Pennington County

Storm Water Quality Manual

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Pennington County - Storm Water Quality Manual

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101 INTRODUCTION

This *Storm Water Quality Manual* has been developed based upon the City of Rapid City's Storm Water Quality Manual. Because Pennington County's permitted MS4 is located within Rapid City's three-mile platting jurisdiction and Rapid City's one-mile air quality jurisdiction, staff felt that consistency with storm water and erosion control requirements, guidelines and criteria was important. However, it has been revised to reflect the needs of Pennington County and provides criteria and guidance for erosion and sediment control in Pennington County.

A. General

The Environmental Protection Agency (EPA) issued regulations on November 16, 1990, that require steps be taken to improve the quality of storm water from industrial activities, including certain construction activities. These criteria were developed to help mitigate the increased soil erosion and subsequent deposition of sediment offsite during the period of construction from start of earth disturbance until final landscaping and storm water quality measures are effectively in place. Compliance with these criteria will help meet the requirements of the EPA storm water regulations. Submittal of a Construction Permit to Pennington County does not supersede the requirement for the applicant to also obtain any required permits from the State of South Dakota, such as a Storm Water Permit for Construction Activities. If you are planning a construction project, you may need a State Storm Water Permit and a County Construction Permit for storm water discharges from a construction site. Construction activities include:

- Clearing, grading, or excavation;
- Road building;
- Construction of roads;
- Stockpiling; and
- Demolition activities.

Any construction activity disturbing **one** or more acres must have coverage under the South Dakota Department of Environment and Natural Resources (DENR) storm water permit. Any sites that are part of a larger plan or sale may also need a permit, if the total plan meets the acreage requirement. In Pennington County, the County requires a Construction Permit for Construction Activity on sites disturbing 10,000 square feet or larger.

In South Dakota, DENR has issued the General Permit for Storm Water Discharges Associated with Construction Activity. A General Permit is a permit for a specific activity issued throughout the state. The permit covers anyone meeting the conditions of the General Permit. There is no fee for this permit. The permit has simple and uniform terms to prevent any storm water from becoming polluted prior to leaving a construction site.

Persons who obtain a Construction Permit from Pennington County should read and understand the conditions of DENR's General Permit. A copy of the General Permit is available in adobe acrobat format from the DENR website at:

http://www.state.sd.us/denr/DES/Surfacewater/stormcon.htm.

You may also obtain a hard copy of the permit and these forms by contacting DENR:

Department of Environment and Natural Resources
Surface Water Quality Program
Joe Foss Building
523 East Capitol
Pierre, SD 57501-3181

Implementation and maintenance of erosion control measures are ultimately the responsibility of the property owner. Because site conditions will affect the suitability and effectiveness of erosion control measures, a Construction Permit specific to each site is required. In addition, should the approved Construction Permit not function as intended, and it is determined by Pennington County that additional measures are needed; the owner will have to provide additional measures needed to reduce soil erosion and sediment discharged from the construction site.

It is not the intent of this Section to preclude the use of other techniques or to override a contractor's ability or responsibility to use the most appropriate methods of analysis or practices. When conditions warrant special consideration or when more sophisticated methods are justified by engineering or economic considerations, the designer is encouraged to use these methods. Approval to use such methods shall be obtained from the Planning Director. Low temperature weather does not preclude the use of erosion and sediment controls. Nothing in this Section limits the right of the County to impose additional or more stringent standards to reduce soil erosion and provide sediment control.

1. Exemptions

Exemptions from the Construction Permit process will be considered according to the Section 507 (A) of the Pennington County Zoning Ordinance; however, exempting the owner from applying for a Construction Permit does not exempt the owner from controlling erosion of soil at each construction site through the use of the techniques described in this manual. Storm drain inlet protection must be utilized at all times, even if the work is exempt from the Construction Permit, to reduce sediments from entering storm drainage systems.

2. Exceptions

The Planning Director may temporarily waive or modify the standards of this section for extenuating circumstances. Upon request, the Planning Director may consider waiving or modifying any of the standards which are deemed inappropriate or too restrictive for site specific conditions by granting an exception. These site specific exceptions may be granted at the time of Construction Permit approval or if a formal request is made for a permit revision. Request for exceptions must be submitted in a format that is deemed acceptable by the Planning Director.

B. Performance Objectives

The objectives for erosion and sediment control during construction include the following:

- Conduct all land-disturbing activities to effectively reduce accelerated soil erosion and reduce sediment movement and deposition offsite.
- Schedule construction activities to minimize the total amount of soil exposed at any given time to reduce the period of accelerated soil erosion.
- Establish temporary or permanent cover on areas that have been disturbed as soon as possible after final grading is completed.
- Design and construct all temporary or permanent facilities for the conveyance of water around, through, or from the disturbed area to reduce the flow of water to non-erosive velocities.
- Remove sediment caused by accelerated soil erosion from surface runoff water before it leaves the site.
- Stabilize the areas of land disturbance with permanent vegetative cover or storm water quality control measures.

C. Construction Permit

A Construction Permit must be approved by the Planning Director prior to any unauthorized soil disturbance activities in Pennington County. The items required for the permit are presented in Section 300 of this *manual* and in Section 507 (A) of the *Pennington County Zoning Ordinance*. The Construction Permit is reviewed to ensure compliance with these standards anytime a site's planned development changes impact to the soil disturbance activities. If this review determines that the permit needs revision, it must be revised and approved by the County prior to the soil disturbance activities caused by the planned development changes. The permit must be approved prior to any earth disturbing activities unless the activity is defined as an exemption. Acceptance of the Construction Permit Application does not imply acceptance or approval of the Construction Permit, Site Plan, drainage plans, utility plans, street or road plans, design of retaining walls, or any other aspect of site development or disturbance.

1. Erosion and Sediment Control for Minor Impact Construction Sites

Individual lots in a subdivision, which has an approved Construction Permit, shall not be considered a separate construction project, but rather as a part of the subdivision development as a whole. These sites are referred to as Minor Impact Construction Sites (MICS). It will be the responsibility of the homeowner and their contractors to conform to all requirements of the approved permit for the subdivision. Subdivision plans must incorporate a separate detail drawing and narrative describing minimum erosion control measures for MICS within the approved subdivision. It is understood that Pennington County may require additional erosion and sediment control measures if unforeseen erosion or sediment control problems occur or if the submitted Construction Permit does not function as intended.

2. Minor Impact Construction Site Construction Permit Requirements

The MICS Construction Permit Application shall include a separate detail drawing demonstrating the typical minimum erosion and sediment control measures, Best Management Practices (BMPs), for each type of typical standard platted lot within the subdivision. In addition to the above, the permit application shall also include:

a. Subdivision Name
b. Subdivision Location
c. Erosion Control Soil Surface Stabilization is Required
d. Stabilized Staging Area as Deemed Necessary
e. Concrete Washout Area as Deemed Necessary
f. Stockpile Area as Deemed Necessary
g. Non-structural BMP as Deemed Necessary
h. Detailed Sediment Control Structural BMPs

The MICS Construction Permit shall also have a narrative describing the minimum typical erosion control measures for each type of typical standard platted lot within the subdivision. The narrative shall include the following:

a. Lot owner or general contractor is responsible for training all subcontractors to follow this Construction Permit prior to entering the work area. Training/discussions with subcontractors shall include but not be limited to:

    i. Define limits of construction
    ii. Define location and limits of stockpile areas if required
    iii. Removal of sediment and debris leaving property
    iv. Location of stabilized staging area and protection requirements if required
    v. Restricted use of vehicles or equipment on and off of unstabilized areas with entrance and egress through the lots vehicle tracking station
    vi. Location of Concrete Washout Area on lot or subdivision if required
    vii. Identify required structural and nonstructural BMP that must be maintained
    viii. Identify soil surface stabilization measures that should not be disturbed

b. Individual lot owner and/or their general contractor shall be responsible for implementing and maintaining the subdivision's approved structural BMP that is now located on their property and within their approved limits of construction.

c. Lot owner and general contractor or their representative shall ensure that soils, landscape materials, rock, or mulch is not stockpiled, stored, or placed on streets, sidewalks, or storm water flow lines.

102 EROSION CONTROL

Planning for the installation of permanent or temporary soil erosion controls is needed in advance of all major soil disturbance activities on the construction site. After construction begins, soil surface stabilization shall be applied within 14 days to all disturbed areas that may not be at final grade but will remain dormant (undisturbed) for periods longer than an additional 21 calendar days. Within 14 days after final grade is reached on any portion of the site, permanent or temporary soil surface stabilization shall be applied to disturbed areas and soil stockpiles. When the initiation of stabilization measures are stopped due to snow cover or arid conditions, stabilization measures shall be initiated as soon as possible.

Soil surface stabilization protects soil from the erosive forces of raindrop impact, flowing water, and wind. Erosion control practices include surface roughening, mulching, erosion control blankets, and, establishment of vegetative cover by seeding and mulching, and the early application of gravel base on areas to be paved. Stabilization measures to be used shall be appropriate for the time of year, site conditions, and estimated duration of use. The maximum time limits of land exposure for selection of erosion controls are summarized in Table 1-1.

A. Stabilization of Disturbed Areas and Soil Stockpiles

- Permanent or temporary soil stabilization shall be applied to disturbed areas within two weeks after rough grading. Soil stabilization refers to measures which protect soil from erosive forces of raindrop impact and flowing water. Applicable practices include vegetative establishment, mulching, and early application of gravel base on areas to be paved. Soil stabilization measures selected shall be appropriate for the time of year, site conditions, and estimated duration of use.

- Soil stockpiles shall be established or protected with sediment-trapping measures to prevent soil loss.

B. Establishment of Permanent Vegetation

A permanent vegetative cover must be established on denuded areas not otherwise permanently stabilized. Establishment of permanent vegetation is when all soil disturbing activities at the site have been completed and a uniform perennial vegetative cover with a density of 70% of the native cover for unpaved areas and areas not covered by permanent structures has been established, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

- Will construction be absent two years or more?
  Yes - Permanent Revegetation
  No - Protect with temporary revegetation or Mulch

- Are the seasonal limitations for seeding in affect?
  Yes - Protect with temporary revegetation, mulch, or other approved method until permanent revegetation can be performed
  No - Permanent Revegetation

- Are slopes 3:1 or steeper?
  Yes - Erosion control blanket or bonded fiber matrix
  No - Mulch

C. Surface Roughening

Surface roughening, also referred to as scarification, provides temporary stabilization of disturbed areas from wind and water erosion. It is particularly useful where temporary revegetation cannot be immediately established due to seasonal planting limitations. The soil surface is considered roughened if depressions are created two (2) to four (4) inches deep and are spaced approximately four (4) to six (6) inches apart. If slopes are sufficiently rough after final grading, no further treatment is required. The surface of exposed soil can be roughened by a number of techniques and equipment. A chisel or ripping implement can be used in most soil conditions. Roughening cannot be performed in very sandy or rocky soil. Surface roughening, also referred to as scarification, shall be performed after final grading. Fill slopes can be constructed with a roughened surface. Cut slopes that have been smooth graded can be roughened as a subsequent operation. Roughening of ridges and depressions shall follow along the contours of the slope. On slopes steeper than 2:1, the tracks left by a dozer working perpendicular to the contour can leave acceptable horizontal depressions.

Care shall be taken not to drive vehicles or equipment over areas that have been scarified. Tire tracks will smooth the roughened surface and encourage runoff to collect into channels. As surface roughening is only a temporary control, additional treatments may be necessary to maintain the soil surface in a roughened condition.

D. Mulching/Seeding

All disturbed areas shall be mulched, or seeded and mulched, within 14 days after final grade is reached on any portion of the site not otherwise permanently stabilized. Areas that will remain in an interim condition for more than one (1) year shall also be seeded.

To protect newly seeded areas and to provide temporary cover on other disturbed areas that will not require temporary revegetation or cannot be seeded due to seeding date limitations, a mulch or compost shall be applied.

1. Mulching

Materials

a. Grass Hay or Straw Mulch - Grass hay or straw mulching shall be substantially free of noxious weed seeds and objectionable foreign matter. The mulch shall have been baled dry, in bales of approximately equal weight and shall be relatively dry when applied. The Planning Director will reject materials having characteristics, making them unsuitable for the purpose intended. Bromegrass is not an acceptable mulch.

b. Fiber Mulch - Fiber Mulching shall contain no germination or growth inhibiting factors and shall have the property of becoming evenly dispersed and suspended when agitated in water. When sprayed uniformly on the surface of the soil, the fibers shall form a blotter-like ground cover, which will readily absorb water and allow infiltration to the underlying soil without restricting emergence of seedlings. Weight specification from suppliers, and for all applications, shall refer only to air dry weight of the fiber, considered to be 10 percent moisture. The fiber mulch material shall be supplied in packages marked by the manufacturer to show the air dry weight content. Suppliers shall certify that laboratory and field testing of their product has been accomplished, and that it meets all of the foregoing requirements.

c. Compost and Wood Chip Mulch - Compost shall be ¾ in. minus and ⅜ in. minus screened material. Wood Chip Mulch shall be material passing the ¾ in. screen. No chemical additives shall be added during the composting process. The process shall be completely natural utilizing the organic feedstock, water and air. The material shall be composted to a ratio of 30 parts carbon to 1 part nitrogen before screening the material. The compost shall be registered through the South Dakota Department of Agriculture as a soil amendment.

d. Hydroseeding Tackifier Amendment - Hydro seeding tackifier amendment shall be a safe, non-toxic polymer that can be used with any paper or fiber mulch products. The anionic high molecular weight polymer binds the hydroseeding media to the soil particles. The tackifier shall be hydropholic and allow water into the mulch matrix. The tackifier shall be a synthetic material that is free of weed seed and any organic containments. It shall be compatible with biostimulants, fertilizers and surfactants. It shall not clump in the tank and clog the spray nozzle. The tackifier lubricates the slurry mix and tightens the slurry stream and will increase the shooting distance. The tackifier will break down from UV light in 5-6 weeks. The tackifier can be used as a temporary dust abatement in non-traffic areas. The tackifier can be applied as a temporary soil stabilizer to protect against erosion. The tackifier can be applied through hydraulic equipment for clarifying sediment/holding ponds.

Construction

a. Grass Hay or Straw Mulch

i. Placing Mulch - The rate of application shall be 4000 lbs. per acre. The mulch shall be placed within forty-eight (48) hours after the seeding has been completed. Mulching operations shall not be performed during periods of high winds, which preclude the proper placing of the mulch. The placing of mulch shall begin on the windward side of the areas to be covered.

The mulch shall be blown from a machine designed for that purpose and uniformly distributed over the seeded areas. The machine for placing the mulch shall be of an approved type, which will blow or eject, by constant air stream, a controlled amount of mulch. The machine shall cause a minimum of cutting or breakage in the length of the mulch.

Mulch containing excessive moisture, which prevents uniform feeding through the machine, shall not be used. Bales shall be broken up and loosened as they are fed into the blower to avoid placing of matted or unbroken lumps.

Mulch shall be placed uniformly over the seeded areas at rates specified in the Construction Permit. Approximately ten percent (10%) of the soil surface shall be visible through the mulch blanket prior to mulch tiller (punching) operation.

Any existing cover left in place shall be used as mulch, and the specified rate for mulching shall be reduced to leave ten percent (10%) of the soil surface visible through the mulch blanket and a loose thickness of cover of about one (1) inch prior to the punching operation.

Excessive cover, which will smother seedlings of small seeded grasses, shall be prohibited. The Planning Director may order the placement of mulch on any area where protection is considered necessary to forestall erosion or encourage turf establishment.

b. Punching - Immediately following application, the mulch shall be punched into the soil by a mulch tiller consisting of a series of dull, flat disks with notched or cutout edges. The disks shall be approximately twenty (20) inches in diameter, one-fourth (1/4) inch thick, and shall be spaced approximately eight (8) inches apart and shall be fitted with scrapers.

   Working width of the tiller shall not exceed six (6) feet per member, but may be operated in gangs of not over three (3) members. The tiller shall be operated on contour, except on slopes 3:1 or steeper, where the Planning Director may require diagonal operation and, if necessary, dual drive wheelers or crawler tread on the tractor to minimize side slip and rutting damage to slopes.

   Tiller members shall be ballasted to push mulch into the soil approximately three (3) inches with ends exposed above the soil surface. When light disking is required in existing cover so the seed can be drilled into a depth of one (1) to one and one-half (1 1/2) inches, the tiller members shall be ballasted to push mulch into the soil with the ends exposed above the soil surface.

   The mulch tiller shall follow as closely as possible behind the mulch blower. Mulch shall not be blown when the wind velocity causes appreciable displacement before it can be anchored by the mulch tiller. The Planning Director may require more than one (1) pass of the mulch tiller or diagonal passes where necessary to assure adequate anchoring.

c. Fiber Mulch - Rate of application shall be 2000 lbs. per acre. Excessive thickness of mulch, which will smother grass seedlings, shall be avoided. Mulch shall be placed on a given area as soon as possible, or within 48 hours after seeding.

d. Compost - Apply a ¼ inch layer of compost over the seeded area, then water to protect against hot, dry weather or drying winds.

e. Hydroseeding Tackifier Amendment

   i. Hydro seeding - When using as a tackifier with paper or fiber mulch, add three pounds per acre. Slowly pour the tackifier into the water and thoroughly mix in the tank. Add mulch, seed, fertilizer and any other components in the tank and thoroughly mix.

   ii. Straw Tacking - Apply three pounds per acre with 750 pounds of wood or paper mulch.

iii. Temporary Dust Control - Apply to non-traffic areas at a rate of three pounds per acre with 1000 gallons of water. On slopes of 4:1 to 2:1 apply at a rate of 6-12 pounds per acre.

iv. Clarifying sediment/holding ponds - Slowly pour two-three pounds of tackifier into 1000 gallons of water while the tank is agitating. Thoroughly mix for 15 minutes and spray to one surface acre of water.

f. Care During Construction and Final Acceptance - Traffic, either foot, equipment, or vehicular, shall be kept to a minimum over the seeded and mulched areas.

The Contractor shall, prior to acceptance of the project, re-mulch any area on which the original mulch has been displaced as a result of excessive wind, water, or other causes.

2. Seeding

When bulk seed is referred to, it is defined as total seed, including pure live seed (PLS), inert matter, crop seed, and weed seed.

<u>Materials</u>

a. General - The seed furnished shall be the best quality seed available for the kind and variety specified. The seed shall comply with the requirements of the South Dakota Seed Law and shall be "Blue Tag" certified governed by Federal Regulations.

b. Origin Limitations - Seed furnished shall have been grown in South Dakota or an area comparable to South Dakota's growing conditions.

c. Seed Testing - Seed shall be tested within eighteen (18) months prior to the planting date. Testing shall be, performed by a commercial seed testing lab or a registered member of the Society of Commercial Seed Analysts (Registered Seed Technologist).

d. Labeling - Before seeding begins, the Contractor shall verify that each bag of seed delivered to the project bears a tag, which shows the following information:

- Name and address of supplier.
- Project number for which the seed is to be used.
- Suppliers lot number for each kind of seed in the mixture.
- Origin (where grown) for each kind of seed.
- Purity, germination, and other information required by South Dakota Seed Law for each kind of seed.
- Pounds of bulk seed of each kind of seed in each bag.
- Total pounds of bulk seed mixture in each bag.

- Pounds of pure live seed (PLS) of each kind of seed in each bag.
- Total pounds of pure live seed (PLS) mixture in each bag.
- Dormant seed and hard seed.

e. Seed Mixes - Seed mixes for small applications, under two acres, may be the following:

- Irrigated Lawn mix
  80% of at least 3 varieties of Kentucky Bluegrass
  20% Perremial Ryegrass

  Rate of application – 175# per acre

- Non-irrigated lawn mix
  20% Blue Fescue
  20% Chewings Fescue
  20% Creeping Red Fescue
  20% Hard Fescue
  10% Perrenial Ryegrass
  10% NuBlue Kentucky Bluegrass

  Rate of application – 200# per acre

- Road Ditch mix
  40% Crested Wheatgrass
  30% Perrenial Ryegrass
  20% Hard Fescue
  10% Annual Ryegrass

  Rate of application – 100# per acre

Seed mixes for seeding areas over two acres shall be designed to meet site-specific requirements, such as soil type, orientation, slope, irrigation/no-irrigation, soil nutrients, and other. The Contractor shall submit a seed mix listing the specific varieties of seed in the mix intended for use with the Construction Permit Application.

Construction Requirements

a. General - Within seasonal limitations, seeding shall be done as soon as finish grading and topsoiling have been completed. The topsoil to be used in the areas to be seeded or hydroseeded shall have a minimum depth of 6 inches. Seeding or related work shall not be done when the condition of the soil is such that a satisfactory seedbed or uniform seed placement cannot be obtained. Seed shall not be sown when the wind is strong enough to interfere with uniform seed application. Seed shall not be sown on areas under water. Slopes shall be worked longitudinally, on contour, during the preparation of areas, drilling, and after seeding.

b. Seasonal Limitations - Seeding shall not be done between June 15 and August 31. Seeding may be done when the ground is not frozen and condition of the soil permits preparation of a satisfactory seedbed.

c. Equipment and Methods

- Drilling - The specified seed mixture shall be drilled in uniformly, using a press drill equipped with individually mounted, adjustable, spring-loaded, double-disk furrow openers, fitting with depth control bands or drums. The depth control bands or drums shall provide a loose planting depth of one to one and one-half (1 - 1 ½) inches (distance from band to edge of opener disk) before compaction by the press wheel and a final planting depth of three-fourths to one (3/4 – 1) inch behind the press wheel. The press drill shall be mounted on rear press wheels, which carry a major portion of the weight of the drill and having no weight carrying wheels at the ends of the seed box. The press wheels shall be mounted independently of the furrow openers. A press wheel shall follow directly behind each opener to compact the soil over the drill row. The seed box shall be equipped with positive feed mechanisms, which will accurately meter the seed to be planted, and agitators which will prevent bridging in the seed box and keep seeds uniformly mixed during drilling. The drill shall conform to the following:

  Drill Width Maximums:
  Single Units..10 feet
  Flex coupled side-by-side units......................16 feet
  (max. two 8-foot members)

Each drill shall be equipped with a meter, which will measure the area covered by the drill. Each drill shall be equipped with fabricated baffles or partitions mounted a maximum of two (2) feet on centers and flush with the top of the seed box and extending downward to within four (4) inches of the bottom of the seed box.

- Hydro seeding - The specified seed mixture shall be hydro seeded uniformly, using a hydro seeder. The hydro seeder shall be equipped with a gear-driven pump and a paddle agitator. Agitation by re-circulation from the pump will not be allowed. Agitation shall be sufficient to produce homogeneous slurry of seed and fertilizer in the designated proportions. Fertilizer of the specified formulation shall be included at the specified rate.

Specified seed mixtures shall be included at the specified rate. No seed shall be added to the slurry until immediately prior to beginning the seeding operation. Legume seed shall be pellet inoculated with the appropriate bacteria. Inoculation rates shall be four times that required for dry seeding. The time allowed between placement of seed in the hydro seeder and emptying of the hydro seeder tank shall not exceed thirty (30) minutes. Wood cellulose fiber mulch shall be degradable, wood cellulose fiber or one hundred percent (100%) recycled long-fiber pulp, free from weeds or other foreign matter toxic to seed germination and suitable for hydro mulching.

d. Care during Construction and Final Inspection - The Contractor is responsible for smoothing dirt ridges, which result from his operations or from traffic. Such ridges shall be smoothed so they will not interfere with future mowing. Following completion of seeding operations, foot, vehicular, or equipment traffic over the seeded area shall be kept to a minimum. Areas damaged from such traffic shall be reworked and reseeded as determined by the Planning Director. The Contractor shall, prior to acceptance of the project, reseed any area on which the original seed has been lost or displaced.

e. Watering - After seed, fertilizer and mulch have been placed, it shall be watered to provide a moist condition through the mulch as well as into the underlying soil bed. For a period of three weeks after seeding and initial watering, the Contractor shall apply adequate water to insure proper germination of the seed and growth of the grass. At the end of the three (3) week watering period, the Planning Director will make an inspection to determine if the grass is alive and growing. If seed has not satisfactorily rooted into the soil and is not alive and growing, the Planning Director will determine if new seed and/or additional watering, at the Contractors expense, are required. Replaced seed shall be watered as required for the original.

After the Planning Directors acceptance of the newly seeded areas, the Contractor shall notify all affected property owners, with notification of watering requirements provided by the Owner, that they will be responsible for watering the newly seeded areas. The Contractor shall provide written verification that affected property owners have both been notified and have accepted the condition of the newly seeded areas. The growing season is defined as May through September.

Mats, blankets, and nets are available to help stabilize steep slopes and drainage channels. Depending on the product, these may be used alone or in conjunction with straw mulch, fiber mulch or compost. Normally, use of these products will be restricted to relatively small areas. Mats made of jute, coconut fiber, or various geosynthetic fibers can be used instead of mulch. Blankets are straw mulch that have been woven and oftentimes include a synthetic layer or net. Plastic netting may be used to anchor mulch. See Section 102-E for specifications.

E. Erosion Control Blankets or Turf-Reinforcement Mats (TRMs)

Erosion control blankets are biodegradable, open-weave blankets used for establishing and reinforcing vegetation on slopes, ditch bottoms and shorelines. TRMs are synthetic, non-degradable mats that are usually buried to add stability to soils. They come in a wide range of designs and have been proven to be valuable on slopes and in channel-lining applications. Erosion control blankets and TRMs are especially useful in critical areas such as swales, long channels and slopes steeper than 3:1.

1. Erosion Control Blankets

a. Description

Erosion-control blankets are biodegradable, open-weave blankets used for establishing and reinforcing vegetation on slopes, ditch bottoms and shorelines. Erosion-control blankets and TRMs, are especially useful in critical areas such as swales, long channels and slopes steeper than 3:1.

b. Design

Several categories are provided with different service application and specific uses as shown in the *Erosion Control Blanket Fabric Category Table* below.

Erosion Control Blanket Fabric Category Table

Category	Service Application	Use	Acceptable Types
1	Very Temporary	Flat areas, shoulder drain outlets, roadway shoulders, lawns, mowed areas.	Straw, wood fiber, rapidly degradable netting on one side
2	One Season	Slopes 3:1 and steeper less than 50 ft long, ditches with gradients 2% or less, flow velocities less than 5.0 fps.	Straw, wood fiber, netting on one side
3	One Season	Slopes 3:1 and steeper, more than 50 ft long, ditches with gradients 3% or less, flow velocities less than 6.5 fps.	Straw, wood fiber, netting on one side
4	Semipermanent	Ditches with gradients 4% or less, flow velocities less than 8.0 fps, flow depth 6 inches or less.	Straw/coconut, wood fiber, netting on two sides
5	Semipermanent	Ditches with gradients 8% or less, flow velocities less than 15.0 fps and flow depth less than 8 inches, watercourse banks within the normal flow elevation.	Coconut fiber, netting on two sides

Erosion-control blankets shall consist of a uniform web of interlocking fibers with net backing. The blanket shall be of uniform thickness, with the material fibers being evenly distributed over the area of the blanket. The blankets shall be porous enough to promote plant growth yet shield the underlying soil surface from erosion. All material shall have been properly cured to achieve curled and barbed fibers. All blankets shall be smolder resistant.

The net backing on each blanket shall consist of polypropylene mesh. For Category 1 blankets, the net backing should start to decompose after one month with 80% breakdown occurring within three months. For Category 2 and 3 blankets, the netting should contain sufficient UV stabilization for breakdown to occur within a normal growing season. For Category 4 and 5 blankets, the netting should be UV stabilized to provide a service life of two to three years.

Install erosion-control blankets per manufacturer's recommendations.

2. Turf-Reinforcement Mats (TRM)

Turf-reinforcement mats are synthetic, non-degradable mats that are usually buried to add stability to soils. They come in a wide range of designs and have been proven to be valuable on slopes and in channel-lining applications.

TRMs consisting of non-degradable, three-dimensional matrix materials should be used with expected velocities of 15 fps and shear stress of 8lbs/sf. Beyond these velocities and shears, vegetated structures such as articulated block, cable concrete and cribwalls, should be considered.

Install TRMs per manufacturer's recommendations.

a. Maintenance

Inspect erosion-control blankets and TRMs periodically, and after rainstorms to check for rill erosion, dislocation or failure. Where erosion is observed, repair or replace fabric.

Continue inspections until vegetation is established. If washout occurs, repair the slope grade, reseed and reinstall fabric.

F. Revegetation

A viable vegetative cover shall be established within one (1) year on all disturbed areas and soil stockpiles not otherwise permanently stabilized. Vegetation is not considered established until a ground cover is achieved, which, in the opinion of the County, is sufficiently mature to control soil erosion and can survive severe weather conditions.

1. Seedbed Preparation

Initial preparation of newly graded areas for seeding shall be worked to a minimum depth of 6 inches. Every effort shall be made to obtain this depth on the first pass with tillage equipment. The implement used shall be a tool carrier with rigid shanks and sweeps or chisels or a heavy duty disk as appropriate to the conditions. The implement shall have positive means of controlling depth of penetration.

Lumps or clods exposed by the initial pass of tillage equipment over three (3) inches in diameter shall be broken up. The number of additional passes required breaking up lumps or clods shall be kept to a minimum. Working the soil to a fine, pulverized condition shall be avoided.

After seedbed preparation has been completed, the Contractor shall pick up and dispose of all loose stones or boulders having a vertical projection of two 2) inches (or more above the soil surface. Logs, stumps, brush, weeds, cables, or other foreign material, which might interfere with the proper operation of drills, mowers, or other implements, shall be disposed of by the Contractor.

2. Temporary Revegetation

Temporary revegetation is required on all disturbed areas having a period of exposure prior to final stabilization of one (1) year or longer. All temporary seeding shall be protected with mulch.

To provide temporary vegetative cover on disturbed areas that will not be paved, built upon, or fully landscaped within 12 months but will be completed within 24 months, plant an appropriate annual grass and mulch the planted areas.

3. Permanent Revegetation

To provide vegetative cover on disturbed areas not paved or built upon for two years or longer, or for an indeterminate length of time, a perennial grass mix shall be planted. Each site will have different characteristics, and a landscape professional should be contacted to determine the most suitable seed mix for a specific site (See Section 102-D-2). All permanent seeding shall be protected with mulch.

G. Roads and Soil Stockpiles

Road cuts, road fills, and parking lot areas shall be covered with the appropriate aggregate base course on the surfaces to be paved in lieu of mulching. Early application of road base is suitable where a layer of course aggregate is specified for final road or parking lot construction. This practice may not be desirable in all instances, and is not needed when final pavement construction will take place within 30 days of grading to final contours. All non-paved portions of road cut, fill, and parking lot areas shall be seeded and mulched as soon as possible after final grading has occurred, but in no case later than 14 days after grading has been completed.

Soils stockpiled for more than 60 days shall be seeded with a temporary or permanent grass cover within 14 days after completion of stockpile construction. Mulching is recommended to assure vegetation establishment. If stockpiles are located within close proximity to a drainage way (i.e., one hundred 100 feet), additional sediment control measures, such as a temporary diversion dike, silt fence or filter sock shall be provided.

H. Riprap at Inlets and Outlets

1. Requirements

Stone for riprap shall be hard, angular, and durable and shall have a minimum weight of 155 pounds per cubic foot. Stone may either be quarried ledge rock or field stone. Stone shall be free from overburden, spoil, shale, and organic material and shall meet the following gradation requirements.

	Size of Stone (lbs.)	% of Total Weight
Class I	150 to 100	15 to 25
	100 to 50	15 to 45
	50 to 5	15 to 55
	5 to 0	0 to 10
Class II	500 to 300	15 to 25
	300 to 150	15 to 45
	150 to 15	15 to 55
	15 to 0	0 to 15
Class III	1000 to 600	15 to 25
	600 to 300	15 to 45
	300 to 30	15 to 55
	30 to 0	0 to 15
Class IV	1400 to 1000	15 to 25
	1000 to 500	15 to 45
	500 to 50	15 to 55
	50 to 0	0 to 15
Class V	2000 to 1400	15 to 25
	1400 to 700	15 to 45
	700 to 70	15 to 55
	70 to 0	0 to 20

Each load of riprap shall be well graded from the smallest to the maximum size specified. No more than five percent (5%) by weight shall pass a one-half (1/2) inch square opening sieve.

2. Filter Material

Filter material shall consist of clean, hard, durable, open graded sand, gravel, or rock, crushed or uncrushed, meeting the following gradation requirements by dry weight:

Passing a 3 inch sieve........………….. 100%
Passing a 3/4 inch sieve……………... 70 to 95%
Passing a No. 4 sieve....……………….40 to 75%
Passing a No. 200 sieve....…………….0 to 8%

The P.I. of the filter material shall not exceed six (6).

The material shall be obtained from approved sources, which contain no organic matter or soft friable particles. Pit run local material will be acceptable if the specifications are met.

3. Testing

Plasticity Index...........………………. SD 207
Specific Gravity...........……………… SD 210

103 SEDIMENT CONTROL

Installation of Sediment Control Measures shall comply with the following:

- All construction sites must install necessary perimeter sediment control measures called out in their approved Construction Permit prior to any earth disturbing activities unless the activity is defined in Section 507 (A) of the Pennington County Zoning Ordinance as an exception. This only allows the minimum amount of soil disturbance necessary that is directly related to the installation of these sediment control measures.
- The installation of all other sediment entrapment and control facilities shall begin before major land disturbance activities begin on a construction site in accordance with their time schedule established in their Construction Permit.
- Sediment control will be site specific (located on the site under construction unless designated and approved by the Planning Director) and can include vehicle tracking controls; sod buffer strips around the lower perimeter of the land disturbance; sediment barriers, filters, dikes, traps, or sediment basins; or a combination of any or all of these measures.
- Sediment controls shall be constructed before land disturbance takes place. Earthen structures such as dams, dikes, and diversions shall be mulched within 14 days of installation. Earthen structures that are expected to remain in place for more than one (1) year shall be seeded and mulched.

A. Vehicle Tracking

Wherever construction vehicles enter onto paved public roads, provisions shall be made to prevent the transport of sediment (mud and dirt) by vehicles tracking onto the paved surface. Stabilized access, parking, staging, and loading and unloading areas will reduce the likelihood that vehicles will come into contact with mud. Sites that have not voluntarily implemented these practices may be required to construct a stabilized vehicle tracking control device.

For sites greater than two (2) acres, a stabilized vehicle tracking control shall be constructed. Whenever deemed necessary by Pennington County, wash racks shall be installed to remove mud and dirt from the vehicle and its tires before it enters onto public roads. Whenever sediment is transported onto a public road, regardless of the size of the site, the road shall be cleaned at the end of each day. Sediment shall be removed from roads by shoveling or sweeping and be transported to a controlled sediment disposal area. Street washing shall not be allowed until after sediment is removed in this manner. Storm sewer inlet protective measures shall be in place at the time of street washing.

B. Slope—Length and Runoff Considerations

Cut-and-fill slopes shall be designed and constructed to minimize erosion. This requires consideration of the length and steepness of the slope, the soil type, upslope drainage area, groundwater conditions, and other applicable factors. Slopes that are found to be eroding excessively will require additional slope stabilization until the problem is corrected. The following guidelines shall assist Contractors in developing an adequate design:

- Rough soil surfaces are preferred over smooth surfaces on slopes (see Section 102-A).
- Temporary slope diversion dikes (as discussed in Section 103-B-1) can be constructed at the top of long or steep slopes, or hill slopes that have an upslope tributary drainage area over five (5) acres. Diversion dikes or terraces (Sections 103-B-1 and 103-B-3) may also be used to reduce slope length within the disturbed area.

  Temporary diversion dikes shall be provided whenever:

  $$S^2L>2.5$$

  Where: S = slope of the upstream tributary area (in feet/foot); and
  L = length of the upstream slope (in feet)

- Concentrated storm water shall not be allowed to flow down cut or fill slopes unless contained within an adequately-sized temporary channel diversion, a permanent channel, or temporary slope drain (see Section 103-B-4).
- Wherever a slope face crosses a water seepage plane that endangers the stability of the slope, adequate drainage shall be provided.
- Provide sediment traps, basins, or barriers below slopes to reduce off-site sediment transport or to reduce slope lengths.

