1.4.4 Plan Development and Implementation

B. Construction Phase Controls

Section 5 - Additional Considerations and Further Discussion on Submittal Requirements and Design Guidelines

This section describes in more detail practices and BMPs noted above to guide the applicant in developing appropriate ESCP submittals. The reviewers may require demonstration that the following have been considered:

I. Site Management

a. Phasing - Phasing is a preventive measure defined as: One portion of the site is disturbed at any one time to construct the infrastructure necessary to complete that phase. Subsequent phases are not started until earlier phases are substantially complete and exposed soils are stabilized. The plan reviewers will not allow a site plan to proceed without the applicant demonstrating that all feasible opportunities for phasing have been implemented. Construction sites greater than 25 acres are required to show phasing of disturbance tailored to the specific site conditions. Items that shall be considered to determine the effectiveness in phasing include: size of disturbed area, compatibility with construction sequence (e.g. Stormwater controls, then utilities, then roads, then pads), proximity to CEFs or waterways, slope steepness. Sites less than 25 acres must demonstrate on the grading plan the areas to be disturbed and how it was minimized.

b. Temporary Stabilization - The construction sequence must indicate the length of time that phases will remain disturbed. The designer must anticipate the construction process and identify times when disturbed areas will be dormant (i.e. not making progress toward a benchmark phase) for 14 days or longer. These areas must be identified on the ESCP and the temporary stabilization practices described. Inspectors will make note of length of time of dormant disturbed areas and require coverage on Day 15. Approved practices include: rock rip rap for concentrated flow areas and vehicle access; Flexible Growth Medium, Bonded Fiber Matrix, Turf Reinforcement Mat or Rolled Erosion Control Product for Slopes steeper than 4:1, and bark or wood chip mulch or sod for areas flatter than ~~4:1~~ 2:1 slopes. Spoil piles will require daily cover or demonstration of adequate perimeter containment to prevent the migration of spoils outside of the defined spoil pile footprint. Unacceptable practices include broadcasting seed, paper based hydromulch, and wood fiber based hydromulch without a tackifier. Inspectors will require invoice from applicator showing certification of mix as FRM or BFM. Inspectors have authority to require additional application of temporary stabilizer if visual inspection shows inadequate coverage.

c. No offsite flow can flow onto the Limits of Construction of the disturbed phase. ESCP must show locations where pass-through flows may be safely diverted around disturbed areas and routed at a properly stabilized discharge point to downstream drainage conveyance. Proper stabilization shall be determined by the Environmental Inspector.

d. ESCP must show all designated construction access points and equipment travel paths. In particular, if there are any CEFs, protected water ways or trees, the ESCP must demonstrate that construction access is diverted at least 25 feet from such features. In addition to temporary stabilization

measures for construction access, plans must demonstrate methods for ensuring that construction vehicles do not track sediment onto roadways.

e. Spoils may not be located in the 100 year flood plain, Critical Water Quality Zone, within 150 feet of a CEF or within 25 ft. of a concentrated flow path with more than 5 acres contributing drainage area.

********* END

1.4.5. Temporary Structural Practices

P. Reserved ~~**Inlet Protection** (*See* Standard manual item 628S-2 for detail)~~

~~1. Description.~~

~~Temporary sediment barrier made of non-woven or woven material which is water permeable but will trap water-borne sediment for protection of curb inlets.~~

~~2. Purpose.~~

~~The goal of an inlet protection device is to intercept and filter water borne sediment and other pollutants from unprotected areas of limited extent and reduce the amount of sediment entering the storm system.~~

~~An inlet protection device:~~

- ~~Should not cause flooding when it clogs with debris,~~
- ~~Should maximize pollutant reduction,~~
- ~~Should require inexpensive maintenance,~~
- ~~May not be used as a stand alone method of sedimentation control.~~

~~3. Conditions Where Practice Applies.~~

~~Inlet protection is to be used for every inlet that is hydraulically connected to the limits of construction of disturbed areas. Methods where inlet protection is allowable as the primary sedimentation control shall be all construction in a street or R.O.W. including street cuts, milling operations, repair or maintenance to asphalt or subgrade, construction of turn lanes, utility installations, concrete or asphalt saw cutting, or at the direction of City of Austin personnel.~~

~~4. Design Criteria.~~

~~The inlet protection is required for both curb inlets and area inlets where disturbed areas drain to these inlets. It is not to be used as a substitute for erosion controls outside the roadway where controls could~~

~~keep the sediment out of the roadway. Inlet protection should be a barrier that is set over or within the inlet that meets the goals of inlet protection mentioned above.~~

- ~~Drainage Area - less than two (2) acres.~~

- ~~Material - The fabric must correspond to The following requirements:~~

~~**Table 1.4.5.P.1 Material Requirements**~~		
~~**Property**~~	~~**Test method**~~	~~**ASTM Requirements**~~
~~Fabric Weight~~	~~D 3776~~	~~≥ 3.0 ounces/square yard~~
~~Ultraviolet (UV) Radiation Stability~~	~~D 4355~~	~~70% strength retained min., After 500 hours in xenon arc device~~
~~Mullen Burst Strength~~	~~D 3786~~	~~≥ 120 pound per square inch~~
~~Water Flow Rate~~	~~D 4491~~	~~≥ 275 gallons/minute/square feet~~

~~This material should have a maximum expected useful life of approximately eighteen (18) months. The inlet protection devices should be constructed in a manner that will facilitate clean out and disposal of trapped sediment while minimizing interference with construction activities. They should also be constructed such that: a) any ponding of storm water will not cause excessive R.O.W. flooding (i.e. ≤ 4 inches of standing water); b) or damage to the structure or adjacent areas.~~

- ~~Coverage - The fabric/wire should completely cover the opening of the inlet and devices should be installed without protruding parts that could be a traffic, worker, or pedestrian hazard. Where sections of the fabric overlap, they shall overlap at least three (3) inches.~~

- ~~Attachment - The inlet filter shall be attached in a way that they can easily be removed and are not secured or attached by the use of sand bags. The inlet filter must be removed upon completion of work. If removal damages the concrete curb, the curb must be repaired immediately.~~

~~5. Maintenance.~~

~~Frequent maintenance of the inlet protection control structure is necessary to prevent clogging. Accumulated silt shall be removed when it reaches a depth of two (2) inches or one-third the height of the inlet throat, and disposed of in a manner which will not cause additional siltation.~~

********* END

1.4.6 Permanent Structural Practices

D. ~~Stone~~ Rock Riprap.

1. Description.

A layer of loose rock or aggregate placed over an erodible soil surface.

