City of Bee Cave

Environmental Criteria Manual

(ADOPTED Q2 2022)

PREFACE

The City of Bee Cave's Engineering Criteria Manuals (ETM) were promulgated to administer and implement the City's Unified Development Code (UDC) in providing concise and comprehensive criteria for proper planning, design and coordination of all facilities applicable within the City of Bee Cave.

The guidelines and criteria presented in the Environmental Criteria Manual provide a foundation or starting point for rational engineering design decisions. The standards contained herein are based largely upon the guidelines and policies promulgated by the City of Austin and the Lower Colorado River Authority.

The design criteria established in the Environmental Criteria Manual affect the review and approval of erosion and sedimentation control plans, water quality plans, environmental assessments, and other development related plans and plats.

The legal authority for enforcement of this document is derived from Article 7 of the Bee Cave Unified Development Code. Any changes to this document shall be made in accordance with the promulgation procedure outlined the Bee Cave UDC.

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SECTION 1. WATER QUALITY MANAGEMENT

1.1 GENERAL

The information in this section is intended to define the technical design criteria needed to achieve the water quality policy goals identified in Article 7 of the City UDC. These rules apply to all land located within the City limits and to the City's extraterritorial jurisdiction areas.

Appeals concerning the enforcement of these rules shall be brought to the City of Bee Cave City Engineer.

1.2 ADMINISTRATIVE

1.2.1 FISCAL SURETY

A. Fiscal Surety Calculations.

Fiscal surety required by the City in conjunction with proposed development projects (subdivision, site plan, or other construction project) shall be calculated in accordance with applicable city policies. For fiscal surety required by Article 2, Section 2.4.4 of the UDC, the calculations shall use the total area within the Limits of Construction and must be prepared by a consulting engineer.

Revegetation costs shall be based on placing topsoil, grading, hydromulching/seeding, watering, and must include costs of administering a contract to complete these tasks. The quantity of hydromulch and revegetation shall be based on the entire Limit of Construction, excluding only those areas of existing improvements including impervious cover not proposed to be demolished.

The calculations are subject to review and approval by the City Engineer

An estimate prepared and certified by a professional engineer shall be submitted to the City as a calculation of the fiscal requirement. The engineer must be experienced in design and construction of public streets, drainage systems, utilities, and/or sitework and construction estimating. The estimate:

1. shall be based on three (3) recent contracts (within the past 2 years) or bids for similar work in the area or three (3) bids submitted by the professional engineer;
2. shall include, at minimum, the date, name of the development, site plan or construction plan number;
3. shall be sealed by the professional engineer;
4. must be reviewed and approved by the City Engineer

B. Submittal Requirements for Projects.

1. Water Quality Control Plan for Site Plans and Subdivision Construction Plan Submittals.
   - **(i)** All applications for development must include a water quality control plan. This water quality plan must be a construction plan sheet or sheets designated as the "Water Quality Control Plan" and sealed by a registered, professional engineer with experience in water quality control design. The plan shall include the following:
     - **(1)** All applicable required development information as outlined in Article 7 of the UDC,
     - **(2)** The location of proposed water quality controls, as described in the Engineering Report, which are necessary to meet the pollution prevention requirements outlined in Article 7 of the UDC.

(3) The delineation of water quality and access easements, or lots, if required, for inspection and maintenance of the water quality controls. Prior to approval of preliminary plans for single family subdivisions, all water quality easements, as well as a conceptual preliminary water quality plan to justify the design of the control must be shown. If retention and irrigation exists or is proposed as part of a water quality control, these areas for irrigation must be clearly identified;

(4) Details of proposed water quality controls referenced specifically to the water quality methodology contained in the Engineer's Report. (These details may be provided on a separate plan sheet, if necessary, with appropriate references and cross-sections provided on the Water Quality Control Plan);

(5) Sequencing of the project, to include a mid-construction conference for each phase with the City Engineering staff, which will be coordinated based on completion of buildings, drainage facilities, water quality controls and temporary erosion controls for each phase;

(6) Information concerning the pre-construction and mid-construction meetings must appear in the sequence of construction in order to limit the discharge of sediment entering of waterways.

(7) A temporary erosion and sedimentation control plan which shows the location of silt fences, rock berms, interceptor swales, etc., to scale. The plan shall consider construction phasing as applicable to limit the amount of area disturbed at one time.

(8) Impervious cover calculations based on the net site area and proposed impervious cover for the drainage basin to each control. Any areas proposed for development which do not drain to controls and their respective impervious cover must be identified; and,

(9) Specific notes that identify:

- Pollution prevention measures proposed to satisfy requirements of Article 7 of the UDC of, and the appropriate enforcement mechanisms used (covenants, restrictions, etc.); and,
- Special conditions required as a result of a "limited adjustment" approved by City Council, if applicable.

2. Water Quality Engineering Report.

(i) Article 7, Section 7.3.2 of City of Bee Cave UDC requires water quality controls and/or other onsite pollution prevention and assimilation techniques so that at least 90% of the average annual pollutant load of suspended solids, total phosphorous, and oil and grease are removed. To demonstrate compliance with these requirements, the applicant must submit the below additional information in the Engineering Report. The pollutant loading information shall be taken from the City of Bee Cave's pollutant loading spreadsheet:

(1) The methodology and water quality control strategy proposed to achieve the target pollutant load reductions;

(2) Calculations illustrating the target pollutant loads expected for the proposed development with an accompanying explanation of how these figures were derived;

(3) Calculations illustrating expected pollutant load reductions for the controls proposed with an accompanying explanation of how these figures were derived; and,

(4) Special conditions approved by the City for installation or maintenance of proposed water quality controls used to achieve the target pollutant load reductions.

3. Requirements for Preliminary Plans and Final Plats

Preliminary plans and final plats for single family/duplex subdivisions must show the location of water quality easements for controls. A schematic of the control must be provided. In addition, documentation must be provided which details the method of treatment with calculations based on this treatment methodology which demonstrate that the easement is adequate for the conceptual control.

Preliminary plans or final plats for commercial or multi-family subdivisions which contain public roads must identify the location of water quality controls for the roadways and their easements. Documentation of the location of water quality controls and the easements which contain them for commercial and multi-family lots shall be deferred to the site plan stage.

4. Additional Temporary Erosion/Sedimentation Control Requirements.

(i) The Erosion/Sedimentation Control Plan must include notes that contain the following information:

(1) Designation of an Environmental Project Manager who is on site >90% of the time, is required to be at the pre- construction and mid-construction meetings, and is responsible for compliance of the temporary erosion and sedimentation controls. This person is responsible for ensuring compliance of the controls during the construction period. Should the Project Manager need to be absent from the site for an extended period (in excess of one week), City staff should be informed of the name of a designated replacement.

The temporary erosion and sedimentation control plan must show to scale the location of all temporary and permanent erosion and sedimentation controls, permanent water quality controls and flood controls. Symbols used to show controls must be clear and distinctive.

(2) Modifications and additions to the approved Erosion and Sedimentation Control Plan must be approved by both the City Engineer and the sealing engineer, employed by the owner.

(3) Disturbed areas must be maintained to prevent erosion and sediment discharge to any waterways or drainage facilities offsite.

(This does not affect the expiration of the site plan or building permit. This requirement applies to sites that have suspended work and are experiencing erosion control problems due to disturbed soil conditions).

(4) It shall be a violation of the Code to allow sediment from a construction site to enter a classified waterway due to a failure to maintain the required erosion and sedimentation controls or to follow the approved construction sequence.

(ii) At a minimum, the following sequence of construction shall be used for all development. The applicant is encouraged to provide any additional details appropriate for the particular development. The owner/operator of the development is responsible for the following:

(1) Install erosion controls as indicated on the approved site plan.

(2) Have the Environmental Project Manager contact the City of Bee Cave City Engineer to schedule a preconstruction coordination meeting to be held on site.

(3) Revise erosion controls, if needed, to comply with Inspectors' directives, and review construction schedule relative to the water quality plan requirements and the erosion control plan.

(4) Install temporary sedimentation ponds and rough grade site.

(5) Inspect and maintain temporary controls weekly and prior to anticipated rainfall events, and after rainfall events, as needed.

(6) Permanently stabilize areas within ten days of construction completion of a specific area, as distinguished from the entire site.

(7) Have Environmental Project Manager schedule a mid-construction conference to coordinate changes in the construction schedule and evaluate effectiveness of the erosion control plan after possible construction alterations to the site. Participants shall be: the City Inspector, Project Engineer, General Contractor and Environmental Project Manager. Identify anticipated completion date and coordinate final construction sequence and inspection schedule with a City Inspector.

(8) Clean out permanent controls and install/maintain filter media.

(9) Complete construction and revegetate disturbed areas, including the removal of any remaining temporary controls, or execute a developers contract for the revegetation along with the engineer's concurrence letter submitted to the City after the engineer inspects the site.

5. Fiscal Security.

(i) It is typical for fiscal security to be posted for all new water quality controls, in addition to project Erosion and Sedimentation (E&S) Control fiscal. The fiscal security shall be used to ensure the structural integrity, proper construction, and appropriate operation of the control for at least the first year of operation. The fiscal security shall be posted prior to approval of the subdivision construction plan or site plan and shall be in addition to fiscal postings for temporary erosion controls.
The fiscal security shall be returned to the applicant no earlier than one year after completion of the development, and only upon:

(1) The receipt of a certified engineering concurrence letter verifying that the controls are constructed in conformance with the approved design, and

(2) After inspection and approval by the City.

(ii) This fiscal shall be calculated according to the following formulas:

(1) Single Family Residential Subdivision.
Single Family Residential Subdivision Fiscal Amount = Cost of controls × .10

This fiscal shall not be collected if it is duplicative of general subdivision requirements for fiscal.

(2) Multi-family and Commercial Development.

Drainage Area of Control	Formula
0 - 1.0 acres	Fiscal = Cost of Controls × .50
> 1.0—5.0 acres	Fiscal = Cost of Controls × .25
> 5.0 acres	Fiscal = Cost of controls × .10

6. Access for Maintenance and Inspection.

To provide necessary access for inspection and maintenance required pursuant to Article 7, Section 7.3.3(L) of the City of Bee Cave UDC, water quality controls must be contained within a water quality easement or restricted, platted lot. These easements or restricted lots are to ensure that the designated water quality controls may be accessed by the city, are maintained in a functioning condition, and not disturbed by future activities. The easement documents are to clearly communicate to subsequent land owners or lessees that water quality restrictions exist on the property and any alternative use or alteration must be approved by the City.

For a single-family/duplex development, water quality easements are required to be shown on the preliminary plan and final plat. For commercial or multi-family development, water quality easements for water quality controls will be required at the site plan stage. Site plan applications must be accompanied by appropriate easement documents.

7. Operating Permit.

(i) These rules shall implement the operating permit requirements for multi-family, single-family, or commercial development subject. Non-refundable fees for the permits shall be collected in accordance with fee ordinances passed or amended by the City Council.

(ii) General Operating Permit Requirements.

(1) All new water quality controls for commercial, single-family, and multi-family sites must obtain an annual operating permit. The owner/operator is responsible for maintenance of the control in accordance with Article 7, Section 7.3.3(D) of the City of Bee Cave UDC and for annual permit renewal. The first operating permit shall be issued upon:

(1) The completion of construction, if applicable,

(2) Inspection of the control after review of the maintenance plan accompanying the engineer's concurrence letter,

(3) Final inspection approval by the City Engineer,

(4) The issuance of a Certificate of Compliance or a Certificate of Occupancy, if applicable, and

(5) Payment of the permit fee.

(iii) Operating Permit Procedures.
All water quality controls proposed to satisfy the requirements of Article 7, Section 7.3 of the City of Bee Cave UDC must be maintained in accordance with Article 7, Section 7.3 of the UDC, and each permitted facility will be inspected each year by the City to confirm that proper maintenance, as described in the maintenance plan, has occurred prior to renewal of the permit. An operating permit is required for all developed sites within the City Limits/ETJ with existing water quality controls with the exception of those constructed prior to 2002.

(iv) Permit Information Requirements.
The standard permit application form will include the following components and must be submitted to the City with the site plan for new construction, or no later than 30 days prior to the renewal date shown on an existing permit:

(v) General information.

(1) Name and address of the water quality control,

(2) Name, title and business phone number of owner/operator,

(3) Single point of contact name and phone number,

(4) Mailing address of owner/operator,

(5) Site plan number on file with the City for the facility,

(6) Previous operating permit number; if applicable,

(7) Signature block for City approval.

Facility maintenance information to be provided to the City by the applicant:

(1) Special conditions required by restrictive covenant, or by agreement as a condition of City approval,
(2) Maintenance records and date of last maintenance,
(3) Name of Contractor who performed the required maintenance,
(4) Results of required maintenance (actions taken, materials removed, disposal location, components replaced), ensuring compliance with Code and,
(5) Single point of contact name and phone number.

Inspections by City.

(1) Compliance with Code and operating permit requirements will be verified by an on-site inspection by the City's engineering staff.
(2) Maintenance inspections will be conducted during normal business hours.

Permit Renewal.

It is the responsibility of the permittee to apply for renewal of their permit no later than 30 days before the existing permit expires. The application must be accompanied by payment of the appropriate renewal fee, updated information concerning ownership or facility operation and enforcement status. Upon receipt of all information and fees, including a favorable inspection and maintenance report, the City will renew the permit for a period of one (1) year.

Any repair work or modifications of a control not specified in the maintenance plan will require an engineer's concurrence letter, prior to renewal of the permit.

Permit renewal will be withheld if there is pending enforcement action against the permittee based on any violations of water quality regulations at the site.

Permit Transfers.

The transfer of an Operating Permit will require the completion of a new permit application and must be submitted no later than 30 days after transfer of ownership or operation of the facility.

Enforcement.

Failure to comply with provisions in the Ordinance or the terms of the Operating Permit, is a violation of the UDC.

Public Records.

The information contained in the permit application is available for public review in accordance with the Texas Open Records Act. Any request for a public record shall be in writing to the Director of the Planning & Development Department, stating the specific record or records requested to be reviewed.

C. Site Construction Management.

1. An on-site Environmental Project Manager shall be responsible for the implementation and ongoing adherence to the approved Water Quality Plan. The designated Environmental Project Manager, is required to be on site >90% of the time during construction activity and is responsible for:
   - **(i)** Coordinating the required pre-construction meeting with an inspector from the Planning & Development Department;
   - **(ii)** Providing the appropriate information on the Environmental Construction Management Information form (Attachment at the pre-construction conference);
   - **(iii)** Conducting visual inspections of all required controls weekly and after runoff events;
   - **(iv)** Contacting the appointed inspection representative of the Planning & Development Department to obtain approval prior to initiating any proposed major modifications or additions to the approved plans;
   - **(v)** Responding within 24 hours to violations identified by the Planning & Development Department, and initiating modifications or additions necessary to bring the project into code compliance;
   - **(vi)** Revising the approved Erosion and Sedimentation Control Plan and Water Quality Plan in coordination with the project engineer as deemed necessary by the Planning & Development Department for major modifications to existing controls or installation of additional controls; and,
   - **(vii)** Arranging a mid-construction conference with the Planning & Development Department. This conference will include a discussion of:
     - **(1)** Erosion control changes necessary for subsequent construction;
     - **(2)** The completion schedule for water quality controls, buildings, parking lots, utilities and revegetation; and,
     - **(3)** The anticipated building occupancy schedule, developer contract requirements and remaining site construction completion issues.

Existing impervious cover is defined as, but not limited to, roads, parking areas, buildings, swimming pools, rooftop landscapes and other impermeable construction covering the natural land surface; on the development site, which existed on the effective date of the applicable watershed ordinance.

A platted lot is defined as a lot that has been legally subdivided, complies with the codes and requirements in effect at the time of its approval by the Planning Commission or Director, and is recorded in the appropriate County Courthouse.

Redevelopment is defined as land disturbing activities on a tract of land with existing impervious cover as described in Article 7, Section 7.3.2(D) of the UDC where none, a portion, or all the existing impervious cover is removed, modified, and/or reused in conjunction with new improvements on a tract of land.

1.2.2 INTERBASIN DIVERSION

A. Development may divert stormwater from one watershed to another if the proposed diversion is less than 20 percent of the gross site area or less than 1 acre, whichever is smaller. The applicant must demonstrate the following:

1. The existing drainage patterns are maintained to the extent feasible.

   Minor diversions of drainage between watersheds are permitted to allow for design flexibility as buildings, parking lots, and other impervious cover are placed along a watershed divide. The diversion should be the minimum amount necessary to accommodate the placement of this development along the divide.

2. There are no adverse environmental or drainage impacts.

The applicant must demonstrate no adverse drainage impacts in accordance with Article 7 and the Drainage Criteria Manual.

Regulations specific to a watershed classification (e.g., impervious cover limits, cut and fill requirements, construction on slopes requirements) shall apply to the watershed boundaries as they exist pre-development. Proposing to change the watershed boundary with a diversion of stormwater does not change the applicable environmental regulations, with the exception of water quality treatment. The development shall provide the level of water quality treatment required for the watershed that the stormwater drains to post-development.

If there are critical environmental features (CEFs) identified on the property and/or within 85 feet of the property boundaries, staff from the Planning & Development Department must determine that the proposed diversions will not adversely impact those features. Interbasin hydrologic diversion can adversely impact wetland and geologic CEFs if the diversion either increases or decreases the quantity, quality, or rate of surface water runoff under which the vegetation, geology, and soils have developed.

The hydrophytic vegetation community and soils that characterize a wetland CEF have adapted over time to a specific range of hydrologic conditions. Reducing flows to wetlands can effectively collapse the wetland vegetation community and the environmental services which it provides. Similarly, increasing the rate of runoff of overland flow which supports a wetland can significantly degrade both the soils and the vegetation community.

The quality, quantity, and rate of overland flow also greatly impacts karst features. The soils, vegetation community, rock formations, and conduits that have developed under the historic moisture regime may not be able to perform properly under altered hydrology. It is imperative to maintain natural patterns and high-quality inflows to recharge features such as sinkholes and caves. Similarly, it is important to ensure no significant increases to the rate of runoff which may increase erosion or sediment loading. Bluffs, rimrocks, and springs may also be adversely affected by increases or decreases to runoff.

1.3 ENVIRONMENTAL RESOURCE INVENTORY

A. Pursuant to the City Bee Cave's UDCs, an Environmental Resource Inventory (ERI) report is required for proposed development located on a tract containing a water quality buffer zone (WQBZ); containing the 100 year floodplain; or with a gradient of more than 25 percent. ERI reports are valid for 7 years after their completion date.

B. The guidance for completing the ERI form is as follows:

1. Site/Project Name - Provide the name of the site or project. If possible, provide the same name that will appear on the development application and the proposed plan set.

2. County Appraisal District Property Identification Number - Provide the County Appraisal District Property Identification Number for all tracts within the proposed development. Identification numbers are available at the county appraisal district's online property search tool.

3. Address/Location - Provide the street address of the proposed development. If no street address exists, then give the street block address; for example, 500 block of Bee Cave Road.

4. Watershed - Identify the watershed(s) present on site.:

5. Aquifer Zones -Indicate whether the site is within the Edwards Aquifer Contributing Zone.

6. Floodplain Modification - If any floodplain modifications are proposed with this development project, check all conditions that apply. Unless the proposed floodplain modification is necessary to protect public health and safety or necessary for development, floodplain modifications are generally not allowed and are subject to approval by the City Engineer on a case by case basis.

7. Proposed Utility Lines – Installation of utility lines in WQBZs shall be in accordance with Article 7, Section 7.3.2(C)(5) of the City of Bee Cave UDC.

8. Critical Environmental Features (CEFs) - Identify, describe and provide protective measures for all CEFs on site and within 85 feet of the site boundaries. Guidance for protective measures is in ECM 1.10.0. If no CEFs are present, enter a zero in the space(s) provided. If CEF(s) are present on site or within 85 feet of site boundaries, include the Critical Environmental Feature Worksheet as an attachment to the ERI report. Provide color photographs and detailed description of each CEF(s). The CEF description should supplement information not included in the CEF worksheet such as, presence of wetland and/or spring-indicator plant species, direct or indirect indicators of recharge infiltration at point recharge features, etc. If the standard buffer is not proposed, provide rationale for the proposed alternative buffer.

9. Maps - Provide four maps; a geologic map with two foot topographic contours, a historic aerial photo (greater than or equal to 15 years), a soils map, a CEF and well locations map on the most current (less than 5 years) aerial photo with two foot topographic contours. All maps must show a north arrow, a legend, map scale, the property boundaries and areas within 85 feet of the site. Geologic maps and digital data are available online from the Bureau of Economic Geology STATMAP GIS Database. Soils information and digital soil data files are available at the USDA NRCS web soil survey. Historic and current aerial photography with two-foot contour interval is available at the City of Austin links below.

   The CEF location map must show all CEFs and wells on site on current aerial photo. For all CEFs show the standard 85 foot buffer. If an alternative buffer or wetland mitigation is proposed, show both the standard buffer and proposed alternative buffer/mitigation. Use shading and/or hatching to differentiate between the two buffer areas.

10. Hydrogeologic Report - An ERI must include a hydrogeologic report. The purpose of this component is to provide detailed information on the site geology, soils, and topography to offer insight on the occurrence of CEFs on the site.

    Surface Soils - Provide a list of the surface soil units present on site. Include the soil series unit name and subgroup (taxonomic classification), the soil hydrologic group and soil thickness. All soils information is provided online by USDA NCRS County Soil Survey Maps. For example:

    Houston Black, **2** to 8 percent (HoD2), Udic Pellusterts; Group D; 0 to 8.5-feet.

    Soil series and their taxonomic classification (e.g. Mollisol-Udic Paleustalfs) aid with the identification potential CEF areas. The soils with an Aquic or an Udic moisture regime classification are saturated for all or most of time, and are likely to support wetland plant communities. The ability to transmit or impede water flow is characterized in the County Soil Survey for each soil series with a hydrologic group definition of A, B, C or D in the table of "Estimated Soil Properties Significant in Engineering." The hydrologic group and soil thickness are useful for identifying potential areas of high infiltration or very slow infiltration where point recharge features or wetlands may occur.

    Provide a description of topography and drainages. The description of the topography facilitates the evaluation of steep slopes, where rimrocks may be present.

Geology - List the group and formation of the surface geologic units. Provide the member names for rock unit over the Barton Springs Segment of the Edwards Aquifer. In all other areas, provide the member name if available or known. Geologic Maps are available from the Bureau of Economic Geology. A table with the common stratigraphic groups, formations and member names is provided below:

Group	Formation	Members
Quaternary Terrace and Alluvial Deposits		Recent Channel Deposit
		Colorado Lower Terrace
		Colorado High Terrace
Navarro Group	Kemp	
	Corsicana	
Taylor Group	Bergstrom	
	Pecan Gap	
	Sprinkle	
Austin Group	Austin Chalk	Mckown
		Pflugerville
		Pyroclastic and Igneous Intrusives
		Burditt Marl
		Dessau Chalk
		Jonah
		Vinson
		Atco
Eagle Ford Group	Eagle Ford Shale	South Bosque
		Bouldin Flags
		Cloice Shale
		Pepper Shale
Washita Group	Buda Limestone	
	Del Rio Clay	
	Georgetown Limestone	
Fredericksburg Group (Edwards Group)	Person	Marine
		Leached & Collapsed
		Regional Dense
	Kainer	Grainstone
		Kirschberg Evaporite
		Dolomitic

	Comanche Peak Formation - Only within the Northern Edwards		
	Walnut	Basal Nodular Mbr.	Valley Key Marl
			Whitestone Lentile
			Cedar Park
			Bee Cave
			Bull Creek
Trinity Group	Upper Glen Rose	Member 5	
		Member 4	
		Member 3	
		Member 2	
		Member 1	

Provide a brief description of the site geology, such as the location of rock outcrops, faults observed or mapped on site. Based on site observations, determine if the mapped geologic units are present on site. Describe any relationship between the location of CEFs and the geologic units. Example: Several lithologic contacts have a higher propensity for karst development and for the occurrence of contact springs and seeps.

Wells - Provide the number of wells on or within 85-ft. of the site. If no wells are present, enter "zero" in the space provided. Include all oil and water wells, recorded and unrecorded that are active, abandoned, capped, or monitoring. If the site has, or proposes to receive water or wastewater service from the WTCPUA, all active water wells must be registered with the WTCPUA (see Wastewater Utilities Report). All wells must comply with 16 TAC Chapter 76 and local groundwater district rules; if any. Both inactive and active wells should be reported the local groundwater district. Identify all off site wells by contacting neighboring land owners and research the Texas Water Development Board water well data online.

11. Vegetation Report - An ERI must include a vegetation report. The description of the plant communities shall include the description of protected riparian areas on site. Protected riparian areas have minimum canopy extent of ½ acre, voids in tree canopy comprise less than 30 percent of the total area, at least 50 percent of all trees have diameters of eight inches or greater measured at 4½ feet above ground, and are dominant by a diversity of trees by presence of at least three riparian tree species. Riparian tree species include such trees as post oak, blackjack oak, cedar elm, eastern red cedar, mesquite, pecan, American elm, hackberry, green ash, box elder, and other trees. List the dominant woodland, grassland/prairie/savanna, and hydrophytic plant species present on site. Provide both common and scientific names in tables. If a plant community is not present on site, check 'no' and enter n/a in the table.

12. Wastewater Utilities Report - Indicate the type of wastewater treatment proposed for the development by checking the appropriate box. Confirm that the site wastewater collection systems will be constructed to accordance all State, County and City standards.

    If applicable, attach the calculation for the sizing of the wastewater drainfield or wastewater irrigation area(s) or indicate appropriate site plan sheet with the calculations.

    Provide environmental justification for the location of wastewater lines within the WQBZ. Discuss alterative alignments or construction methods that were considered or will be used to reduce environmental impacts to CEFs, riparian area, and watercourses.

If over the Edwards Aquifer, describe the wastewater disposal systems proposed for the site, its treatment level and effects on receiving watercourses or the Edwards Aquifer.

13. Provide signature and contact information for person that certifies that, to best of their knowledge, the responses provided are accurate. If the site is over the Edwards recharge zone, the qualified Geologist [as defined in ECM 1.12.3(A)] must seal and sign the report.

    Attach additional information as required, including the Functional Assessment, additional maps, CEF photographs and descriptions, if required.

1.4 EROSION AND SEDIMENTATION CONTROL CRITERIA

1.4.1 INTRODUCTION

The purpose of this section is to provide a resource document and policy for the protection of land and water resources, as to minimize the adverse effects of erosion and sedimentation per the City of Bee Cave's UDC. Additionally, the criteria have been fashioned to complement the language of the Texas Pollution Discharge Elimination System (TPDES) Construction General Permit.

The conversion of land from its natural state or agricultural use to urban use accelerates the processes of erosion and sedimentation. These negatively impact the city's drinking water supply, aquatic life and the recreational resource provided by them.

Construction related sediment can be a significant pollutant of streams, lakes, ponds and reservoirs. Not only does sediment reduce the quality of water for boating, fishing, swimming and other water-oriented recreation, it also creates maintenance problems due to excessive wear on pumps and due to the reduced capacity of streams, lakes and other waterways. Another problem associated with sediment is the affinity of pesticides, phosphates and many other chemical pollutants for soil particles. These pollutants are carried to the waterway on the sediment and further reduce the quality of the water.

Mankind accelerates the erosion process by modifying the topography, soil conditions, vegetative cover and drainage patterns during construction to suit its needs. The clearing and grading of land to convert it from a natural state to cultivated row crops greatly increases the potential for erosion. The magnitude of this increase can be as much as 200 times. In addition, earth moving and construction to convert agricultural land to urban uses such as roads, houses, shopping centers, schools and airports increases the erosion potential another ten (10) times (Erosion and Sedimentation Control Guidelines for Developing Areas in Texas, U.S.D.A., S.C.S., Temple, Texas, 1976). After full urbanization takes place in a watershed, however, erosion usually decreases several fold from that experienced during the period of construction (Virginia Erosion and Sedimentation Control Handbook, Second Edition, 1980) and may decrease from that occurring before construction.

As additional development and urban growth takes place in Bee Cave, the value of all land and water resources increases. The conservation of these resources is easier and less expensive than their restoration.

On most development projects, the major period for erosion potential exists between the time when the existing vegetation is removed to begin site work and the completion of construction and revegetation. There are numerous activities associated with construction and land development that accelerate the rate of erosion. Virtually all of these actions involve the removal of vegetation and/or the movement of the native geologic structure to provide a construction site. The adverse impact upon the site and the environment in general can be reduced if these actions are taken with some thought to the resultant erosion.

The control criteria included in this manual provide several methods to address the dual problems of erosion and sedimentation, but are in no way a complete outline of the possible actions to provide adequate reductions. We therefore encourage innovation and suggestions to improve or expand on these concepts. Any questions concerning the criteria or the use of measures not included in the manual should be directed to the Planning & Development Department.

The Erosion and Sedimentation Control Criteria are established and reviewed by the Planning & Development Department. Development permit review is conducted by the Development Services Department and construction inspection oversight by the Environmental Inspection Section of the Site and Subdivision Inspection Division.

1.4.2 CITY OF BEE CAVE EROSION AND SEDIMENTATION CONTROL POLICY A.

A. Purpose and Application.

The City of Bee Cave Erosion and Sedimentation Control policy shall govern the planning, design, installation, maintenance and inspection of temporary and permanent erosion and sedimentation controls associated with development within the City of Bee Cave and all areas subject to its extraterritorial jurisdiction. Finally, this policy is the official criteria manual required by the TPDES MS4 permit, and as such strives to comply with all federal and state mandates updating the permit. At this time, neither the NPDES nor the TPDES General Permits require Effluent Limit Guidelines (ELG).

B. Policy.

It shall be the policy of the City of Bee Cave that erosion and sedimentation controls are required for all construction and development, conducted with or without a permit, including without limitation commercial, multi-family, single-family, and duplex construction, the construction of all roads, utilities, parks, golf courses, water quality basins, detention basins, and all other activities utilizing clearing, trenching, grading or other construction techniques. It is the intent of City of Bee Cave policy to closely parallel the requirements set forth in the Texas Pollution Discharge Elimination System (TPDES) Construction General Permit, the City of Bee Cave MS4 permit and any applicable updates to NPDES or TPDES.

1. The objectives of this policy are to:

   (i) Minimize the erosion and transport of soil resulting from development activities.

   (ii) Prevent sedimentation in streams, creeks, lakes, waterways, storm drains, etc. by ensuring no off-site transport of disturbed sediment for the 2-year 24-hour storm during construction and through establishment of permanent controls.

   (iii) Protect and improve the quality of surface water in the Bee Cave environment and maintain and improve the quality and quantity of recharge to groundwater supplies, especially the Edwards aquifer.

   (iv) Minimize flooding hazards and silt removal cost associated with excessive sediment accumulation in storm drains and waterways.

   (v) Preserve and protect existing vegetation to the greatest extent possible, particularly native plant and wildlife habitats.

The following sections present the minimum requirements for the planning, design, construction, operation and maintenance of erosion and sedimentation control facilities and should be used as a resource document to help developers and engineers plan and implement their projects to provide protection from erosion or sedimentation. The adequacy of the plan to meet the letter and intent of this section will be determined by the Planning & Development Department. Please note that projects that require a building permit, but not a site plan permit, are required to complete the TPDES Construction Site Notice (Small or large depending on size. See Appendix H, Figures 1- 2, 1-3, 1-4, 1-5. Or click on TCEQ link at:

http://www.tceq.state.tx.us/assets/public/permitting/waterquality/attachments/stormwater/txr150000.pdf

Figure 1-1.1 (Appendix H) outlines the general sequence of events that take place in the planning, review, approval, construction and inspection of an Erosion and Sedimentation Control Plan. See **Section 1.4.4**(B)3 for the E&S control plan submittal requirements. The City of Bee Cave Planning & Development Department shall not be responsible to anyone for the use or reliance on any portion of this manual and shall not incur any obligation or liability for damages, including consequential damages, arising out of or in connection with the use, interpretation, or reliance on any specification or guidelines contained herein.

C. Plans and Computations.

Plans and computations to support all erosion and sedimentation control designs shall be submitted to the Planning & Development Department for review. Plans and computations shall be in such form as to allow for timely and consistent review and to be made a part of the permanent record for future reference. Computations shall be required for BMPs that rely on detention, sedimentation, filtration, diversion and velocity control. The reviewer may deny an application if the applicant cannot support Erosion and Sedimentation control designs with appropriate calculations. All engineering computations shall be certified by a Licensed Professional Engineer with competence in this area as required by Texas Engineering Practice Act, Section 137. All ESCPs shall be signed by a Licensed Professional Engineer (TX) or a Certified Professional in Erosion and Sedimentation Control {(CPESC)(**http://cpesc.org/**)}. If the ESCP itself contains engineering calculations, then a Licensed Professional Engineer must seal and sign the ESCP. All drainage calculations shall be done in accordance with the guidelines in the Drainage Criteria Manual.

1.4.3 DEFINITIONS (IN ACCORDANCE WITH TPDES GENERAL PERMIT AND COBC TECHNICAL MANUALS)

A. Arid Areas - Areas with an average annual rainfall of 0 to 10 inches.

B. Baseflow - The discharge in a channel that is relatively constant, occurring between storm runoff events. That flow which can be expected on a daily basis without storm flows.

C. Best Management Practices (BMPs) - Schedules of activities, prohibitions of practices, maintenance procedures, structural controls, local ordinances, and other management practices to prevent or reduce the discharge of pollutants. BMPs also include treatment requirements, operating procedures, and practices to control construction site runoff, spills or leaks, waste disposal, or drainage from raw material storage areas.

D. Bonded Fiber Matrix (BFM) - Bonded Fiber Matrix shall consist of long thermally refined wood fibers produced from grinding clean, whole wood chips and cross-linked hydro-colloidal tackifiers.

E. Certified Inspector - A person who has received training and is licensed by CPESC, CESSWI or CISEC to inspect and maintain erosion and sediment control practices.

F. Clearing - Any activity that removes the vegetative surface cover. Mass clearing is defined as the practice of clearing the entire site of all vegetation (except protected trees) to prepare for final grading. This is opposed to Selective clearing, which only disturbs the soil and vegetation where a road or infrastructure will be placed.

G. Commencement of Construction - The initial disturbance of soils associated with clearing, grading, or excavation activities, as well as other construction-related activities (e.g., stockpiling of fill material, demolition).

H. Common Plan of Development - A construction activity that is completed in separate stages, separate phases, or in combination with other construction activities. A common plan of development (also known as a "common plan of development or sale") is identified by the documentation for the construction project that identifies the scope of the project, and may include plats, blueprints, marketing plans, contracts, building permits, a public notice or hearing, zoning requests, or other similar documentation and activities. A common plan of development does not necessarily include all construction projects within the jurisdiction of a public entity (e.g., a city or university). Construction of roads or buildings in different parts of the jurisdiction would be considered separate "common plans," with only the interconnected parts of a project being considered part of a "common plan" (e.g., a building and its associated parking lot and driveways, airport runway and associated taxiways, a building complex, etc.). Where discrete construction projects occur within a larger common plan of development or sale but are located ¼ mile or more apart, and the area between the projects is not being disturbed, each individual project can be treated as a separate plan of development or sale, provided that any interconnecting road, pipeline or utility project that is part of the same "common plan" is not included in the area to be disturbed.

I. Control Plan - indicating the specific measures and sequencing to be used to control sediment and erosion on a development site during and after construction.

J. Discharge - For the purposes of this permit, the drainage, release, or disposal of pollutants in storm water and certain non- storm water from areas where soil disturbing activities (e.g., clearing, grading, excavation, stockpiling of fill material, and demolition), construction materials or equipment storage or maintenance(e.g., fill piles, borrow area, concrete truck washout, fueling), or other industrial storm water directly related to the construction process (e.g., concrete or asphalt batch plants) are located.

K. Drainage Way - Any channel that conveys surface runoff throughout the site.

L. Edwards Aquifer - As defined under Texas Administrative Code § 213.3 of this title (relating to the Edwards Aquifer), that portion of an arcuate belt of porous, water-bearing, predominantly carbonate rocks known as the Edwards and Associated Limestones in the Balcones Fault Zone trending from west to east to northeast in Kinney, Uvalde, Medina, Bexar, Comal, Hays, Travis, and Williamson Counties; and composed of the Salmon Peak Limestone, McKnight Formation, West Nueces Formation, Devil's River Limestone, Person Formation, Kainer Formation, Edwards Formation, and Georgetown Formation. The permeable aquifer units generally overlie the less-permeable Glen Rose Formation to the south, overlie the less permeable Comanche Peak and Walnut Formations north of the Colorado River, and underlie the less permeable Del Rio Clay regionally.

M. Edwards Aquifer Contributing Zone - The area or watershed where runoff from precipitation flows downgradient to the recharge zone of the Edwards Aquifer. The contributing zone is located upstream (upgradient) and generally north and northwest of the recharge zone for the following counties: all areas within Kinney County, except the area within the watershed draining to Segment 2304 of the Rio Grande Basin; all areas within Uvalde, Medina, Bexar, and Comal Counties; all areas within Hays and Travis Counties, except the area within the watersheds draining to the Colorado River above a point 1.3 miles upstream from Tom Miller Dam, Lake Austin at the confluence of Barrow Brook Cove, Segment 1403 of the Colorado River Basin; and all areas within Williamson County, except the area within the watersheds draining to the Lampasas River above the dam at Stillhouse Hollow reservoir, Segment 1216 of the Brazos River Basin. The contributing zone is illustrated on the Edwards Aquifer map viewer at http://www.tceq.state.tx.us/compliance/field_ops/eapp/mapdisclaimer.html

N. Edwards Aquifer Recharge Zone - Generally, that area where the stratigraphic units constituting the Edwards Aquifer crop out, including the outcrops of other geologic formations in proximity to the Edwards Aquifer, where caves, sinkholes, faults, fractures, or other permeable features would create a potential for recharge of surface waters into the Edwards Aquifer. The recharge zone is identified as that area designated as such on official maps located in the offices of the Texas Commission on Environmental Quality and the Construction General Permit TPDES General Permit TXR150000 The Edwards Aquifer Map Viewer, located at http://www.tceq.state.tx.us/compliance/field_ops/eapp/mapdisclaimer.html can be used to determine where the recharge zone is located.

O. Erosion Control - A measure that prevents erosion.

P. Erosion and Sediment - A set of plans prepared by or under the direction of a certified professional.

Q. Facility or Activity - For the purpose of this permit, a construction site or construction support activity that is regulated under this general permit, including all contiguous land and fixtures (e.g., ponds and materials stockpiles), structures, or appurtances used at a construction site or industrial site described by this general permit.

R. Fiber Reinforced Matrix (FRM) - Fiber Reinforced Matrix shall consist of long thermally refined wood fibers produced from grinding clean, whole wood chips, crimped interlocking fibers, cross-linked hydro-colloidal tackifiers and performance enhancing additives.