1. Slope Diversion Dikes

A temporary slope diversion dike is a horizontal ridge of soil placed perpendicular to the slope and angled slightly to provide drainage along the contour. Temporary diversion dikes can be constructed by excavation of a V-shaped trench or ditch and placement of the fill on the downslope side of the cut.

There are two types of temporary slope diversion dikes:

- A diversion dike located at the top of a slope to divert upland runoff away from the disturbed area. The discharge from undisturbed or previously-developed upland areas collected by these diversion dikes may be directed to a permanent channel or temporary channel diversion. (See Section 104-B)
- A diversion dike located at the base or midslope of a disturbed area to divert sediment-laden water to a sediment trap or basin. The discharge from these diversion dikes may be directed to a temporary slope drain or sediment basin.

2. Roads and Roadside Swales

The drainage system provided for roads will define to some extent the length and area of individual slope segments within the disturbed area. A number of smaller hillslope segments will be created by construction of roads. These areas shall require erosion control as described in Section 102, and sediment controls dependent on the size of upslope tributary area. (See Section 103-C)

For road areas that are not paved within 30 days of final grading, and have not received early application of roadbase (see Section 102-D), rough-cut street controls shall be used. These are runoff barriers that are constructed at intervals down the road. The barrier projects perpendicular to the longitudinal slope from the outer edge of the roadside swale to the crown of the road. The barriers are positioned alternately from the right and left side of the road to allow construction traffic to pass in the unbarricaded lane.

3. Terracing

Sediment can be controlled on slopes that are particularly steep by using terracing. During grading, relatively flat sections, or terraces, are created and separated at intervals by steep slope segments. The steep slope segments are prone to erosion, however, and must be stabilized in some manner. Retaining walls, gabions, cribbing, deadman anchors, rock-filled slope mattresses, and other types of soil retention systems are available for use. These shall be specified in the Construction Permit and installed according to manufacturer's instructions.

4. Slope Drains

There are certain instances when runoff must be directed down a slope within the disturbed area. A temporary slope drain can be used to protect these hillslope areas from scour and additional erosion. A number of alternative designs and materials can be used for a slope drain. The sizing of temporary slope drains shall be defined but do not need rigorous hydraulic analysis. Slope drains shall be sized for a two (2) year storm event. The discharge from all slope drains shall be directed to a stabilized outlet. (See Section 104-C)

C. Sediment Entrapment Facilities

Sediment entrapment facilities are necessary to reduce sediment discharges to downstream properties and receiving waters. Sediment entrapment facilities include silt fences, sod filter strips, sediment traps, sediment basins, silt ditches, wattles, logs and compost socks. The type of sediment entrapment facility to be used depends on the tributary area, basin slope, and slope length of the upstream area. Table 1-2 summarizes the recommended maximum tributary areas, slope lengths, and slopes for seven types of sediment entrapment facilities.

All runoff leaving a disturbed area shall pass through a sediment entrapment facility before it exits the site and flows downstream. An established green filter strip may be adequate for small sites, provided the limits for tributary slope are not exceeded and the flow is not concentrated. Silt fences, wattles, or compost socks may be used for somewhat larger areas, depending on the upslope drainage area. When the tributary area is less than five (5) acres but greater than that allowed for silt fences, wattles, or compost socks, runoff shall be collected in diversion swales and routed through temporary sediment traps.

1. Silt Fence

A silt fence is made of a woven synthetic material that filters runoff. Silt fence can be placed as a temporary barrier at the base of a disturbed area but is not recommended for use in a channel or swale. The material is durable and will last for more than one season if properly installed and maintained.

a. Design

Install silt fences on the contour and construct so that flow cannot bypass the ends. Ensure that the drainage area is no greater than ¼ acre per 100 feet of fence. The use of silt fence as a sediment barrier shall not be used in areas of concentrated flow, such as ditches.

Ensure that the depth of impounded water does not exceed two (2) feet at any point along the fence. The fence must be tied into the slope so that the base of the fence is above the design storage depth. When plastic mesh is used on the heavy duty silt fence, the mesh backing shall be joined to the geotextile at the top with two rows of stitching.

A one (1) foot high by two (2) foot wide berm of compost can be placed at the base of the sediment fence over the fabric lip. Placing the compost over the fabric fence lip eliminates the need to trench and bury the fabric. The compost particle sizes shall be the following: 3 inch-100% passing, 1 inch-90% to 100% passing, ¾ inch-70% to 100% passing, ¼ inch-30% to 75% passing, maximum particle length of 6 inches.

Alternately, a compost berm may be placed in lieu of silt fence. The berm shall be a minimum of two (2) feet high by four (4) feet wide. The particle sizes shall be the following: 3 inch-100% passing, 1 inch-90% to 100% passing, ¾ inch-70% to 100% passing, ¼ inch-30% to 75% passing, maximum particle length of six (6) inches.

Maximum allowable slope lengths contributing runoff to a silt fence are listed in the *Silt Fence Slope Criteria Table*.

Silt Fence Slope Criteria Table

Constructed Slope	**Maximum Slope Length (feet)**
2H:1V	50
3H:1V	75
4H:1V	125
5H:1V	175
Flatter than 5H:1V	200

b. Types

The following three types of silt fences are designated for use based on conditions. For details on each type of fence see the *Silt Fence Specifications Table*.

Heavy Duty: Use at locations where extra strength is required, such as near water bodies; on areas with unstable wetland soils, steep slopes, highly erodible soils or high runoff; and on areas that are inaccessible to equipment.

Preassembled: For light-duty applications, to protect temporary construction or to supplement the other types of silt fence. This type is installed with plow-type equipment with pre-attached stakes spread at six (6) to eight (8) foot intervals.

Machine-Sliced Installation: Appropriate for general use during site grading and to protect critical areas.

Silt Fence Specifications Table

	Heavy Duty		**Machine Sliced**	**Preassembled**
Description	Composite of mesh backing, posts, geotextile and fasteners, assembled		Machine installed geotextile fastened to posts on site	Ready-to-install geotextile attached to driveable posts
Geotextile				
Type	Woven		Woven Monofilament	Woven
Width	48 inches		36 inches	36 inches
Grab Tensile ASTM C4632	100 lb. minimum		130 lb. minimum	100 lb. minimum
Apparent Opening Size ASTM D4751	#20-70 sieve		#30-40 sieve	#20-70 sieve
UV Stability ASTM D4355 500 hours	70 percent minimum		70 percent minimum	70 percent minimum
Flow Rate ASTM D4491 gal/min/sf	NA		100 gal/min/sf	NA
Top Fastening Component	6-inch overlap, top of mesh backing		Selvaged edge	Sewn-in cord
Net Backing				
Material	Woven wire mesh	Plastic mesh	NA	NA
Steel Wire Gauge	14 min.	NA	NA	NA
Max. Mesh Opening	6 inches	2 inches	NA	NA
Rope for Ditch Check				
Type	NA		Polyethylene	NA
Diameter	NA		5/8-inch minimum	NA

Silt Fence Specifications Table (Con't)

Posts			
Material	Steel T-post	Steel T-post with welded plate	Wood
Minimum Size	1.26 lbs/in/ft	1.26 lbs/in/ft	2 x 2 inch
Minimum Length	5 feet	5 feet	5 feet
Min. Embedment	24 inches	24 inches	18 inches
Maximum Spacing	8 feet	6 feet	6 feet
Post Fastener	U-shaped clips	Plastic zip ties, 50 lb. tensile strength	Gun staples
Minimum Fasteners per post	3(for both woven wire and mesh)	3	5
Minimum Fastener Spacing on post	2 foot	1 foot	1 foot

c. Maintenance

Inspect silt fences at least once a week and after each rainfall, or as required by the NPDES permit. Make any required repairs immediately. Repair scoured areas on the back side of the fence at this time to prevent future problems.

Replace silt fence fabric that has torn, collapsed, decomposed or otherwise become ineffective within 24 hours of discovery.

Remove silt deposits once they reach 30 percent of the height of the fence to provide storage volume for the next rain and to reduce pressure on the fence.

Silt fences are to be removed upon stabilization of the contributing drainage area. Accumulated sediment may be spread to form a surface for turf or other vegetation establishment, or disposed of elsewhere. The area should be reshaped to permit natural drainage.

2. Compost Berm

Mulch berms are sediment-trapping devices using composted materials applied with a pneumatic blower device or equivalent. Mulch berms trap sediment by filtering water passing through the berm and allowing water to pond, creating a settling of solids. Mulch berms can be used in areas where runoff is in the form of sheet flow. Mulch berms can also be used in sensitive environmental areas, where migration of aquatic life is impeded by the use of silt fence. These shall be specified in the Construction Permit.

3. Compost Socks, Straw Wattles, Excelsior Logs

These devices are sediment trapping devices which trap sediment by filtering water passing through the sock, wattle, or log and allowing water to pond, allowing the settling of solids. These devices may be used in sensitive environmental areas, where migration of aquatic life is impeded by the use of silt fence. Since trenching is not required for the installation of these devices, these devices may be used in a number of situations where disturbance of the ground is not possible or preferable, such as on frozen ground, pavement, hard or compacted surfaces and rocky soil (or areas where trenching is not allowed due to it causing additional sediment disturbing activities). These devices shall be specified in the permit and installed according to manufacturer's instructions.

4. Filter Strips

Vegetated filter strips cause deposition of sediment within the area of vegetation. Buffer strips of natural vegetation can be left at the time of site grading, or can be created by using sod. A dense ground cover is necessary or runoff will channelize within the area. A minimum width of 20 feet is recommended.

5. Sediment Traps

A sediment trap is a temporary structure that is designed to fill with sediment. A sediment trap can be constructed by either excavating below grade or building an embankment across a swale. Excavated traps are less prone to failure than embankments. No pipe is used at the outlet, as in a sediment basin, and an open-channel spillway shall be included in the design. A minimum of 3,600 cubic feet of storage volume or the volume required for the one-half (1/2) inch of rainfall, which ever is greater, shall be provided for each tributary acre.

If sediment traps are incorporated into the Construction Permit, provide the following:

- Sediment volume required and provided.
- Length, width, and depth of the trap.
- Provide the top elevation of the berm, and length, and elevation for the overflow assembly.

6. Sediment Basins

Areas draining more than 10 acres shall be routed through a sediment basin. Sediment basins shall be designed to a minimum 3,600 cubic feet of volume per tributary acre and be cleaned out prior to becoming half full. Tributary acres shall be the total potential disturbed acres at one time drained to the sediment basin from a construction site or larger common plan of development or sale. This does not have to apply to storm water flows from acres that are:

- Undisturbed onsite areas with no erosion and sediment control issues.
- Previously disturbed onsite areas that have achieved final stabilization.
- Disturbed or undisturbed areas not within the construction site or larger common plan of development or sale.

If the site is to include a post construction storm water quality or flood control detention facility, the permanent detention facility may be used as the temporary sediment basin, provided the outlets are designed for construction activities and are later modified for post construction activities upon completion of construction and final stabilization of disturbed soils. Such permanent detention facilities or post construction water quality BMP's shall be restored to design grades, volumes, and configurations after site development is completed and the project is finalized. The outlet from a sediment basin shall be designed to empty its volume in no less than 16 hours.

When practicable, the basin length shall be no less than twice the basin width. The inflow structures at the entrance of the basin shall be designed to dissipate inflow energy and to spread the flow so as to achieve uniform flow throughout the basin's width. The gravel and rip rap horseshoe sediment basin should be utilized when drainage culverts are already in place prior to site construction activities since existing culverts and roadway fill sections readily afford sediment storage area.

If sediment basins are incorporated into the Construction Permit, provide the following information:

- Delineate the tributary drainage area to each sediment basin.
- Sediment volume required and provided.
- Length, width, and depth of the basin.
- For sediment basins, give the top elevation of the berm, and length, and elevation for the overflow assembly. The outlet structure size and invert elevations will also be provided.

For drainage locations serving less than 10 acres, a sediment basin or a combination of sediment basin(s) and sediment traps providing storage for 3,600 cubic feet of storage per acre drained may be required along with silt fences, socks, wattles, logs, silt ditches, or equivalent sediment controls on all sideslope and downslope boundaries of the construction area.

7. Silt Ditch

A silt ditch is constructed by excavating a small channel along and parallel to the existing contours of the land. Silt ditch can be placed as a temporary barrier at the base of a disturbed area but is not recommended for use in a channel or swale. Silt ditch shall be designed to a minimum 3,600 cubic feet of volume per tributary acre.

The berm constructed on the downstream side of the excavated channel shall be seeded and mulched immediately after construction.

104 DRAINAGEWAY PROTECTION

At times, construction activities must occur adjacent to or within a drainageway. Bottom sediments will be disturbed and transported downstream when that occurs. To minimize the movement of sediments resulting from construction activities that take place within any drainageway temporary facilities can be installed to divert flowing water around such sediment-generating construction activities.

A. Working Within or Crossing a Waterway

Whenever work occurs within a waterway, the following shall be considered as appropriate:

- Construction vehicles shall be kept out of a waterway to the maximum extent practicable. Where in-channel work is necessary, steps, such as temporary channel diversions, shall be taken to stabilize the work area during construction to control erosion. The channel (including bed and banks) shall be restabilized immediately after in-channel work is completed.
- Where an actively-flowing watercourse must be crossed regularly by construction vehicles, a temporary crossing shall be provided. Two primary methods are available: a culverted crossing and a stream ford. A culverted crossing shall be designed to pass the two-year design flow. A ford shall be lined with a minimum six (6) inch thick layer of one and a half (1.5) inch diameter rock. A permit is required for placement of fill in a waterway under Section 404 of the Clean Water Act. The Corps of Engineers office in Pierre, South Dakota, shall be contacted about the requirements for obtaining a 404 permit.
- Whenever feasible, a temporary channel diversion (see Section 104-B) shall be used to bypass the work areas when work takes place within a channel.
- Whenever possible, construction in a waterway shall be sequenced to begin at the most downstream point and work progressively upstream installing required channel and grade control facilities.
- Complete work in small segments, exposing as little of the channel at a time as possible.
- Where possible, perform all in-channel work between September 15 and April 15.
- A Floodplain Development Permit may be required for work in a waterway per Pennington County requirements.

B. Temporary Channel Diversions

Limiting construction activities within actively-flowing water will significantly reduce sediment movement downstream from these activities. This can be done by using a temporary diversion facility that carries water around construction activities taking place within a waterway.

1. Purpose

A temporary stream diversion is the diverting of the base flow of a perennial stream around a construction site by use of a conduit (pipe) or small diversion ditch. Its purpose is:

- To maintain stream flow continuity, quality and habitat and provide a dry working environment for the construction activities.
- To allow the installation of a structure in a perennial stream with minimal impacts on stream turbidity. By temporarily diverting the stream's base flow away from the construction areas and into a stable pipe or channel system, clean water is kept out of the active construction area.

This practice applies where flows are low enough and/or the watershed is small enough to allow normal base flows to be handled practically in a conduit (pipe) or small diversion ditch. It is intended for those situations where the temporary stream diversion will only be needed during the summer-fall months of low stream flow, where the time of construction can be minimized, and the site can be stabilized before winter. For projects involving large streams or rivers that are expected to be under construction for a long period of time, more permanent engineered structures will be needed.

2. Considerations

Any work with a stream is subject to the rules and regulations of the U.S. Army Corps of Engineers for in-stream modifications (404 permits), DENR, and Pennington County.

a. *Timing* - Timing the installation of this measure is critical to minimize impacts on fisheries.

b. *Phasing* **-** To minimize the impact to the stream, phasing the operations must be considered before the stream is diverted. This measure needs to be quickly and carefully installed, well maintained and removed as soon as possible when the construction area is stable.

c. *Constriction of the channel* **-** These practices will increase the velocity of flow due to constriction of the channel and will create a higher potential for erosion and movement of sediments in the stream channel.

d. *Flooding* **-** Any flood flows during the construction period can be expected to damage or destroy this practice. It may contribute to the flooding effects.

e. *Maintenance* **-** This practice is a high maintenance item, and should be considered for use in a cautious manner. The impact of failure on downstream facilities should be carefully considered. In addition, aquatic needs such as fish passage may preclude the use of this practice.

3. Planning Criteria

Select design methods that will least disrupt the existing terrain for the stream reach. Consider the effort that will be required to restore the area after the temporary stream diversion is removed. The following criteria must be considered when selecting a temporary stream diversion method:

a. *Time of year* - The time of year may preclude the selection of one or more of the standard methods due to fish spawning or migration restrictions.
b. *Site Location* - Locate the temporary stream diversion where there will be the least disturbance to the soils of the existing waterway banks.
c. *Removal of the structure* - Ease of removal and subsequent damage to the waterway should be primary factors in considering the choice of a design of the stream diversion.
d. *Maintenance* - This is a high maintenance item. Weather reports need to be monitored and the structure prepared for anticipated storm events.

4. Design Criteria

The construction of any specific temporary stream diversion shall not cause a significant water level difference between the upstream and downstream water surface elevations (not to exceed 1%) and the velocity should be maintained at a rate similar to existing flow conditions.

a. *Fish Passage* - Consult with the South Dakota Game, Fish and Parks for dates of fish spawning or migration within the waterway the work is to occur.
b. *Water Fluctuation* - The base flows of all streams must be maintained at all time.
c. *Time of Operation* - All temporary stream diversions shall be removed within two (2) calendar days after the structure is no longer needed. Unless prior written approval is obtained, all structures shall be removed and the area stabilized before winter.
d. *Aggregate* - There shall be no earth, sands, silts, clays or organic material used for construction within the waterway channel.
e. *Sandbags* - Sandbags shall consist of materials, which are resistant to ultra-violet radiation, tearing and puncture, and woven tightly

enough to prevent leakage of fill material (i.e., sand, fine gravel, etc.).

Provisions for temporary stabilization of the inlet, outlet, and return channel shall be included in the design. The materials used in construction must be sound, and capable of withstanding the loads applied. The materials must also be durable and maintain their integrity for the life of the project.

- Excavation of the channel shall begin at the downstream end and proceed upstream. All excavated materials shall be stockpiled outside of the floodplain and temporarily stabilized to prevent re-entry into the stream channel.
- The height of the diversion structure shall be one half the distance from the streambed to stream bank plus one foot.
- All dewatering of the construction area shall be pumped to a dewatering basin prior to reentering the stream.
- All excavation materials shall be disposed of in an approved disposal area outside the 100- year floodplain unless otherwise approved.
- The downstream and upstream connection to the natural channel shall be constructed under dry conditions. Sandbags shall contain the stream.
- The process of excavation and stabilization shall be a continuous (uninterrupted) operation. All materials shall be on-site prior to channel construction.
- Periodic inspection and maintenance shall be performed as needed to ensure that the diversion, streambed and streambanks are maintained and not damaged. Maintenance shall include removal and disposal of any trapped sediment or debris. Sediment shall be disposed of outside of the flood plain and stabilized.

5. Removal of the Diversion

- Water shall not be allowed through the natural stream until all construction is completed.· When the diversion is no longer needed, all structures shall be removed within two (2) calendar days.
- After diversion of the stream back to the natural streambed, the temporary diversion channel shall be backfilled and stabilized. Points of tie-in to the natural channel shall be stabilized.

Permanent drainage channels shall be constructed at the earliest possible stage of development. Temporary channel diversions shall not remain in place for more than two (2) years prior to removal or replacement by permanent facilities.

C. Stability Considerations

Temporary channels are not likely to be in service long enough to establish adequate vegetative lining. Temporary channel diversions must be designed to be stable for the design flow with the channel shear stress less than the critical tractive shear stress for the channel lining material. Unlined channels shall not be used unless it can be demonstrated that an unlined channel will not erode during the design flow.

D. Outlet Protection

The outlets of slope drains, culverts, sediment traps, and sediment basins shall be protected from erosion and scour. Outlet protection shall be provided where the velocity of flow will exceed the maximum permissible velocity of the material where discharge occurs. This may require the use of a riprap apron at the outlet location.

Check dams can be used in ditches or swales and downstream of the outlets of temporary slope drains, culverts, sediment traps, and sediment basins. Check dams reduce the velocity of concentrated flows and trap sediment eroded from the upstream ditch or swale. They are not a primary sediment trapping facility and are a temporary flow-control structure.

Check dams may be used under the following conditions:

- In temporary or permanent swales that need protection during the establishment of grasses;
- In permanent swales that need protection prior to installation of a non-erodible lining;
- In temporary ditches or swales that need protection where construction of a non-erodible lining is not practicable.

Check dams shall be constructed of four (4) to six (6) inch angular rock or compost socks to a maximum height of two (2) feet. The center of the top of the dam shall be six (6) inches lower than the sides to concentrate the flow to the channel center. Where multiple check dams are used, the top of the lower dam shall be at the same topographical elevation as the toe of the upper dam.

Sediment that collects behind a check dam shall be removed when the sediment reaches the spillway level. Check dams constructed in permanent swales shall be removed when perennial grasses have become established, or immediately prior to installation of a non-erodible lining. All of the rock and accumulated sediment shall be removed, and the area seeded and mulched, or otherwise stabilized. The compost sock check dam may remain in place if it is intended to be permanently vegetated.

E. Inlet Protection

All storm sewer inlets that are made operable during construction shall be protected to prevent sediment-laden runoff from entering the conveyance system without first being filtered or otherwise treated to remove sediment. There are numerous methods and devices that can be used to protect inlets. These methods and devices shall be specified in the Construction Permit and installed according to manufacturer's instructions. Inlets may be temporarily blocked to prevent sediment-laden runoff from entering storm sewers. Inlet protection measures shall be removed after upstream disturbed areas are stabilized.

Caution must be used in temporarily blocking inlets to assure that localized flooding conditions do not develop.

Inlet protection shall be removed from storm sewer inlets within paved street sections or parking lots during the winter months between December 1 and February 15. The County may require removals earlier than December 1 or installations later than February 15. During the period when inlet protection has been removed, alternate erosion control methods for inlet protection must be employed if ground is not stabilized by frozen conditions.

105 UNDERGROUND UTILITY CONSTRUCTION

The construction of underground utility lines that are not exempted (see Section 101-A-1) shall be subject to the following criteria:

- Where consistent with safety and space considerations, excavated material is to be placed on the uphill side of trenches.
- Trench dewatering devices shall discharge in a manner that will not adversely affect flowing streams, wetlands, drainage systems, or offsite from the property. Site dewatering permit requirements shall be discussed with the South Dakota Department of Environment and Natural Resources.
- Provide storm sewer inlet protection (see Section 104-D) whenever soil erosion from the excavated material has the potential for entering the storm drainage system.

106 DISPOSITION OF TEMPORARY MEASURES

All temporary erosion and sediment control measures shall be removed and disposed within 30 days after final site stabilization is achieved, or after the temporary measures are no longer needed, whichever occurs earliest, or as authorized by the Planning Director. For example, a site containing only one building shall have temporary erosion control measures removed after building construction is complete and final landscaping is in place.

Temporary erosion control measures shall be removed from a commercial construction site or residential subdivision only after streets are paved and all areas have achieved final stabilization. Trapped sediment and disturbed soil areas resulting from the disposal of temporary measures shall be returned to final permit grades and permanently stabilized to prevent further soil erosion.

As part of the Construction Permit, the Site Plan shall include a schedule of removal dates for temporary control measures. The schedule shall be consistent with key construction items such as street paving, final stabilization of disturbed areas, or installation of structural storm water controls.

107 MAINTENANCE

All temporary and permanent erosion and sediment control practices shall be maintained and repaired by the owner during the construction phase as needed to assure continued performance of their intended function. Sediment traps and basins will require periodic sediment removal when the design storage level is half full. All facilities shall be inspected by the owner or owner's representative following each heavy precipitation or snowmelt event that results in runoff.

As part of the Construction Permit, the person(s) preparing the Site Plan shall submit a schedule of planned maintenance activities for temporary and permanent erosion and sediment control measures. The schedule shall be consistent with the level of maintenance required for the control measures proposed in the permit. A suggested maintenance plan is located in the Appendix as Table 1-5.

108 POLLUTION PREVENTION USING NONSTRUCTURAL BMPS

Nonstructural BMPs are to be a part of construction activities.

A. Objectives in the Use of Nonstructural BMPs

Nonstructural BMPs differ from the structural BMPs because they focus on activities to control water quality rather than physical structures. Because they rely on actions and not structures, nonstructural BMPs must be implemented constantly and repetitively over time. There are two main objectives of using nonstructural BMPs. These are:

- Reduce or eliminate the pollutants that impact water quality at their source, thus reducing the need for structural control requirements. The use of nonstructural BMP practices may assist structural BMP efficiency and may eliminate the need for additional storm water treatment.
- Address water quality concerns that are not considered cost-effective by structural controls such as implementing a spill prevention and containment program.

B. Nonstructural BMP Effectiveness

To be effective, nonstructural BMPs need to prevent or reduce the sources of storm water pollution. They fall into the general categories of prevention and source controls. The objectives for promoting the use of nonstructural BMPs are as follows:

- Improve the quality of receiving waters.
- Increase consistency with storm water quality objectives.
- Increase consistency with structural BMPs.
- Improve cost-effectiveness.
- Widespread applicability in all urban areas.
- Widespread public acceptance.

C. Pollutant Removal Mechanisms

Nonstructural BMPs can, to some degree, prevent the deposition of pollutants on the urban landscape or remove pollutants at their source. The source of pollutants for assimilation into storm water is the land surface itself, especially the impervious surfaces in the urban area. Thus, it is expected that when nonstructural measures are effectively implemented, they will reduce the amount of pollutants being deposited on land surfaces for eventual contact with storm water and transported to the receiving water system.

D. Selection of Appropriate Nonstructural BMPs

Development projects shall include nonstructural BMPs as listed in Table 1-3.

E. Good Housekeeping

1. Descriptions

Good housekeeping requires keeping potential areas where pollutants exist clean and orderly.

2. Application

Good housekeeping practices are designed to maintain a clean and orderly work environment. The most effective first steps towards preventing pollution in storm water from work sites simply involves using good common sense to improve the facility's basic housekeeping methods. Some simple procedures a site can use to promote good housekeeping are improved operation and maintenance of machinery and processes, material storage practices, material inventory controls, routine and regular cleanup schedules, maintaining well organized work areas, signage, and educational programs for employees and the general public about all of these practices.

3. Contact Information Display Requirement

The owner/developer shall post a 24-hour, seven (7) days-a-week sign with the contractor's contact name and contractor's phone number readily visible at the development site entrance. A Pennington County approved 24-hour contact number to register complaints must also be included on the sign.

The contact information shall be clearly readable, securely anchored, and appropriately weatherproofed to assure its integrity throughout construction. The following or similar format shall be used:

To report erosion, sediment, spill, or other problems at this construction site to the responsible contractor call:

Contractor Name

Contractor Phone

To register a complaint about this construction site to Pennington County call 605-394-2186.

4. Implementation

These BMPs are applicable to the following areas: operation and maintenance, material storage, material inventory, and training and participation.

5. Operation and Maintenance

To assure that equipment and work related processes are working well, the following practices can be implemented:

- Maintain dry and clean floors and ground surfaces by using brooms, shovels, vacuum cleaners, or cleaning machines rather than wet cleanup methods.
- Regularly pick up and dispose of garbage and waste material.
- Make sure all equipment and related processes are working properly and preventative maintenance is kept up with on both.
- Routinely inspect equipment and processes for leaks or conditions that could lead to discharges of chemicals or contact of storm water with raw materials, intermediate materials, waste materials, or products used on site.
- Assure all spill cleanup procedures are understood by employees. Training of employees on proper cleanup procedures shall be implemented.
- Designate separate areas of the site for auto parking, vehicle refueling, and routine maintenance.
- Clean up leaks, drips, and other spills immediately.
- Cover and maintain dumpsters and waste receptacles.

6. Material Storage Practices

Improperly storing material on site can lead to the release of materials and chemicals that can cause storm water runoff pollution. Proper storage techniques include the following:

- Provide adequate aisle space to facilitate material transfer and ease of access for inspection.
- Store containers, drums, and bags away from direct traffic routes to prevent accidental spills.

- Stack containers according to manufacturer's instructions to avoid damaging the containers from improper weight distribution.
- Store containers on pallets or similar devices to prevent corrosion of containers that results from containers coming in contact with moisture on the ground.
- Store toxic or hazardous liquids within curbed areas or secondary containers.
- Assign responsibility of hazardous material inventory to a limited number of people who are trained to handle such materials.

7. Material Inventory Practices

An up-to-date inventory kept on all materials (both hazardous and nonhazardous) present on site will help track how materials are stored and handled onsite, and identify which materials and activities pose the most risk to the environment. The following description provides the basic steps in completing a material inventory:

- Identify all chemical substances present at work site. Perform a walk-through of the site, review purchase orders, list all chemical substances used, and obtain Material Safety Data Sheets (MSDS) for all chemicals.
- Label all containers. Labels shall provide name and type of substance, stock number, expiration date, health hazards, handling suggestions, and first aid information. This information can also be found on an MSDS.
- Clearly mark on the hazardous materials inventory which chemicals require special handling, storage, use, and disposal considerations. Decisions on the amounts of hazardous materials that are stored on site shall include an evaluation of any emergency control systems that are in place. All storage areas shall be designed to contain any spills.

8. Training and Participation

Frequent and proper training in good housekeeping techniques reduces the possibility of chemicals or equipment that will be mishandled. Reducing waste generation is another important pollution prevention technique. The following are ways to get people involved in good housekeeping practices:

- Provide information sessions on good housekeeping practices in training programs.
- Discuss good housekeeping at meetings.
- Publicize pollution prevention concepts through posters or signs.

F. Spill Prevention and Response

1. Primary Users

Facilities with fluids such as fuel, paints, and other liquids both hazardous and nonhazardous.

2. Description and Application

This BMP includes measures to be taken to assure that spills do not result in water quality impacts. Spills and leaks together are one of the largest sources of storm water pollutants, and in most cases are avoidable.

3. Implementation

a. Spill Prevention Measures

The following preventative strategies are recommended where fluids are commonly present:

- Identify all equipment that may be exposed to storm water, pollutants that may be generated, and possible sources of leaks or discharges.
- Perform regular maintenance of each piece of equipment to check for proper operation, leaks, malfunctions, and evidence of leaks or discharge (stains). Develop a procedure for spill reporting, cleanup, and repair.
- Drain or replace motor oil or other automotive fluids in an area away from streams or storm or sanitary sewer inlets. Collect spent fluids and recycle or dispose of properly.
- In fueling areas, clean up spills with dry cleanup methods (absorbents), and use damp cloths on gas pumps and damp mops on floors instead of a hose. An important part of spill prevention is employee training. Make sure employees are trained in spill prevention practices and adhere to them.

The best way to prevent pollutants from entering the storm drains is to prevent storm water from contacting equipment or surfaces that may have oil, grease, or other pollutants. Some good activities to help prevent negative impacts on storm water quality include:

- Properly dispose of storm water that has collected in containment areas (may need permit if contaminated).
- Adopt effective housekeeping practices.
- Assure adequate security to prevent vandalism.

G. Identification of Spill Areas

It is important to identify potential spill areas and their drainage points to determine preventative measures and spill response actions. Areas and activities that are most vulnerable to spills include transportation facilities where vehicle spills could be a problem:

- Loading and unloading areas
- Storage areas
- Process activities
- Dust or particulate generating processes
- Waste disposal activities

In addition to these areas, evaluate spill potential in other areas (access roads, parking lots, power generating facilities, etc.). It is also important to estimate the possible spill volume and drainage paths.

H. Material Handling Procedures

Outdoor materials handling procedures include:

- For permanent and long-term (greater than three (3) months) storage, keep bulk solid materials (including raw materials, sand, gravel, topsoil, compost, concrete, packing materials, and metal products) covered or protected from storm water.
- Isolate and consolidate bulk materials from storm water runoff by providing berms or other means to keep the material from migrating into drainage systems.
- When possible, store materials such as salt, hazardous materials, and other materials prone to leaching when exposed to storm water on a paved surface.
- Locate material storage areas away from storm drains, ponds, and drainageways.
- Hazardous materials must be stored according to federal, state, and local HazMat requirements.
- Adopt procedures that reduce the chance of spills or leaks during filling or transfer of materials.
- Substitute less or nontoxic materials for toxic materials.

I. Spill Response Procedures and Equipment

- Wipe up small spills with a shop rag, store shop rags in covered rag container, and dispose of properly (or take to professional cleaning service and inform them of the materials on the rag).
- Contain medium-sized spills with absorbents (kitty litter, sawdust, etc.) and use inflatable berms or absorbent rolls or “snakes” as temporary booms for the spill.

Store and dispose of absorbents properly. Wet/dry vacuums may also be used, but not for volatile fluids.

- For large spills, first contain the spill and plug storm drain inlets where the liquid may migrate offsite, then clean up the spill. Contact appropriate emergency response agency according to state and local requirements.

1. Spill Plan Development

The Construction Permit shall include a description of construction and waste materials expected to be stored on-site, with updates as appropriate. The Construction Permit shall also include a description of controls to reduce pollutants from these materials including storage practices to minimize exposure of the materials to storm water, and spill prevention and response.

2. Advantages and Disadvantages

Table 1-4 lists the advantages and disadvantages of different BMPs for spills.

109 INSPECTIONS

The owner/developer shall assure that qualified personnel inspect the site at least once every 7 calendar days and within 24 hours of the end of a storm that is one-half (1/2) inch or greater to confirm Construction Permit compliance. The minimum qualifications for who shall perform inspections based on the size of the site and the disturbed area are listed below.

SIZE OF SITE DISTURBED AREA MINIMUM QUALIFICATIONS

- Less than 10,000 square feet - Formal inspections are not required; however these sites are still required to perform erosion and sediment control to protect the storm drainage system and drainage areas.

- Greater than or equal to 10,000 square feet but less than one acre – Formal inspections will be performed by Planning Department personnel and/or the Drainage Engineer. All inspection forms will be reviewed and deemed in compliance with Pennington County requirements by the Pennington County Planning Director and/or Drainage Engineer.

- Greater than or equal to one acre – Formal inspections will be performed by the Contractor's Staff, Pennington County and DENR.

Based on the results of the inspection, the Construction Permit shall be revised and implemented, in no case later than seven (7) calendar days following the inspection. The inspection shall look for evidence of or the potential for pollutants entering the drainage system or leaving the site and shall include disturbed areas of the construction site that have not been finally stabilize, areas used for storage of materials, structural and nonstructural control measures, and locations where vehicles enter or exit the site.

A report summarizing the areas inspected, name(s) and title(s) of personnel making the inspection, the date(s) of the inspection, major observations, and corrective actions taken shall be made and retained as part of the Construction Permit for a least three (3) years. Such reports shall identify any incidents of noncompliance. Where an inspection does not identify any incidents of noncompliance, the report shall contain a certification that the site is in compliance with the Construction Permit.

110 DEFINITIONS

ACRE – 43,560 square feet.

BEST MANAGEMENT PRACTICES (BMP's) – Non-structural or structural device, measure, facility, or activity which helps to achieve soil erosion and storm water management control objectives at a site.

CLEAN WATER ACT (CWA) – The Federal Water Pollution Control Act (33 U.S.C. § 1251 et seq.), and any subsequent amendments thereto.

CLEARING – Any activity that removes the vegetative surface cover.

CONSTRUCTION ACTIVITY – Ground surface disturbing activities, which include, but are not limited to, clearing, grading, excavation, demolition, installation of new or improved haul roads and access roads, staging areas, stockpiling of fill materials, and borrow areas. Construction does not include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of the facility.

CONSTRUCTION PERMIT – Permit issued by Pennington County for construction, excavating, clearing, and/or any land disturbing activity.

DENR – South Dakota Department of Environment and Natural Resources.

DRAINAGE WAY – A channel that conveys surface runoff throughout the site.

DISTURBANCE – Any type of activity that involves grading, clearing, moving topsoil, rock, or any other natural surface from property. Includes bringing in fill material onto the site.

EROSION - The wearing away of the land surface by water, wind, ice, or other geological agents, including the detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

EROSION CONTROL – Measures which prevent erosion.

EROSION CONTROL MEASURES - Practices that slow or stop erosion.

ERODIBILITY - The susceptibility of a particular soil type to erosion by water or wind.

