and contributing areas clean of debris			
No dumping of yard wastes into biofilter			
Litter (branches, etc.) have been removed			
2. Vegetation	(Monthly)		
Plant height not less than design water depth			
Fertilized per specifications			
No evidence of erosion			
Grass height not greater than 6 inches			
Is plant composition according to approved plans?			
No placement of inappropriate plants			
3. Dewatering	(Monthly)		
Biofilter dewaters between storms			
No evidence of standing water			
4. Check dams or energy dissipators	(Annual, After Major Storm)		
No evidence of sediment buildup			
Sumps should not be more than 50% full of sediment			
No evidence of erosion at downstream toe of drop structures			
5. Sediment deposition	(Annual)		
Swale clean of sediments			
Sediments should not be > than 20% of swale design depth			
6. Outlets/overflow spillway	(Annual, After Major Storm)		
Good condition, no need for repair			
No evidence of erosion			
No evidence of any blockages			
7. Integrity of biofilter	(Annual)		
Biofilter has not been blocked or filled inappropriately			

Inspection Frequency Key Annual, Monthly, After Major Storm

Action to be taken:

If any of the answers to the above items are checked unsatisfactory, a time frame shall be established for their correction or repair

No action necessary. Continue routine inspections ________________
Correct noted facility deficiencies by ______________________

Facility repairs were indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection accomplished on ______________________________

Site reinspection was satisfactory. Next routine inspection is scheduled for approximately:

____

____
Signature of Inspector

Infiltration Paving Maintenance Inspection Report

Date________________________ Time ________________________

Project ____

Location____Individual

Conducting the Inspection____“As Built” Plans available____________Y/N___________

11. Inspection frequency shown in parentheses after item being considered

		Satisfactory	Unsatisfactory
1. Debris on infiltration paving parking area	(Monthly)		
Paving area clean of debris			
2. Vegetation	(Monthly)		
Mowing done when needed			
Fertilized per specifications			
No evidence of erosion			
3. Dewatering	(Monthly)		
Infiltration paving dewaters between storms			
4. Sediments	(Monthly)		
Area clean of sediments			
Area vacuum swept on a periodic basis			
5. Structural condition	(Annual)		
No evidence of surface deterioration			
No evidence of rutting or spalling			
Inspection Frequency Key	Annual, Monthly, After Major Storm		

Action to be taken:

If any of the answers to the above items are checked unsatisfactory, a time frame shall be established for their correction or repair

No action necessary. Continue routine inspections __________________
Correct noted facility deficiencies by ________________________

Facility repairs were indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection accomplished on _________________________________

Site reinspection was satisfactory. Next routine inspection is scheduled for approximately:

____

____
Signature of Inspector

Filtration Facility Maintenance Inspection Report

Date________________________ Time ________________________

Project ____

Location____Individual

Conducting the Inspection_____"As Built" Plans available____________Y/N___________

12. Warning: If filtration facility has a watertight cover, be careful regarding the possibility of flammable gases within the facility. Care should be taken lighting a match or smoking while inspecting facilities that are not vented.

13. Inspection frequency shown in parentheses after item being considered

Item	Frequency	Satisfactory	Unsatisfactory
1. Debris cleanout	(Monthly)		
Contributing areas clean of debris			
Filtration facility clean of debris			
Inlets and outlets clear of debris			
2. Vegetation	(Monthly)		
Contributing drainage area stabilized			
No evidence of erosion			
Area mowed and clippings removed			
3. Oil and grease	(Monthly)		
No evidence of filter surface clogging			
Activities in drainage area minimize oil & grease entry			
4. Water retention where required	(Monthly)		
Water holding chambers at normal pool			
No evidence of leakage			
5. Sediment deposition	(Annual)		
Filtration chamber clean of sediments			
Water chambers not more than ½ full of sediments			
6. Structural components	(Annual)		
No evidence of structural deterioration			
Any grates are in good condition			
No evidence of spalling or cracking of structural parts			
7. Outlets/overflow spillway	(Annual)		
Good condition, no need for repair			
No evidence of erosion (if draining into a natural chamber)			
8. Overall function of facility	(Annual)		
No evidence of flow bypassing facility			
No noticeable odors outside of facility			

Inspection Frequency Key Annual, Monthly, After Major Storm

Action to be taken:

If any of the answers to the above items are checked unsatisfactory, a time frame shall be established for their correction or repair

No action necessary. Continue routine inspections __________________
Correct noted facility deficiencies by ________________________

Facility repairs were indicated and completed. Site reinspection is necessary to verify corrections or improvements.

Site reinspection accomplished on _________________________________

Site reinspection was satisfactory. Next routine inspection is scheduled for approximately:

____

____
Signature of Inspector

Appendix A

APPENDIX A – DEFINITIONS

For the purposes of this Stormwater Manual, the following terms, phrases, words, and their derivatives shall have the definitions stated below.

1 **Accelerated Erosion** means erosion caused by development activities that exceeds the natural processes by which the surface of the land is worn away by the action of water, wind, or chemical action.
2 **Applicant** Is the property owner or agent of a property owner who submits an application to the city for a land disturbance activity pursuant to this manual.
3 **Approving Agency** means the City of Berea and their duly authorized designees are responsible for implementing all the provisions within current city ordinances.
4 **Bankful Elevation** is the water level, or stage, at which the stream, river, or lake is at the top of its banks and any further rise would result in water moving into the floodplain (NOAA Glossary).
5 **Bedrock** is in place solid rock.
6 **Bench** A relatively level step excavated into earth material on which fill is to be placed.
7 **Best Management Practices (BMPs)** A technique or series of techniques, which are proven to be effective in controlling runoff, erosion, and sedimentation to prevent or reduce the discharge of pollutants to waters of the Commonwealth. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw materials storage.
8 **Borrow** Is earth material acquired from an off-site location for use in grading on a site.
9 **Buffer Zone** The area defined from bankful elevation extending toward a construction activity that shall be protected from disturbance.
10 **Building** means any structure, either temporary or permanent, having walls and a roof, designed for the shelter of any person, animal, or property, and occupying more than 100 square feet of area.
11 **Building Inspector** The person from the governing agency that reviews, approves, and provides inspection services related to building/structure activities.
12 **Certificate of Occupancy** Issued by the Building Inspector after final inspection of a constructed structure has been made and found to be in substantial compliance with all the requirements of this all applicable codes.
13 **Certificate of Stabilization** Is issued by the City after final inspection of a site has been made and found to be in substantial compliance with all requirements of this manual and governing ordinance.
14 **Channel** means a natural or artificial watercourse with a definite bed and banks that conducts continuously or periodically flowing water.
15 **City Inspector** is any person from the Approving Agency authorized to perform and enforce site inspections.
16 **Clearing and Grubbing** is the cutting and removal of trees, shrubs, bushes, windfalls and other vegetation including removal of stumps, roots, and other remains in the designated areas.
17 **Contractor** is the person who contracts with the permittee, landowner, developer, or another contractor (i.e. subcontractor) to undertake any or all the land disturbance activities covered by this chapter.
18 **Co-Permittee** is any person, other than the permittee, including but not limited to a developer or contractor who has or represents financial or operational control over the land disturbing activity.
19 **Critical areas** are within 25 ft of, and on a positive slope toward a “Water of the Commonwealth” (as defined in KRS 244.01-010(33)).

20 **Dedication** means the deliberate appropriation of property by its owner for general public use.

21 **Detention** means the temporary storage of storm runoff in a stormwater management practice with the goals of controlling peak discharge rates and providing gravity settling of pollutants.

22 **Detention Facility** means a detention basin or alternative structure designed for the purpose of temporary storage of stream flow or surface runoff and gradual release of stored water at controlled rates.

23 **Developer** is any person, firm, corporation, sole proprietorship, partnership, state agency, or political subdivision thereof engaged in the development or re-development of property.

24 **Development** 1) The improvement of property for any purpose involving building; 2) Subdivision, or the division of a tract or parcel of land in to 2 or more parcels; 3) the combination of any two or more lots, tracts, or parcels of property for any purpose; 4) the preparation of land for any of the above purposes.