S. Final Stabilization - A construction site status where any of the following conditions are met:

1. All soil disturbing activities at the site have been completed and a uniform (i.e., evenly distributed, without large bare areas) perennial vegetative cover with a density of at least 95% of the vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.
2. For individual lots in a residential construction site by either:
   - **(i)** the homebuilder completing final stabilization as specified in condition (a) above; or
   - **(ii)** the homebuilder establishing temporary stabilization for an individual lot prior to the time of transfer of the ownership of the home to the buyer and after informing the homeowner of the need for, and benefits of, final stabilization. If temporary stabilization is not feasible, then the homebuilder may fulfill this requirement by retaining perimeter controls or other best management practices, and informing the homeowner of the need for removal of temporary controls and the establishment of final stabilization.
3. For construction activities on land used for agricultural purposes (e.g. pipelines across crop or range land), final stabilization may be accomplished by returning the disturbed land to its preconstruction agricultural use. Areas disturbed that were not previously used for agricultural activities, such as buffer strips immediately adjacent to surface water and areas that are not being returned to their preconstruction agricultural use must meet the final stabilization conditions of condition (a) above.

T. Fugitive sediment - Sediment resulting from earth disturbing activities that is mobilized by wind or water and transported from the construction site to any point outside the limits of construction.

U. Grading - Excavation or fill of material, including the resulting conditions thereof.

V. Hyperchlorination of Waterlines - Treatment of potable water lines or tanks with chlorine for disinfection purposes, typically following repair or partial replacement of the waterline or tank, and subsequently flushing the contents.

W. Indian Country Land - (from 40 CFR 122.2) (1) all land within the limits of any Indian reservation under the jurisdiction of the United States government, notwithstanding the issuance of any patent, and, including rights-of-way running through the reservation; (2) all dependent Indian communities with the borders of the United States whether within the originally or subsequently acquired territory thereof, and whether within or without the limits of a state; and (3) all Indian allotments, the Indian titles to which have not been extinguished, including rights-of-way running through the same.

X. Indian Tribe - (from 40 CFR 122.2) any Indian Tribe, band, group, or community recognized by the Secretary of the Interior and exercising governmental authority over a Federal Indian Reservation.

Y. Large Construction Activity - Construction activities including clearing, grading, and excavating that result in land disturbance of equal to or greater than five (5) acres of land. Large construction activity also includes the disturbance of less than five (5) acres of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than five (5) acres of land. Large construction activity does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site (e.g., the routine grading of existing dirt roads, asphalt overlays of existing roads, the routine clearing of existing right- of-ways, and similar maintenance activities.)

Z. Municipal Separate Storm Sewer System (MS4) - A separate storm sewer system owned or operated by the United States, a state, city, town, county, district, association, or other public body (created by or pursuant to state law) having jurisdiction over the disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under state law such as a sewer district, flood control or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, that discharges to surface water in the state.

AA. Notice of Change (NOC) - Written notification to the executive director from a discharger authorized under this permit, providing changes to information that was previously provided to the agency in a notice of intent form.

BB. Notice of Intent (NOI) - A written submission to the executive director from an applicant requesting coverage under this general permit.

CC. Notice of Termination (NOT) - A written submission to the executive director from a discharger authorized under a general permit requesting termination of coverage.

DD. Operator - The person or persons associated with a large or small construction activity that is either a primary or secondary operator as defined below:

1. Primary Operator - the person or persons associated with a large or small construction activity that meets either of the following two criteria:

(i) the person or persons have operational control over construction plans and specifications, including the ability to make modifications to those plans and specifications; or

(ii) the person or persons have day-to-day operational control of those activities at a construction site that are necessary to ensure compliance with a storm water pollution prevention plan (SWP3) for the site or other permit conditions (e.g., they are authorized to direct workers at a site to carry out activities required by the SWP3 or comply with other permit conditions).

2. Secondary Operator - The person whose operational control is limited to the employment of other operators or to the ability to approve or disapprove changes to plans and specifications. A secondary operator is also defined as a primary operator and must comply with the permit requirements for primary operators if there are no other operators at the construction site.

EE. Outfall - For the purpose of this permit, a point source at the point where storm water runoff associated with construction activity discharges to surface water in the state and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels, or other conveyances that connect segments of the same stream or other water of the U.S. and are used to convey waters of the U.S.

FF. Perimeter Control - A barrier that prevents sediment from leaving a site by detaining sediment-laden runoff or diverting it to a sediment trap or basin.

GG. Permanent Stabilization - The use of practices that prevent exposed soil from eroding upon achieving final grade. Permanent stabilization includes a broad range of items such as vegetation, structures which cover the soil to protect, paving, and post development stormwater controls that shall be implemented within 7 calendar days after completion of construction activities or each phase of construction. For the purposes of this section, construction activities are considered complete upon submittal of the engineer's concurrence letter.

HH. Permittee - An operator authorized under this general permit. The authorization may be gained through submission of a notice of intent, by waiver, or by meeting the requirements for automatic coverage to discharge storm water runoff and certain non-storm water discharges.

II. Phasing - Clearing a parcel of land in distinct phases, with the stabilization of each phase completed before the clearing of the next.

JJ. Point Source - (from 40 CFR §122.2) Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are, or may be, discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

KK. Pollutant - Dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, filter backwash, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal, and agricultural waste discharged into any surface water in the state. The term "pollutant" does not include tail water or runoff water from irrigation or rainwater runoff from cultivated or uncultivated rangeland, pastureland, and farmland. For the purpose of this permit, the term "pollutant" includes sediment.

LL. Pollution - (from Texas Water Code §26.001(14)) The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any surface water in the state that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property or to public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

MM. Rainfall Erosivity Factor (R factor) - the total annual erosive potential that is due to climatic effects, and is part of the Revised Universal Soil Loss Equation (RUSLE).

NN. Sediment Control - Measures that prevent eroded sediment from leaving the site. Semiarid Areas - areas with an average annual rainfall of 10 to 20 inches.

OO. Separate Storm Sewer System - A conveyance or system of conveyances (including roads with drainage systems, streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains), designed or used for collecting or conveying storm water; that is not a combined sewer, and that is not part of a publicly owned treatment works (POTW).

PP. Site Development - The construction or reconstruction of a building or road; the placement of a structure on land; the excavation, mining, dredging, grading or filling of land; the removal of vegetation from land; or the deposit of refuse or waste on land.

QQ. Small Construction Activity - Construction activities including clearing, grading, and excavating that result in land disturbance of equal to or greater than one (1) acre and less than five (5) acres of land. Small construction activity also includes the disturbance of less than one (1) acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than one (1) and less than five (5) acres of land. Small construction activity does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the site. (e.g., the routine grading of existing dirt roads, asphalt overlays of existing roads, the routine clearing of existing right-of-ways, and similar maintenance activities.)

RR. Start of Construction - The first land-disturbing activity associated with a development, including land preparation such as clearing, grading, and filling and demolition; installation of streets and walkways; excavation for basements, footings, piers, or foundations; erection of temporary forms; and installation of accessory buildings such as garages.

SS. Storm Water (or Storm Water Runoff) - Rainfall runoff, snow melt runoff, and surface runoff and drainage.

TT. Storm Water Associated with Construction Activity - Storm water runoff from a construction activity where soil disturbing activities (including clearing, grading, excavating) result in the disturbance of one (1) or more acres of total land area, or are part of a larger common plan of development or sale that will result in disturbance of one (1) or more acres of total land area.

UU. Structural Control (or Practice) - A pollution prevention practice that requires the construction of a device, or the use of a device, to capture or prevent pollution in storm water runoff. Structural controls and practices may include but are not limited to: silt fences, earthen dikes, drainage swales, sediment traps, check dams, subsurface drains, storm drain inlet protection, rock outlet protection, reinforced soil retaining systems, gabions, and temporary or permanent sediment basins.

VV. Surface Water in the State - Lakes, bays, ponds, impounding reservoirs, springs, rivers, streams, creeks, estuaries, wetlands, marshes, inlets, canals, the Gulf of Mexico inside the territorial limits of the state (from the mean high water mark (MHWM) out 10.36 miles into the Gulf), and all other bodies of surface water, natural or artificial, inland or coastal, fresh or salt, navigable or nonnavigable, and including the beds and banks of all water-courses and bodies of surface water, that are wholly or partially inside or bordering the state or subject to the jurisdiction of the state; except that waters in treatment systems which are authorized by state or federal law, regulation, or permit, and which are created for the purpose of waste treatment are not considered to be water in the state.

WW. Temporary Stabilization - A condition where exposed soils or disturbed areas which are dormant for 14 days or longer are provided a protective cover or other structural control to prevent the mobilization and migration of pollutants. Use of bark mulch, Fiber Reinforced Matrix (FRM), Bonded Fiber Matrix (BFM), soil retention blanket, Turf Reinforcement Mat (TRM), sod, rock rip rap, or other cover that prevents the detachment of soil particles until final stabilization is achieved.

XX. Waters of the United States - (from 40 CFR, Part122, Section 2) Waters of the United States or waters of the U.S. means:

1. all waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
2. all interstate waters, including interstate wetlands;
3. all other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds that the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:
   - **(i)** which are or could be used by interstate or foreign travelers for recreational or other purposes;
   - **(ii)** from which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
   - **(iii)** which are used or could be used for industrial purposes by industries in interstate commerce;

4. all impoundments of waters otherwise defined as waters of the United States under this definition;
5. tributaries of waters identified in paragraphs (a) through (d) of this definition;
6. the territorial sea; and
7. wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition.

Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA (other than cooling ponds as defined in 40 CFR '423.11(m) which also meet the criteria of this definition) are not waters of the United States. This exclusion applies only to manmade bodies of water which neither were originally created in waters of the United States (such as disposal area in wetlands) nor resulted from the impoundment of waters of the United States. Waters of the United States do not include prior converted cropland. Notwithstanding the determination of an area's status as prior converted cropland by any other federal agency, for the purposes of the Clean Water Act, the final authority regarding Clean Water Act jurisdiction remains with EPA.

YY. Watercourse - Any body of water, including, but not limited to lakes, ponds, rivers, streams, and bodies of water delineated by City of Bee Cave, USGS, USACE or TCEQ.

ZZ. Waterway - A channel that directs surface runoff to a watercourse or to the public storm drain.

1.4.4 PLAN DEVELOPMENT AND IMPLEMENTATION

A. Erosion and Sedimentation Control Process Outline.

Implementation of an effective erosion and sedimentation control plan requires a project management approach where responsibility is assigned during each phase to assure proper design, installation, maintenance, inspection, and when necessary, repair or replacement of controls during the construction. The project owner, engineer and contractor are all integrally involved in this process from start to finish. In addition, an understanding by the responsible individuals of the complete process required to design and implement erosion and sedimentation controls will assist them in preparing appropriate plans, speed the review and approval process, result in fewer on-site changes or problems, and provide the appropriate degree of protection for the environment.

B. Construction Phase Controls.

1. General Concepts.

The goal of erosion and sedimentation control is to limit as much as possible the detachment and transport of sediment from construction sites and the finished projects they eventually become. Sediment is transported off-site through one of four means:

(i) Stormwater runoff,
(ii) Water discharges (e.g. pumping of water out of trenches, open channels (creeks, rivers, ditches) or foundation and basement excavations),
(iii) Vehicles, and
(iv) Wind.

Stormwater runoff and water discharges are the primary means by which sediment is transported from construction sites.

Sediment becomes suspended in runoff as it flows over or out of disturbed areas seeking the lowest path of least resistance. It is very important to realize that in order to control this suspended sediment, the means by which it is transported, water, and must first be successfully controlled. The principal tasks are to keep the sediment from entering the runoff or, once in it, to separate and trap the suspended sediment before it can leave the site. The techniques to accomplish this consist of two basic types: site management practices and structural controls.

Site management practices focus on the prevention of erosion and include methods such as minimizing the area of the site that is disturbed at any one time during construction, preserving the existing natural vegetation to the greatest extent feasible, covering exposed soils with temporary stabilization soon after disturbance and restoring vegetation as rapidly as possible in disturbed areas. A related method would be to revegetate between phases of a project, when there will be a delay between these phases. Additional site management techniques include keeping the velocity of stormwater below the erosive level, promoting sheet flow rather than concentrated flow, and protecting and maintaining stable slopes.

Structural controls utilize engineered devices (such as channels, berms, silt fences, ponds, etc.) to keep sediment on-site. This is accomplished in a two-stage process consisting of drainage control followed by sediment removal.

2. Drainage Control.

The control of on-site drainage is essential to the process, as this must be accomplished first in order to successfully separate and trap suspended sediment. Drainage control is accomplished by strategically placing structural controls at locations where they will intercept stormwater runoff as it flows towards the lower portions of a site. These control devices must be substantial enough to withstand the anticipated runoff velocity and either must direct the flow to another control device or must be shaped to temporarily pool the runoff behind the structure. At this point in the process, trapping of sediment can occur. If the drainage control stage is unsuccessful or only partially successful, it will correspondingly limit the amount of sediment that will be trapped. Reviewers shall require calculations to demonstrate that drainage controls have the capacity to withstand the velocity of the 10-year 24-hour storm and all detention sedimentation controls shall be shown to have capture volume for the two-year 24-hour storm as well as the volume of sediment generated from a two-year 24-hour storm. Drainage controls shall have a drawdown time of 72 hours.

3. Sediment Control.

Sediment trapping, i.e. the separation of the sediment from the runoff, occurs primarily by sedimentation: when suspended materials settle out as runoff velocity is decreased, and the sediment is trapped and left behind to be removed later, while the runoff is released to drain off-site.

The other methods by which sediment leaves a site, vehicles and wind, can be controlled in a manner similar to runoff. The first step is to control the mechanism that moves the sediment and the second step is to capture the sediment. For vehicles this entails directing them to a limited number of stabilized exits where most of the attached soil or mud can fall or be washed off. Wind-blown dust, although generally not a major problem, can be controlled with barriers that slow velocity and prevent transport. In addition, excessive dust can be controlled with regular wetting of the dust source. Special additives to the water used for dust control (i.e. dust palliatives) will assist in preventing the resuspension of dust when the moisture has evaporated.

The previous paragraphs describe the basic process that occurs in implementing successful structural erosion and sedimentation controls. Variations of this process can be employed, depending on the type, number, and location of structural control devices used. However, the basic concepts and engineering functions involved in successful erosion and sedimentation control applications remain the same regardless of which specific structural devices or techniques are employed. Whether or not a plan is judged to be able to adequately meet the letter and intent of the policy in section 1.4.2 (B) will be determined by the Planning & Development Department Staff. Because each site is unique, this volume cannot prescribe an upfront pre-approved recipe that will ensure site plan approval. However, following the submittal requirements in section 3 will demonstrate to the reviewer that a thoughtful, rigorous analysis of the potential pollutants, runoff pathways, and methods for control have been considered.

In the following sections, design of temporary and permanent controls for sites will be more fully examined.

4. Design Guidelines.

There are several methods available to reduce erosion and sedimentation problems at construction sites. Site management methods are one of the most economical ways to accomplish this control. This section introduces several new or underutilized methods that will be required as part of the Plan Submittals. Phasing, limiting the extent of existing vegetation that is disturbed, planning the necessary locations of the disturbance, restricting construction traffic to those locations, and revegetating or otherwise stabilizing any disturbed area are examples of this type of planning, hereafter referred to as Prevention.

More common methods, however, use structural controls to take advantage of the reduced ability of water to carry sediment when its velocity is reduced. Temporary structural control devices can be grouped into one or more functional categories, defined by its particular application on a site. Recognition of the function of each control at the point where it is to be used is critical in choosing the most effective measure for each location. Three functional categories have been identified and are described below:

(i) Diversion - A control device used for diversion is strategically placed on a site to intercept runoff and divert it to another location. A diversion may be installed to keep clean water from crossing and eroding a disturbed area or to move runoff with silt to a location where it can be treated more effectively. (see COA Standards 621S-1 and 622 S-1) All sites that receive off-site runoff must install flow diversion devices designed to handle the concentrated flow and divert it around the disturbed area in a non-erosive manner to the receiving drainage system downstream of the site. Diversion capacity shall be the runoff volume of the 10-year, 24-hour storm. All diversions shall be designed to withstand erosion from the velocity of the 10-year, 24-hour storm.

(ii) Flow Spreading/Velocity Reduction - This category of control applies to smaller flow amounts which may be diverted onto undisturbed ground while at the same time allowing a small amount of flow to pass over and through the device. The control device can also function as a grade control to reduce the length and steepness of a slope to prevent rills and gullies. These controls are normally situated at a right angle to the flow path and are spaced to ensure not erosive velocities. This form of control attempts to restore a sheet flow condition such that the velocity and depth of flow are so low that sediment cannot be effectively carried by the runoff. (See Figure 1.6.7 B.3 level spreader or rock berm)

(iii) Detention/Sedimentation - Runoff is ponded behind a structure allowing the sediment to drop out of suspension and be trapped in the detention pool because of the reduction in runoff velocity. Previously, silt fences were classified as detention/filtration devices. Recent research by the University of Texas and Texas Department of Transportation demonstrated that silt fences function primarily as detention/sedimentation due to clogging of the pores. They were found often to be undersized and improperly installed as detention/sedimentation devices. Therefore, silt fence criteria in section 1.4 have been updated to reflect the actual function of silt fences under field conditions.

Detention/sedimentation structures must be designed to withstand the force and velocity from a 10-year frequency storm without failing. Larger storms shall be bypassed via stabilized conveyances. Those devices that employ sedimentation must provide the storage volume for the runoff from a 2-year, 24-hour storm under compacted site conditions. The sedimentation basins must be designed such that drawdown time is 72 hours via surface skimmers. The design must include considerations for overflows to ensure that the device and its detention pool remain intact. Detention/sedimentation structures shall not be sited in natural drainage channels, draws or ravines that are directly connected to off-site drainage features like creeks, rivers, ponds or recharge features. In particular, this means that silt fences shall not be used to control concentrated or channelized flow and sedimentation basins shall not be constructed in natural draws because failures of the earthen retaining system are often catastrophic to the downstream receiving waters.

The procedure for developing an effective erosion and sedimentation control plan (henceforth adopting the NPDES nomenclature of Erosion and Sedimentation Control Plan (ESCP)) for a construction project involves several required steps, as indicated below. During plan review, the reviewer shall have final authority regarding the proper implementation of the ESCP. The submittals must demonstrate to the satisfaction of the reviewer that all potential sources of sediment and other construction related pollution have been identified and minimized. The plan shall not move forward until the reviewer has been satisfied that the letter and intent of this section have been satisfied.

5. Permanent Erosion and Sedimentation Control.

The design of effective permanent erosion and sedimentation controls and their installation as a part of the construction process is an obvious and necessary final step. Without adequate permanent controls, exposed or disturbed soil may erode, stream banks may become unstable, and sedimentation will occur in streams and lakes decreasing the recreational and aesthetic potential, reducing the diversity of plant and animal life, and potentially, threatening the quality of drinking water. Permanent controls include a broad range of items such as vegetation to hold soil in place, structures which cover the soil to protect it, and water quality improvement devices (e.g. sedimentation/ filtration basins) which remove sediment once it is being carried by runoff.

Permanent controls shall be designed for less frequent (i.e. larger) storm flows than temporary controls, in order to maintain long-term effectiveness. The City of Austin Drainage Criteria Manual requires all drainage facilities, including channels, storm sewers inlets, detention ponds and water quality facilities, to be designed to intercept and transport runoff from a 25-year frequency storm. Flows greater than a 25-year frequency up to and including a 100-year frequency storm must be contained within defined rights-of-way or drainage easements. The project engineer, therefore, shall design these facilities such that velocities are below erosive values for the particular soil conditions and the 25-year, 24-hour storm event, and that all structures can withstand the forces generated by the expected flows of the 25-year, 24-hour storm event. Likewise, on-site, privately owned drainage facilities and other areas subject to runoff shall be designed to withstand the maximum projected flows and velocities.

Permanent vegetation for minimizing erosion and sedimentation should be selected for its suitability in the general area, proposed land uses, and desired aesthetic, or landscaping, effect. In general, revegetation of disturbed areas using species of plants found naturally in the area of the site will have the best long-term success, especially in locations where care is likely to be minimal (e.g. in utility easements and road right-of-way). Using a mixture of grasses, forbs, shrubs and trees will maximize the ability of the vegetation to hold and protect the soil, by providing a variety of root structures at varying depths. Anytime that revegetation is achieved by seeding, it shall be accompanied by the appropriate soil retention blanket from Standard Specification 605 or with a FRM or BFM. Broadcasting of seed is not acceptable, nor is paper-based hydromulch or wood-fiber based with no tackifier acceptable. Additional information regarding revegetation can be found in **Section 2**, Landscape, and **Section 5**, Construction in Parks, in this Manual.

Care should be taken to avoid introducing aggressive species of non-native plants in sensitive environmental areas where they may supplant natives. Top soil imported from outside the site area often is source on undesirable weeds and grasses. See City of Austin Standard Specifications 130S and 601S and 609S.

Similar to the design of temporary controls, the design of permanent facilities must assess the expected permanent drainage characteristics of the site. Factors to be investigated include:

(i) Patterns of flow on the site, including locations of sheet or channelized flow, with calculated depths and velocities.

(ii) Off-site flows that must be passed through the site.

(iii) Discharge characteristics of all proposed structures that intercept drainage - e.g. culverts, streets and drives, detention ponds, sedimentation/filtration basins, storm sewers, etc.

With this information, the designer can determine the type and extent of permanent controls that will be required.

Where runoff is concentrated the engineer should attempt to return the flow to a sheet flow condition. This will generally result in much lower velocity with less erosion. In addition, flow will encourage vegetative filtration of the runoff to remove sediment and other pollutants, including those originating on adjacent impervious surfaces. When flow occurs over vegetated ground, the type of plants and their ability to withstand the expected velocity should be investigated.

If velocities are high, it should be determined if the rate of flow can be decreased without causing significant flooding. This might be done by reducing the slope, roughening the surface or modifying the shape of the channel. Where velocities are too high to permit vegetation, structural methods to protect the surface should be investigated. In general, the most "natural" technique should be used commensurate with the degree of protection needed and any risks involved - i.e. stone rip-rap would be preferable to concrete rip-rap; stacked stone walls would be preferred over formed concrete walls.

In those locations where it is feasible, flows should be released onto undisturbed well-vegetated areas. If it is necessary, permanent structural devices may be utilized to spread flow and reduce velocity.

Where flows are released into channels, erosion shall be prevented by assuring adequate vegetative cover, using appropriate protective materials or reducing velocity. Channel transitions, cuts, and fills without structural protection shall be smooth and natural to avoid unstable banks or slopes that might erode or collapse.

Whatever the site conditions, it is incumbent upon the designer to demonstrate to the reviewer, via accepted scientific and engineering methodology, that the permanent conditions are sufficient to withstand the erosive forces (shears and velocities) of the 25-year, 24 hour storm event. Use the DCM for acceptable calculations.

Good site management techniques will also benefit permanent erosion and sedimentation control. Proper land grading to achieve stable, maintainable slopes, the use of terraces in steeper cut areas, and vigorous stands of mixed vegetation (grasses, forbs, and trees) will retard stormwater flow, prevent erosion of soil, and capture sediment and pollutants from upslope areas.

Submittal requirements for permanent stabilization controls are the same as for the temporary construction phase controls. Refer to **Section 1.4.4(B).**

C. Plan Review Procedures.

According to the UDCs, designs for erosion and sedimentation controls included with subdivision, site plan or site development permit applications will be reviewed by the Planning & Development Department. General criteria for review of plans are provided below. Reviewers shall not approve plans unless satisfied that the specific and general criteria provided in ECM 1.4 have been demonstrated and certified by a Licensed Professional Engineer (TX) or a Certified Professional in Erosion and Sedimentation Control (CPESC).

In addition, for all plans, the applicant must post fiscal surety, consisting of a letter-of-credit, cash, or a bond, for the cost of the erosion and sedimentation controls proposed for the site and the anticipated cost of clean-up of a sediment discharge as outlined in Appendix S. This money may be used by the city to provide controls, if the contractor does not properly install or maintain the temporary controls; it may be used to complete the revegetation of a site if the owner refuses or is unable to do so; it may be used to clean-up any on-site or off-site sediment spills that degrade public or private property if the contractor refuses to abide by the clean-up plan specified by the Planning & Development Department. This fiscal surety must be approved and accepted by the Planning & Development Department prior to final approval of the plans.

D. Procedures During Construction.

Proper installation, maintenance, and inspection of the approved control methods during the construction of a project are the final steps in assuring effective control of erosion and sedimentation. Implementation requires the combined efforts of the project engineer, contractor, owner, city inspectors, and, when needed, reviewers working together to achieve the best feasible control. The following sections highlight specific areas of individual and shared responsibility during the construction phase.

1. Project Management.

Knowledgeable and committed on-site management is important for the successful implementation of erosion and sedimentation controls, especially temporary control measures during construction. To accomplish this, it is required that the owner designate a "project manager" or "site supervisor". The designated city inspector(s) responsible for the inspection and enforcement of erosion and sedimentation regulations can work with this individual to ensure that these requirements are met. The design engineer and the project manager working with a knowledgeable and involved city inspector will help to assure that effective controls are properly implemented and maintained.

2. On-site Pre-construction Meeting.

Prior to the beginning of any development activities, the erosion/sedimentation controls (per the ESCP) and tree and natural area protection specified in the approved plan must be in place. The owner will request the appropriate city department to schedule a preconstruction conference to assure that controls are in compliance with this manual and the approved plan and to correct any inadequacies in the plan that are identified during the inspection. This inspection will be held within five (5) days of notification and will be attended by the permit holder, design engineer, ESCP designer, contractor and representatives from all relevant city departments. No construction activities other than those required for installation of the erosion sedimentation control plan can proceed until this inspection is completed.

Subsequent to this inspection and completion of any necessary corrections, the contractor may begin construction activity.

At a minimum, the following items should be discussed at this meeting:

(i) The first phase of temporary controls (i.e. all perimeter controls installed at the edge of the disturbed area) and tree protection measures and all installation and maintenance specifications, adjustments, and additions (such as interior controls after rough cut and fill operations) necessary during upcoming stages of construction.

(ii) The site management requirements for the project, including sequence of construction, phasing, temporary stabilization, temporary and permanent spoil disposal areas (on and off site), haul roads and site access, designated construction storage and staging areas, limits of clearing and disturbance, and requirements for construction in and around stream channels or other critical environmental areas.

(iii) Permanent controls, such as detention and filtration ponds, related grading and drainage, revegetation schedule, seed mixes and special requirements.

(iv) City inspection and inspection-related administrative procedures, such as duties and responsibilities of individual Departments' inspectors, coordination between inspectors, requirements for final project release, Certificates of Occupancy, etc.

At this stage the inspector should assure himself that the erosion and sedimentation control plan appears adequate. The following guidelines should be used in determining the adequacy of the plan:

(i) Controls should be located such that they will intercept and capture or divert the intended flow without bypassing runoff from the 2-year storm.

(ii) All control devices should be used within specified contributing drainage acreage limits and in appropriate site applications.

(iii) All disturbed areas that could cause sedimentation should be protected by at least one temporary control in addition to the Limits of Construction perimeter controls.

(iv) All disturbed areas such as fills, steep slopes and channels must have control measures that will remain in place and trap sediment resulting from at least the two-year storm.

(v) The plan must be adequately phased to be effective during all stages of construction.

In addition, it is recommended that the city inspector and other involved personnel inspect and note existing natural conditions adjacent to and downstream of the controls prior to construction. Reinspection of these areas during construction can reveal evidence of disturbance or sedimentation resulting from inadequate control measures on the project.

3. Inspection by the Contractor.

To assure continued effective operation of each methodology, a licensed engineer (or person directly supervised by the licensed engineer) or certified inspector (CPESC, CPESC - IT, CISEC, CISEC - IT, CESSWI, or CESSWI - IT), (hereafter referred to as owner's representative) shall conduct ongoing inspections of all erosion/sedimentation controls and direct the person or firm responsible for maintenance to make any repairs or modifications necessary, within 48 hours of the initial notification. The owner's representative shall inspect the controls daily and keep on the job site an inspection log with updated entries at a minimum of once every 5 business days. Appendix P-8 contains a template of an acceptable inspection log. The log shall contain at a minimum the following information: date and time of inspection, recording of previous days weather conditions, including rainfall, a list of all controls and a map of the contributing sub-basins to each control; condition of controls for each sub-basin; required maintenance; date that maintenance was performed; construction sequence for temporary stabilization, phasing and movable BMPs. Signature of owner's representative. The City inspector shall have the right to request and review the inspection log at the job site.

Daily inspections shall be made by the contractor and silt accumulation upstream of temporary control measures must be removed when depth reaches six (6) inches or one-third (⅓) of the installed height of the control whichever is less. Prior to acceptance or approval of the project by the City, haul roads and waterway crossings constructed for temporary access must be removed, accumulated sediment removed from the waterway and any basins that will be used as permanent stormwater controls and the area returned to original grade and revegetated. All land clearing debris shall be disposed of prior to acceptance of the project by the City.

4. Compliance Inspection by the City.

The Planning & Development Department is primarily responsible for the inspection and enforcement of erosion and sedimentation control requirements on site developments and subdivisions. The City will monitor compliance with plan requirements and judge the effectiveness of the controls during different stages of construction and before and after significant rainfall.

5. Compliance Criteria.

The criteria used to determine the compliance or non-compliance of a project's temporary erosion and sedimentation controls include the following:

(i) The project must have a valid, current city development permit or site plan.

(ii) The project must be in substantial compliance with the approved plans and specifications (ESCP) for the development permit. This is determined by inspection of various items at the site.

(iii) Structural control practices which should be inspected are the following:

(iv) Controls must be installed in all required areas in accordance with approved plans and specifications.

(v) Materials must meet minimum requirements.

(vi) Maintenance must be performed when trapped sediment exceeds allowed limits.

(vii) Disturbances to erosion and sedimentation controls by construction activity or runoff must be repaired within 48 hours of discovery (as determined by the inspection log or by the City inspector).

(viii) Temporary removal of portions of controls during necessary construction activities is allowed if the controls are replaced by the end of the work day. Additions or adjustments to the ESCP are necessary if the controls cannot be replaced in their original location.

Site Management practices which should be reviewed include the following:

(i) Construction sequence and phasing must follow approved plans.

(ii) Disturbed areas cannot be outside the LOC as shown on the approved plans, including fill areas, haul roads, and storage areas.

(iii) All temporary and permanent spoil disposal areas, both on and off-site, must comply with approved plans and ordinances.

(iv) All disturbed areas which are dormant for 14 days or longer shall be temporarily stabilized during construction to prevent soil detachment from wind or rain.

(v) Construction in creek channels requires that upstream flows be impounded upstream of the work site and routed around the construction area anytime there is equipment in the channel. Spoils must be removed from the channel of any creek or drainage way and its associated floodplain at the end of each work day.

The installed controls must prevent sedimentation in off-site or undisturbed areas.

If the installed erosion and sedimentation controls are in compliance with the approved plans but are not adequate to prevent the transport of sediment from the disturbed areas, plan adjustments or a plan revision must be made.

6. Inspection Before and After Rainfall.

Controls and adjacent downstream areas should be carefully inspected just prior to expected significant (> one-half inch) rainfall and inspected following significant rainfall events to assess the effectiveness of the controls and any adjustments, repair, or maintenance necessary. Inspection of the erosion and sedimentation controls this time is the most effective way to determine whether the plan is adequate.

The following guidelines can be used to determine the adequacy of controls after a rainfall:

(i) All visible drainage patterns left on-site after rainfall, especially areas of channelized flow (e.g. rills and gullies), should be carefully noted and the resulting effects of these on the structural controls should be observed. Concentrated flow areas, low points in perimeters, and channels adjacent to the project will usually be the critical areas where off-site sedimentation will be most likely to occur.

(ii) Overtopping, undermining, or bypassing of the structural controls will require repairs, adjustments, relocation, or additional controls. Before taking these actions, determine if failures were due to inadequate installation, improper location, or greater runoff than the control was designed to handle.

(iii) Above all, note where sediment has been carried on or off site. If controls appear to be intact and contain visible, significant amounts of sediment build up, this is evidence that they are working correctly. Visible amounts of sediment carried off of the project site is evidence that the temporary controls are not working as intended and that adjustments are needed. Any sediment carried off-site shall be retrieved by the contractor and returned to the site and stabilized. Any off- site damages that occur from fugitive sediment that exits a site shall be mitigated by the contractor per a mitigation plan approved by COA. If contractor refuses to remediate, COA may retain fiscal surety deposited to cover remediation.

The inspector and site personnel can recognize sediment that has been carried off of a particular project site by noting similarities in color, texture, and grain size to the soil existing on the site. It is recommended that existing off-site conditions be noted or documented before construction in order to help assess the effectiveness of the erosion and sedimentation controls during construction. Inspectors should also note the condition and operating characteristics of detention and water quality ponds under inspection after rainfall events in order to assess their performance prior to acceptance of a project.

7. Revisions to Controls.

Most erosion and sedimentation controls will normally require some minor adjustments or additions during construction. These are known as "field revisions" and will not require a plan revision if approved by the Engineer and the inspector. Significant modifications to the controls or the ESCP, however, may require a plan correction or revision and resubmittal to the City.

8. Enforcement of Non-compliance by the City.

The city inspector responsible for environmental regulations can take enforcement action under Article 7, Section 7.3.3 of the city's UDCs for non-compliance with erosion and sedimentation requirement on a project site.

Enforcement action can be by way of the issuance of a Stop Work Order. Issuance of a Stop Work Order stops all city inspection services and utility connections from all departments until the deficiencies are corrected and the Stop Work Order is released by the City. Violations of environmental regulations may also be enforced by the City through the suspension of the site plan or through the court system.

On projects that have obtained the required development permit/site plan from the city and where routine inspections reveal inadequacies in the controls, the inspector will give a verbal warning to the responsible personnel at the site of any noted and what corrective action is necessary. If, after a minimum period of 24 hours from this verbal warning, the deficiencies are not corrected, the inspector may deliver a written notice of non-compliance to the responsible on-site personnel. If, after an additional minimum period of 24 hours, the deficiencies are not corrected, the inspector can issue a Stop Work Order to stop work on the project until the deficiencies are corrected. If the temporary or permanent controls fail such that construction sediment migrates off the site, it shall be the responsibility of the Contractor to:

(i) retrieve the fugitive sediment to the satisfaction of the City of Bee Cave inspector

(ii) restore the off-site areas impacted by fugitive sediment to pre- disturbance conditions (determined by the City inspector, pre-disturbance photos and the impacted landowner(s));

(iii) revise or repair erosion and sedimentation controls within 48 hours of failure to the satisfaction of City Inspector.

Enforcement action can proceed immediately without a 48-hour warning period by the city inspector in some situations. These include the following:

(i) Project is within the jurisdiction of the city but has started construction without obtaining the required development permit or site plan.

(ii) Project has a valid permit but work was initiated without the required preconstruction meeting and without installation of temporary controls.

(iii) When significant or irreparable damage is judged to be occurring on a permitted site, the inspector may first ask the contractor to cease all work in the area of the violation. If the contractor complies with the verbal stop-work order and immediately institutes corrective measures in the area of the job violation, the inspector will not issue a Stop Work Order. If the work in violation is not stopped and corrective measures are not taken, the inspector may issue a Citation or Stop Work Order for the entire project.

9. Project Release or Acceptance by the City.

Upon completion of the site construction and revegetation of a project site, the design engineer shall submit an engineer's letter of concurrence to the Planning & Development Department indicating that construction, including revegetation, is complete and in substantial conformity with the approved plans. After receiving this letter, a final inspection will be scheduled by the appropriate city inspector.

As part of the final inspection, the city will inspect for the following environmental requirements:

(i) Determine that grass coverage and revegetation, including type of grasses, topsoil, temporary and permanent stabilization, are complete and in accordance with the plan requirements.

(ii) Determine that all drainage facilities, including water quality facilities and permanent structural controls, are installed in accordance with the plans. Any water quality facilities with sediment deposits will not be accepted until the contractor cleans the facilities and re-installs the appropriate media such that it is per specifications of ECM 1.6.7.

(iii) Note any unauthorized disturbance of the site or vegetation and ensure that all disturbed areas, including haul roads and spoil sites are revegetated.

(iv) Determine that all special environmentally related requirements, such as replacement trees and buffer zone restoration, are complete.

(v) Note all temporary erosion and sedimentation control measures that will still be required due to incomplete revegetation. All controls and sediment must be removed upon the completion of revegetation and before the full fiscal deposit for erosion and sedimentation controls is released through the Development Services Department.

When all revegetation is completed as required by the plans and specifications the project can be certified for acceptance.

10. Developer's Contracts.

Article 7, Section 7.3.3 of the City UDCs requires that a separate and enforceable agreement to ensure revegetation be signed by the city and the developer of a project if maintenance responsibility for constructed facilities is accepted, or a temporary certificate of occupancy is issued, by the city before the required revegetation coverage is complete.

This agreement is in the form of a standard Developer's Contract in which the developer agrees to complete the required revegetation within a specified period of time, normally a 4-month period. The contract is tied to a fiscal surety in the form of a letter of credit, a cash deposit, or a bond. The amount of this fiscal surety is determined by the amount of disturbed area that will be required to be revegetated for the project. All areas disturbed as part of the project and any adjacent areas that were disturbed by the construction of the project will be required to be revegetated. The Contract states that if the required revegetation is not completed within the specified period of time, the city will use the deposited funds to ensure revegetation is completed.

The city can consider longer Developer's Contract periods for projects accomplishing revegetation with native grasses. The factors that will be considered for approval of longer revegetation periods than four months will be: (a) the erosion and sedimentation potential of a particular project area which will be exposed to erosion for a longer period of time (temporary erosion and sedimentation measures must be constantly maintained until completion), (b) the use of only minimum amounts of topsoil to reduce erosion potential, (c) postponement of initial seeding until a more suitable seasonal time, (d) the good faith effort on the part of the developer/owner to accomplish project completion and revegetation as soon as practically possible.

Upon satisfactory completion of any outstanding items identified by the inspector, final release or acceptance of the project can occur.

E. Maintenance Responsibilities After Construction.

Following release or acceptance of a project (and termination of the development permit) the property owner is responsible for maintaining the project site. The release of excessive amounts of sediment in stormwater runoff is prohibited by the Environmental Control and Conservation Code. Any person causing stoppage, damage or restriction of flow in any storm sewer or watercourse may be liable to the city for repairs to these waterways.

F. Additional Recommendations and Requirements for Selected Projects.

It has been recognized that particular types of construction projects or projects in particular areas have common problems that are less frequently experienced in other circumstances. This section provides additional guidance for the engineer, reviewer, contractor, and inspector in order to better design, install and maintain effective temporary erosion and sedimentation controls.