2. Purpose.

The purpose of rock riprap is to protect the soil surface from the erosive forces of water.

3. Condition Where Practice Applies.

This practice applies to soil-water interfaces where the soil conditions, water turbulence and velocity, expected vegetative cover and ground water conditions are such that the soil may erode under the design flow conditions. Rock ~~R~~riprap may be used, as appropriate, at such places as storm drain outlets, channel banks and/or bottoms, roadside ditches, drop structures and shorelines.

4. Design Criteria.

The design of rock riprap for erosion control includes determination of a rock size and gradation to resist movement for the design hydraulic conditions. In addition an underlying filter layer that prevents migration of soils through the armor is often required. Rock size selection is based on the water forces acting on the rock matrix during the design discharge. The design discharge for sizing rock riprap for the portion of channels and ditches protected with stone riprap shall be the peak discharge from a one hundred (100) year frequency rainfall event. The roughness coefficient, “n”, of riprap is highly dependent on the size of the rock used in the gradation and the depth of flow over the armor surface. At low flow depths the relative effect of rock riprap size on roughness is greater than that at higher flow depths. Significant guidance regarding roughness estimation exists in the literature, however the equation adapted for the Federal Highway Administration Hydraulic Engineering Circular No. 15, "Design of Roadside Channels with Flexible Linings" (2005) is recommended for determining the roughness value for the constructed riprap surface:

$$n = \frac{0.262\, d^{\frac{1}{6}}}{2.25 + 5.23 \log (d/D_{50})}$$

where:

d = the average channel flow depth (ft)

D_{50} = ~~diameter of rock for which 50 percent of rocks in the gradation are larger (feet)~~ median rock diameter for which 50% of the gradation is comprised of rocks of equal or smaller size (feet)

5. Rock Riprap Size and Gradation.

Rock riprap should be of sufficient size and properly graded that the stone weight and interlocking characteristics of the rock mixture resists movement when exposed to hydraulic stresses. The curve in Figure 1-22 in Appendix V of this manual provides an estimate of individual minimum rock ~~stone~~ sizes

(diameter and weight of a specimen) for a range of channel velocities that may be stable up to 17 feet per second. The chart was adapted from the United States Bureau of Reclamation, "Hydraulic Design of Stilling Basins and Energy Dissipators, Engineering Monograph No. 25", (1983). The rock ~~stone~~ size rating curve was based on laboratory flume tests and prototype stilling basins observed by the Bureau of Reclamation. The ~~stone~~ rock riprap sizing criteria is most applicable to high energy environments. The curve can be represented with the following expression:

$$D_{50} = 0.0105\ V^{2.06}$$

where:

D_{50} = median rock diameter (feet)

V = average water velocity (ft/sec)

Stone weight can be estimated assuming a shape midway between a sphere and a cube using ~~the spherical equivalent volume and unit weight of the stone material~~ the following expression (adapted from ASTM D5519).

$$\mathbf{W_{50} = 47.54 D_{50}^{3} S_g}$$

$$\cancel{W_{50} = 32.67 D_{50}^{3} S_g}$$

where:

W_{50} = median ~~individual~~ stone weight ~~for which 50 percent of rocks in the gradation are heavier (lbs)~~ for which 50% of the gradation is comprised of rocks of equal or lesser weight (lbs)

S_g = specific gravity of the stone

Stone weight varies with the source of the material. For quartz the specific gravity is approximately 2.65, where many types of native Texas limestone can vary from 2.3 to 2.5. For placed rock riprap the minimum recommended specific gravity ~~should be~~ is 2.4.

Rock riprap gradation ~~A well-graded mixture~~, as used herein, is defined as ~~a mixture with a sufficient fraction of other sizes to fill the progressively smaller voids between the larger stones~~ an allowable particle size distribution based on the median particle diameter, or D50. The rock riprap gradation shall conform to the gradation table below. Neither the width nor the thickness of a single stone shall be less than one third of its length. ~~A riprap layer containing 50 percent of the rock pieces smaller than the required size is more stable than a single stone of the required size. Generally, the mixture should consist of stones having length, width and thickness dimensions as nearly equal as practical and should not be flat~~

~~slabs. The range of rock sizes for a well-graded mixture should fall within the following gradation ranges relative to the specified median rock size (D_{50}).~~

Rock Riprap Gradation Table								
Rock Riprap Class by Median Particle Diameter (D50)		**D15 (in)**		**D50 (in)**		**D85 (in)**		**D100 (in)**
Class	**Diameter (in)**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**	**Max**
I	**6**	3.7	5.2	5.7	6.9	7.8	9.2	12.0
II	**9**	5.5	7.8	8.5	10.5	11.5	14.0	18.0
III	**12**	7.3	10.5	11.5	14.0	15.5	18.5	24.0
IV	**15**	9.2	13.0	14.5	17.5	19.5	23.0	30.0
V	**18**	11.0	15.5	17.0	20.5	23.5	27.5	36.0
VI	**21**	13.0	18.5	20.0	24.0	27.5	32.5	42.0
VII	**24**	14.5	21.0	23.0	27.5	31.0	37.0	48.0
VIII	**30**	18.5	26.0	28.5	34.5	39.0	46.0	60.0
IX	**36**	22.0	31.5	34.0	41.5	47.0	55.5	72.0
X	**42**	25.5	36.5	40.0	48.5	54.5	64.5	84.0

Reference: National Cooperative Highway Research Program, "NCHRP Report 568 - Riprap Design Criteria, Recommended Specifications, and Quality Control."