25 **Easement** describes a legal right granted by a landowner to a grantee allowing the entry and use of private land for stormwater management purposes. Granting of an easement to install drainage facilities does not obligate the City of Berea to provide maintenance services; it merely protects the drainage system from encroachment by other parties.

26 **Engineer** is a professional engineer licensed in the Commonwealth of Kentucky to practice in the field of civil works.

27 **Erosion** The wearing away of the ground surface as a result of the movement of wind, water, ice, and/or land disturbance activities.

28 **EPSC (Erosion Protection and Sediment Control)** is the prevention of soil erosion and control of solid material during land disturbing activities to prevent its transport out of the disturbed area by means of air, water, gravity, or ice through the selection of Best Management Practices (BMP).

29 **Erosion Control Inspector** is a person designated by the Approving Agency who has attended a Berea sponsored or approved training course in EPSC.

30 **Fee in Lieu** means a payment of money in place of meeting all or part of the stormwater performance standards required by this ordinance.

31 ***Final Stabilization*** means that:

a. All soil disturbing activities at the site have been completed and either (1) a uniform perennial vegetative cover with a density of 70% of native background vegetation cover for the area has been established on all unpaved areas and areas not covered by permanent structures or equivalent stabilization measures (i.e. riprap, gabions, or geotextiles) have been employed.

b. For individual lots in residential construction, final stabilization means, the lot either has completed final stabilization as specified above by the homebuilder or the homebuilder has established temporary stabilization including perimeter controls for an individual lot prior to occupation of the home by the homeowner and informing the homeowner of the need for, and benefits of, final stabilization.

32 **Floodplain** is the 100-year floodplain which is that area adjoining a watercourse which could be inundated by a flood that has a one (1) percent chance of being equaled or exceeded in any given year and is delineated on the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM).

33 **General Permit** A KPDES Storm Water General Permit for storm water discharges related to construction activities that disturb one acre or more. Coverage under this general storm water permit is obtained by filing a Notice of Intent (NOI) with the Kentucky Division of Water (KDOW) and receiving approval from said agency and developing a SWPPP.

34 **Grade** is the vertical location of the ground surface.

(1) *Existing grade* is the grade (contour of the land) prior to land disturbance.

(2) *Rough grade* is the stage at which the grade approximately conforms to the approved plan.

(3) *Finish grade* is the final grade of the site which conforms to the approved plan.

35 **Groundwater Management Area** means a geographically defined area that may be particularly sensitive in terms of groundwater quantity and /or quality by nature of the use or movement of groundwater, or the relationship between groundwater an surface water, and where special management measures are deemed necessary to protect groundwater and surface water resources.

36 **High quality waters or** HQW means those "waters of the Commonwealth" that have been categorized by the Kentucky Division of Water as high quality pursuant to the requirements of 401 KAR 10:030, Section 1(3).

37 **Hotspot** means an area where land use or activities generate highly contaminated runoff, with concentrations of pollutants in excess of those typically found in stormwater.

38 **Impervious Cover** means those surfaces that cannot effectively infiltrate rainfall (e.g., building rooftops, pavement, sidewalks, driveways, etc.).

39 **Impaired Waters** means those streams, rivers and lakes that currently do not meet their designated use classification and associated water quality standards under the Clean Water Act.

40 **Infill Development** means land development that occurs within designated areas based on local land use, watershed, and/or utility plans where the surrounding area is generally developed, and where the site or area is either vacant or has previously been used for another purpose.

41 **Industrial Stormwater Permit** means a National Pollutant Discharge Elimination System permit issued to a commercial industry or group of industries which regulates the pollutant levels associated with industrial stormwater discharges or specifies on-site pollution control strategies.

42 **Infiltration** means the process of percolating stormwater into the subsoil.

43 **Infiltration Facility** means any structure or device designed to infiltrate retained water to the subsurface. These facilities may be above grade or below grade.

44 **Land Development** means a human-made change to, or construction on, the land surface that changes its runoff characteristics.

45 **Land Disturbance Activity** means any land change that may result in soil erosion from wind, water and/or ice and the movement of sediments into or upon waters, lands, or rights-of-way within the city, including but not limited to building demolition, clearing and grubbing, grading, excavating, transporting and filling of land. Land disturbance activity does not include the following:

(1) Minor land disturbance activities including, but not limited to, underground utility repairs, replacement of existing utilities, home gardens, minor repairs, and maintenance work.

(2) Installation of fence, sign, telephone, and electric poles and other kinds of posts or poles.

(3) Emergency work to protect life, limb, or property and emergency repairs. If the land disturbing activity would have required an approved SWPPP except for the emergency, then the land area disturbed shall be shaped and stabilized in accordance with the requirements of this chapter.

46 **Landowner** means the legal or beneficial owner of land, including those holding the right to purchase or lease the land, or any other person holding proprietary rights in the land.

47 **Maintenance Agreement** means a legally recorded document that acts as a property deed restriction, and which provides for long-term maintenance of stormwater management practices.

48 **Municipal Separate Storm Sewer System (MS4)** means publicly-owned facilities by which stormwater is collected and /or conveyed, including but not limited to any roads with drainage systems, municipal streets, gutters, curbs, catch basins, inlets, piped storm drain, pumping

facilities, retention and detention basins, natural and human-made or altered drainage ditches/channels, reservoirs and other drainage structures.

49 **Non-Structural Measure** means a stormwater control and treatment technique that used natural processes, restoration or enhancement of natural systems, or design approaches to control runoff and/or reduce pollutant levels. Such measures are used in lieu of or to supplement structural practices on a land development site. Non-structural measures include, but are not limited to: minimization and/or disconnection of impervious surfaces; development design that reduces the rate and volume of runoff; restoration or enhancement of natural areas such as riparian areas, wetlands, and forests; and on-lot practices such as rain barrels, cisterns, and vegetated areas that intercept roof and driveway runoff.

50 **Nonpoint Source Pollution** means pollution from any source other than from any discernible, confined, and discrete conveyances, and shall include, but not be limited to, pollutants from agricultural, silvicultural, mining, construction, subsurface disposal and urban runoff sources.

51 **Notice of Intent (NOI)** means submission of the NOI to KDOW acts as the notice that the identified party intends to be authorized by a KPDES permit issued for stormwater discharges associated with construction activity.

52 **Notice of Termination (NOT)** is submitted to KDOW to terminate your KPDES permit coverage for stormwater discharges associated with construction activity.

53 **Offset Fee** means a monetary compensation paid to a local government for failure to meet pollutant load reduction targets.

54 **Off-Site Facility** means a stormwater management measure located outside the subject property boundary described in the permit application for land development activity.

55 **On-Site Facility** means a stormwater management measure located within the subject property boundary described in the permit application for land development activity.

56 **Outfall** the point of discharge to any watercourse from a public or private stormwater drainage system (piped or un-piped) as defined in the KPDES statewide general permit for MS4s (KYG20).

57 **Owner** the owner, mortgagee or person, firm or corporation in control of a piece of land; or any other person authorized to act as the agent for the owner; any person who submits a stormwater management concept or design plan for approval, or requests issuance of a permit, when required, authorizing land development to commence; and any person responsible for complying with an approved stormwater management design plan.

58 **Perimeter Control Plan (PCP)** describes a plan that includes erosion control practices that must be completed before general site construction begins.

59 **Permittee** the applicant in whose name a valid Land Disturbance Permit is duly issued pursuant to this chapter and his/her agents, employees, and others acting under his/her direction.

60 **Codes and Planning Director** is the person in charge of the daily administration of the City of Berea's Development Ordinance and the Stormwater Ordinance.

61 **Pollutant** means and includes dredged spoil, solid waste, incinerator residue, sewage, sewage sludge, garbage, chemical, biological or radioactive materials, heat, wrecked or discarded equipment, rock, sand, soil, industrial, municipal or agricultural waste, and any substance resulting from the development, processing, or recovery of any natural resource which may be discharged into water.

62 **Private Development/Redevelopment** means developments that are not the responsibility of the state or local municipality to provide maintenance on including storm sewers, stormwater facilities, and roads.

63 **Public Development/Redevelopment** means developments that are the responsibility of the state or local municipality to provide maintenance on including storm sewers, stormwater facilities, and roads.