1. Major Utility Projects.

Major water and wastewater line installations can be challenging projects in which to accomplish effective temporary controls because of the limited working space and easements often involved. The location of wastewater lines along creeks and in flood plains can create additional problems. Maintenance and access roads are frequently added after construction is complete, rather than being designed into the project.

Silt fence can be an effective perimeter control along the route of the pipeline. Rock berms and reinforced rock berms are appropriate for use as flow diverters, energy dissipators, grade control, and level spreaders. Hay bales dikes generally are not recommended for use. Triangular filter dikes can be used in short sections across the disturbed area. The triangular dikes must be placed such that the bottom of the dike is in full contact with the ground.

A two-phased plan should be implemented for these type of projects. Prior to construction, perimeter controls should be required parallel to the line installation and to provide protection at channels, spoil areas, and haul roads. These controls should not be directly disturbed by the trenching activity. In the second phase, after the pipe is installed and backfilled, interior controls may be located perpendicular to or diagonally over the pipe installation area. These will control runoff and sediment in areas which do not drain into the parallel controls to the side. These controls are especially necessary on steep slopes which drain parallel to the line installation. These interior controls should be installed as soon after the backfilling of the trench as possible and should be situated to still allow access to the rest of the project by the contractor.

(i) Site Management Practices
Site management is crucial to the success of temporary erosion and sedimentation controls on this type of project. Especially important are temporary and permanent spoil disposal areas which must be adequate to handle the amount of material generated by the project, or the spoil material can overwhelm the easements, erosion controls, and tree protection.

Projects should follow the recommendations for construction adjacent to creeks and waterways and water discharges from construction sites discussed later in this section. This is especially true if any boring or tunneling operations will be performed as part of the job. In addition, there must be adequate accessways and haul roads approved for the project beforehand to allow access and equipment passage while keeping the limits of disturbance as small as possible.

Utility installations along or within existing paved roadways should follow the guidelines for protection of existing drainage facilities with temporary erosion and sedimentation controls.

2. Construction in Creeks and Channels (> 5 Acres).

Projects in this category include some utilities, creek and channel improvements, regional detention ponds, bridges and culverts. In general, a two phase plan should be implemented for these drainage improvements. Construction in creek channels requires that upstream flows be impounded upstream of the work site and routed around the construction area anytime there is equipment in the channel. Spoils must be removed from the channel of any creek or drainage way and its associated floodplain at the end of each work day. It shall be the responsibility of the Engineer of Record or the ESCP preparer to designate on the ESCP and construction plans the method of dewatering the drainage feature. The

ESCP shall include the sequence of construction and the temporary and permanent stabilization of the drainage feature after disturbance. If significant areas adjacent to but above the channel are disturbed, silt fence should be installed parallel to the top of the bank to prevent from entering the waterway from the sides. All erosion and sedimentation controls for upland areas shall be located outside of concentrated flow paths.

Bridge construction, which has localized impact on the channel, may require only a single phase plan with appropriate field adjustments. These silt fences should be adjusted as necessary as the bridge construction progresses.

When constructing detention ponds, a perimeter control, typically of silt fence, should be placed first along the downslope sides of the pond beyond the limits of the proposed grading work. After the pond is graded and the outlet is complete, the silt fence should be adjusted such that it passes over the top of the outlet pipe on the outside of the pond. A semi-circular section of reinforced rock berm or silt fence can be added inside the pond at the outlet to improve sedimentation inside the pond. Figure 1-1.6 in Appendix H of this manual indicates how these controls might be installed.

(i) Site Management Practices
Good site management practices are essential to the success of erosion and sedimentation controls for projects in larger waterways. Examples of several practices are provided below:

(1) Fill Material Storage - At the end of each work day the contractor should remove all loose excavated material from the channel and 100-year floodplain as delineated on the approved plan. No construction or fill materials can be stored within the limits of the channel or 100-year floodplain.

(2) Temporary Creek Crossings - Temporary crossings composed of soil may not be used. They must be removed entirely from the stream bed as soon as possible.

(3) Flow Across Construction Operations in a Channel
Water-filled channels should always be de-watered if possible rather than attempting to conduct construction operations directly in them. This prevents the water from coming in contact with the disturbed soil and becoming silted. In larger channels de-watering can be done in one-half of the stream at a time. The design of dikes or berms to direct flow in channels should consider the possibility of these structures increasing flood levels during high flow conditions or eroding and contributing to increased downstream sedimentation. These structures and all associated construction should remain in the channel for the shortest time possible.

(ii) Dewatering or Diversion of Stream Flow - The temporary damming and diversion (by pumping or gravity) of base flow around construction activities under way in a channel is required. This flow is then safely discharged further downstream and prevented from coming in contact with areas disturbed by the construction activity. Any time construction equipment or activity is placed in the channel, the flow at that time shall be diverted around the construction site and discharged in a non-erosive manner downstream of the channel construction. Sandbags are not an acceptable diversion structure in channels.

(1) Stream flow that does become silted from construction activity must not be discharged directly back into the stream, but must be temporarily detained until the sediment has settled out. All water discharges should comply with the recommendations for Water Discharges from Construction Sites.

(2) Bore Pit Locations - Bore pits should be located as far as possible from the main channel of any waterway. Bore pits located near stream beds greatly increase sedimentation into the waterway and are susceptible to frequent flooding.

(3) Frequent removal of sediment collected in treatment devices will reduce the risk of sediment release due to a sudden failure of an overloaded control.

3. General Permit Utilities and Maintenance Activities.

Work which is considered under permits for general utility installation and maintenance includes:

(1) Natural gas main service/repair for pipelines less than 200 feet in length.

(2) TV cable installation/repair within subdivisions and right-of-way.

(3) Telephone cable installation/repair within subdivisions and right-of-way.

(4) West Travis County Public Utility Agency water or waste water extensions less than 300 feet in length and routine and emergency repairs of existing facilities.

(5) City of Bee Cave Parks installation, repair or landscaping of minor park facilities.

(6) City of Bee Cave street and drainage maintenance and repair.

(7) City of Austin/PEC Electric Utility Department routine installation and maintenance of overhead electric distribution system facilities.

For small utilities projects, the two-phase erosion and sedimentation control plan used for major utilities can also be implemented. The first phase would include perimeter controls parallel to the line installation. The second phase would include interior controls installed perpendicular and diagonally over the trenched line after it is backfilled. Often, few temporary controls are necessary in flat areas for these types of small projects. Key areas for temporary control are roadside ditches or drainage swales, stream crossings, and steep slopes. Silt fences, rock berms, and small lengths of triangular filter dikes are recommended controls.

(ii) Site Management Practices

For these projects, close on-site supervision and management of the fill material generated by the construction and timely removal of the excess spoil can often be more effective than temporary controls. In addition, appropriate protection of existing drainage facilities and revegetation after construction should be considered during design and installation phases.

4. Water Discharges from Construction Sites.

A common erosion and sedimentation control problem other than stormwater runoff that can cause significant off-site sedimentation problems from construction sites is the discharge of silted water during certain construction operations. Pump and Filter Press systems are acceptable and appropriate for removing sediment from water prior to discharging into surface water or storm drain. Mobile filter presses that have capacity to remove up to -400 mesh particle size are recommended and acceptable. The following list contains the five most common types of water discharges from construction sites that can cause significant off-site sedimentation problems and the recommended control techniques used in these situations.

(i) Boring or Tunneling Operations That Discharge Sediment Laden Water.

All silted water and slurry generated by the construction can be pumped into one or more temporary earthen pits or metal tanks to allow the sediment to settle before discharging the clean water. These temporary sedimentation facilities must be adequately sized to be most effective and may be constructed in series to improve sediment removal.

(ii) Groundwater or Channel Flow Seepage into Trenches or Excavations.

Settling or removing of the silt laden water can be done as described in the item above. In addition, the work area can be de-watered by temporarily damming the flow and pumping the flow around the construction, to prevent it from entering the trench or excavation. Innovative or alternative methods, such as end-of-pipe socks, may also be proposed.

Accumulated Stormwater in Trenches or Excavations after Rainfall. Recommended solutions are as described above.

(iii) Flushing Water From Water and Wastewater Utility Lines or Storage Tanks.
Prior to placing the utility lines in service, they must be flushed to remove accumulated debris or to sterilize the pipelines. If this water does not contain silt, use a hose extension to allow the water to be discharged to an undisturbed, vegetated area. Discharging clean water over an unvegetated area may create an erosion and sedimentation problem if velocities are high enough to erode the disturbed earth. If the water to be discharged contains silt, it should be treated using the techniques described above: detention/sedimentation or removal off-site.

5. Protection of Existing Drainage Facilities.

Construction projects located in or adjacent to developed areas with existing drainage facilities often require partial protection of these drainage facilities for effective erosion and sedimentation control. This must be done in a manner that will effectively trap sediment without impeding the stormwater drainage flow and function of the facility. Inlets should never be completely sealed.

(i) Curb Inlets. (See 1.4.5P) Area Inlets.
Surround the inlet with reinforced silt fencing or reinforced rock berms. Sediment will be trapped mainly by detention/ sedimentation with some filtration.

(ii) Detention Pond Outlets.
Reinforced rock berms or reinforced silt fencing should be placed around the outlet on the inside of the pond to enhance sedimentation, especially during low flow events and when the pond is not fully revegetated. Temporary controls preferably should be placed inside the pond outlet rather than outside. If placed outside, a semicircular rock berm or reinforced rock berm should be placed immediately below the outlet headwall.

1.4.5 TEMPORARY STRUCTURAL PRACTICES

A. Mulching (See City of Austin Specifications manual item 645S-1 for detail)

1. Description.

Mulching is the process of applying wood mulch, wood chips, or other organic material to the exposed soil surface to protect it from erosive forces (wind, water, etc.) and to conserve soil moisture until plants can become established.

Mulching shall not be considered a primary erosion control, but shall be used in conjunction with other approved controls. The effectiveness of using Mulching as an erosion control technique depends on:

(i) The type of mulch used
(ii) Mulch morphology
(iii) Application rate
(iv) Method of application: the mulching material can be placed mechanically or by hand.
(v) Soil type
(vi) Slope

(vii) Climatic characteristics

(viii) Proper preparation of application area (uniform application surface to ensure optimal mulch to soil contact)

2. Materials.

Mulching material can be manufactured on or off the project site. It consists primarily of organic material, separated at the point of generation, and may include: shredded bark, stump grindings, or composted bark

The mulching shall have the following composition:

(1) Use wood chips produced from a three (3) inch minus screening process (equivalent to TXDOT Item 161 Section 1.6.2.B Wood Chip requirements).

(2) Large portions of silts, clays, or fine sands are not acceptable in the mix.

Mulching material is composed of a well-graded mixture of particle sizes and may contain rocks less than 2” in diameter. Mulching material must be free of refuse, physical contaminants, and material toxic to plant growth. It is not acceptable for the mulching material to contain ground construction debris, biosolids, or manure.

Prior to placement a representative sample of the mulching material must be accepted by the project engineer or his/her designee and by the city inspector.

3. Installation.

Mulching is performed after grading and soil surface preparation is completed.

(1) Mulching is not recommended on 2:1 slopes or steeper.

(2) Mulching on slopes of 3:1 or flatter use a minimum depth of 4 inches. Apply mulching material a minimum of three (3) feet over the shoulder and beyond the base of the slope or into existing vegetation where possible to prevent rill formation and transport of the material (Figure 1.4.5.A).

(3) The mulch may be placed with a hydraulic bucket, a pneumatic blower, or by hand.

(4) The effectiveness of the mulching material depends on good contact between the soil and mulching material. Maximum contact with the soil promotes increased infiltration and sediment trap formations. If the mulching material does not make full contact with the soil, is perched above the soil by clods, or stays suspended above depressed areas, severe rill erosion can occur beneath it. Therefore mulching material must be placed to ensure maximum contact with the soil. Provide a smooth application surface by tracking, rolling, raking, etc. to ensure an optimal mulch to soil contact.

(5) The mulching material shall be placed evenly and uniformly to provide 100% coverage.

4. Where mulching is not allowed as an erosion control:

(1) On slopes with groundwater seepage;

(2) At low points with concentrated flows and in gullies;

(3) On slopes equal to or steeper than 2:1;

(4) At the bottom of steep perimeter slopes exceeding 100 feet in length (large up-gradient watershed);

(5) Below culvert outlet aprons, and

(6) Around catch basins and closed storm system outlets.

(7) Within a stormwater control structure.

(8) No mulching material shall be placed within 100 feet of any source of surface water or drinking water supply.

(9) Mulching shall not be used as a primary perimeter site erosion control.

5. Inspection and Maintenance.

(1) The mulched area shall be inspected regularly and after each large rainfall. Any required repairs shall be made immediately, with additional mulching material placed on top of the mulch to reach the recommended thickness.

(2) When the mix is decomposed, clogged with sediment, eroded or ineffective, it must be replaced or repaired.

(3) Vegetation adds stability and should be promoted.

(4) If the mulch is not removed prior to revegetation, it should be spread out into the landscape to a depth that will not prevent seed germination and will encourage effective revegetation of the site.

References:

Foltz, Dooley (2003), Comparison of Erosion Reduction Between Wood Strand and Agricultural Straw, Trans. ASAE 46(5): 1389-1396.

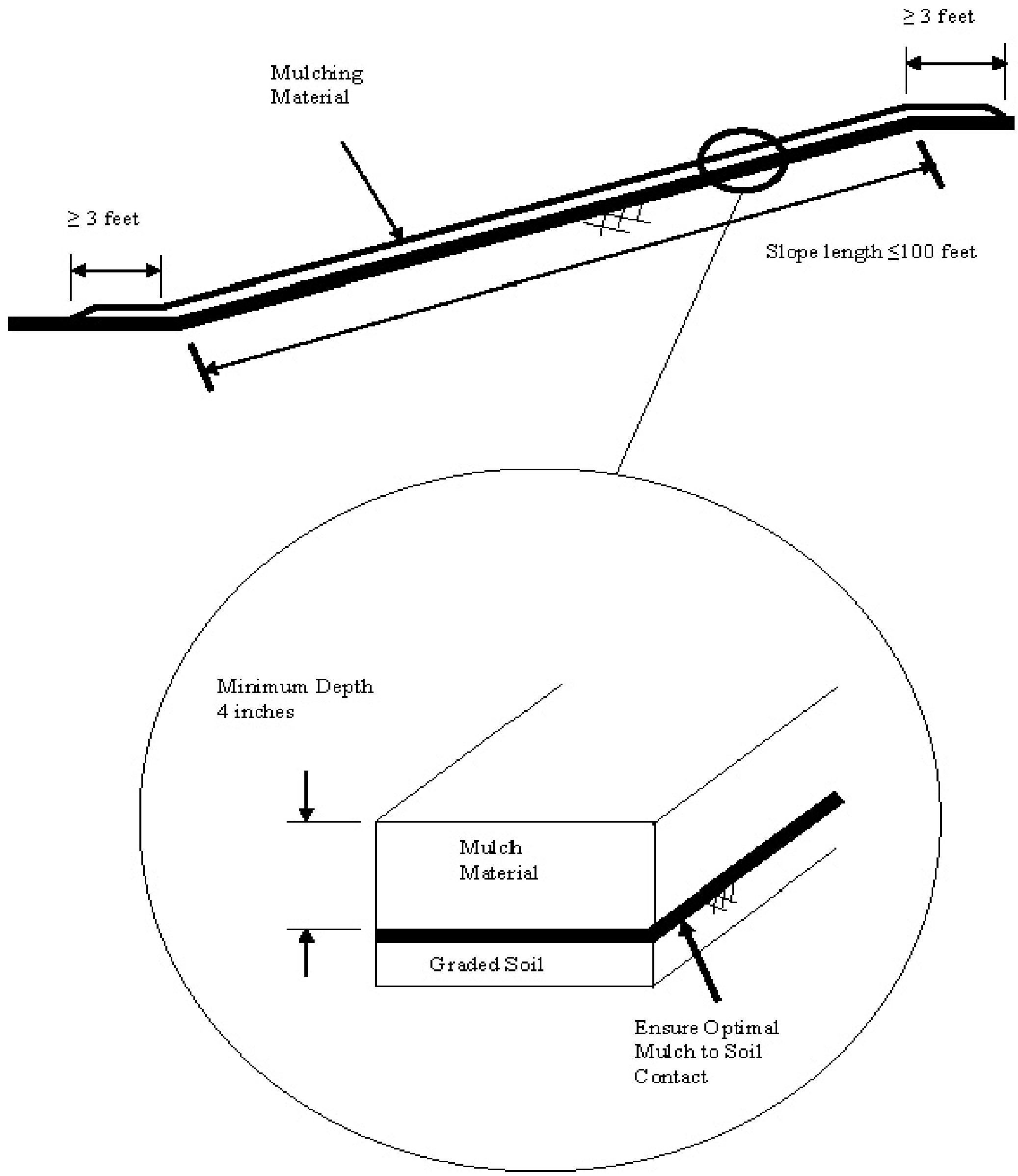
Demars, Long, and Ives (2000), Use of Wood Waste Materials for Erosion Control, NETCR 20

McCoy and Noble (2002), Use of Compost & Mulch for Storm Water Management, Erosion & Sediment Control, TCEQ

Wischmeier, W.H. and D.D. Smith (1978), "Predicting Rainfall Erosion Losses - A Guide to Conservation Planning" U.S. Department of Agriculture, Agriculture Handbook No. 537

NOTE: THIS METHOD IS NOT A PRIMARY EROSION CONTROL AND SHOULD BE USED IN CONJUNCTION WITH MULCH SOCKS, SILT FENCES, MULCH BERMS, AND OTHER APPROVED METHODS OF SEDIMENTATION AND EROSION CONTROL.

Figure 1.4.5.A.1 Mulching Detail



B. Diversion, Interceptor and Perimeter Dikes. (See City of Austin Standard Specifications manual items 622S, 630S, and 635S and Specifications manual items 622S-1, 630S-1, and 635S-1 respectively for detail)

1. Definition.

A temporary ridge of compacted soil located either (1) immediately above cut or fill slopes, (2) across disturbed areas or rights of way or (3) along the perimeter of the site or disturbed areas.

2. Purpose.

(i) A diversion dike intercepts runoff from small upland areas and diverts it away from exposed slopes to a stabilized outlet, such as a rock berm, brush berm or stone outlet structure.

(ii) An interceptor dike shortens the length of exposed slopes by intercepting runoff and diverting it to a stabilized outlet.

(iii) A perimeter dike prevents off-site runoff from entering the disturbed area and prevents sediment laden storm runoff from leaving the construction-site or disturbed area.

3. Conditions Where Practice Applies.

Dikes are generally used for the period of construction to intercept and reroute runoff around disturbed areas to prevent excessive erosion until permanent drainage features are installed and/or slopes are stabilized. The repose characteristics of the material of construction should be considered for installations on steep slopes.

4. Design Criteria.

The following criteria shall be observed.

(1) Drainage Area - Less than five (5) acres (recommended)

(2) Top Width - Two (2) feet minimum

(3) Height (compacted fill) - 18 inches minimum height measured from the top of the existing round at the upslope toe to top of the dike

(4) Side Slopes - 2:1 or flatter

(5) Stabilization - Where slope of channel is one (1) to five (5) percent, stabilization is required if velocity exceeds one (1) foot per second; over five (5) percent, stabilization shall be required.

(6) Stabilization, when required, shall be demonstrated to prevent erosion up to the 25-year, 24-hour storm.

(7) Spacing.

• Slope of disturbed areas above dike	greater than 10%	5-10%	less than 5%
• Maximum distance between dikes:	100 ft.	200 ft.	300 ft.

5. Outlet.

(i) Diverted runoff from a protected or stabilized area shall outfall directly to an undisturbed stabilized area or into a level spreader (see **Section 1.4.3** C) or grade stabilization structure (see **Section 1.4.3** H).

(ii) Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device such as a rock berm, brush berm, stone outlet structure, sediment trap or sediment basin or to an area protected by any of these practices.

C. Interceptor and Perimeter Swales. (See City of Austin Standard Specifications manual items 631S and 636S and Specifications manual items 631S-1 and 636S-1 for detail)

1. Definition.

A temporary excavated drainageway located across disturbed areas or rights of way or along the perimeter of a construction site.

2. Purpose.

Interceptor swales shorten the length of exposed slope by intercepting runoff. Perimeter swales prevent off-site runoff from entering the disturbed area or prevent sediment-laden runoff from leaving the construction site or disturbed area. The outflow from a swale must be directed to a stabilized outlet or sediment trapping device.

3. Conditions Where Practice Applies.

Interceptor swales are constructed across disturbed easements/rights of way, such as for utility cuts and streets or disturbed areas such as graded parking lots or land fills. The perimeter swale is used for the period of construction at the perimeter of the disturbed area. The perimeter swale also is used to prevent storm runoff from entering the disturbed area.

This runoff shall be adequately handled to prevent damage due to flooding or erosion to adjacent property. Swales shall remain in place until the disturbed area is permanently stabilized.

4. Design Criteria.

The following criteria shall be observed.

(1) Drainage Area - Less than five (5) acres (recommended)

(2) Top Width - Four (4) feet minimum and the bottom shall be level.

(3) Depth - One (1) foot minimum

(4) Side Slopes - 2:1 or flatter

(5) Grade - One (1) to three (3) percent; must have positive drainage (sufficient grade to drain) to an adequate outlet.

(6) Stabilization - Where slope of channel is one (1) to five (5) percent, stabilization is required if velocity exceeds one (1) foot per second; over five (5) percent, stabilization shall be required.

Stabilization, when required, shall demonstrate that erosion is prevented for up to the 2-year, 24-hour storm flow.

(1) Traffic Crossings - all points where vehicles will cross swales must be stabilized as above, except the stone lining shall be at least six (6) inches in thickness for the full width of the traffic crossing.

(2) Spacing

Slope of right of way or disturbed area:	greater than 10%	5-10%	less than 5%
Minimum distance	100 ft.	200 ft.	300 ft.

5. Outlet.

(i) Diverted runoff from a protected or stabilized upland area shall outlet directly onto an undisturbed stabilized area, level spreader or into a grade stabilization structure.

(ii) Diverted runoff from a disturbed or exposed upland area shall be conveyed to a sediment trapping device, such as a rock berm, brush berm, stone outlet structure, sediment trap or sediment basin or to an area protected by any of these practices.

(iii) The on-site location of the swale may need to be adjusted to meet field conditions in order to utilize the most suitable outlet.

D. Stone Outlet Structures. (See City of Austin Standard Specifications manual item 643S and City of Austin Specifications manual item 643S-1 for detail)

1. Definition.

A temporary crushed stone dike installed in conjunction with and as a part of a diversion dike, interceptor dike or perimeter dike.

2. Purpose.

The purpose of the stone outlet structure is to provide a protected outlet for a diversion dike, interceptor dike or perimeter dike to provide for diffusion of concentrated flow and to allow the area behind the dike to dewater.

3. Conditions Where Practice Applies.

Stone outlet structures apply to any point of discharge where there is need to dispose of runoff at a protected outlet or to diffuse concentrated flow for the duration of the period of construction.

4. Design Criteria.

The drainage area above the structure is recommended to be less than five (5) acres. The minimum length, in feet, of the crest of the stone outlet structure shall be equal to six (6) times the number of acres of contributing drainage area.

Maximum allowable flow through rate is 40 gallons per minute per foot squared. The crest of the stone dike shall be at least six (6) inches lower than the lowest elevation of the top of the earth dike and shall be level. The stone shall be crushed stone. Unless otherwise specified, all aggregate used in a stone outlet structure shall be three (3) to five (5) inches open graded rock or larger. A fabric core consisting of geotextile wrapped stone having a minimum diameter of one (1) foot shall be incorporated into the structure. The stone outlet structure shall be located so as to discharge onto an already stabilized area or into a stable watercourse. Stabilization shall consist of complete vegetative cover, paving, etc., sufficiently established to be erosion resistant.

Fabric core specification shall be nonwoven polypropylene, polyethylene or polyamide geotextile, minimum unit weight 4-½ ounces per square yard, mullen burst strength exceeding 250 pounds per square inch, ultraviolet stability exceeding 70 percent and equivalent opening size exceeding 40.

5. Maintenance.

The area upstream from the stone outlet structure shall be maintained in a condition which will allow sediment to be removed following the runoff of a rainfall event. Periodic inspections (after each rainfall) shall be made by the contractor and when the silt reaches a depth equal to 1/3 the height of the structure or one (1) foot, whichever is less, accumulated silt shall be removed and disposed of at an approved site in a manner that will not contribute to additional siltation. The

structure shall be reshaped as needed during inspection. The structure shall be left in place until all upstream areas are stabilized and accumulated silt is removed.

E. Rock Berm. (See City of Austin Standard Specifications manual item 639S and Specifications manual item 639S-1 for detail)

1. Description.

A temporary berm constructed of open graded rock installed at the toe of a slope or the perimeter of a developing or disturbed area. Rock berms are appropriate for use as flow diverters, energy dissipators, grade control, and level spreaders to release the water in sheet flow.

2. Conditions Where Practice Applies. The rock berm is used:

(1) To convert concentrated flow to sheet flow or to prevent sheet flow from concentrating.

(2) Where the contributing drainage area is generally less than five (5) acres.

3. Design Criteria.

A rock berm is constructed at the perimeter of a disturbed site within the developing area. It is not to be constructed outside the property lines without obtaining a legal easement from the affected adjacent property owners.

The following criteria shall be observed.

(1) Drainage Area - Less than five (5) acres (recommended)

(2) Height - 18 inches minimum height measured from the top of the existing ground at the upslope toe to top of the berm.

(3) Top Width - Two (2) foot minimum

(4) Side Slopes - 2:1 or flatter

(5) Woven Wire Sheathing - Hexagonal opening hardware netting (such as poultry netting) secured with hog rings. Width = as required

Wire = 20 gauge, galvanized

Opening = Hexagon, one (1) inch in diameter

Woven wire sheathing is required when there is concentration of water above the berm.

(1) Grade - Berms will be built along the contour at zero (0) percent grade or as near as possible.

(2) Material - Open graded rock three (3) to five (5) inches diameter (for sheet flow or concentrated flow condition).

4. Outlet.

Runoff shall outfall directly to an undisturbed stabilized area.

5. Maintenance.

The area upstream from the rock berm shall be maintained in a condition which will allow sediment to be removed following the runoff of a rainfall event. Weekly or after each rainfall, inspection shall be made by the responsible party and if the sediment reaches a depth equal to 1/3 the height of the berm or one (1) foot, whichever is less, it shall be removed and the accumulated sediment disposed of at an approved site in a manner that will not contribute to additional sedimentation.

F. Mulch Socks. (See City of Austin Specifications manual item 648S-1 and Standard Specifications manual item 648S for details)

1. Description.

A mulch sock is mulch material encased in mesh to form a tube/roll. A technique used to intercept sheet flow and pond runoff, allowing sediment to fall out of suspension, and often filtering sediment as well. Mulch socks provide an environmentally-sensitive and cost-effective alternative to sediment fence.

2. Material.

Mulching material can be manufactured on or off the project site. It consists primarily of organic material, separated at the point of generation, and may include: shredded bark, stump grindings, or composted bark.

The mulch shall have the following composition:

Use untreated wood chips produced from a 3 (three) inch minus screening process (equivalent to TxDOT Item 161, Compost, Section 1.6.2.B, Wood Chip requirements).

Large portions of silts, clays, or fine sands are not acceptable in the mix.

The pH should fall between 5.5 and 8.5.

The organic matter content is ≥25%, dry weight basis.

Mulch material must be free of refuse, physical contaminants, and material toxic to plant growth. It is not acceptable for the mulch material to contain ground construction debris, biosolids, or manure.

The sock material mesh opening shall be equal to or less than 3/8 inch (10 mm) and the material tensile strength shall be equal to or greater than 202 psi (14.2 kg/cm 2).

Prior to placement, a representative sample of the mulching material must be accepted by the project engineer or his/her designee and by the city inspector.

3. Installation.

Use 12- or 18-inch diameter mulch socks for all sediment control applications. The 18-inch diameter sock material has proven to be the most consistent for all sediment control applications (TxDOT, April 2006).

Mulch socks should be used at the base of slopes no steeper than 2:1 and should not exceed the maximum spacing criteria provide in Table 1.4.5.F.1 for a given slope category. The spacing criteria are based on the maximum drainage area, in square feet, above a 100 feet wide section of mulch sock.

Place mulch socks at a 5' or greater distance away from the toe of slopes to maximize space available for sediment deposition.

When placed on level contours sheet flow of water should be perpendicular to the mulch sock at impact and un- concentrated.

Install mulch socks using rebar stakes with a minimum 3/8-inch diameter and a minimum length of 48-inches, wood stakes with a minimum dimensions of 1 inch by 2 inch and a minimum length of 48 inches, or earth anchors placed behind the mulch sock on 4-foot centers. Drive the stakes in the ground to a minimum depth of 24-inches leaving less than 12- inches of post above the exposed mulch socks. It is preferable to cut the post flush with the top of the mulch sock.

In order to prevent the movement or floating of the mulch log during rain events or construction operations, install stakes on the front side placed on 4-foot centers.

In order to prevent water flowing around the ends of mulch socks, point the ends upslope to place them at a higher elevation.

In order to prevent water flowing between the gaps between the joints of adjacent ends of mulch socks lap the ends of adjacent mulch socks a minimum of 12 inches. Never stack mulch socks on top of one another.

Mulch socks can be placed around the perimeter of affected areas, if the area is flat or the perimeter is on contour. Socks should be placed using 'smiles' and j-hooks. (See Section 1.4.5.G., Silt Fence for proper placement and J hook details.)

Do not place socks where they cannot pond water.

For steeper slopes, an additional sock can be constructed on the top of the slope and within the slope area as determined by specific field conditions. Multiple socks are recommended on steeper slopes.

Do not use mulch socks in areas of concentrated flow, as they are intended to control sheet flow only.

4. Where mulch socks are not allowed as a sediment control:

On slopes with groundwater seepage;

In concentrated flow situations or in runoff channels;

On slopes equal to or steeper than 2:1;

At the bottom of steep perimeter slopes exceeding 100 feet in length (large up-gradient watershed);

Below culvert outlet aprons, and

Around catch basins and closed storm system outlets.

Within a stormwater control structure.

5. Inspection and Maintenance

Inspect mulch socks after installation for gaps under the mulch socks and for gaps between the joints of adjacent ends of mulch socks.

Inspect every 7-days and within 24-hours of a rainfall event of 0.5-inches or greater event and replace or repair if necessary.

Sediment retained by the sock shall be removed when it has reached 1/3 of the exposed height of the sock. Alternatively, the sediment and sock can be stabilized with vegetation at the end of construction.

Mulch socks can be vegetated or unvegetated. Vegetated mulch socks can be left in place. The vegetation grows into the slope, further anchoring the filter sock. Unvegetated filter socks are often cut open when the project is completed, and the mulch is spread around the site as soil amendment. The mulch should be spread out into the landscape to a depth that will not prevent seed germination and encourage effective revegetation of the site.

References:

Demars, Long, and Ives (2001), Performance Specifications for Wood Waste Materials As An Erosion Control Mulch And As A Filter Berm, NETCR 25.

City of Austin, Mabel Davis Park Site Remediation, Standard Technical Specifications, Compost/Mulch Filter Berm - Section 02273 (2004), Volume 2.

Storey, et al. (2006), Water Quality Characteristics and Performance of Compost Filter Berms, Report 0-4572-1, Texas Department of Transportation.

Table 1.4.5.F.1 Mulch Socks and Maximum Slope Lengths for 12" and 18" Sock Diameters.

Slope	Max. Slope Length Between 18 in. Dia. Sock (ft)	Max. Drainage Area (sf) per 100 ft of Sock
100:1-50:1	100	10000
50:1-30:1	75	7500
30:1-25:1	65	6500
25:1-20:1	50	4800
20:1-10:1	25	2600
10:1-5:1	15	1300
5:1-2:1	10	1000

Slope	Max. Slope Length Between 12 in. Dia. Sock (ft)	Max. Drainage Area (sf) per 100 ft of Sock
100:1-50:1	100	6000
50:1-30:1	40	4000
30:1-25:1	30	3000
25:1-20:1	25	2600
20-1:10-1	15	1300
10:1-5:1	10	1000
5:1-2:1	5	500

G. Silt Fence. (See City of Austin Standard Specifications manual item 642S and Standards manual 642S-1 for details)

1. Description.

Silt Fence is a temporary barrier made of non-woven polypropylene, polyethylene, or polyamide material that is trenched or sliced into the ground and supported by posts on the downstream side of the fabric. Silt fence works by intercepting sheet flow from slopes, causing the runoff to pond behind the fence, thereby promoting deposition of sediment on the

uphill side of the fence. They are most effective when designed to provide comprehensive water and sediment control throughout a construction site and if used in conjunction with erosion control practices.

A common misconception among many designers is that the silt fence actually "filters" suspended particles from runoff. The effectiveness of silt fence is primarily derived from its ability to pond water behind the fence. This ponding action allows suspended particles to settle out on the uphill side of the fence. Particles are not removed by filtering the runoff through the fabric.

2. Purpose.

Used to control sheet flow runoff from disturbed land, silt fencing may also be used to create a sediment trap for removal of suspended particles from low volume concentrated flows. The removal efficiency of silt fencing depends mainly on the detention time of the runoff behind the control. The detention time is controlled by the geometry of the upstream pond, hydraulic properties of the fabric, and maintenance of the control (Barrett et al., 1998).

3. Conditions Where Practice Applies.

Silt fence is used during the period of construction near the perimeter of a disturbed area to intercept sediment. This fence shall remain in place until the disturbed area is permanently stabilized. Silt fence should not be used where there is a concentration of water in a channel or drainage way or where soil conditions prevent a minimum toe-in depth of six (6) inches or installation of support post to a minimum depth of 12 inches. If concentrated flow occurs after installation, corrective action must be taken such as placing rock berms in the areas of concentrated flow.

4. Design Criteria.

Silt fence is typically constructed near the perimeter of a disturbed site within the developing area. It is not to be constructed outside the property lines without obtaining a legal easement from the affected adjacent property owners.

The following criteria shall be observed:

(i) Drainage Area - Consult Table 1.4.5.G.1 for maximum drainage area allowed for a specific slope category. If the drainage area to the silt fence exceeds this value, additional silt fence should be installed to break up the runoff into multiple storage areas.

(1) Height – 24-inch minimum height measured from the existing of graded ground. For Design purposes use the following criteria:

(2) Assume a construction Total Suspended Solids (TSS) concentration = 3000 mg/L.

(3) Use a target removal of sediment particle equal to or greater than diameter (d) = 20 microns.

(4) Use the Influent Particle size distribution of the solids suspended in runoff shown in Figure 1.4.5.g (Barrett et al, 1998)

(ii) Overland flow:

(1) General guidelines. Silt fence for sediment and slope control should be installed along the contour of the slope (i.e. the entire length should be at the same elevation). The maximum drainage area to the silt fence should not exceed those shown on Table 1.4.5.G.1. The spacing criterion is based on the maximum drainage area, in square feet, above a 100 feet wide section of silt fencing. 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. This limits the impact if a failure occurs, and prevents large volumes of water from accumulating and flowing to one end of the installation, which may cause damage to the fence.

(2) Sediment control. When used for sediment control, silt fence should be located to provide the storage volume behind the fence that will contain the runoff from the 2 year storm. Table 1.4.5.G.1 provides the spacing on uniform slopes necessary to achieve this storage volume. If the designer proposed an alternative configuration, it must be demonstrated that 2 year storm runoff volume is contained and released in a manner such that the effluent concentration does not exceed effluent standards of City of Bee Cave Code Article 7 as well as the baseline TSS conditions in ECM **1.6.9.3** Table 1-10. The design presumptions are stated above.

Larger storage volumes increase the sediment removal efficiency of the silt fence, and decrease the required replacement/clean-out intervals.

A common location to place silt fence for sediment control is at the toe of a slope. When used for this application, the silt fence should be located at least five (5) feet from the toe of the slope to ensure that a large storage volume is available for runoff and sediment.

For sediment control applications, the maximum drainage area to the silt fence should not exceed those shown on Table 1.4.5.G.1. If the contributing area exceeds this value, additional silt fence should be installed to break up the runoff into multiple storage areas. When used as a velocity control measure for sheet flow on long slopes of disturbed ground, silt fence should be placed at the spacing interval and not exceed the drainage area to the fence stated in the table below:

(3) Slope control. Silt fence can be installed on a slope to reduce the effective slope length and limit the velocity of runoff flowing down the slope (see Table 1.4.5.G.1). Silt fence also helps prevent concentrated flows from developing, which can cause rill and gully erosion. As a secondary benefit, silt fence installed on slopes can remove suspended sediment from runoff that results from any erosion that has occurred. For slopes that receive runoff from above, a silt fence should be placed at the top of the slope to control the velocity of the flow running onto the slope, and to spread the runoff out into sheet flow.

Table 1.4.5.G.1: Maximum spacing between silt fences on slopes		
Slope	**Spacing Interval (ft)**	**Max. Drainage Area (sf)**
100:1 to 50:1 (1-2%)	500	25,000
50:1 to 30:1 (2-3.3%)	250	15,000
30:1 to 25:1 (3.3-4%)	150	12,000

25:1 to 20:1 (4-5%)	120	10,000
20:1 to 10:1 (5-10%)	100	5,000
10:1 to 5:1 (10-20%)	50	2,500
5:1 to 2:1 (20-50%)	10	1,000

(4) Perimeter control. Silt fence is commonly used as a perimeter control along streets or adjacent to water bodies to prevent polluted water from leaving the site. When a diversion or perimeter control silt fence is installed in the direction of a slope, a 20-foot length of fence should be turned in, across the slope, at regular intervals (100 feet) to create a "J"-hook (see "J" hook detail).

These "J"-hooks act as check dams, controlling the velocity of the diverted runoff as it travels along the fence.

(iii) Concentrated flow. Not allowed

(iv) Diversion. Silt fence can also be utilized as a synthetic diversion structure to redirect clean water around a site and intercept sediment-laden runoff and transport it to a sediment removal practice. Must demonstrate additional BMPs designed to prevent rill/gully erosion due to concentrated flow along the perimeter of the silt fence.

5. Materials Specifications.

See City of Austin Standard Specifications 642S for material specification and installation details.

6. Troubleshooting

- Inspect BMPs prior to forecast rain, daily during extended rain events, after rain events, weekly during the rainy season, and at two-week intervals during the non-rainy season.
- Repair undercut silt fences.
- Repair or replace split, torn, slumping, or weathered fabric. The lifespan of silt fence fabric is generally 5 to 8 months.
- Silt fences that are damaged and become unsuitable for the intended purpose should be removed from the site of work, disposed of, and replaced with new silt fence barriers.
- Sediment that accumulates in the silt fence must be periodically removed in order to maintain silt fence effectiveness. Sediment should be removed when the sediment accumulation reaches approximately one-half of the fence height (one foot) on the silt fence. Sediment removed during maintenance may be incorporated into earthwork on the site or disposed at an appropriate location. Upon removal of silt fence, accumulated sediment must also be removed and disposed of properly.
- Silt fences should be left in place until the upstream area is permanently stabilized. Until then, the silt fence must be inspected and maintained.
- Holes, depressions, or other ground disturbance caused by the removal of the silt fences should be backfilled and repaired.