FACILITY – Anything that controls the discharge of storm water. Storm water facilities include storage facilities (ponds, vaults, underground tanks, and infiltration systems); water quality facilities (wetponds, biofiltration swales, constructed wetlands, sand filters, and oil/water separators); and conveyance systems (ditches, pipes, and catch basins).

FINAL STABILIZATION - Completion of all land disturbing activities, removal of all temporary sediment controls, establishment of vegetative cover on exposed soil areas, and installation of permanent roads and structural storm water quality best management practices.

IMPERVIOUS AREA – Impermeable surfaces such as paved driveways, parking areas, sidewalks, or roads which prevent infiltration of water into soil.

MAPPING UNIT - Soil name and symbol given in the Soil Conservation Service Soil Survey for each soil type.

MINOR IMPACT CONSTRUCTION SITES (MICS) - Individual lots involving less than one (1) acre of disturbed area in a subdivision or larger common plan of development which shall not be considered separate construction projects, but rather as a part of the subdivision development as a whole.

MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) – A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains:

1. Owned and operated by a state, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under state law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;
2. Designed or used for collecting or conveying storm water;
3. Which is not a combined sewer; and
4. Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR §122.2.

PERMANENT - Installation of land-surface cover, or erosion and sediment control measures that will remain in place for a long period of time.

PLANNING DIRECTOR – The Pennington County Planning Director, Pennington County Planning Department staff working under the direction of the Pennington County Planning Director, or other employees or independent contractors of Pennington County designated by the Pennington County Planning Director to enforce Section 507 (A) of the Pennington County Zoning Ordinance.

POLLUTANT – Any dredged spoil, solid waste, incinerator residue, sewage, sewage sludge, garbage, trash, munitions, chemical wastes, biological material, radioactive material, heat, wrecked or discarded equipment, rock, sand, cellar dirt, or other industrial, municipal, or agricultural waste discharged into waters of the state. This term does not mean sewage from watercraft; or water, gas, or other material which is injected into a well to facilitate production of oil or gas; or water derived in association with oil and gas production and disposed of in a well, if the well used to facilitate production or for disposal purposes and is approved by the appropriate state authority.

SEDIMENTATION - The process of solid materials, both inorganic (mineral) and organic, coming to rest on the earth's surface either above or below sea level.

SEDIMENT - Particulate solid material, either inorganic or organic, that will settle or be deposited in a liquid under the force of gravity.

SEDIMENT BARRIER - Device which prevents sediment from traveling past the installation point.

SEDIMENT BASIN - A depression either excavated or formed by a dam that holds water and debris and facilitates sedimentation of soil particles. Normally used for drainage areas equal to and greater than 5.0 acres.

SEDIMENT TRAP - A small depression that holds water and debris and facilitates sedimentation. Normally used for drainage areas less than 5.0 acres.

SITE PLAN – Plan showing, in detail, the boundaries of a site and the location of all improvements, utilities, drainage, structures, and specific measures, and their location, used to control sediment and erosion, for a specific parcel of land.

STABILIZATION – The use of practices that limit exposed soils from eroding, including but not limited to grass, trees, sod, mulch, or other materials which prevent erosion and maintain moisture.

STORM WATER – Any surface flow, runoff, and/or drainage consisting entirely of water from any form of natural precipitation~~,~~ and resulting from such precipitation.

TEMPORARY - Installation of erosion or sediment control measures, either structural or nonstructural, that are planned to be removed or inactivated after a period of time.

VIABLE VEGETATIVE COVER - A measure of performance for establishment of appropriate vegetative cover (or density) on sites planned for revegetation for the period of duration or successful growth as accepted by the City and county of jurisdiction.

WATERCOURSE - A natural or artificial channel through which storm water or flood water can flow, either regularly or intermittently.

111 APPENDIX

Table 1-1

Maximum Time Limits of Land Exposures for Selection of Erosion Controls

Erosion Control Method Maximum	Allowable Period of Exposure (Months)
Surface Roughening	1
Mulching	12
Temporary Revegetation	12-24
Permanent Revegetation	24 or more
Soil Stockpile Revegetation	2
Early Application of Road Base	1

Table 1-2

Sediment Entrapment Facility Limitations

	Allowable Limits		
Sediment Control Facility	**Max Tributary Drainage Area (ac)**	**Max Tributary Slope Lengths (ft)**	**Tributary Slope Gradients**
Sod Filter Strips	n/a	50	6:1 (17%)
Silt Fence	0.5 per 100 linear foot	50 75 125 175 200	2:1 (50%) 3:1 4:1 5:1 Flatter than 5:1
Silt Ditch	0.5 per 100 linear foot	n/a	n/a
Sediment Trap	5.0	n/a	n/a
Sediment Basin	n/a	n/a	n/a
Straw Wattle – 9" Diameter	n/a	20* 20* 20* 50 75	2:1 3:1 4:1 5:1 Flatter than 5:1
Compost Stock – 8" Diameter	n/a	25* 50* 75 100 125	2:1 3:1 4:1 5:1 Flatter than 5:1

Table 1-2 (Con't)

Sediment Entrapment Facility Limitations

	Allowable Limits		
Sediment Control Facility	**Max Tributary Drainage Area (ac)**	**Max Tributary Slope Lengths (ft)**	**Tributary Slope Gradients**
Compost Stock – 12" Diameter	n/a	25 50 100 125 250	2:1 3:1 4:1 5:1 Flatter than 5:1
Compost Stock – 18" Diameter	n/a	50 75 150 200 300	2:1 3:1 4:1 5:1 Flatter than 5:1
Compost Stock – 24" Diameter	n/a	75 100 200 250 350	2:1 3:1 4:1 5:1 Flatter than 5:1
Compost Berm	n/a	25 50 100 125 250	2:1 3:1 4:1 5:1 Flatter than 5:1

Table 1-3

Nonstructural BMP Requirements for Various Projects

Nonstructural BMP	**Project Description and Requirement**
Good Housekeeping	Required for all projects
Spill Prevention and Response	▪ Small projects with nonreportable quantities of hazardous materials: select BMPs as appropriate. ▪ Medium sized projects with nonreportable quantities of hazardous materials: selected BMPs as appropriate; spill prevention plan reviewed on case by case basis. ▪ Reportable quantities of hazardous materials or large projects: spill prevention plan required.

Table 1-4

Advantages and Disadvantages of BMPs for Spill Prevention and Response BMPs

Best Management Practice Advantages Disadvantages
Drip pans. Pans used to contain small volumes of leaks. Inexpensive; simple installation and operation; possible reuse/recycle of material; empty/discarded containers can be used as drip pans. Small volumes; inspected and cleaned frequently; must be secured during poor weather conditions, and personnel must be trained in proper disposal methods.
Covering. Enclosure of outdoor materials, equipment, containers, or processes. Simple and effective; usually inexpensive. Frequent inspection, possible health/safety problems if built over certain activities, large structures can be expensive.
Vehicle positioning. Locating trucks or rail cars to prevent spills during transfer of materials. Inexpensive, easy, effective. May require redesign of loading and unloading areas, requires signage to designated areas.
Loading/Unloading by Air Pressure or Vacuum. For transfer of dry chemicals or solids. Quick and simple; economical if materials can be recovered; minimize exposure of pollutants to storm water. Costly to install and maintain; may be inappropriate for denser materials, site specific design; dust collectors may need permit under Clean Air Act.
Sweeping. With brooms to remove small quantities of dry chemicals/solids exposed to precipitation. Inexpensive, no special training; recycling opportunities. Labor-intensive; limited to small releases of dry materials, requires disposal to solid waste container.
Shoveling. For removal of large quantities of dry materials, wet solids and sludge. Inexpensive; recycling opportunities, remediate larger releases; wet and dry releases. Labor-intensive; not appropriate for large spills, requires backfill of excavated areas to maintain grade.
Excavation. By plow or backhoe for large releases of dry material and contaminated areas. Cost-effective for cleaning up dry materials release; common and simple. Less precise, less recycling and reuse opportunities, may require imported material for backfill.
Dust Control (Industrial). Water spraying, negative pressure systems, collector systems, filter systems, street sweeping. May reduce respiratory problems in employees around the site; may cause less loss of material and save money; efficient collection of larger dust particles. More expensive than manual systems; difficult to maintain by plant personnel; labor and equipment intensive; street sweepers may not be effective for all pollutants.
Signs and Labels. Inexpensive and easily used. Must be updated/maintained so they are legible, subject to vandalism and loss.
Security. To prevent accidental or intentional release of materials. Preventative safeguard; easier detection of vandals, thieves, spills, leaks, releases; prevents spills with better lighting, no unauthorized access to facility. May not be feasible for smaller facilities; may be costly; may increase energy costs due to increased lighting; dispersed locations require individuals enclosures, requires maintenance.
Area Control Measures. Good housekeeping measures, brushing off clothing before leaving area, etc. Easy to implement; results in cleaner facility and improved work environment. May be seen as tedious by employees and may not be followed.

Table 1-4 (Con't)

Advantages and Disadvantages of BMPs for Spill Prevention and Response BMPs

Best Management Practice Advantages Disadvantages
Preservation of Natural Vegetation. Can handle more storm water runoff than newly seeded areas; effective immediately; increases filter capacity; enhances aesthetics; provides areas for infiltration; wildlife can remain undisturbed; provides noise buffers; less maintenance than new vegetation. Planning required to preserve and maintain existing vegetation; may not be cost-effective with high land costs; may constrict area available for construction activities, may require signage or fencing, subject to disturbance.
Temporary Seeding. Short-term vegetative cover on disturbed areas. Inexpensive and easy to do; establishes plant cover quickly in good conditions; stabilizes soils well; aesthetic; sedimentation controls for other site areas; helps reduce maintenance costs of other controls. Requires soil preparation, may require mulching or reseeding of failed areas, seasonally limited, may require signage or fencing, subject to disturbance.

Table 1-5

Maintenance Activities for Erosion and Sediment Control BMPs

Vehicle Tracking Pad. ▪ The street areas adjacent to the tracking pad shall be cleaned daily at the end of each construction day with a street sweeper with vacuum capabilities. ▪ New rock shall be added to the tracking pad whenever the existing rock becomes buried. ▪ Periodic top-dressing with additional rock, or removal and reinstallation of the pad may be necessary to prevent tracking of mud onto paved roads.
Grading. ▪ Periodically check all graded areas and the supporting erosion and sediment control practices, especially after heavy rainfalls. ▪ Promptly remove all sediment from diversions and other water-disposal practices. If washouts or breaks occur, repair them immediately. ▪ Promptly maintain small, eroded areas before they become significant gullies.
Check Dams. ▪ Inspect check dams and drainage ways for damage after each runoff event. ▪ Anticipate submergence and deposition above the check dam and erosion from high flows around the edges of the dam. ▪ Correct all damage immediately. If significant erosion occurs between dams, additional protection may be required. This may include a protective liner in that portion of the channel or placing additional check dams. ▪ Remove sediment accumulated behind the dams as needed to prevent damage to channel vegetation, allow the channel to drain through the check dam, and prevent large flows from carrying sediment over the dam. ▪ Add materials or remove and replace materials in the dams as needed to maintain design height, cross section, and flow through characteristics.

Table 1-5 (Con't)

Maintenance Activities for Erosion and Sediment Control BMPs

Silt Fence. ▪ Inspect silt fence at least once a week and after each rainfall event of greater than 0.5 inches. Make any required repairs immediately. Repair scoured areas on the back side of the fence at this time to prevent future problems. ▪ Repair silt fence fabric that has torn, collapsed, decomposed or otherwise become ineffective within 24 hours of discovery. ▪ Remove silt deposits once they reach 30 percent of the height of the fence to provide storage volume for the next rain and to reduce pressure on the fence. ▪ Silt fences are to be removed upon stabilization of the contributing drainage area. ▪ Accumulated sediment may be spread to form a surface for turf or other vegetation establishment, or disposed of elsewhere. The area should be reshaped and revegetated to permit natural drainage.
Compost Socks, Straw Wattles, Excelsior Logs. ▪ Inspect device at least once a week and after each rainfall event of greater than 0.5 inches. Make any required repairs immediately. Repair scoured areas on the back side of the device at this time to prevent future problems. ▪ Repair the device fabric that has torn, decomposed or otherwise become ineffective within 24 hours of discovery. ▪ Remove silt deposits once they reach 33 percent of the height of the device to provide storage volume for the next rain. ▪ These devices shall be routinely inspected to make sure they hold their shape and are producing adequate flow through.
Compost Berms. ▪ Inspect the compost berm at least once a week and after each rainfall event of greater than 0.5 inches. Make any required repairs immediately. ▪ Repair scoured areas on the back side of the berm at this time to prevent future problems. ▪ Remove silt deposits once they reach 30 percent of the height of the berm to provide storage volume for the next rain.
Inlet Protection. ▪ Inspect inlet protection devices at least once a week and after each rainfall event of greater than 0.5 inches. Make any required repairs immediately. ▪ Remove silt deposits once they reach 30 percent of the height of the device to provide storage volume for the next rain. ▪ Geotextiles and rock shall be cleaned or replaced as needed due to plugging and/or draw down restrictions.
Sediment Basins and Traps. ▪ Perform inspections at least once a week and after each rainfall event of greater than 0.5 inches. ▪ Remove sediment when the basin or trap becomes half full. ▪ Excavated sediment must be placed in a location where it will not easily erode again. ▪ If the outlet becomes clogged with sediment, it shall be cleaned to restore its flow capacity.

Table 1-5 (Con't)

Maintenance Activities for Erosion and Sediment Control BMPs

Mulch and Compost. Inspect mulch and compost blankets periodically, and after rainstorms to check for rill erosion, dislocation or failure. Where erosion is observed, apply additional mulch or compost.
Erosion Control Blankets and Turf Reinforcement Mats. Inspect at least once a week and after each rainfall event of greater than 0.5 inches. Make any required repairs immediately.

SECTION 200 – POST-CONSTRUCTION STORMWATER QUALITY

201 GENERAL STATEMENT

Land development changes not only the physical, but also the chemical and biological conditions of Rapid City's waterways and water resources. This section describes the changes that occur due to development, the resulting storm water runoff impacts, and the Best Management Practices (BMPs) which can be used for improving storm water quality. The design goal of the BMPs is to achieve removal of 80 percent of the total suspended solids (TSS) from the first half-inch (1/2) of rainfall at a designated site. A Construction Permit is required according to Section 507 (A) of the Pennington County Zoning Ordinance and the items required for the permit are presented in Section 300 of this manual.

A. Development Changes Land and Runoff

When land is developed, the hydrology, or the natural cycle of water is disrupted and altered. Clearing removes the vegetation that intercepts, slows and returns rainfall to the air through evaporation and transpiration. Grading flattens hilly terrain and fills in natural depressions that slow and provide temporary storage for rainfall. The topsoil and sponge-like layers of humus are scraped and removed and the remaining subsoil is compacted. Rainfall that once seeped into the ground now runs off the surface. The addition of buildings, roadways, parking lots and other surfaces that are impervious to rainfall further reduces infiltration and increases runoff.

Depending on the magnitude of changes to the land surface, the total runoff volume can increase dramatically. These changes not only increase the total volume of runoff, but also accelerate the rate at which runoff flows across the land. This effect is further exacerbated by drainage systems such as gutters, storm sewers and lined channels that are designed to quickly carry runoff to creeks and lakes. Development and impervious surfaces also reduce the amount of water that infiltrates into the soil and groundwater, thus reducing the amount of water that can recharge aquifers and feed creek flow during periods of dry weather.

Finally, development and urbanization affect not only the quantity of storm water runoff, but also its quality. Development increases both the concentration and types of pollutants carried by runoff. As it runs over rooftops and lawns, parking lots and industrial sites, storm water picks up and transports a variety of contaminants and pollutants to downstream waterbodies. The loss of the original topsoil and vegetation removes a valuable filtering mechanism for storm water runoff.

The cumulative impact of development and urban activities, and the resultant changes to both storm water quantity and quality in the entire land area that drains to a creek or lake determines the conditions of the waterbody. This land area that drains to the waterbody is known as its watershed. Urban development within a watershed has a number of direct impacts on downstream waters and waterways. These impacts include:

- Changes to stream flow
- Changes to stream geometry
- Impacts to aquatic habitat
- Water quality impacts

B. Changes to Stream Flow

Urban development alters the hydrology of watersheds and streams by disrupting the natural water cycle. This results in:

- Increased Runoff Volumes – Land surface changes can dramatically increase the total volume of runoff generated in a developed watershed.
- Increased Peak Runoff Discharges – Increased peak discharges for a developed watershed can be two (2) to five (5) times higher than those for an undisturbed watershed.
- Greater Runoff Velocities – Impervious surfaces and compacted soils, as well as improvements to the drainage system such as storm drains, pipes and ditches, increase the speed at which rainfall runs off land surfaces within a watershed.
- Timing – As runoff velocities increase, it takes less time for water to run off the land and reach a creek or other waterbody.
- Increased Frequency of Bankfull and Near Bankfull Events – Increased runoff volumes and peak flows increase the frequency and duration of smaller bankfull and near bankfull events which are the primary channel forming events.
- Increased Flooding – Increased runoff volumes and peaks also increase the frequency, duration and severity of out-of-bank flooding.
- Lower Dry Weather Flows (Baseflow) – Reduced infiltration of storm water runoff causes creeks to have less baseflow during dry weather periods and reduces the amount of rainfall recharging groundwater aquifers.

C. Changes to Creek Geometry

The changes in the rates and amounts of runoff from developed watersheds directly affect the morphology, or physical shape and character, of Pennington County's waterways. Some of the impacts due to urban development include:

- Creek Widening and Bank Erosion – Creek channels widen to accommodate and convey the increased runoff and higher stream flows from developed areas. More frequent small and moderate runoff events undercut and scour the lower parts of the creek bank, causing the steeper banks to slump and collapse during larger storms. Higher flow velocities further increase creek bank erosion rates. A creek can widen many times its original size due to post-development runoff.
- Creek Downcutting – Another way that creeks accommodate higher flows is by downcutting their creek bed. This causes instability in the creek profile, or

elevation along a creek’s flow path, which increases velocity and triggers further channel erosion both upstream and downstream.

- Loss of Riparian Tree Canopy – As creek banks are gradually undercut and slump into the channel, the trees that had protected the banks are exposed at the roots. This leaves them more likely to be uprooted during major storms, further weakening bank structure.
- Changes in the Channel Bed Due to Sedimentation – Due to channel erosion and other sources upstream, sediments are deposited in the stream as sandbars and other features, covering the channel bed, or substrate, with shifting deposits of mud, silt and sand.
- Increase in the Floodplain Elevation – To accommodate the higher peak flow rate, a stream’s floodplain elevation typically increases following development in a watershed due to higher peak flows. This problem is compounded by building and filling in floodplain areas, which cause flood heights to rise even further. Property and structures that had not previously been subject to flooding may now be at risk.

D. Impacts to Aquatic Habitat

Along with changes in stream hydrology and morphology, the habitat value of creeks diminishes due to development in a wastershed. Impacts on habitat include:

- Degradation of Habitat Structure – Higher and faster flows due to development can scour channels and wash away entire biological communities. Creek bank erosion and the loss of riparian vegetation reduce habitat for many fish species and other aquatic life, while sediment deposits can smother bottom-dwelling organisms and aquatic habitat.
- Loss of Pool-Riffle Structure – Creeks draining undeveloped watersheds often contain pools of deeper, more slowly flowing water that alternate with “riffles” or shoals of shallower, faster flowing water. These pools and riffles provide valuable habitat for fish and aquatic insects. As a result of the increased flows and sediment loads from urban watersheds, the pools and riffles disappear and are replaced with more uniform, and often shallower, streambeds that provide less varied aquatic habitat.
- Reduce Baseflows – Reduced baseflows due to increased impervious cover in a watershed and the loss of rainfall infiltration into the soil and water table adversely affect in-stream habitats, especially during periods of drought.
- Increased Creek Temperature – Runoff from warm impervious areas, storage in impoundments, loss of riparian vegetation and shallow channels can all cause an increase in temperature in urban creeks. Increased temperatures can reduce dissolved oxygen levels and disrupt the food chain. Certain aquatic species can only survive within a narrow temperature range.
- Decline in Abundance and Biodiversity – When there is a reduction in various habitats and habitat quality, both the number and the variety, or diversity, of organisms (wetland plants, fish, macroinvertebrates, etc.) is also reduced.

Fish and other aquatic organisms are impacted not only by the habitat changes brought on by increased storm water runoff quantity, but are often also adversely affected by water quality changes due to development and resultant land use activities in a watershed.

E. Water Quality Impacts

Nonpoint source pollution, which is the primary cause of polluted storm water runoff and water quality impairment, comes from many diffuse or scattered sources – many of which are the result of human activities within a watershed. Development concentrates and increases the amount of these nonpoint source pollutants. As storm water runoff moves across the land surface, it picks up and carries away both natural and humanmade pollutants, depositing them into Pennington County's creeks, lakes, wetlands, and underground aquifers.

Water quality degradation in urbanizing watersheds starts when development begins. Erosion from construction sites and other disturbed areas contribute large amounts of sediment to various waterbodies. As construction and development proceed, impervious surfaces replace the natural land cover and pollutants from human activities begin to accumulate on these surfaces. During storm events, these pollutants are then washed off into the various waterbodies. Storm water also causes discharges from sewer overflows and leaching from septic tanks. There are a number of other causes of nonpoint source pollution in urban areas that are not specifically related to wet weather events including leaking sewer pipes, sanitary sewage spills, and illicit discharge of commercial/industrial wastewater and wash waters to storm drains. Due to the magnitude of the problem, it is important to understand the nature and sources of urban storm water pollution. Some of the most frequently occurring pollution impacts and their sources for urban creeks are:

- Reduced Oxygen in Creeks – The decomposition process of organic matter uses up dissolved oxygen (DO) in the water, which is essential to fish and other aquatic life. As organic matter is washed off by storm water, dissolved oxygen levels in receiving waters can be rapidly depleted. If the DO deficit is severe enough, fish kills may occur and stream life can weaken and die. In addition, oxygen depletion can affect the release of toxic chemicals and nutrients from sediments deposited in a waterway. All forms of organic matter in urban storm water runoff such as leaves, grass clippings and pet waste contribute to the problem. In addition, there are a number of non-storm water discharges of organic matter to surface waters such as sanitary sewer leakage and septic tank leaching.
- Nutrient Enrichment – Runoff from urban watersheds contains increased nutrients such as nitrogen or phosphorus compounds. Increased nutrient levels are a problem as they promote weed and algae growth in lakes, creeks, and estuaries. Algae blooms block sunlight from reaching the underwater grasses and deplete oxygen in bottom waters. In addition, nitrification of ammonia by microorganisms can consume dissolved oxygen, while nitrates can contaminate groundwater supplies. Sources of nutrients in the urban environment include washoff of fertilizers and vegetative litter, animal wastes,

sewer overflows and leaks, septic tank seepage, detergents, and the dry and wet fallout of materials in the atmosphere.

- Microbial Contamination – The level of bacteria, viruses and other microbes found in urban storm water runoff often exceeds public health standards for water contact recreation such as swimming and wading. Microbes can also increase the cost of treating drinking water. The main sources of these contaminants are sewer overflows, septic tanks, pet waste, and urban wildlife such as pigeons, waterfowl, squirrels, and raccoons.
- Hydrocarbons – Oils, greases and gasoline contain a wide array of hydrocarbon compounds, some of which have shown to be carcinogenic, tumorigenic and mutagenic in certain species of fish. In addition, in large quantities, oil can impact drinking water supplies and affect recreational use of waters. Oils and other hydrocarbons are washed off roads and parking lots, primarily due to engine leakage from vehicles. Other sources include the improper disposal of motor oil in storm drains and creeks, spills at fueling stations and restaurant grease traps.
- Toxic Materials – Besides oils and greases, urban storm water runoff can contain a wide variety of other toxicants and compounds including heavy metals such as lead, zinc, copper, and cadmium, and organic pollutants such as pesticides, PCBs, and phenols. These contaminants are of concern because they are toxic to aquatic organisms and can bioaccumulate in the food chain. In addition, they also impair drinking water sources and human health. Many of these toxicants accumulate in the sediments of creeks and lakes. Sources of these contaminants include industrial and commercial sites, urban surfaces such as rooftops and painted areas, vehicles and other machinery, improperly disposed household chemicals, landfills, hazardous waste sites and atmospheric deposition.
- Sedimentation – Eroded soils are a common component of urban storm water and are a pollutant in their own right. Excessive sediment can be detrimental to aquatic life by interfering with photosynthesis, respiration, growth and reproduction. Sediment particles transport other pollutants that are attached to their surfaces including nutrients, trace metals and hydrocarbons. High turbidity due to sediment increases the cost of treating drinking water and reduces the value of surface waters for industrial and recreational use. Sediment also fills ditches and small streams and clogs storm sewers and pipes, causing flooding and property damage. Erosion from construction sites, exposed soils, street runoff, and creek bank erosion are the primary sources of sediment in urban runoff.
- Higher Water Temperatures – As runoff flows over impervious surfaces such as asphalt and concrete, it increases in temperature before reaching a creek or lake. Water temperatures are also increased due to shallow lakes and impoundments along a watercourse as well as fewer trees along creeks to shade the water. Since warm water can hold less dissolved oxygen than cold water, this "thermal pollution" further reduces oxygen levels in depleted urban creeks. Temperature changes can severely disrupt certain aquatic species,

such as trout and stoneflies, which can survive only within a narrow temperature range.

- Trash and Debris – Considerable quantities of trash and other debris are washed through storm drain systems and into creeks and lakes. The primary impact is the creation of an aesthetic "eyesore" in waterways and a reduction in recreational value. In smaller creeks, debris can cause blockage of the channel, which can result in localized flooding and erosion.

F. Effects on Lakes

Storm water runoff into lakes and reservoirs can have some unique negative effects. A notable impact of urban runoff is the filing in of lakes with sediment. Another significant water quality impact on lakes related to storm water runoff is nutrient enrichment. This can result in the undesirable growth of algae and aquatic plants. Lakes do not flush contaminants as quickly as creeks and act as sinks for nutrients, metals and sediments. This means that lakes can take longer to recover if contaminated.

G. Addressing Storm water Impacts

The focus of this Manual is how to effectively deal with the impacts of storm water runoff on water quality through effective and comprehensive storm water quality management. Storm water quality management involves the prevention and mitigation of storm water runoff quantity and quality impacts as described in this Section through a variety of methods and mechanisms.

202 STORM WATER SIZING CRITERIA

A. Provide Water Quality Capture Volume

A fundamental requirement for any site addressing storm water quality is to provide water quality capture volume (WQCV). One (1) or more of (5) five types of water quality basins, each draining slowly to provide for long-term settling of sediment particles, may be selected to provide WQCV watershed inches as shown in Figure 2.1 in the Appendix. These BMPs are described in detail in the following sections:

Section 203 -

A. Porous Landscape Detention
B. Extended Detention Basin
C. Sand Filter Extended Detention Basin
D. Constructed Wetland Basin

The following BMP must be used with a BMP that meets the WQCV criteria. It does not provide WQCV by itself. It can however provide additional water quality treatment and aesthetic value:

Section 203 –

E. Constructed Wetlands Channel
F. Grass Buffer
G. Grass Swale

The following BMP does not meet the WQCV criteria. It is only intended for use in highly urbanized areas, such as redevelopment conditions, where existing development precludes the ability to meet the WQCV criteria. For BMPs that do not meet the WQCV criteria, calculation of a WQCV is not required, but the design considerations that must be provided including the following:

- match site considerations with manufactures guidelines and specifications,
- design calculations (sizing and treatment volume) and narrative,
- specify what operation and maintenance is required,
- if used as part of the erosion and sediment control during construction, insert shall be reconfigured according to manufacture's guidelines if applicable, and
- overflow should be designed so that storms in excess of the devise's hydraulic capacity bypass the treatment and is treated by another quality BMP.

This BMP must be approved for use by the Planning Director. In determining BMP approval, preference will be given to structural BMPs providing WQCV as listed in this section.

Section 203 -

H. Water Quality Catch Basins and Water Quality Catch Basin Inserts

The following BMP meets the WQCV criteria. Provide runoff capture volume as indicated in Section 203 – I.

Section 203 -

I. Bioretention

B. Estimation of the Required Water Quality Capture Volume (WQCV)

The WQCV in watershed inches and for total volume for most BMPs is determined following the steps below:

- Identify/select the drain time for the BMP to be designed. This will typically fall within the following four categories, 6-hr, 12-hr, 24-hr or 40-hr.
- For the post development condition determine the total contributing drainage area to the BMP and the fraction of mapped impervious area for the total contributing drainage area. The mapped impervious area includes all impervious area (i.e. both connected and unconnected hydraulically). Impervious areas that are routed through BMPs that provide pretreatment will be accounted for using the design credits methodology described later.

- Knowing the fraction of mapped impervious area and the BMP design drain time, Figure 2.1 can be used to determine the WQCV in watershed inches. The total treatment volume is then equal to the total drainage area times the WQCV. Instead of Figure 2.1, the equation below can be used to calculate WQCV in watershed inches:

$$WQCV = 1.16*a*(0.91I^3 - 1.191I^2 + 0.78I)$$

Where: WQCV = Water Quality Capture Volume, watershed inches
6-hr drain time, a = 0.7
12-hr drain time, a = 0.8
24-hr drain time, a = 0.9
40-hr drain time, a = 1.0
I = fraction of mapped impervious area
(i.e. 35 % mapped impervious area = 0.35)

$$DesignVolume = \left[\frac{WaterQualityCaptureVolume}{12}\right] * Area$$

203 BEST MANAGEMENT PRACTICES (BMPS)

A. Porous Landscape Detention

1. Description

Porous landscape detention consists of a low lying vegetated area underlain by a sand bed with an underdrain pipe. A shallow surcharge zone exists above the porous landscape detention for temporary storage of the WQCV. During a storm, accumulated runoff ponds in the vegetated zone and gradually infiltrates into the underlying sand bed, filling the void spaces of the sand. The underdrain gradually dewaters the sand bed and discharges the runoff to a nearby channel, swale, or storm sewer. This BMP allows WQCV to be provided on a site that has little open area available for storm water detention.

2. General Application

Location - A porous landscape detention can be located in just about any of the open areas of a site. It is ideally suited for small installations such as:

- Parking lot islands
- Street medians
- Roadside swale features
- Site entrance or buffer features

This BMP may also be implemented at a larger scale, serving as an infiltration basin for an entire site if desired, provided the water quality capture volume and average depth requirements contained in this section are met. Vegetation may consist of irrigated bluegrass or natural grasses with shrub and tree plantings if desired.

3. General Properties

a. General

A primary advantage of porous landscape detention is making it possible to provide WQCV on a site while reducing the impact on developable land. It works well with irrigated bluegrass, whereas experience has shown that conditions in the bottom of extended detention basins become too wet for bluegrass. A porous landscape detention provides a natural moisture source for vegetation, enabling "green areas" to exist with reduced irrigation. The primary drawback of porous landscape detention is a potential for clogging if a moderate to high level of silts and clays is allowed to flow into the facility. Also, this BMP needs to be avoided close to building foundations or other areas where expansive soils are present, although an underdrain and impermeable liner can reduce some of this concern.

b. Physical Site Suitability

If an underdrain system is incorporated into this BMP, porous landscape detention is suited for about any site regardless of in-situ soil type. If sandy soils are present, the facility can be installed without an underdrain (infiltration option); sandy subsoils are not a requirement. This BMP has a relatively flat surface area, and may be more difficult to incorporate into steeply sloping terrain.

c. Pollutant Removal

Although not tested to date in the Rapid City or Pennington County area, the amount of pollutant removed by this BMP should be significant and should equal or exceed the removal rates provided by sand filters. In addition to settling, porous landscape detention provides for filtering, adsorption, and biological uptake of constituents in storm water. See Table 2-1 for estimated ranges in pollutant removals. See Table 2-4 for maintenance requirements for a porous landscape detention.

4. Design Considerations

Figure 2.2 shows a cross section for a porous landscape detention. When implemented using multiple small installations on a site, it is increasingly important to accurately account for each upstream drainage area tributary to each porous landscape detention site to make sure that each facility is properly sized, and that all portions of the development site are directed to a porous landscape detention.

5. Design Procedure

The following steps outline the porous landscape detention design procedure and criteria:

Step 1: Basin Storage Volume

Provide a storage volume based on a 12-hour drain time.

- Find the required storage volume (watershed inches of runoff). Using the tributary areas imperviousness, determine the required WQCV (watershed inches of runoff) using Figure 2.1, based on the porous landscape detention 12-hour drain time.
- Calculate the design volume in cubic feet as follows:

$$DesignVolume = \left[\frac{WaterQualityCaptureVolume}{12}\right] * Area$$

In which:
Area = The watershed area tributary to the porous landscape detention basin (square feet)

Step 2: Surface Area

Maintain an average WQCV depth between 6 inches and 12 inches. Average depth of the water is defined as water volume divided by the water surface area.

- Calculate the minimum required surface area as follows:

$$SurfaceArea = \left[\frac{Design\ Volume\ (ft^3)}{d_{av}}\right]$$

In which:
d_{av} = average depth (feet) of the water in the porous landscape detention basin.

Step 3: Sand-Peat Media

Provide, as a minimum, an 18-inch-thick layer of well mixed sand and peat (⅔ sand and ⅓ peat) for plant growth as shown in Figure 2.2. Keep the top surface as flat as possible, while avoiding vegetated side slopes steeper than 4:1. Non-vegetated vertical walls are also a design option. When installing in type NRCS Type D or expansive soils and no subdrain outlet is possible, use a total sand-peat mixed layer thickness of 36-inches and no granular subbase.

Step 4: Granular Subbase

Whenever an under-drain is used or when the soils are not expansive (i.e., soils are NRCS Type A, B, or C) and an under-drain is not used, use an 8-inch layer of granular subbase with all fractured faces meeting the requirements of Type 1 – Bedding Material, Standard Specification 112.

Step 5: Membrane Liner

If expansive or NRCS Type D soils are present, install an impermeable 15 mil thick, or heavier, liner on the bottom and sides of the basin. If soils are not expansive (i.e., NRCS Type A, B, or C), use porous geotextile fabric to line the entire basin bottom and sides. Porous membrane liner shall be of woven monofilament as manufactured by Carthage Mills-Carthage 15 percent (or equal) having an open surface area of 12–15 percent, with openings equivalent to AOS U.S. Std. Sieve size of 40 to 50.

B. Extended Detention Basin

1. Description

An extended detention basin is a sedimentation basin designed to totally drain dry over an extended time after storm water runoff ends. It is an adaptation of a detention basin used for flood control. The primary difference is in the outlet design. The extended detention basin uses a much smaller outlet that extends the draining time of the more frequently occurring runoff events to facilitate pollutant removal. The extended detention basin's drain time for the brim-full water quality capture volume (i.e., time to fully evacuate the design capture volume) of 40 hours is recommended to remove a significant portion of fine particulate pollutants found in urban storm water runoff.

Soluble pollutant removal can be somewhat enhanced by providing a small wetland marsh or ponding area in the basin's bottom to promote biological uptake. The basins are considered to be "dry" because they are designed not to have a significant permanent pool of water remaining between storm water runoff events. However, an extended detention basin may develop wetland vegetation and sometimes shallow pools in the bottom portions of the facilities.

2. General Application

An extended detention basin can be used to enhance storm water runoff quality and reduce peak storm water runoff rates. If these basins are constructed early in the development cycle, they can also be used to trap sediment from construction activities within the tributary drainage area. The accumulated sediment, however, will need to be removed after upstream land disturbances cease and before the basin is placed into final long-term use. Also, an extended detention basin can sometimes be retrofitted into existing flood control detention basins.

Extended detention basins can be used to improve the quality of urban runoff from roads, parking lots, residential neighborhoods, commercial areas, and industrial sites and are generally used for regional or follow-up treatment. They can also be used as an onsite BMP and work well in conjunction with other BMPs, such as upstream onsite source controls and downstream infiltration/filtration basins or wetland channels. If desired, a flood routing detention volume can be provided above the WQCV of the basin.