64 **Redevelopment** means any construction, alteration or improvement involving land disturbance performed in areas where existing land use is high density commercial, industrial, institutional or multi-family residential.

65 **Responsible Party** means any individual, partnership, firm, company or any other legal entity that is named on a stormwater maintenance agreement as responsible for long-term operation and maintenance of one or more stormwater BMPs.

66 **Retention Facility** is a temporary or permanent natural or manmade structure that provides for the storage of storm water runoff by means of a permanent pool of water.

67 **Riparian Buffer** see Buffer Zone.

68 **Runoff** is rainfall, snowmelt, or irrigation water flowing over the ground surface.

69 **Sediment** means soils or other surficial materials transported or deposited by the action of wind, water, ice, or gravity as a product of erosion.

70 **Sedimentation** the process or action of deposition sediment that is determined to have been caused by erosion.

71 **Site** means the entire area of land on which the land disturbance activity is proposed in the land disturbance permit application.

72 **Site Plan** is a plan or set of plans showing the details of any land disturbance activity of a site including but not limited to the construction of: structures, open and enclosed drainage facilities, stormwater management facilities, parking lots, driveways, curbs, pavements, sidewalks, bike paths, recreational facilities, ground covers, plantings, and landscaping.

73 **Slope** the incline of a ground surface expressed as a ratio of horizontal distance to vertical distance.

74 **Soil** naturally occurring surficial deposits overlying bedrock.

75 **Stop Work Order** means an order issued which requires that all construction activity on a site be stopped.

76 **Stormwater Management** means the use of structural or non-structural practices that are designed to reduce stormwater runoff pollutant loads, discharge volumes, peak flow discharge rates and detrimental changes in stream temperature that affect water quality and habitat.

77 **Stormwater Procedures Manual** a compilation of rules, design criteria, guidelines and standards adopted by the City of Richmond as being proven methods of controlling construction related surface runoff, erosion and sedimentation.

78 **Stormwater Pollution Prevention Plan (SWPPP)** means a site-specific, written document that: (1) identifies potential sources of stormwater pollution at the construction site; (2) describes practices to reduce pollutants in stormwater discharges from the construction site; and identifies procedures the operator will implement to comply with the terms and conditions of a construction general permit, including a Pollution Control Plan.

79 **Stormwater Retrofit** means a stormwater BMP designed for an existing development site that previously had either no stormwater BMP in place or a practice inadequate to meet the stormwater management requirements of the site.

80 **Stormwater Runoff** means stormwater run-off, snow melt run-off, and surface run-off and drainage.

81 **Stormwater Treatment Practices (STPs)** means measures, either structural or nonstructural, that are determined to be the most effective, practical means of preventing or reducing point source or nonpoint source pollution inputs to stormwater runoff and water bodies.

82 **Stream Buffer** means an area of land at or near a stream bank, wetland, or waterbody that has intrinsic water quality value due to the ecological and biological processes it performs or is otherwise sensitive to changes which may result in significant degradation to water quality.

83 **Stripping** any activity which removes or significantly disturbs the vegetative surface cover including clearing, grubbing of stumps and root mat, and topsoil removal.

84 **Structure** anything manufactured, constructed or erected which is normally attached to or positioned on land, including buildings, portable structures, earthen structures, roads, parking lots, and paved storage.
85 **Topsoil** the upper layer of soil.
86 **Utility** is the owner/operator of any underground facility including an underground line, facility, system, and its appurtenances used to produce, store, convey, transmit, or distribute communications, data, electricity, power, heat, gas, oil, petroleum products, potable water, stormwater, steam, sewage and other similar substances.
87 **Water Pollution** means the alteration of the physical, thermal, chemical, biological, or radioactive properties of the waters of the Commonwealth in such a manner, condition, or quantity that will be detrimental to the public health or welfare, to animal or aquatic life or marine life, to the use of such waters as present or future sources of public water supply or to the use of such waters for recreational, commercial, industrial, agricultural, or other legitimate purposes.
88 **Watercourse** means a channel, which gathers or carries surface water.
89 **Watershed** is a region draining to a specific river, river system, or body of water.
90 **Wetlands** a lowland area such as a marsh, that is saturated with moisture, as defined in Sec. 404, Federal Water Pollution Control Act Amendments of 1987.

Appendix B

Construction Site Stormwater Pollution Prevention Plan (SWPPP)

This Stormwater Pollution Prevention Plan (SWPPP) narrative and the attached plan sheets address requirements of the Kentucky Division of Water (DOW) KYR10 General Permit and the City of Berea's Erosion and Sediment Control (ESC) Plan, which is required for a City of Berea Land Disturbance Permit.

1) PROJECT NAME AND CONTACT INFORMATION

Project Name and Location

Site Owner Name and contact Information

Plan Preparer: (name and contact information)

Date:

City of Berea Checklist and KY DOW NOI Attached: Yes_____ No_______

Construction Site SWPPP/BMP Plan Manager and Contact Information

Project Start and End Dates

Start:_________________
End:__________________

Engineer shall seal, sign and date the bottom of this page

2) SITE DESCRIPTION

This section of the SWPPP shall include a written description of the following items or maps:

a. Description of the Project:
   i. Site conditions (flat; sloping; steep slopes over 15%; presence of trees; soil conditions; drainage; sinkholes, streams present; impaired water body according to DOW.
   ii. Description of the nature of the project (residential, commercial, size, stages of development, preservation of certain areas from development, etc.)

b. A general location map (i.e. a portion of a city or county map), which locates the site within the overall drainage pattern of the city and/or county. The preference for the general location map is a color US Geological Survey Quadrangle map or equal.

c. A vicinity map (8 1/2 "x 11") of sufficient scale to show the project site location and the major streets and highways in and around the project location. Also show the property boundary of the project site. Scale of the map must be a standard engineering scale. Show a clear and definite delineation of any one hundred (100) year floodplain on or near the site. Additional information about this map is located in the EPSC design requirements.

d. Data collection for all features of the site shall extend at least 50 feet beyond the property lines, to ensure that all construction activity will not have an adverse impact on the adjacent properties. This includes structures, trees, utilities and other features that may have impact on the plans for the subject site. In some cases where terrain and proposed improvements may adversely affect the adjacent property, the distance may be increased, at the discretion of the city.

e. Latitude and longitude of the site

f. Name(s) of nearest receiving waters. If there are no sinkholes, wetland or special aquatic sites near or receiving discharges then include a statement indication there are none.

g. Estimates of the total area (acreage) of the site and the total area of the site that is expected to be disturbed by excavation, grading, or other activities including off-site borrow and fill areas.

h. An estimate of the runoff coefficient of the site for both the pre-construction and post-construction conditions and data describing the soil or the quality of any discharge from the site.

i. All engineering calculations related to the design of erosion control methods.

j. A description of the intended sequence of major activities, which disturb soils for major portions of the site. Include timing of activities when it becomes available.

i. Work crew orientation,
ii. Construction access – install entrance to site, initial construction routes, initial areas designated for vehicle parking,
iii. Sediment traps and barriers – basins, traps, sediment fences, outlet protection,
iv. Runoff and run-on controls – diversion ditches or berms, perimeter dikes,
v. Land clearing and grading – site-preparation (cutting, filling, and grading, sediment traps, barriers, diversions, drains, surface roughening),
vi. Runoff conveyance system – storm drains, channels, inlet and outlet protection, slope drains,
vii. Surface stabilization – temporary and permanent seeding, mulching, sodding, riprap,
viii. Building construction – buildings, utilities, paving
ix. Landscaping and final stabilization – place topsoil, trees and shrubs, permanent seeding, mulching, sodding.
x. Removal of temporary erosion control devices.

k. A description and location of any discharge associated with industrial activities other than construction. If there are no locations then include a statement indicating there are no industrial activity locations associated with this SWPPP.

l. Location of good housekeeping protocols (i.e. waste management provisions, adequate material staging areas, concrete washout areas, spill prevention and response, etc).

m. TMDLs and Pollutants of Concern in Receiving Waters. If there are no TMDLs or the stream is not listed on the Kentucky Impaired Waters (303d) list then include a statement that there are none.

n. Endangered or threatened species. If there are no endangered or threatened species found in the proximity to the construction site then include a statement indicating there are none.

o. Listed Historic structures or sites. If there are none associated with storm water discharges or activities then include a statement indication there are none.