Figure 1.4.5.G Influent Particle Size Distribution of the Suspended Solids in Runoff.

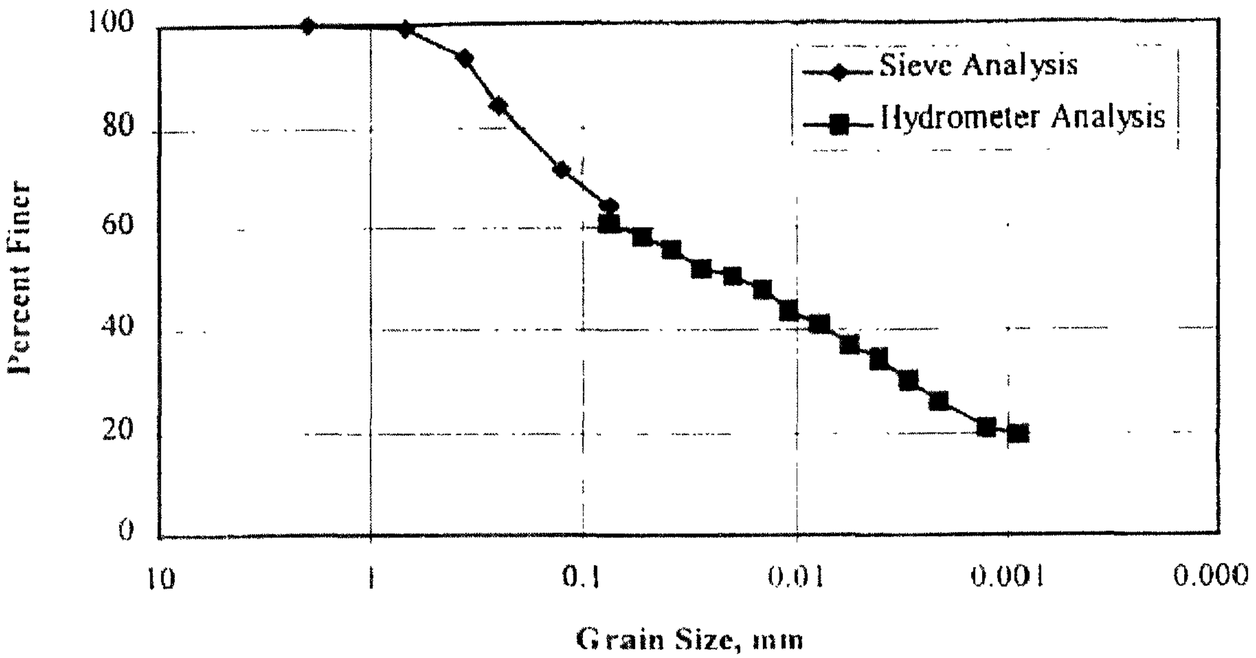


Figure 1.4.5.G.1 Silt Fence Installation

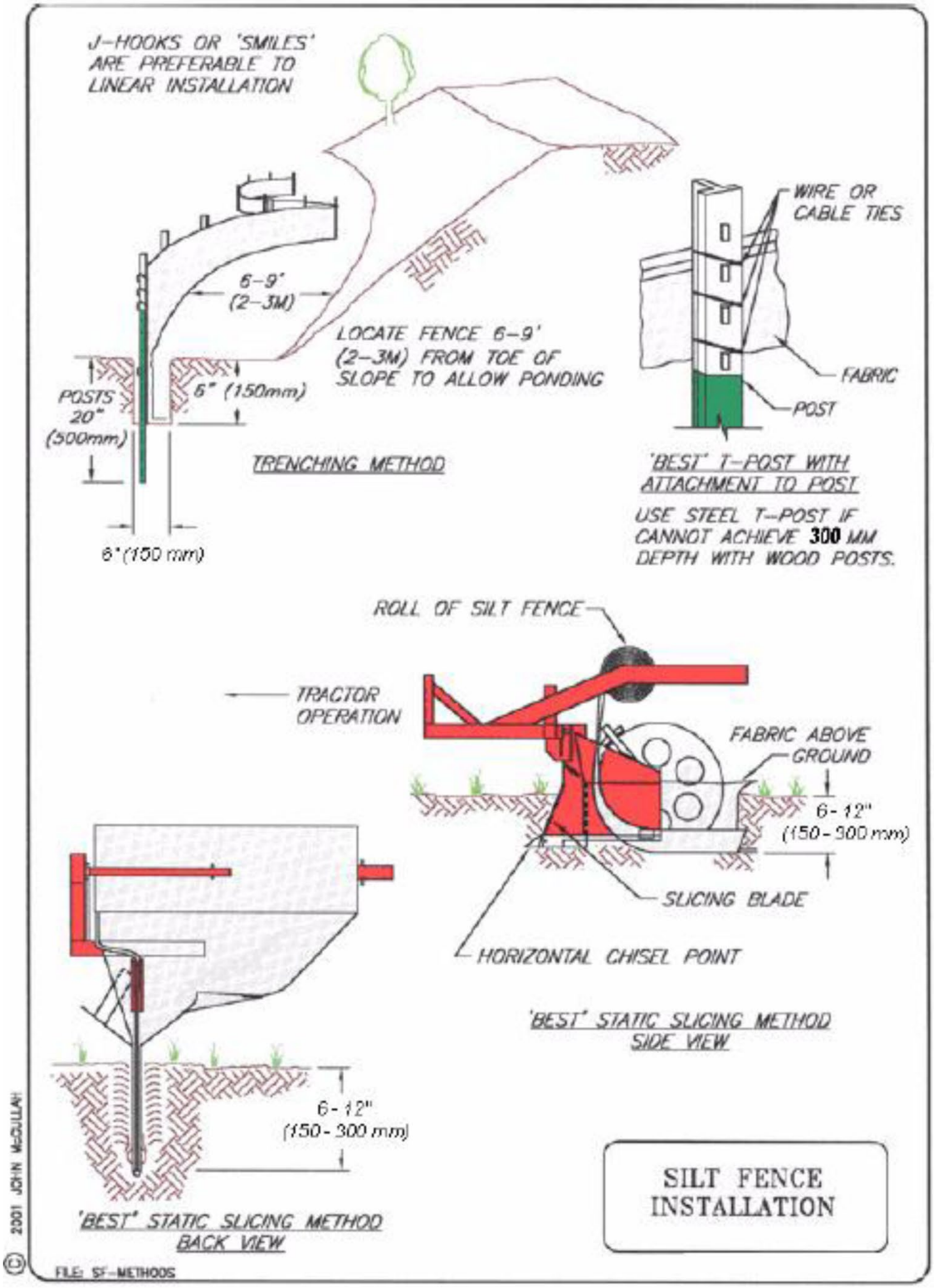


Figure 1.4.5.G.2 Silt Fence Placement — One Slope

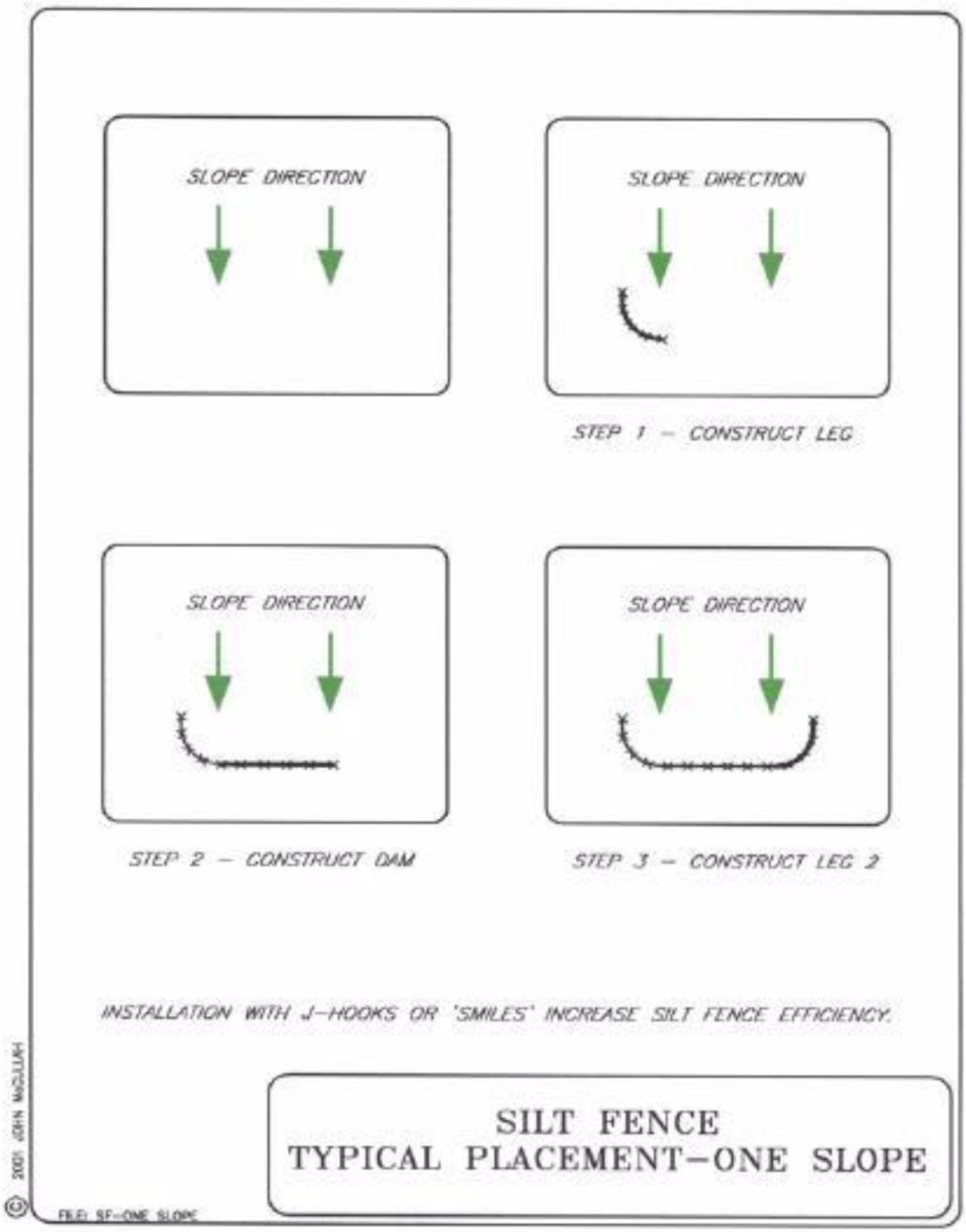


Figure 1.4.5.G.3 Silt Fence Placement for Perimeter Control

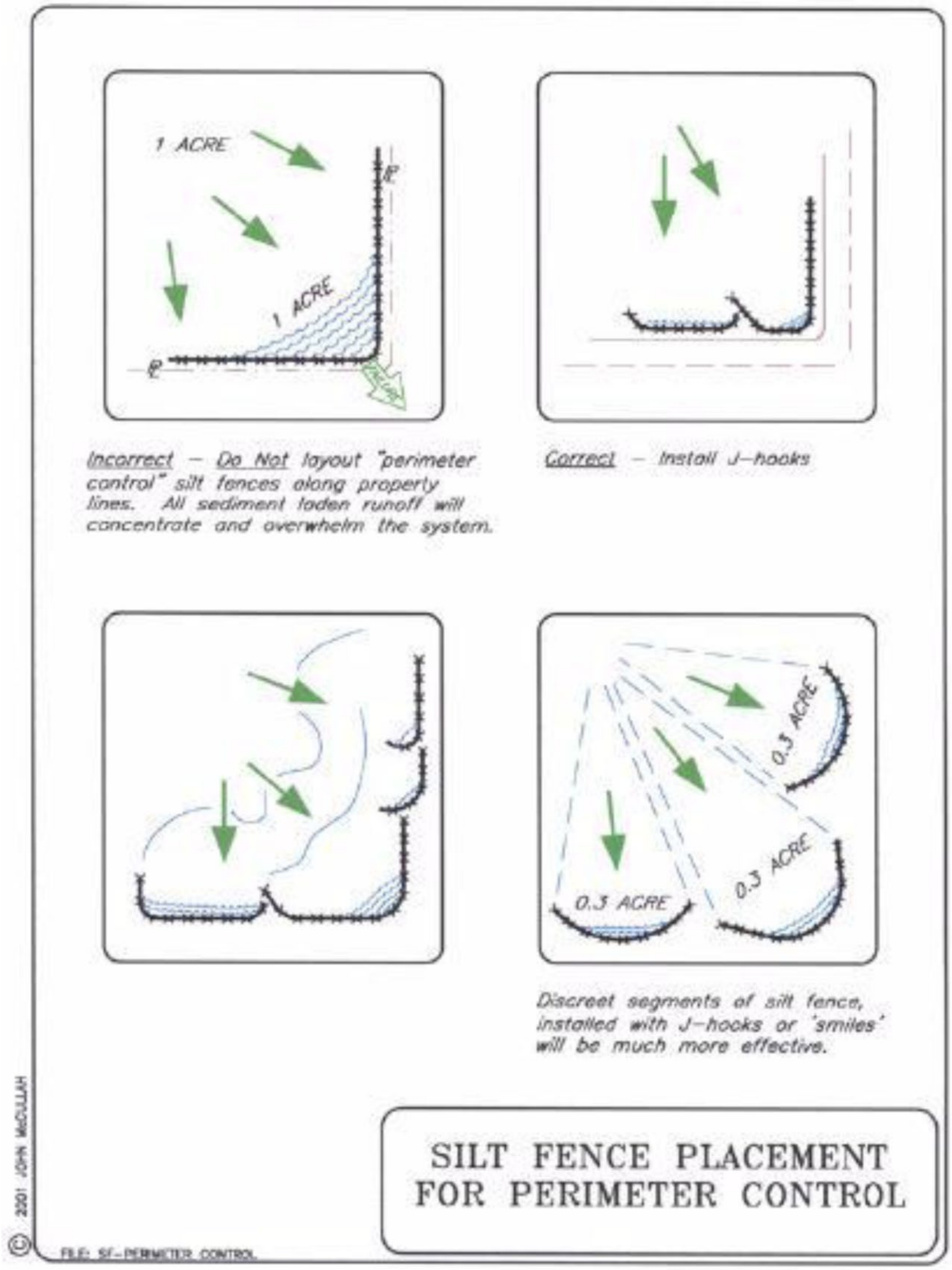
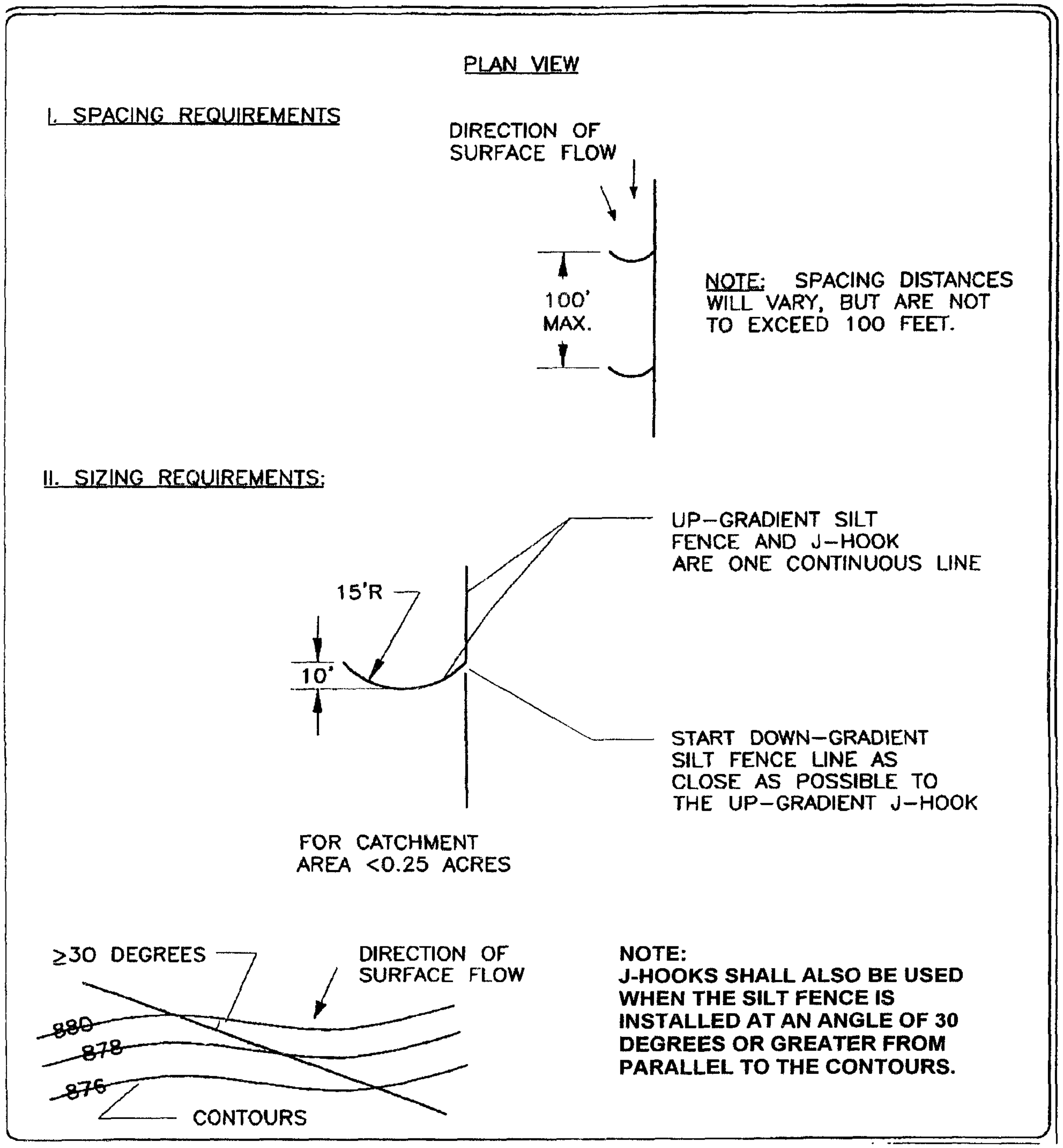


Figure 1.4.5.G.4 Silt Fence J - Hook Detail



H. Triangular Sediment Filter Dikes. (See City of Austin Standard Specifications manual item 648S and Standards manual item 648S for detail)

1. Description.

   A temporary barrier constructed of wire mesh and geotextile fabric, installed along a flat area.

2. Purpose.

The purpose of a triangular sediment filter dike is to intercept and detain water-borne sediment from a stabilized construction entrance, roadway utility work, small utility repairs, underground storage tank removals, or minor redevelopment projects.

3. Conditions Where Practice Applies.

The triangle sediment filter dike is used where:

(1) There is no concentration of water in a channel or other drainage way above the barrier, and

(2) If concentrated flow occurs after installation, corrective action must be taken such as placing rock berms in the areas of concentrated flow.

(3) Contributing drainage area is limited to sheetflow from the stabilized construction entrance. Additionally, the triangle sediment filter dike should be placed across the construction entrance(s) at the end of the day to form a continuous perimeter sedimentation control in conjunction with other approved perimeter controls.

(4) There is work within a parking lot covered with asphalt, the dike should be placed on the asphalt and the skirt weighed down with rock or a continuous wood strip nailed to the asphalt.

(5) There is roadway or small utility work. The dike should be placed to intercept stormwater prior to entering the inlet.

(6) There is underground storage tank removal or installation.

(7) There is minor redevelopment on a site and no other types of sediment control are feasible.

4. Design Criteria.

(1) See City of Austin Standard Specification 628S.

I. Hay Bale Dikes. (See City of Austin Standard Specifications manual item 628S and Standards manual item 628S-1 for detail)

1. Description.

A temporary barrier constructed with hay bales with a life expectancy of two (2) months or less.

2. Purpose.

The purpose of a hay bale dike is to intercept and detain small amounts of sediment from unprotected areas of limited extent. The use of this type of sediment control is only acceptable for above ground and underground storage tank construction or removal projects.

3. Conditions Where Practice Applies. The hay bale dike is used where:

(1) No other practice is feasible, and

(2) There is no concentration of water in a channel or other drainage way above the barrier and

(3) If concentrated flow occurs after installation, corrective action must be taken such as placing rock berms in the areas of concentrated flow.

(4) Construction activities and revegetation will be completed in three (3) months or less.

(5) Contributing drainage area is less than 2,500 square feet.

4. Design Criteria.

A design is not required. The following criteria shall be observed:

All bale dikes shall be placed on the contour. Bales shall be embedded a minimum of four (4) inches and securely anchored using 3/8-inch diameter rebar stakes driven through the bales. Bales that are not able to be imbedded and are place on impervious cover should be placed level with the concrete and have all bales butted end to end with no voids or gaps between them. Bales shall be bound by either wire or nylon string. Jute or cotton binding is unacceptable. Bales shall be replaced every two (2) months or more often during wet weather when loss of structural integrity is accelerated.

J. Mulch Berm (See City of Austin Standard Specifications manual item 647S and Standards manual 647S-1 for details)

1. Description.

Mulch Berm is a temporary sedimentation control made of wood mulch, wood chips, or other organic material used to intercept sheet flow and pond runoff. Mulch berms provide a three-dimensional filter that retains sediment and other pollutants (e.g., suspended solids) while allowing the cleaned water to flow through the berm. Mulch berms can be used in place of traditional sediment controls such as a silt fence or in conjunction with other approved controls.

The effectiveness of using Mulch berm as a sediment control technique depends on:

(1) The type of mulch used
(2) Mulch morphology
(3) Drainage area to section of berm
(4) Method of application: the mulch berm material can be placed mechanically or by hand.
(5) Soil type
(6) Slope
(7) Climatic characteristics
(8) Proper preparation of application area (uniform application surface to ensure optimal mulch to soil contact)

2. Materials.

Mulch berm material can be manufactured on or off the project site. It consists primarily of organic material, separated at the point of generation, and may include: shredded bark, stump grindings, or composted bark

The mulch berm shall have the following composition:

(1) Use untreated wood chips less than or equal to 5 inches in length with 95% passing a 2-inch screen and less than 30% passing a 1-inch screen (TXDOT Special Specification 1011, Mulch Filter Berm).
(2) Large portions of silts, clays, or fine sands are not acceptable in the mix.

Mulch berm material is composed of a mixture of particle sizes and may contain rocks less than 2 inches in diameter. Mulch berm material must be free of refuse, physical contaminants, and material toxic to plant growth. It is not acceptable for the mulch berm material to contain ground construction debris, biosolids, or manure.

Prior to placement a representative sample of the mulch berm material must be accepted by the project engineer or his/her designee and by the city inspector.

3. Installation.

(1) A Mulch Berm is not allowed on 2:1 slopes or steeper.
(2) Mulch Berm maximum slope spacing criteria must be followed (see Table 1.4.5.J.1) The spacing criterion is based on the maximum drainage area, in square feet, above a 100 feet wide section of mulch berm.

(3) Mulch Berms should be a minimum 24 inches high and 36 inches wide. (Figure 1.4.5.J).

(4) Mulch Berms should be installed parallel to the base of the slope or the other affected area. For best filtration, a mulch berm should be placed on the level contour of a slope so that flows are dissipated into uniform sheet flow which has little energy for transporting sediment (see section 1.4.5.G., Silt Fence for proper placement).

(5) The mulch may be placed with a hydraulic bucket, a pneumatic blower, or by hand.

(6) When a diversion or perimeter control mulch berm is installed in the direction of a slope, a 20-foot length of berm should be turned in, across the slope, at regular intervals (See Table 1.4.5.J.1 spacing criteria) to create a "J"-hook (see ECM 1.4.5.G, Silt Fence "J" hook detail). These "J"-hooks act as check dams, controlling the velocity of the diverted runoff as it travels along the berm.

4. Where a mulch berm is not allowed as a sediment control:

(1) On slopes with groundwater seepage;

(2) In concentrated flow situations or in runoff channels;

(3) On slopes equal to or steeper than 2:1;

(4) At the bottom of steep perimeter slopes exceeding 100 feet in length (large up-gradient watershed);

(5) Below culvert outlet aprons, and

(6) Around catch basins and closed storm system outlets.

(7) Within a stormwater control structure.

5. Inspection and Maintenance.

(1) Inspect every 7-days and within 24-hours of a rainfall event of 0.5-inches or greater event and replace or repair if necessary.

(2) Sediments collected at the base shall be removed when they reach 1/3 of the exposed height of the mulch berm.

(3) Vegetation adds stability and should be promoted.

(4) If the mulch is not removed prior to revegetation, it should be spread out into the landscape to a depth that will not prevent seed germination and encourage effective revegetation of the site.

References:

1. City of Austin, Mabel Davis Park Site Remediation, Standard Technical Specifications, Compost/Mulch Filter Berm - Section 02273 (2004), Volume 2

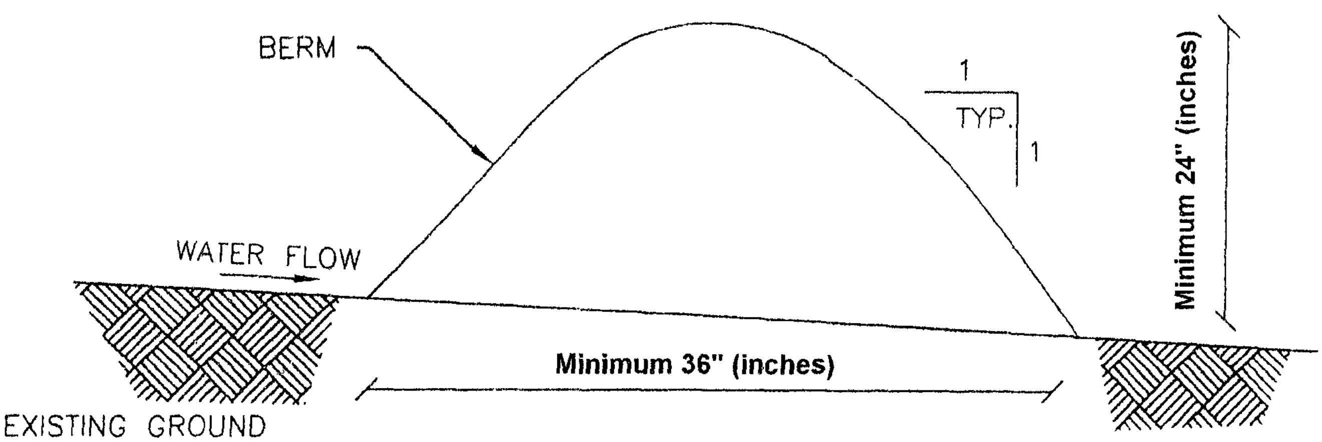
2. Storey, et al. (2006), Water Quality Characteristics and Performance of Compost Filter Berms, Report 0-4572-1, Texas Department of Transportation

3. Demars, and Long (2001), Performance Specifications for Wood Waste Materials as an Erosion Control Mulch and as a Filter Berm, NETCR 25

TABLE 1.4.5.J.1. Maximum Spacing Between Mulch Berms On Slopes

Slope	Spacing Interval (ft)	Max. Drainage Area (sf) per 100 ft of Berm
100:1 to 50:1 (1-2%)	100	10,000
50:1 to 30:1 (2-3.3%)	75	7,500
30:1 to 25:1 (3.3-4%)	65	6,500
25:1 to 20:1 (4-5%)	50	4,800
20:1 to 10:1 (5-10%)	25	2,600
10:1 to 5:1 (10-20%)	15	1,300
5:1 to 2:1 (20-50%)	10	1,000

Figure 1.4.5.J Typical Mulch Berm



K. Sediment Basin.

1. Definition

An earthen embankment suitably located to capture runoff, with a trapezoidal spillway lined with an impermeable geotextile or laminated plastic membrane, and equipped with a floating skimmer for dewatering.

2. Purpose

Sediment basins are designed to provide an area for runoff to pool and settle out a portion of the sediment carried down gradient. Past designs used a perforated riser for dewatering, which allowed water to leave the basin from all depths. One way to improve the sediment capture rate is to have an outlet which dewaters the basin from the top of the water column where the water is cleanest. A skimmer is probably the most common method to dewater a sediment basin from the surface. The basic concept is that the skimmer does not dewater the basin as fast as runoff enters it, but instead allows the basin to fill and then slowly drain over hours or days. This process has two effects. First, the sediment in the runoff has more time to settle out prior to discharge. Second, a pool of water forms early in a storm event and this further increases sedimentation rates in the basin. Many of the storms will produce more volume than the typical sediment basin capacity and flow rates in excess of the skimmer capability, resulting in flow over the emergency spillway. This water is also coming from the top of the water column and has thereby been "treated" to remove sediment as much as possible. (Adapted from SoilFacts: Dewatering Sediment Basins Using Surface Outlets. N. C. State University, Soil Science Department.)

3. Conditions Where Practice Applies

Skimmer sediment basins are needed where drainage areas are too large for temporary sediment traps. Do not locate the skimmer sediment basin in intermittent or perennial streams.

4. Planning Considerations

Select locations for skimmer basins during initial site evaluation. Install skimmer sediment basins before any site grading takes place within the drainage area.

Select skimmer sediment basin sites to capture sediment from all areas that are not treated adequately by other sediment control measures. Always consider access for cleanout and disposal of the trapped sediment. Locations where a pond can be formed by constructing a low dam across a natural swale are generally preferred to sites that require excavation. Where practical, divert sediment-free runoff away from the basin.

A skimmer is a sedimentation basin dewatering control device that withdraws water from the basin's water surface, thus removing the highest quality water for delivery to the uncontrolled environment. A skimmer is shown in Figure 6.64a. By properly sizing the skimmer's control orifice, the skimmer can be made to dewater a design hydrologic event in a prescribed period. Because the spillway is actually used relatively frequently, it should be carefully stabilized using geotextiles, or rock if necessary, that can withstand the expected flows. The spillway should be placed as far from the inlet of the basin as possible to maximize sedimentation before discharge. The spillway should be located in natural groundcover to the greatest extent possible

The costs of using a skimmer system are similar, or occasionally less, than a conventional rock outlet or perforated riser. However, the basin is more efficient in removing sediment. Another advantage of the skimmer is that it can be reused on future projects. The main disadvantage of the skimmer is that it does require frequent maintenance, primarily in removing debris from the inlet.

A skimmer must dewater the basin from the top of the water surface. The rate of dewatering must be controlled. A dewatering time of 24 to 72 hours is required. Any skimmer design that dewaters from the surface at a controlled rate is acceptable.

Figure 1.4.5.K.1 Schematic of a Skimmer

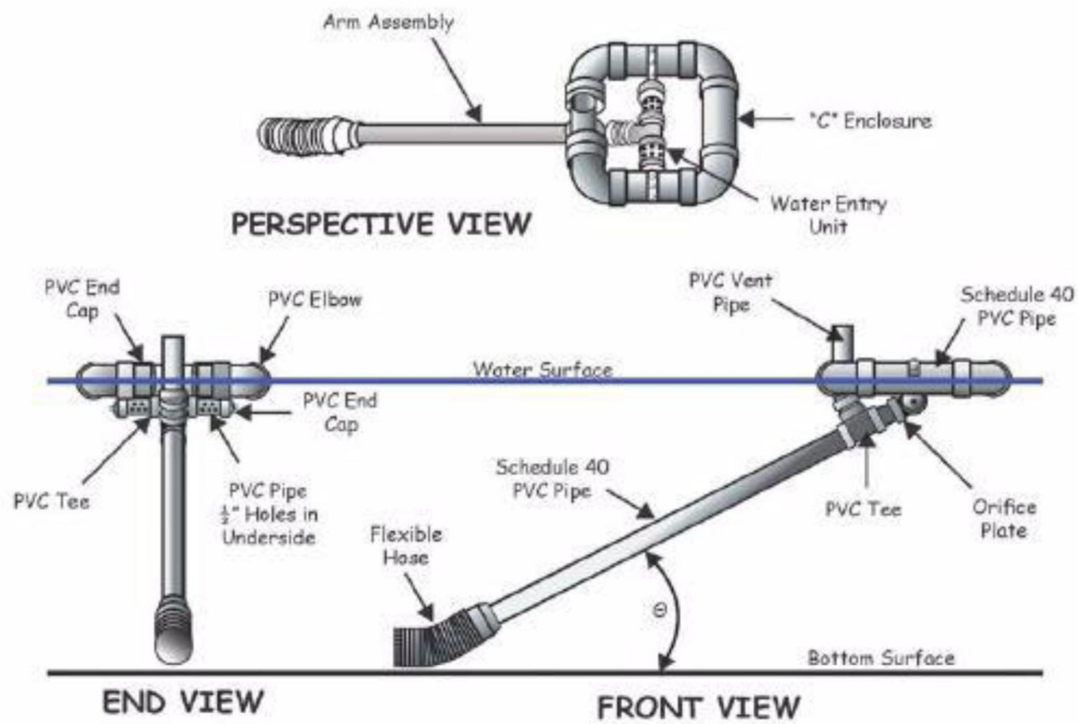


Figure 6.64a Schematic of a skimmer, from Pennsylvania Erosion and Sediment Pollution Control Manual, March, 2000.

5. Skimmer Orifice Diameter

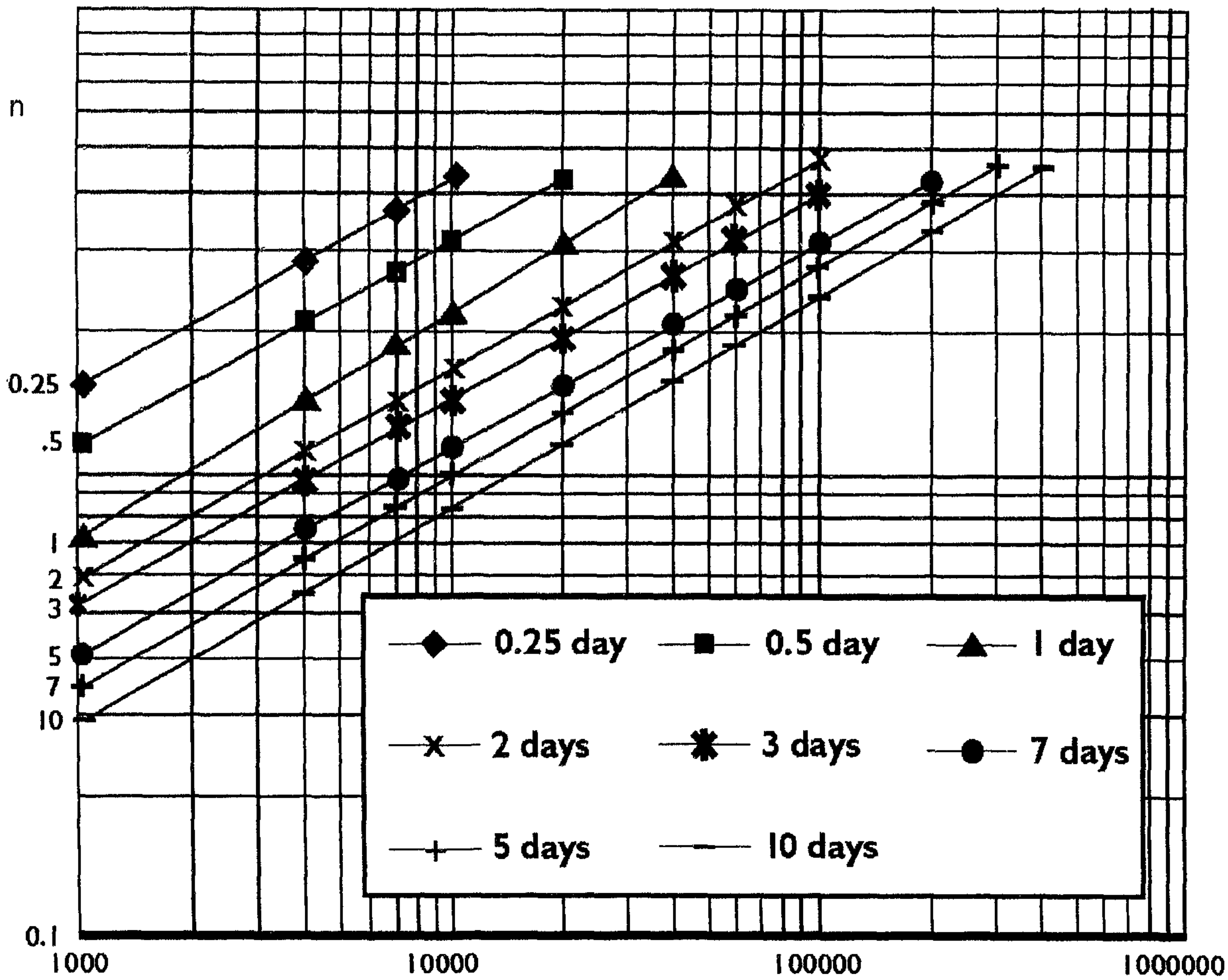
   In order to streamline the orifice sizing procedure, Figure 6.64b, may be used. This design chart assumes the designer knows or has determined the sedimentation basin's water storage volume in cubic feet and the desired dewatering time (in days) for the basin under consideration. The skimmer orifice size (in inches) can be read by entering Figure 6.64b from the x-axis with the basin's water storage volume (in cubic feet), moving vertically to the line that represents the basin's desired dewatering time (in days), then moving to the left to the y-axis.

6. Design Example

   Example: The design professional in charge of designing the sedimentation basin for a 10-acre construction site desires to use a skimmer to control dewatering of a sedimentation basin. The sedimentation basin for a 10-acre disturbed area requires a water storage volume of 18,000 cubic feet. The desired dewatering time is 1-3 days.

   Solution: Using the water storage volume of 18,000 cubic feet and the 1-3 day dewatering time on Figure 6.64b, a 2-inch orifice diameter is required. (Adapted from Proper Sizing of the Control Orifice for the Faircloth Skimmer. Pennsylvania State University Department of Agricultural and Biological Engineering Fact Sheet #252.)

Figure 6.64b Skimmer orifice diameter as a function of the basin volume and basin dewatering time. Rev. 6/06



6.64.3 Table 1.4-D Skimmer Design Criteria.

Summary:	Skimmer Sediment Basin
Primary Spillway:	Trapezoidal spillway with impermeable membrane
Maximum Drainage Area:	10 Acres
Minimum Volume:	1,800 cubic feet per acre of disturbed area
Minimum Surface Area:	325 square feet per cfs of Q10 peak inflow

Minimum L/W Ratio	2:1
Maximum L/W Ratio:	6:1
Minimum Depth:	2 feet
Dewatering Mechanism	Skimmer
Minimum Dewatering Time:	24 hours
Baffles Required:	3 baffles

7. Design Considerations

Drainage areas—Limit drainage areas to 10 acres.