3. General Properties

a. General

An extended detention basin can be designed to provide other benefits such as recreation and open space opportunities in addition to reducing peak runoff rates and improving water quality. They are effective in removing particulate matter and associated heavy metals and other pollutants. As with other BMPs, safety issues need to be addressed through proper design.

b. Physical Site Suitability

Normally, the land required for an extended detention basin is about 0.5 to 2.0 percent of the total tributary development area. In high groundwater areas, instead consider the use of retention ponds in order to avoid many of the problems that can occur when the extended detention basin's bottom is located below the seasonal high water table. Soil maps should be consulted, and soil borings may be needed to establish design geotechnical parameters.

c. Pollutant Removal

The pollutant removal range of an extended detention basin is presented in Table 2-1. Removal of suspended solids and metals can be moderate to high, and removal of nutrients is low to moderate. The removal of nutrients can be improved when a small shallow pool or wetland is included as part of the basin's bottom or the basin is followed by BMPs more efficient at removing soluble pollutants, such as a filtration system, constructed wetlands, or wetland channels. The major factor controlling the degree of pollutant removal is the emptying time provided by the outlet. The rate and degree of removal will also depend on influent particle sizes. Metals, oil and grease, and some nutrients have a close affinity for suspended sediment and will be removed partially through sedimentation.

d. Aesthetics and Multiple Uses

Since an extended detention basin is designed to drain very slowly, its bottom and lower portions will be inundated frequently for extended periods of time. Grasses in this frequently inundated zone will tend to die off, with only the species that can survive the specific environment at each site eventually prevailing. In addition, the bottom will be the depository of all the sediment that settles out in the basin. As a result, the bottom can be muddy and may have an undesirable appearance. To reduce this problem and to improve the basin's availability for other uses (such as open space, habitat, and passive recreation), the contractor should provide a lower-stage basin as suggested in the Two-Stage Design procedure. As an alternative, a retention pond could be used, in which the settling occurs primarily within the permanent pool.

e. Design Considerations

Whenever desirable and feasible, incorporate the extended detention basin within a larger flood control basin. Whenever possible, try to provide for other urban uses such as passive recreation and wildlife habitat. If multiple uses are being contemplated, consider the multiplestage detention basin to limit inundation of passive recreational areas to one or two occurrences a year. Generally, the area within the WQCV is not well suited for active recreation facilities such as ballparks, playing fields, and picnic areas. These are best located above the WQCV pool level. Figure 2.3 shows a representative layout of an extended detention basin.

Water quality impacts including higher water temperatures need to be reviewed by the design if the extended detention basin is close enough to cold water fisheries to potentially change the temperature of the receiving waters. Perforated outlet and trash rack configurations are illustrated in Figures 2.4, 2.5, and 2.7 through 2.11. Figure 2.7 equates the WQCV that needs to be emptied over 40 hours to the total required area of perforations per row for the standard configurations shown in that section. The chart is based on the rows being equally spaced vertically at 4-inch centers. The total area of perforations per row is then used to determine the number of uniformly sized holes per row as shown in Figures 2.8 and 2.9. One or more perforated columns on a perforated orifice plate integrated into the front of the outlet can be used. Other types of outlets may also be used, provided they control the release of the WQCV in a manner consistent with the drain time requirements.

Although the soil types beneath the pond seldom prevent the use of this BMP, they should be considered during design. Any potential exfiltration capacity should be considered a short-term characteristic and ignored in the design of the WQCV because exfiltration will decrease over time as the soils clog with fine sediment and as the groundwater beneath the basin develops a mound that surfaces into the basin.

High groundwater should not preclude the use of an extended detention basin. Groundwater, however, should be considered during design and construction, and the outlet design must account for any upstream base flows that enter the basin or that may result from groundwater surfacing within the basin itself.

Stable, all weather access to critical elements of the pond, such as the inflow area, outlet, spillway, and sediment collection areas, must be provided for maintenance purposes. Maintenance requirements for the extended detention basin are provided in Table 2-5.

4. Design Procedure and Criteria

The following steps outline the design procedure and criteria for an extended detention basin:

Step 1: Detention Pond Storage Volume

Provide a storage volume equal to 120 percent of the WQCV based on a 40-hour drain time, above the lowest outlet (i.e., perforation) in the basin. The additional 20 percent of storage volume provides for sediment accumulation and the resultant loss in storage volume.

- Determine the WQCV tributary catchment's percent imperviousness.
- Find the required storage volume (watershed inches of runoff). Determine the required WQCV watershed inches of runoff using Figure 2.1, based on the extended detention basin's 40-hour drain time. Calculate the design volume in acre-feet as follows:

$$\text{Design Volume} = \left[\frac{\text{WaterQualityCaptureVolume}}{12}\right] * \text{Area} * 1.2$$

In which:
Area = The watershed area tributary to the extended detention basin (acres)
1.2 factor = Multiplier of 1.2 to account for the additional 20 percent of required storage for sediment accumulation

Step 2: Outlet Control

The outlet controls are to be designed to release the WQCV (i.e., not the "design volume") over a 40-hour period, with no more than 50 percent of the WQCV being released in 12 hours. Refer to the Appendix for schematics pertaining to structure geometry; grates, trash racks, and screens; outlet type (orifice plate or perforated riser pipe); cutoff collar size and location; and all other necessary components. For a perforated outlet, use Figure 2.7 to calculate the required area per row based on WQCV and the depth of perforations at the outlet. See Figures 2.8 and 2.9 to determine the appropriate perforation geometry and number of rows (the lowest perforations should be set at the water surface elevation of the outlet micropool). The total outlet area can then be calculated by multiplying the area per row by the number of rows. Figure 2.6 contains typical outlet structure notes applicable to the design of outlet structures.

Step 3: Trash Rack

Provide a trash rack of sufficient size to prevent clogging of the primary water quality outlet. Size the rack so as not to interfere with the hydraulic capacity of the outlet. Using the total outlet area and the selected perforation diameter (or height), Figures 2.4, 2.5, 2.10, or 2.11 will help to determine the minimum open area required for the trash rack. Use one half of the perforated plate's total outlet area to calculate the trash rack's size. This accounts for the variable inundation of the outlet orifices. Figures 2.4, 2.5, and 2.10 were developed as suggested standardized outlet designs for smaller sites.

Step 4: Basin Shape

Shape the pond whenever possible with a gradual expansion from the inflow area and a gradual contraction toward the outlet, thereby minimizing short circuiting. It is best to have a basin length to width ratio between 2:1 and 3:1. It may be necessary to modify the inflow and outlet points through the use of pipes, swales, or channels to accomplish this. Always maximize the distance between the inlet and the outlet.

Step 5: Two-Stage Design

A two-stage design with a pool that fills often with frequently occurring runoff minimizes standing water and sediment deposition in the remainder of the basin. The two stages are as follows:

- *Top Stage* **-** The top stage should be 2 or more feet deep with its bottom sloped at 2 percent toward the low-flow channel.
- *Bottom Stage* **-** The active surcharge storage basin of the bottom stage should be 1.0 to 2.0 feet deep below the bottom of the top stage and store no less than 3 percent of the WQCV. Provide a micropool below the bottom active storage volume of the lower stage at the outlet point. The pool should be one half the depth of the upper WQCV depth or 2.5 feet, whichever is larger.

Step 6: Low-Flow Channel

Conveys low flows from the forebay to the bottom stage. Erosion protection should be provided where the low-flow channel enters the bottom stage. Lining the low-flow channel with riprap is recommended. Make it at least nine (9) inches deep if buried riprap is used. At a minimum provide capacity equal to twice the release capacity at the upstream forebay outlet.

Step 7: Basin Side Slopes

Basin side slopes should be stable and gentle to facilitate maintenance and access. Side slopes shall be no steeper than 4:1.

Step 8: Dam Embankment

The embankment should be designed not to fail during a 100-year or larger storm. Embankment slopes should be no steeper than 3:1, and planted with turf-forming grasses. Poorly compacted native soils should be excavated and replaced. Embankment soils should be compacted to at least 95 percent of their maximum density according to ASTM D 698-70 (Modified Proctor).

Step 9: Vegetation

Bottom vegetation provides erosion control and sediment entrapment. Pond bottom, berms, and side sloping areas may be planted with native grasses or with irrigated turf, depending on the local setting.

Step 10: Maintenance Access

All weather stable access to the bottom, forebay, and outlet controls area shall be provided for maintenance vehicles. Maximum grades should not exceed 10 percent and a stable driving surface capable for use by maintenance equipment. If conditions warrant, a gravel or hard surface shall be provided.

Step 11: Inflow Point

Dissipate flow energy at the pond's inflow point(s) to limit erosion and promote particle sedimentation.

Step 12: Forebay Design

Provide the opportunity for larger particles to settle out in the inflow area, the area that has a solid surface bottom, to facilitate mechanical sediment removal. A rock berm should be constructed between the forebay and the main extended detention basin. The forebay volume of the permanent pool should be about 5 percent of the design water quality capture volume. A pipe throughout the berm to convey water to the main body of the extended detention basin should be offset from the inflow streamline to prevent short circuiting and should be sized to drain the forebay volume in five (5) minutes. Presedimentation forebays shall only be utilized when the extended detention basin water quality capture volume exceeds 4,000 cubic feet.

Step 13: Flood Storage

Combining the water quality facility with a flood control facility is recommended. The 100-year or other floods may be detained above the WQCV. See *Section 203-K*, Incorporating WQCV into Storm Water Quantity Detention Basins, for further guidance.

Step 14: Multiple Uses

Whenever desirable and feasible, incorporate the extended detention basin within a larger flood control basin. Also, whenever possible, try to provide for other urban uses such as active or passive recreation and wildlife habitat. If multiple uses are being contemplated, use the multiple-stage detention basin to limit inundation of passive recreational areas to one or two occurrences a year. Generally, the area within the WQCV is not well suited for active recreation facilities such as ballparks, playing fields, and picnic areas. These are best located above the WQCV level.

C. Sand Filter Extended Detention Basin

1. Description

A sand filter extended detention basin is a storm water filter consisting of a runoff storage zone underlain by a sand bed with an underdrain system. During a storm, accumulated runoff ponds in the surcharge zone and gradually infiltrates into the underlying sand bed, filling the void spaces of the sand. The underdrain gradually dewaters the sand bed and discharges the runoff to a nearby channel, swale, or storm sewer.

2. General Application

A sand filter extended detention basin is generally suited to off-line, onsite configurations where there is no base flow and the sediment load is relatively low.

3. General Properties

a. General

Primary advantages of sand filter extended detention basins include effective water quality enhancement through settling and filtering. The primary drawback is a potential for clogging if a moderate to high level of silts and clays is allowed to flow into the facility. For this reason, it should not be put into operation while construction activities are taking place in the tributary catchment. Also, this BMP should not be located close to building foundations or other areas where expansive soils are a concern, although an underdrain and impermeable liner can reduce some of this concern.

b. Physical Site Suitability

Since an underdrain system is incorporated into this BMP, a sand filter extended detention basin is suited for about any site; the presence of sandy subsoils is not a requirement. This BMP has a relatively flat surface area, so it may be more challenging to incorporate it into steeply sloping terrain.

c. Pollutant Removal

Although not fully tested to date in the Pennington County area, the tests on filter vaults throughout the United States show that the amount of pollutant removed by this BMP should be significant and should at least equal the removal rates by sand filters tested elsewhere. See Table 2-1 for estimated ranges in pollutant removals.

d. Maintenance Needs

Before selecting this BMP, be sure that the maintenance specified in Table 2-6 will be provided by the owner with responsibilities negotiated with Pennington County. This BMP's performance is dependant on having regular maintenance provided.

4. Design Procedure and Criteria

The layout of a sand filter extended detention basin is shown in Figure 2.12. The following steps outline the design procedure and criteria for a sand filter extended detention basin.

Step 1: Basin Storage Volume

Provide a storage volume equal to 100 percent of the WQCV based on a 40-hour drain time, above the sand bed of the basin.

- Determine the WQCV tributary catchment's percent imperviousness.
- Find the required storage volume (watershed inches of runoff).
- Determine the required WQCV (watershed inches of runoff) using Figure 2.1, based on the sand filter extended detention basin's 40-hour drain time.
- Calculate the design volume in acre-feet as follows:

$$Design\ Volume = \left[\frac{WaterQualityCaptureVolume}{12} \right] * \ Area$$

In which:
Area = The watershed area tributary to the sand filter extended detention basin (acres)

Step 2: Basin Depth

Maximum design volume depth shall be 3 feet.

Step 3: Filter's Surface Area

Calculate the minimum sand filter area (As) at the basin's bottom with the following equation:

As = *Design Volume / 3* *43,560 (square feet)

Step 4: Outlet Controls

An 18-inch layer of sand (Standard Specification, Section 105: Fine Aggregate for use in Portland cement concrete) over an 8-inch gravel layer (Standard Specification, Section 116: Type 3-Aggregates for asphalt surface treatment) shall line the entire sand filter extended detention basin for purposes of draining the WQCV. If expansive soils are a concern or if the tributary catchment has chemical or petroleum products handled or stored, install a 15 mil thick impermeable membrane below the gravel layer. In addition, an overflow shall be provided to convey flows in excess of the WQCV out of the basin.

D. Constructed Wetlands Basin

1. Description

A constructed wetlands basin is a shallow retention pond that requires a perennial base flow to permit the growth of rushes, willows, cattails, and reeds to slow down runoff and allow time for sedimentation, filtering, and biological uptake. Constructed wetlands basins differ from "natural" wetlands as they are totally human artifacts that are built to enhance storm water quality. Sometimes small wetlands that exist along ephemeral drainageways could be enlarged and incorporated into the constructed wetland system. Such action, however, requires the approval of federal and state regulators.

2. General Application

A constructed wetlands basin can be used as a follow-up structural BMP in a watershed or as a stand-alone onsite facility if the owner provides sufficient water to sustain the wetland. Flood control storage can be provided above the constructed wetlands basin's WQCV pool to act as a multiuse facility. A constructed wetlands basin requires a net influx of water to maintain its vegetation and microorganisms. A complete water budget analysis is necessary to assure the adequacy of the base flow.

The basic formula for the water budget is as follows:

$$\Delta S / \Delta t = Q_i - Q_o$$

Where:
$\Delta S / \Delta t$ = the change in storage volume per change in time
Q_i = the flow rate of water entering the wetland, vol/time
Q_o = the flow rate of water leaving the wetland, vol/time

All values are given in consistent units of volume per unit time unless otherwise specified:

For water entering a wetland the formula is:

$$Q_i = P + R_I + B_I + G_I$$

Where:
P = Direct precipitation on impoundment area
R_I = Storm water runoff from contributing drainage area

B_I = Base flow entering the wetlands
G_I = Seepage and springs from ground water sources

For water leaving the formula is:

$$Q_o = E + T + R_o + B_o + G_o$$

Where:
E = Evaporation from surface
T = Transpiration from plants
R_o = Storm water outflow
B_o = Base flow leaving the wetlands
G_o = Deep percolation below the root zone of the substrate

To assure adequate base flow using the water budget analysis, the value of all variables should be determined and the net influx of water ($Q_I - Q_o$) must be greater than the change in storage volume divided by change in storage time.

3. General Properties

a. General

A constructed wetlands basin offers several potential advantages, such as natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal. It can also provide an effective follow-up treatment to onsite and source control BMPs that rely upon settling of larger sediment particles. In other words, it offers yet another effective structural BMP for larger tributary catchments. The primary drawback of the constructed wetlands basin is the need for a continuous base flow to assure viable wetland growth. In addition, silt and scum can accumulate, and unless properly designed and built, can be flushed out during larger storms. In addition, in order to maintain a healthy wetland growth, the surcharge depth for WQCV above the permanent water surface cannot exceed 2 feet. Along with routine good housekeeping maintenance, occasional cleaning will be required when sediment accumulations become too large and affect performance. Periodic sediment removal is also needed for proper distribution of growth zones and of water movement within the wetland.

b. Physical Site Suitability

A perennial base flow is needed to sustain a wetland, and should be determined using a water budget analysis. Loamy soils are needed in a wetland bottom to allow plants to take root. Infiltration through a wetland bottom cannot be relied upon because the bottom is either covered by soils of low permeability or because the groundwater is higher than the wetland's bottom. Also, wetland basins require a nearzero longitudinal slope, which can be provided using embankments.

c. Pollutant Removal

See Table 2-1 for estimated ranges in pollutant removals. Reported removal efficiencies of constructed wetlands vary significantly. Primary variables influencing removal efficiencies include design, influent concentrations, hydrology, soils, climate, and maintenance. With periodic sediment removal and routine maintenance, removal efficiencies for sediments, organic matter, and metals can be moderate to high; for phosphorous, low to high; and for nitrogen, zero to moderate. Pollutants are removed primarily through sedimentation and entrapment, with some of the removal occurring through biological uptake by vegetation and microorganisms. Without a continuous dryweather base flow, salts and algae can concentrate in the water column and can be released into the receiving water in higher levels at the beginning of a storm event as they are washed out.

d. Design Considerations

Figure 2.13 illustrates an idealized constructed wetlands basin. An analysis of the water budget is needed to show the net inflow of water is sufficient to meet all the projected losses (such as evaporation, evapotranspiration, and seepage for each season of operation). Insufficient inflow can cause the wetland to become saline or to die off. Typical maintenance requirements for wetland BMPs include the items listed in Table 2-8.

4. Design Procedure and Criteria

The following steps outline the design procedure for a constructed wetlands basin.

Step 1: Basin Surcharge Storage Volume

Provide a surcharge storage volume equal to the WQCV based on a 24-hour drain time, above the lowest outlet (i.e., perforation) in the basin.

- Determine the WQCV using the tributary catchments percent imperviousness.
- Find the required storage surcharge volume (watershed inches of runoff) above the permanent pool level. Determine the required storage (watershed inches of runoff) using Figure 2.1, based on the constructed wetland basin 24-hour drain time. Calculate the surcharge volume in acre-feet as follows:

$$Design\ Volume = \left[\frac{WaterQualityCaptureVolume}{12}\right] * Area$$

In which:

Area = The drainage area tributary to the constructed wetlands basin (acres).

Step 2: Wetland Pond Depth and Volume

The volume of the permanent wetland pool shall be no less than 75 percent of the WQCV found in Step 1. Proper distribution of wetland habitat is needed to establish a diverse ecology. Distribute pond area in accordance with Table 2-7.

Step 3: Depth of Surcharge

The surcharge depth of the WQCV above the permanent pool's WQCV water surface shall not exceed 2.0 feet.

Step 4: Outlet Control

Provide outlet controls that limit WQCV depth to 2 feet or less. Use a water quality outlet that is capable of releasing the WQCV in no less than a 24-hour period. Refer to Figures 2.14, 2.15, and 2.16 for schematics pertaining to structure geometry; grates, trash racks, and screens; outlet type (orifice plate or perforated riser pipe); cutoff collar size and location; and all other necessary components. Use Figure 2.17 to calculate the required area per row based on WQCV and the depth of perforations at the outlet. See Figures 2.8 and 2.9 for the appropriate perforation geometry and number of rows (the lowest perforations should be set at the water surface elevation of the outlet pool). The total outlet area can then be calculated by multiplying the area per row by the number of rows. Minimize the number of columns and maximize the perforation hole diameter when designing the outlet to reduce chances of clogging. Figure 2.6 contains typical outlet structure notes applicable to the design of outlet structures.

Step 5: Trash Rack

Provide a trash rack of sufficient size to prevent clogging of the primary water quality outlet. Size the rack so as not to interfere with the hydraulic capacity of the outlet. Using the total outlet area and the selected perforation diameter (or height), Figures 2.4, 2.5, 2.10, or 2.11 will help to determine the minimum open area required for the trash rack. If a perforated vertical plate or riser is used, use one half of the total outlet area to calculate the trash rack's size. This accounts for the variable inundation of the outlet orifices. Figures 2.4, 2.5, and 2.10 were developed as suggested standardized outlet designs for smaller sites.

Step 6: Basin Use

Determine if flood storage or other uses will be provided for above the wetland surcharge storage or in a separate facility. Design for combined uses when they are to be provided.

Step 7: Basin Shape

Shape the pond with a gradual expansion from the inflow and a gradual contraction to the outlet, thereby limiting short circuiting. The basin length to width ratio between the inflow area and outlet should be 2:1 to 4:1, with 3:1 recommended. It may be necessary to modify the inflow area and outlet point through the use of pipes, swales, or channels to accomplish this. Always maximize the distance between the inlet and outlet.

Step 8: Basin Side Slopes

Basin side slopes are to be stable and gentle to facilitate maintenance and access needs. Side slopes should be no steeper than 4:1.

Step 9: Base Flow

A net influx of water that exceeds all of the losses must be available throughout the year. The following equation and parameters can be used to estimate the net quantity of base flow available at a site:

$$Q_{Net} = Q_{Inflow} - Q_{Evap} - Q_{Seepage} - Q_{E.T.}$$

Where:
Q_{Net} = Net quantity of base flow (acre-feet/year)
Q_{Inflow}= Estimated base flow (acre-feet/year)
(estimate by seasonal measurements and/or comparison to similar watersheds)
Q_{Evap} = Loss attributed to evaporation less the precipitation (acre-feet/year)
(computed for average water surface)
$Q_{Seepage}$ = Loss (or gain) attributed to seepage to groundwater (acre-feet/year)
$Q_{E.T.}$ = Loss attributed to plant evapotranspiration
(computed for average plant area above water surface, not including the surface)

Step 10: Inflow Area and Outlet Protection

Provide a means to dissipate flow energy entering the basin to limit sediment resuspension. Outlets should be placed in an outlet bay that is at least 3 feet deep. The outlet should be protected from clogging by a skimmer shield that starts at the bottom of the permanent pool and extends above the maximum capture volume depth. Also provide for a trash rack.

Step 11: Forebay Design

Provide the opportunity for larger particles to settle out in an area that has a solid driving surface bottom for vehicles to facilitate sediment removal. The forebay volume of the permanent pool should be 5 to 10 percent of the design water quality capture volume.

Step 12: Vegetation

Cattails, sedges, reeds, and wetland grasses should be planted in the wetland bottom. Berms and side-sloping areas should be planted with native or irrigated turf-forming grasses. Initial establishment of the wetlands requires control of the water depth. After planting wetland species, the permanent pool should be kept at 3 to 4 inches to allow growth and to help establish the plants, after which the pool should be raised to its final operating level.

Step 13: Maintenance Access

Vehicle access to the forebay and outlet area must be provided for maintenance and removal of bottom sediments. Maximum grades should not exceed 10 percent, and a stabilized, all-weather driving surface capable for use by maintenance equipment shall be provided. If conditions warrant, a gravel or hard surface shall be provided.

E. Constructed Wetlands Channel

1. Description

Constructed wetland-bottomed channels take advantage of dense natural vegetation (rushes, willows, cattails, and reeds) to slow down runoff and allow time for settling out sediment and biological uptake. Constructed wetlands differ from "natural" wetlands as they are artificial and are built to enhance storm water quality. Sometimes small wetlands that exist along ephemeral drainageways may be enlarged and incorporated into the constructed wetland system. Such action, however, requires the approval of federal and state regulators.

2. General Application

Wetland bottom channels can be used in the following two ways:

- A wetland can be established in a totally man-made channel and can act as a conveyance system and water quality enhancement facility. This design can be used along wide and gently sloping channels.
- A wetland bottom channel can be located downstream of a storm water detention facility (water quality and/or flood control) where a large portion of the sediment load can be removed. The wetland channel then receives storm water and base flows as they drain from the detention facility, provides water quality enhancement, and at the same time conveys it downstream. The application of a wetland channel is recommended upstream of receiving waters and within lesser (i.e., ephemeral) receiving waters, thereby delivering better quality water to the more significant receiving water system.

A constructed wetland channel requires a net influx of water to maintain its vegetation and microorganisms. A complete water budget analysis is necessary to assure the adequacy of the base flow.

3. General Properties

a. General

Constructed wetlands offer several potential advantages, such as natural aesthetic qualities, wildlife habitat, erosion control, and pollutant removal. Constructed wetlands provide an effective follow-up treatment to onsite and source control BMPs that rely upon settling of larger sediment particles.

The primary drawback to wetlands is the need for a continuous base flow to assure their presence. In addition, salts and scum can accumulate, and unless properly designed and built, can be flushed out during larger storms.

Other drawbacks include the need for regular maintenance to provide nutrient removal. Regular harvesting and removal of aquatic plants, cattails, and willows are required if the removal of nutrients in significant amounts has to be assured. Even with that, recent data puts into question the net effectiveness of wetlands in removing nitrogen compounds and some form of phosphates. Periodic sediment removal is also necessary to maintain the proper distribution of growth zones and of water movement within the wetland.

b. Physical Site Suitability

A perennial base flow is needed to sustain a wetland, and should be determined using a water budget analysis. Loamy soils are needed in wetland bottoms to allow plants to take root. Infiltration through a wetland bottom cannot be relied upon because the bottom is either covered by soils of low permeability or because the groundwater is higher than the wetland's bottom. Wetland bottom channels also require a near-zero longitudinal slope; drop structures are used to create and maintain a flat grade.

c. Pollutant Removal

Removal efficiencies of constructed wetlands vary significantly. Primary variables influencing removal efficiencies include design, influent concentrations, hydrology, soils, climate, and maintenance. With periodic sediment removal and plant harvesting, expected removal efficiencies for sediments, organic matter, and metals can be moderate to high; for phosphorous, low to moderate; and for nitrogen, zero to low. Pollutants are removed primarily through sedimentation and entrapment, with some of the removal occurring through biological uptake by vegetation and microorganisms. Without a continuous dry-weather base flow, salts and algae can concentrate in the water column and can be released into the receiving water in higher levels at the beginning of a storm event as they are washed out.

4. Design Considerations

Wetlands can be set into a drainageway to form a wetland bottom channel as shown in Figure 2.18. An analysis of the water budget is needed so that the inflow of water throughout the year is sufficient to meet all the projected losses (such as evaporation, evapotranspiration, and seepage) for satisfactory functioning of the wetland. An insufficient base flow could cause the wetland bottom channel to dry out and die. Maintenance requirements for wetland BMPs are shown in Table 2-8.

5. Design Procedure and Criteria

The following steps outline the constructed wetlands channel design procedure. Refer to Figure 2.18 for its design components.

Step 1: Design Discharge
Determine the 2-year peak flow rate in the wetland channel without reducing it for any upstream ponding or flood routing effects. The channel shall also meet the conveyance requirements of the Storm Water Design Manual.

Step 2: Channel Geometry

Define the newly-built channel's geometry to pass the design 2-year flow rate at 2.0 feet per second with a channel depth between 2.0 and 4.0 feet. The channel cross section should be trapezoidal with side slopes of 4:1 (horizontal/vertical) or flatter. Bottom width shall be no less than 8.0 feet.

Step 3: Longitudinal Slope

Set the longitudinal slope using Manning's equation and a Manning's roughness coefficient of n=0.03, for the 2-year flow rate. If the desired longitudinal slope can not be satisfied with existing terrain, grade control checks or small drop structures must be incorporated to provide desired slope.

Step 4: Final Channel Capacity

Calculate the final (or mature) channel capacity during a 2-year flood using a Manning's roughness coefficient of n = 0.08 and the same geometry and slope used when initially designing the channel with n = 0.03. The channel shall also provide enough capacity to contain the flow during a 100-year flood while maintaining 1 foot of free-board. Adjustment of the channel capacity may be done by increasing the bottom width of the channel. Minimum bottom width shall be 8 feet.

Step 5: Drop Structures

Drop structures should be designed considering low and high flow hydraulic conditions using standard engineering practices.

Step 6: Vegetation

Vegetate the channel bottom and side slopes to provide solid entrapment and biological nutrient uptake. Cover the channel bottom with loamy soils, upon which cattails, sedges, and reeds should be established. Side slopes should be planted with native or irrigated turf grasses.

Step 7: Maintenance Access

Vehicle access along the channel length must be provided for maintenance. Maximum grades should not exceed 10 percent, and a stabilized, all-weather driving surface capable for use by maintenance equipment shall be provided.

F. Grass Buffer

1. Description

Grass buffer strips are uniformly graded and densely vegetated areas of turf grass. They require sheet flow to promote filtration, infiltration, and settling to reduce runoff pollutants. Grass buffers differ from grass swales as they are designed to accommodate overland sheet flow rather than concentrated or channelized flow. They can be used to remove larger sediment from runoff from impervious areas.

Whenever concentrated runoff occurs, it should be evenly distributed across the width of the buffer via a flow spreader. This may be a porous pavement strip or another type of structure used to achieve uniform sheet-flow conditions. Grass buffers can also be combined with riparian zones in treating sheet flows and in stabilizing channel banks adjacent to major drainage ways and receiving waters. Grass buffers can be interspersed with shrubs and trees to improve their aesthetics and to provide shading.

2. General Application

A grass buffer can be used in residential and commercial areas. They are typically located adjacent to impervious areas. When used, they should be incorporated into site drainage, street drainage, and master drainage planning. Because their effectiveness depends on having an evenly distributed sheet flow over their surface, the size of the contributing area and the associated volume of runoff have to be limited. Flow can be directly accepted from an impervious area such as a parking lot or building roofs, provided the flow is distributed uniformly over the strip. Grass buffers provide only marginal pollutant removal and require that follow-up structural BMPs be provided. They do, however, help to reduce some of the runoff volume from small storms.

3. General Properties

a. General

The grass and other vegetation can provide aesthetically pleasing green space, which can be incorporated into a development landscaping plan. Eventually, the grass strip next to the spreader or the pavement will accumulate sufficient sediment to block runoff. At that point, a portion of the grass buffer strip will need to be removed and replaced. Perforated drains may be required where soils are not suited for infiltration.

b. Physical Site Suitability

After final grading, the site should have a uniform slope and be capable of maintaining an even sheet flow throughout without concentrating runoff into shallow swales or rivulets. The allowable tributary area depends on the width, length, and the soils that lay under the grass buffer. The National Resources Conservation Service (NRCS) Hydrologic Soil Groups A and B provide the best infiltration capacity, while Soil Groups C and D provide best site stability. The swelling potential of underlying soils should also be taken into account in how the soils may affect adjacent structures and pavement when water is delivered to the grassed areas.

c. Pollutant Removal

Pollutant removal depends on many factors, such as soil permeability, site slope, the flow path length along the buffer, the characteristics of drainage area, runoff volumes and velocities, and the type of vegetation. The general pollutant removal of both particulate and soluble pollutants is projected to be low to moderate. Grass buffers rely primarily upon the settling and interception of solids, and to only a minor degree, on biological uptake and runoff infiltration. See Table 2-1 for an estimated range of pollutant removals. Maintenance requirements for this BMP are listed in Table 2-2.

4. Design Considerations

Design of grass buffers is based primarily on maintaining sheet-flow conditions across a uniformly graded, dense grass cover strip. When a grass buffer is used over unstable slopes, soils, or vegetation, rills and gullies will form that will disrupt sheet flow. The resultant short-circuiting will invalidate the intended water quality benefits. Grass buffers should be protected from excessive pedestrian or vehicular traffic that can damage the grass cover and affect even sheet-flow distribution. A mixture of grass and trees may offer benefits for slope stability and improved aesthetics.

5. Design Procedure and Criteria

The following steps outline the grass buffer design procedure and criteria. Figure 2.19 is a schematic of the facility and its components.

Step 1: Design Discharge

Determine the 2-year peak flow rate of the area draining to the grass buffer. Also, determine the flow control type; sheet or concentrated.

Step 2: Minimum Length

Calculate the minimum length (normal to flow) of the grass buffer. The upstream flow needs to be uniformly distributed over this length. General guidance suggests that the hydraulic load should not exceed 0.05 cfs/linear foot of buffer during a 2-year storm to maintain a sheet flow of less than one (1) inch throughout dense grass that is at least two (2) inches high. The minimum design length (normal to flow) is therefore calculated as:

$$L_G = \frac{Q_{2\text{-year}}}{0.05}$$

In which:
L_G = Minimum design length (feet)
$Q_{2\text{-year}}$ = Peak discharge supplied to the grass buffers by a 2-year event (cfs) (Longer lengths may be used)

Step 3: Minimum Width

The minimum width (WG) (the distance along the sheet flow direction) of the grass buffer shall be determined by the following criteria for onsite and concentrated flow control conditions:

- Sheet Flow Control (use the larger value)

  $W_G = 0.2L_I$ or 10 feet

  In which:
  L_I = The length of flow path of the sheet flow over the upstream impervious surface (feet)

- Concentrated Flow Control (use the larger value)

  $W_G = 0.15(A_t/L_t)$ or 10 feet

  In which:
  A_t = The tributary area (square feet)
  L_t = The length of the tributary inflow normal to flow spreader (i.e., width of flow spreader (feet))

A generally rectangular-shaped strip is preferred and should be free of gullies or rills that concentrate the overland flow.

Step 4: Maximum Slope

Design slope in the direction of flow shall not exceed 4 percent.

Step 5: Flow Distribution

Incorporate a device on the upstream end of the buffer to evenly distribute flows along the design length. Slotted curbing, modular block porous pavement (MBP), or other spreader devices can be used to apply flows. Concentrated flow supplied to the grass buffer must use a level spreader (or a similar concept) to evenly distribute flow onto the buffer.

Step 6: Vegetation

Plant the grass buffer with dense turf to promote sedimentation and entrapment and to protect against erosion. Irrigation may be required.

Step 7: Outflow Collection

Provide a means for outflow collection. Most of the runoff during significant events will not be infiltrated and will require a collection and conveyance system. In some cases, the use of under-drains can maintain better infiltration rates as the soils saturate and help dry out the buffer after storms or irrigation periods.

G. Grass Swale

1. Description

They are densely vegetated drainage ways with low-pitched side slopes that collect and slowly convey runoff. Design of their longitudinal slope and cross section size forces the flow to be slow and shallow, thereby facilitating sedimentation while limiting erosion. Berms or check dams should be installed perpendicular to the flow as needed to slow it down and encourage settling and infiltration.

2. General Application

A grass swale can be located to collect overland flows from areas such as parking lots, buildings, residential yards, roadways, and grass buffer strips. They can be made a part of the plans to minimize a directly connected impervious area by using them as an alternative to a curb-and-gutter system. A grass swale is set below adjacent ground level, and runoff enters the swales over grassy banks. The potential exists for wetland vegetation to become established if the swale experiences standing water or if there is a base flow. A site with a base flow should be managed as either a swale with an unlined trickle channel, or as a wetland bottom channel, the latter providing an additional BMP to storm water runoff.

3. General Properties

a. General

A grass swale can be more aesthetically pleasing than concrete or rock-lined drainage systems. Although limited by the infiltration capacity of local soils, this BMP can also provide some reduction in runoff volumes from small storms. Dense grasses can reduce flow velocities and protect against erosion during larger storm events. Swales in residential and commercial settings can also be used to limit the extent of directly connected impervious areas.

b. Physical Site Suitability

A grass swale is practical only at sites with general ground slopes of less than four (4) percent and are definitely not practical for sites steeper than six (6) percent. The longitudinal slopes of a grass swale should be kept to less than 1.0 percent, which often necessitates the use of grade control checks or drop structures. Where the general terrain slope exceeds four (4) percent, a grass swale is often practical only on the upslope side of the adjacent street. When soils with high permeability (for example, Class A or B) are available, the swale will infiltrate a portion of the runoff into the ground, but such soils are not required for effective application of this BMP. When Class C and D soils are present, the use of a sand/gravel underdrain is recommended.

c. Pollutant Removal

Removal rates reported in literature vary and fall into the low to medium range. Under good soil conditions and low-flow velocities, moderate removal of suspended solids and associated other constituents can be expected. If soil conditions permit, infiltration can remove low to moderate loads of soluble pollutants when flow velocities are very low. As a result, small frequently occurring storms can benefit the most. See Table 2-1 for estimated ranges in pollutant removal rates by this BMP. Maintenance considerations for this BMP are listed in Table 2-3.

4. Design Considerations

Figure 2.20 shows trapezoidal and triangular swale configurations. A grass swale is sized to maintain a low velocity during small storms and to collect and convey larger runoff events, all for the projected fully developed land use conditions. A healthy turf grass cover must be developed to foster dense vegetation. Permanent irrigation in some cases may be necessary. Judicious use of grass swales can replace both the curb-and-gutter systems and greatly reduce the storm sewer systems in the upper portions of each watershed when designed to convey the "initial storm" (for example, a 2- or a 5-year storm) at slow velocities. However, if one or both sides of the grass swale are also to be used as a grass buffer, the design of the grass buffer has to follow the requirements of *Section 203-F*, Grass Buffers.