3) PERIMETER CONTROL PLAN AND EROSION PREVENTION AND SEDIMENT CONTROL DESIGN AND MAINTENANCE MEASURES

The purpose of this section is to identify the types of erosion and sediment controls used during construction activities and establish standard protocols. This is the Perimeter Control Plan (PCP) and Erosion Protection and Sediment Control Plan (EPSC). The PCP plan shall be shown on a separate sheet for the contractor's benefit, as well as shown on the EPSC sheet for continuity of all EPSC practices.

a. The design, testing, installation, and maintenance of erosion protection and sediment control operation and facilities shall adhere to the criteria, standards and specifications as set forth in the most recent version of the *Kentucky Erosion Prevention and Sediment Control Manual and Field Guide* or the City of Berea's Stormwater Manual.

b. Submit all engineering calculations related to the design of erosion control methods

c. Prepare a written description of appropriate control measures (i.e. Best Management Practices – BMPs) that will be implemented as part of the construction activity to control pollutants in stormwater discharges. The written description must clearly describe for each major activity, appropriate control measures and the general timing (or sequence) during the construction process that the measures will be implemented as well as maintenance procedures for all BMPs during construction. This narrative will describe the sequence of all construction activity, including stripping and clearing, rough grading, construction of utilities, infrastructure, and construction of buildings, final grading and landscaping. Sequencing shall identify the expected date each activity will occur and the expected duration of each. A description should be given describing the relationship between implementation of stormwater quality measures and phases of construction activities, from the beginning of site work to the final completion of construction.

   This narrative will include required temporary stabilization plans and sequence of implementation including seeding mixture, method of seedbed preparation and kind and quantity of mulching. Permanent stabilization plans and sequence of implementation including seeding mixtures and rates, types of sod, method of seedbed preparation, expected seeding dates, type and rate of lime and fertilizer application, and kind and quantity of mulching should also be included.

   This narrative will also include details for both temporary and permanent erosion control structures and stabilization measures to be employed. Include all appropriate engineering design parameters in the text.

d. This narrative shall also describe all PCP measures that must be installed before general site construction begins. Perimeter Control Plan PCP objectives shall focus on:

   i. Downstream points and outfall areas
   ii. Protect adjacent properties by the use of vegetated strips along lower perimeters, sediment barriers, filters, diversion berms, sediment basins or other means acceptable to the city
   iii. Minimizing erosion and control sedimentation
   iv. Reducing the velocity of flows from the project site
   v. Does not necessitate protection of the entire site boundary

   PCP requirements include:

   i. The permittee shall utilize sediment control measures that consider the type of flow, site terrain, soil type and other relevant factors
   ii. Buffer strips may only be utilized for sheet flow

iii. Supplemental control measures shall be utilized when a single control device or measure proves ineffective
iv. Location and description of construction entrances and exits that comply, or exceed, the BMP minimum standards. All sites require sufficient temporary construction entrances to ensure that sediment is not tracked off the construction site.

e. Prepare an Erosion Protection and Sediment Control drawing/plan, and any control detail drawings illustrating the BMPs to be used. Special site detail drawings may be required for critical areas of the plan. This plan is a working document that summarizes the implementation of BMPs throughout the project construction, including erosion control, sediment control and location of chemical and waste controls.

The plan shall be drawn at a reasonably appropriate scale (in no case smaller than 1"=100') and shall include sufficient information to evaluate the environmental characteristics of the affected areas, the potential impacts of the proposed grading on water resources, phases and sequencing of the work, and measures proposed to minimize soil erosion and off-site sedimentation. The plan shall show

i. Legend with the name of the project, location, client's name and address, preparer's name and address and phone, date, with scale and north arrow depicted on map;
ii. Property lines;
iii. Names of adjacent property owners;
iv. Data collection for all features of the site shall extend at least 50 feet beyond the property lines, to ensure that all construction activity will not have an adverse impact on the adjacent properties. In some cases where terrain and proposed improvements may adversely affect the adjacent property, the distance may be increased, at the discretion of the city. This includes structures, utilities and other storm water facilities.
v. Offsite existing structures, streets, utilities and other infrastructure that may be affected by the land disturbance on the subject property;
vi. all slopes over 15%;
vii. location of existing trees or tree stands;
viii. soil conditions;
ix. existing drainage features, including streams, ditches, swales, sinkholes, wetlands and other significant geographic features; impaired water body according to DOW
x. Clear delineation of any one hundred (100) year floodplain on or near the site;
xi. On-site contractor staging areas for equipment, fuel storage, site materials and temporary facilities;
xii. Locations of on-site and off-site material, stockpiles, waste storage, borrow areas;

xiii. existing and proposed two-foot contours, and direction of stormwater flow before and after major grading activities;
xiv. Existing and proposed storm drainage system, including arrows showing drainage flow patterns;
xv. Onsite existing and proposed structures, streets, parking areas, detention/retention ponds, other BMPs, utilities and other infrastructure affected by the land disturbance on the subject property;
xvi. all proposed impervious areas, including measurements in square feet;
xvii. clear delineation of areas of vegetation or trees to be saved or protected;
xviii. benchmark location(s), description(s) and elevation(s) above sea level;
xix. any other item referenced in the SWPPP;
xx. limits of disturbed areas;
xxi. detailed cost estimate for all stormwater management control measures

The owner/developer/contractor shall perform all clearing, grading, drainage, construction, sequencing, and development in strict accordance with the approved SWPPP and these regulations.

f. Include a statement identifying which permittee is responsible for implementation.

g. Include statements for Erosion and Sediment controls – Short and Long Term Goals and Criteria that include the following:

i. The construction-phase erosion and sediment controls should be designed to retain sediment on site to the maximum extent practicable.
ii. All control measures must be properly selected, installed and maintained in accordance with the manufacturer's specifications and good engineering practices. If periodic inspections or other information indicates a control has been used inappropriately, or incorrectly, the permittee must replace or modify the control for site situations.
iii. If sediment escapes the construction site, off-site accumulations of sediment must be removed at a frequency sufficient to minimize offsite impacts. Sediment accumulation in streets and curbs will be swept/cleaned daily if necessary.
iv. Sediment must be removed from sediment traps or sedimentation ponds when the design capacity has been reduced by 50%.
v. Litter, construction debris, and construction chemicals exposed to stormwater shall be prevented from becoming a pollutant source for storm water discharges (i.e. screening outfalls, picked up daily)
vi. Dump trucks hauling material from the construction site will be covered with a tarpaulin to prevent loss of construction debris and dirt.
vii. Cut and fill slopes shall be no greater than 2H:1V, unless approved by the City of Berea

viii. Clearing and grading, except that necessary to establish sediment control devices, shall not commence until sediment control devices have been installed, including all temporary perimeter sediment controls and stabilized construction entrances

ix. All BMPs shall be maintained in an effective, operational condition.

x. Maintenance measures shall be performed before the next storm event.

xi. No more than 25 acres will be disturbed at any one time. No new disturbed area will be created until previously disturbed areas are temporarily or permanently stabilized on an acre-for-acre basis

xii. Land disturbance activities will be phased to minimize the amount of soil exposed and the length of exposure time. The overall objective will be to achieve final grades as quickly as possible.

xiii. Top soil stockpiles and disturbed portions of the site where construction activity stops for 14 days or more will be stabilized with temporary seed and mulch no later than 14 days from the last construction activity in that area of the site.

xiv. Disturbed portions of the site where construction activities are completed will be stabilized with permanent seed no later than 14 days after completion of grading in that area.

xv. Effective dust control measures such as adequate moisture content or approved dust suppressants shall be taken as needed.

xvi. The following practices shall be described as appropriate for the project, depending on whether the item is applicable to the project:

1. Areas of the site not affected by construction shall be protected by signs, construction fence, etc. to maintain the undisturbed character of the site.
2. Geotextiles
3. Sod stabilization
4. Vegetative buffer strips
5. Protection of trees
6. Preservation of mature vegetation
7. Silt fences
8. Earth berms or dikes
9. Drainage swales
10. Sediment traps
11. Ditch check dams
12. Subsurface drains
13. Pipe slope drains
14. Level spreaders
15. Storm drain inlet or outlet protection
16. Rock outlet protection
17. Reinforced soil retaining systems
18. Gabions
19. Temporary and permanent sediment basins
20. Rock berms
21. Diversion ditches or other techniques where upland runoff occurs past disturbed areas

h. Include a statement about chemical and waste disposal.

   i. Waste materials that may leach pollutants (paint, detergents, solvents, pesticides, acids, fertilizers, caulk, oil/grease, liquids, soluble, etc., and their containers) will be collected and stored in covered metal dumpsters and serviced by a licensed waste management company.
   ii. All construction debris and other wastes that do not leach pollutants will be deposited in either a closed or open-topped dumpster. The dumpster will be emptied when full, and the contents dumped in a licensed landfill.
   iii. No construction waste will be buried on-site.
   iv. All hazardous waste will be disposed of in the manner specified by local or state regulation or by the manufacturer.
   v. Sanitary waste will be collected from the portable units on a frequent, periodic basis by a licensed sanitary waste management contractor.
   vi. Concrete waste from concrete trucks shall be returned to the concrete plant, or deposited at a designated containment area on site, constructed in a manner to prevent run-off from entering the street, storm water drainage systems or waterways. Wash water may not be deposited in streets, curbs, gutters, storm drains, or waterways.

i. Include a statement that spill prevention and good housekeeping shall be required to reduce the risk of discharge into the stormwater system
   i. Store all products in a neat, orderly manner away from any portion of the storm drainage system.
   ii. Keep products in original containers and keep all material safety data sheets (MSDS) on-site.
   iii. Dust will be controlled by water sprayed form a tanker truck as needed during dry weather.
   iv. All spills shall be cleaned up immediately with approved methods.

j. The permittee shall notify the City in writing of any substantial field changes made to the approved plans. Changes made to the plan must be approved by the city engineer.

INSPECTIONS

Include statements in the SWPPP of all steps to be taken, by a qualified person, to perform inspections of site controls. Steps included, but are not necessarily limited to the items below:

a. Prior to commencing construction activities the permittee shall schedule a pre-construction meeting with the City of Berea. The permittee shall provide a 7-day notice to approving agency prior to pre-construction meeting.

b. The permittee shall notify the City of Berea 24 hours in advance of conducting inspections, except in the case of post-rainfall event inspections.

i. At a minimum, the permittee shall conduct a self-inspection at the following stages:
   1. Completion of perimeter erosion and sediment controls
   2. Completion of clearing and grubbing
   3. Installation of temporary erosion controls
   4. Completion of final grading and ground stabilization
   5. Prior to the fiscal security release
   6. Monthly after areas have been temporarily or permanently stabilized
   7. Every 7 days or every 14 days and after each rainfall event that exceeds 0.5 inches.

ii. The City of Berea may increase or decrease the number of required inspection as deemed necessary to ensure an effective SWPPP and shall have the right to enter the property of the permittee without notice.

c. The permittee shall prepare an inspection report after each self-inspection and shall keep copies at the job site at all times, and may be required to fax or email the inspection report to the City of Berea, if deemed necessary. At a minimum, the inspection report shall include the date, time of day, name of the person conducting the inspection, company represented, scope of the inspection, major observations relating to the SWPPP and BMPs installed, appropriate photographs, and subsequent changes. The City of Berea has the right to make regular inspections to ensure the validity of the inspection reports.

d. All inspections shall be provided to the City of Berea in a digital format before a Certificate of Occupancy or Construction guarantee is released.

e. The permittee shall be self-policing and shall correct or remedy any EPSC measures that are not effective or functioning properly at all times during various phases of construction. All updates to EPSC measures shall be accurately noted in the SWPPP.

f. The SWPPP must be updated throughout the construction project and available for on-site review.

g. Maintain a set of as-built drawings for all newly installed stormwater facilities

4) CERTIFICATIONS

Contractor and Subcontractor Certifications

SWPPP Files, Updates, and Amendments

This SWPP Plan and related documents (i.e. NOI, inspection reports, US ACE permits, etc.) will be kept on file at the construction site by ______________________, the Site Manager. The SWPPP will be updated by the Owner and/or site manager to reflect any and all significant changes in site conditions, selection of BMPs, the presence of any unlisted potential pollutants on site, or changes in the Site Manager, contractor, subcontractors, or other key information. Updates and amendments will be made in writing within seven (7) days and will be appended to the original BMP Plan and available for review.

Stormwater Pollution Prevention Plan Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

I certify under penalty of law that I understand the terms and conditions of the general KPDES permit that authorizes the stormwater discharges associated with the construction site activity identified as part of this certification.

Signature:______________________________ Date:____________________

Printed Name:___________________________

Name of Company:____

Address of Company:____

City, State, Zip:____

Phone: ____

Site Manger: _______________________________________

Phone:______________________ Cell Phone:______________________

Fax:____

Email:____

Subcontractor Certification

The subcontractors below certify under penalty of law that they understand the terms and conditions of the general KPDES permit and authorizes the stormwater discharges associated with the construction site activity identified as part of this certification.

Signature:_____________________________ Date:___________________

Printed Name:__________________________

Name of Company:____

Address of Company:_______________________________________

City, State, Zip:____

Phone: ____

Appendix C

STORMWATER MANAGEMENT/BMP FACILITIES
OPERATION AND MAINTENANCE AGREEMENT

THIS AGREEMENT, made and entered into this____day of____________, 20___, by and between (Insert Full Name of Owner)____hereinafter called the "Landowner", and City of Berea, hereinafter called the "City". WITNESSETH, that WHEREAS, the Landowner is the owner of certain real property described as (Madison County tax Map/Parcel Identification Number)____as recorded by deed in the land records of Madison County, Kentucky, Deed Book________ ____Page____________, hereinafter called the "Property".

WHEREAS, the Landowner is proceeding to build on and develop the property; and

WHEREAS, the Site Plan/Subdivision Plan known as_________________________________ (Name of Plan/Development), hereinafter called the "Plan", which is expressly made a part hereof, as approved or to be approved by the City, provides for detention and/or treatment of stormwater within the confines of the property; and

WHEREAS, the City and the Landowner, its successors and assigns, including any homeowners association, agree that the health, safety, and welfare of the residents of Berea, Kentucky require that on-site stormwater management/BMP facilities be constructed and maintained on the Property; and

WHEREAS, the City requires that on-site stormwater management/BMP facilities as shown on the Plan be constructed and adequately maintained by the Landowner, its successors and assigns, including any homeowners association.

NOW, THEREFORE, in consideration of the foregoing premises, the mutual covenants contained herein, and the following terms and conditions, the parties hereto agree as follows:

1. The on-site stormwater management/BMP facilities shall be constructed by the Landowner, its successors and assigns, in accordance with the plans and specifications identified in the Plan.
2. The Landowner, its successors and assigns, including any homeowners association, shall adequately maintain the stormwater management/BMP facilities. This includes all pipes and channels built to convey stormwater to the facility, as well as all structures,

improvements, and vegetation provided to control the quantity and quality of the stormwater. Adequate maintenance is herein defined as good working condition so that these facilities are performing their design functions. The Annual Inspection Report is to be used to establish if the working condition of the facility is acceptable to the City.