Design basin life—Ensure a design basin life of 3 years or less. Dam height—Limit dam height to 5 feet.

Basin locations—Select areas that:

(1) Provide capacity for storage of sediment from as much of the planned disturbed area as practical;
(2) Exclude runoff from undisturbed areas where practical;
(3) Provide access for sediment removal throughout the life of the project;
(4) Interfere minimally with construction activities.

Basin shape—Ensure that the flow length to basin width ratio is at least 2:1 to improve trapping efficiency. Length is measured at the elevation of the principal spillway.

Storage volume—Ensure that the sediment storage volume of the basin, as measured to the elevation of the crest of the principal spillway, is at least 1,800 cubic feet per acre for the disturbed area draining into the basin (1,800 cubic feet is equivalent to half an inch of sediment per acre of basin disturbed area).

Remove sediment from the basin when approximately one-half of the storage volume has been filled.

Spillway capacity—The spillway system must carry the peak runoff from the 10-year storm with a minimum 1 foot of freeboard in the spillway. Base runoff computations on the disturbed soil cover conditions expected during the effective life of the structure.

Sediment cleanout elevation—Determine the elevation at which the invert of the basin would be half-full. This elevation should also be marked in the field with a permanent stake set at this ground elevation (not the top of the stake).

Basin dewatering—The basin should be provided with a surface outlet. A floating skimmer should be attached to a Schedule 40 PVC barrel pipe of the same diameter as the skimmer arm. The orifice in the skimmer will control the rate of dewatering. The skimmer should be sized to dewater the basin in 24-72 hours (1-3 days).

Outlet Protection—Discharge velocities must be within allowable limits for the receiving stream (References: Outlet Protection).

Basin spillway—Construct the entire flow area of the spillway in undisturbed soil if possible. Make the cross section trapezoidal with side slopes of 3:1 or flatter.

(1) Capacity—The minimum design capacity of the spillway must be the peak rate of runoff from the 10-year storm. Maximum depth of flow during the peak runoff should be 6 inches. In no case should the freeboard of the spillway be less than 1 foot above the design depth of flow.

(2) Velocity—Ensure that the velocity of flow discharged from the basin is nonerosive for the existing conditions. When velocities exceed that allowable for the receiving areas, provide outlet protection (References: Outlet Protection).

Embankment—Ensure that embankments for skimmer sediment basins do not exceed 5 feet in height (measured at the center line from the original ground surface to the top of the embankment). Keep the crest of the spillway outlet a minimum of 1.5 feet below the top of the embankment. Additional freeboard may be added to the embankment height which allows flow through a designated bypass location. Construct embankments with a minimum top width of 5 feet and side slopes of 2:1 or flatter. Machine compact the embankments.

Excavation—Where sediment pools are formed or enlarged by excavation, keep side slopes at 2:1 or flatter for safety.

Erosion protection—Stabilize all areas disturbed by construction (except the lower half of the sediment pool) by suitable means immediately after completing the basin (References: Surface Stabilization).

Trap efficiency—Improve sediment basin trapping efficiency by employing the following considerations in the basin design:

(1) Surface area—In the design of the settling pond, allow the largest surface area possible.

(2) Length—Maximize the length-to-width ratio of the basin to prevent short circuiting, and ensure use of the entire design settling area.

(3) Baffles—Provide a minimum of three porous baffles to evenly distribute flow across the basin and reduce turbulence.

(4) Inlets—Area between the sediment inlets and the basin should be stabilized by geotextile material, with or without rocks (Figure 6.64c shows the area with rocks). The inlet to basin should be located the greatest distance possible from the principal spillway.

(5) Dewatering—Allow the maximum reasonable detention period before the basin is completely dewatered (at least 24 hours).

(6) Inflow rate—Reduce the inflow velocity and divert all sediment-free runoff.

Figure 6.64c Example Of A Sediment Basin With A Skimmer Outlet And Emergency Spillway. From Pennsylvania Erosion And Sediment Pollution Control Manual, March, 2000.

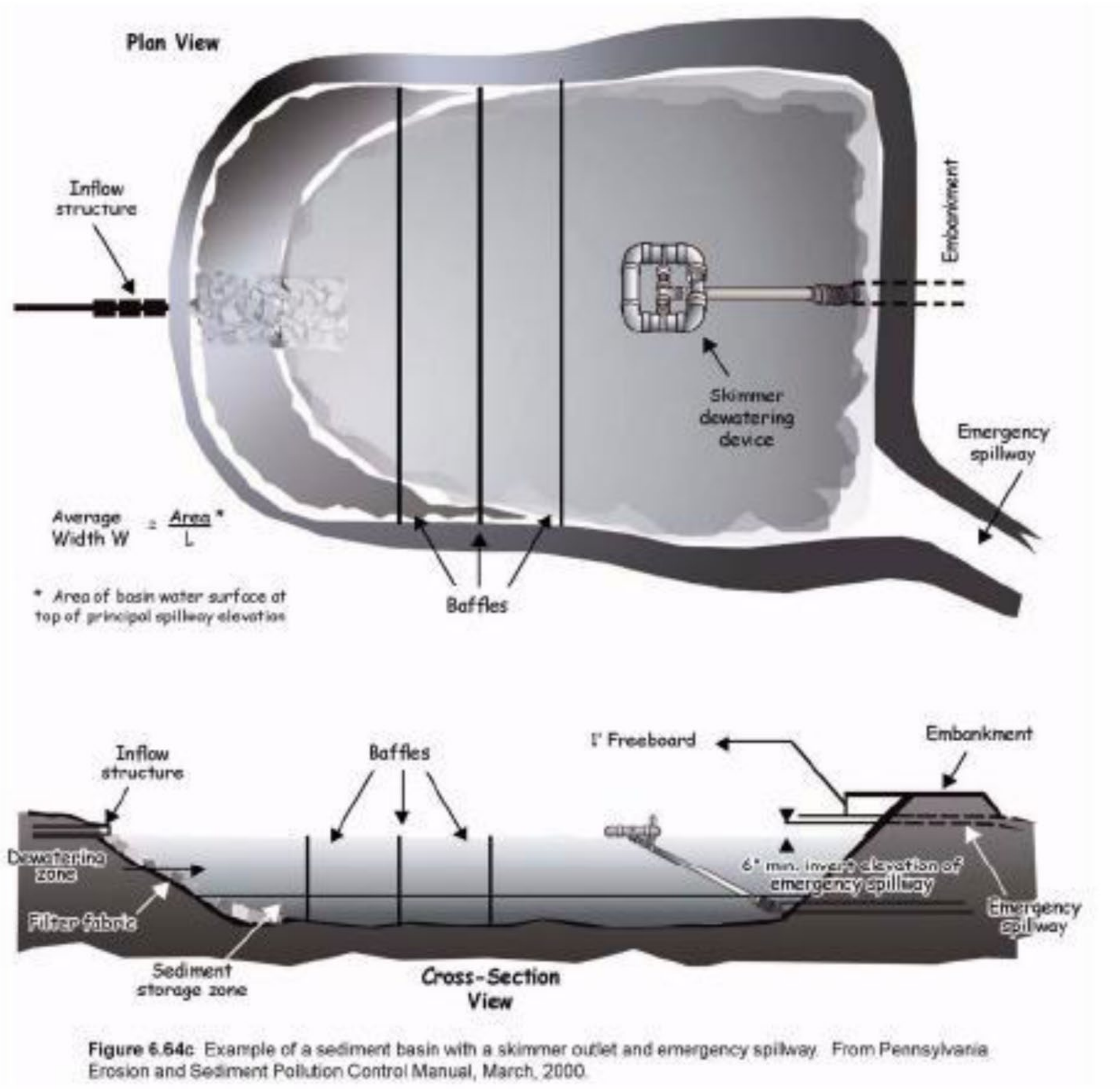


Figure 6.64c Example of a sediment basin with a skimmer outlet and emergency spillway. From Pennsylvania Erosion and Sediment Pollution Control Manual, March, 2000.

8. Construction Specifications

   (i) Clear, grub, and strip the area under the embankment of all vegetation and root mat. Remove all surface soil containing high amounts of organic matter and stockpile or dispose of it properly. Haul all objectionable material to the designated disposal area. Place temporary sediment control measures below basin as needed

(ii) Ensure that fill material for the embankment is free of roots, woody vegetation, organic matter, and other objectionable material. Place the fill in lifts not to exceed 9 inches, and machine compact it. Over fill the embankment 6 inches to allow for settlement.

(iii) Shape the basin to the specified dimensions. Prevent the skimming device from settling into the mud by excavating a shallow pit under the skimmer or providing a low support under the skimmer of stone or timber.

(iv) Place the barrel (typically 4-inch Schedule 40 PVC pipe) on a firm, smooth foundation of impervious soil. Do not use pervious material such as sand, gravel, or crushed stone as backfill around the pipe. Place the fill material around the pipe spillway in 4-inch layers and compact it under and around the pipe to at least the same density as the adjacent embankment. Care must be taken not to raise the pipe from the firm contact with its foundation when compacting under the pipe haunches. Place a minimum depth of 2 feet of compacted backfill over the pipe spillway before crossing it with construction equipment. In no case should the pipe conduit be installed by cutting a trench through the dam after the embankment is complete.

(v) Assemble the skimmer following the manufacturer's instructions, or as designed.

(vi) Lay the assembled skimmer on the bottom of the basin with the flexible joint at the inlet of the barrel pipe. Attach the flexible joint to the barrel pipe and position the skimmer over the excavated pit or support. Be sure to attach a rope to the skimmer and anchor it to the side of the basin. This will be used to pull the skimmer to the side for maintenance.

(vii) Earthen spillways—Install the spillway in undisturbed soil to the greatest extent possible. The achievement of planned elevations, grade, design width, and entrance and exit channel slopes are critical to the successful operation of the spillway. The spillway should be lined with laminated plastic or impermeable geotextile fabric. The fabric must be wide and long enough to cover the bottom and sides and extend onto the top of the dam for anchoring in a trench. The edges may be secured with 8-inch staples or pins. The fabric must be long enough to extend down the slope and exit onto stable ground. The width of the fabric must be one piece, not joined or spliced; otherwise water can get under the fabric. If the length of the fabric is insufficient for the entire length of the spillway, multiple sections, spanning the complete width, may be used. The upper section(s) should overlap the lower section(s) so that water cannot flow under the fabric. Secure the upper edge and sides of the fabric in a trench with staples or pins. (Adapted from "A Manual for Designing, Installing and Maintaining Skimmer Sediment Basins." February, 1999. J. W. Faircloth & Son.).

(viii) Inlets—Discharge water into the basin in a manner to prevent erosion. Use temporary slope drains or diversions with outlet protection to divert sediment-laden water to the upper end of the pool area to improve basin trap efficiency (References: Runoff Control Measures and Outlet Protection).

(ix) Erosion control—Construct the structure so that the disturbed area is minimized. Divert surface water away from bare areas. Complete the embankment before the area is cleared. Stabilize the emergency spillway embankment and all other disturbed areas above the crest of the principal spillway immediately after construction (References: Surface Stabilization).

(x) Install porous baffles as specified in Practice 6.65, Porous Baffles.

(xi) After all the sediment-producing areas have been permanently stabilized, remove the structure and all the unstable sediment. Smooth the area to blend with the adjoining areas and stabilize properly (References: Surface Stabilization).

Reference

Jarrett, A. R. Proper Sizing of the Control Orifice for the Faircloth Skimmer. Pennsylvania State University Department of Agricultural and Biological Engineering Fact Sheet #252. **http://www.age.psu.edu/extension/factsheets/f/F252.pdf**

Jarrett, A. R. Controlling the Dewatering of Sedimentation Basins. Pennsylvania State University Department of Agricultural and Biological Engineering Fact Sheet #253.

http://www.age.psu.edu/extension/factsheets/f/F253.pdf

Erosion and Sediment Pollution Control Manual, March, 2000. Commonwealth of Pennsylvania Dept. of Environmental Protection, Office of Water Management, Document #363-2134-008.

http://www.co.centre.pa.us/conservation/esmanual.pdf

McLaughlin, Richard. SoilFacts: Dewatering Sediment Basins Using Surface Outlets. N. C. State University, Soil Science Department.

A Manual for Designing, Installing and Maintaining Skimmer Sediment Basins. February, 1999. J. W. Faircloth & Son.

9. Maintenance

Inspect skimmer sediment basins at least weekly and after each significant (one-half inch or greater) rainfall event and repair immediately. Remove sediment and restore the basin to its original dimensions when sediment accumulates to one- half the height of the first baffle. Pull the skimmer to one side so that the sediment underneath it can be excavated.

Excavate the sediment from the entire basin, not just around the skimmer or the first cell. Make sure vegetation growing in the bottom of the basin does not hold down the skimmer.

Repair the baffles if they are damaged. Re-anchor the baffles if water is flowing underneath or around them.

If the skimmer is clogged with trash and there is water in the basin, usually jerking on the rope will make the skimmer bob up and down and dislodge the debris and restore flow. If this does not work, pull the skimmer over to the side of the basin and remove the debris. Also check the orifice inside the skimmer to see if it is clogged; if so remove the debris.

If the skimmer arm or barrel pipe is clogged, the orifice can be removed and the obstruction cleared with a plumber's snake or by flushing with water. Be sure and replace the orifice before repositioning the skimmer.

Check the fabric lined spillway for damage and make any required repairs with fabric that spans the full width of the spillway. Check the embankment, spillways, and outlet for erosion damage, and inspect the embankment for piping and settlement. Make all necessary repairs immediately. Remove all trash and other debris from the skimmer and pool areas.

Freezing weather can result in ice forming in the basin. Some special precautions should be taken in the winter to prevent the skimmer from plugging with ice.

Sedimentation basins shall not be allowed as stand alone BMPs. Applicant must demonstrate appropriate site management practices, temporary stabilization measures, perimeter and internal controls instead of just relying on a sediment basin at the outlet of the project. Temporary sediment basins and traps are not allowed to be constructed in concentrated flow paths, draws, creeks or other drainage features exist that have contributing drainage areas greater than 40 acres.

Detention/sedimentation structures must be designed to withstand the force and velocity from a 10-year frequency storm without failing. Larger storms shall be bypassed via stabilized conveyances. Those devices that employ sedimentation must provide the storage volume for the runoff from a 2-year, 24 hour storm under compacted site conditions. The sedimentation basins must be designed such that drawdown time is 72 hours via surface skimmers. The design must include considerations for overflows to ensure that the device and its detention pool remain intact. Detention/sedimentation structures shall not be sited in natural drainage channels, draws or ravines that are directly connected to off-site drainage features like creeks, rivers, ponds or recharge features. In particular, this means that silt fences shall not be used to control concentrated or channelized flow and sedimentation basins shall not be constructed in natural draws because failures of the earthen retaining system are often catastrophic to the downstream receiving waters.

Antiseep - antiseep collars will be required when the soil conditions or length of service make piping through the backfill a possibility.

The number of collars shall be determined from the backfill conditions and the length of pipe installed.

Cutoff collars will be spaced at not more than 25 foot centers. If only one (1) is used, it should be placed not more than 25 feet from the riser. Collars and their connections to the pipe shall be watertight and located no closer than two (2) feet to a pipe joint.

(1) Emergency spillway - Emergency spillways shall be constructed so as to handle the 25-year frequency storm without damage to the structure from erosion. The emergency spillway cross section shall be trapezoidal with a minimum bottom width of ten (10) feet.

The minimum capacity of the emergency spillway shall be that required to pass the peak rate of runoff from the 25-year frequency storm, less any reduction due to flow in the riser.

Velocities - The velocity of flow in the exit channel shall not exceed maximum permissible velocities for vegetated channels. For channels with erosion protection other than vegetation, velocities shall be within the nonerosive range for the type of protection used.

Erosion protection - Erosion protection shall be provided by vegetation as prescribed in this manual.

Freeboard - Freeboard is the difference between the design high water elevation in the emergency spillway and the top of the compacted embankment. If there is no emergency spillway, it is the difference between the water surface elevation required to pass the design flow through the discharge piping and the top of the compacted embankment. The freeboard shall be at least one (1) foot.

10. Embankment Cross Section.

The minimum top width shall be three (3) feet. The side slopes shall not be steeper than 3:1.

11. Entrance of Runoff into Basin.

Points of entrance of surface runoff into excavated sediment basins shall be protected to prevent erosion. Diversions, grade stabilization structures or other water control devices shall be installed as necessary to ensure direction of runoff and protect points of entry into the basin.

12. Disposal.

The sediment shall be placed in an approved spoils disposal site.

13. Safety.

Sediment basins are attractive to children and can be very dangerous. Therefore, they shall be fenced or otherwise made inaccessible to people or animals, unless this is deemed unnecessary due to the remoteness of the site or other circumstances.

14. Information to be Submitted with Design.

Sediment basin design and construction plans submitted for review to the City of Bee Cave shall include all relevant information as required by the UDC and Engineering Technical Manuals.

The following outlines this relevant information:

(1) Specific location of basin.

(2) Plan view of dam, storage basin and emergency spillway.

(3) Cross section of dams, low-flow riser and emergency spillway; profile of emergency spillway.

(4) Details of pipe connections, riser to pipe connection, riserbase, trash rack, antivortex device and when required, antiseep collars.

(5) Runoff calculations for the two (2) year and 25-year frequency storms.

(6) Storage Computation:

- Total required.
- Total available.
- Level of sediment at which cleanout shall be required; to be stated as a distance from the riser crest to the sediment surface.
- Calculations showing design of piping and emergency spillway.
- Other information deemed necessary by the Planning & Development Department.

L. Sediment Trap. (See City of Austin Standard Specifications manual item 644S and Specifications manual item 644S-1 for detail)

1. Description.

A small temporary basin formed by excavation and/or an embankment to intercept sediment-laden runoff and to trap and retain the sediment.

2. Purpose.

The purpose of a sediment trap is to intercept sediment-laden runoff and trap the sediment in order to protect drainageways, properties and rights of way below the sediment trap from sedimentation.

3. Conditions Where Practice Applies.

A sediment trap is usually installed at points of discharge from disturbed areas.

4. Design Criteria.

If any of the design criteria presented here cannot be met, see **Section 1.4.5** K "Sediment Basin".

5. Drainage Area.

The drainage area for a sediment trap is recommended to be less than five (5) acres.

6. Location.

The sediment trap should be located to obtain the maximum storage benefit from the terrain, for ease of cleanout and disposal of the trapped sediment and to minimize interference with construction activities.

7. Trap Size.

The volume of a sediment trap as measured at the elevation of the crest of the outlet shall be at least 1800 cubic feet per acre of drainage area. The volume of the trap shall be calculated using standard mathematical procedures.

8. Trap Cleanout.

Sediment shall be removed and the trap restored to its original dimensions when the sediment has accumulated to ½ of the design depth of the trap or one (1) foot, whichever is less. Sediment removed from the trap shall be deposited in an approved spoils area and in such a manner that it will not cause additional siltation.

9. Embankment.

The embankment shall be mechanically compacted.

10. Excavation.

All excavation operations shall be carried out in such a manner that erosion and water pollution shall be minimal. Any excavated portion of sediment trap shall have 2:1 or flatter slopes.

11. Outlet.

There are two (2) types of outlets for sediment traps. Sediment traps are named according to the type of outlet. Each type has different design criteria and will be discussed separately. The outlets shall be designed, constructed and maintained in such a manner that sediment does not leave the trap and that erosion of the outlet does not occur. A trap may have several different outlets with each outlet conveying part of the flow based on the criteria below and the combined outlet capacity shall meet that criteria.

A pipe outlet sediment trap consists of a basin formed by an embankment or excavation along with an embankment. The outlet for the trap is through a perforated riser and a pipe through the embankment. The outlet pipe and riser shall be made of corrugated metal or polyvinyl chloride. The riser diameter shall be of the same or larger diameter than the pipe. The top of the embankment shall be at least 1-½ feet above the crest of the riser. The length of the riser shall be perforated to achieve a 40 hour or longer draw-down time. All pipe connections shall be watertight. The capacity of the riser shall be sufficient to handle the peak flow from the 25 year storm.

A stone outlet sediment trap consists of a basin formed by an embankment or excavation and an embankment. The outlet for the trap is over a level stone section. The stone outlet for a sediment trap differs from that for a stone outlet structure because of the intentional ponding of water behind the stone. To provide for a ponding area, a triple layer geotextile fabric wrapped stone core having a nominal diameter of one (1) foot shall be placed in the outlet structure. The core shall be covered by a minimum of six (6) inches of stone.

The minimum length (feet) of the outlet shall be equal to six (6) times the drainage area (acres). The crest of the outlet (top of stone) shall be at least one (1) foot below the top of the embankment. Unless otherwise specified, all aggregate used shall be at least three (3) inches thick and shall not exceed ½ cubic foot in volume.

Geotextile fabric specification shall be woven polypropylene, polyethylene or polyamide geotextile, minimum unit weight 4.5 ounce per square yard, mullen burst strength greater than 250 pounds per square inch, ultraviolet stability exceeding 70 percent and equivalent opening size exceeding 40.

12. Sediment Plan Details.

There is no standard symbol for a sediment trap. Each trap shall be delineated on the plans in such a manner that it will not be confused with any other features. Each trap on a plan shall have a number and the numbers shall be consecutive. The following information shall be shown for each trap in a summary table form on the same sheet that the trap is on:

(1) Type of trap;

(2) Size of outlet;

(3) Trap dimensions

(4) Embankment height and excavation depth;

(5) Drainage area.

M. Sediment Trapping Devices for Excavation Pumpage.

1. Description.

A sediment tank or a temporary pit which is constructed to trap and filter sediment from water pumped from excavated areas.

2. Purpose.

Sediment Tank - traps and retains sediment from water being pumped from excavated areas.

Sump Pit - collects water retained in excavated areas and removes sediment before the water is pumped from the site.

3. Conditions Where Practice Applies.

Sediment tanks are generally used for the period of deep excavation where space is limited.

Sump pits are constructed for collecting water during construction; particularly useful during excavation for building foundations.

4. Design Criteria.

(i) Sediment Tank.
The location of sediment tank shall be convenient for clean out and disposal of the trapped sediment and shall minimize the interference with construction activities. The size of the tank can be estimated from the following formula:

Storage (cubic foot) = 16 x pump discharge (gallons per minute).

(ii) Sump Pit.
A perforated standpipe shall be placed in the center of the pit to collect filtered water. A base of two (2) inch aggregate shall be placed in the pit to a depth of 12 inches. The pit surrounding the standpipe shall be backfilled with two (2) inch aggregate after installing the standpipe. Discharge of water pumped from the standpipe shall be conveyed to a sediment trapping device such as a rock berm, brush berm, stone outlet structure, sediment trap or sediment basin or to an area protected by any of these devices. The number of sump pits and their locations shall be determined by an engineer.

N. Stabilized Construction Entrance. (See Standard Specifications manual item 641S and Specifications manual item 641S-1 for detail)

1. Description.

A stabilized pad of crushed stone located at any point where traffic will be entering or leaving a construction site to or from a public right of way, street, alley, sidewalk or parking area.

2. Purpose.

The purpose of a stabilized construction entrance is to reduce or eliminate the tracking or flowing of sediment onto public rights of way.

3. Conditions Where Practice Applies.

   A stabilized construction entrance applies to all points of construction ingress and egress.

4. Design Criteria.

   The following design criteria shall be observed:

   (1) Stone Size - Stone size shall be four (4) to eight (8) inch or larger open graded rock.

   (2) Drainage - Entrance must be properly graded or incorporate a drainage swale to prevent runoff from leaving the construction site.

   (3) Thickness - Not less than eight (8) inches.

   (4) Width - Not less than full width of all points of ingress or egress.

   (5) Length - As required, but not less than 50 feet.

5. Maintenance.

   The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights of way. This may require periodic top dressing with additional stone as conditions demand and repair and/or clean out of any measures used to trap sediment. All sediment spilled, dropped, washed or tracked onto public rights of way must be removed immediately by contractor.

   When necessary, wheels must be cleaned to remove sediment prior to entrance onto public right of way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch or watercourse using approved methods.

O. Pipe Slope Drain. (See City of Austin Standard Specifications manual item 637S and Specifications manual item 637S-1 and 637S-2 for detail)

1. Description.

   A flexible tubing and/or rigid pipe with prefabricated entrance section temporarily placed to extend from the top of a slope to the bottom of a slope.

2. Purpose.

   The purpose of the pipe slope drain is to convey surface runoff safely down slopes without causing erosion.

3. Conditions Where Practice Applies.

   Pipe slope drains are to be used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. Recommended maximum drainage area is five (5) acres.

4. Design Criteria.

   Unless otherwise specified, pipe slope drains are to be sized as follows:

TABLE 1.4-E PIPE SLOPE DRAIN SIZES		
SIZE	PIPE/TUBING DIAMETER (D) (INCH)	MAXIMUM DRAINAGE AREA (ACRES)
PSD-12	12	.5
PSD-18	18	1.5

PSD-21	21	2.5
PSD-24	24	3.5
PSD-30	30	5.0

5. Inlet.

The height of the earth dike at the entrance to the pipe slope drain shall be equal to or greater than the diameter of the pipe (D), plus 12 inches and shall be adequate to prohibit overtopping by the 100 year storm.

6. Outlet.

Pipe slope drain shall outlet onto a riprap apron and then into a stabilized area or stable watercourse. A sediment trapping device shall be used to trap sediment from any sediment-laden water conveyed by the pipe slope drain.

P. Turbidity Curtain.

1. Definition

A turbidity curtain is a temporary fabric curtain with very low permeability, installed in a waterway or waterbody to minimize sediment transport. Turbidity curtain is installed at an angle not greater than 45 degrees parallel to the direction to flow.

2. Purpose

The purpose of this practice is to provide sediment containment while construction activities are occurring in or directly adjacent to a waterway or waterbody. Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. **http://water.epa.gov/type/rsl/monitoring/vms55.cfm**

3. Conditions Where Practice Applies

This practice applies where construction activities are located within or adjacent to a perennial waterbody. This includes but is not limited to bridge construction, utility work, stream bank restoration, shoreline modification and dredging.

DOT Type II—"Moving Water" Floating Turbidity Curtains Permeable & Impermeable, are most commonly used for water conditions typical to Austin area lakes. This is slow to medium current applications, with currents in one direction & up to 5 feet/second, such as in rivers, and large lakes with moderate to strong winds and waves.

If the current exceeds 5 feet per second, other methods to divert flow away from the turbidity curtain such as temporary concrete traffic curtains, coffer dams, pumping, or sheet piling should be considered.

4. Design Criteria

This section establishes the minimum standards for design, installation and performance requirements.

(i) Installation — Details of construction not listed in the text shall conform to the pertinent requirements of Figure 1.4.5.P.1 and Figure 1.4.5.P.2.

(1) The curtain shall be installed before construction activities are initiated. Contractor will provide notice to the Environmental inspector 48 hours prior to installation and will include in the sequence of construction when the turbidity curtain will be installed.

(2) The curtain shall remain in place and be maintained until the construction activity is completed and the disturbed area has stabilized.

(3) The ends of the curtain shall be securely anchored and keyed into the shoreline to fully enclose the area where sediment may enter the water.

(4) A turbidity curtain shall not be installed perpendicular to the direction of flow in a waterway or waterbody. Turbidity curtain shall be installed at an angle not greater than 45 degrees parallel to the direction to flow.

(5) Driven posts shall be used to hold the curtain in position. The maximum spacing between posts shall be 10 feet. When curtain height exceeds 8 feet, post spacing may need to be decreased.

(6) When bedrock prevents the installation of posts, float devices may be used. Flotation devices shall be flexible, buoyant units contained in an individual flotation sleeve or collar attached to the turbidity curtain. Use solid expanded polystyrene logs or equivalent having a 49 square inch minimum end area. Polystyrene beads or chips shall not be used as a flotation device. Buoyancy provided by the flotation devices shall be sufficient to support the weight of the turbidity curtain and maintain a freeboard of at least one-third of the flotation device cross section above the water surface. Refer to Figure 1.4.5.P.2.

(7) The curtain shall extend to the bottom of the water body when depth of water is eight feet or less. For application in waters exceeding eight feet in depth, the curtain may extend to the desired depth, however the curtain shall not be required to exceed eight feet below the water surface unless special conditions warrant otherwise. The curtain shall be weighted at the bottom (as shown in USACE Standard Detail EP 1110-01-16) to maintain the desired depth.

(8) Ballast or anchors shall be used to hold the curtain in a vertical position. Bottom load lines may consist of a chain incorporated into the bottom hem of the screen, of sufficient weight to serve as ballast to hold the screen in a vertical position. Additional anchorage shall be provided if necessary.

(9) Danger buoys shall be used as required by Coast Guard regulations for navigable waterways or City of Bee Cave permit when working in navigable waters.

(ii) Plans and Specifications — Plans and specifications for installing a turbidity curtain shall be in keeping with this standard and attached detail drawing and shall describe the requirements for applying the practice to achieve its intended purpose:

(1) Location of turbidity curtain.

(2) Material specification conforming to standard C. Plans, standard detail drawings, and specifications shall include schedule sequence or notes for installation, inspection, and maintenance. The responsible party shall be identified.

(iii) Material

(1) Components of the turbidity curtain system shall be clean and free of exotic species.

(2) Top load lines shall consist of steel cable sufficient to support the load of the turbidity curtain system.

(3) Fabric shall be selected according to the specifications in Table 1.

Table 1. Fabric Specifications for Turbidity Curtain

Requirement	Method	Value
Min. grab tensile strength	ASTM D 4632	200 lb (890 N)
Min. puncture strength	ASTM D 4833	90 lb (400 N)
Maximum permeability	ASTM D 4491	≤1×10 -7 cm/s
Min. ultraviolet stability	ASTM D 4355	70%

Source: WisDOT Spec 628.2.10.

(iv) Operation and Maintenance

(1) Turbidity curtains shall be inspected daily by Contractor and repaired/adjusted as necessary to maintain proper installation practice, compliance with site plan, and as directed by the City. Third party inspection shall be performed weekly and maintain inspection log.

(2) Turbidity curtains shall not be removed until the water contained within the curtain has equal or lower turbidity than the waterway or waterbody, or if a flood event is imminent.

(3) Care shall be taken when removing the curtain to minimize the release or re-suspension of sediment.

(4) Turbidity curtains that have been previously used in other water bodies must be properly cleaned to prevent the spread of invasive exotic species from other sites. If any materials (including turbidity curtains, bouys and chains) have been previously used, they shall be disinfected with vinegar or cleaned with hot water greater than 104 deg. F then allowed to completely dry for a minimum period of five days. If there are any questions about the occurrence of zebra mussels (Dreissena polymorpha), Giant salvinia (Salvinia molesta), or other aquatic invasive species in a waterbody that you have worked in, are working in, or intend to work in, contact the Texas Parks and Wildlife Department.

Figure 1.4.5.P.1. Type I and II Turbidity Curtain

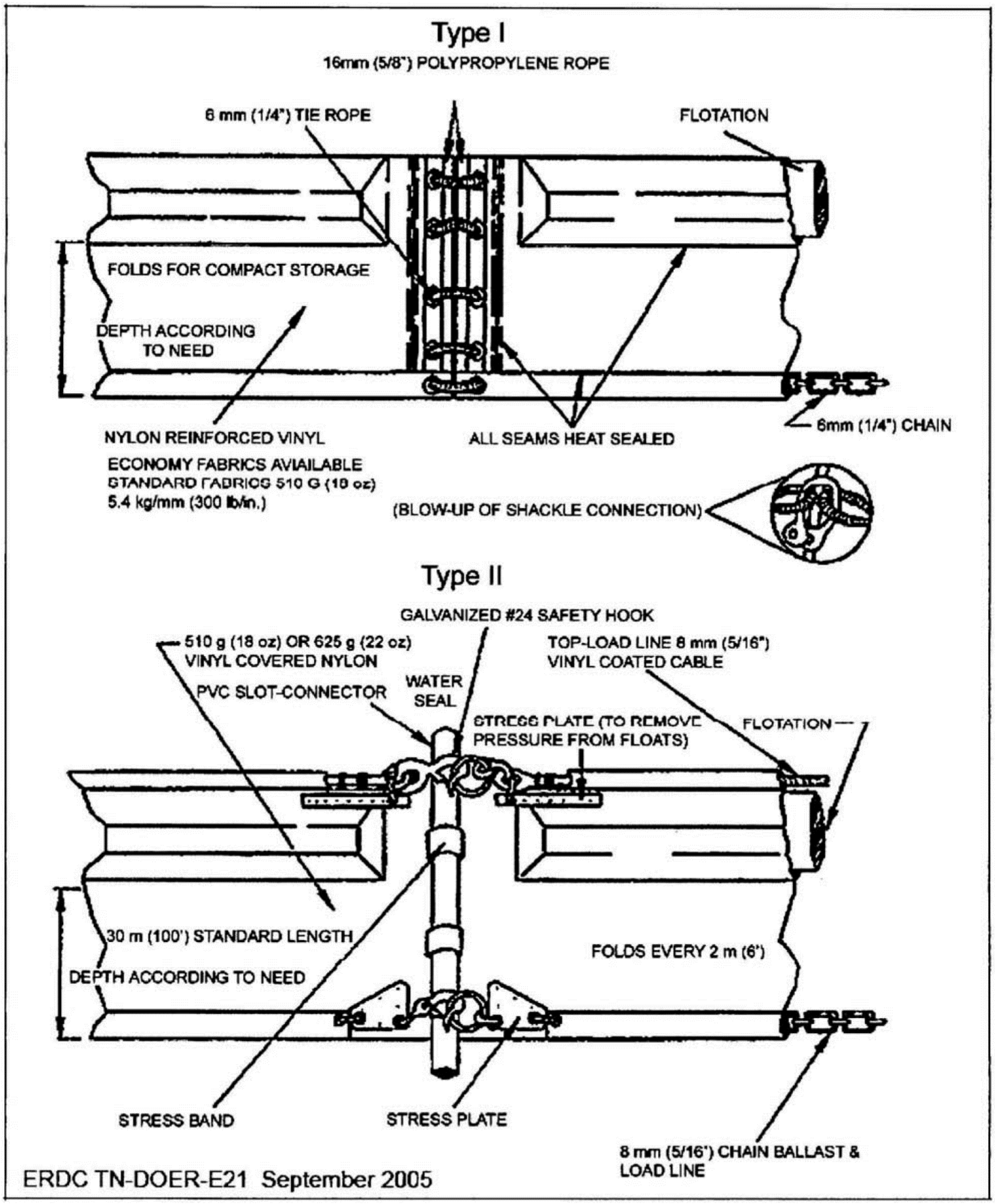
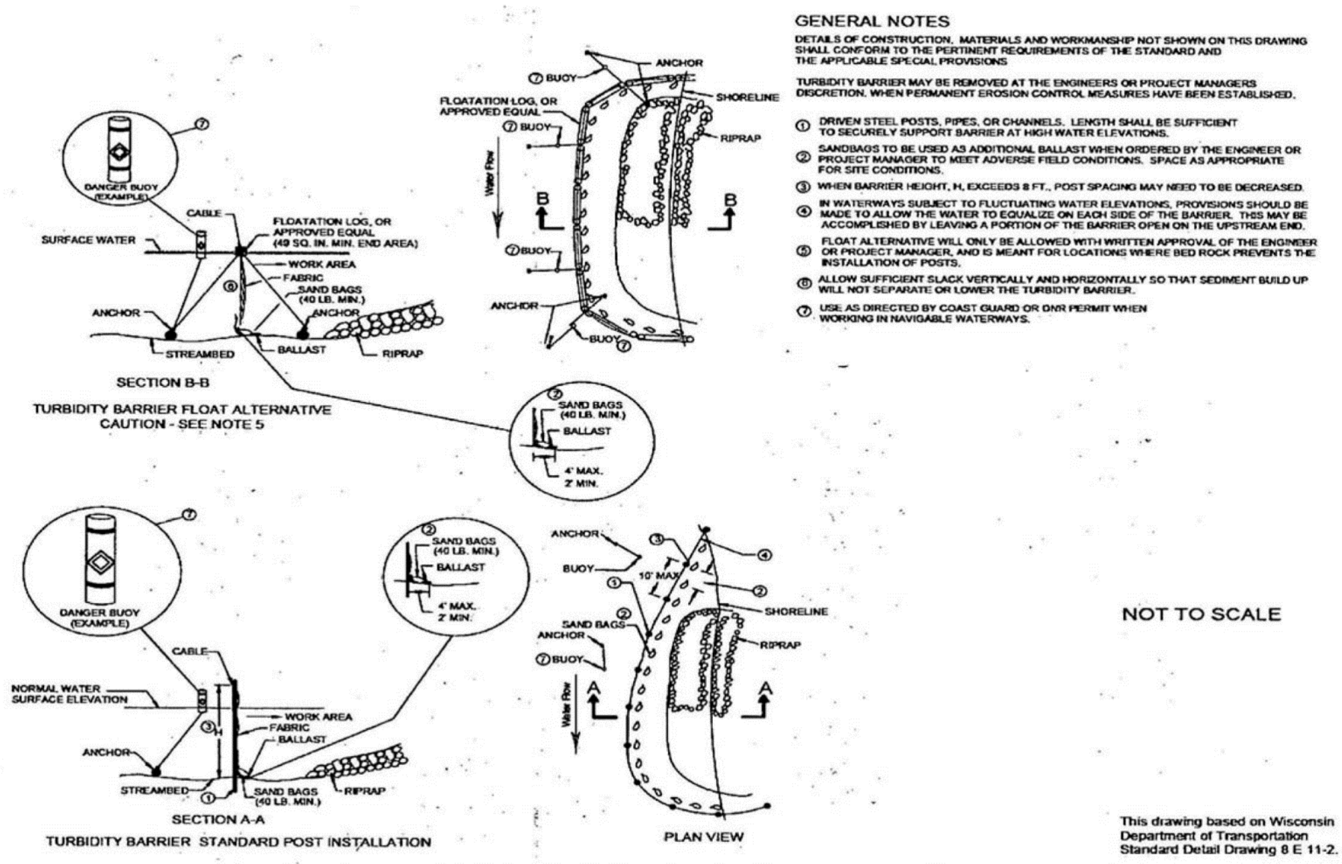


Figure 1.4.5.P.2 Turbidity Curtain Placement Details



Q. Dust Control.

1. Description.

Controlling dust movement on construction sites and roads.

2. Purpose.

To prevent blowing and movement of dust from exposed soil surfaces, reduce on and off-site damage, health hazards and improve traffic safety.

3. Conditions Where Practice Applies.

This practice is applicable to areas subject to dust blowing and movement where on and off-site damage is likely without treatment.

4. Procedures.

(i) Temporary Methods.

(1) Mulching - See **Section 1.4.5.A**.

(2) Vegetative Stabilization - See **Section 1.4.7**.