5. Design Procedure and Criteria

The following steps outline the grass swale design procedure and criteria.

Step 1: Design Discharge

Determine the 2-year flow rate in the proposed grass swale.

Step 2: Swale Geometry

Select geometry for the grass swale. The cross section should be trapezoidal or triangular. The side slopes shall be flatter than 4:1 (horizontal/ vertical). The wider the wetted area of the swale, the slower the flow and the more effective it is in removing pollutants.

Step 3: Longitudinal Slope

Maintain a longitudinal slope for the grass swale between 0.2 and 1.0 percent. If the longitudinal slope requirements can not be satisfied with available terrain, grade control checks or small drop structures must be incorporated to maintain the required longitudinal slope. If the slope of the swale exceeds 0.5 percent, the swale must be vegetated with irrigated turf grass.

Step 4: Flow Velocity and Depth

Calculate the velocity and depth of flow through the swale. Based on Manning's equation and a Manning's roughness coefficient of n=0.05, find the channel velocity and depth using the 2-year flow rate determined in Step 1.

Step 5: Maximum Flow Velocity

Maximum flow velocity of the channel shall not exceed 1.5 feet per second and the maximum flow depth shall not exceed 2 feet at the 2- year peak flow rate. If these conditions are not attained, repeat steps 2 through 4, each time altering the depth and bottom width or longitudinal slopes until these criteria are satisfied.

Step 6: Vegetation

Vegetate the grass swale with dense turf grass to promote sedimentation, filtration, and nutrient uptake, and to limit erosion through maintenance of low-flow velocities.

Step 7: Street and Driveway Crossings

If applicable, small culverts at each street crossing and/or driveway crossing may be used to provide onsite WQCV in a similar fashion to an extended detention basin (if adequate volume is available).

Step 8: Drainage and Flood Control

Check the water surface during larger storms such as the 5-year through the 100-year event to assure that drainage from these larger events is being controlled without flooding critical areas.

H. Water Quality Catch Basins and Water Quality Catch Basin Inserts Description

A catch basin is an inlet to the storm drain system that typically includes a grate or curb inlet and a sump to capture sediment, debris, and associated pollutants. Catch basins act as pretreatment for other treatment practices by capturing large sediments. The performance of catch basins at removing sediment and other pollutants depends on the design of the catch basin (e.g., the size of the sump) and maintenance procedures to retain the storage available in the sump to capture sediment. Catch basin efficiency can be improved using inserts, which can be designed to remove oil and grease, trash, debris, and sediment. There are various manufacturers of water quality catch basins and the efficiency may vary with the manufacturer.

1. Applicability

Catch basins are used in drainage systems throughout the United States. Ideal application of catch basins is as pretreatment to another storm water management practice. Catch basin inserts for both new development and retrofits at existing sites may be preferred when available land is limited, as in urbanized areas.

2. Siting and Design Considerations

The performance of catch basins is related to the volume in the sump (i.e., the storage in the catch basin below the outlet). Lager et al. (1997) described an "optimal" catch basin sizing criterion, which relates all catch basin dimensions to the diameter of the outlet pipe (D):

- The diameter of the catch basin should be equal to 4D.
- The sump depth should be at least 4D. This depth should be increased if cleaning is infrequent or if the area draining to the catch basin has high sediment loads.
- The top of the outlet pipe should be 1.5D from the bottom of the inlet to the catch basin.

Catch basins can also be sized to accommodate the volume of sediment that enters the system. Pitt et al. (1997) proposed a sizing criterion based on the concentration of sediment in storm water runoff. The catch basin is sized, with a factor of safety, to accommodate the annual sediment load in the catch basin sump. This method is preferable where high sediment loads are anticipated, and where the optimal design described above is suspected to provide little treatment.

I. Bioretention

1. Definition

A typical bioretention area is shown in Figure 2.21. Two general types of bioretention facilities exist: off-line and on-line areas. Off-line bioretention areas consist of sand and soil mixtures planted with native plants, which receive runoff from overland flow or from a diversion structure in a traditional drainage system. On-line bioretention areas have the same composition as off-line areas, but are located in grass swales or other conveyance systems that have been modified to enhance pollutant removal by quiescent settling and biofiltration.

2. Purpose

Bioretention is an efficient method for removing a wide variety of pollutants, such as suspended solids and nutrients. It can also be an effective means of reducing peak runoff rates and recharging groundwater by infiltrating runoff. However, not all bioretention facilities will necessarily be optimized for all of these functions.

3. Application

Bioretention areas consisting of sand and soil mixtures planted with native plants, which filter urban runoff, can be used in residential and nonresidential developments. Sources of runoff can be overland flow from impervious areas or discharge diverted from a drainage pipe. Also, on-line bioretention facilities use check dams or other barriers to retain flow in grass swales.

Bioretention facilities are most effective if they receive runoff as close as possible to the source. A site designer needs to look for opportunities to incorporate bioretention facilities throughout the site and minimize the use of inlets, pipes, and downstream controls.

Bioretention should not be used in areas with the following characteristics:

- The water table is within 6 feet of the land surface (the use of collector pipes may reduce this limitation).
- Mature trees would be removed for constructing the bioretention area.
- Slopes are 20 percent or greater.
- An unstable soil stratum is in the area.

a. Off-Line

Off-line bioretention facilities can be applied to most development situations. They are particularly applicable in urban areas where the opportunities and the land available for controlling storm water reliably are scarce. Bioretention facilities may be installed in median strips, parking lot islands, or lawn areas of commercial developments. They also can be used in residential subdivisions with open drainage systems or in easements located around lots. Figure 2.22 shows a bioretention area receiving runoff diverted from a storm sewer.

b. On-Line

On-line bioretention facilities use check dams to “collect” the water in the bioretention area, as shown in Figure 2.23. Adding a bioretention area behind the check dam allows filtering and sedimentation to occur. Check dams should only be used in small open channels or in filter strips that drain five (5) acres or less. Runoff from storms larger than the water quality design storm should safely flow over or bypass the bioretention area.

4. Recommended Design Criteria

a. Performance-Based Guidelines

Bioretention facilities should be optimized to treat the runoff generated by the water quality design storm. The peak discharge from larger storms should be bypassed, if possible.

A homogenous soil mix of 50 percent construction sand; 20 to 30 percent topsoil with less than five (5) percent clay content, and 20 to 30 percent organic compost containing no animal waste provides a planting medium with adequate infiltration capacity. Soil amendments can be added according to the plant species selected. (This soil guidance is taken from the North Carolina BMP manual).

In areas where clay contents are higher and the soil is not conducive to infiltration, the bioretention facility can be modified with a collector pipe system installed beneath the basin to form a bioretention filter. The City of Alexandria, Virginia, has developed design guidelines for bioretention filters (City of Alexandria, 1995) and collector pipes for areas of clay soil. As a standard practice, a collector pipe system is now used on all bioretention applications.

Bioretention areas can be used successfully in a wide range of drainage areas. Median strips, ramp loops, and parking lot islands are examples of small drainage areas (less than 1 acre). In large drainage areas (less than 10 acres), diversion structures and energy dissipation devices need to be incorporated into the design to preserve the integrity of the bioretention area.

It is recommended that the size of the bioretention area be five (5) to seven (7) percent of the drainage area multiplied by the *c* coefficient of the Rational Formula (Prince George's County, 1993). However, both smaller and larger ranges are allowed. Ongoing monitoring data will provide better guidance on the design of these facilities. The land required for bioretention facilities can be reduced by partially substituting vertical-extended detention storage for horizontal storage.

Check dams, as shown in Figure 2.23, reduce the velocity of concentrated storm water flows, promoting sedimentation behind the dam. If properly anchored, railroad ties, gabions, or rock filter berms may be used as check dams. The use of railroad ties is shown in Figure 2.23. The use of gabions as a drop structure is shown in Figure 2.23. These types of structures can be used in swales with moderate slopes.

Check dams must be sized and constructed correctly and maintained properly, or they will be either washed out or contribute to flooding. The relationship between ponding depth and discharge rate can be computed by using the critical-depth formula, which accounts for a generalized weir profile. The relevant equation is:

$$Q = ((A^3 \text{ x } g) / T)^{½}$$

Where:
Q = discharge rate
A = area subtended by top of check dam and ponding elevation
T = width of check dam
g = gravitational constant

Check dams can be constructed of either rock or logs. The use of other natural materials available on the site that can withstand the storm water flow velocities is acceptable. Check dams should not be constructed from straw bales or silt fences because concentrated flows quickly wash out these materials.

Maximum velocity reduction is achieved if the toe of the upstream check dam is at the same elevation as the top of the downstream dam. The center section of the dam should be lower than the edge sections to minimize the potential for erosion of the abutments during frequently occurring storm events.

b. Operation and Maintenance

Monthly inspections are recommended until the plants are established. Annual inspections should then be performed. Accumulated sediment behind check dams should be removed when it reaches one half of the sump depth.

c. Considerations

If used, collector pipe systems in bioretention areas can become clogged by underlying clay soil. Pipe cleanouts are recommended to facilitate unclogging of the pipes without disturbing the bioretention areas.

5. Specifications and Methodology

a. Planting Plan

Using plants in bioretention areas is intended to replicate a terrestrial forest community ecosystem. The components of this community include trees, a shrub layer, and an herbaceous layer. Native plants should be able to tolerate typical storm water pollutant loads, variable soil moisture, and ponding fluctuations (Prince George's County, 1993). Designers are encouraged to check other sources, such as The Agronomy Guide, the Field Office Technical Guide, and local nurseries, to identify plants that can adapt to specific site conditions. The plant material layout should resemble a random and natural placement of plants rather than a standard landscaped approach with trees and shrubs in rows or other orderly fashion. The location of the plant material should provide optimal conditions for plant establishment and growth (Prince George's County, 1993).

b. Off-Line Bioretention Areas

There are six major components to the bioretention area:

- Grass buffer strip or energy dissipation area
- Ponding or treatment area
- Planting soil

- Sand bed (optional)
- Organic layer
- Plant material

The grass buffer strip or energy-dissipation area filters particles from the runoff and reduces its velocity. The sand bed further slows the velocity of the runoff, spreads the runoff over the basin, filters part of the water, provides positive drainage to prevent anaerobic conditions in the planting soil, and enhances infiltration from the basin.

The ponding area functions as storage area for runoff awaiting treatment and as presettling basin for particulates that have not been filtered out by the grass buffer. The organic or mulch layer acts as a filter for pollutants, protects the soil from eroding, and is an environment for microorganisms to degrade petroleum-based compounds and other pollutants.

The planting soil layer nurtures the plants with stored water and nutrients. Clay particles in the soil adsorb heavy metals, nutrients, hydrocarbons, and other pollutants. The plant species are selected on the basis of their documented ability to cycle and assimilate nutrients, pollutants, and metals through the interaction among plants, soil, and organic layers (Bitter and Bowers, 1994). The minimum depth of the planting soil layer should be three (3) to four (4) feet.

The number of tree and shrub plantings may vary, especially in areas where aesthetics and visibility are vital to site development, and the density should be determined on an individual site basis. The minimum and maximum number of individual plants and spacing recommended are shown in Table 2-9. A minimum of three (3) species of trees and three (3) species of shrubs should be selected to assure diversity.

As with any BMP, sizing rules are continually changing. Although the site requirements will determine the actual dimensions, the following dimensions are recommended for bioretention areas:

- Minimum width is 10 to 15 feet.
- Minimum length is 30 to 40 feet.
- The ponded area should have a maximum depth of six (6) inches. If collector pipes are used, the maximum pond depth can be increased to 12 inches.
- The planting soil should have a minimum depth of four (4) feet. Figures 2.23 and 2.24 show a profile and plan

of a typical bioretention area. A curb diversion structure or curb opening can be installed to divert gutter flow to a bioretention area.

c. On-Line Bioretention Areas

A bioretention area upstream of a check dam is constructed with similar specifications as the off-line bioretention areas. The depth of the planting soil zone can be reduced (1 to 2 feet) if the drainage area is small (less than 2 acres).

Rock check dams usually are constructed of approximately 8- to 12- inch rock. The rock is placed either by hand or mechanically, but never just dumped into the swale. The dam must completely span the ditch or swale to prevent being washed out. The rock used must be large enough to stay in place, given the expected design flow through the channel.

Railroad tie check dams are illustrated in Figure 2.23. The railroad ties should be embedded into the soil at least 18 inches. Gabion applications are illustrated in Figure 2.23.

J. Other BMPs

Use of BMPs other than those listed in this manual may be allowed when approved by the Planning Director on a case by case basis.

K. Incorporating Water Quality Capture Volume into Storm Water Quantity Detention Basins

Wherever possible, it is recommended that WQCV facilities be incorporated into storm water quantity detention facilities. This is relatively straightforward for an extended detention basin, constructed wetland basin, and a retention pond. The 100-year detention level is provided above the WQCV and the outlet structure is designed to control two or more different releases. Figures 2.4 and 2.5 show examples of combined quality/quantity outlet structures. Figure 2.6 contains typical outlet structure notes applicable to the design of outlet structures. Storm water quantity detention could be provided above the WQCV for porous pavement and landscape detention, provided the drain times for the larger events are kept short. The following approach is suggested:

- Water Quality: The full WQCV is to be provided according to the design procedures documented for the Structural BMP.
- 100-Year Storm: The WQCV plus the full 100-year detention volume is to be provided.

L. Acknowledgement

The descriptions of the BMPs contained in this chapter were adapted from descriptions of BMPs found in City of Rapid City's Stormwater Quality Manual.

M. References *(from the City of Rapid City's Stormwater Quality Manual)*

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204 STORM WATER BETTER SITE DESIGN AND DESIGN CREDITS

A. Overview

The first step in addressing storm water management begins with site planning and the design process. Development projects can be designed to reduce their impact on watersheds when careful efforts are made to conserve natural areas, reduce impervious cover and better integrate storm water treatment. By implementing a combination of these nonstructural approaches collectively known as *storm water better site design practices*, it is possible to reduce the amount of runoff and pollutants that are generated from a site and provide for some nonstructural on-site treatment and control of runoff.

The goals of better site design include:

- Managing storm water as close to the point of origin as possible and minimizing collection and conveyance
- Preventing storm water impacts rather than mitigating them
- Utilizing simple, nonstructural methods for storm water management that are lower cost and lower maintenance than structural controls
- Creating a multifunctional landscape
- Using Hydrology as a framework for site design

Better site design for storm water management includes a number of site design techniques such as preserving natural features and resources, effectively laying out the site elements to reduce impact, reducing the amount of impervious surfaces, and utilizing natural features on the site for storm water management. The aim is to reduce the environmental impact "footprint" of the site while retaining and enhancing the owner/developer's purpose and vision for the site. Many of the better site design concepts can reduce the cost of infrastructure while maintaining or even increasing the value of the property.

Reduction of adverse storm water runoff impacts through the use of better site design should be the first consideration of the design engineer (typically hired by contractor or landowner). Operationally, economically, and aesthetically, the use of better site design practices offers significant benefits over treating and controlling runoff downstream. Therefore, all opportunities for using these methods should be explored and all options exhausted before considering structural storm water controls.

The reduction in runoff and pollutants using better site design can reduce the required runoff peak and volumes that need to be conveyed and controlled on a site and, therefore, the size and cost of necessary drainage infrastructure and structural storm water controls. In some cases, the use of better site design practices may eliminate the need for structural controls entirely. Hence, better site design concepts can be viewed as both a water quantity and water quality management tool. Several of the site design practices described in this section provide a calculable reduction or site design "credit" which can be applied to the storm water sizing criteria requirements.

The use of storm water better site design can also have a number of other ancillary benefits including:

- Reduced construction costs
- Increased property value
- More open space for recreation
- More pedestrian friendly neighborhoods
- Protection of sensitive forests, wetlands and habitats
- More aesthetically pleasing and naturally attractive landscape
- Easier compliance with wetland and other resource protection regulations

B. Application of Design Credits

Runoff from impervious surfaces can be routed over or through selected BMPs to reduce the connected impervious area. These BMPs are not considered, treatment BMPs (in that they are not designed to treat the WQCV). However, by routing runoff from impervious area over or through these BMPs the total contributing area is reduced to what is called the effective contributing area. BMPs that can be applied for design credits include:

Conservation of Natural Features and Resources
Preserved Riparian Buffers

Vegetated Buffers
Vegetated Swales

The basic approach to account for reduced connected impervious area is as follows:

1. Select and size an appropriate BMP to route runoff from impervious area over or through prior to entering a main drainage way or WQCV treatment BMP.
2. Calculate the impervious area draining through or over the BMP being applied for design credits.
3. Calculate the effective drainage area by subtracting the impervious area being treated from the total site contributing area.
4. Use the effective drainage area times the WQCV (watershed inches) to determine the final WQCV.

C. List of Storm Water Better Site Design Practices and Techniques

The storm water better site design practices and techniques covered in this manual are grouped into four categories and are listed below:

Conservation of Natural Features and Resources

- Preserve Undisturbed Natural Areas
- Preserve Riparian Buffers
- Avoid Floodplains
- Avoid Steep Slopes
- Minimize Siting on Porous or Erodible Soils

Lower Impact Site Design Techniques

- Fit Design to the Terrain
- Locate Development in Less Sensitive Areas
- Reduce Limits of Clearing and Grading
- Utilize Open Space Development
- Consider Creative Development Design

Reduction in Impervious Cover

- Reduce Roadway Lengths and Widths
- Reduce Building Footprints
- Reduce Parking Footprints
- Reduce Setbacks and Frontages
- Use Fewer or Alternative Cul-de-Sacs
- Create Parking Lot Stormwater “Islands”

Utilization of Natural Features for Stormwater Management

- Use Buffers and Undisturbed Areas
- Use Natural Drainageways Instead of Storm Sewers
- Use Vegetated Swale Instead of Curb and Gutter
- Drain Rooftop Runoff to Pervious Areas

1. Conservation of Natural Features and Resources

Conservation of natural features is integral to better site design. The first step in the better site design process is to identify and preserve the natural features and resources that can be used in the protection of water resources by reducing storm water runoff, providing runoff storage, reducing flooding, preventing soil erosion, promoting infiltration, and removing storm water pollutants. Some of the natural features that should be taken into account include:

- Areas of undisturbed vegetation
- Floodplains and riparian areas
- Ridgetops and steep slopes
- Natural drainage pathways
- Intermittent and perennial creeks
- Wetlands
- Aquifers and recharge areas
- Soils
- Shallow bedrock or high water table
- Other natural features or critical are:

Some of the ways used to conserve natural features and resources described over the next several pages include the following methods:

- Preserve Undisturbed Natural Areas
- Preserve Riparian Buffers
- Avoid Floodplains
- Avoid Steep Slopes
- Minimize Siting on Porous or Erodible Soils

Delineation of natural features is typically done through a comprehensive site analysis and inventory before any site layout design is performed. From this site analysis, a concept plan for a site can be prepared that provides for the conservation and protection of natural features.

a. Preserve Undisturbed Natural Areas

Important natural features and areas such as undisturbed forested and vegetated areas, natural drainageways, stream corridors, wetlands and other important site features should be delineated and placed into conservation areas.
The key benefits include:

- Conserving undisturbed natural areas helps to preserve a portion of the site's natural predevelopment hydrology

- Can be used as nonstructural storm water filtering and infiltration zones
- Helps to preserve the site's natural character and aesthetic features
- May increase the value of the developed property
- A storm water site design credit can be taken

Use this practice by:

- Delineating natural areas before performing site layout and design
- Ensure that conservation areas and native vegetation are protected in an undisturbed state throughout construction and occupancy

Site Design Credit

A storm water credit can be taken when undisturbed natural areas are conserved on a site, thereby retaining their pre-development hydrologic and water quality characteristics. Under this credit, a designer would be able to subtract conservation areas from the total site area when computing the water quality volume requirements.

Rule: Subtract conservation areas from total site area when computing water quality volume requirements.

Criteria:

- Conservation area cannot be disturbed during project construction
- Shall be protected by limits of disturbance clearly shown on all construction drawings
- Shall be located within an acceptable conservation easement instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management], and
- Shall have a minimum contiguous area requirement of 10,000 square feet

b. Preserve Riparian Buffers

Naturally vegetated buffers should be delineated and preserved along perennial creeks, lakes, and wetlands.

The key benefits include:

- Riparian buffers can be used as nonstructural storm water filtering and infiltration zones
- Keeps structures out of the floodplain and provides a right-of-way for large flood events
- Helps to preserve riparian ecosystems and habitats
- A storm water site design credit can be taken

Use this practice by:

- Delineate and preserve naturally vegetated riparian buffers
- Ensure that buffers and native vegetation are protected throughout construction and occupancy

Site Design Credit

This credit can be taken when storm water runoff is effectively treated by a stream buffer. Effective treatment constitutes treating runoff through overland flow in a naturally vegetated or forested buffer. Under the proposed credit, a designer would be able to subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements. The design of the stream buffer treatment system must use appropriate methods for conveying flows above the 2-yr storm event.

Rule: Subtract areas draining via overland flow to the buffer from total site area when computing water quality volume requirements.

Criteria:

- The minimum undisturbed buffer width shall be 50 feet
- The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces
- The average contributing slope shall be 3% maximum unless a flow spreader is used
- Runoff shall enter the buffer as overland sheet flow. A flow spreader can be supplied to ensure this, or if average contributing slope criteria cannot be met
- Not applicable if *overland flow filtration/groundwater recharge credit is already being taken*

- Buffers shall remain unmanaged other than routine debris removal
- Shall be located within an acceptable buffer easement instrument that ensures perpetual protection of the proposed area.

c. Avoid Floodplains

Floodplain areas should be avoided for homes and other structures to minimize risk to human life and property damage, and to allow the natural stream corridor to accommodate flood flows.

The key benefits include:

- Preserving floodplains provides a natural right-of-way and temporary storage for large flood events
- Keeps people and structures out of harm's way
- Helps to preserve riparian ecosystems and habitats
- Can be combined with riparian buffer protection to create linear greenways

Use this practice by:

- Obtain maps of the 100-year floodplain and floodway
- Ensure that all development activities do not encroach on the designated floodplain areas

d. Avoid Steep Slopes

Steep slopes should be avoided due to the potential for soil erosion and increased sediment loading. Excessive grading and flattening of hills and ridges should be minimized.

The key benefits include:

- Preserving steep slopes helps to prevent soil erosion and degradation of storm water runoff
- Steep slopes can be kept in an undisturbed natural condition to help stabilize hillsides and soils
- Building on flatter areas will reduce the need for cut-and-fill and grading

Use this practice by:

- Avoid development on steep slope areas, especially those with a grade of 15% or greater
- Minimize grading and flattening of hills and ridges

f. Minimize Siting on Porous or Erodible Soils

Porous soils such as sand and gravels provide an opportunity for groundwater recharge of storm water runoff and should be preserved as a potential storm water management option. Unstable or easily erodible soils should be avoided due to their greater erosion potential.

The key benefits include:

- Areas with highly permeable soils can be used as nonstructural storm water infiltration zones. A storm water site design credit can be taken
- Avoiding high erodible or unstable soils can prevent erosion and sedimentation problems and water quality degradation

Use this practice by:

- Use soil surveys to determine site soil types
- Leave areas of porous or highly erodible soils as undisturbed conservation areas

Site Design Credit

This credit can be taken when “overland flow filtration/infiltration zones” are incorporated into the site design to receive runoff from rooftops or other small impervious areas (e.g., driveways, small parking lots, etc.). This can be achieved by grading the site to promote overland vegetative filtering or by providing infiltration or “rain garden” areas. If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality volume requirements. An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.
Rule: If impervious areas are adequately disconnected, they can be deducted from total site area when computing the water quality volume requirements.

Criteria:

- Relatively permeable soils should be present
- Runoff shall not come from a designated hotspot

- The maximum contributing impervious flow path length shall be 75 feet
- Downspouts shall be at least 10 feet away from the nearest impervious surface to discourage "re-connections"
- The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or structural stormwater control
- The length of the "disconnection" shall be equal to or greater than the contributing length
- The surface impervious area to any one discharge location shall not exceed 5,000 square feet
- For those areas draining directly to a buffer, either the overland flow filtration **or** the stream buffer credit can be used

2. Lower Impact Site Design Techniques

a. Fit Design to the Terrain

The layout of roadways and buildings on a site should generally conform to the landforms on a site. Natural drainage ways and stream buffer areas should be preserved by designing road layouts around them. Buildings should be sited to utilize the natural grading and drainage system and avoid the unnecessary disturbance of vegetation and soils.

The key benefits include:

- Helps to preserve the natural hydrology and drainage ways of a site
- Reduces the need for grading and land disturbance
- Provides a framework for site design and layout

Use this practice by:

- Develop roadway patterns to fit the site terrain. Locate buildings and impervious surfaces away from steep slopes, drainage ways and floodplains

b. Locate Development in Less Sensitive Areas

To minimize the hydrologic impacts on the existing site land cover, the area of development should be located in areas of the site that are less sensitive to disturbance or have a lower value in terms of hydrologic function.

The key benefits include:

- Helps to preserve the natural hydrology and drainage ways of a site
- Makes most efficient use of natural site features for preventing and mitigating storm water impacts
- Provides a framework for site design and layout

Use this practice by:

- Lay out the site design to minimize the hydrologic impact of structures and impervious surfaces

c. Reduce Limits of Clearing and Grading

Clearing and grading of the site should be limited to the minimum amount needed for the development and road access. Site footprinting should be used to disturb the smallest possible land area on a site.

The key benefits include:

- Preserves more undisturbed natural areas on a development site
- Techniques can be used to help protect natural conservation areas and other site features

Use this practice by:

- Establish limits of disturbance for all development activities
- Use site footprinting to minimize clearing and land disturbance

d. Utilize Open Space Development

Open space site designs incorporate smaller lot sizes to reduce overall impervious cover while providing more undisturbed open space and protection of water resources.
The key benefits include:

- Preserves conservation areas on a development site
- Can be used to preserve natural hydrology and drainage ways

- Can be used to help protect natural conservation areas and other site features
- Reduces the need for grading and land disturbance
- Reduces infrastructure needs and overall development costs

Use this practice by:

- Use a site design which concentrates development and preserves open space and natural areas of the site

e. Consider Creative Development Design

Planned Unit Developments (PUDs) allow a developer or site designer the flexibility to design a residential, commercial, industrial, or mixed-use development in a fashion that best promotes effective stormwater management and the protection of environmentally sensitive areas.

The key benefits include:

- Allows flexibility to developers to implement creative site designs which include storm water better site design practices
- May be useful for implementing an open space development

Use this practice by:

- Determine the type and nature of deviations allowed and other criteria for receiving PUD approval

3. Reduction of Impervious Cover

The level of impervious cover, i.e. rooftops, parking lots, roadways, sidewalks and other surfaces that do not allow rainfall to infiltrate into the soil, is an essential factor to consider in better site design for storm water management. Increased impervious cover means increased storm water generation and increased pollutant loadings. Thus by reducing the area of total impervious surface on a site, a site designer can directly reduce the volume of storm water runoff and associated pollutants that are generated. It can also reduce the size and cost of necessary infrastructure for storm water drainage, conveyance, and control and treatment. Some of the ways that impervious cover can be reduced in a development include:

- Reduce Roadway Lengths and Widths
- Reduce Building Footprints

- Reduce Parking Footprints
- Reduce Setbacks and Frontages
- Use Fewer or Alternative Cul-de-Sacs
- Create Parking Lot Stormwater Islands

a. Reduce Roadway Lengths and Widths

Roadway lengths and widths should be minimized on a development site where possible to reduce overall imperviousness.

The key benefits include:

- Reduces the amount of impervious cover and associated runoff and pollutants generated
- Reduces the costs associated with road construction and maintenance

Use this practice by:

- Consider different site and road layouts that reduce overall street length
- Minimize street width by using narrower street designs

b. Reduce Building Footprints

The impervious footprint of commercial buildings and residences can be reduced by using alternate or taller buildings while maintaining the same floor to area ratio.

The key benefits include:

- Reduces the amount of impervious cover and associated runoff and pollutants generated

Use this practice by:

- Use alternate or taller building designs to reduce the impervious footprint of buildings

c. Reduce the Parking Footprint

Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, parking decks, and using porous paver surfaces or porous concrete in overflow parking areas where feasible and possible.

The key benefits include:

- Reduces the amount of impervious cover and associated runoff and pollutants generated

Use this practice by:

- Reduce the number of parking spaces
- Minimize stall dimensions
- Consider parking structures and shared parking
- Use alternative porous surface for overflow area

d. Reduce Setbacks and Frontages

Use smaller front and side setbacks and narrower frontages to reduce total road length and driveway lengths.

The key benefits include:

- Reduces the amount of impervious cover and associated runoff and pollutants generated

Use this practice by:

- Reduce building and home front and side setbacks
- Consider narrower frontages

e. Use Fewer or Alternative Cul-de-Sacs

Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should also be considered.

The key benefits include:

- Reduces the amount of impervious cover and associated runoff and pollutants generated

Use this practice by:

- Consider alternative cul-de-sac designs

f. Create Parking Lot Stormwater "Islands"

Provide storm water treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

The key benefits include:

- Reduces the amount of impervious cover and associated runoff and pollutants generated
- Provides an opportunity for the siting of structural control facilities
- Trees in parking lots provide shading for cars and are more visually appealing

Use this practice by:

- Integrate porous areas such as landscaped islands, swales, filter strips and bioretention areas in a parking lot design

4. Utilization of Natural Features for Storm Water Management

Traditional storm water drainage design tends to ignore and replace natural drainage patterns and often results in overly efficient hydraulic conveyance systems. Structural storm water controls are costly and often can require high levels of maintenance for optimal operation. Through use of natural site features and drainage systems, careful site design can reduce the need and size of structural conveyance systems and controls.

Almost all sites contain natural features which can be used to help manage and mitigate runoff from development. Features on a development site might include natural drainage patterns, depressions, permeable soils, wetlands, floodplains, and undisturbed vegetated areas that can be used to reduce runoff, provide infiltration and storm water filtering of pollutants and sediment, recycle nutrients, and maximize on-site storage of storm water. Site design should seek to utilize the natural and/or nonstructural drainage system and improve the effectiveness of natural systems rather than to ignore or replace them. These natural systems typically require low or no maintenance and will continue to function many years into the future.

Some of the methods of incorporating natural features into an overall storm water management site plan include the following practices:

- Use Buffers and Undisturbed Areas
- Use Natural Drainage Ways Instead of Storm Sewers
- Use Vegetated Swales instead of Curb and Gutter
- Drain Runoff to Pervious Areas

a. Use Buffers and Undisturbed Areas

Undisturbed natural areas such as forested conservation areas and stream buffers can be used to treat and control storm water runoff from other areas of the site with proper design.

The key benefits include:

- Riparian buffers and undisturbed vegetated areas can be used to filter and infiltrate storm water runoff
- Natural depressions can provide inexpensive storage and detention of storm water flows
- A storm water site design credit can be taken (see Site Design Credit under Preserve Riparian Buffers)

Use this practice by:

- Direct runoff towards buffers and undisturbed areas using a level spreader to ensure sheet flow
- Utilize natural depressions for runoff storage

b. Use Natural Drainage Ways Instead of Storm Sewers

The natural drainage paths of a site can be used instead of constructing underground storm sewers or concrete open channels. Vegetated swales in lieu of curb and gutter should only be used with prior approval from the Growth Management Department.

The key benefits include:

- Use of natural drainage ways reduces the cost of constructing storm sewers or other conveyances, and may reduce the need for land disturbance and grading
- Natural drainage paths are less hydraulically efficient than man-made conveyances, resulting in longer travel times and lower peak discharges
- Can be combined with buffer systems to allow for storm water filtration and infiltration

Use this practice by:

- Preserve natural flow paths in the site design
- Direct runoff to natural drainage ways, ensuring that peak flows and velocities will not cause channel erosion

c. Use Vegetated Swales Instead of Curb and Gutter

Where density, topography, soils, slope, and safety issues permit, vegetated open channels can be used in the street right-of-way to convey and treat storm water runoff from roadways.

The key benefits include:

- Reduces the cost of road and storm sewer construction
- Provides for some runoff storage and infiltration, as well as treatment of storm water
- A storm water site design credit can be taken

Use this practice by:

- Use vegetated open channels (enhanced wet or dry swales or grass channels) in place of curb and gutter to convey and treat storm water runoff

Site Design Credit

This credit may be taken when vegetated (grass) channels are used for water quality treatment. Under the proposed credit, a designer would be able to subtract the areas draining to a grass channel from total site area when computing water quality volume requirements. A vegetated channel can fully meet the water quality volume requirements for certain kinds of low-density residential development. An added benefit will be that the post-development peak discharges will likely be lower due to a longer time of concentration for the site.

This credit cannot be taken if grass channels are being used as a limited application structural storm water control towards meeting the removal goal for WQCV treatment.
Rule: Subtract the areas draining to a grass channel from total site area when computing water quality volume requirements.

Criteria:

- The credit shall only be applied to moderate or low density residential land uses (3 dwelling units per acre maximum)
- The maximum flow velocity for water quality design storm shall be less than or equal to 1.0 foot per second
- The minimum residence time for the water quality storm shall be 5 minutes
- The bottom width shall be a maximum of 6 feet. If a larger channel is needed use of a compound cross section is required
- The side slopes shall be 4:1 (horizontal: vertical) or flatter
- The channel slope shall be 3 percent or less

d. Drain Runoff to Pervious Areas

Where possible, direct runoff from impervious areas such as rooftops, roadways, and parking lots to pervious areas, open channels or vegetated areas to provide for water quality treatment and infiltration. Avoid routing runoff directly to the structural storm water conveyance system.

The key benefits include:

- Sending runoff to pervious vegetated areas increases overland flow time and reduces peak flows
- Vegetated areas can often filter and infiltrate storm water runoff
- A storm water site design credit can be taken (see Site Design Credit under Minimize Siting on Porous or Erodible Soils)

Use this practice by:

- Minimize directly connected impervious areas and drain runoff as sheet flow to pervious vegetated areas

TABLE 2-1

BMP Pollutant Removal Ranges for Storm Water Runoff and Most Probable Range for BMPs

Type of BMP	(1)	TSS	TP	TN	TZ	TPb	BOD	Bacteria
Grass Buffer	LRR:	10-50	0-30	0-10	1-10	N/A	N/A	N/A
	EPR	10-20	0-10	0-10	0-10	N/A	N/A	N/A
Grass Swale	LRR:	20-60	0-40	0-30	0-40	N/A	N/A	N/A
	EPR	20-40	0-15	0-15	0-20	N/A	N/A	N/A
Modular Block Porous Pavement	LRR:	80-95	65	75-85	98	80	80	N/A
	EPR	70-90	40-55	10-20	40-80	60-70	N/A	N/A
Porous Pavement Detention	LRR:	8-96	5-92	-130-85	10-98	60-80	60-80	N/A
	EPR	70-90	40-55	10-20	40-80	60-70	N/A	N/A
Porous Landscape Detention	LRR:	8-96	5-82	-100-85	10-98	60-90	60-80	N/A
	EPR	70-90	40-55	20-55	50-80	60-80	N/A	N/A
Extended Detention Basin	LRR:	50-70	10-20	10-20	30-60	75-90	N/A	50-90
	EPR	55-75	45-55	10-20	30-60	55-80	N/A	N/A
Constructed Wetland Basin	LRR:	40-94	-4-90	21	-29-82	27-94	18	N/A
	EPR	50-60	40-80	20-50	30-60	40-80	N/A	N/A
Retention Pond	LRR:	70-91	0-79	0-80	0-71	9-95	0-69	N/A
	EPR	80-90	45-70	20-60	20-60	60-80	N/A	N/A
Sand Filter Extended Detention	LRR:	8-96	5-92	-129-84	10-98	60-80	60-80	N/A
	EPR	80-90	45-55	35-55	50-80	60-80	60-80	N/A
Constructed Wetland Channel*	LRR:	20-60	0-40	0-30	0-40	N/A	N/A	N/A
	EPR	30-50	20-40	10-30	20-40	20-40	N/A	N/A

(1) LRR Literature reported range, **EPR**-expected probable range of annual performance by BMPs.
N/A Insufficient data to make an assessment
*The **EPR** rates for a Constructed Wetland Channel assume the wetland surface area is equal or greater than 0.5% of the tributary total impervious area.