3. The Landowner, its successors and assigns, shall inspect the stormwater management/BMP facility and submit an inspection report annually. The purpose of the inspection is to assure safe and proper functioning of the facilities. The inspection shall cover the entire facilities, berms, outlet structure, pond areas, access roads, etc. Deficiencies shall be noted in the inspection report.
4. The Landowner, its successors and assigns, hereby grant permission to the City, its authorized agents and employees, to enter upon the Property and to inspect the stormwater management/BMP facilities whenever the City deems necessary. The purpose of inspection is to follow-up on reported deficiencies and/or to respond to citizen complaints. The City shall provide the Landowner, its successors and assigns, copies of the inspection findings and a directive to commence with the repairs if necessary.
5. In the event the Landowner, its successors and assigns, fails to maintain the stormwater management/BMP facilities in good working condition acceptable to the City, the City may enter upon the Property and take <u>whatever steps necessary</u> to correct deficiencies identified in the inspection report and to charge the costs of such repairs to the Landowner, its successors and assigns. This provision shall not be construed to allow the City to erect any structure of permanent nature on the land of the Landowner outside of the easement for the stormwater management/BMP facilities. It is expressly understood and agreed that the City is under no obligation to routinely maintain or repair said facilities, and in no event shall this Agreement be construed to impose any such obligation on the City.
6. The Landowner, its successors and assigns, will perform the work necessary to keep these facilities in good working order as appropriate. In the event a maintenance schedule for the stormwater management/BMP facilities (including sediment removal) is outlined on the approved plans, the schedule will be followed.
7. In the event the City pursuant to this Agreement, performs work of any nature, or expends any funds in performance of said work for labor, use of equipment, supplies, materials, and the like, the Landowner, its successors and assigns, shall reimburse the

City upon demand, within thirty (30) days of receipt thereof for all actual costs incurred by the City hereunder.

8. This Agreement imposes no liability of any kind whatsoever on the City and the Landowner agrees to hold the City harmless from any liability in the event the stormwater management/BMP facilities fail to operate properly.
9. This Agreement shall be recorded among the land records of Madison County, Kentucky, and shall constitute a covenant running with the land, and shall be binding on the Landowner, its administrators, executors, assigns, heirs and any other successors in interests, including any homeowners association.

WITNESS the following signatures and seals:

____
Company/Corporation/Partnership Name (Seal)

By: ____

____
(Type Name)

____
(Type Title)

STATE OF KENTUCKY

COUNTY OF MADISON

The foregoing Agreement was acknowledged before me this_____day of__________, 20___, by

____.

____
NOTARY PUBLIC

My Commission Expires: _____________

CITY OF BEREA, KENTUCKY

By: ______________________________________

____
(Name)

____
(Title)

STATE OF KENTUCKY

COUNTY OF MADISON

The foregoing Agreement was acknowledged before me this_____day of__________, 20___, by

____.

____
NOTARY PUBLIC

My Commission Expires: ____________

Approved as to Form:

________________________________ ___________
City Attorney Date

Appendix D Forms

As-Designed and As-Built Hydrology for Detention Pond
City of Berea, Kentucky

Add additional tables for multiple ponds on each development.

Date: ________________________ Project: _____________________________________

Land Development Permit #: __________ Engineer: _____________________________

E-mail: ____________________________ Phone: _______________________________

The following is the minimum information required in a standard hydrology study submitted to the City of Berea. Additional information may be required for site specific conditions. It shall be at all times the responsibility of the engineer of record to accurately model and report the conditions on the site. The City of Berea accepts no responsibility for errors or omissions from this report.

Please submit an As-Built Hydrology report, one set of As-Built Survey drawings, and an annotated copy of these comments to the City of Berea Codes and Planning for review. Direct questions regarding the checklist and submittal requirements to City of Berea Codes and Planning (859) 986-8528.

AS-BUILT SURVEY FOR WET, DRY OR EXTENDED-DETENTION PONDS

1.	□	Survey is signed, sealed and dated by a Registered Land Surveyor licensed in the state of Kentucky.
2.	□	Contours are shown at 1-foot intervals.
3.	□	Bottom of pond elevations are shown to enable verification of positive drainage.
4.	□	Top of wall shots or dam elevation statement is included on the survey to verify freeboard. Top width of embankment is shown.
5.	□	The required water quality volume for each pond is shown on the survey.
6.	□	The maximum limits of ponding are shown. The 100-year water surface elevation is shown.
7.	□	The location of the pond is shown with respect to property lines, R/W lines, buildings, other easements, etc.
8.	□	A detail of the outlet control structure showing pertinent dimensions and elevations of weirs, orifices, outfall pipes, etc., is included on the survey.
9.	□	Water quality and channel protection orifices include filtration/trash rack to reduce the likelihood of clogging.
10.	□	15-foot access and maintenance easement are shown around the pond. The access easement is sloped at 20% or flatter.

AS-BUILT HYDROLOGY STUDY FOR WET, DRY AND EXTENDED-DETENTION PONDS

1.	□	Hydrology is signed, sealed and dated by a Professional Engineer licensed in the state of Kentucky.
2.	□	Water quality volume provided in the as-built pond is equal or greater than the as-designed volume. The elevation of the water quality volume is indicated on the stage/storage table. Revisions to water quality orifice size/elevation are justified by calculations.
3.	□	Channel protection volume provided in the as-built pond is equal or greater than the as-designed volume. The elevation of the channel protection volume is indicated on the stage/storage table. Revisions to channel protection orifice size/elevation are justified by calculations.
4.	□	The post development storm flows do not exceed the predevelopment storm flows for the 10yr-6hr, 100yr-6hr, 100yr-24hr design storms.
5.	□	Stage/storage relationship, 100-year hydrographs for all basins and routed pond(s) are provided. The beginning routing elevation for the as-built pond is provided.
6.	□	Use the following tables as an example to organize the hydrology information.

Pond #___					
Design Storm	As-Designed Release Rates (cfs)	As-Built Release Rates (cfs)	As-Designed Water Surface Elevation (ft)	As-Built Water Surface Elevation (ft)	As-Built Freeboard Provided (ft)
10yr-6hr					
100yr-6hr					
100yr-24hr					

Pond #___						
	Water Quality Volume (cf)	Channel Protection Volume (cf)	Diameter of Water Quality Orifice (ft)	Elevation of Water Quality Orifice (ft)	Diameter of Channel Protection Orifice (ft)	Elevation of Channel Protection Orifice (ft)
As-Designed						
As-Built						

Detention Structure Characteristics
City of Berea, Kentucky

Item	Control Structure	Applicant Use	Official Use
1	Orifice(s) and weirs sizes and elevations match hydrologic model output?		
2	Control structure detail provided in plans?		
3	Minimum clear space of 6-inches provided from top of riser to bottom of structure lid?		
4	Minimum orifice diameter > 4"?		
5	Backwater effects possible for outlet pipe? If so, have they been analyzed?		
6	1-ft separation from bottom of structure to lowest orifice?		
7	1-ft minimum separation from lowest orifice to outlet pipe invert?		
8	Capacity of overflow riser adequate to pass 100-year storm?		
9	Grated bar inlet structure provided and designed to pass 100-year storm? Bar spacing 4"?		
	Emergency Spillway	**Applicant Use**	**Official Use**
1	Emergency spillway provided and designed to pass 100-year developed peak flow?		
2	One foot (1') minimum freeboard above maximum water surface elevation?		
3	Discharge from spillway or overflow directly to downstream conveyance system or other acceptable discharge point?		
4	Armored to full width, beginning at a point 2 ft below the 100yr-24hr water elevation inside the pond and extending it across the berm embankment to downstream where the emergency overflow reenters the conveyance system?		
	Signage and Fencing	**Applicant Use**	**Official Use**
1	Fencing provided where pond slope greater than 3H:1V above emergency overflow water surface, or where there are walls greater than 30-inches in height?		
2	If a public facility – pond tract fenced with 6-ft chain link?		
3	Wood fence or other alternative fencing/shrubbery screening allowed for private facilities?		
	Planting and Landscaping	**Applicant Use**	**Official Use**
1	Disturbed soil quality and depth restored?		
2	Pond interior side slopes and bottom sodded or seeded with appropriate seed mixture?		
3	All remaining areas of storm pond tract seeded, sodded or landscaped?		
4	No trees or shrubs within 25-feet of inlet or outlet pipes or drainage structures?		
5	No water seeking plants such as willow or poplar within 50-ft of structures?		
6	Trees and shrubs planted in clumps to form landscape island a minimum of 6-feet apart and 6-feet to fences and other barriers?		