(3) Tillage - To roughen surface and bring clods to the surface. This is an emergency measure which should be used before soil blowing starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches apart, spring-toothed harrows and similar plows are examples of equipment which may produce the desired effect.

(4) Irrigation - Site is sprinkled with water until the surface is moist. Repeat as needed.

(5) Barriers - Solid board fences, snow fences, burlap fences, crate walls, bales of hay, and similar materials can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 15 times their height are effective in controlling soil blowing.

(6) Alternative dust control methods must be approved by the Environmental Inspector prior to use.

1.4.6 PERMANENT STRUCTURAL PRACTICES

A. Diversion.

1. Description.

A drainageway of parabolic or trapezoidal cross section, with a supporting ridge on the lower side that is constructed across the slope.

2. Purpose.

The purpose of a diversion is to intercept and convey runoff to stable outlets at nonerosive velocities.

3. Conditions Where Practice Applies. Diversions are used where:

(1) Runoff from higher areas is or has potential for damaging property, causing erosion or interfering with or preventing the establishment of vegetation on lower areas.

(2) The length of slopes need to be reduced so that soil loss will be reduced to a minimum.

(3) Diversions are only applicable below stabilized or protected areas. Avoid establishment on slopes greater than 15 percent.

4. Design Criteria.

The design procedures for parabolic and trapezoidal channels shall conform to the Drainage Criteria Manual.

5. Location.

Diversion location shall be determined by considering outlet conditions, topography, land use, soil type, length of slope and the layout of the proposed development.

6. Capacity.

The constructed diversion shall have capacity to carry, as a minimum, the peak discharge from a ten (10) year frequency rainfall event with freeboard of not less than one (1) foot.

Diversions designed to protect homes, schools, industrial buildings, roads, parking lots and comparable high-risk areas and those designed to function in connection with other structures, shall have sufficient capacity to carry peak runoff expected from the 25-year storm.

7. Velocity and Grade.

The maximum permissible velocities of flow for the native grasses and soil conditions in Travis County have not been determined. Research of this type is planned, but until it is completed, design velocities should be held to below six (6) feet per second on grades up to five (5) percent, five (5) feet per second on slopes from five (5) to ten (10) percent and four (4) feet per second on slopes over ten (10) percent.

8. Cross Section.

The diversion channel shall be parabolic or trapezoidal in shape.

The diversion shall be designed to have stable side slopes. The side slopes shall not be steeper than 2:1 and shall be flat enough to insure ease of maintenance of the structure and its protective vegetative cover.

The ridge shall have a minimum width of four (4) feet at the design water elevation; a minimum of one (1) foot freeboard.

9. Outlets.

Each diversion shall have a stable outlet. The outlet may be a constructed or natural waterway, a stabilized open channel, grade stabilization structure, etc. In all cases, the outlet must discharge in such a manner as not to cause erosion. Outlets shall be constructed and stabilized prior to the operation of the diversion.

B. Standards for Grass-Lined Swales.

1. Description.

A natural or manmade drainageway of parabolic or trapezoidal cross section that is below adjacent ground level and is stabilized by suitable vegetation. The flow is normally wide and shallow and conveys the runoff down the slope.

2. Purpose.

The purpose of a grass-lined swale is to convey runoff without causing damage by erosion.

3. Conditions Where Practice Applies.

Grass-lined swales are used where added channel capacity and/or stabilization is required to control erosion resulting from concentrated runoff and where such control can be achieved by this practice alone or in combination with others.

4. Design Criteria.

5. Capacity.

The minimum capacity shall be that required to confine the peak rate of runoff expected from a ten (10) year frequency rainfall event or a higher frequency corresponding to the hazard involved. This requirement for confinement may be waived on slopes of less than one (1) percent where out-of-bank flow will not cause erosion or property damage.

Where there is base flow, it shall be handled by a subsurface drain or a stone or gabion mattress lined low flow channel. The capacity of the subsurface drain or low flow channel shall be five (5) percent of the design peak flow or as determined by actual measurement of the maximum base flow.

The design procedure for parabolic and trapezoidal channels is contained in the Drainage Criteria Manual.

6. Velocity and Grade.

The maximum permissible velocities of flow for the native grasses and soil conditions in Travis County have not been determined. Research of this type is planned, but until it is completed, design velocities should be held to below six (6) feet per second on grades up to five (5) percent, five (5) feet per second on slopes from five (5) to ten (10) percent and four (4) feet per second on slopes over ten (10) percent.

7. Cross Section.

The design water surface elevation of a waterway receiving water from diversions or other tributary channels shall be equal to or less than the design water surface elevation in the diversion or other tributary channels (see Figures 1-19 and 1-20 in Appendix H of this manual for "Grass-Lined Swales" for details).

8. Outlets.

Each waterway shall have a stable outlet. The outlet may be another waterway, a stabilized open channel, grade stabilization structure, etc. In all cases, the outlet must discharge in such a manner as not to cause erosion. Outlets shall be constructed and stabilized prior to the operation of the waterway.

9. Drainage.

Subsurface drainage measures shall be provided for sites having high water tables or seepage problems, except where water-tolerant vegetation, such as Switch grass or Indian grass can be used.

Where there is base flow, a subsurface drain or concrete low flow channel shall be required.

10. Stabilization.

Waterways shall be stabilized immediately after final grading in accordance with the appropriate standards for critical area stabilization.

C. Level Spreader. (See 1.6.7.B.1 for Rock Level Spreader specifications and refer to 1.6.7.B Vegetative Filter Strips for design criteria)

1. Description.

An outlet constructed at zero (0) percent grade across the slope whereby concentrated runoff may be discharged at nonerosive velocities into undisturbed area stabilized by existing vegetation.

2. Purpose.

The purpose of the level spreader is to convert a concentrated flow of sediment-free runoff (e.g., diversion outlets) into sheet flow and to outlet it onto areas stabilized by existing vegetation without causing erosion.

3. Conditions Where Practice Applies.

The level spreader is used only in those situations where the spreader can be constructed on undisturbed soil, where the area directly below the level lip is stabilized by existing vegetation, where the drainage area above the spreader is stabilized by existing vegetation and where the water will not be reconcentrated immediately below the point of discharge.

4. Design Criteria.

The design criteria for level spreader shall be a maximum of one (1) cubic foot per second per foot of length, based on the peak rate of flow from a ten (10) year frequency rainfall event. The minimum length shall be five (5) feet. An alternate such as grade stabilization structure, grassed waterway, etc., should be considered where the length of the level spreader exceeds 20 feet.

5. Outlets.

Final discharge will be over the level lip protected with fiber glass matting erosion stops and jute or excelsior protective material onto an existing stabilized area. The stabilized area shall have a complete vegetative cover sufficiently established to be erosion resistant.

D. 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 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:

where:

d = the average channel flow depth (ft)

D 50 = 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 H of this manual provides an estimate of individual minimum rock sizes (diameter and weight of a spherical 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 size rating curve was based on laboratory flume tests and prototype stilling basins observed by the Bureau of Reclamation. The rock riprap sizing criteria is most applicable to high energy environments. The curve can be represented with the following expression:

D 50 = 0.0105V 2.06

where:

D50 = 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 following expression (adapted from ASTM D5519).

$$W_{50} = 47.54 D_{50}^{3} S_{g}$$

where:

W_{50} = median stone weight 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 is 2.4.

Rock riprap gradation, as used herein, is defined as 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.

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."

The rock riprap layer thickness shall be no less than the maximum stone size (D100) or 1.5 times the D50, 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. Rock Riprap Gradation Field Verification.

Rock gradations larger than Class I may require field testing as traditional test methods such as sieves or mechanical sorting machines may be impractical. Where projects require field verification of the rock riprap size class and gradation, the test methods described in City of Austin Standard Specification 591S Riprap for Slope Stabilization may be used.

7. 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:

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 (D15) of the upper/coarser layer to the 85 percent particle size (D85) 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.

E. Gabions. (See City of Austin Standard Specifications manual item 594S and Specifications manual item 594S-1 and 594S-2 for detail)

1. Description.

   Compartmented rectangular containers made of heavily galvanized and plastic-coated steel wire woven in a uniform hexagonal pattern, with an opening of approximately three (3) x four (4) inches, then filled with stone.

2. Purpose.

   The purpose of gabions is to protect the soil surface from the erosive forces of water or to retain unstable soil in a more vertical condition.

3. Condition Where Practice Applies.

   This practice applies to soil faces where the soil conditions, erosive forces, expected vegetative cover and ground water conditions are such that the soil may erode under the design conditions. Gabions may be used, as appropriate, at such places as storm drain outlets, weirs, channel banks and/or bottoms, roadside ditches, drop structures, shorelines and earth retaining structures.

4. Design Criteria.

The minimum design discharge for that portion of channels and ditches protected with gabions shall be peak discharge from a ten (10) year frequency rainfall event. The roughness coefficient, "n", to be used for determining flow in the gabion protected channel shall be:

TABLE 1-3 ROUGHNESS COEFFICIENT FOR GABIONS	
n	Stone Size
0.028	4 inches
0.029	5 inches
0.030	6 inches
0.031	7 inches
0.0315	8 inches
Source: City of Austin	

Gabion weirs should be founded on a gabion apron which extends downstream. The length of the apron will vary with the hydraulic and soil conditions.

In no case will the apron extend downstream less than the minimum length shown in Table 1-4 below:

TABLE 1-4 APRON LENGTH	
Gravel	6 feet
Coarse or Medium Sand	9 feet
Fine or Silty Sand	12 feet
Clay	9 feet
Source: City of Austin	

Gabion earth retaining structures will be designed in conformance with the manufacturer's recommendations.

5. Materials.

The wire mesh shall consist of plastic-coated (polyvinyl chloride) galvanized wire with a diameter of 0.0842 inches for revet mattress and 0.155 inch for all other applications. The wire for salvages and corners shall be plastic-coated galvanized wire with a diameter of 0.1305 inch. Tie and connecting wire shall be plastic-coated wire with a diameter of 0.084.

The stone fill material shall consist of hard, durable, clean stone, four (4) to eight (8) inches in size.

F. Subsurface Drain.

1. Description.

A conduit, such as pipe or tubing, installed beneath the ground surface which intercepts, collects and/or conveys drainage water.

2. Purpose.

A subsurface drain may serve one (1) or more of the following purposes:

(1) Improve the soil environment for vegetable growth by regulating the water table and ground water flow.

(2) Intercept and prevent ground water movement into a wet area and to handle base flow for grassed waterways.

(3) Relieve artesian pressures.

(4) Remove surface runoff.

(5) Provide internal drainage of slopes to improve their stability and reduce erosion.

(6) Provide internal drainage behind bulkheads, retaining walls, etc.

(7) Replace existing subsurface drains that are interrupted or destroyed by construction operations.

(8) Provide subsurface drainage to dewater stormwater management structures.

(9) Improve dewatering of sediment in sediment basins (see **Section 1.4.5** K "Sediment Basins" for additional information).

3. Conditions Where Practice Applies.

Subsurface drains are used where lowering or controlling ground water or surface runoff is required. The soil shall have enough depth and permeability to permit installation of an effective system. This standard does not apply to storm drainage systems or foundation drains.

An outlet for the drainage systems shall be available, either by gravity flow or by pumping. The outlet shall be adequate for the quantity of water to be discharged without damage above or below the point of discharge.

4. Design Criteria.

The required capacity shall be determined by one (1) or more of the following:

(1) Where subsurface drainage is to be uniform over an area through a systematic pattern of drains, a drainage coefficient of one (1) inch to be removed in 24 hours shall be used.

(2) Where subsurface drainage is to be by random system, a minimum inflow rate of 1.5 cubic feet per second per 1,000 feet of line shall be used to determine the required capacity.

For interceptor subsurface drains on sloping land, increase the inflow rate as follows:

Land Slopes	Increase Inflow Rate By
2 - 5 percent	10 percent
5 - 12 percent	20 percent
over 12 percent	30 percent

(3) Additional design capacity must be provided if surface water is allowed to enter the system.

5. Size of Subsurface Drain.

The size of the subsurface drains shall be determined in accordance with the Drainage Criteria Manual.

6. Depth and Spacing.

The minimum depth of cover of subsurface drains shall be 24 inches, where possible. The minimum depth of cover may be reduced to a minimum of 12 inches where it is not possible to attain the 24 inch depth and where the drain is not subject to damage by equipment loading. Roots from some types of vegetation can plug drains as the drains get closer to the surface.

The spacing of drain laterals will be dependent on the permeability of the soil, the depth of installation of the drains and degree of drainage required. Generally, drains installed 36 inches deep and spaced 50 feet center to center will be adequate.

7. Minimum Velocity and Grade.

The minimum grade for subsurface drains shall be 0.10 percent. Where surface water enters the system, a velocity of not less than two (2) feet per second shall be used to establish the minimum grades. Provisions shall be made for preventing debris or sediment from entering the system by means of filters or collection and periodic removal of sediment from installed traps.

8. Materials for Subsurface Drains.

Acceptable subsurface drain materials include perforated, continuous closed joint conduits of polyethylene plastic, concrete, corrugated metal, asbestos-cement, bituminized fiber and polyvinyl chloride.

The conduit shall meet strength and durability requirements of the site.

9. Loading.

The allowable loads on subsurface drain conduits shall be based on the trench and bedding conditions specified for the job. A safety factor of not less than 1.5 shall be used in computing the maximum allowable depth of cover for a particular type of conduit.

10. Envelopes and Envelope Material.

Envelopes shall be used around subsurface drains for proper bedding of the conduit. Not less than ten (10) inches of envelope material shall be used for sand-gravel envelopes. Where necessary to improve the characteristics of flow of ground water into the conduit, more envelope material may be required.

Envelope material shall be placed to the height of the uppermost seepage strata. Behind bulkhead and retaining walls, it shall go to within 12 inches of the top of the structure. This does not cover the design of filter materials where needed.

Materials used for envelopes shall not contain materials which will cause an accumulation of sediment in the conduit or render the envelope unsuitable for building of the conduit. Envelope materials shall consist of sand-gravel material, all of which shall pass a 1½ inch sieve, 90 to 100 percent shall pass a ¾ inch sieve and not more than ten (10) percent shall pass a Number 40 sieve.

The conduit shall be placed and bedded in a sand-gravel envelope. A minimum of three (3) inches depth of envelope material shall be placed on the bottom of a conventional trench. The conduit shall be placed on this and the trench completely filled with envelope material to a minimum depth of three (3) inches above the conduit.

Envelope Material:

Soft or yielding soil under the drain shall be stabilized where required and lines protected from settlement by adding gravel or other suitable material to the trench, by placing the conduit on plank or other rigid support or by using long sections of perforated or watertight pipe with adequate strength to insure satisfactory subsurface drain performance.

The envelope shall be interrupted every ten (10) feet by an impervious cutoff wall. This wall shall fit tightly around the pipe and prohibit the continued flow of water through the envelope, thus forcing it into the conduit.

11. Auxiliary Structure and Subsurface Drain Protection.

The outlet shall be protected against erosion and undermining of the conduit, against damaging periods of submergence and against entry of rodents or other animals into the subsurface drain.

A continuous ten (10) foot section of corrugated metal, cast iron, polyvinyl chloride or steel pipe without perforations shall be used at the outlet end of the line and shall outlet above the normal elevation of low flow in the outlet ditch. No envelope material shall be used around the ten (10) foot section of pipe. Two-thirds (2/3) of the pipe shall extend to a point above the toe of the ditch side slope or the side slope shall be protected from erosion.

Conduits under roadways and embankments shall be watertight and designed to withstand the expected loads.

Where surface water is to be admitted to subsurface drains, inlets shall be designed to exclude debris and prevent sediment from entering the conduit. Lines flowing under pressure shall be designed to withstand the resulting pressures and velocity of flow. Surface waterways shall be used where feasible.

The upper end of each subsurface drain line shall be capped with a tight fitting cap of the same material as the conduit or other durable material, unless connected to a structure.

G. Land Grading.

1. Description.

Reshaping of the existing topography in accordance with a plan as determined by engineering survey and layout.

2. Purpose.

The purpose of land grading is to provide for erosion control and vegetative establishment on those areas where the existing topography is to be reshaped by grading according to plan.

3. Design Criteria.

The grading plan should be based upon the incorporation of building designs and street layouts that fit and utilize existing topography and desirable natural surroundings to avoid extreme grade modifications. Information submitted will provide sufficient topographic surveys and soil investigations to determine limitations that must be imposed on the grading operation related to slope stability, effect on adjacent properties and drainage patterns, measures for drainage and water removal and vegetative treatment, etc.

The plan must show existing and proposed contours of the area(s) to be graded. The plan shall also include practices for erosion control, slope stabilization, safe disposal of runoff water and drainage, such as waterways, lined ditches, reverse slope benches (include grade and cross section), grade stabilization structures, retaining walls and surface and subsurface drains. The plan shall also include scheduling and phasing of these practices; the following shall be incorporated into the plan:

(1) Provisions shall be made to safely conduct surface runoff to storm drains, protected outlets or to stable water courses to insure that surface runoff will not damage slopes or other graded areas (see **Section 1.4.6** "Permanent Structural Practices").

(2) Cut and fill slopes shall be designed to the natural angle of repose for the material. Without approval of the Director of Transportation and Public Services, they will be no steeper than 2:1, except for cut slopes in solid limestone. Where the slope is to be mowed, the maximum slope shall be no steeper than 3:1 (4:1 is preferred because of safety factors related to mowing steep slopes).

(3) Reverse slope benches or diversions shall be provided whenever the vertical interval (height) of any 2:1 through 5:1 slope exceeds 15 feet. Benches shall be located so as to divide the slope face as equally as possible and shall convey the water to a stable outlet. Soils, seeps, rock outcrops, etc., shall also be taken into consideration when designing benches.

Benches shall be wide enough to accommodate the construction equipment in use and provide for ease of maintenance.

Benches shall be designed with a reverse slope of 5:1 or flatter to the toe of the upper slope and with a minimum of one

foot in depth. Bench gradient to the outlet shall be between one (1) and two (2) percent.

The flow length within a bench shall not exceed 800 feet unless accompanied by appropriate design and computations (see **Section 1.4.5** "Temporary Structural Practices").

Surface water shall be diverted from the face of all cut and/or fill slopes by the use of diversions, ditches and swales or conveyed down slope by the use of designed structure, except where:

(1) The length of overland flow (in feet) to the crest of the slope shall not exceed the distance "A" given in the following diagram and example for any combination of side slopes and vertical intervals and;

(2) The face of slope is or shall be stabilized and the face of all graded slopes shall be protected from surface runoff until they are stabilized and;

(3) The face of the slope shall not be subjected to any concentrated flows of surface water from natural drainageways, graded swales, downspouts, etc.

(4) The maximum total horizontal overland flow distance "B" shall not exceed 15 times the side slope "X" of the cut or fill slope. Maximum allowable overland flow distance (in feet) to the top of the slope with no diversion of surface water will be determined by use of the formulas found in **Section 2** "Determination of Storm Runoff" of the Drainage Criteria Manual.

H. Grade Stabilization Structure (Paved Chute or Flume).

1. Definition.

A channel lined with bituminous concrete, Portland cement concrete or comparable nonerodable material placed to extend from the top of a slope to the bottom of a slope.

2. Purpose.

The purpose of the paved chute or flume is to convey surface runoff safely down slopes without causing erosion.

3. Conditions Where Practice Applies.

A paved chute or flume is to be used where concentrated flow of surface runoff must be conveyed down a slope in order to prevent erosion. The maximum allowable drainage area shall be 36 acres.

4. Design Criteria.

(i) Size Group A.
The height (H) of the dike at the entrance is at least 1.5 feet.

The depth (d) of the chute down the slope is at least eight (8) inches.

The length (L) of the inlet and outlet sections is five (5) feet.

(ii) Size Group B.
The height (H) of the dike at the entrance is at least two (2) feet.

The depth (d) of the chute down the slope is at least ten (10) inches.

The length (L) of the inlet and the outlet sections is six (6) feet.

(iii) Each size group has various bottom widths and allowable drainage areas as shown below:

Size 1/	Bottom Width, b, Ft.	Maximum Drainage Area Acres
A-2	2	5
A-4	4	8
A-6	6	11
A-8	8	14
A-10	10	18
B-4	4	14
B-6	6	20
B-8	8	25
B-10	10	31
B-12	12	36

Note: 1/ The size is designated with a letter and a number, such as A-6, which means a chute or flume in Size Group A with a six (6) foot bottom width. The selected size shall be shown on the plans.

If a minimum of 75 percent of the drainage area will have a good grass or woodland cover throughout the life of the structure, the drainage areas listed above may be increased by 50 percent. If a minimum of 75 percent of the drainage area will have a good mulch cover throughout the life of the structure, the drainage areas listed above may be increased by 25 percent.

5. Outlet.

When a paved chute or flume is used, the velocity at its outfall shall be checked for erosion potential downstream and when required, energy dissipation structures shall be installed.

1.4.7 VEGETATIVE PRACTICES

A. Temporary Vegetative Stabilization of Disturbed Areas.

1. Description.

Stabilize soil in disturbed areas with temporary vegetation. Refer to Section 1.4.5.A. - Mulching for other temporary stabilization options.

2. Purpose.

To stabilize the soil; to reduce damages from sediment and runoff to downstream areas; improve wildlife habitat; enhance natural beauty.

3. Conditions Where Practice Applies.

Use vegetation to temporarily stabilize the soil on disturbed, graded or cleared areas prior to establishment of permanent vegetation.

4. Design Criteria.

Prior to vegetative establishment, install needed erosion control practices, such as diversions, grade stabilization structures, berms, dikes, level spreaders, and sediment basins. Final grading and shaping has usually not been completed for temporary stabilization.

5. Fertilizer.

For temporary vegetative establishment, fertilizer may be applied if a soil test indicates the need for additional nutrients. For more information, refer to City of Austin Standard Specification 606S, Fertilizer. In order to avoid the conveyance of nutrients off- site, the timing of fertilization shall not occur when rainfall is expected or during slow plant growth or dormancy (i.e., during the cool season for warm-season plants). Chemical fertilizer may not be applied in the Water Quality Buffer Zone.

6. Seed Bed Preparation.

Prepare a suitable seed bed which allows good seed-to-soil contact and soil conditions that are conducive to vegetative growth. Do not disturb the soil within the critical root zone of existing trees. See Section 1.4.8.B. or information regarding the protection of trees in construction areas. Areas of compacted soil shall be loosened to minimum depths between six (6) and twelve (12) inches, or deeper, depending on the extent of compaction, the location of compaction, and the type and nature of soils affected by compaction (e.g., shallow vs deep, wet vs dry). In cases where minimum depths of six (6) to twelve (12) inches is not attainable (i.e., shallow soil above bedrock) apply decompaction to the depth of soil present.

Decompaction can be achieved by tilling, plowing, discing, raking, ripping or other acceptable means before seeding. After seed bed preparation, heavy equipment must not be driven over soils. In areas where no topsoil exists, or where imported topsoil is needed for vegetative establishment, the subgrade shall be loosened by discing or by scarifying to a depth of at least two (2) inches prior to placement to permit bonding of the topsoil to the subsoil. Placement of topsoil shall not occur in such a manner or location such that stormwater runoff is likely to transport the material downstream (e.g. over bedrock in an area of concentrated flow). All disturbed areas to be revegetated are required to have a minimum of six (6) inches of topsoil. Topsoil, when used, shall meet the definition of topsoil as defined in Standard Specification 601S.3.A Salvaging and Placing Topsoil. Topsoil salvaged from the existing site may often be used, but it should meet the same standards as set forth in these standards.

The following are general threshold levels of compaction as determined by three compaction testing methods, including bulk density method, standard proctor method, and penetration resistance method.

Compaction levels that are detrimental to root growth are dependent on soil type which typically varies from site to site and must be determined by an Engineer, Landscape Architect, Soil Scientist, or their designated representative before compaction testing occurs.

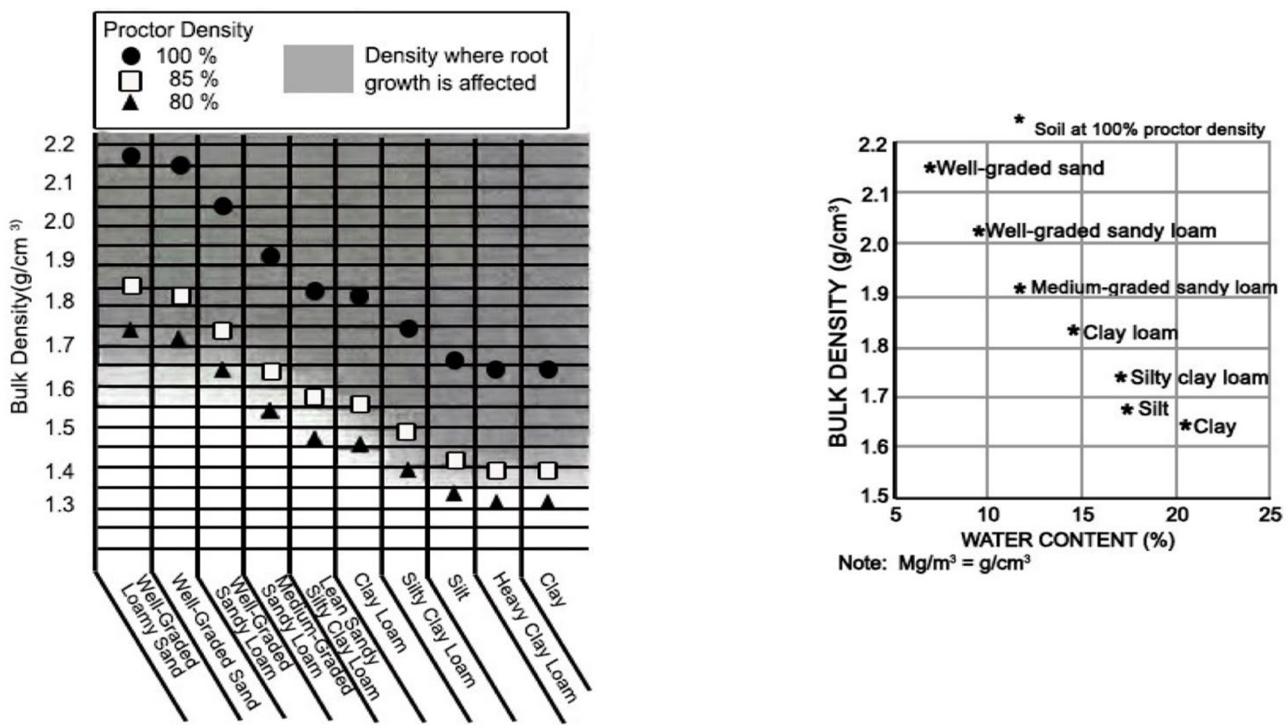
Acceptable Compaction: Good rooting anticipated, but increasing settlement expected as compaction is reduced and/or in soil with a high organic matter content.

(i) Bulk Density Method: Varies by soil type (see Figure 1.4.7-1).

(ii) Standard Proctor Method: 75 - 85 percent; soil below 75 percent is unstable and will settle excessively.

(iii) Penetration Resistance Method: 75 to 250 p.s.i.; soil below 75 p.s.i. becomes increasingly unstable and will settle excessively.

Figure 1.4.7-1: The Relationships Of Soil Types To Bulk Density And Proctor Values. Source: Urban (2008) Up By Roots.



7. Seeding.

If seeding is to be conducted during the cool season (September 15 to March 1) plant species noted as "cool season cover crop" from the Tables in City of Austin Standard Specification 604S and/or 609S. Warm season seeding (March 2 to September 14) shall follow City of Austin standard specification 604S (seeding for erosion control) and 609S (native grassland seeding and planting for restoration). Apply seed uniformly with broadcast method, a seed spreader, drill, cultipacker seeder or hydroseeder (slurry includes seed, fertilizer and binder - see item 8[next]).

Length of seed germination is dependent on weather, soil moisture, species type and other variables. For native seed it can range from two to five weeks. If inadequate germination is evidenced, reseeding shall be required.

8. Protection of Seed Bed with Hydromulch or Soil Retention Blanket.

Newly-installed temporary vegetation must be protected by hydromulch or soil retention blanket (refer to City of Austin Standard Specification 605S Soil Retention Blanket) immediately after seeding. Protection of the seed bed shall occur in a manner that will allow seed germination and that encourages effective vegetative growth. Hydromulching, when used, shall comply with the requirements of Table 1.4.7-A: Hydromulching for Temporary Vegetative Stabilization. The following hydromulch requirements are in accordance with the Erosion Control Technology Council (ECTC). The ECTC has set its mission to be the recognized industry authority in the development of standards, testing, and installation techniques for rolled erosion control products (RECPs), hydraulic erosion control products (HECPs) and sediment retention fiber rolls (SRFRs).

Table 1.4.7-A: Hydromulching for Temporary Vegetative Stabilization

Material	Description	Longevity	Typical Applications	Application Rates
100% or any blend of wood, cellulose, straw, and/or cotton plant material (except no mulch shall exceed 30% paper)	70% or greater Wood/Straw 30% or less Paper or Natural Fibers	0—3 months	Moderate slopes; from flat to 3:1	1,500 to 2,000 lbs per acre

(i) Hydraulic Mulch. Hydraulically-applied material(s) containing defibrated paper, wood and/or natural fibers that may or may not contain tackifiers used to facilitate revegetation establishment on mild slopes and designed to be functional for up to 3 months. Refer to Table 1.4.7-B for mulch properties and to Standard Specification 604S - Seeding for additional mulch requirements.

Table 1.4.7-B: Properties of Hydraulic Mulch

Property (Test Method)	Required Value
Moisture content %	12.0% ±3.0% (max.)
Organic matter %	90% ±1% Oven Dry Basis (min.)
Tacking Agent	0% or greater
Water holding capacity	500% or greater

9. Watering

Supplemental watering may be required to germinate seed and maintain growth. Depending on the weather and constituents of a seed mix, new plantings may require daily watering for the first week or longer after sowing to ensure germination, with reduced irrigation post-germination to ensure growth, plant health and vigor. Irrigation shall occur at rates and frequencies determined by a licensed irrigator or other qualified professional, and as allowed by the West Travis County Public Utility Agency or WICD No. 17 and the current water restrictions and water conservation initiatives. Significant rainfall (on-site rainfall of half-inch or greater) may allow the postponement of watering until the next scheduled irrigation.

B. Permanent Vegetative Stabilization of Disturbed Areas.

1. Description.

Permanent vegetative stabilization may comprise the installation of vegetation such as sod and bunch grasses, forbs, shrubs, and/or trees on critical disturbed areas. When seeded, newly installed permanent vegetation must be protected by hydromulch or soil retention blanket (refer to Standard Specification 605S Soil Retention Blanket).

2. Purpose.

To stabilize the soil, to reduce damages from sediment and runoff to downstream areas, improve wildlife habitat, enhance natural beauty.

3. Conditions Where Practice Applies.

Disturbed, graded or cleared areas which are subject to erosion and where a permanent, long-lived vegetative cover is needed.

4. Design Criteria.

(i) Standard Specifications
For areas that are seeded refer to City of Austin Standard Specification 604S - Seeding for Erosion Control or 609S - Native Grassland Seeding and Planting for Restoration (whichever is applicable). For areas that are sodded refer to City of Austin Standard Specification 602S - Sodding for Erosion Control.

(ii) Site Preparation.
Install needed erosion control practices, such as interceptor dikes, berms and spreaders, contour ripping, erosion stops, channel liners and sediment basins.

Grade as needed and feasible to permit the use of conventional equipment for seed bed preparation, seeding, mulch applications, anchoring and maintenance.

5. Bed Preparation.

Prepare a suitable bed which allows good contact between the soil and the seed or sod (whichever is used).

Areas of compacted soil shall be loosened by plowing, discing, raking or other acceptable means to a depth of six (6) inches or greater prior to seeding or sodding.

In areas where no topsoil exists, or where topsoil is needed for vegetative establishment, the subgrade shall be loosened by discing or by scarifying to a depth of at least two (2) inches prior to placement of six (6) inches of topsoil to permit bonding of the topsoil to the subsoil.

All disturbed areas to be revegetated are required to place a minimum of six (6) inches of topsoil. Topsoil, when used, shall meet the definition of topsoil as defined in standard specification 601S.3.A Salvaging and Placing Topsoil.

Topsoil salvaged from the existing site may often be used, but it should meet the same standards as set forth in these standards. Placement of topsoil shall not occur in such a manner or location such that stormwater runoff is likely to transport the material downstream (e.g. over bedrock in an area of concentrated flow).

6. Fertilizer.

   For permanent vegetative establishment, fertilizer may be applied if a soil test indicates the need for additional nutrients. For more information, refer to City of Austin Standard Specification 606S, Fertilizer. In order to avoid the conveyance of nutrients off- site, the timing shall not occur when rainfall is imminent, or during slow plant growth or dormancy (i.e., during the cool season for warm-season plants). Chemical fertilizer may not be applied in the Water Quality Buffer Zone.

7. Seeding.

   Select the appropriate species in the tables provided in City of Austin Standard Specification 604S and/or 609S. All seeding work must conform to these specifications.

8. Protection of Seed Bed with Hydromulch or Soil Retention Blanket.

   When seeded, newly-installed permanent vegetation must be protected by hydromulch or soil retention blanket (refer to Standard Specification 605S Soil Retention Blanket) immediately after seeding. Protection of the seed bed shall occur in a manner that will allow seed germination and that encourages effective vegetative growth. Hydromulching, when used, shall comply with the requirements of Table 1.4.7-C: Hydromulching for Permanent Vegetative Stabilization. The following hydromulch requirements are in accordance with the Erosion Control Technology Council (ECTC). The ECTC has set its mission to be the recognized industry authority in the development of standards, testing, and installation techniques for rolled erosion control products (RECPs), hydraulic erosion control products (HECPs) and sediment retention fiber rolls (SRFRs).

Table 1.4.7-C: Hydromulching for Permanent Vegetative Stabilization

Material	Description	Longevity	Typical Applications	Application Rates
Bonded Fiber Matrix (BFM)	80% Organic defibrated fibers 10% Tackifier	6 months	On slopes up to 2:1 and erosive soil conditions	2,500 to 4,000 lbs per acre (see manufacturers recommendations)
Fiber Reinforced Matrix (FRM)	65% Organic defibrated fibers 25% Reinforcing Fibers or less 10% Tackifier	Up to 12 months	On slopes up to 1:1 and erosive soil conditions	3,000 to 4,500 lbs per acre (see manufacturers recommendations)

(i) Bonded Fiber Matrix (BFM): Bonded Fiber Matrix shall consist of organic defibrated fibers and cross-linked hydro- colloidal tackifiers. Refer to Table 1.4.7-D for mulch properties and to Standard Specification 604S - Seeding for additional mulch requirements.

Table 1.4.7-D: Properties of Bonded Fiber Matrix

Property (Test Method)	Required Value
Moisture content %	12% ±3.0% (max.)
Organic matter %	75% ±3% Oven Dry Basis (min.)

Cross-linked Hydro-colloidal Tackifiers	10.0% ±1%
Water holding capacity	500% or greater
Mass per unit area (ASTM D6566)	10.0 oz/square yard (min.)
Thickness (ASTM D6525)	0.12 inch (min.)
Ground Cover (ASTM D6567)	97% (min.)
Functional Longevity	6 months (min.)
% Effectiveness	90% (min.)
Cure time	24 hours
Vegetative Establishment (ASTM D7322)	400%

(ii) Fiber Reinforced Matrix (FRM). Fiber Reinforced Matrix shall consist of organic defibrated fibers produced from grinding clean, whole wood chips, crimped interlocking fibers, cross-linked insoluble hydro-colloidal tackifiers and reinforcing natural and/or synthetic fibers. Refer to Table 1.4.7-E for mulch properties and to Standard Specification 604S - Seeding for additional mulch requirements.

Table 1.4.7-E: Properties of Fiber Reinforced Matrix

Property (Test Method)	Required Value
Moisture content %	12% ±3.0% (max.)
Organic matter % - organic fiber	65% ±3.5% Oven Dry Basis (min.)
Organic matter % - reinforcing fibers	25% or less
Cross-linked Hydro-colloidal Tackifiers	10.0% ±1%
Water holding capacity	500% or greater
Mass per unit area (ASTM D6566)	11.0 oz/square yard (min.)
Thickness (ASTM D6525)	0.16 inch (min.)
Ground Cover (ASTM D6567)	97% (min.)
Functional Longevity	12 months (min.)
% Effectiveness	99% (min.)
Cure time	24 hours
Vegetative Establishment (ASTM D7322)	500%

9. Sodding.

Sodding is an acceptable practice for permanent vegetative stabilization. Installation of sod shall comply with practices described in Standard Specification 602S - Sodding. Sod placed on slopes greater than 3:1 must be staked using biodegradable landscape staples.

10. Rooted Plants.

Installation of rooted plants - including bare root, live root, and container-grown plants - in conjunction with other methods, is an acceptable means of achieving permanent vegetative stabilization. Installation of rooted plants shall comply with practices described in Standard Specification 608S - Planting.

11. Irrigation.

Supplemental watering may be required to germinate seed and maintain growth of rooted plants. Depending on the weather and constituents of a seed mix, new plantings may require daily watering for the first week or longer after sowing to ensure germination, with reduced irrigation post-germination to ensure growth, plant health and vigor. Irrigation shall occur at rates and frequencies determined by a licensed irrigator or other qualified professional, and as allowed by the water service provider and the current water restrictions and water conservation initiatives. Significant rainfall (on-site rainfall of half-inch or greater) may allow the postponement of watering until the next scheduled irrigation.

12. Maintenance.

Maintenance is a vital factor in providing an adequate vegetative erosion control cover. Monitoring, watering, mulching and weeding shall be required during the period of establishment to ensure planting success. Maintenance practices shall comply with construction methods and plant establishment requirements described in Standard Specifications 604S, 608S, and 609S.

(i) Reseeding - Inspect all seeded areas for failures and reseed as necessary per 609S.

(ii) Replanting - Failure of rooted plant requires replacement per Standard Specification 608S.

(iii) Weeding - Anticipate weed problems prior to planting desired plants and control weeds as necessary to curb competition and enable proposed vegetation to thrive. Weed types and amounts are dependent on weather, season, soil quality, and site conditions. Refer to Standard Specifications 604 and 609 for weed lists. Treatment methods shall be tailored for each situation, and should follow current Integrated Pest Management (IPM) guidelines and Invasive Species Management Plan.

C. Protection of Trees in Construction Areas.

1. Description.

Protection of desirable trees from mechanical and other injury while the land is being converted to urban use.

2. Purpose.

To employ the necessary protective measures to insure the survival of desirable trees for shade, beautification and vegetative cover.

3. Conditions Where Practice Applies.

On areas now occupied by single specimen trees or groups of trees.

(i) Criteria for deciding upon the trees to leave:

(1) Aesthetic values: Consideration should be given to autumn foliage, flowering habits, bark and crown characteristics and type of fruit.

(2) Freedom from disease and rot.