TABLE 2-2

Irrigated Grass Buffer Strip Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing	Maintain a dense grass cover at a recommended length of 2 to 4 inches. Collect and dispose of cuttings offsite or use a mulching mower.	Routine-as needed or recommended by inspection.
Lawn care	Use the minimum amounts of biodegradable, nontoxic fertilizers and herbicides needed to maintain dense grass cover, free of weeds. Reseed and patch damaged areas.	Routine-as needed.
Irrigation	Adjust the timing sequence and water cover to maintain the required minimum soil moisture for dense grass growth. Do not overwater.	As needed.
Litter removal	Remove litter and debris to prevent gully development, enhance aesthetics, and prevent floatables from being washed offsite.	Routine-as needed by inspection.
Inspections	Inspect irrigation, turf grass density, flow distribution, gully development, and traces of pedestrian or vehicular traffic and request repairs as needed.	Annually and after each major storm (that is, larger than 0.75 inch in precipitation.)
Turf replacement	To lower the turf below the surface of the adjacent pavement, use a level flow spreader so that the sheet flow is not blocked and will not cause water to back up onto the upstream pavement.	As needed when water ponding becomes too high or too frequent a problem. The need for turf replacement will be higher if the pavement sanded in winter to improve tire traction on ice. Otherwise, expect replacement every 5 to 15 years.

TABLE 2-3

Grass-Lined Swale Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Maintain irrigated grass at 2 to 4 inches tall and nonirrigated native grass at 6 to 8 inches tall or taller if necessary. Collect cuttings and dispose of them offsite or use a mulching mower.	Routine-as needed.
Debris and litter removal	Keep the area clean for aesthetic reasons, which also reduces floatables being flushed downstream.	Routine-as needed by inspection, but no less than two times per year.
Sediment removal	Remove accumulated sediment near culverts and in channels to maintain flow capacity. Replace the grass areas damaged in the process.	Routine-as needed by inspection. Estimate the need to remove sediment from 3 to 10 percent of total length per year, as determined by annual inspection.
Grass reseeding and mulching	Maintain a healthy dense grass in channel and side slope.	Nonroutine-as needed by annual inspection.
Inspections	Check the grass for uniformity of cover, sediment accumulation in the swale, and near culverts.	Routine-annual inspection is suggested.

TABLE 2-4

Porous Landscape Detention Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and vegetative care	Occasional mowing of grasses and weed removal to limit unwanted vegetation. Typically maintain irrigated turf grass as 2 to 4 inches tall and nonirrigated native turf grasses at 4 to 6 inches. Mowing can be increased to 8 inches for water conservation or taller if needed.	Routine-depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from detention area to minimize clogging of the sand media.	Routine-depending on aesthetic requirements.
Landscaping removal and replacement	The sandy loam turf and landscaping layer will clog with time. This layer will need to be removed and replaced, along with all turf and other vegetation growing on the surface, to rehabilitate infiltration rates.	Every 5 to 10 years; depending on infiltration rates needed to drain the WQCV in 12 hours or less. May need to do it more frequently if infiltration rates are too low to achieve this goal.
Inspections	Inspect detention area if the sand media is allowing acceptable infiltration.	Routine-biannual inspection of hydraulic performance.

Table 2-5

Extended Detention Basin Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Occasionally moving to limit unwanted vegetation. Maintain irrigated turf grass as 2 to 4 inches tall and nonirrigated native turf grasses 4 to 6 inches. Mowing can be increased to 8 inches for water conservation or taller if needed.	Routine-depending on aesthetic requirements.
Debris and litter removal	Remove litter and debris from entire pond to minimize outlet clogging and aethetics.	Routine-including just before annual storm seasons and following significant rainfall events.
Erosion and sediment control	Repair and revegetate eroded areas in the basin and channels.	No routine-periodic and repair as necessary based on inspection
Structural	Repair pond inlets, outlets, forebays, low flow channel liners, and energy dissipators whenever damage is discovered.	Nonroutine-repair as neededbased on regular inspections.
Inspections	Inspect basins to insure that the basin continues to function as initially intended. Examine the outlet for clogging, erosion, slumping, excessive sedimentation levels, overgrowth, embankment and spillway integrity, and damage to any structural element.	Routine-annual inspection of hydraulic and structural facilities. Also check for obvious problems during routine maintenance visits, especially for plugging of outlets.
Nuisance control	Address odor, insects, and overgrowth issues associated with stagnant or standing water in the bottom zone.	Nonroutine-handle as necessary per inspection or local complaints.
Sediment removal	Remove accumulated sediment from the forebay, micro-pool, and the bottom of the basin.	Nonroutine-performed when sediment accumulation occupies 20 percent of the WQCV. This may vary, but expect to do this every 10 to 20 years, as necessary per inspection if no construction activities take place in the tributary watershed. The forebay and the micro-pool will require more frequent cleanout than other areas of the basin; every 1 or 2 years.

Table 2-6

Sand Filter Detention Basin Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Debris and litter removal	Remove debris and litter from detention area to minimize clogging of the sand media.	Routine-depending on aesthetic requirements.
Landscaping removal and replacement	If the sand filter is covered with rock mulch, bluegrass, or other landscaping covers, the cover must be removed to allow access to the sand media. Replace landscaping cover after maintenance of sand media is complete.	Every 2 to 5 years.
Scarify filter surface	Scarify top 3 to 5 inched by raking the filter's surface.	Once per year or when needed to promote drainage.
Sand filter removal	Remove the top 3 inches of sand from the sand filter. After a third removal, backfill with 9 inches of new sand to return the sand depth to 18 inches. Minimum sand depth is 12 inches.	If no construction activities take place in the tributary watershed, every 2 to 5 years, depending on observed drain times, namely when it takes more than 24 hours to empty a 3-foot deep pool. Otherwise more often. Expect to clean out forebay every 1 to 5 years.
Inspections	Inspect detention area to determine if the sand media is allowing acceptable infiltration.	Routine-biannual inspection of hydraulic performance, one after a significant rainfall.

Table 2-7

Wetland Pool Area Distribution

Components	Percent of Permanent Pool Surface Area	Water Design Depth
Forebay, outlet and free water surface areas	30% to 50%	2 to 4 feet deep
Wetland zones with emergent vegetation	56% to 70%	6 to 12 inches deep*

*One-third to one-half of this zone should be 6 inches deep.

Table 2-8

Constructed Wetlands Maintenance Considerations

Required Action	Maintenance Objective	Frequency of Action
Lawn mowing and lawn care	Mow occasionally to limit unwanted vegetation. Maintain irrigated turf grass at 2 to 4 inches tall and nonirrigated native turf grasses at 4 to 6 inches. Mowing can be increased to 8 inches for water conservation or taller if needed.	Routine- depending on aesthetic requirements.
Debris and litter removal	Remove debris and litter from entire pond to minimize outlet clogging and aesthetics. Include removal of floatable material from the pond's surface.	Routine-including just before annual storm seasons and following significant rainfall events.
Sediment removal	Remove accumulated sediment and material along with much of the wetland growth. Reestablish growth zone depths and spatial distribution. Revegetate with original wetland species,	Nonroutine-every 10 to 20 years as needed by inspection if no construction activities take place in the tributary watershed. More often if they do. Expect to clean out forebay every 1 to 5 years.
Inspections	Observe inlet and outlet works for operability. Verify the structural integrity of all structural elements, slopes, and embankments.	Routine-at least once a year, preferably once during one rainfall even resulting in runoff.

Table 2-9

Recommended Tree and Shrub Spacing

	Tree Spacing (feet)	Shrub Spacing (feet)	Total Density (stems/acre)
Maximum	19	12	400
Average	12	8	1,000
Minimum	11	7	1,250

Source: Prince George's County, 1993.

Table 2-10a

Standardized WQCV Outlet Design Using Circular Openings (2" diameter maximum). Minimum Width (W_{conc}) of concrete opening for a Well-Screen-Type Trash Rack. Requires minimum water depth below lowest perforation of 2'4".

Maximum Diameter of Circular Opening (inches)	Width of Trash Rack Opening (W_{conc}) per column Holes as Function of Water Depth H					
	H = 2.0'	H = 3.0'	H = 4.0'	H = 5.0'	H = 6.0'	Maximum Number of Columns
≤ 0.25	3 inches	3 inches	3 inches	3 inches	3 inches	14
≤ 0.50	3 inches	3 inches	3 inches	3 inches	3 inches	14
≤ 0.75	3 inches	6 inches	6 inches	6 inches	6 inches	7
≤ 1.00	6 inches	9 inches	9 inches	9 inches	9 inches	4
≤ 1.25	9 inches	12 inches	12 inches	12 inches	15 inches	2
≤ 1.50	12 inches	15 inches	18 inches	18 inches	18 inches	2
≤ 1.75	18 inches	21 inches	21 inches	24 inches	24 inches	1
≤ 2.00	21 inches	24 inches	27 inches	30 inches	30 inches	1

Table 2-10b

Standardized WQCV Outlet Design Using 2" Diameter Circular Openings.

Maximum Width of Opening	Screen #93 VEE Wire Slot Opening	Support Rod Type	Support Rod, On-Center Spacing	Total Screen Thickness	Carbon Steel Frame Type
9"	0.139	#156 VEE	¾"	0.31"	⅜" x 1.0" flat bar
18"	0.139	TE 0.74" x 0.50"	1"	0.655"	¾" x 1.0" angle
24"	0.139	TE 0.74" x 0.75"	1"	1.03"	1.0" x 1½" angle
27"	0.139	TE 0.74" x 0.75"	1"	1.03"	1.0" x 1½" angle
30"	0.139	TE 0.74" x 1.0"	1"	1.155"	1¼" x ½" angle
36"	0.139	TE 0.74" x 1.0"	1"	1.155"	1¼" x 1½" angle
42"	0.139	TE 0.74" x 1.0"	1"	1.155"	1¼" x 1½" angle

Table 2-11a

Standardized WQCV Outlet Design Using 2” Height Rectangular Openings. Minimum Width ($W_{opening}$) of Opening for an Aluminum Bar Grate Trash Rack

Maximum Width W of 2” height Rectangular Opening (inches)	Minimum Width of Trash Rack Opening as a Function of Water Depth H					
	H = 2.0’	H = 3.0’	H = 4.0’	H = 5.0’	H = 6.0’	Spacing of Bearing Bars, Cross Rods
< 2.0	2.0’	2.5’	2.5’	2.5’	3.0’	1 $^{3}/_{16}$”, 2”
< 2.5	2.5’	3.0’	3.0’	3.5’	3.5’	1 $^{3}/_{16}$”, 2”
< 3.0	3.0’	3.5’	3.5’	4.0’	4.0’	1 $^{3}/_{16}$”, 2”
< 3.5	3.5’	4.0’	4.5’	4.5’	5.0’	1 $^{3}/_{16}$”, 2”
< 4.0	3.5’	4.5’	5.0’	5.0’	5.5’	1 $^{3}/_{16}$”, 2”
< 4.5	4.0’	4.5’	5.0’	5.5’	5.5’	1 $^{3}/_{16}$”, 4”
< 5.0	4.0’	5.0’	5.5’	6.0’	6.0’	1 $^{3}/_{16}$”, 4”
< 5.5	4.5’	5.5’	6.0’	6.5’	7.0’	1 $^{3}/_{16}$”, 4”
< 6.0	5.0’	6.0’	6.5’	7.0’	7.5’	1 $^{3}/_{16}$”, 4”
< 6.5	5.5’	6.5’	7.0’	7.5’	8.0’	1 $^{3}/_{16}$”, 4”
< 7.0	6.0’	7.0’	7.5’	8.5’	8.5’	1 $^{3}/_{16}$”, 4”
< 7.5	6.0’	7.5’	8.5’	9.0’	9.5’	1 $^{3}/_{16}$”, 4”
< 8.0	6.5’	8.0’	9.0’	9.5’	10.’	1 $^{3}/_{16}$”, 4”
< 8.5	7.0’	8.5’	9.5’	10.0’	n/a	1 $^{3}/_{16}$”, 4”
< 9.0	7.5’	9.0’	10.0’	n/a	n/a	1 $^{3}/_{16}$”, 4”
< 9.5	8.0’	9.5’	n/a	n/a	n/a	1 $^{3}/_{16}$”, 4”
< 10.0	8.5’	10.0’	n/a	n/a	n/a	1 $^{3}/_{16}$”, 4”
< 10.5	8.5’	n/a	n/a	n/a	n/a	1 $^{3}/_{16}$”, 4”
< 11.0	9.0’	n/a	n/a	n/a	n/a	1 $^{3}/_{16}$”, 4”
< 11.5	9.5’	n/a	n/a	n/a	n/a	1 $^{3}/_{16}$”, 4”
< 12.0	10.0’	n/a	n/a	n/a	n/a	1 $^{3}/_{16}$”, 4”

Table 2-11b

Standardized WQCV Outlet Design Using 2” Height Rectangular Openings.

Water Depth Above Lowest Opening, H	**Minimum Bearing Bar Size, Bearing Bars Aligned Vertically**
2.0’	1” x $^{3}/_{16}$”
3.0’	1¼” x $^{3}/_{16}$”
4.0’	1¾” x $^{3}/_{16}$”
5.0’	2” x $^{3}/_{16}$”
6.0’	2¼” x $^{3}/_{16}$”

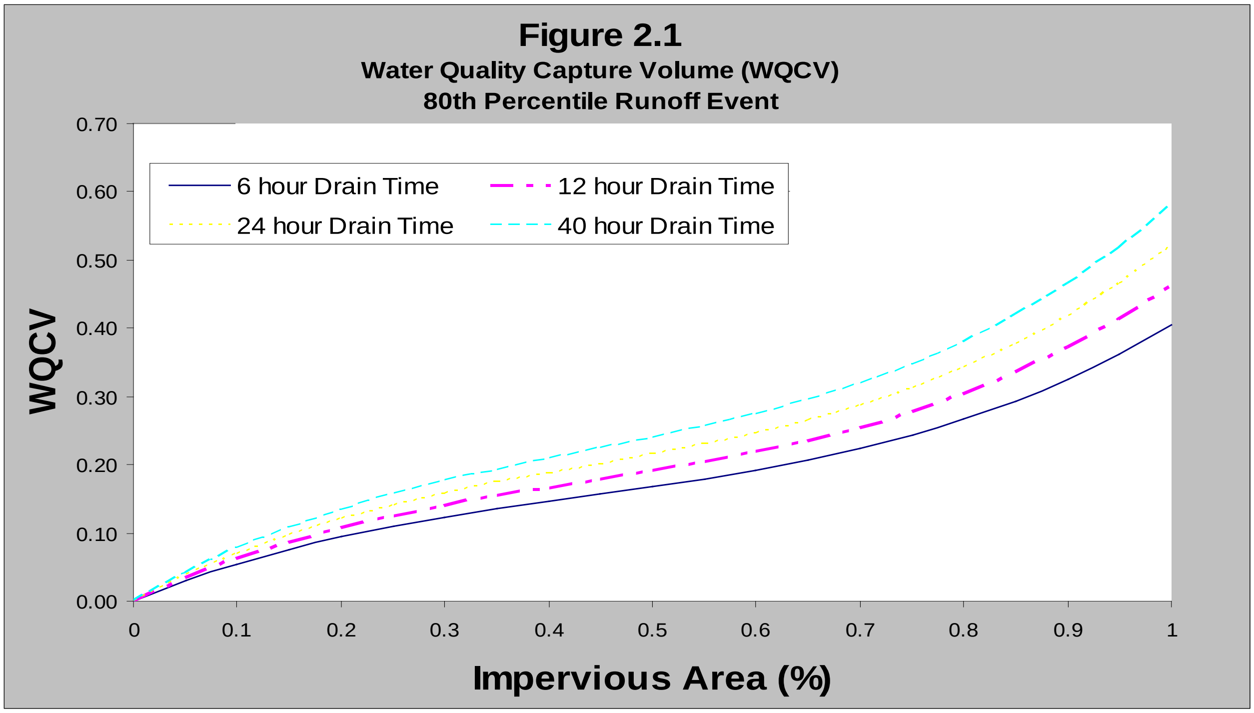
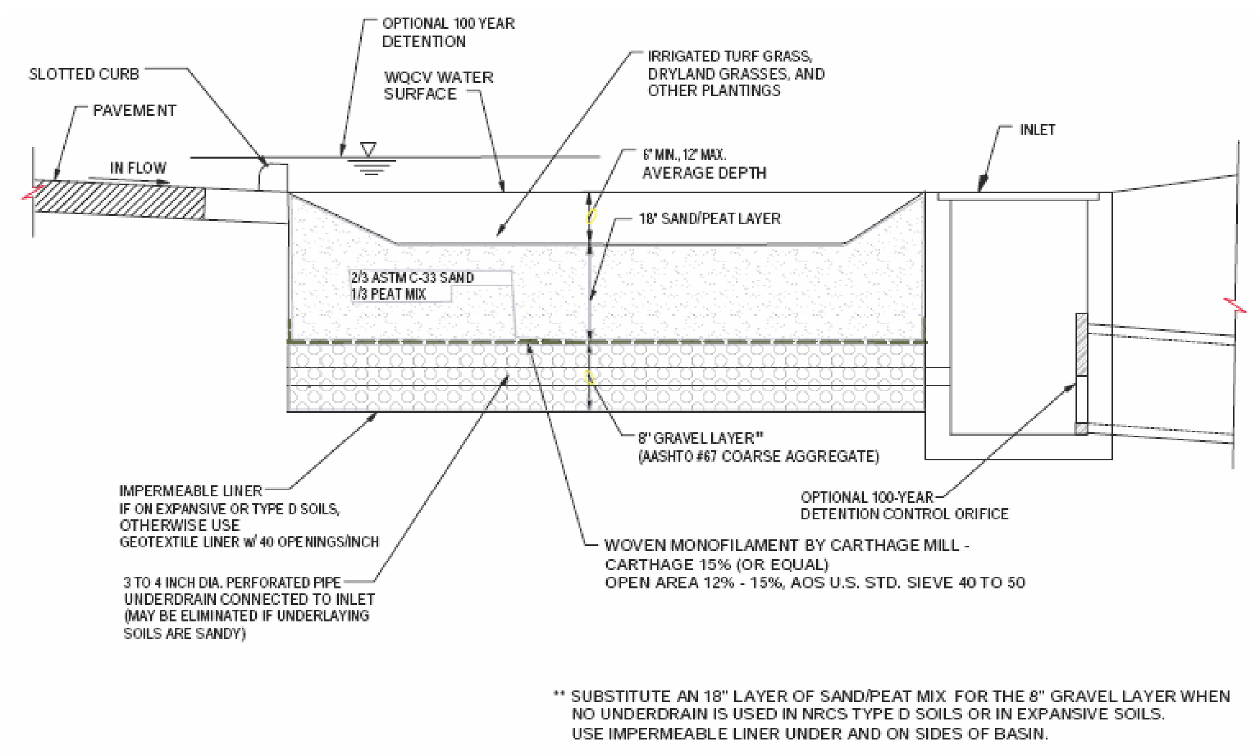


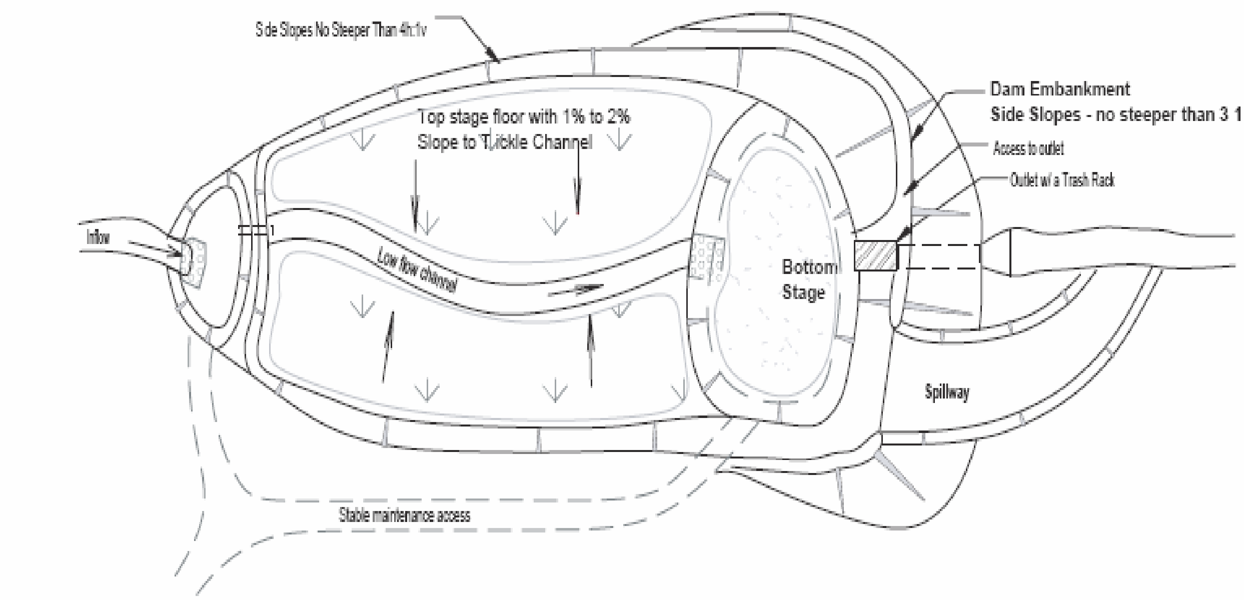
Figure 2.1
Water Quality Capture Volume (WQCV)
80th Percentile Runoff Event

Figure 2.2
Porous Landscape Detention (PLD)

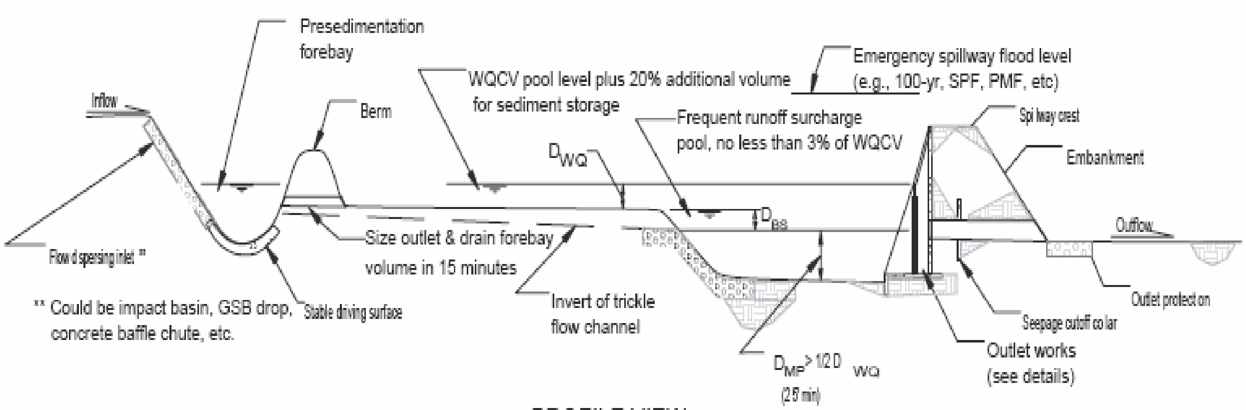


Source: City of Sioux Falls, 2008

Figure 2.3
Extended Detention Basin Sedimentation Facility



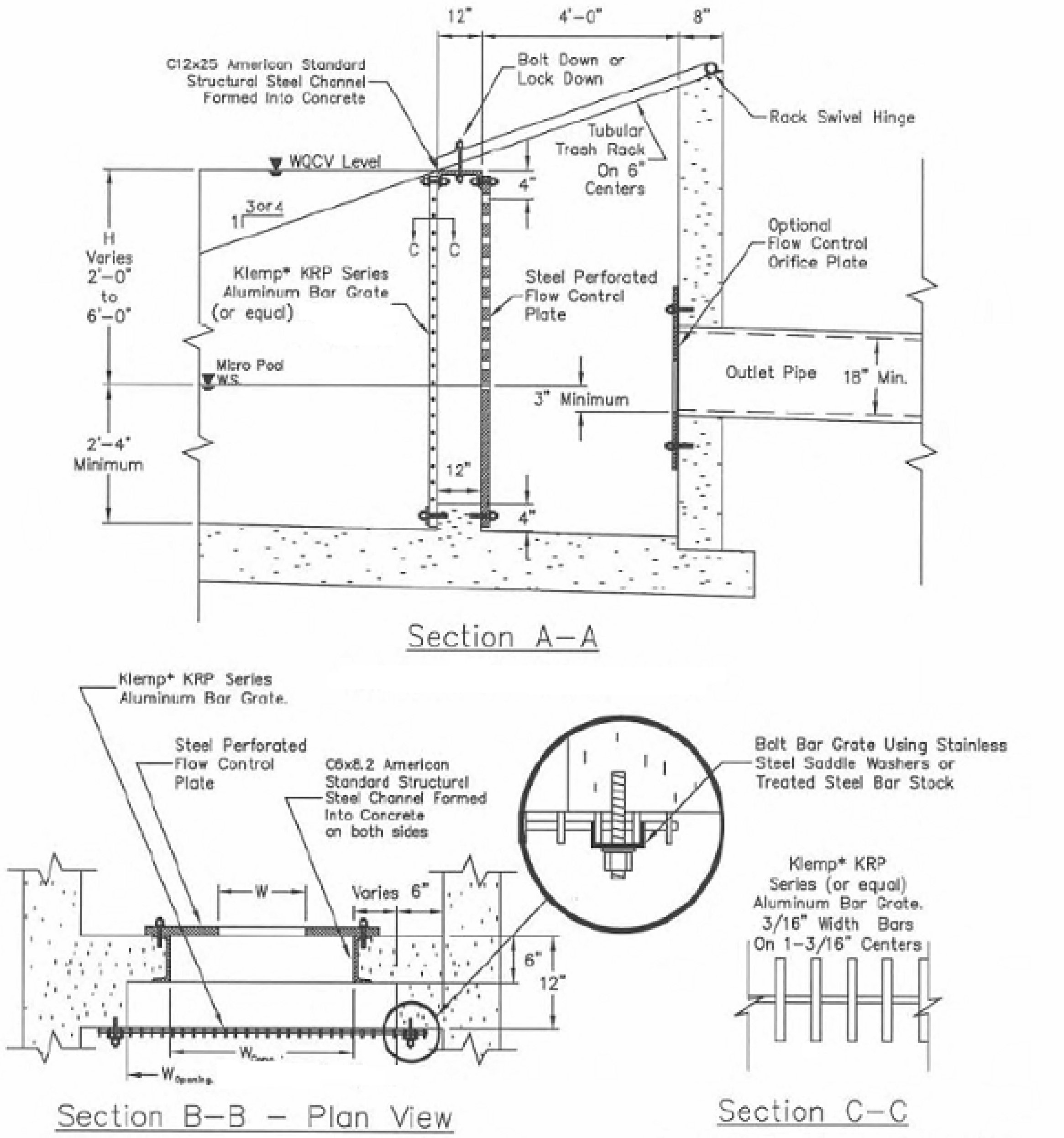
PLAN VIEW
Not to Scale



PROFILE VIEW
Not to Scale

Source: City of Sioux Falls, 2008

Figure 2.4
Trash Rack and Outlet Design for WQCV Outlets with Rectangular Openings



Limits for this Standardized Design:

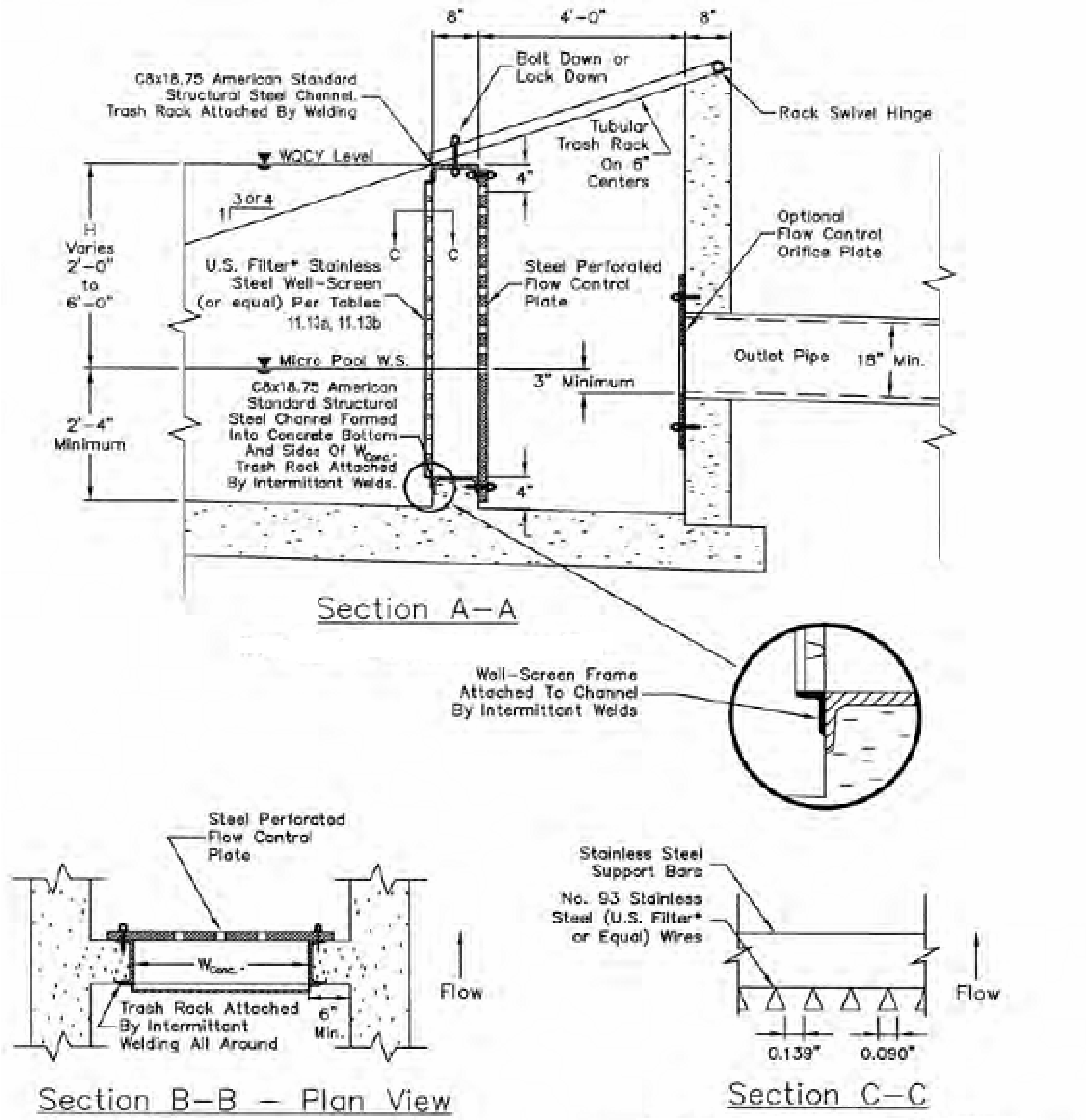
1. All outlet plate openings are rectangular.
2. Height of all rectangular openings = 2 inches.
3. For trash rack opening width ($W_{Opening}$)
4. Concrete opening for outlet plate ($W_{Conc.}$) = W + 12 inches

*Klemp Corporation, Orem, Utah, USA

R Value = (net open area)/(gross rack area)
= 0.71 for cross rods on 2" centers
= 0.77 for cross rods on 4" centers

Source: City of Sioux Falls, 2008

Figure 2.5
Trash Rack and Outlet Design for WQCV Outlets with Circular Openings



Limits for this Standardized Design:

1. All outlet plate openings are circular.
2. Maximum diameter of opening = 2 inches.

*U.S. Filter, St. Paul, Minnesota, USA

R Value = (net open area)/(gross rack area) = 0.60

Source: City of Sioux Falls, 2008

Figure 2.6

Typical Outlet Structure Notes:

1. The details shown are intended to show design concepts. Preparation of final design plans, addressing details of structural adequacy, excavation, foundation preparation, concrete work, reinforcing steel, backfill, metalwork, and appurtenances, including preparation of technical specifications, are the responsibility of the design engineer.

2. Alternate designs to the typical outlet structures shown may be considered; however, alternate designs must address the hydraulic and trash handling functional elements of the structures shown.

3. Wingwalls shown are intended to enable the structure to be backfilled to be flush with the side slopes of the basin, which is the recommended geometry. Other geometries may be considered if their designs related to public safety, aesthetics, maintainability, and function are equal to or better than the designs shown.

4. Permanent Water Surface shown refers to micro-pool for Extended Detention Basin or permanent pool for Constructed Wetland Basin or Retention Pond.

5. An orifice plate is shown as the outflow control; however, an upturned pipe, with orifices may also be used. See Figure 2.8 for orifice design information.

6. A Vertical Trash Rack option is generally shown; however, an Adverse-Slope Trash Rack may also be used. Continuous-Slope Trash Racks for use with WQCV outlets are not recommended. See Figure 2.10 for trash rack design information.

7. References are made to 2- or 10-year detention above the WQCV; however, detention above the WQCV may be sized for any storm event.

8. The underdrain, including a shutoff valve, from the perimeter of the pond is required for a Wetland Basin and a Retention Pond. An underdrain, without a shutoff valve, is optional for the micro-pool and may be used to help dry the micro-pool during dry-weather periods.

9. When outlet designs differ from those shown herein:

   a) Provide needed orifices that are distributed over the vertical height of the WQCV, with the lowest orifice located at 2'-6" or more above the bottom of the micro-pool.

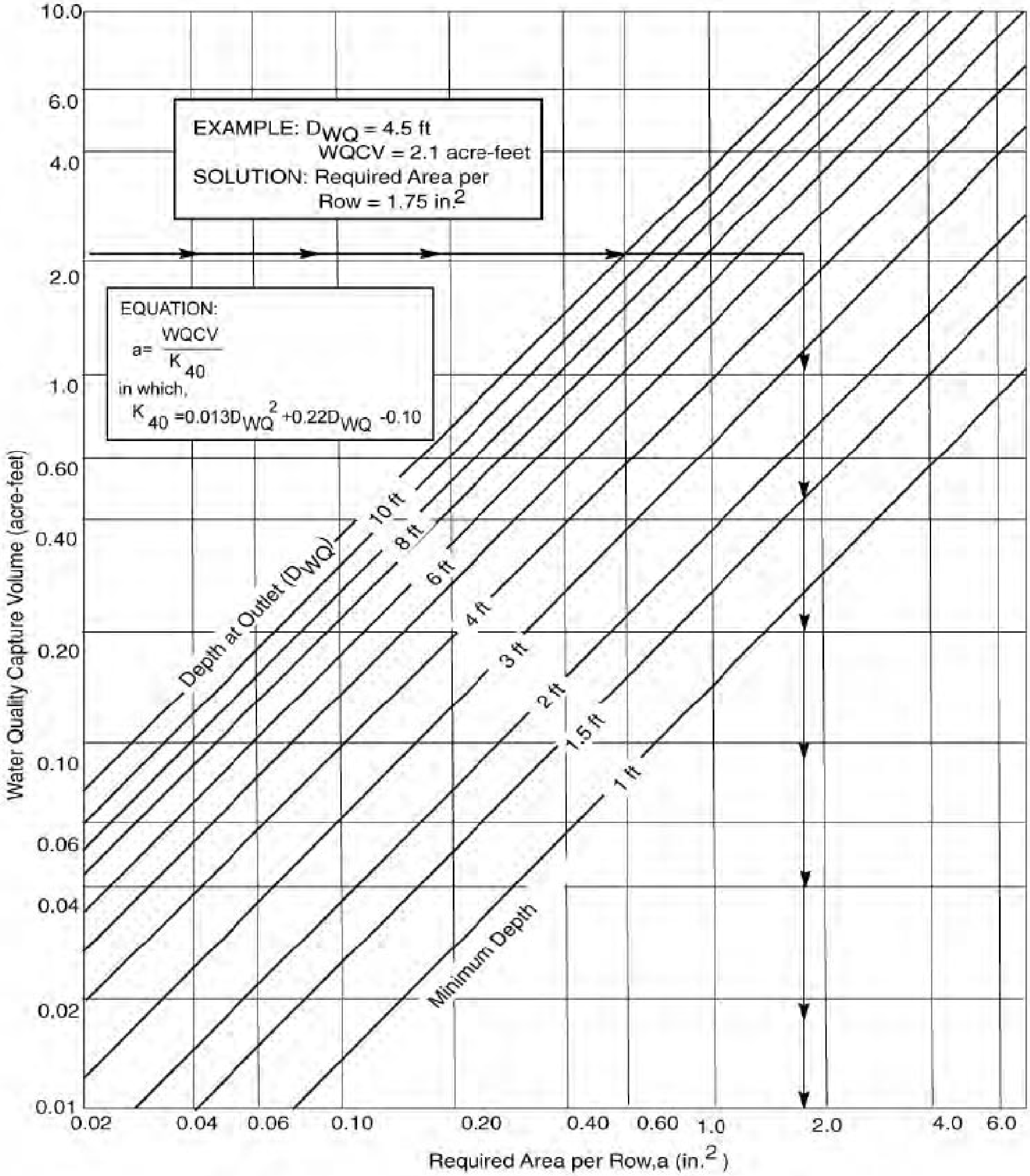
   b) Provide full hydraulic calculations demonstrating that the outlet will provide no less than the minimum required drain time of the Water Quality Capture Volume for the BMP type being designed.

   c) All outlet openings (i.e., orifices) shall be protected by a trash rack sized to provide a minimum net opening area called for by Figure 2.11 , and all trash rack opening dimensions shall be smaller than the smallest dimension of the outlet orifices.

   d) Trash racks shall be manufactured from stainless steel or aluminum alloy structurally designed to not fail under a full hydrostatic load on the upstream side.