Detention Basin Review Checklist
City of Berea, Kentucky

Item	Detention Basin Review Checklist	Applicant Use	Official Use
1	Verify input model for pre-development and developed land use, soil type and areas are consistent with site plan and other documentation.		
2	Interconnected pond simulation model used to size detention pond utilizing SCS runoff hydrographs.		
3	If separate threshold discharge areas exist, verify that they meet criteria.		
4	If impervious areas are not included in model because they are considered ineffective, verify that dispersion criteria are met per appropriate BMP to designated impervious area as ineffective.		
5	Verify model report is submitted and verify that detention facility meets discharge criteria.		
6	Verify model computer file is submitted with project, consider running model to verify report conclusions.		
7	Check that layout of detention pond and control structure design shown on site plans/drainage plans is consistent with results of model.		
8	A schematic of the hydrologic modeling parameters (network diagram of model, or equivalent) should be provided with basin designations matching basin designations on drainage work map required to be included in the Drainage Report.		
9	Is a permit from Division of Water required?		
10	Is a separate tract established that encompasses the detention pond, access roads, and associated appurtenances and structures and is there is at least a 20-ft separation between any facilities, the catch point of fill or cut slopes, or access road to the tract line?		
11	Interior side slopes steeper than 3H:1V are provided with protective fencing.		
12	If interior or exterior side slopes steeper than 2H:1V are proposed, is the design addressed in the geotechnical report by a licensed professional engineer with geotechnical expertise?		
13	If retaining walls or rockeries are proposed have they been designed by a licensed professional engineer?		
14	Is the flow path from pond inlet to outlet maximized to the extent feasible to prevent sedimentation? Verify that the inlet to the pond is not via the control structure or outflow conveyance system.		
15	Is a debris barrier (trash rack) provided for the pond outlet and for any pond inlet pipes?		
16	If an embankment is proposed (i.e. berm construction above existing grade) to impound water, a geotechnical engineer is required to design the embankment for slopes steeper than 2H:1V and greater than 6-ft in height.		
17	Is a pond berm embankment “key” equal to 50% of the berm embankment cross-sectional height and width included in the design?		
18	Is the pond berm embankment constructed on fill soils? If so, a geotechnical engineer shall provide design services to be included in geotechnical report.		

Item	Detention Basin Review Checklist	Applicant Use	Official Use
19	Are anti-seepage collars provided on pipes through embankments ponding greater than 8-ft of water?		
20	Is compaction specified by a geotechnical engineer for any pond berm embankment soils?		
21	Is all exposed earth on embankment either sodded or seeded? No trees or shrubs are allowed on berms taller than 4 feet. Trees or shrubs planted on berms 4 feet or smaller shall not exceed 20 feet mature height and have a fibrous root system.		
22	Is the top of berm width at least 10-feet, or as recommended by a geotechnical engineer? Berms used for maintenance road access shall have a minimum width of 15-feet.		
23	Is the maximum water surface elevation shown on the drainage plan and also shown in the pond cross-section?		
24	Is there at least a 2-foot vertical clearance from the maximum water surface to any structures (buildings) within 25-feet?		
25	Is there at least a 20-foot horizontal separation from the maximum water surface to property lines, structures, sewer lines and the tract property boundary line?		
26	Is access to the detention pond provided from a public street or right-of-way?		
27	Is a 15-foot minimum easement provided for access to a detention pond outside of the public right of way? A minimum 12-foot width all weather road surface such as crushed rock shall be provided		
28	Is an access road provided to the control structure and other drainage structures associated with the detention pond? If pond maintenance is to be performed from the access road (i.e. no ramp to pond bottom) the access road should extend around the pond perimeter.		
29	Pond access road grade must be less than 15% and less than 12% to the control structure? Access ramp width shall be at least 12-feet wide.		
30	Access ramp section of suitable design to provide year round access? Standard section of geotextile over native soils with 6-inches of crushed rock allowed, but slope limited to 12% maximum for this design.		
31	Ramp extended to bottom of pond for bottom area greater than 1,500 square feet? Otherwise ramp may end 4 feet (measured horizontally) from pond bottom.		
32	Minimum horizontal curve radius 40-feet.		
33	If access road length exceeds 75-ft a turnaround must be provided for a 31-ft length design vehicle with an inside wheel path radius of 40-ft.		
34	Is paved apron provided where access road connects to paved public roadway?		
35	Is a gate or are bollards provided for the access road? Vehicle access shall be limited by a locking gate or bollards. Gates are required if pond is fenced and must be located only on a straight section of road?		
36	Access ramp required unless applicant demonstrated that a 20-ft reach track hoe can access all areas of the pond from the perimeter access road? Perimeter access road shall be extended around entire perimeter of pond (see above).		

Land Disturbance Permit Application
City of Berea, Kentucky

Date: ___________

Applicant (the Responsible Party): _____Owner _____Contractor __________________Other (describe)

Property Owner
Name: ____
Address: ____
Phone: ____________________________________ Email: ____________________________________

Project/Property information
Location/Address: ____
Estimated Start Date: __________________________ Estimate Completion Date: __________________
Type of Development/Description of Work:
____
____
____
Total Parcel Area (acres):____________________ Total Disturbed Area (acres):____________________
Will excavated material be removed from site?: ______ Will fill material be brought to site?:_________
If yes, is the other site covered by a land disturbance Permit?:___________________________________

Contractor information
Company Name: _______________________________________ Phone: _________________________
Address: ____
Contact name: ______________________________ Contact Phone: _____________________________
Contact email: ____

Engineer/Designer
Company Name: _______________________________________ Phone: _________________________
Address: ____
Contact name: ______________________________ Contact Phone: _____________________________
Contact email: ____

Submittal Checklist:
Print “Yes” or “Not Applicable” (N/A)

_____ Stormwater Pollution Prevention Plan (SWPPP)
_____ KY Construction Permit (KYR10 or Individual)
_____ KY DOW 401 Water Quality Certificate
_____ KY Stream construction Permit
_____ US Corps of Engineers 404 Permit
_____ FEMA LOMR or CLOMR
_____ KY Transportation Cabinet Encroachment Permit
_____ Planning and Zoning Approval
_____ Site Plan Review Checklist
_____ Set of Finalized Construction Plans and Specs
_____ Copy of Approved Kentucky DOW NOI
_____ Application Fee
_____ Completed Maintenance Agreement

I hereby certify, under penalty of law, that I have reviewed this document and understand the erosion protection and sediment control requirements, construction site requirements and will adhere to any and all ordinances and regulations adopted by the city. I understand that there requirements will be inspected and enforced by the city and failure to comply may result in the issuance of a “stop work order” and / or other penalties until compliance is accomplished.

I also certify that the information supplied is complete and correct, and that I am the owner or the authorized agent of the owner or have permission of the owner to obtain this permit, and to undertake the subject work, and that the work will conform to all applicable codes, regulations, manuals and other applicable laws which related to the property.

Signature of Owner or Agent ____ Date: ______________

Printed Name ____ Title: _______________________________

FEES:
Application fee is to be paid as part of permit approval.

New Single Family Lot - $25
Less than 1 Acre - $100
1 – 5 Acres - $200
Over 5 Acres - $300

Internal Use Only
Land Disturbance Permit Number: ____________
Date Received: __________________
Date paid: _________________
Permit Effective Date: _________________

SMALL LOT EROSION PREVENTION AND SEDIMENT CONTROL PLAN

FOR SINGLE FAMILY RESIDENTIAL CONSTRUCTION AND SITE GRADING OF LESS THAN ONE (1) ACRE

City of Berea, Kentucky, Department of Codes and Planning, 212 Chestnut Street, Berea, KY 40403
Phone: (859) 986-8528 Ext. 2050, dvanwinkle@bereaky.gov

A building permit WILL NOT BE ISSUED until this form is filled out completely on both sides

Permit #:					Date:		
Owner Name:					Phone #:		
Contractor Name:					Phone #:		
Project Address:					Acreage Total:		
CLT Map #:		Parcel:			Zone:		
Subdivision:					Lot #:		
Minimum Setbacks:	Front:	Left:		Right:		Rear:	
Flood Plain Development Permit Required?		Yes		No			

1. Review approved subdivision SWPPP plans and single family general permit KYR100000 and grade lot in accordance to these plans *(available at City of Berea, Department of Codes and Planning, 212 Chestnut Street, Berea, KY 40403. Call (859) 986-8528 to schedule a review).*
2. Provide erosion control to trap soil prior to beginning site grading. Refer to Kentucky Erosion Prevention & Sediment Control Field Guide.
3. Each property owner should protect their property by providing lot line swales/berms to direct on site drainage to street or existing drainageways in accordance with the larger drainage plan (if applicable).
4. Permanent stabilization or ground cover must be established prior to removal of requirements in #2 above.
5. Direct roof and other storm drains to avoid damage to adjacent property owners and roads.
6. Install 15" driveway culverts as a minimum, if required for roadside ditches (HDPE or Concrete). A larger pipe will be used based on size of ditch and upstream and downstream pipe sizes.
7. A KYTC encroachment permit will be required for a single family residential located on a State Highway.
8. Contact the Department of Codes and Planning, (859) 986-8528, if the following circumstances are encountered:
   a. Sinkholes (25 feet minimum buffer or as listed on the approved subdivision plat)
   b. Lakes, streams, wetlands, ponds or running streams require **water quality buffers.**
   c. Slopes exceeding 15%
   d. Flood Zones
   e. Large drainage ditches crossed by driveways or drainage easements
9. If the lot is part of a larger plan of development, a copy of the signed Notice of Coverage must be provided along with this application.