(3) Life span of trees: Some are considered short-lived trees.

(4) Wildlife values: Oaks, hickories, dogwoods, etc., have a high food value.

(5) Comfort index: Summer temperatures are generally ten (10) degrees cooler under stands of hardwoods than cedars.

(6) Sudden exposure: To direct sunlight and ability to withstand radiated heat from proposed buildings and pavement.

(7) Space needed: For future growth and relationship to structures, electric and telephone lines, water and sewer lines, driveways and streets. Mark trees with bright paint or ribbon so there is no doubt as to which trees are to be left and protected from damage during construction.

D. Dust Control.

1. Description.

Controlling dust movement on construction-sites and roads.

2. Purpose.

To prevent blowing and movement of dust from exposed soil surfaces, reduce on and off-site damage, health hazards and improve traffic safety.

3. Conditions Where Practice Applies.

This practice is applicable to areas subject to dust blowing and movement where on and off-site damage is likely without treatment.

4. Procedures

(i) Temporary Methods.

(1) Mulches - See **Section 1.4.5**.

(2) Vegetative Cover - See **Section 1.4.7**.

(3) Spray-on Adhesives - On mineral soils (not effective on muck soils). Keep traffic off these areas.

TABLE 1-5
SPRAY-ON ADHESIVES

	Water Dilution	Type of Nozzle	Apply-Gallons/Acre
Anionic asphalt emulsion	7:1	Fine Spray	1,200
Latex emulsion	12½ :1	Fine Spray	235
Resin-in-water emulsion	4:1	Fine Spray	300
Source: City of Austin			

(4) Tillage - To roughen surface and bring clods to the surface. This is an emergency measure which should be used before soil blowing starts. Begin plowing on windward side of site. Chisel-type plows spaced about 12 inches apart, spring- toothed harrows and similar plows are examples of equipment which may produce the desired effect.

(5) Irrigation - This is generally done as an emergency treatment. Site is sprinkled with water until the surface is moist. Repeat as needed.

(6) Barriers - Solid board fences, snow fences, burlap fences, crate walls, bales of hay and similar materials can be used to control air currents and soil blowing. Barriers placed at right angles to prevailing currents at intervals of about 15 times their height are effective in controlling soil blowing.

(ii) Permanent Methods.

(1) Permanent Vegetation - See **Section 1.4.7**.

(2) Stone - Cover surface with crushed stone or coarse gravel.

1.5 STREAM BUFFERS

1.5.1 INTRODUCTION

The Water Quality Buffer Zone is the primary stream buffer established by Article 7, Section 7.3.2(C)(5) of the City's UDC.

By promoting healthy soils and vegetation along the creek corridor and allowing the stream adequate space to migrate over time, stream buffers help control flood impacts, reduce channel erosion and property loss, help maintain good water quality, reduce operation and maintenance costs, and provide multiple community benefits.

1.5.2 BUFFER GEOMETRY

A. Buffer Width

Water Quality Buffer Zone

In all watersheds, Water Quality Buffer Zones are present along any drainage way which has greater than 30 acres of contributing drainage. The extent of any Water Quality Buffer Zone shall be defined as an 85' offset from the extent of the 2-year storm event inundation boundary along qualifying drainage ways. Along Little Barton Creek, the Water Quality Buffer Zone shall be defined as a 300' offset from the extent of the 2-year inundation boundary. Appropriate background information/data and required back-up is listed below when a project establishes a Water Quality Buffer Zone. A hydrologic model should be generated and submitted to the Planning & Development Department when a Water Quality Buffer Zone is delineated as part of a project. Below are example inputs for a 2-year meteorologic model in HEC-HMS which could be utilized to determine the 2-year inundation boundary. Alternate modeling programs may be utilized, as may alternative meteorologic models, however these elements should be coordinated with City staff prior to submittal. For major waterways which have substantial contributing drainage (100+ acres), the applicant should account for proper basin hydrologic routing within their hydrology model. The city's preference for routing methodology is that the Modified-Puls method be utilized, however alternative routing methodologies are allowed and shall be coordinated with City Staff.

Meteorologic Models

Precipitation: Hypothetical Storm

Method: SCS Type 3

Point Depth: 4.14 in.

Area Reduction: None

A corresponding hydraulic model shall also be submitted to the Planning & Development Department when a Water Quality Buffer Zone is delineated as part of a project. While the City is open to a project utilizing a 2-D hydraulic modeling approach for Water Quality Buffer Zone delineation, a standard 1-D hydraulic model is preferred. Below are a few hydraulic modeling requirements:

(i) Maximum Distance between any two cross-sections shall not exceed 500 feet.

(ii) All centerlines and cross-section provided shall be properly georeferenced.

(iii) The hydraulic model cross sections shall be generated from survey data where possible, and where survey data is not available the cross sections may be developed from 3-ft by 3-ft Lidar DEMs (or higher resolution).

(iv) Below are suggested tolerances to be utilized within the model:

- **(1)** Horizontal Filter Tolerance: 0.25
- **(2)** Vertical Filter Tolerance: 0.25
- **(3)** Collinear Vertical Filter Tolerance: 0.25
- **(4)** Collinear Minimum Change Slope: 0.005

B. Additional Design Criteria

It must be demonstrated that any discharge being released over an established buffer zone shall have diffused sheet flow; in order to obtain this condition, consideration should be made providing appropriate flow diffusion structures at all storm outfalls which flow into established waterways. It must be demonstrated, via appropriate back-up calculations, that discharges over buffer zones have peak velocities of less than five (5) fps at the 2-year design storm.

C. Exemptions

A Water Quality Buffer Zone does not apply to:

- **(1)** a previously modified drainage feature constructed primarily to serve a public roadway right-of-way if staff from the Planning & Development Department determine that the feature does not possess any natural and traditional character and cannot be reasonably restored to a natural condition;
- **(2)** drainage that is enclosed within a storm drain.

1.5.3 DEVELOPMENT ALLOWED IN THE WATER QUALITY BUFFER ZONE

Refer to City of Bee Cave UDC Article 7 for development allowed within the WQBZ.

1.6 DESIGN GUIDELINES FOR WATER QUALITY CONTROLS

1.6.1 INTRODUCTION

This document provides guidelines for both the design of stormwater controls to enhance water quality and for the long-term maintenance of these facilities. These guidelines should be followed in order to provide protection for the water resources in the Bee Cave area and to minimize time and effort in obtaining project review and approval. It is recognized that not all sites will permit ponds to be designed strictly according to these guidelines and that innovative designs are possible. However, such deviations from these guidelines must be approved by the Planning & Development Department

Stormwater can have significant impact on the water quality of creeks and the Colorado River. To minimize the effect of non-point source pollutants in stormwater, stormwater quality control measures (SCMs, or controls) are required to serve development. Controls are designed to improve water quality by removing suspended particulate matter and associated constituents such as bacteria, nutrients and metals.

For the purposes of water quality control design, the water quality standard for new development in the City of Bee Cave is treatment of 90% of Total Suspended Solids (TSS), Total Phosphorus (TP), and Oil & Grease (O&G) average annual pollutant loads generated from new developments. Applicants are encouraged to contact the Planning & Development staff prior to submitting plans proposing innovative practices. Minimum design guidelines for acceptable SCMs are outlined in **Section 1.6.7**.

1.6.2 GENERAL DESIGN GUIDELINES

The following section discusses general design parameters which most stormwater quality control measures (SCMs) have in common. These parameters include the volume of run-off which is to be treated, a method to capture this volume, and liner requirements.

A. Capture Volume or Water Quality Volume. The primary control strategy for water quality basins is to capture a minimum volume of stormwater runoff for treatment, and to release the treated volume in no less than forty-eight (48) hours and no more than seventy-two (72) hours. The minimum volume is the first one-half (0.5) inch of runoff plus an additional one-tenth (0.1) inch for each ten (10) percent increase of the gross impervious cover over twenty (20) percent of the contributing drainage area to the WQCM. This depth of runoff from the contributing drainage area to the control is and will be referred to as the Capture Volume, also known as the "Water Quality Volume (WQV)." The WQV must consist of runoff from all impervious surfaces such as roadways, parking areas and roof tops, and all developed pervious areas in accordance with the City of Bee Cave UDC's Article 7. Water quality treatment is not required for runoff from lands left in their natural state, e.g., greenbelts and open spaces. Runoff from these areas must be routed around the water quality basin or it must be included in the WQV.

Because travel time from distant contributing areas reduces the effectiveness of the water quality controls in capturing all of the water quality volume, a maximum contributing drainage area of fifty (50) acres per water quality control basin is recommended.

B. Water Quality Volume Diversion Structures.

1. Off-line SCMs are required to have a diversion structure or splitter box which will capture the water quality volume. A typical approach for achieving capture of the water quality volume is to construct a diversion weir in the stormwater channel. For SCMs that require a diversion structure the following minimum design standards must be provided:

   (i) The height of the diversion weir must be equal to or greater than the surface elevation of the water quality volume in the SCM.

   (ii) The diversion structure must be capable of passing the peak flow rate of the twenty-five (25) year storm into the stormwater control measure.

   (iii) The maximum velocity entering the water quality basin shall not exceed two (2) feet per second.

   (iv) When runoff in excess of the water quality volume enters the stormwater channel it will spill over the diversion weir. The diversion weir must be designed to pass the peak flow rate of the one hundred (100) year design storm past the SCM with a head over the diversion weir of no more than one foot.

   (v) The water quality pond design shall allow enough freeboard to pass the design flow rate for the 100 year storm over the splitter/diversion structure without overtopping of any side walls of the pond, plus an additional 5% of the total fill height or three inches, whichever is greater, to allow for construction irregularities and long term soil settling.

Figures 1-48 through 1-50 in Appendix H of this manual presents examples of these structures.

2. SCMs that are allowed to stack the required detention volume or allow all storm events to flow through the SCM above the water quality volume are as follows:

   (1) Partial/Full sedimentation with sand filtration or biofiltration controls

   (2) Extended Detention

   (3) Retention Irrigation controls.

   (4) Batch Detention

   (5) Rain Gardens

   (6) Wet Ponds

   In-line SCMs that propose to stack the required detention volume or allow all storm events to flow through the SCM above the water quality volume must comply with the following criteria:

(ii) The velocity of the flows entering the SCM for the developed 100 year peak flow must not exceed two feet per second.

(iii) Velocity breaks and energy dissipation should be incorporated into the design to reduce erosive impacts on the SCM and to protect the medium (sand or biofiltration) from washing out or eroding.

(iv) Detention pond and SCM wall elevations must meet the minimum freeboard requirements provided in the Drainage Criteria Manual.

C. Basin Liners. All wet ponds require an impermeable liner. Impermeable liners may be clay, geosynthetic clay liner (GCL), geomembrane, or other approved liner, depending on the application. The analysis and design should entail a comprehensive review of the site specific conditions to determine the most appropriate type of liner for the site, and should include a stability assessment of the pond side slope. The criteria in item 1 below is applicable to any size wet pond.

1. The following criteria applies to wet ponds:

   There are a number of important engineering design and construction considerations for wet pond liners. A geotechnical engineer must be involved in all aspects of the liner design. All liner studies, plans, details, specifications and other related documents must be sealed by a geotechnical engineer. Careful attention must be paid to each of the following areas:

(i) Liner subgrade - A stable subgrade is very important in the construction of the pond. Careful evaluation must be conducted to ensure the liner will be placed on a suitable base. If any voids are encountered, proper geotechnical analysis must be performed to ensure that the integrity of the liner can be maintained. Proof rolling must be conducted as necessary to determine the suitability of the subgrade, and any suspect areas must be reworked and recompacted, or the weak soils removed and replaced with suitable fill material. The subgrade for geomembrane or GCL must be smooth and contain no particles greater than 0.375 inch diameter.

(ii) Liner characteristics - At least three types of liners can be considered, including a clay liner of appropriate thickness and permeability, a geomembrane liner, and GCL. Alternative liner designs may also be considered and shall be approved at the discretion of the City Engineer.

(1) If geomembrane is used, it must have a minimum thickness of thirty (30) mils and be ultraviolet resistant. Use of a geomembrane also requires that a suitable geotextile fabric be placed on the top and bottom of the membrane for puncture protection if any particles greater than 0.375 inch are present in the cover soil or subgrade surface, respectively. The geotextile material must have a minimum unit weight of 8 oz./sq. yd., a minimum puncture strength of 125 lbs., a minimum Mullen Burst Strength of 400 psi, and a minimum tensile strength of 200 lbs. The designer must demonstrate the liner's impermeability, and the method of liner protection to be used during maintenance and sediment removal operations. Equivalent methods for protection of the geomembrane liner will be considered by the Planning & Development Department on a case by case basis. Equivalency will be judged on the basis of ability to protect the geomembrane from puncture, tearing and abrasion. Individuals installing geomembrane liners must be trained and/or certified by the liner manufacturer. See City of Austin Standard Details 661-4 and 661-5 which illustrate acceptable geomembrane liner end details for use on concrete walls, stacked stone walls, and earthen embankments.

(2) If a clay liner is used, it must be designed for the site-specific conditions by a geotechnical engineer, and must have a minimum thickness of twelve (12) inches or greater. Coefficient of permeability must be 1x10-7 cm/sec or less. Other parameters must be as follows: plasticity index of not less than 15; liquid limit of not less than 30; and at least 30% clay particles passing the No. 200 sieve, with a maximum particle size of 1 inch. Soil must be processed to reduce clod size as much as possible prior to compaction and compaction of the lifts must be done using footed rollers. Clay compaction must be no less than 95% of Standard Proctor Density at or above optimum moisture content or 90% of Modified Proctor Density at a moisture content between 1% dry and 3% wet of optimum. Soil sampling and testing must be conducted on the borrow source and installed liner samples as applicable. Liner material verification sampling and testing should occur at frequencies which must be in accordance with the QA/QC plan. In-situ materials may be used if it can be demonstrated that all required liner parameters will be met. If the clay liner is to be overlain by a drainage layer, a suitable geotextile fabric must be placed on the surface of the liner prior to placement of the drainage layer to prevent plugging of the drain by the clay liner. Standard Detail 661-5 illustrates this placement.

(3) Geomembrane or GCL liner placement over excavated rock requires installation of protective material to prevent damage to the liner. Examples of protective material include spray-on fiberglass, additional clay liner material, or placement of a geosynthetic fabric.

(4) An alternative liner design may be approved by the City Engineer if it can be demonstrated by the responsible party that the liner is at least equivalent to or exceeds the above requirements.

(iii) Handling of liner penetrations - Liner penetrations are one of the areas of the pond that are most susceptible to leakage. It is critical that the design and construction of these areas pay special attention to liner continuity around these interface points. Detailed analysis must be performed related to the handling of all areas of liner penetrations such as pipe inlet and outlet structures, headwalls, and areas where concrete access ramps, maintenance and pump pads interface with the liner. Penetrations for wet ponds should be placed to minimize the hydraulic head over the penetration. Consideration must be given to the need for special applications such as anti-seep collars, gaskets, clay or bentonite plugs, special backfill and compaction, and other measures to prevent leakage around all these areas.

(1) Submerged Inlets and Storm Sewers - Due to excessive leakage issues submerged inlets and storm sewers to SCMs are to be avoided whenever possible. In situations where site conditions require a submerged inlet or storm sewer then the portion of the inlet pipe that is placed below the water quality elevation must be designed to store water, not simply convey it. In these situations the pond liner must extend and surround the portion of the inlet pipe or storm sewer that is designed to be under water and all structural elements and piping below the water quality elevation shall be watertight. Acceptable watertight piping includes gasketed RCP, PVC, and wastewater grade HDPE. Leak testing of the system will be performed to verify that the system is watertight and able to perform as designed.

(iv) Protecting the liner from erosion - The integrity of the liner, particularly a clay liner, can be severely compromised by any erosion that may occur at the surface of the liner. The design must provide appropriate mechanisms to prevent erosion of the liner at all areas, including the inlet structure and the separation berm between the forebay and main pool of wet ponds. Additionally, the liner must be continuous under wet pond separation berms to minimize the potential for leakage at the equalization/interbasin pipe.

(v) Protecting the liner against damage and loss of moisture - It is imperative that the clay liner be kept moist during construction and prior to the time the basin is filled. Otherwise, cracks can develop in the clay, particularly during the hotter months of the year, thereby rendering it susceptible to leakage. Provisions must be included in the construction documents that require the contractor to protect the liner against loss of moisture until the basin is completely filled. Damage to unprotected clay, GCL, or geomembrane liners can also occur due to passage of equipment during construction or during future sediment removal and maintenance operations. To minimize the possibility of damage and drying, all liner designs should include a protective soil layer over the liner with a minimum thickness of 12 inches for clay liners, and 24 inches for GCL and geomembrane (the 24-inch thickness can be reduced for liners which are never to undergo traffic by heavy equipment or are otherwise protected from heavy equipment). The protective cover layer includes 6-inches of topsoil per Section 1.4.7.B.

(vi) Liner Plans and Specifications - The engineer must prepare the necessary plans and specifications to provide the contractor clear direction for the construction of the liner and all related components. Construction details must be included for all liner cross-sections, penetrations, and any other areas requiring special attention and/or guidance to ensure proper construction. A scale drawing of the area to be lined, including a grid established across the base and side slopes of the pond with target elevations shown, must also be prepared by the engineer. This grid will provide a basis for verification of liner thickness during construction and will be used for the purpose of recording elevation data prior to placement of the initial lift and following placement of the final lift. All required testing, standards, procedures, and material properties must be spelled out in detail in the documents. Parties who are responsible for any surveying, sampling, testing and other verification requirements must be identified in the documents.

(vii) Groundwater Control - Liners constructed below groundwater will require dewatering as necessary to allow construction of the liner. To prevent damage to the liner due to uplift pressures after termination of dewatering or during future maintenance, the liner must include placement of sufficient soil ballast or additional thickness of clay liner to resist any uplift pressures. Alternative designs to relieve liner uplift pressure (French drain, etc.) will be considered and must be approved by the City Engineer.

(viii) Construction Quality Assurance/Quality Control Plan - A construction Quality Assurance/Quality Control (QA/QC) Plan must be prepared by the engineer for the purpose of providing a basis for all construction/installation and testing of the liner system during the liner construction process. The QA/QC plan must be approved by the City prior to liner construction.

(1) For clay liners, the QA/QC plan must include, but not be limited to, the following items: recordkeeping documents, including daily construction reports, inspection and test data sheets, non-conformance and corrective measure reports, design and specification changes, and all other documentation accumulated by inspection personnel during construction; pre-construction soil sampling, testing and documentation protocol, including the type of information to be documented for each sample, and the test procedures to be used; protocol during construction, including the monitoring of the subgrade, as well as material placement (including items such as density testing and moisture content, lift thickness and bonding, processing of soil and reduction of clods, footed compaction equipment, and number of passes of compaction equipment), sampling and testing procedures, frequencies and other requirements. Also, the handling of any liner perforations as a result of various types of testing must be addressed along with guidance on how to address any deficiencies that may be discovered, including corrective measures to be taken.

(2) For geomembrane and GCL liners, the QA/QC plan must include, but not be limited to, the following items: geomembrane/GCL manufacturing and delivery data requirements, including raw materials properties, roll and production quality assurance and control data requirements, along with transportation, handling and storage requirements, and conformance testing; installer qualifications requirements; installation requirements, including surface preparation, system anchorage, geomembrane/GCL placement (including, but not limited to panel identification, placement and installation schedule), seaming information (including, as applicable to geomembrane or GCL, seam layout, preparation, equipment, weather conditions, trial welds, general procedures, non-destructive testing and destructive testing), identification of defects and repair procedures, and geomembrane/GCL acceptance procedures.

(ix) Soils and Liner Evaluation Report (SLER), Geosynthetic Clay Liner Evaluation Report (GCLER), or Geomembrane Liner Evaluation Report (GLER) - All liner construction and QA/QC activities must be under the supervision of an independent licensed engineer with experience in geotechnical engineering. The engineer or designated representative must be on site during all significant liner construction activities, including but not limited to:

(1) At the beginning of liner construction to inspect subgrade acceptability;

(2) During the processing of clay liner material for placement to ensure adequate moisture conditioning and particle size reduction;

(3) During placement of clay liner lifts to ensure 6 inch maximum lift depth is not exceeded and compaction is sufficient;

(4) During all geomembrane installation;

(5) During clay and geomembrane liner testing;

(6) Prior to placement of successive clay lifts to verify acceptability of prior lift surface;

(7) During construction of penetrations and any other construction that will affect the integrity of the liner (access ramps, pump pads, etc.).

(8) During placement of protective soil layer.

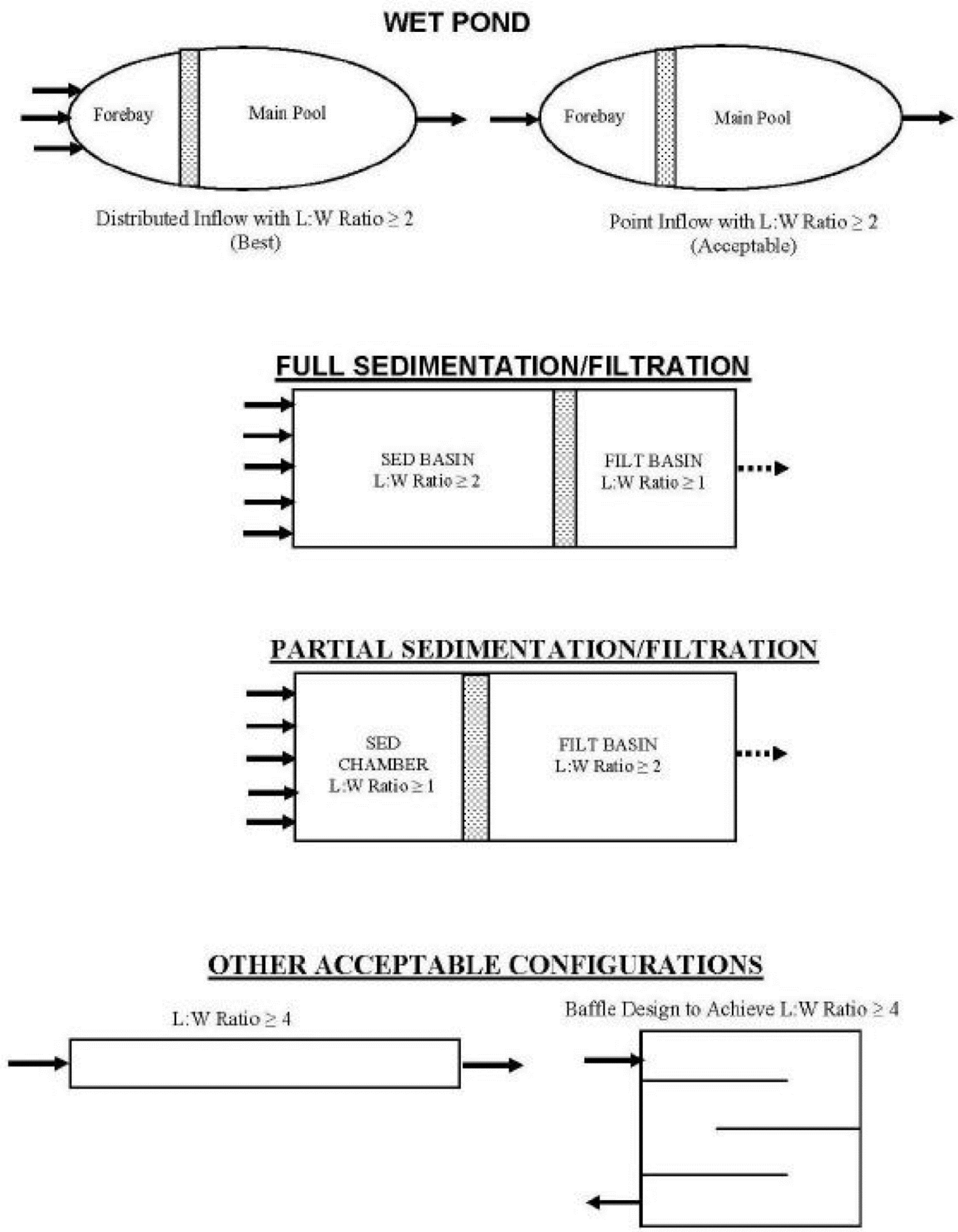
Following completion of the liner construction, SLER, GCLER, or GLER (as applicable for the type of liner installed) must be prepared under the direction of and sealed by the engineer and submitted to the City. The report is intended to provide documentation of all installation methods and testing procedures conducted during the installation of the liner and to provide evidence that the liner was constructed in accordance with the construction plans, technical specifications and QA/QC plan.

(x) Water Level Monitoring for liner integrity verification in wet ponds - After the filling and installation of aquatic vegetation in a wet pond, the water level of the permanent pool shall be measured monitored for a minimum of eight weeks. The engineer shall specify the method and frequency of monitoring, and the responsible party for conducting water level monitoring. The engineer shall perform a water balance to determine that the water loss does not exceed anticipated losses from calculated liner leakage, evaporation, plant transpiration and discharge. All monitoring data and calculations must be documented and submitted to the City of Bee Cave for review.

D. Short-Circuiting and Dead Storage. All water quality controls shall be designed to minimize short-circuiting (flow reaching the outlet structure before utilizing the entire water quality volume and/or surface area) and dead storage (areas within the basin which are by-passed by the flow regime and are, therefore, ineffective in the treatment process). Irregular shapes shall be avoided, or shall use baffles or other measures to achieve adequate hydraulic efficiency. Inlet and outlet structures shall be located at extreme ends of the basin. Pilot channels are discouraged in water quality ponds due to the creation of short-circuiting and standing water problems.

For sedimentation basins, sediment chambers, and filtration basins the inflow shall be discharged into the basin uniformly across the basin width (see Figure 1-48, Appendix H). Ideally the inlet (diversion) structure should be designed to provide this uniform flow distribution; if not a flow spreader is required in the basin to distribute flows. Use the flow spreader design criteria shown in Figure 1.6.5.A, Full Sedimentation/Filtration Riser Pipe Outlet System and Determining Location of Flow Spreader in Filtration Basin or the reinforced vegetated hedgerow shown in Figure 1.6.7.C.2, Partial Sedimentation/Biofiltration pond. See Figure 1.6.2.D for preferred configurations for different SCMs (Note: Some figures are shown as rectangular shapes for simplicity; designs are not required to have straight edges).

Figure 1.6.2.D Water Quality Control Configurations (adapted from Persson, Somes, Wong. Hydraulics Efficiency of Constructed Wetlands and Ponds, 1999)

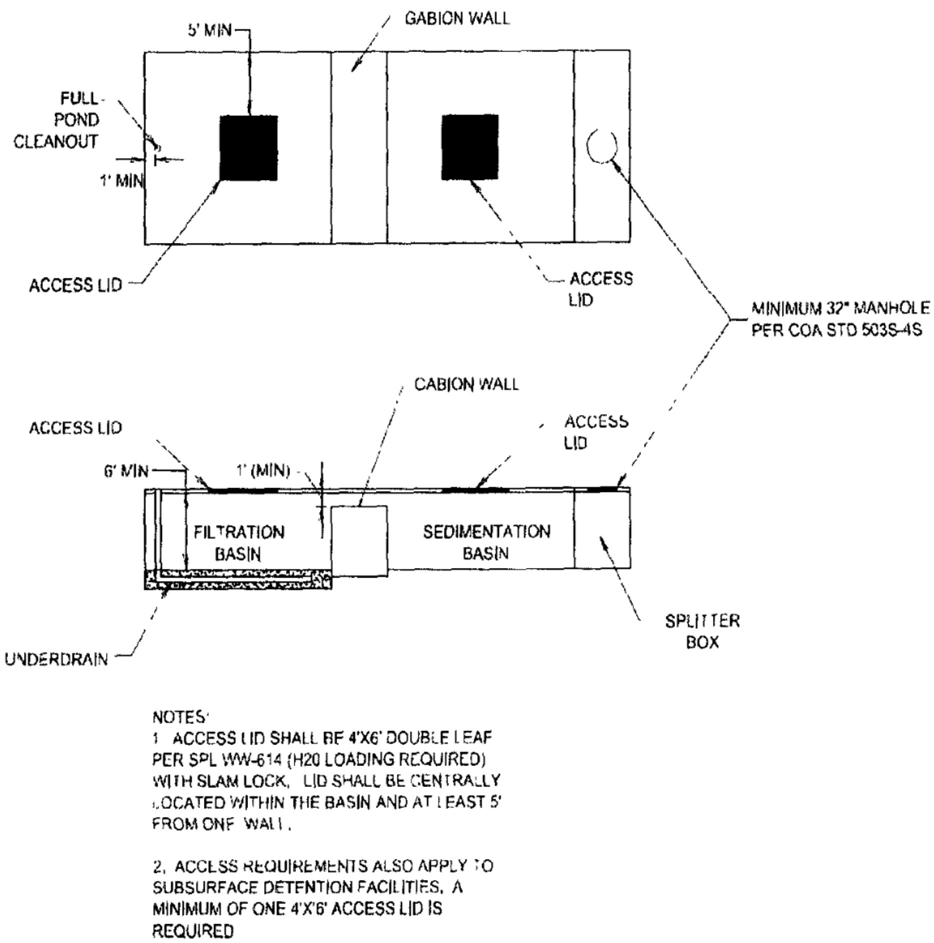


E. Subsurface Ponds. Based upon field observations, subsurface ponds can be difficult to inspect and maintain due to accessibility and constructability restraints. This section describes the minimum design and submittal requirements for subsurface ponds.

1. The Engineer of Record shall prepare and submit a Subsurface Pond Maintenance (SPM) plan for the proposed development to be reviewed as part of the Site Development Permit. This document shall be signed and sealed by a Licensed Professional Engineer in the State of Texas.

2. An SPM plan must contain the following minimum components:

(i) Access. Adequate access including at least one temporary staging area for each subsurface pond must be provided for inspection and maintenance purposes. See Figure 1.6.2.E for minimum design standards for access points and sizing.



(ii) Inspections. Underground water quality facilities must be inspected at least once every six months and at least once annually during, or immediately following, a significant rainfall event to evaluate facility operation. During each inspection, erosion areas inside and downstream of the underground water quality facility must be identified and repaired immediately. With each inspection, any damage to the structural elements of the system (pipes, concrete drainage structures, retaining walls, etc.) must be identified and repaired immediately. Cracks, voids and undermining should be patched/filled to prevent additional structural damage. At least once annually, a pond drawdown report for each subsurface pond shall be completed in conjunction with a rainfall event equal to or greater than the design capture depth of the subsurface facility or a test of the pond after being filled by a secondary water source. The drawdown report shall indicate the date and time the pond(s) were observed full and the date and time the ponds were observed to be empty verifying that the sedimentation and filtration chambers both drawdown in the time frames as required by the ECM. At least one inspection shall be done annually by a 3rd party inspector and an annual 3rd party inspection report shall be submitted to the City for review. The City shall be notified at least seven days prior to the annual 3rd party inspection to allow for the opportunity for observation. The annual 3rd party inspection report shall be sealed by a Texas Professional Engineer, shall include photographs of the sedimentation and filtration chambers, and the drawdown verification report.

(iii) Sediment Removal. Remove sediment from the inlet structure and sedimentation chamber when sediment buildup reaches a depth of 6 inches or when the proper functioning of inlet and outlet structures is impaired. Sediment should be cleared from the inlet structure at least every year and from the sedimentation basin at least every 5 years.

(iv) Media Replacement. Maintenance of the filter media is necessary when the drawdown time exceeds 96 hours provided all other components of the pond are functioning correctly. When this occurs, the upper layer of sand should be removed and replaced with new material meeting the original specifications. If dewatering of the system is necessary due to lack of functionality, ensure dewatering is properly conducted.

(v) Debris and Litter Removal. Debris and litter should be removed regularly. Particular attention should be paid to floating debris that can eventually clog the control device or riser.

(vi) Filter Underdrain. Clean underdrain piping network to remove any sediment buildup as needed to maintain design drawdown time.

(vii) Responsibility. The responsibility of the inspection and maintenance of all subsurface ponds shall be the responsibility of the owner/operator of the facilities.

The requirements discussed above should be considered minimum requirements for a SPM plan. In developing a SPM plan, the engineer should consider the plan to be site-specific, and therefore add any additional requirements to ensure the pond has adequate access and can be inspected. During the course of inspections and field observations, adjustments to the SPM may be required. The plan may be amended with the submission of additional or amended parts of the plan and approval by the City Engineer.

3. For commercial and multi-family developments, a restrictive covenant and site plan notes will establish the requirements for the implementation and on-going maintenance of the SPM plan. The restrictive covenant must be in a form approved by the City's Legal Council.

F. Integrated Pest Management Guidelines. Integrated Pest Management (IPM) plans are required for the following stormwater control measures (SCMs):

Wet pond - 1.6.5

Retention/Irrigation Systems - 1.6.7.A

Vegetative Filter Strips - 1.6.7.B

Biofiltration - 1.6.7.C

Rainwater Harvesting - 1 .6.7.D

Non-Required Vegetation - 1.6.7.G

Rain Garden - 1.6.7.H

Extended Detention – 1.6.6

Batch Detention – 1.6.6

The management of these SCMs must adhere to the techniques and control options described in this section and documented in an approved IPM plan. 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. Manage the treatment system in conformance with the following criteria:
   - **(i)** Applicability of Plan - These performance requirements apply to the entire SCM, as well as areas immediately adjacent to and related to the facility (including access areas, easements, irrigation and infiltration areas, etc.).
   - **(ii)** Vegetation Functions - The vegetation in an SCM is integral and necessary for it to function properly. A minimum of 95% of the vegetation shall be alive and viable throughout the life of the system. No bare areas greater than 10 square feet may exist. These performance requirements apply to the entire SCM including the pond bottom, side slopes, and areas adjacent to the pond.
   - **(iii)** Mowing and/or Trimming - Mowing and/or trimming of herbaceous vegetation shall occur with certain restrictions.
   - **(iv)** Tall 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. In all cases, clippings and trimmings shall be bagged and removed from the site.
   - **(v)** Turf and other 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 four (4) inches from the ground. All clippings and trimmings shall be bagged and removed from the site.
   - **(vi)** Weed Management - A weed is generally defined as any plant in the wrong place. Refer to the original design and construction documents when uncertainty exists as to the appropriateness of a specific plant. Preventing the introduction of weeds is the most practical and cost-effective method for their management. Avoid bare soil by minimizing soil disturbance and properly managing desirable vegetation. Remove weeds early in their growth stage; before they set seed. Allow the desired vegetation to out-compete the weeds. It is necessary to allocate greater resources on landscape maintenance during the initial 3-year establishment period. During this time weed "pressure" from the drainage area will be greatest, as will availability of bare surface areas within the treatment system. These factors allow weeds to gain a foothold, especially during the first few months of the life of the water quality control.
   - **(vii)** Cultivation - May be done with hand tools; using cultivating machines is not acceptable. Cultivation can be repeated at 2— 3 week intervals during the growing season. Any bare areas must be re-seeded.
   - **(viii)** Biofiltration and Rain Garden SCMs - Mulching to control weeds by blocking light and air space is acceptable.

(1) Wood 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 to cover the soil surface both in the sediment basin and the filter basin.

(2) Gravel or crushed recycled glass equivalent in size to gravel may be used to cover the soil surface in biofiltration.

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

(ix) Pesticides (includes herbicides) and Fertilizer - The use of landscape chemicals, including fertilizer and pesticides, are not allowed within the treatment system without the approval of the City's IPM Coordinator. For additional information, contact the Planning & Development Department.

(x) Invasive or Noxious plants - Plant species listed as invasive or noxious by the Texas Department of Agriculture are not allowed to be planted or grown naturally in SCMs or their associated areas. Additionally, the City of Austin has a list of recommended top invasive plants to avoid. Refer to the following website for the list of plants and additional information: **http://www.austintexas.gov/invasive.**

(xi) Mosquito Management - SCMs shall not be a breeding place for mosquitoes. Incidental standing water must not be present for longer than four days (96 hours). If water exists for periods longer than this, the party responsible for maintenance shall remove the water from the SCM and conduct any repairs or design flaws to ensure that this condition is not repeated.

(xii) Wildlife and Pet Management - In addition to water quality treatment, SCMs offer environmental benefits such as providing food and habitat for wildlife. Pets may also be attracted to them. Digging or burrowing by animals is particularly troublesome. Activities by animals within the SCM should be discouraged so to not interfere with its functions and design objectives. Where on-going problems with wildlife exist, fencing or similar exclusionary methods shall be implemented.

(xiii) Irrigation System Performance - Not all water quality treatment facilities include an irrigation system. When an irrigation system exists evaluate the efficiency of the system on a periodic basis, especially at the beginning of each irrigation season. The evaluation shall identify problems with the system and ensure that problems are properly addressed (See Section 1.6.3.D, Irrigation Guidelines).

(xiv) Erosion - Erosion damage to the treatment system shall be repaired immediately. Determine the cause of the erosion and address the situation to prevent it from recurring.

(xv) Restrictive Covenant - A restrictive covenant is required to be filed. The restrictive covenant is the legal document requiring the use of IPM on a given site.

2. Plan Notes

(1) For commercial and multi-family developments site plan notes will establish the requirements for the implementation and on-going maintenance of the IPM plan.

(2) For residential subdivision development, the developer must include plat notes approved by the City regarding the use of pesticides and fertilizers through an IPM plan.

Public Education Program - All applicants proposing SCMs on residential development lots must provide these guidelines to all homeowners and tenants.

Plans for Specific Pests and Other Landscape Issues - Refer to the Grow Green website for updated versions of recommended management techniques for specific pests and issues. **http://www.austintexas.gov/department/grow-green**

G. Water Quality Facilities In-Series. Facilities can be designed and constructed in-series to achieve the total TSS, TP, and O&G removal requirements of the City of Bee Cave using the guidelines in this subsection.

The efficiency of each subsequent water quality facility in-series is calculated to be less considering the pollutants that are most readily removed are captured within the first water quality facility. Therefore, the following equation shall be utilized individually for TSS, TP, and O&G based on the efficiency rating of the selected facility to calculate the total efficiency of the water quality facilities in-series:

$$E_{TOT} = [1 - ((1 - E_1) \times (1 - 0.65E_2) \times (1 - 0.25E_3))] \times 100$$

Where:

E_{TOT} = Total TSS, TP, or O&G removal efficiency of series (%)

E_1 = Removal efficiency of first facility (decimal)

E_2 = Removal efficiency of second facility (decimal)

E_3 = Removal efficiency of third facility (decimal)

1.6.3 MAINTENANCE AND CONSTRUCTION REQUIREMENTS

A. Maintenance Responsibilities. Proper maintenance is as important as engineering design and construction in order to ensure that water quality controls, referred to herein as stormwater control measures (SCMs), will function effectively. Article 7 of the City's UDCs requires maintenance be performed on SCMs when necessary as defined by this section.