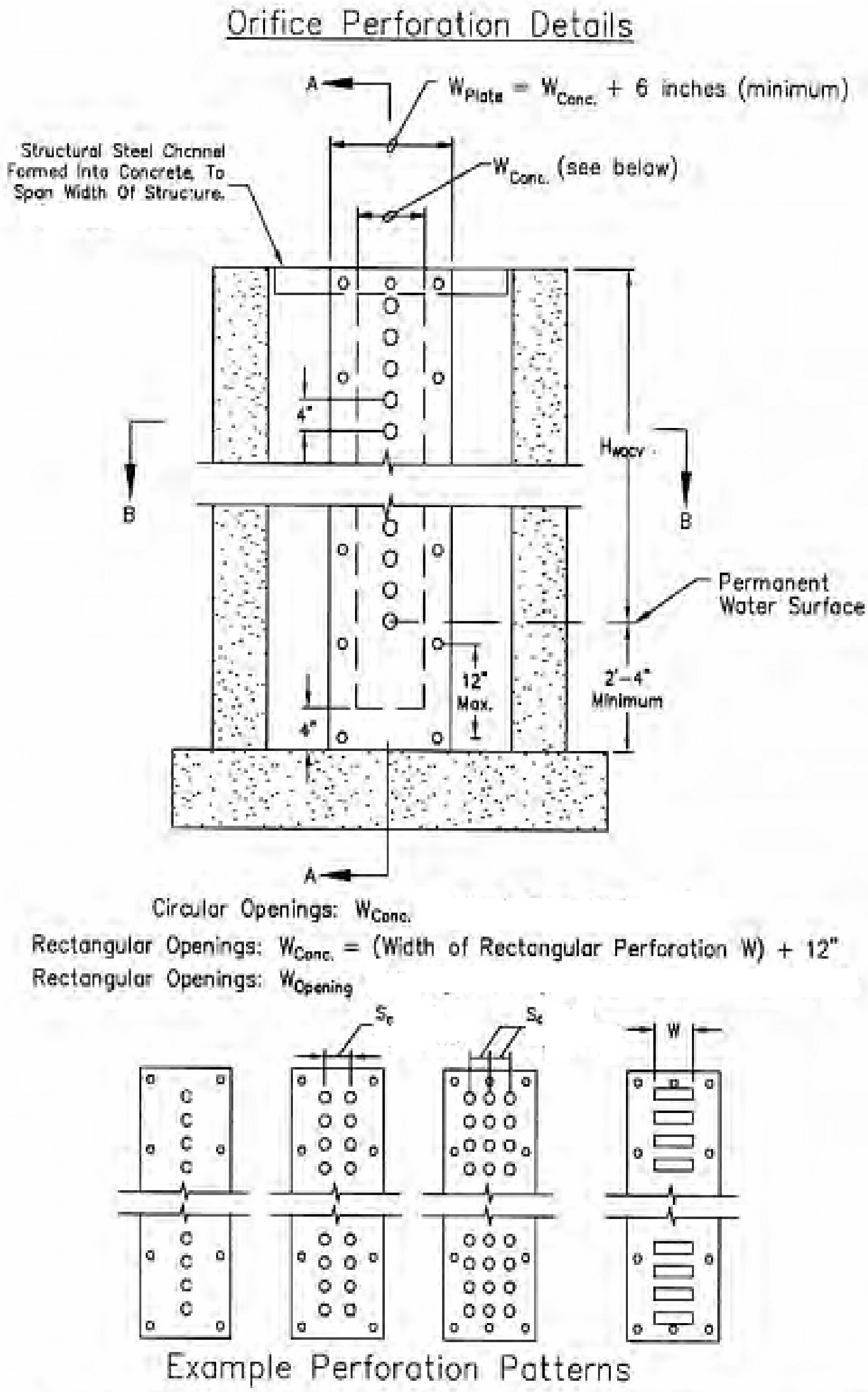
Source: City of Sioux Falls, 2008

Figure 2.7
Water Quality Outlet Sizing



Source: City of Sioux Falls, 2008

Figure 2.8



Note: The goal in designing the outlet is to minimize the number of columns of perforations that will drain the WQCV in the desired time. Do not, however, increase the diameter of circular perforations or the height of the rectangular perforations beyond 2 inches. Use the allowed perforation shapes and configurations shown above along with Figure 2.9 to determine the pattern that provides an area per row closest to that required without exceeding it.

Source: City of Sioux Falls, 2008

Figure 2.9

Orifice Plate Perforation Sizing

Circular Perforation Sizing

Chart may be applied to orifice plate or vertical pipe outlet.

Hole Dia (in) *	Hole Dia (in)	Min. Sc (in)	Area per Row (sq in)		
			n=1	n=2	n=3
1/4	0.250	1	0.05	0.10	0.15
5/16	0.313	2	0.08	0.15	0.23
3/8	0.375	2	0.11	0.22	0.33
7/16	0.438	2	0.15	0.30	0.45
1/2	0.500	2	0.20	0.39	0.59
9/16	0.563	3	0.25	0.50	0.76
5/8	0.625	3	0.31	0.61	0.92
11/16	0.688	3	0.37	0.74	1.11
3/4	0.750	3	0.44	0.88	1.33
13/16	0.813	3	0.52	1.04	1.56
7/8	0.875	3	0.60	1.20	1.80
15/16	0.938	3	0.69	1.38	2.07
1	1.000	4	0.79	1.57	2.36
1 1/16	1.063	4	0.89	1.77	2.66
1 1/8	1.125	4	0.99	1.99	2.98
1 3/16	1.188	4	1.11	2.22	3.32
1 1/4	1.250	4	1.23	2.45	3.68
1 5/16	1.313	4	1.35	2.71	4.06
1 3/8	1.375	4	1.48	2.97	4.45
1 7/16	1.438	4	1.62	3.25	4.87
1 1/2	1.500	4	1.77	3.53	5.30
1 9/16	1.563	4	1.92	3.83	5.75
1 5/8	1.625	4	2.07	4.15	6.22
1 11/16	1.688	4	2.24	4.47	6.71
1 3/4	1.750	4	2.41	4.81	7.22
1 13/16	1.813	4	2.58	5.16	7.74
1 7/8	1.875	4	2.76	5.52	8.28
1 15/16	1.938	4	2.95	5.90	8.84
2	2.000	4	3.14	6.28	9.42
n = Number of columns of perforations					
Minimum steel plate thickness			1/4 "	5/16 "	3/8 "

* Designer may interpolate to the nearest 32nd inch to better match the required area, if desired.

Rectangular Perforation Sizing

Only one column of rectangular perforations allowed.

Rectangular Height = 2 inches

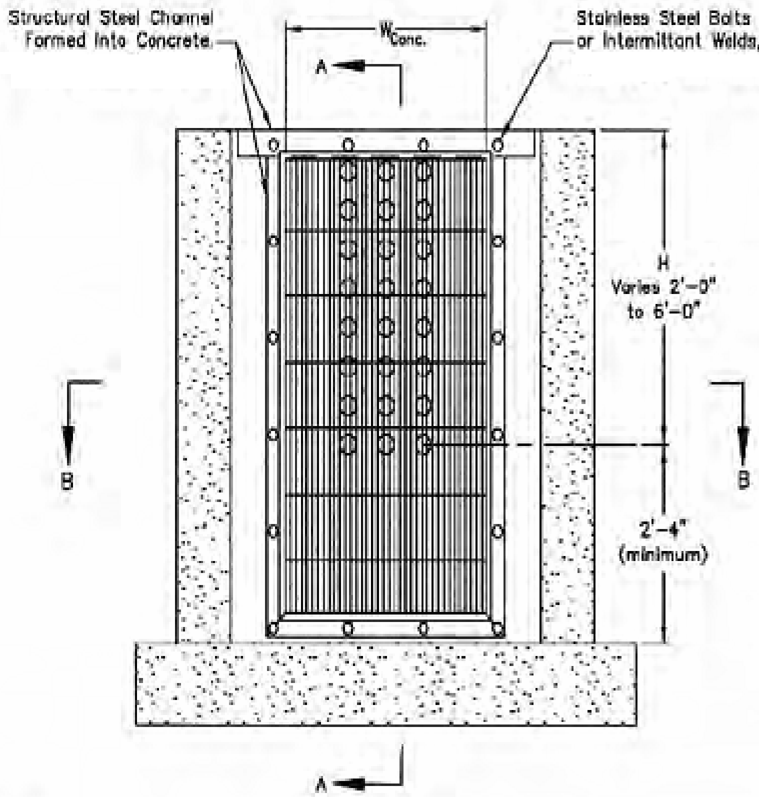
$$\text{Rectangular Width (inches)} = \frac{\text{Required Area per Row (sq in)}}{2''}$$

Rectangular Hole Width	Min. Steel Thickness
5"	1/4 "
6"	1/4 "
7"	5/32 "
8"	5/16 "
9"	1'/32 "
10"	3/8 "
>10"	1/2 "

Source: City of Sioux Falls, 2008

Figure 2.10
Suggested Trash Rack Design

Note: Vertical WQCV Trash Racks are shown in Figures 2.4, 2.5, 2.10 for suggested standardized outlet design. Adverse-Slope Trash Rack design may be used for non-standardized designs, but must meet minimum design criteria.



Elevation

WQCV Trash Racks:

1. Well-screen trash racks shall be stainless steel and shall be attached by intermittant welds along the edge of the mounting frame.
2. Bar grate trash racks shall be aluminum and shall be bolted using stainless steel hardware.
3. Trash Rack widths are for specified trash rack material. Finer well-screen or mesh size than specified is acceptable, however, trash rack dimensions need to be adjusted for materials having a different open area/gross area ratio (R value)
4. Structural design of trash rack shall be based on full hydrostatic head with zero head downstream of the rack.

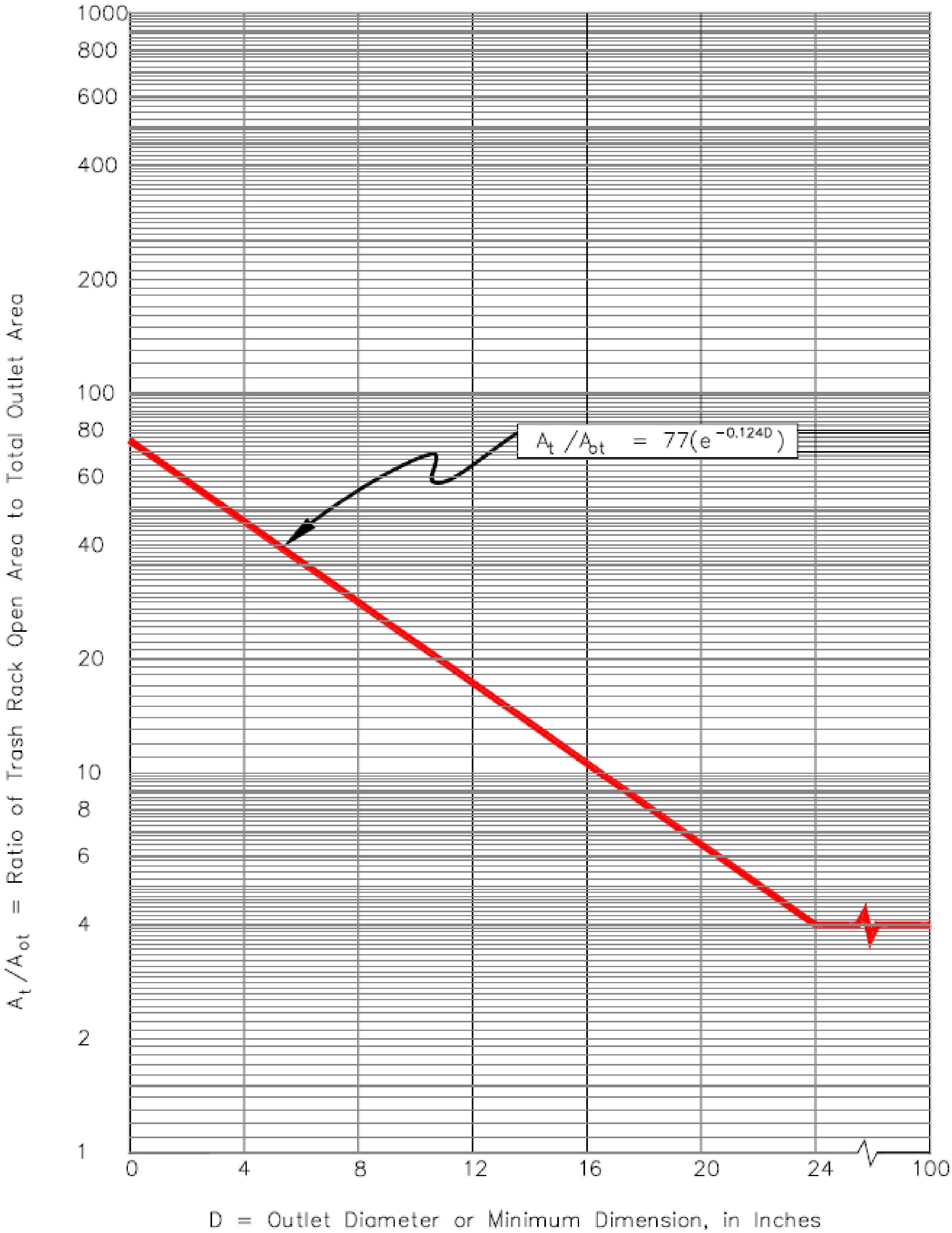
Overflow Trash Racks:

1. All trash racks shall be mounted using stainless steel hardware and provided with hinged and lockable or boltable access panels.
2. Trash racks shall be stainless steel, aluminum, or steel. Steel trash racks shall be hot dip galvanized and may be hot powder painted after galvanizing.
3. Trash Racks shall be designed such that the diagonal dimension of each opening is smaller than the diameter of the outlet pipe.
4. Structural design of trash rack shall be based on full hydrostatic head with zero head downstream of the rack.

Source: City of Sioux Falls, 2008

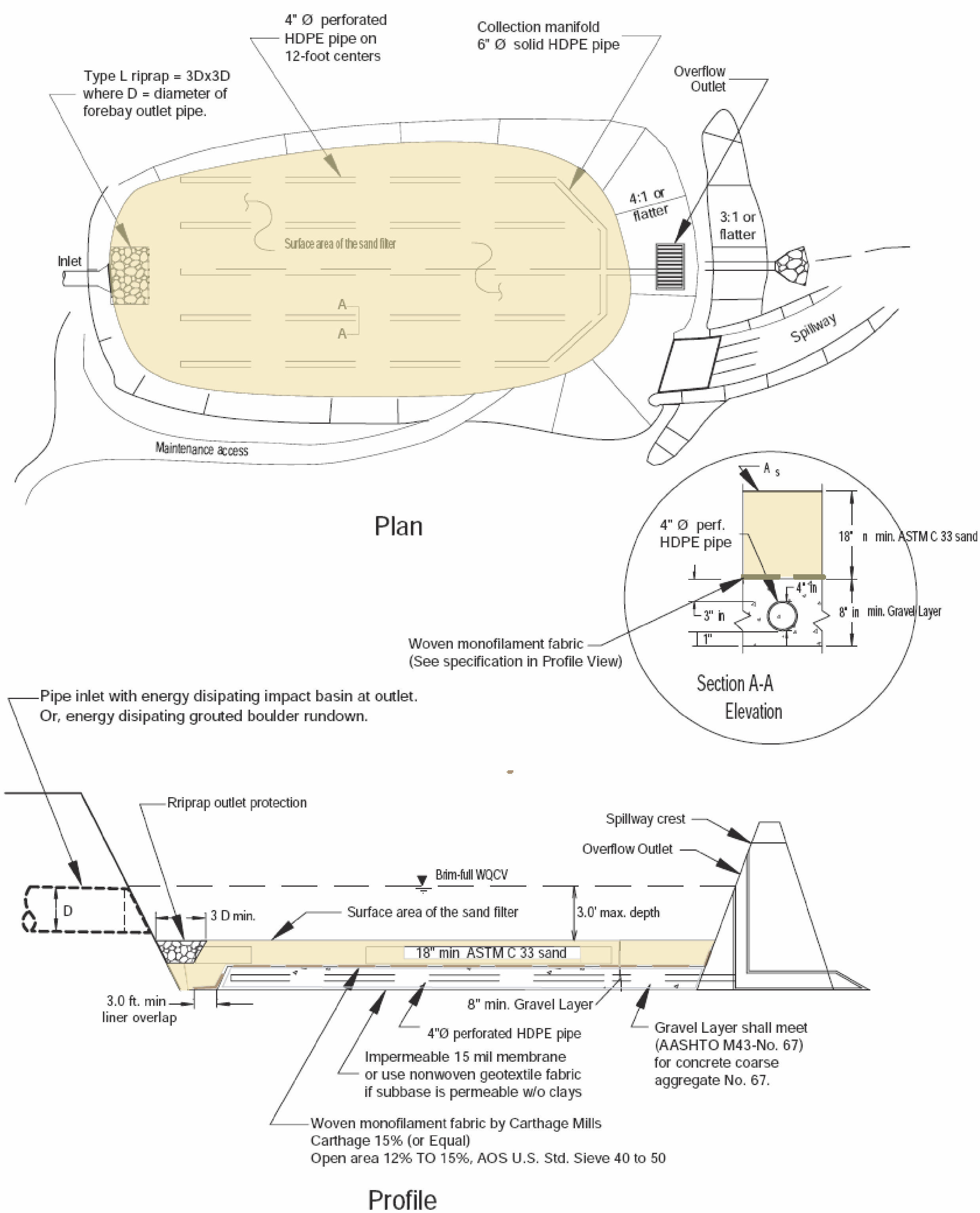
Figure 2.11

Minimum Trash Rack Open Area – Extended Range



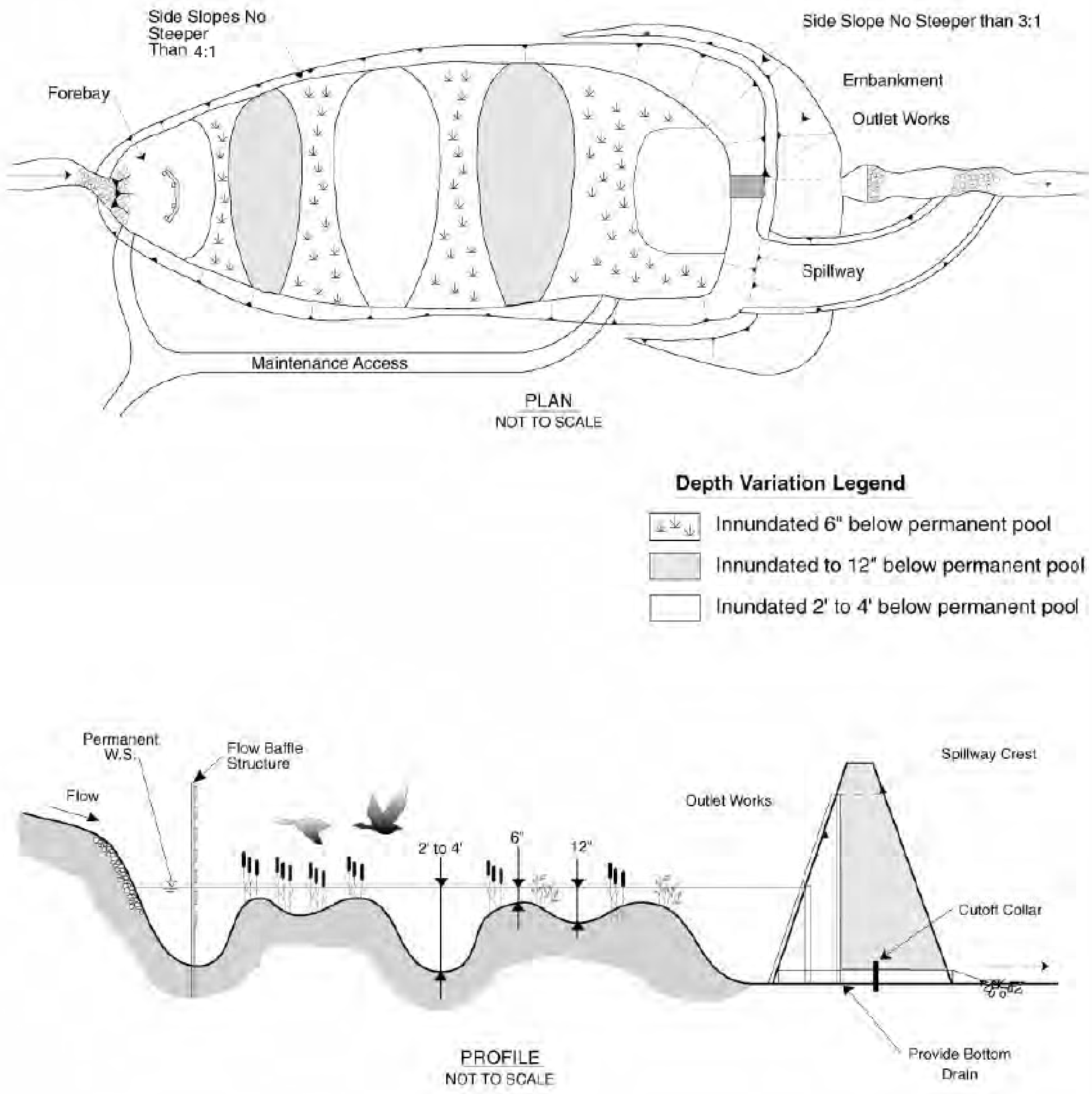
Source: City of Sioux Falls, 2008

Figure 2.12
Sand Filter Extended Detention Basin



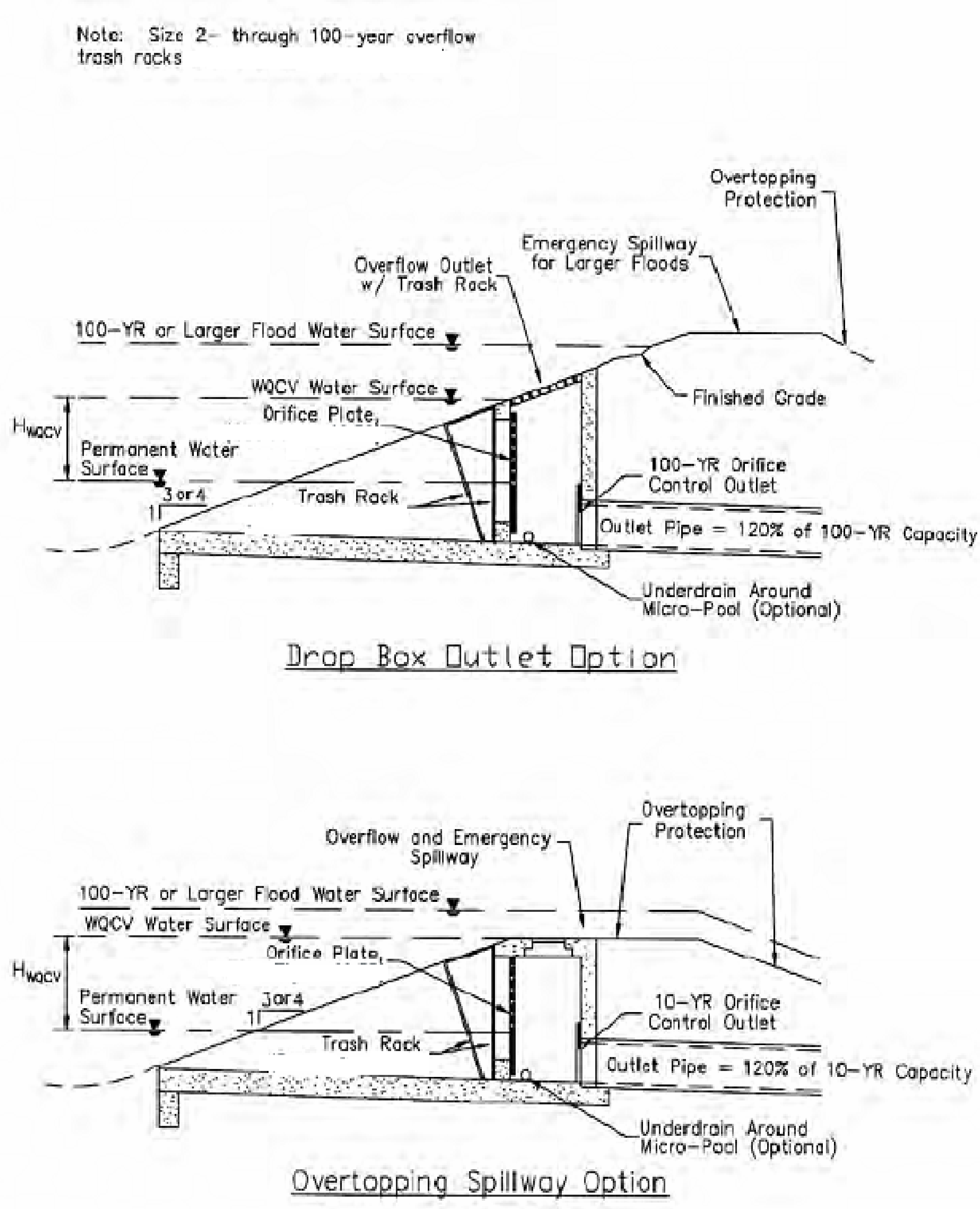
Source: City of Sioux Falls, 2008

Figure 2.13
Constructed Wetland Basin Sedimentation



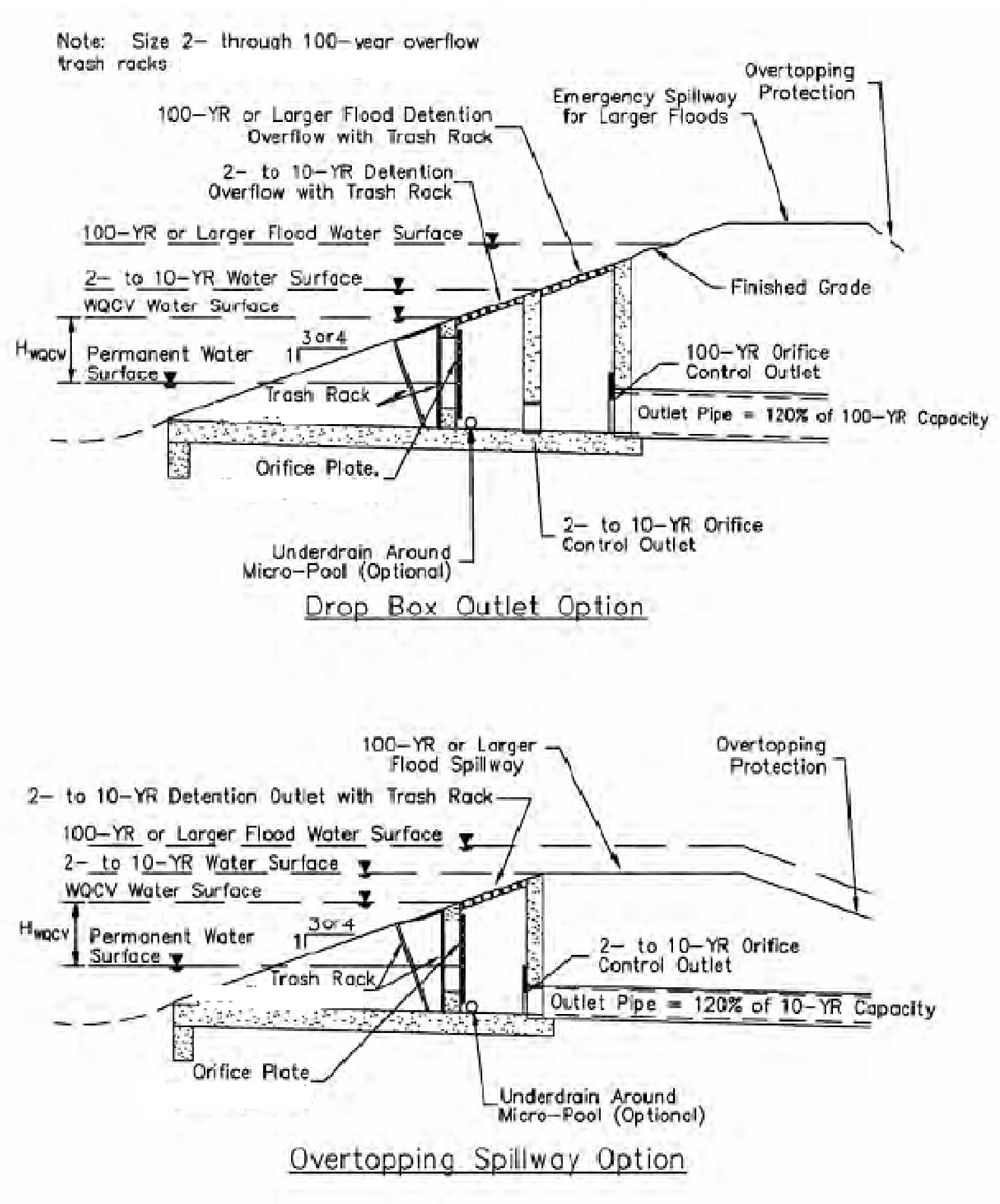
Source: City of Sioux Falls, 2008

Figure 2.14
WQCV Outlet Structure Profiles Including 100-year Detention



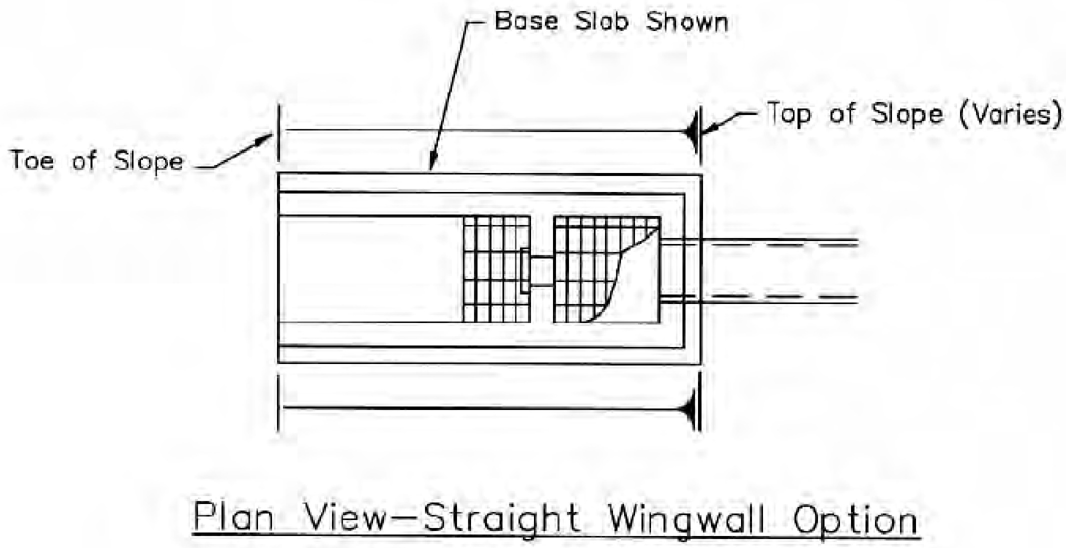
Source: City of Sioux Falls, 2008

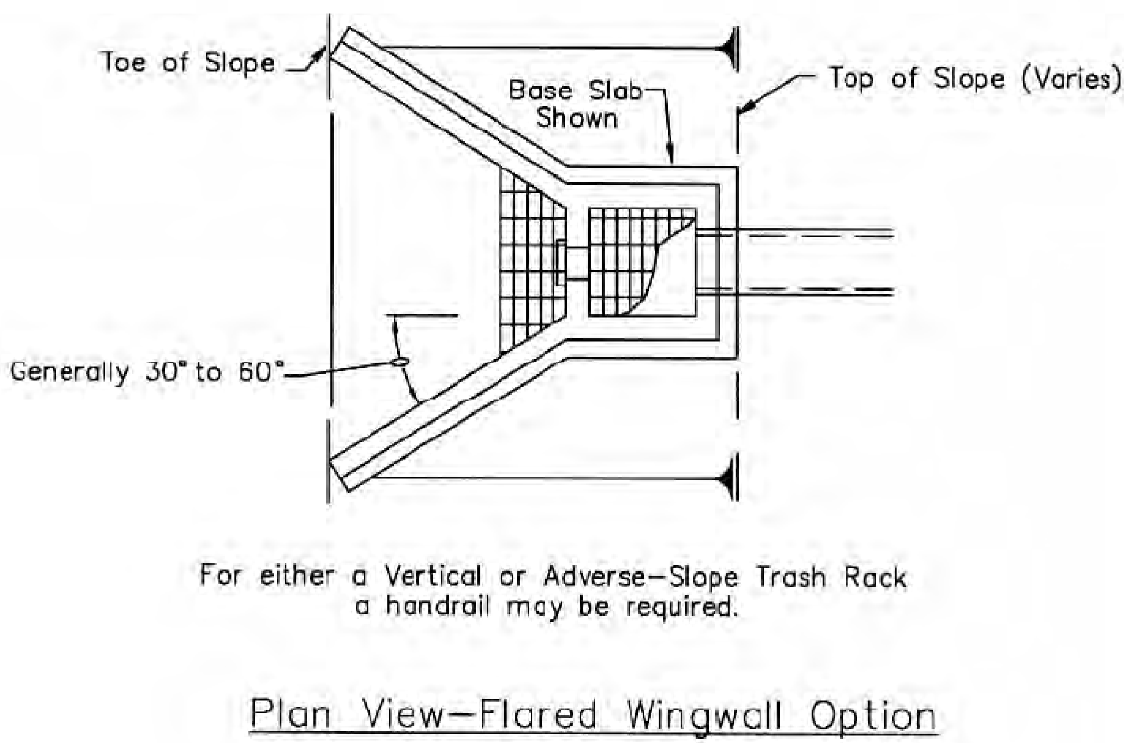
Figure 2.15
WQCV Outlet Structure Profiles Including 2 to 10-year and 100-year Detention