~~***Relative Stone Size (inches)***~~	~~***Percent of Gradation Smaller than***~~	~~***Stone Size Designation***~~
~~1.7 - 2.0 * D_{50}~~	~~100~~	~~D_{100}~~
~~1.3 - 1.7 * D_{50}~~	~~85~~	~~D_{85}~~
~~1.0 - 1.3 * D_{50}~~	~~50~~	~~D_{50}~~
~~0.5 - 1.0 * D_{50}~~	~~15~~	~~D_{15}~~

~~The City of Austin gradation was adapted from recommendations in the Federal Highways Administration "Hydraulic Engineering Circular No. 11 - Design of Riprap Revetment" , the National Cooperative Highway Research Program, "NCHRP Report 568 - Riprap Design Criteria, Recommended Specifications, and Design Criteria", the US Army Corps of Engineers "Engineer Manual EM 1110-2-1601 - Hydraulic Design of Flood Control Channels" and the U.S Department of Agriculture, Soil Conservation Service "Technical Release No. 69 - Riprap for Slope Protection Against Wave Action."~~

The rock riprap layer thickness shall be no less than the maximum stone size (D_{100}) or 1.5 times the D_{50}, whichever produces the greater thickness. For applications in drainage channels the riprap layer should be a minimum of 2.0 times as thick as the median stone size specified.

6. Filter.

A filter is a transitional layer of material placed between the riprap and the underlying soil surface intended to prevent soil movement through the riprap and permit relief of hydrostatic pressure within the

soils. Filters can prevent loss of the underlying soil through piping or from surface water causing erosion beneath the riprap. A filter is recommended especially when the riprap is placed on noncohesive material that is subject to significant subsurface drainage. Areas where water surface levels fluctuate frequently and areas of high groundwater levels should include filters in the design of riprap revetment.

A filter can be of two (2) general forms. A fabric filter is one or more layers layer of geotextile filter fabric manufactured for that express purpose and a granular filter is one or more graded layers of sand, gravel or stone.

The proper design of filters is critical to the stability of riprap installations on channel banks. If openings in the filter are too large, excessive flow piping through the filter can cause erosion and failure of the bank material below the filter. On the other hand, if the openings in the filter are too small, the build-up of hydrostatic pressures behind the filter can cause a slip plane to form along the filter resulting in massive translational slide failure.

To determine the need for a filter and to properly design granular filters the gradation of the armor layer, filter layers and adjacent strata to meet the following criteria:

$$\frac{D_{15(Upper)}}{D_{85(Lower)}} < 5 < \frac{D_{15(Upper)}}{D_{15(Lower)}} < 40$$

In the above relationships, "upper" refers to the overlying material and "lower" refers to the underlying material. The relationships must hold between the filter and base material and between the riprap and the filter. A filter ratio of 5 or less between layers will usually result in a stable condition. The filter ratio is defined as the ratio of the 15 percent particle size (D_{15}) of the upper/coarser layer to the 85 percent particle size (D_{85}) of the lower/finer layer. An additional requirement for stability is that the ratio of the 15 percent particle size of the upper/coarser material to the 15 percent particle size of the lower/finer material should exceed 5 but not be less than 40. When determining the need for a filter the upper layer represents the rock armor and the lower layer represents the finer underlying substrate. In design, the filter material will be evaluated relative to the rock armor and the underlying material. In cases where the requirements cannot be met with a single gradation multiple layers of granular filter material of varying gradations may be required to meet the criteria. The thickness of a granular filter layer should be no less than 1.5 times the maximum size in the filter gradation. The minimum allowable thickness for a filter blanket shall be 102 mm (4 in).

In design of an appropriate geotextile as a riprap filter, soil retention , permeability, clogging survivability should be considered. Detailed design guidance for selection of geotextiles as a riprap filter can be found in the Federal Highway Administration "Geosynthetic Design and Construction Guidelines" (FHWA-HI-95-038). With the exception of problematic soils or high velocity conditions associated with steep channels and rundowns, geotextile filters may usually be selected based on the apparent opening size (AOS) of the geotextile and the soil type as shown in the following table from FHWA-HI-95-038.

Maximum AOS for Geotextile Filters

Soil Type	Maximum AOS (mm)
Non cohesive, less than 15 percent passing the US #200	0.43
Non cohesive, 15 to 50 percent passing the US #200 sieve	0.25
Non cohesive, more than 50 percent passing the US #200 sieve	0.22
Cohesive, plasticity index greater than 7	0.30

Although they are usually more economical than granular filters, geotextile filters are difficult to install in underwater, ultimately degrade and can create a failure slip plane when placed against non-cohesive bank material and on steep slopes. Geotextile filter fabric shall be installed with sufficient anchoring and overlap between seams according to the manufacturer's recommendations to ensure full filter barrier protection of the subgrade after riprap installation.

Riprap should not be dumped directly onto the geotextile filter fabric, because it may tear or displace the fabric. A four (4) inch minimum thickness granular cushion layer of gravel or sand may be specified over the filter fabric when the riprap stones cannot be placed as to not damage the fabric. Side slopes shall be 2:1 or flatter in order for the gravel or sand not to slide down the filter cloth before placing the riprap.

********* END

1.6.3. Maintenance and Construction Requirements

C. Major Maintenance Requirements

6. Biofiltration and Rain Gardens (Sections 1.6.7.C and 1.6.7.H).

Vegetation Maintenance.

Once vegetation is established, biofiltration systems should require less maintenance than sand filtration systems because the vegetation protects the filtration media from surface crusting and sediment clogging. Plant roots also provide a pathway for water to permeate down into the media, thus further enhancing the hydraulic performance of the system. Unless damaged by unusual sediment loads, high flows, or vandalism, the biofiltration media should be left undisturbed and allowed to age naturally.

Performance Requirements.

A minimum of 95% of the vegetation shall be alive and viable for one year following installation. No bare areas greater than 10 square foot may exist. These performance requirements apply to the entire pond including the pond bottom, side slopes, and areas adjacent to the pond.

Landscape Maintenance.

A lack of maintenance considerations in the design of a landscape commonly results in a site that is more maintenance intensive (i.e., costly) than necessary and/or appropriate for its purpose, and one that requires the routine use of practices that are undesirable (e.g., extensive pesticide use, intensive pruning of plants that grow too large for the spaces they occupy). It is important that the designer include maintenance considerations and IPM throughout the planning and design phase of a biofiltration project. To the extent possible, these criteria are designed to minimize the potential for pests and the amount of maintenance required for the biofiltration pond. Landscapes should be designed to allow for the access and aid the maneuverability of maintenance equipment (e.g., if areas of the pond are designed to be mown, acute angles should be avoided in turf areas; wide angles, gentle, sweeping curves, and straight lines are easier to mow).