Please choose the most appropriate answer.

- For single-family residential sites affecting <1 acre, choose one of the following options:
  The most appropriate EPSC plan, from the back side of this form, is option__________or a combination of options_________&_______.
- Are water quality buffers required on this site? (Check One) o Yes o No
  If yes, locate the water feature and the associated buffer on the option chosen on the back side of this form.

Failure to install and maintain Erosion Prevention & Sedimentation Control (EPSC) measures may result in violations and/or fines.

Applicant must initial on lines 1 & 2 below

_____1. Roads must not be damaged in the delivery of materials or equipment to the construction site. Parking of light or heavy equipment and placement of materials or portable toilets in the right of way (R.O.W) is not allowed. Vehicles in the R.O.W over 24 hours may be towed at the owner's expense.

_____2. Existing utilities and utility easements must remain undisturbed. It is prohibited to change the grade or construct a permanent structure above the existing utility or within the utility easement. Call Kentucky 811.

I hereby certify that I have read and examined this application and know the same to be true and correct. I understand that this is my application for coverage under the Kentucky Division of Water General Permit (if applicable). All provisions of laws and resolutions governing this type of work will be complied with whether specified herein or not. This permit shall not be construed as authority to violate or cancel the provisions of any Federal, State or Local law regulating construction or the performance of construction.

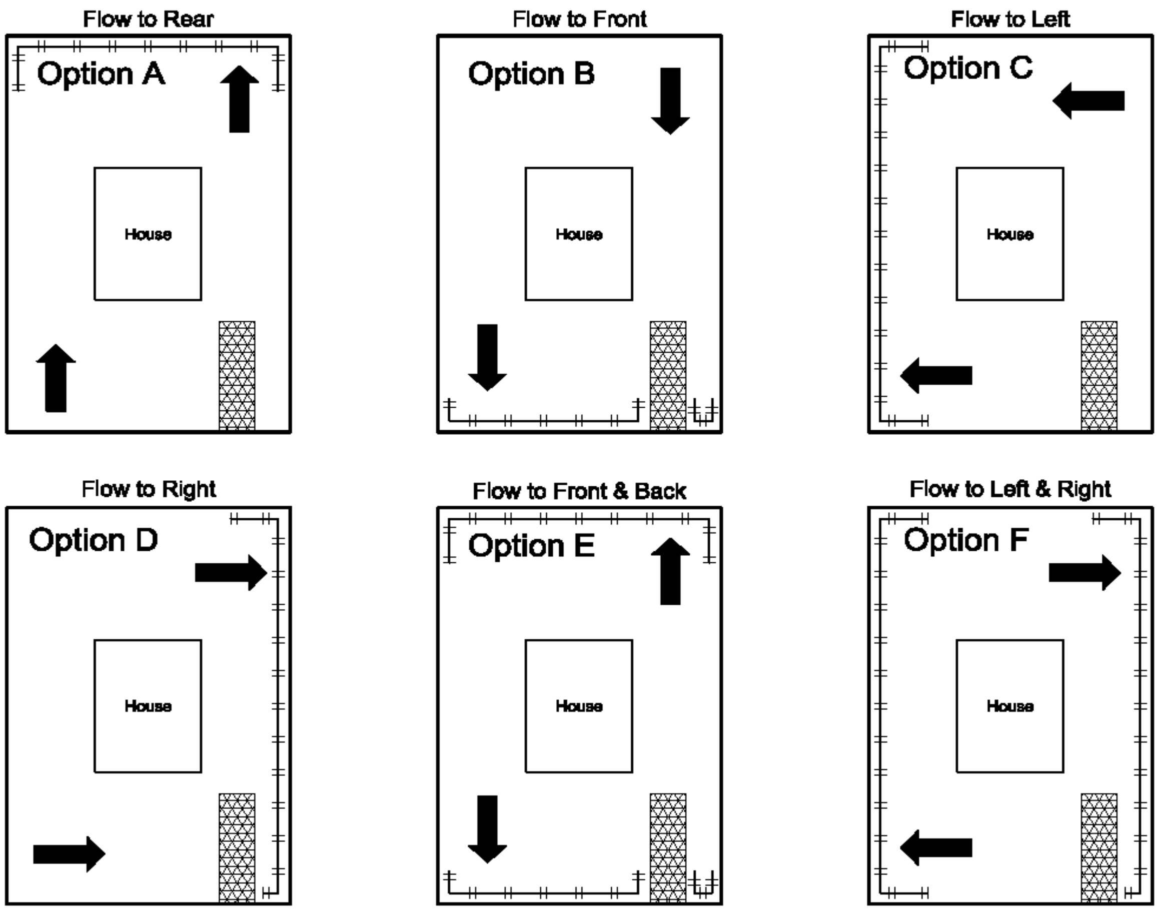
_______________________________ _______________________________ ________________

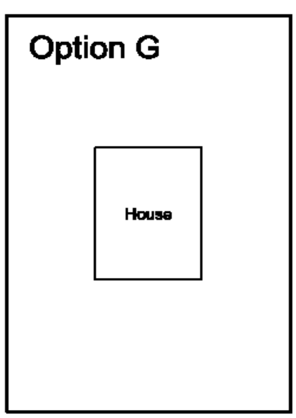
Applicant's Signature Applicant's Printed Name Date

EROSION PREVENTION & SEDIMENTATION CONTROL (EPSC) PLAN OPTIONS FOR BUILDING PERMITS

INSTRUCTIONS: Identify one or any combination of letters for the EPSC schematic that best describes the measures that will be used on this property during construction. If Options A-F do not adequately reflect site conditions, add flow lines and EPSC measures to Option G, as appropriate. **Any water features (lakes, streams, ponds, etc.) must be clearly shown along with the associated buffer on the option chosen (A-G) on this form.**

Legend
Sediment barrier, such as silt fence
Stabilized construction entrance
Direction of Flow (points downhill)





If Options A-F do not adequately reflect site conditions, add flow lines and EPSC measures to *Option G, as appropriate.*

Additional Note:

The City of Berea Stormwater Ordinance requires that anyone conducting land- disturbing activities must prevent sediment from leaving the site. ***Furthermore, conducting any land-*** **disturbing activity of one acre or more requires a Land Disturbance Permit before initiating land-disturbing activities. This includes project-related fill material and borrow, waste or stockpile areas in addition to the building site.** Land disturbing activity means any activity on a property that results in a change in the existing soil and/or the existing soil topography. Land disturbing activities include, but are not limited to, development, re-development, demolition, construction, reconstruction, clearing, grading, filling, logging and/or tree chipping operations, haul roads associated with the development, and excavation. Contact the City of Berea for a Land Disturbance permit.

Appendix E

APPENDIX E - REFERENCES

Lexington-Fayette Urban County Government. Stormwater Manual, 2009

Lexington-Fayette Urban County Government. Standard Drawings, 2008

City of Richmond, Kentucky. Stormwater Procedures Manual, January, 2013

Win TR55 User Manual, National Resources Conservation Services, Version Date: April 19, 2002

City of Clarksville, Tennessee. Storm Water Management Manual, June, 2014.

Urban Drainage and Flood Control District, 2480 West 26th Avenue Suite 156-B Denver, CO 80211.

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Appendix F

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