Source: City of Sioux Falls, 2008

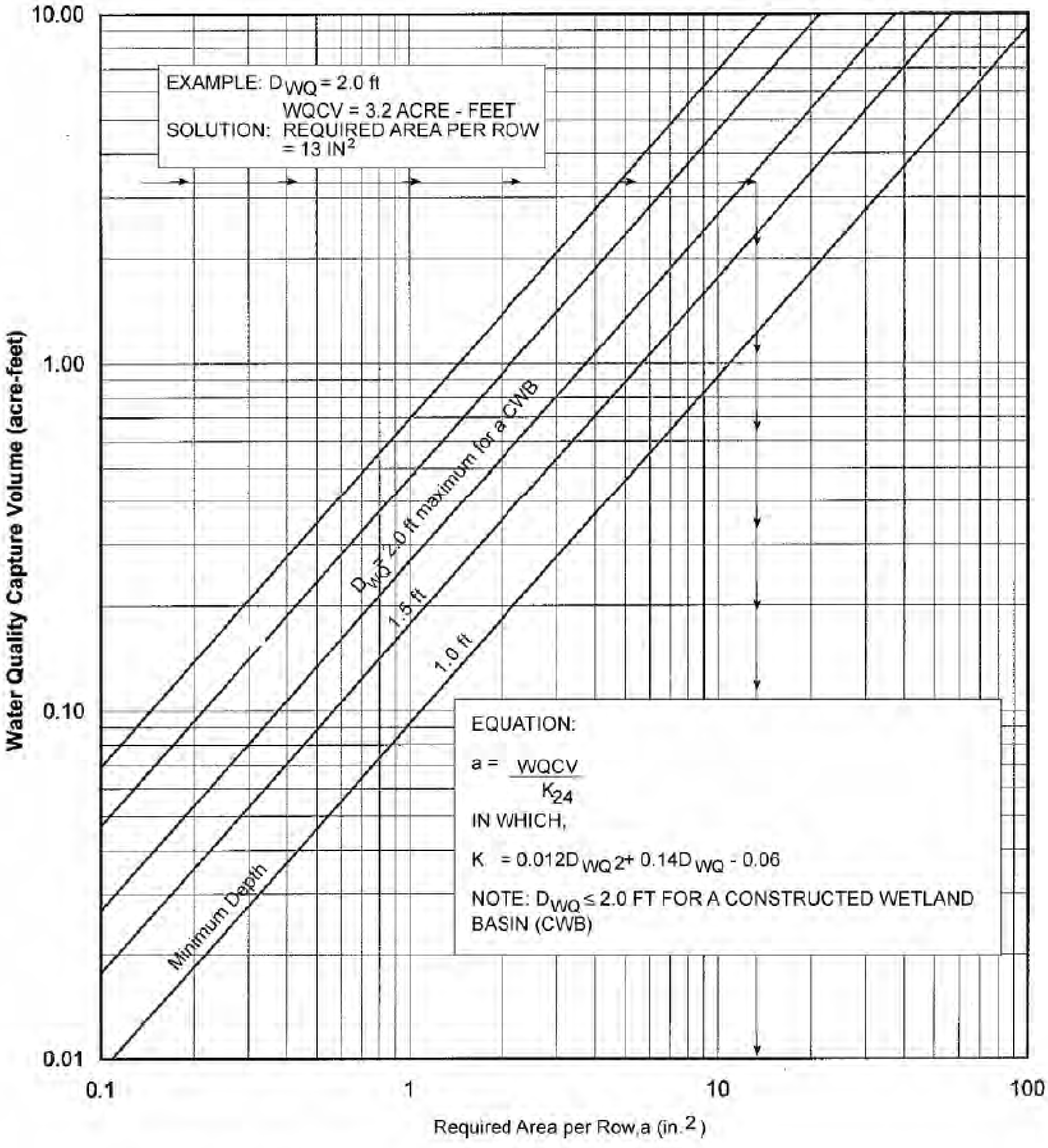
Figure 2.16
WQCV Outlet Structure Wingwall Configurations





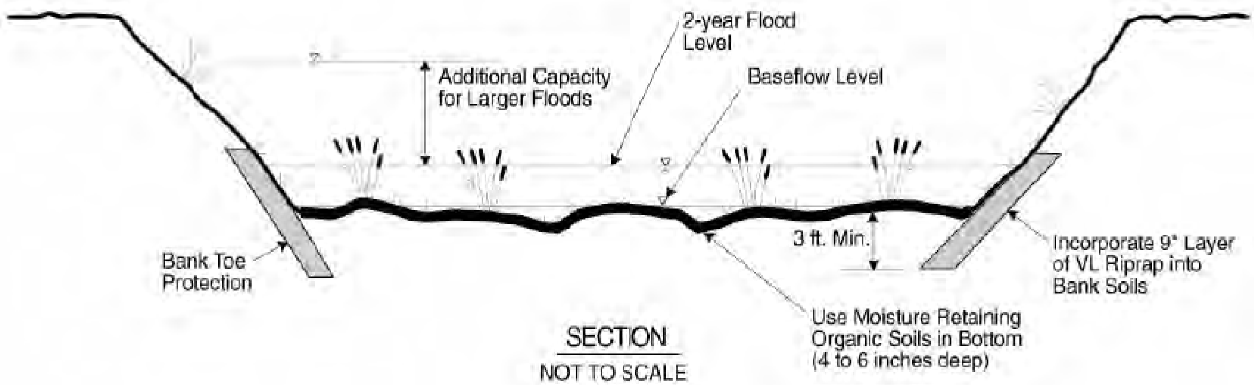
Source: City of Sioux Falls, 2008

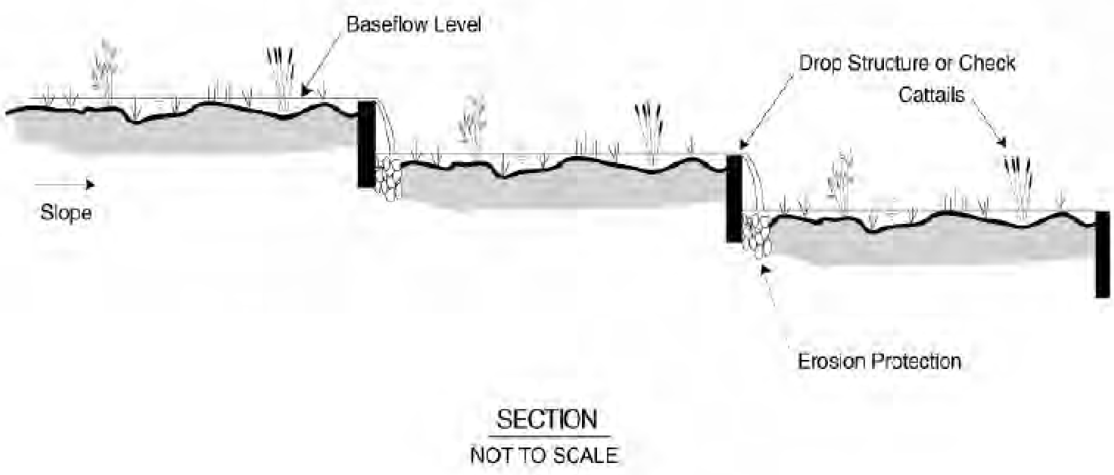
Figure 2.17
Water Quality Outlet Sizing: Constructed Wetland w/24-hour Drain Time of Capture Volume



Source: City of Sioux Falls, 2008

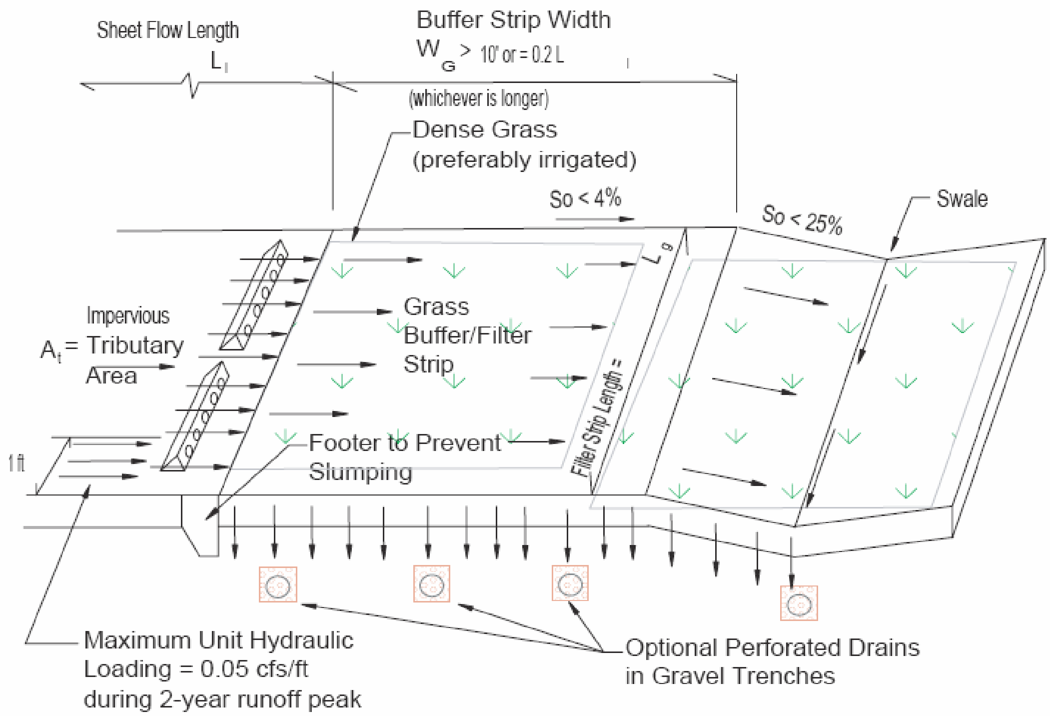
Figure 2.18
Constructed Wetland Channel





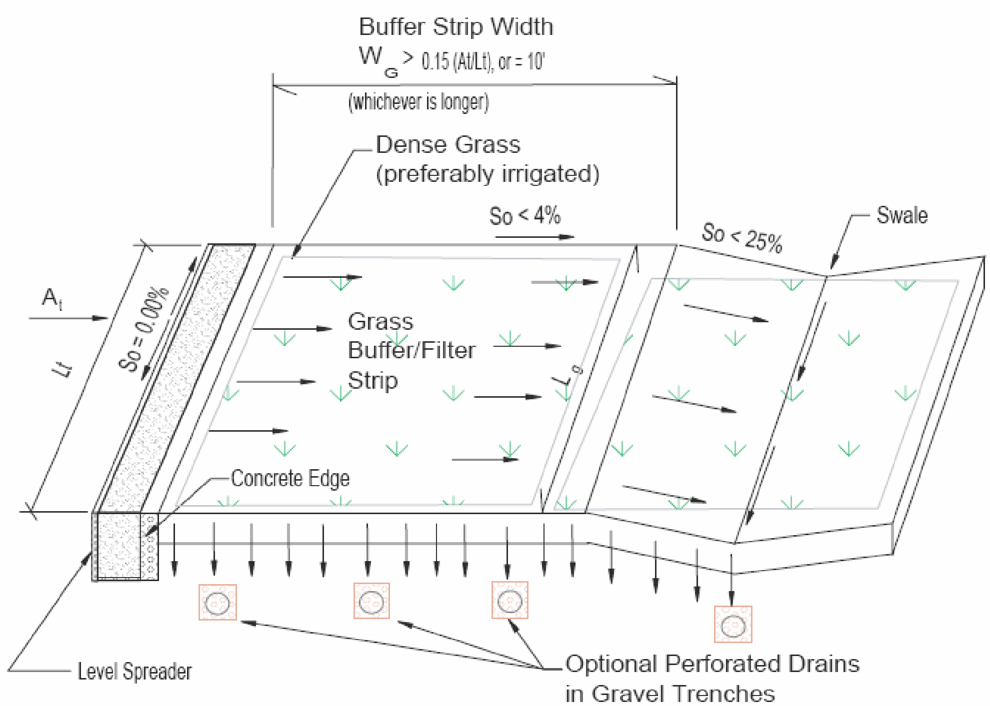
Source: City of Sioux Falls, 2008

Figure 2.19
Grass Buffers



SHEET FLOW CONTROL

Not To Scale

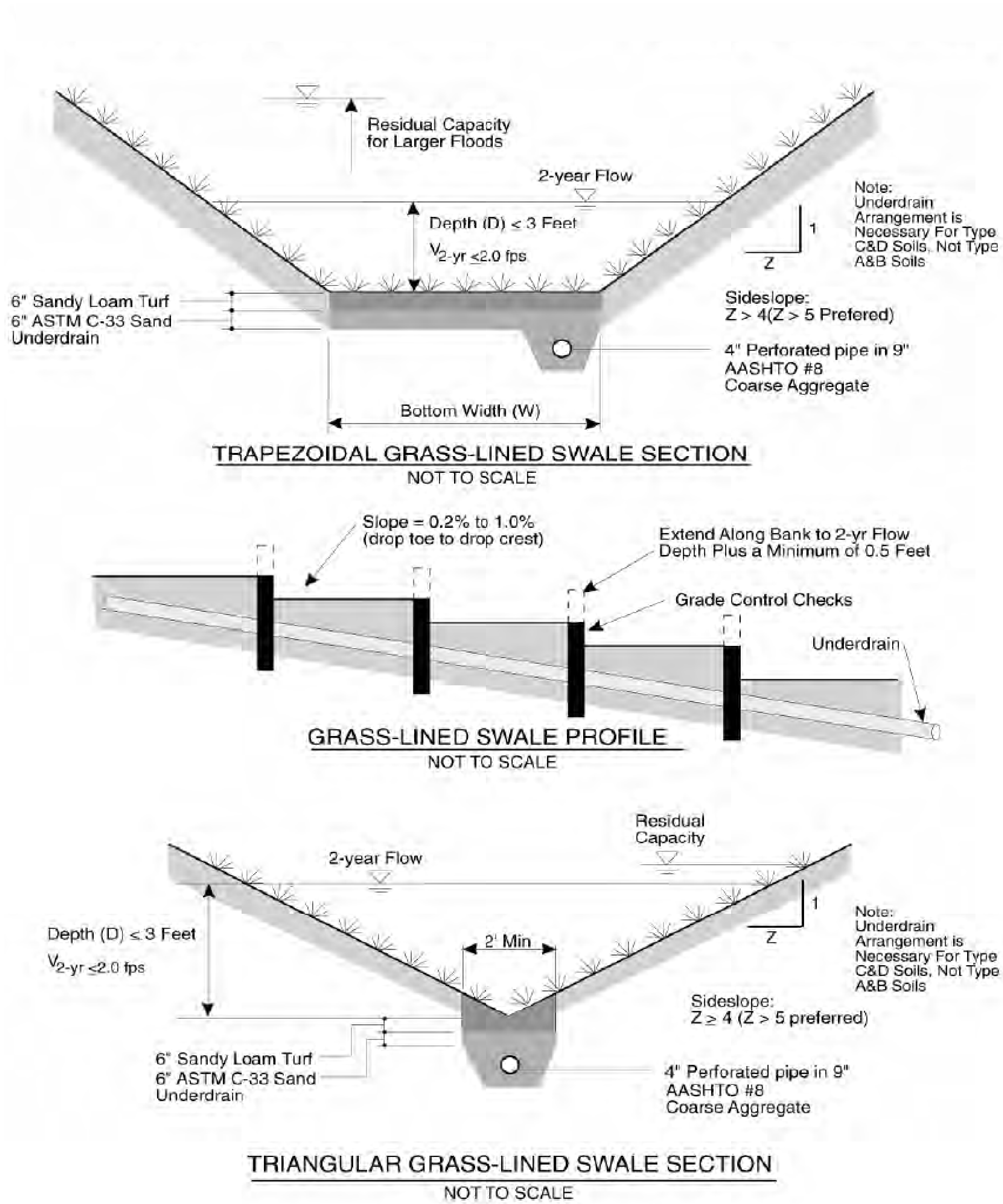


CONCENTRATED FLOW CONTROL

Not To Scale

Source: City of Sioux Falls, 2008

Figure 2.20
Grass Swale



Source: City of Sioux Falls, 2008

Figure 2.21
Profile of Bioretention Area

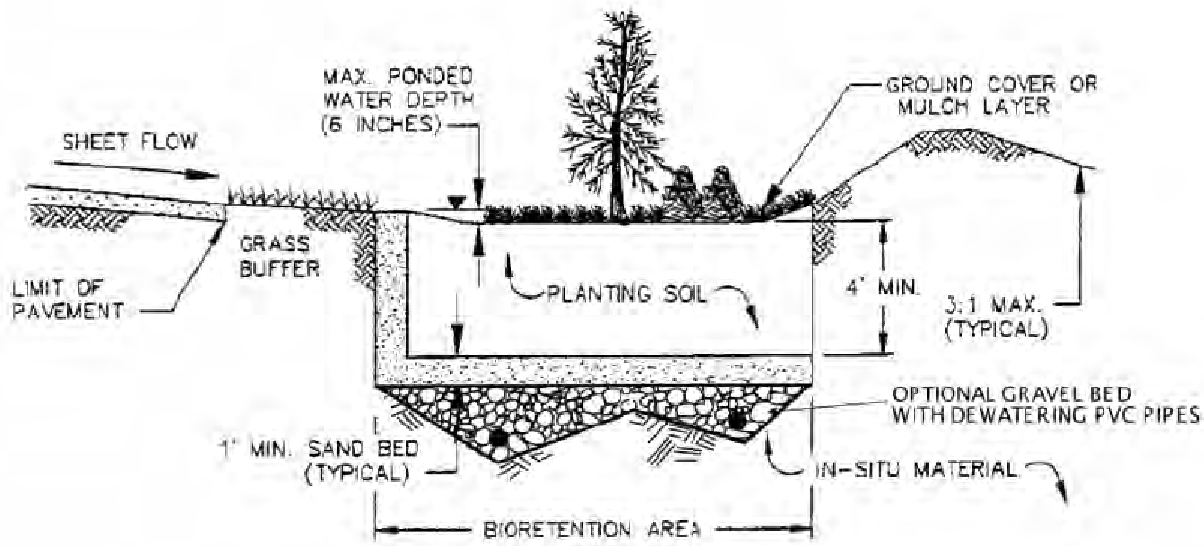
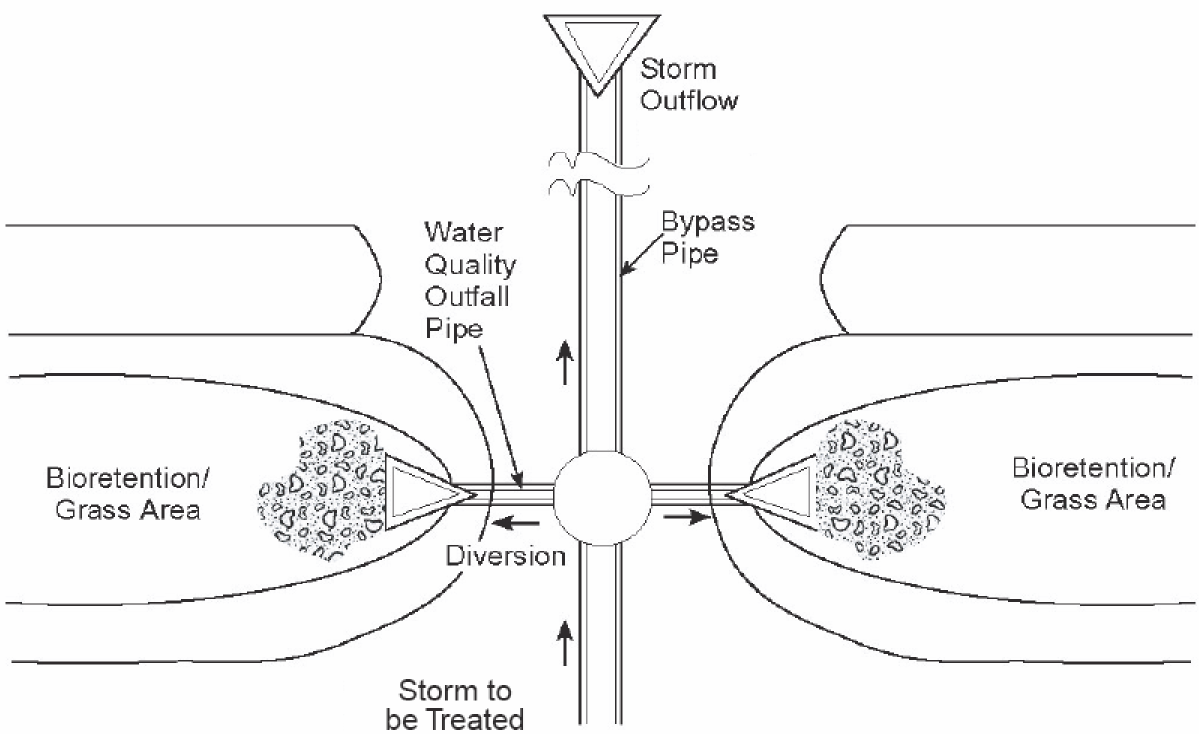
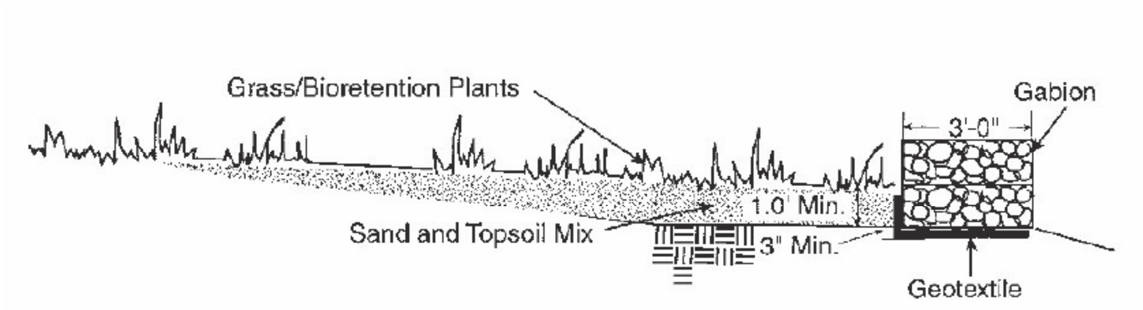


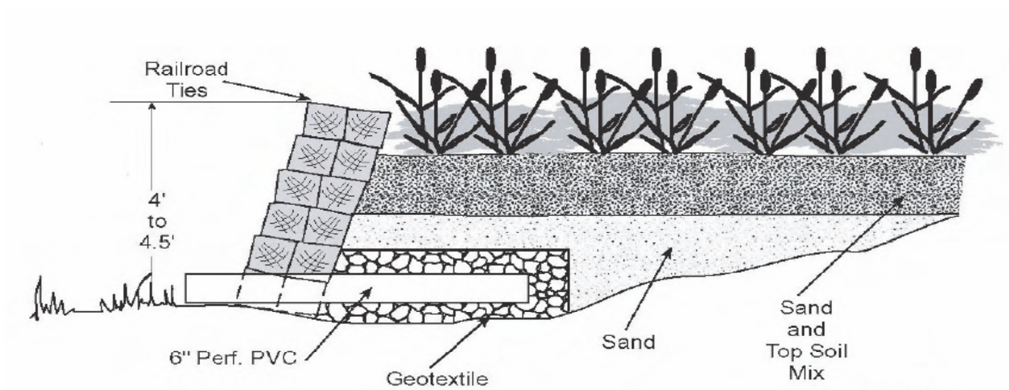
Figure 2.22
Storm Sewer Diversion to Bioretention Area

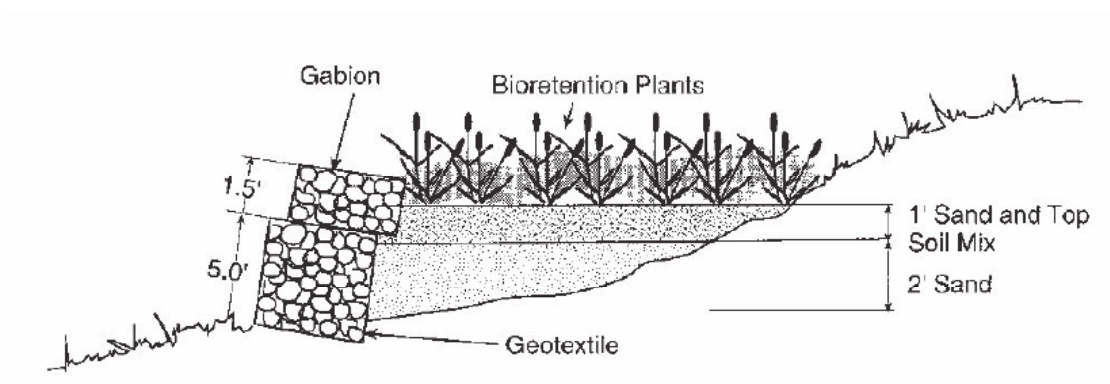


Source: City of Sioux Falls, 2008

Figure 2.23
Cross Sections of Bioretention Areas

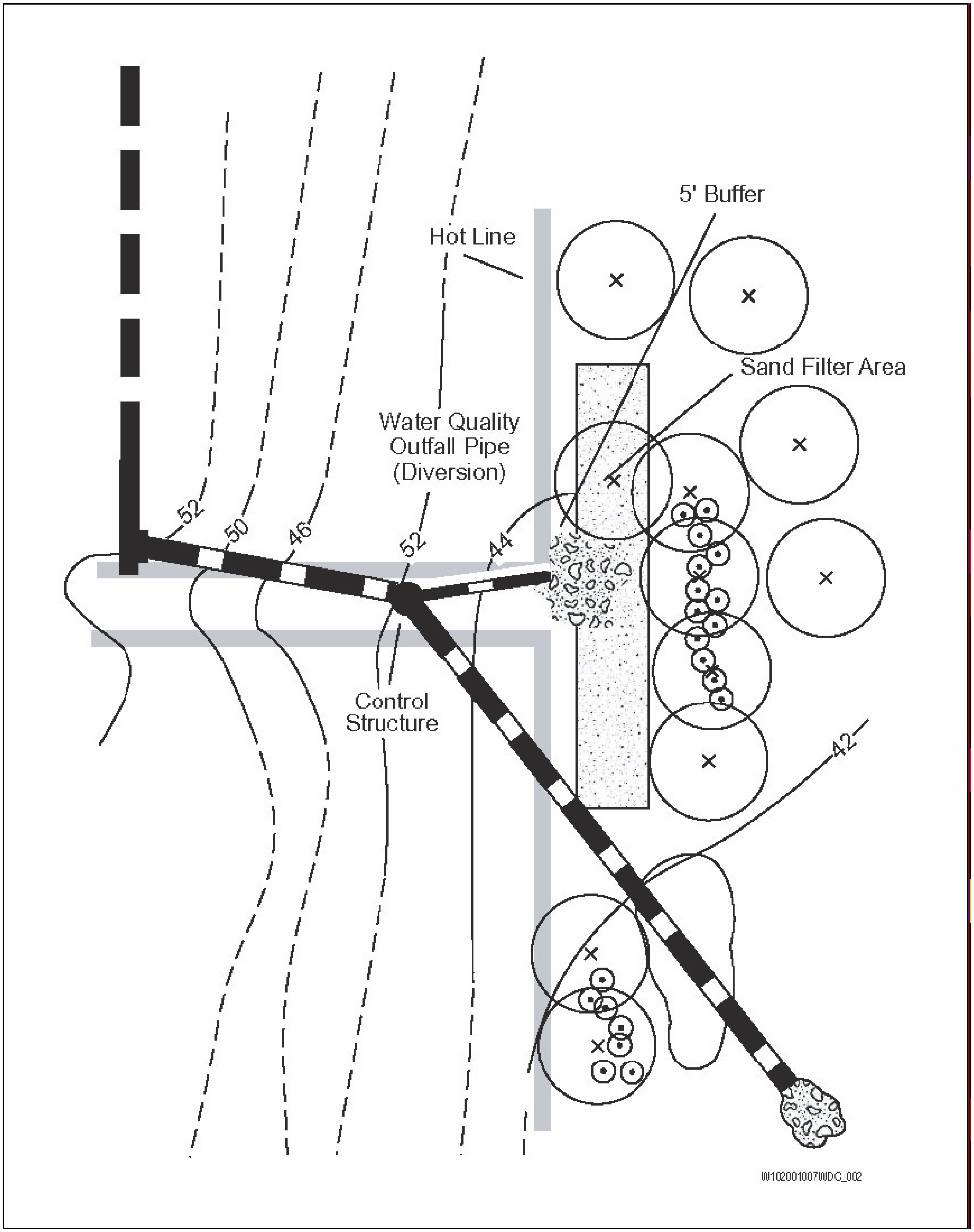






Source: City of Sioux Falls, 2008

Figure 2.24
Bioretention Plan View



Source: City of Sioux Falls, 2008

SECTION 300 CONSTRUCTION PERMIT REQUIREMENTS

301 CONSTRUCTION PERMIT

Unless otherwise exempt, a Construction Permit is required prior to persons engaging in any excavation, clearing, or land disturbance greater than or equal to 10,000 square feet, unless the disturbance is exempt under the provisions of Section 507 (A) of the Pennington County Zoning Ordinance.

The Construction Permit Application must be submitted and approved prior to the start of any work related to construction activity.

302 CONSTRUCTION PERMIT SUBMITTAL REQUIREMENTS

The permit application shall include, at a minimum, the following items:

- Name, address, and telephone number of the applicant and the person preparing the plan or SWPPP;
- A description of the overall project, location, and type of construction activity;
- Site Plan or SWPPP
- Controls – sediment and erosion
- Stabilization Practices and date of final stabilization

A. Site Plan or SWPPP

Each site plan shall provide a description of potential pollutant sources and other information as indicated below:

- A description of the existing site conditions including topography, vegetation, drainage, and wetlands;
- The names of surface waters, residential area, roads, and other features at or near the development area that may receive discharges from the project site;
- Estimates of the area of the site and the area that is expected to be disturbed by excavation, grading, grubbing, or other activities during the life of the project in acres;
- A description of the intended sequence of activities that disturb soils for major portions of the site including the time of exposure of each area prior to completion of temporary or permanent erosion and sediment control measures;
- A description of the soil within the disturbed area(s);
- Other information or data as may be reasonably required by the Planning Director.
- The following statement with a signature block for the owner/developer acknowledging the review and acceptance of responsibility: "This *Construction Permit Application* appears to fulfill the technical criteria and the criteria for the Storm Water Quality Manual requirements of Pennington County. I understand that additional erosion control measures may be needed if unforeseen erosion or

sediment control problems occur. The requirements of this permit shall run with the land and be the obligation of the landowner until such time as the terms of the permit are properly completed, modified, or voided.";

- A site map indicating:
  - property line;
  - drainage patterns and proposed topography location, extent, and the slopes of all grading activities;
  - areas of soil disturbance;
  - location of major structural and nonstructural controls identified in the permit;
  - location of areas where stabilization practices are expected to occur;
  - surface waters, including an aerial extent of wetland acreage; and
  - locations where storm water is discharged to surface water.

B. Controls

The permit application shall describe for each major activity: a) appropriate control measures; b) when they will be implemented during the construction process; and c) who is responsible for implementation. The description and implementation of controls shall address the following minimum components:

1. Erosion and Sediment Controls Goals and Criteria

- Erosion and sediment controls must retain sediment on site to the maximum extent practicable.
- 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 owner/developer/contractor must replace or modify the control for site situations.
- If sediment escapes the construction site, off-site accumulations of sediment must be removed at a frequency sufficient to minimize offsite impacts. The permit must be modified to prevent further sedimentation off-site.
- The design capacity of sediment traps and sedimentation ponds must be included in the permit. At a minimum, sediment must be removed from sediment traps or sedimentation ponds when design capacity has been reduced by 50% or more.
- Litter, construction debris, and construction chemicals shall be properly handled to prevent contributing pollutants to storm water discharges.
- Concrete wash water shall not be discharged into state waters / storm systems.
- Offsite material storage areas used solely by the permitted project are considered a part of the project and shall be addressed in the pollution prevention plan.

2. Structural Practices

The permit shall include a description of structural practices to divert flows from exposed soils, store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site to the degree possible. Placement of structural practices in floodplains and wetlands should be avoided to the degree possible. The installation of these devices may be subject to Section 404 of the federal Clean Water Act.

- For common drainage locations, a temporary (or permanent) sediment basin providing at least 3,600 cubic feet of storage per acre drained, or equivalent control measures, shall be provided where attainable until final stabilization of the site. This requirement does not apply to flows that are either undisturbed or have undergone final stabilization, or where such flows are diverted around both the disturbed area and the sediment basin. If the required temporary sediment basin or equivalent controls are not attainable, smaller sediment basins and/or sediment traps shall be used.
- At a minimum, effective sediment controls are required for all side slopes and down slope boundaries of the construction area.
- Use of a combination of sediment and erosion control measure is encouraged to achieve maximum pollutant removal.

3. Storm Water Management

The permit shall include a description of practices that will be installed during the construction process to control pollutants in storm water discharges occurring after construction operations have been completed. Such practices may include:

- Storm water ponds; flow reduction by use of open vegetated swales and natural depressions; infiltration of runoff onsite; and sequential systems which combine several practices. The permit shall include an explanation of the technical basis used to select the practices to control pollution where flows exceed predevelopment levels.
- Velocity dissipation devices shall be placed at discharge locations and along the length of any outfall channel to minimize erosion and protect the receiving water. Under this permit, owners/developers/contractors are responsible for the installation and maintenance of storm water management measures prior to final stabilization of the site. Under this permit, owners/developers/contractors are responsible for maintenance until storm water discharges associated with construction activity have been eliminated from the site and a notice of termination (NOT) has been submitted to the South Dakota Department of Environment and Natural Resources.

4. Other Controls

- The permit shall include a description of procedures to maintain vegetation, erosion and sediment control measures, and other protective measures. This includes minimizing tracking of sediments off-site and generation of dust.
- The permit shall include a description of construction and waste materials expected to be stored on-site, with updates as appropriate. The permit shall also include a description of controls to reduce pollutants from these materials including storage practices to minimize exposure of the materials to storm water, and spill prevention and response.
- Maintenance. All erosion and sediment control measures and other protective measures identified in the permit must be maintained in effective operating condition. If site inspections identify BMPs that are not operating effectively, maintenance shall be performed before the next anticipated storm event, or as necessary to maintain the continued effectiveness of storm water controls. If maintenance prior to the next anticipated storm event is impracticable, maintenance must be scheduled and accomplished as soon as practicable.
- Inspections. The owner/developer/contractor shall ensure that qualified personnel who are familiar with permit conditions, conduct an inspection of the site at least once every seven (7) calendar days and within 24 hours of the end of a storm that is one-half (1/2) inch or greater or a snowmelt event that causes surface erosion. A “qualified” person is someone who has worked with erosion and sediment controls for a period of at least one year, or certified person, or architect, or landscape architect, or professional engineer. Where runoff is unlikely due to winter conditions, such inspections shall be conducted at least once per month. The inspection shall include disturbed areas of the construction site that have not been finally stabilized, areas used for storage of materials, structural control measures, and locations where vehicles enter or exit the site. These areas shall be inspected for evidence of, or the potential for, pollutants entering the drainage system, and erosion and sediment control measures identified in the plan shall be observed to ensure that they are operating correctly and sediment is not tracked offsite.

  A report shall be made summarizing the areas inspected, the name(s) and title(s) of personnel making the inspection, the date(s) of the inspection, major observations, and corrective actions taken. These reports shall be retained as part of the plan for at least three (3) years after the site has reached final stabilization and coverage under the permit has been terminated. Such reports shall identify any incidents of non-compliance. Based on the results of the inspection, the plan shall be revised and implemented, in no case later than seven (7) calendar days following the inspection. Where an inspection does not identify any incidents of noncompliance, the report shall contain a certification that the site is in compliance with the plan and this permit. The report shall be signed in accordance with the signatory requirements of this permit.

C. Stabilization Practices

The permit application shall include a description and schedule of interim and permanent stabilization practices; a record of the dates when major grading activities occur, when construction activities temporarily or permanently cease on a portion of the site, and when stabilization measures are initiated. Site plans should ensure that existing vegetation is preserved where possible and that disturbed portions of the site are stabilized. Stabilization measures shall be initiated as soon as possible, but in no case later than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased. Initiation of final or temporary stabilization may exceed the 14-day limit if earth-disturbing activities will be resumed within 21 days. All other exceptions must be approved on an individual basis by the Planning Director. Final stabilization must be completed within one year of project completion or two years from the Construction Permit issue date, whichever occurs sooner.