A. Mowing and/or Trimming.

Mowing and/or trimming of vegetation is allowable with certain restrictions.

1. Tall Herbaceous and Medium Herbaceous Plants.

Trimming activities must not impinge on the growing tips (basal crown) of the bunchgrasses. Cutting these grasses below the basal crown will severely stress and possibly kill them. These plants shall be cut no lower than 18" from the ground. The annual physical removal of all woody weeds from the filtration basin is required.

2. Short Herbaceous Plants.

Sod-forming grasses may be mown or trimmed to an appropriate height. These plants shall not be scalped; cut no lower than 3" from the ground.

B. Integrated Pest Management (IPM).

An integrated pest management (IPM) plan and associated restrictive covenant is required for a biofiltration pond. IPM is a continuous system of controlling pests (weeds, diseases, insects or others) in which pests are identified, action thresholds are considered, all possible control options are evaluated and selected control(s) are implemented. Control options--which include biological, cultural, manual, mechanical and chemical methods--are used to prevent or remedy unacceptable pest activity or damage. Choice of control option(s) is based on effectiveness, environmental impact, site characteristics, worker/public health and safety, and economics. The goal of an IPM system is to manage pests and the environment to balance benefits of control, costs, public health and environmental quality. IPM takes advantage of all appropriate pest management options.

1. Weed Management.

Preventing the introduction of weeds is the most practical and cost-effective method for their management. Do not allow bare soil to be present, design it out of the system. Prevention programs include such techniques as limiting weed seed dispersal, minimizing soil disturbance, and properly managing desirable vegetation. Remove weeds early in their growth stage, before they set seed. (One year of seeds is equal to seven years of weeds) Allow the desired vegetation to out-compete the weeds.

a. Mulch: Control weeds by blocking light and air space.

i. Bark mulch, the traditional material for minimizing weeds in ornamental landscapes, is not recommended because it will tend to float or otherwise be washed out of the system. The innovative use of non-traditional mulches will be required when ornamental beds are used in biofiltration facilities. Gravel is permitted ~~as mulch~~ to cover the soil surface both in the sediment basin and the filter basin.

ii. Gravel or crushed recycled glass equivalent in size to gravel may be used ~~as mulch~~ to cover the soil surface in biofiltration.

iii. Weed fabric is not permitted in biofiltration due to the potential for clogging of the pores.

b. Cultivation: Cultivating cuts the weed roots below the soil to reduce root carbohydrates. May be done by hand tools only; using cultivating machines is not acceptable. Repeat cultivation at 2-3 week intervals during the growing season. Keep hoes sharp and in good condition to reduce the effort needed. Any bare areas must be re-seeded.

c. Organic herbicides: Be aware that organic herbicides must be used with caution and can be dangerous in concentrated form. Personal protective equipment must be used: rubber gloves, long pants, eye protection. The use of organic herbicides is restricted to the following products:

i. Acetic acid (20% vinegar) is effective on small annuals.

ii. Essential oils: Includes cinnamon, clove, summer savory and thyme must be used at the appropriate concentration. Effective on a limited number of species.

2. Mosquito Management.

Biofiltration ponds shall not become breeding places for mosquitoes. Meet the drainage requirements established per 1.6.7 (C). Once the pond has drained, remaining incidental standing water must not be present for longer than four days (96 hours) thereafter.

3. Wildlife and Pet Management.

In addition to water quality treatment, biofiltration ponds offer additional benefits such as providing food and habitat for wildlife. Pets may also be attracted to them. However, activities by animals within a pond shall not interfere with pond functions and design objectives. Digging or burrowing by animals in the filtration basin is particularly troublesome. There is the potential for certain animals to become a pest of biofiltration ponds in the Austin area. Evaluate the potential for problems due to animal activity in the proposed pond site. Where the potential exists for problematic activity, fencing or similar exclusionary method shall be provided.

********* END

1.6.5.A – Design Guidelines for Sedimentation/Filtration Systems

3. Sedimentation Basin Details. The sedimentation basin consists of an inlet structure, flow spreader (if inlet structure does not provide flow spreading), settling area and, outlet structure. The sedimentation basin design should maximize the distance from where the heavier sediment is deposited near the inlet to where the outlet structure is located. This will improve basin performance and reduce maintenance requirements. It is recommended that the bottom of the sedimentation basin (and invert of riser pipe) be [3] 2 inches higher than the top of the filtration bed, to prevent excessive tailwater effects that can prolong drawdown times. See Figure 1.6.5.A.

- Inlet Structure/Flow Spreader. The inflow of the water quality pond should pass through the splitter structure where the water quality volume is separated (see section 1.6.2B). The water quality volume should be discharged uniformly and at low velocity into the sedimentation basin in order to maintain near quiescent conditions which are necessary for effective treatment. It is desirable for the heavier suspended material to drop out near the front of the basin; thus a drop inlet structure is recommended in order to facilitate sediment removal and maintenance.

The maximum velocity discharged to the sedimentation basin should not exceed two (2) feet per second. To achieve the required low velocity and to uniformly distribute flow into the sedimentation basin a design such as that shown by Figure 1-48 is recommended. If a design such as that shown in Figure 1-50 is used a flow spreader will likely be necessary at the pipe outfall in order to reduce velocities and distribute flow. Also see Section 1.6.2.D. For energy dissipation devices do not use City of Austin Standard 508S-13 as this structure does not promote uniform flow into the basin.

- Outlet Structure. The outlet structure conveys the water quality volume from the sedimentation basin to the filtration basin. The outlet structure shall be designed to provide for a minimum draw-down time of forty-eight (48) hours. The riser pipe should be made from perforated schedule forty (40) PVC pipe. The draw-down time should be achieved by installing a removable PVC cap with the appropriate sized orifice at the end of the riser pipe (the discharges through the perforations should not be used for draw-down time design purposes). The PVC cap must be accessible for maintenance. The perforated riser pipe should be selected from the following table:

TABLE 1-8
PERFORATED RISER PIPES

Riser Pipe Normal Dia. (inches)	Vertical Spacing Between Rows (center to center in inches)	Number of Perforations per Row	Diameter of Perforations (inches)
6	4	4	1
8	4	6	1
10	4	8	1
Source: City of Austin			

This information is based on commercially available pipe. Equivalent designs are acceptable.

The top of the riser should extend above the elevation of the splitter weir or should be fitted with a threaded removable cap.

A trash rack shall be provided for the riser. The trash rack should be made out of galvanized welded wire fabric with a maximum opening size of one (1) inch by one (1) inch and made from twelve (12) gauge wire. The wire joints should be joined using galvanized "J" clips. The rack must be removable to facilitate maintenance. The trash rack should be supported by galvanized or rust-proof posts set into a four (4) inch thick reinforced concrete base. The base should be square with the length of each side being three (3) feet plus the diameter of the riser pipe with the riser centered on the base. The height of the trash rack should extend above the maximum water surface elevation or should have a removable galvanized welded wire lid. If the top of the riser pipe is more than three (3) feet high from the base, removable galvanized cross bracing is required for the riser and trash rack. A cone of two (2) to three (3) inch diameter gravel shall be placed around the pipe to enhance settling. The gravel cone must not include any gravel small enough to enter the riser pipe perforations. If the discharge pipe of the riser is to extend through a concrete wall, a sleeve is required in the wall and a water proof sealant should be used to prevent leaks around the sleeve. Figures 1-53 and 1-54 in Appendix V of this manual illustrate these design considerations for risers.

- Basin Geometry. See Section 1.6.2.D.

The sedimentation basin should have a minimum two (2) percent bottom slope to ensure that the pond will drain adequately even after silt accumulation.

~~• Sediment Trap (Optional). A sediment trap is a storage area which captures sediment and removes it from the basin flow regime. In so doing, the sediment trap inhibits resuspension of solids during subsequent runoff events, improving long-term removal efficiency. The trap also maintains adequate volume to hold the water quality volume which would otherwise be partially lost due to sediment storage. Sediment traps may reduce maintenance requirements by reducing the frequency of sediment removal. It is recommended that the sediment trap volume be equal to ten (10) percent of the sedimentation basin volume.~~

Water collected in the sediment ~~trap~~ basin shall be conveyed to the filtration basin in order to prevent standing water from occurring. All water collected in the sediment ~~trap~~ basin shall drain out within ninety six (96) hours. The invert of the drain pipe should be above the surface of the filtration sand bed. The minimum grading of the piping to the filtration basin should be one quarter (1/4) inch per foot (two (2) percent slope). Access for cleaning the sediment ~~trap~~ basin drain system is necessary.

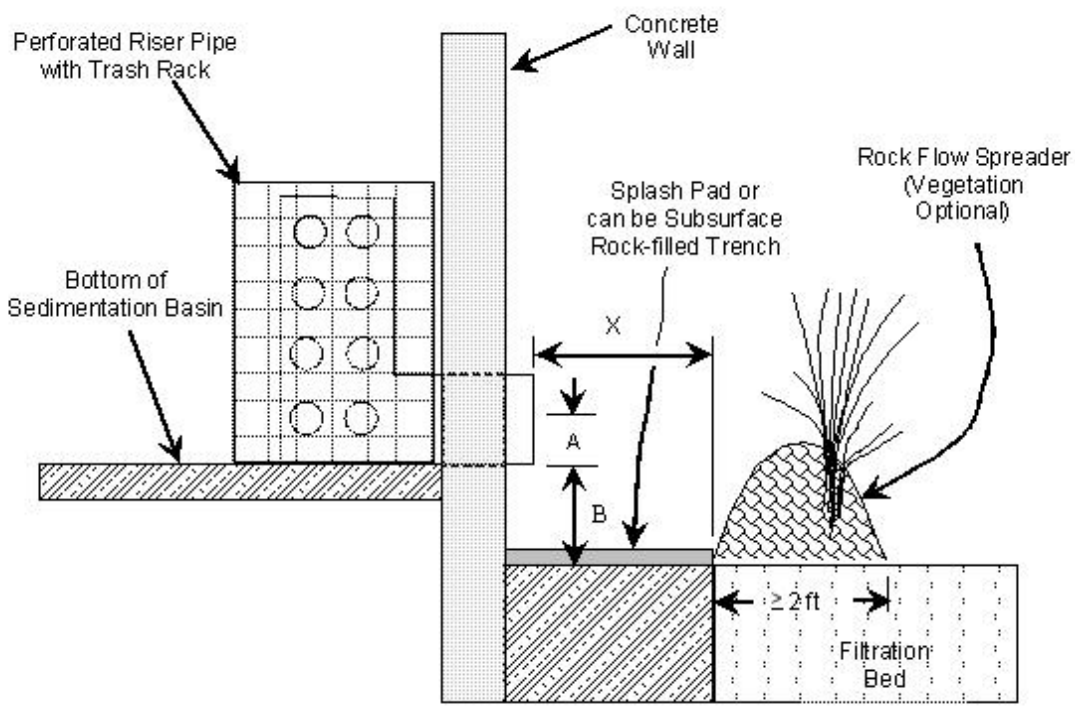
4. Sand Filtration Basin Details. The sand bed filtration system consists of the inlet structure/flow spreader, sand bed, underdrain piping and basin liner.

- Inlet Structure/Flow Spreader. The inlet structure should spread the flow uniformly across the surface of the filter media. See Section 1.6.2.D for acceptable geometry and configuration. See Figure 1.6.5.A below for flow spreader design guidance. A rock flow spreader is recommended. The rocks directly in the flow path of the riser pipe discharge must be sized appropriately to prevent scour and erosion; models such as the US Army Corp of Engineers "Channel Pro" can be used, or other acceptable procedure. For expected maximum velocities in the range of 5-8 fps the following gradation is

recommended for uncontained rocks; contained rock systems (e.g. wire mesh, gabion) are also acceptable and must be sized appropriately:

- D15 6 to 7.9 inches
- D50 8.8 to 10 inches
- D100 11.1 to 15 inches

Figure 1.6.5.A. Full Sedimentation/Filtration Riser Pipe Outlet System and Determining Location of Flow Spreader in Filtration Basin.



Determination of Dimension X, or maximum pipe discharge travel distance:

- Given known riser pipe diameter d, calculate cross-sectional area Ao = $\pi\ d^2/4(ft^2)$
- Calculate maximum riser pipe discharge Q (cfs) using orifice equation
- Calculate maximum discharge velocity v = Q/Ao (ft/sec)
- Calculate "fall time" for flow trajectory t = $\sqrt{\frac{2*(B+A)}{g}}$
- t is in seconds

- B = Recommended ≥ 2" differential between bottom of sedimentation basin and top of filter

- A = pipe radius including thickness + any gap between riser pipe and pond bottom (ft)

- g = gravitational acceleration = 32.2 ft/sec^2

- Calculate X ≥ 1 + v*t (ft)

1 ft is added for margin of safety

- Basin Geometry. See 1.6.2.D for criteria.

- Sand Bed. The sand bed for city-maintained filtration basins must be built to the "Sand Bed with Gravel Layer" configuration below unless topographic constraints make this design unfeasible. Unfeasible is considered: assuming (for the purposes of this selection process only) a maximum ponding depth of three feet in the sedimentation basin, if it is not feasible to obtain an outlet for the drainage from the filtration basin within one-hundred (100) feet of the crest of the filtration embankment, then the "trench design" may be used. For ponds not maintained by the city, the sand bed may be a choice of one of the two configurations given below.

Note: Sand bed depths are final, compacted depths. Consolidation effects must be taken into account. Pre-soaking of media is recommended to induce consolidation so that the correct amount of makeup material can be determined. To pre-soak apply 5-10 gallons of water per sq. ft. of filtration bed, within 1 hour.

- Sand Bed with Gravel Layer (Figures 1-56 and 1-56A in Appendix V of this manual).

The top layer is to be a minimum of eighteen (18) inches of 0.02-0.04 inch diameter sand which corresponds with ASTM C-33 concrete sand (smaller sand size is not acceptable). Under the sand shall be a layer of one-half (0.5) to one and one-half (1.5) inch diameter washed, rounded, river gravel which provides three (3) inches to five (5) inches of cover over the top of the underdrain lateral pipes. Clean, screened, crushed recycled glass no smaller than 3/8 inch is also acceptable. The sand and gravel must be separated by a layer of geotextile fabric meeting the specifications ~~listed in Section 1.4.5.P, Inlet Protection~~ shown in Table 1.6.5.A-1, Geotextile Fabric Requirements.

Sand Bed - Trench Design (Figures 1-56 and 1-56A in Appendix V of this manual).

The top layer shall be twelve (12) to eighteen (18) inches of 0.02-0.04 inch diameter sand which corresponds with ASTM C-33 concrete sand (smaller sand size is not acceptable). Laterals shall be placed in trenches with a covering of one-half (0.5) to one and one-half (1.5) inch diameter washed, rounded river gravel which provides three (3) inches to five (5) inches of cover over the top of the underdrain lateral pipes and geotextile fabric. The geotextile fabric is needed to prevent the filter media from infiltrating into the lateral piping. The geotextile fabric specifications are ~~listed in Section 1.4.5.P, Inlet Protection~~ shown in Table 1.6.5.A-1, Geotextile Fabric Requirements.

- Biofiltration Medium Bed (Figure 1-56D in Appendix V of this manual).

For Biofiltration Media Bed specifications refer to Section 1.6.7.C.4.B.

ADD NEW TABLE 1.6.5.A-1

Table 1.6.5.A-1 Geotextile Fabric Requirements		
Property	**Test method**	**ASTM Requirements**
Fabric Weight	D 3776	≥ 3.0 ounces/square yard
Ultraviolet (UV) Radiation Stability	D 4355	70% strength retained min., After 500 hours in xenon arc device
Mullen Burst Strength	D 3786	≥ 120 pound per square inch
Water Flow Rate	D 4491	≥ 275 gallons/minute/square feet

********* END

1.6.7.C. Biofiltration

4. Biofiltration Basin Details

B. Biofiltration Bed with Underdrain. The biofiltration medium bed for biofiltration basins must be built to the Biofiltration Bed configuration illustrated in Figure 1.6.7.C-3 (for details see Figure 1-56D in Appendix V of this manual). The biofiltration medium layer is to be a minimum of eighteen (18) inches meeting the specifications stated in Section 4A above. Other materials or substances that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations shall not be mixed or dumped within the biofiltration area. Note: Required biofiltration medium bed depths should be interpreted as final consolidated values rather than as initially placed. Under the biofiltration medium shall be an underdrain system that consists of one-half (0.5) to one and one-half (1.5) inch diameter washed, rounded, river gravel surrounding 6 inch Schedule 40 PVC underdrain lateral pipes. The maximum spacing for the laterals should be ten (10) feet between laterals and five (5) feet from a wall or side. The minimum thickness of the gravel envelope is 3 inches. The soil medium and gravel layer must be separated by a filter material. The filter material may be a gravel separation lens consisting of 3/4 - 1/4-inch washed, rounded, river gravel (no limestone) 2 to 3 inches in thickness or a layer of geotextile fabric meeting the specifications ~~listed in Section 1.4.5.P, Inlet Protection~~ shown in Table 1.6.5.A-1, Geotextile Fabric Requirements. To avoid compaction of the biofiltration medium and promote filtration heavy equipment shall not be allowed in biofiltration area after the biofiltration medium has been placed.

********* END

1.6.9.3 Control Measure Design

E. Design of Water Quality Controls Needed to Meet Required Reduction in Pollutant Load. Controls may be used individually or in combined systems to meet the minimum load reduction requirement for each of the pollutants as calculated above. The following guidelines must be used in designing controls to treat runoff from developed sites to show compliance with Code requirements:

- The volume of runoff (water quality volume) to be captured by each water quality control required by the SOS Ordinance shall be determined using the runoff depths shown in Table 1-12 below.

TABLE 1-12
REQUIRED WATER QUALITY CAPTURE VOLUME

Impervious Cover In Drainage Area	Total Runoff (in.)
0%	0.60
5%	0.69
10%	0.78
15%	0.87
20%	0.96
25%	1.05
30%	1.14
35%	1.23
40%	1.32
45%	1.41
50%	1.50
55%	1.59
60%	1.68
65%	1.77
70%	1.86
75%	1.95
80%	2.04
85%	2.13
90%	2.22
95%	2.31
100%	2.40

- ~~Vegetated filter strips shall be used to the maximum extent practicable for the treatment of stormwater runoff. Additional structural water quality controls shall be provided where a vegetated filter strip alone is not sufficient to reduce developed condition pollutant loads to background levels.~~

- Pollutant loads from all developed areas, including areas of impervious cover, lawns, landscaping, gardens, and other maintained areas, shall be considered when determining the level of treatment needed to comply with these regulations. Existing or restored natural areas which are restricted from development and pesticide, herbicide, or fertilizer application through a plat note or restrictive covenant may be excluded from this requirement.

- On-line treatment systems of any type shall be limited to a maximum treatment efficiency of 90 percent, because of the flushing of the control which may occur during large storm events.

- Removal efficiencies for water quality controls shall be as established in the Environmental Criteria Manual, or must be approved by the Director of the WPDR based on reports or studies contained in engineering or scientific literature as described in Section 1.6.9.3.G.

- Stormwater treatment systems for all developments shall be designed such that the full capture volume would be released over a 48 hour period. This will allow better treatment of VOCs, pesticides, herbicides, and other toxics.

- Where water quality control basins located in the Edwards Aquifer Recharge Zone are required to have liners, such liners shall be designed in accordance with the criteria in Section 1.6.5.D.3 of the Environmental Criteria Manual.

- Infiltration systems shall be designed and located to avoid impacts to existing springs and other Critical Environmental Features, including impacts resulting from the discharge of inadequately treated runoff at such locations.

******END

REPLACES EXISTING APPENDIX R-6

APPENDIX R-6
FULL OR PARTIAL BIOFILTRATION POND CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE DATA:

Drainage Area to Control (DA) _____Ac.

Drainage Area Impervious Cover _____%

Capture Depth (CD) _____Inches

25 Year Peak Flow Rate to Control (Q25) _____cfs

100 Year Peak Flow Rate to Control (Q100) _____cfs

WATER QUALITY CONTROL CALCULATIONS:

	Required	Provided
Water Quality Volume (WQV = CD*DA*3630)	_____cf	_____cf
For Full Sedimentation Biofiltration Pond Volume	_____Min. WQV____cf	_____cf
For Partial Sedimentation Biofiltration Pond Volume	__Min. 20% WQV___ cf	_____cf
Filtration Pond Area (See ECM Section 1.6.7.C)	_____ ___sf	_____sf
Water Quality Elevation	_____ft. msl	
Elevation of Splitter Box/Overflow Weir	_____ft. msl	
Length of Splitter Weir	_____ft	
Required Head to Pass Q100	_____Max. 1.0_____ft	_____ft
Pond Freeboard Provided to Pass Q100	_____Min. 0.25_____ft	_____ft

BIOLOGICAL ELEMENTS CALCULATIONS:

Surface Area of Sedimentation Pond (SA)	_____sf	
Sedimentation Pond Plantings (Min. 10% of SA)	_____plants	_____plants
Filtration Pond Plantings (Min. 20% of Filtration Area)	_____plants	_____plants

STAGE-AREA-STORAGE TABLE

Sedimentation Pond:

Stage (ft msl)*	Area (sf)	Storage (cf)

Filtration Pond:

Stage (ft msl)*	Area (sf)	Storage (cf)

*in one foot or less increments

REPLACES EXISTING APPENDIX R-7

APPENDIX R-7
RAINWATER HARVESTINGS SYSTEM CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE DATA:

Drainage Area to Control (DA) _____Ac.

Drainage Area Impervious Cover _____%

Capture Depth (CD) _____Inches

WATER QUALITY CONTROL CALCULATIONS:

	Required	Provided
Water Quality Volume (WQV = CD*DA*3630)	_____cf	_____cf
Convert to Gallons		_____Gallons

OPTION A – CAPTURED RUNOFF GRAVITY DRAINED TO A VEGETATED AREA FOR INFILTRATION:

Drawdown Time (DDT)	_____hours	
Hydraulic Conductivity	_____in/hour	
Lag Time (LT)	_____Min. 12.0_____hours	_____hours
Infiltration Area required	_____sq ft	

OPTION B – CAPTURED RUNOFF USED TO IRRIGATE VEGETATED AREA:

Soil Permeability	_____in/hour	
Drawdown Time	_____Max. 120.0_____hours	_____hours
Irrigation Rate		_____in/hour
Irrigation Area		_____sq ft

NOTE: Soil Depth for Infiltration and Irrigated Areas should be a minimum 12 inches

WATER QUALITY CREDIT

Impervious Area Factor (IAF)	_____Max. 1.0_____	_____
BMP Design Factor (BMPDF)	_____Max. 1.0_____	_____
Water Quality Credit (WQC = IAF * BMPDF)	_____Max. 1.0_____	_____
Water Quality Volume Reduction (WQV * WQC)		_____cf

STAGE-AREA-STORAGE TABLE

Cistern:

Stage (ft)* **Area (sf)** **Storage (cf)**

***in one foot or less increments**

FIGURE 1-1 RECOMMENDED DESIGN VALUES FOR FUNCTIONAL CONTROLS

1. EROSION CONTROLS

FUNCTIONAL CONTROL ECM SECTION	MAX. DRAINAGE AREA and/or SPACING REQUIREMENTS	OTHER DESIGN CONSIDERATION	COMMENTS
MULCHING 1.4.5.A	For slope lengths < 100 feet of exposed or disturbed area	Min. mulch depth of 4 inches Mulch should meet 3 inch minus screening process equivalent to TXDOT Item 161, 1.6.2.B Wood Chip requirements 100% coverage on slope Not recommended on slopes 2:1 or steeper Not acceptable as a control in concentrated flow situations	See Figure 1.4.5.A.1 Surface must be prepared prior to mulch application to ensure optimal mulch to soil contact. Not a primary perimeter erosion control
STABILIZED CONSTRUCTION ENTRANCE 1.4.5.N		Stone Size shall be 4 by 8 inch or larger open graded rock Thickness not less than 8 inches Length not less than 50 feet Width not less than full width of all points of egress or ingress Drainage - Entrance must be properly graded to prevent runoff from leaving the construction site.	Entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights of way.

2. SEDIMENT CONTROLS

MULCH SOCKS (18 inch diameter) 1.4.5.F	Slope 100:1-50:1 50:1–30:1 30:1–25:1 25:1–20:1 20:1-10:1 10:1-5:1 5:1-2:1	Max. Slope Length Between 18 in. Dia. Sock (ft) 100 75 65 50 25 15 10	Max. Drainage Area (sf) per 100ft of Sock 10000 7500 6500 4800 2600 1300 1000	Mulch should meet 3 inch minus screening process equivalent to TXDOT Item 161, 1.6.2.B Wood Chip requirements Not allowed on slopes 2:1 or steeper Not acceptable as a control in concentrated flow situations	See Figure 1.4.5.F Install Mulch Socks using steel T-posts meeting minimum ECM specifications spacing criterion is based on maximum drainage area, in sq. ft., above a 100 ft. section of mulch sock
MULCH SOCKS (12 inch diameter) 1.4.5.F	Slope 100:1-50:1 50:1–30:1 30:1–25:1 25:1–20:1 20:1-10:1 10:1-5:1 5:1-2:1	Max. Slope Length Between 12 in. Dia. Sock (ft) 100 40 30 25 15 10 5	Max. Drainage Area (sf) per 100ft of Sock 6000 4000 3000 2600 1300 1000 500	Mulch should meet 3 inch minus screening process equivalent to TXDOT Item 161, 1.6.2.B Wood Chip requirements Not allowed on slopes 2:1 or steeper Not acceptable as a control in concentrated flow situations	See Figure 1.4.5.F Install Mulch Socks using steel T-posts meeting minimum ECM specifications spacing criterion is based on maximum drainage area, in sq. ft., above a 100 ft. section of mulch sock
SILT FENCE 1.4.5.G	Slope 100:1-50:1 50:1–30:1 30:1–25:1 25:1–20:1 20:1-10:1 10:1-5:1 5:1-2:1	Max. Slope Length Between Silt Fence (ft) 500 250 150 120 100 50 10	Max. Drainage Area (sf) per 100ft of Fence 25,000 15,000 12,000 10,000 5,000 2,500 1,000	Not acceptable as a control in concentrated flow situations At each end of the silt fence a minimum 20-foot segment shall be turned uphill to create a "J" hook (see "J"-hook detail) to prevent ponded water from flowing around the ends of the silt fence. Individual sections of silt fence should be limited to 200-foot lengths.	The removal efficiency of silt fencing depends mainly on the detention time of the runoff behind the control. spacing criterion is based on maximum drainage area, in sq. ft., above a 100 ft. section of silt fence
TRIANGLE SEDIMENT FILTER DIKES 1.4.5.H	Limited to sheetflow from the stabilized construction entrance			Not acceptable as a control in concentrated flow situations	See Standard Specification 628S for installation options
HAY BALE DIKES 1.4.5.I	Drainage area less than 2,500 square feet			Acceptable for above ground and underground storage tank removal projects only Not acceptable as a control in concentrated flow situations	
MULCH BERM 1.4.5.J	Slope 100:1-50:1 50:1–30:1 30:1–25:1 25:1–20:1 20:1-10:1 10:1-5:1 5:1-2:1	Max. Slope Length Between Berms (ft) 100 75 65 50 25 15 10	Max. Drainage Area (sf) per 100ft of Berm 10000 7500 6500 4800 2600 1300 1000	Mulch should be untreated wood chips ≤ 5 inches in length with 95% passing a 2-inch screen and less than 30% passing a 1-inch screen meet TXDOT Special Specification 1011, Mulch Filter Berm rqmts. Not allowed on slopes 2:1 or steeper Not acceptable as a control in concentrated flow situations	See Figure 1.4.5.J Mulch Berms should be a min. 24 inches high and 36 inches wide spacing criterion is based on maximum drainage area, in sq. ft., above a 100 ft. section of mulch berm

FIGURE 1-1 RECOMMENDED DESIGN VALUES FOR FUNCTIONAL CONTROLS

3. ENERGY DISSIPATION

FUNCTIONAL CONTROL ECM SECTION	MAX. DRAINAGE AREA and/or SPACING REQUIREMENTS	OTHER DESIGN CONSIDERATION	COMMENTS
STONE OUTLET STRUCTURE 1.4.5.D	Drainage area less than 5 acres	Minimum length of outlet structure crest/weir shall be equal to 6 times the number of acres of contributing drainage area Material - Open graded rock 3 to 5 inches diameter or larger A fabric core of wrapped stone with a min. diameter of 1 foot shall be incorporated into the structure Minimum freeboard 6 inches over the crest/weir of the outlet structure	Outlet should discharge onto an already erosion resistant stabililzed area
ROCK BERM 1.4.5.E	Drainage area less than 5 acres	Material - Open graded rock 3 to 5 inches diameter for sheet or concentrated flow condition Side slopes 2:1 or flatter Height 18 inches minimum and Width 2 feet minimum	

4. DIVERSION

DIVERSION, INTERCEPTOR AND PERIMETER DIKE 1.4.5.B	Slope > 10% (10:1) 5 - 10% (20:1-10:1) < 5% (20:1) Drainage area less than 5 acres	Maximum distance between dikes (feet) 100 200 300		Side slopes 2:1 or flatter Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment control	Top Width 2 feet minimum Height 18 inches minimum measured from the top of the existing ground at the upslope toe to the the top of the dike
INTERCEPTOR AND PERIMETER SWALE 1.4.5.C	Slope greater than 10% (10:1) 5 - 10% (20:1 - 10:1) less than 5% (20:1) Drainage area less than 5 acres	Maximum distance between swales (feet) 100 200 300		Side slopes 2:1 or flatter Grade 1 to 3 percent; must have positive drainage to an adequate outlet Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment control	Top Width 4 feet minimum Depth of 1 foot minimum
PIPE SLOPE DRAIN: RIGID FLEXIBLE 1.4.5.O	Size of Pipe Slope Drain PSD-12 PSD-18 PSD-21 PSD-24 PSD-30 Drainage area less than 5 acres	Pipe/Tubing Diameter (in) 12 18 21 24 30	Max. Drainage Area To Pipe Slope Drain (ac) 0.5 1.5 2.5 3.5 5.0	Inlet - height of earth dike at the entrance to the pipe slope drain shall be equal or greater than the diameter of the pipe plus 12 inches and shall be adequate to prevent overtopping of 100 year storm. Outlet - a sediment trapping device shall be used to trap sediment from any sediment-laden water conveyed by the pipe slope drain.	Purpose is to convey surface runoff safely down slopes without causing erosion.