Stormwater control measures required for single-family residential, commercial, and multi-family development shall be maintained by the applicable property owner and/or homeowners association. The City will also maintain SCMs designed to service primarily publicly owned roads and facilities. These SCMs must be designed and built according to the appropriate city standards.

B. Maintenance Requirements—Design and Construction.

The design of drainage facilities (including but not limited to headwalls, open channels, storm sewers, area inlets, and detention, retention and stormwater control measures and their appurtenances) shall comply with the requirements of the Drainage Criteria Manual. In addition, SCMs shall comply with the following construction requirements:

1. Sediment removed during construction of a detention, retention, or water quality facilities may be disposed of on-site if properly stabilized according to the practices outlined in the erosion and sedimentation control criteria found in Section 1.4.0 of this manual. After the City of Bee Cave has accepted a stormwater facility, disposal of sediment must be at an approved landfill.

2. During construction of SCMs, temporary erosion and sedimentation controls shall be maintained.

3. If runoff is to enter the sand filtration chamber of a water quality control facility prior to completion of site construction and revegetation, inspection and maintenance of all temporary erosion/sedimentation controls are required, as described in the Environmental Criteria Manual **Section 1.4.4**, to prevent heavy sediment loads caused by home construction from clogging the filtration media.

4. In all cases, trees shall be preserved according to the requirements of **Section 3** of the Environmental Criteria Manual. The access drive and staging area shall be designed to preserve trees 8" (inches) in diameter and greater to the maximum extent possible. Trees 8" in diameter and larger shall be surveyed and shown for the proposed access easement at the time of construction plan permitting.

5. For filtration systems the design media depth must be verified, accounting for consolidation. If insufficient depth is present, additional media must be added and pre-soaked until the design depth is achieved. Pre-soaking - apply 5—10 gallons of water per square foot of media area within one hour.

6. Retaining Walls - Retaining walls within SCMs require water-tightness. Water-tightness in retaining walls is essential to the function of the structure. Waterstops shall be provided during construction of expansion joints in retaining walls per Standard Specification 414S, Concrete Retaining Walls.

7. Grouted Rock Walls - Grouted rock walls are acceptable only if the design includes an impermeable barrier such as an approved geomembrane liner or reinforced concrete retaining wall. Free standing dry stacked rock walls are not acceptable in any SCM.

C. Major Maintenance Requirements.

1. The following maintenance activities shall be performed on all SCMs, in addition to the requirements listed for the individual SCM types, to ensure proper function:

(i) Accumulated paper, trash and debris shall be removed every six (6) months or as necessary to maintain proper operation.

(ii) Structural integrity shall be maintained at all times. Basins and all appurtenances shall be inspected annually, or more frequently if specified, and repairs shall be made if necessary. When maintenance or repairs are performed, the SCM shall be restored to the original lines and grades.

(iii) Corrective maintenance shall occur:

(1) Any time drawdown of the Water Quality Volume does not occur within ninety-six (96) hours (i.e., no standing water is allowed), unless a greater maximum drawdown time is specified in the plans.

(2) For detention ponds only, any time drawdown does not occur within twenty-four (24) hours.

(iv) The inlet and outlet of SCMs shall be maintained unimpeded in order to convey flow at all times. Observed blockages to the inlet and outlet, due to vegetation, sediment, debris, or any other cause, shall be removed.

(v) No unvegetated area shall exceed ten (10) square feet. This performance requirement applies to the entire pond including the pond bottom, side slopes, and areas adjacent to the pond, and is intended to limit erosion.

(vi) Integrated pest management shall be performed and shall adhere to Section 1.6.2.F, Integrated Pest Management Guidelines.

(vii) The minimum vegetation height shall be four (4) inches in the SCM and all appurtenances, including the toe of the berm or wall outside the SCM, where applicable.

(viii) Sediment build-up shall be removed:

(1) When the accumulation exceeds six (6) inches in splitter boxes, wet wells and basins.

(2) When sediment traps are full.

(3) When sediment, of any amount, causes standing water conditions or reduces basin storage by more than 10%.

(ix) When sediment is removed, the following requirements apply:

(1) Irrigation shall be provided, as needed, until vegetation is established (well rooted). See Section 1.6.3.D, Irrigation Guidelines.

(2) The design depth of the filtration media shall be verified. See Section 1.6.3.B.5.

(3) Tilling of the filtration medium is not allowed.

(x) For subsurface ponds maintenance plan requirements, refer to ECM **Section 1.6.2**(E).

2. Sedimentation and Filtration SCMs (**Section 1.6.4**).

(i) Vegetation within the SCM shall not exceed eighteen (18) inches in height at any time, except as called for in the design.

(ii) Vegetation that is mowed or cut shall be removed from the SCM.

3. Detention Basins.

(i) Vegetation within the basin shall not exceed eighteen (18) inches in height at any time.

4. Wet Ponds.

Due to the nature of wet ponds being full of water when in operation, the need for maintenance is not easily visible. However, when the ponds are built in stable upland areas, the need for maintenance of these ponds should be infrequent. Accumulation of sediment in the basin is the primary reason the pond will require intensive maintenance. Because of this, very careful attention should be paid to adequate, well-maintained erosion and sedimentation controls in the contributing drainage area during construction. This, in combination with the sediment forebay, should prevent the requirement of maintenance of the main pool soon after the pond is put online. The following are guidelines for pond maintenance:

(i) During Site Construction - The sediment load to the sediment forebay shall be closely monitored after every storm event. If heavy sediment loads are detected during an inspection, the source should be corrected. Sediment shall be removed from the sediment forebay when one-third of the forebay volume is lost.

(ii) Upon Completion of Site Revegetation - Any sediment build-up (greater than 5% volume loss) shall be removed from the forebay upon completion of site revegetation. The sediment build-up in the main pool shall be checked and if more the ten- percent of the volume is lost, it should be cleaned at that time. Forebay and main pool volumes shall be confirmed by an as-built survey post-construction and shall be provided to the City prior to final site closeout. The as-built survey must provide enough detail to verify the pond was constructed in accordance with the approved pond design.

(iii) Every Three Months for the First Two Years - During the three-month initial inspection cycle, if more than fifteen percent of the volume of the forebay is lost, it shall be cleaned at that time.

(iv) Every Three Months - Turf areas around the pond should be mowed. Accumulated paper, trash, and debris shall be removed every three months or as necessary. Cattails, cottonwoods, and willows can quickly colonize shallow water and the edge of the pond. These species or any areas of plant overgrowth may be thinned at this time or as needed.

(v) Annually - The basin should be inspected annually for side slope erosion and deterioration or damage to the structural elements. Any damage shall be repaired. Large areas, which have dead or missing vegetation, shall be replanted.

- **(vi)** Every Three Years - The sediment build-up in the sediment forebay shall be checked. The sediment forebay shall be cleaned if more than six inches (6”) of sediment build-up is present at any location in the basin or more than twenty percent (20%) of the forebay volume is lost.
- **(vii)** Every Six Years - The sediment build-up in the main pool shall be checked. Sediment shall be removed from the main pool if more than six inches (6”) of sediment build-up is present at any location in the basin or more than twenty percent (20%) of the main pool volume is lost.

5. Retention-Irrigation Systems (Section 1.6.7.A1).

- **(i)** Basins. Structural integrity of basins shall be maintained at all times. Woody vegetation should be controlled/removed to prevent basin leakage. The ability of the basin to retain the water quality volume shall be evaluated by the COBC.
- **(ii)** Irrigation Areas. To the greatest extent practicable, irrigation areas are to remain in their natural state. However, vegetation must be maintained in the irrigation area such that it does not impede the spray of water from the irrigation heads. Tree and shrub trimmings and other large debris must be removed from the irrigation area. See requirements in Section 1.6.7.A.3.(g) and (h) regarding requirements for soil and vegetation in irrigation areas.
- **(iii)** Pumps and Irrigation System. The pumps and irrigation system must be inspected or tested a minimum of six (6) times per year to show all components are operating as intended. Two (2) of these six (6) inspections should be after rain events to ensure that the irrigation system and all of its components perform as designed. This includes controls such as weather stations or rain sensors, delays, valves, alarm system, distribution lines, or other components as specified in the system design. Sprinkler heads must be checked to determine if any are broken, clogged, or not spraying properly. All inspection and testing reports must be kept on site and accessible to the City of Bee Cave.
- **(iv)** The overall system shall be inspected for the ability to retain the water quality volume on site per ECM Section 1.6.7.A.

6. Vegetative Filter Strips (Section 1.6.7.A2).

- **(i)** Filter strips shall be managed so that a dense, healthy vegetative cover is preserved.
- **(ii)** Unmowed vegetative filter strips are preferred. If mowed the cutting height shall be set to a minimum of four (4) inches for turfgrass and a minimum of 18 inches for bunchgrass. Grass clippings must be removed from the VFS in order to prevent export of nutrients.
- **(iii)** Bare spots and areas of erosion identified during inspections must be replanted and restored to meet specification.
- **(iv)** Accumulated sediment shall be removed.
- **(v)** Any disturbance to the filter strip as a result of maintenance procedures or other reasons shall be repaired, including re- establishment of the vegetation.
- **(vi)** Corrective maintenance is required if there is evidence of preferential flow paths around or through the VFS (e.g., upstream "lip" is silted in or installed too low).
- **(vii)** The level spreaders shall be repaired if damaged or not functioning correctly.

7. Biofiltration and Rain Gardens (Sections 1.6.7.A3 and 1.6.7.A8).

- **(i)** Maintenance Considerations in Design.
  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). The designer shall include maintenance considerations and IPM throughout the planning and design phase of a

biofiltration project. 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).

(ii) Routine 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, and biofiltration pond vegetation shall be managed so that a dense, healthy vegetative cover is preserved. The following maintenance items should be performed depending on frequency and time of year:

(1) **Biweekly during first growing season**: Inspect vegetation until 95% vegetative cover is established. **Monthly**: Check for accumulated sediments, remove as needed.

(2) **Quarterly**: Remove debris and accumulated sediment; replace soil media in void areas caused by settlement; repair eroded areas; remulch by hand any void areas.

(3) **Semi-annually**: Remove and replace dead or diseased vegetation that is considered beyond treatment (see planting specifications); treat all diseased trees and shrubs mechanically or by hand depending on the insect or disease infestation. If drawdown exceeds the drawdown time according to Section 1.6.3.C.1, lightly scarify soil with hand cultivator; if standing water remains for greater than 96 hours, remove top layer of sediment, mulch, and potentially vegetation; de-compact soil by scarification, and replace mulch and disturbed vegetation.

(4) **Late winter**: Trim bunch grasses; mow turf grasses; harvest other types of vegetation according to recommendations in the planting specifications. Adhere to Section 1.6.2.F.

(5) **Spring**: Remove previous mulch layer and apply new mulch layer by hand (option) once every two to three years.

(iii) Other items.

(1) Signage shall be used to delineate the boundaries of the biofiltration area that are maintained with minimal mowing, no fertilizers, and limited use of organic herbicides.

8. Rainwater Harvesting (Section 1.6.7.A4).

Proper monitoring and maintenance is important for any system to work appropriately and efficiently. Each configuration will perform differently. After the system has stabilized, inspection and maintenance might be needed several times a year and/or after heavy rainfall events. A pretreatment filter system (i.e., leaf guards, strainers, roof washers, etc.) is required prior to the cistern.

Maintenance activities shall be performed according to the following schedule:

(i) Post Construction:

(1) The control and repair of erosion rills, from the irrigation system, should take place after each rainfall event until the vegetation is well established.

(2) Adjustments to the irrigation area should be considered as the vegetation matures and/or to minimize erosion problem areas.

(ii) Quarterly or after each rain event:

(1) Inspect water tanks periodically to insure proper functioning. Screen inlet and outlet pipes to keep the system closed to mosquitoes. Cap and lock tanks for safety.

(2) Caps should have access ports for interior inspection and maintenance.

(3) Clean pretreatment filter system, gutters, inflow, and outflow pipes as needed; sediment, trash, leaves, or other debris should not be allowed to accumulate to a point where it impedes the proper function of the rainwater harvesting system.

(4) Irrigation systems should be cleaned and damage sprinkler heads replaced. Other items:

(1) The requirements for retention/irrigation systems apply when rainwater harvesting is designed to irrigate a vegetated area - see Section 1.6.3.C.5.

(2) The requirements for vegetative filter strips apply when a rainwater harvesting is designed to discharge to a vegetated area to be infiltrated - see Section 1.6.3.C.8.

9. Porous Pavement (Section 1.6.7.A5). General Maintenance

(i) Verify that the porous pavement receives no off-site runoff.

(ii) Prior to final acceptance it must be demonstrated that the surface saturated hydraulic conductivity of any portion of the porous pavement is at least 20 inches/hour or, if the system is saturated, the entire water quality volume infiltrates into the subgrade within 48 hours.
Use the following testing methods to verify:

(1) For porous concrete and porous asphalt use ASTM C1701.

(2) For open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP) use ASTM C1781.

(iii) Construction and Post construction:

(1) When installing porous concrete, floating and troweling are not used, as those may close the surface pores.

(2) Do not seal or repave with non-porous materials.

(3) No piling of dirt, sand, gravel, or landscape material without covering the pavement first with a durable cover to protect the integrity of the pervious surface.

(4) All landscape cover must be graded to prevent washing and/or floating of such materials onto or through the pervious surface. No off-site flows allowed onto the porous pavement area.

(5) All chemical spills inclusive but not limited to petrochemicals, hydrocarbons, pesticides, and herbicides should be reported to the owner so they can prevent uncontrolled migration.

(6) Chemical migration control may require flushing, and/or the introduction of microbiological organisms to neutralize any impacts to the soil or water.

(iv) Monthly:

(1) Ensure that paving area is clean of debris, ensure that paving dewaters between storms, and ensure that the area is clean of sediments.

(v) Semi-annually:

(1) Ensure that the porous pavement is protected from clogging due to runoff from landscape areas, rooftops, and other areas that may significantly reduce the long-term permeability by diverting flows away.

(vi) Annually:

(1) To ensure that the entire water quality volume infiltrates into the subgrade within 48 hours the pervious surface should be vacuumed to restore the open permeable pores and lift the sediment or other contaminants out that may reduce the long- term permeability.

(2) It is required that this frequency be increased for areas where overhanging vegetation, excessive dirt, and pollutants are frequent.

(3) Inspect the surface for deterioration. As necessary, repair or replace porous pavement or, for open-jointed block pavement or permeable interlocking concrete pavement replenish aggregate within the joints.

10. Non-Required Vegetation (Section 1.6.7.A7).

(i) An approved Integrated Pest Management Plan with a recorded Restrictive covenant is required. It is extremely important that fertilizer and chemical use be minimized; otherwise the Non-required vegetation may become a source of pollution instead of a treatment best management practice. Tree Pruning and vegetation management should be modified (i.e., less frequent and less intensive) to maximize the leaf surface area, or Leaf Area Index (LAI), the 25-year growth root system, and the rainfall interception rate to increase future benefits.

(ii) As non-required vegetation is to have no off-site runoff and is also required to have porous pavement (or undisturbed natural ground) extended to at least the 25-year growth root system, the porous pavement requirements apply (see 1.6.3.C.9).

(iii) Damage to vegetation must be corrected immediately, with replanting done if necessary.

(iv) Irrigation Guidelines.
Temporary irrigation is required to establish plants during the first 12-months after installation. Thereafter irrigation needs should be minimal and an irrigation system whether permanent or temporary may not be necessary depending on the weather, type of plants, and extent of plant establishment.

Supplemental watering after the first 12-months may be required during periods of extended drought if plant replacement occurred after the first year, for more mesic-type plants, and for trees. Trees typically require two to three years of supplemental water. The necessity for continued irrigation after the first year should be made by a landscape professional.

1.6.4 DESIGN GUIDELINES FOR SEDIMENTATION/FILTRATION SYSTEMS

A. Partial Sedimentation/Filtration.

1. Basin Surface Areas and Volume. A filtration rate of 0.0312 gallons per minute per square foot has been selected for design criteria (six (6) feet per day or two (2) million gallons per acre per day). This filtration rate is based on a Darcy's Law coefficient of permeability of two (2) feet per day, an average hydraulic head of three (3) feet and a sand bed depth of 18 inches. This filtration rate is less than that assumed for the filtration basin in the full sedimentation/filtration system due to higher sediment loading and consequent clogging of the filter media. Section A above contains an explanation of how the filtration rate and coefficient of permeability were determined.

Note: The top surface of the sand filter bed must be horizontal, i.e., no grade is allowable.

The following equation gives the minimum surface area required for the filtration basin: $Af = WQV/(4+1.33*H)$

where "Af" is the required surface area of the media in square feet and "WQV" is the water quality volume in cubic feet as defined in Section 1.6.2A, and H is the maximum ponding depth above the filtration media in feet.

The combined volume of the sediment chamber and filtration basin exclusive of the gabion volume must be equal to the water quality volume, i.e., Vs + Vf = water quality volume where "Vs" is the sediment chamber volume and "Vf" is the filtration basin volume.

The volume of the sediment chamber, "V s ", shall be a minimum of 20 percent of the water quality volume. If a splitter box/diversion structure is required, see Section 1.6.2.B, for minimum design standards.

2. Sediment Chamber Details. The sediment chamber consists of an inlet structure/flow spreader, settling area, and outlet structure. It is recommended that the bottom of the sediment chamber be ≥2 inches higher than the top of the filtration bed. The sediment chamber should have a minimum one (1) percent bottom slope to ensure that the pond will drain adequately even after silt accumulation. A minimum two (2) percent bottom slope is required for ponds where the City is responsible for maintenance.

   (1) Inlet Structure/Flow Spreader [see Sections 1.6.2.D and 1.6.4(A)(3) (Inlet Structure)].

   (2) Outlet Structure. The outlet structure should be a berm or wall with multiple outlet ports or a gabion so as to discharge the flow evenly to the filtration basin. Rock gabions should be constructed using five (5) to eight (8) inch diameter rocks. The berm/wall/gabion height should not exceed six (6) feet and high flows should be allowed to overtop the structure (weir flow). Multiple outlet ports should be used in the berm/wall so as to induce flow-spreading. The outflow side should incorporate features to prevent gouging of the sand media (e.g., concrete splash pad or riprap).

3. Sand Filtration Basin Details (see Section 1.6.4(A)(4)). See Figure 1-58 for flow diffuser outlet detail. In addition, install a removable PVC cap with an appropriately sized orifice at the end of the underdrain pipe in order to provide a forty-eight (48) hour drawdown time, to account for significant uncertainties to the actual filtration media hydraulic conductivity over the life of the system.

B. Pollutant Effluent Concentration Values for Sand Filtration Systems. For sedimentation/filtration systems designed in accordance with the guidelines in this section, the pollutant effluent concentrations shall be assumed to be equal to the concentrations listed below in Table 1.6.4.C.1. These concentrations shall also be used for load calculations that demonstrate that alternative controls perform equal to or better than sedimentation/filtration systems.

Table 1.6.4.C.1: Effluent Event Mean Pollutant Concentrations For Sand Filtration Systems For Austin, Texas

Pollutant	Unit	Effluent Concentration
COD	mg/L	22.4
EC	CFU/100 mL	4895
Pb	mg/L	0.00574
TN	mg/L	1.07
TP	mg/L	0.099
TSS	mg/L	20.62
Zn	mg/L	0.0230

Source: Stormwater Quality Evaluation Section, Planning & Development Department. (2013). Impacts of Stormwater Control Measures on Water Quality in Austin, TX. (Report Number CM-13-02). Austin, Texas: City of Austin Planning & Development Department.

1.6.5 DESIGN GUIDELINES FOR WET PONDS

A. Capture Volume. Wet ponds in general are designed to have three stages with three corresponding volumes, which are intended to meet the water quality and detention requirements. The first two stages, permanent pool and extended detention, are required for all ponds and function primarily as a water quality control. The second stage may also serve as a streambank erosion prevention measure. The third stage, flood control detention, serves as a flood control measure and is optional to the design of the wet pond. The permanent pool and extended detention volume shall be designed for the entire drainage area contributing to the control for which water quality controls are not already provided. Offsite areas, which are currently undeveloped, may be assumed undeveloped in the design. The primary reason to require extended detention for all of the developed drainage areas, which have not provided detention, is to prevent pond washout caused by high flow- through rates.

1. Permanent Pool - The permanent pool, the lowest stage of the pond, is designed to hold and treat a volume of runoff between storm events through quiescent settling and biological uptake. The permanent pool should remain nearly full at all times to provide a source of water for wetland plants which are used for biological uptake and to minimize turbulence within the pond during storm events which may result in resuspension of sediment. During storm events, the pond is designed to flush out the treated water and replace it with "new" runoff. The minimum surface area of the permanent pool must be greater than ½ acre (21,780 square feet).

   The effluent concentration of wet ponds is directly related to the time the runoff is held in the pond. The longer the runoff is held in the pond, the more settling and biological uptake that can occur. Based upon national and local monitoring data, a hydraulic residence time of two weeks would provide an equivalent level of water quality treatment as sedimentation/filtration. Therefore, the permanent pool volume should be as large as the amount of runoff produced in a two-week period. To ensure that the pollutant removal can be achieved during the "rainy" season, the rainfall data used is based upon the statistics for the average wettest month. In addition, the volume should be increased to account for losses associated with 15 years of sediment build-up. When the drainage area to the pond contains only uplands, an increase of volume by five percent is acceptable to account for this loss. If the pond is located where it may receive streambed loads, a more detailed analysis will be required to account for storage losses.

   The wettest mean monthly storm, which generates runoff in the Austin area, produces 0.72 inches of rainfall and occurs every 5.45 days. The amount of runoff from 0.72 inches of rainfall can be estimated by multiplying the rainfall depth by the annual runoff-rainfall ratio, R_v , found in Table 1-9 of Section 1.6.9. To achieve the fourteen-day minimum residence time an adjustment coefficient is determined by dividing the desired residence time by the storm reoccurrence interval (5.45 days). Then the runoff depth, reoccurrence coefficient, loss factor, and drainage area are multiplied to determine a volume. The permanent pool volume may be calculated using the following equation:

   V = (RT/RI) * WMMS * R_v * Ls * DA * 1'/12"

   where "V" is the permanent pool volume (ac-ft), "RT" is the desired hydraulic residence time (14 days), "RI" is the reoccurrence interval for the wettest mean monthly storm (5.45 days), "WMMS" is the wettest mean monthly storm depth (0.72"), "R_v " is the runoff-rainfall ratio (Table 1-9 of Section 1.6.9), "Ls" is the storage loss coefficient, and "DA" is the drainage area (ac). By replacing the variables with local values and simplifying, the equation for permanent pool volume for ponds receiving upland runoff is:

   V = 0.162 * R_v * DA

2. Extended Detention - The extended detention portion of the pond minimizes turbulence in the pond by decreasing the pond flow-through rate and increasing the time in which sedimentation can occur during the storm through dynamic settling. The extended detention volume for wet ponds should be designed to detain the one-year, three-hour storm for 72 hours, (Table 1-9A). Through the use of these guidelines, the extended detention volume is considered to meet the streambank erosion requirements. The extended detention volume cannot include the volume provided in the permanent pool because the permanent pool is designed to be full at the start of the rainfall event.

Table 1-9A City of Austin 1-Year, 3-Hour design storm distribution Cumulative Values (inches), 5 minute time increment				
0.0	0.006	0.012	0.019	0.026
0.034	0.043	0.053	0.064	0.077
0.092	0.110	0.134	0.166	0.212
0.287	0.384	0.542	0.802	1.262
1.462	1.587	1.688	1.746	1.784
1.811	1.832	1.849	1.863	1.875
1.885	1.894	1.902	1.910	1.917
1.924	1.93	1.93	1.93	1.93

3. Flood Control Detention (optional) - The standard detention volume should be designed to meet the city's flood control requirement, in accordance with Section 8 of the Drainage Criteria Manual and it may include the volume contained as extended detention.

B. Drainage Area - The drainage area to the pond must have the following characteristics.

1. Size Limits - The drainage area must be large enough to allow an adequate supply of runoff. In addition, the need to provide pond depths great enough to minimize water surface fluctuations, an adequate area for vegetation, and enough surface area to allow aeration dictates this minimum drainage area. Due to these factors, a minimum drainage area of twenty acres is needed. Smaller drainage areas will be considered based upon a demonstration that these factors can be met.

   With very large drainage areas, disturbance of waterways can be excessive, high sediment bed loads can be expected, higher turbulence within the pond due to higher flow-through rates may occur, and maintainability may be decreased. Because of these factors, the drainage area may not exceed 320 acres. This upper limit, however, does not allow, recommend, nor encourage construction within the Water Quality Buffer Zone established along waterways.

2. Phased Development - A wet pond that serves a phased development may not have adequate impervious cover to generate the necessary runoff during the initial phases. In this instance, a plan must be submitted that demonstrates what accommodations will be made to address this concern. Refer to Section 1.6.5, C.5. (second bullet) for more information.

3. Hazardous Materials Traps - Spills of hazardous liquids can severely damage or kill the biota of a wet pond. Therefore, developments where the transportation, storage, or distribution of hazardous materials is anticipated should include hazardous material traps in the drainage system immediately upstream of the wet pond inlet.

C. Basin Elements - The permanent pool volume must be held in two compartments. The first is called the sediment forebay and the second is called the main pool. These basins must consist of deep pools and shallow vegetated benches. Other aspects of the pond include maintenance access points, maintenance pads, an outlet structure, and an impermeable liner.

1. Basin Geometry, Plug Flow, Short-Circuiting, Dead Storage, and Multiple Inlets

Wet ponds work best when the water already in the pond is moved out en masse by incoming flows, a phenomenon called "plug flow." To prevent short-circuiting, water is forced to flow to all potentially available flow routes, avoiding dead zones and maximizing residence time in the pond. It is thus imperative that the pond be designed to enhance plug flow characteristics and minimize short-circuiting and dead storage. Design features that encourage plug flow and avoid dead storage are:

(1) Dissipating energy at the inlet.

(2) Providing a large length-to-width ratio (no less than 2:1).

(3) Provide a broad surface for water exchange using a berm or island that functions as a broad-crested wier, separating the pond into two cells, a sediment forebay and the main pool.

(4) Maximizing the flow path between the inlet and outlet.

Figure 1.6.2.D illustrates preferred designs - significant deviation from these designs is highly discouraged. For City- maintained ponds, designs with short-circuiting or dead storage problems are prohibited unless expressly approved by the City of Bee Cave City Engineer. For ponds not maintained by the City, or that otherwise have dead storage volume that cannot be eliminated, that volume is to be deducted from the permanent pool volume, i.e., additional volume must be provided in the main pool.

Wet ponds with multiple inlets should be avoided. If unavoidable, the design engineer will be required to demonstrate that the proposed design will provide treatment equivalent to a design that does not have multiple inlets. This may require providing additional permanent pool volume. Each inlet must have a sediment forebay provided, as described below.

2. Sediment Forebay - All runoff from impervious areas must discharge into a sediment forebay. The purpose of the sediment forebay is to capture coarse sediment and trash in a location that can be easily assessed for maintenance purposes.

(i) Sediment forebays must be designed to minimize short-circuiting and dead storage problems. Energy dissipation is needed at the inflow point(s) to prevent scouring of the basin floor and to quickly reduce the turbulence within the forebay. The forebay must hold fifteen to twenty-five percent of the permanent pool volume. The sediment forebay and main pool must be separated by an earthen berm (preferably utilized as a portion of the vegetated bench), or using a six inch or thicker reinforced concrete wall. The separating wall will serve as a barrier for heavy sediments, trapping the majority of the sediment in the forebay, which should extend the maintenance interval for draining the entire pond. The top of the wall should be set at twenty-four (24) inches below the permanent pool water surface elevation. This will allow the two basins to be hydraulically connected during normal operation. The submerged earth berm should have a minimum top width of two feet and meet the following conditions: 1.) The material used for construction must be stable when saturated and when the maximum hydrostatic force is applied, 2.) the side slope must be stable when saturated, 3.) shall be constructed to avoid damage to the liner and to prevent seepage between the berm and the liner, and 4.) the berm must protect against erosive forces on the top of the berm in high flow conditions. When the earth berm is used, it should also be included as part of the vegetated bench.

(ii) The forebay and main pool must be hydraulically connected with a horizontal twelve inch or larger Schedule 40 PVC pipe called an inter-basin pipe to ensure that there will be an adequate supply of water in the forebay in dry conditions. The elevation of the inter-basin pipe should be two feet above the bottom of the forebay and a plug valve included in the line to allow independent draining (by pump) of the sediment forebay after drawing both basins down to the top of the separating wall.

(iii) The sediment forebay must have a depth from five to seven feet. A maintenance pad must be provided to allow for routine removal of sediment using heavy equipment soon after the basin is drained without requiring additional time for the basin bottom to dry. The pad is to be made of reinforced concrete and be a minimum of twelve feet by sixteen feet. The pad may be located outside of and adjacent to the forebay, or at the bottom of the forebay. If the latter, the bottom of the forebay should have a minimum two percent slope towards a low point. This maintenance pad must be enlarged as needed to cover the portion of the basin which can not be sloped inward at two percent. An examination of the hydrostatic forces on the maintenance pad when the forebay is empty and the main pool is full should be performed when designing the thickness of the pad. Pads less than four inches in thickness are prohibited. The maintenance pad should not compromise the integrity of the pond liner. The design engineer should incorporate an impermeable membrane or additional liner material to prevent excess leakage at the edge of the maintenance pad. A twelve foot wide concrete maintenance access ramp with a maximum slope of four to one and broom finish must lead from at least twelve inches above the permanent pool elevation to the maintenance pad.

3. Main Pool - The main pool must contain the remainder of the permanent pool volume and have a depth from six to eight feet. Areas deeper than eight feet may result in the pond becoming anaerobic, possibly resulting in odors, and are prohibited unless approved by the City of Bee Cave City Engineer. The main pool must be designed to minimize short-circuiting and dead storage problems; see Figure 1.6.2.D for preferred geometry of the main pool.

4. Vegetated Bench - A permanently submerged shallow wetland area incorporated into and/or surrounding the pond must be provided and is called the vegetated bench. The vegetated bench must be a minimum of five (5) to fifteen (15) percent of the total pond area. The slope of the vegetated bench must be in accordance with Table 1-9B.

Table 1-9B **Vegetated Bench - Minimum and Maximum Slopes**		
Pond Surface Area	Min. Slope	Max. Slope
Less than 2 acres	4:1	3:1
Greater than 2 acres	5:1	4:1

Locating vegetated benches perpendicular to the flow path is recommended, and should include the interbasin berm between the sediment forebay and main pool. Minimum slope criteria for vegetated benches do not apply to the interbasin berm, which shall be flat at the top. The upper limit of the vegetated bench area is the permanent pool elevation, at the pond edge. The lower limit of the vegetated bench has a maximum inundation of twenty-four inches. This vegetated bench must be planted with wetland plants as discussed in 1.6.5, E. Biological Elements. Figure 1-59D in Appendix H of this manual is an example of a typical cross-section of the vegetated bench area.

5. Pond Liner - The sediment forebay and main pool must have an impermeable liner to contain the runoff and to prevent excessive seepage. Leaks or seepage may result in ground water contamination or in severe pond drawdown. Liners may be either clay or geomembrane. A properly functioning wet pond must be able to maintain a permanent pool volume. There are a number of important aspects related to the design of the liner that must be carefully evaluated and designed to ensure a properly functioning pond. Because of the critical nature of the liner element, all liner studies, plans, details, specifications and other related documents must be sealed by a geotechnical engineer and provided with the site plan submittal. Liner design considerations must include, but are not limited to, the items found in Section 1.6.5 C. of this manual entitled "Basin Liners." Other related guidance dealing with aspects of the design of wet pond liners is included below.

   (i) Protective soil layer above the liner - All areas of the pond that are to receive and support vegetation must have a protective soil layer installed on top of the liner, regardless of the type of liner, so that plantings can be properly installed above the liner and the liner integrity can be maintained. This protective soil layer must be a minimum of 12-inches in thickness.

   (ii) Submerged Inlets - Submerged inlets are to be avoided whenever possible. In situations where site conditions require a submerged inlet then the portion of the inlet pipe that is placed below the permanent pool elevation must be designed to store water, not simply convey it. In these situations, the pond liner must extend and surround the portion of the inlet pipe that is designed to be under water.

   (iii) Pond Water Losses, Performance Criteria and Supplemental Water Requirements - While fluctuation of the permanent pool level is to be expected due to climatic conditions, type and extent of vegetation, phased developments and other factors, the minimum level acceptable at any time is 12" below the permanent pool (the lower limit of the marsh zone). A nearby source for make-up (supplemental) water is recommended as a way to maintain an adequate permanent pool level should the level drop. A water balance based on local data must be performed in order to demonstrate compliance with these performance criteria. The water balance should use a daily time step and account for all significant inflows (rainfall, runoff, supplemental water) and outflows (evaporation of open water, evapotranspiration of wetland vegetation/vegetated bench, seepage, water withdrawals). A range of climatic conditions should be modeled, including but not limited to, average and dry years. The water balance serves two purposes. First, it is necessary to provide information for determining pond sizing requirements and any supplemental (makeup) water requirements, as applicable. A minimum water level is necessary for both aquatic plant survival and, if the liner material is clay, to keep the clay moist to prevent cracking. Wet ponds that are operated and/or maintained by the City of Bee Cave must meet the performance criteria assuming that no supplemental water is provided, unless as approved by the City Engineer. Second, a water balance is necessary in order to determine if the pond is experiencing a water loss in excess of normal anticipated losses. It must be performed in order to develop performance criteria for the pond to be measured against upon completion of the pond construction. The engineer must specify criteria for acceptance testing of the pond over a specified period of time, using actual daily water level measurements, actual daily precipitation data, and other required data to determine whether the pond is losing water in excess of anticipated losses.

(1) One reason the permanent pool may stabilize lower than the design level is if development in the contributing watershed is phased in over a long period of time, such that the impervious cover and runoff coefficient at the early phases of construction are less than the final, build-out values. In this case the amount of water available to fill the wet pond may be lower at the earlier development phase, which would strand the vegetated bench below the permanent pool level, an unacceptable situation. The designer and contractor must ensure that the vegetated bench is submerged per the above criteria for wetland plant survival and to maintain liner integrity. It is unacceptable for the water level to remain low for an extended period of time, such that the health of the wetlands plants is threatened due to lack of moisture.

6. Pond Side Slopes - Pond earthen side slopes must not exceed a three to one ratio, and must be designed to ensure their stability, especially when saturated. The pond liner must extend up the side slopes as high as is necessary to maintain a permanent pool volume. Where the liner extends under the separating berm, it is not necessary for the liner to extend up the side slopes of the separating berm. Utility lines may not be located within ten feet from the top of the pond sideslope.

7. Dam Safety - Any pond embankment configuration meeting the criteria for dam safety requirements must follow the criteria outlined in the Drainage Criteria Manual (DCM). Refer to the DCM for additional information related to dam safety.

D. Outlet Structures - The design of the outlet pipe is important to enhance the plug flow characteristics of the pond. This section provides guidelines in designing the outlet structure. Other designs will be evaluated for their ability to provide plug flow and maintainability. In most cases, the ponds will be designed with two primary outlet structures and a maintenance drain. In all cases, energy dissipation is required to prevent erosion at the outfall location. Figure 1-59E in Appendix H of this manual is an example of a typical outlet structure.

1. Extended Detention - The extended detention outlet structure must be constructed using an inverted PVC pipe with the soffit of the inlet set at an elevation which is one half (½) of the permanent pool depth from the bottom. The flow line of the outlet of the pipe must be set at the permanent pool elevation. No outlet other than the extended detention outlet will be permitted below the extended detention volume. In all cases, the pond will be designed so that the minimum pipe diameter is no less than six inches to minimize clogging potential; the size of the orifice at the end of the pipe may be smaller than six inches in order to achieve the required extended detention. If an orifice plate is used to achieve the required 72 hour drawdown, the orifice must be removable and accessible when the pond is at the extended-detention elevation in order to service blockage. It is recommended that this line discharge into the manhole required for the maintenance drain and discussed in that section.

If an orifice is not used to control the drawdown, the flow in the inverted discharge pipe used for extended detention must be calculated using a method that more accurately accounts for energy losses than the orifice equation. One equation that may be used is:

$$Q = A * ((2*g*h)/(1+k_e+k_b+k_f))^{0.5}$$

where Q is flow (cfs), A is the cross-sectional area of the pipe (sf), g is the acceleration due to gravity (32.2 ft/sec^2), ke is the entrance loss coefficient (Table 7-1, DCM), kb is bend losses (Table 5-4, DCM), and kf is the friction loss coefficient. The friction loss coefficient can be found using the equation:

$$K_f = 29*L*n^2/R^{1.33}$$

where L is the pipe length (ft), n is the Manning's roughness coefficient (Table 4-2, DCM), and R is the hydraulic radius (ft).

2. Flood Control Detention - The Drainage Criteria Manual must be referenced for design of the outlet structure to serve for flood control. This outlet must be designed for the 10, 25, and 100-year storm or as required in the DCM. When flood control detention is not needed, an overflow spillway capable of passing the 100-year storm is required at or above the elevation at which the extended detention volume is provided. To enhance water quality, a two to one length to width ratio from the inflow to the outflow must be maintained.

3. Maintenance Drain - A drain line, which can completely or partially drain the permanent pool, must be included where topographic relief exists. The purpose of the drain is to allow for the pond to be drained for long-term maintenance activities. A plug valve must be installed in the line, and the valve must be protected by enclosing it in a manhole set in the pond berm. If the maintenance drain cannot completely drain the pond, a 6 ft. × 6 ft. square concrete pump pad must be provided at the lowest point in the main pool to provide a base for temporary installation of a submersible pump.

E. Biological Elements - Biological elements are an important aspect to the function as well as the aesthetics of the wet pond system. The following criteria must be followed to enhance pollutant removal and minimize undesirable activity.

1. Wetland Plantings - The functions of plants in a wet pond are to 1) physically slow the flow of water and cause suspended particles to fall out; 2) provide a substrate on which associated microbes assimilate organics, metals, and nutrients; 3) take up pollutants from the sediment into the roots; and 4) oxygenate the water.

Use wetland plants as specified below.

To determine the minimum requirement for wetland plant quantity, multiply the surface area (in square feet) of the permanent pool by three percent (0.03). As an example, the following calculation demonstrates how to determine the quantity of plants required for a pond with a surface area of 43,560 square feet.

43,560 × 0.03 = 1,307 plants

Wetland plants may be provided in bare-root form or in containers. Root mass of bare-root plants must be equal in mass to the equivalent container sizes. For the purpose of fulfilling the required minimum plant quantity, it is assumed that the plants to be installed will be 1 gallon size. Other sizes are acceptable but overall the quantity must be equivalent to the required minimum one gallon plants. See Table 1-9C for equivalency.

Table 1-9C One Gallon Equivalency			
Proposed Substitute	**Equivalent To**		
Quantity	Plant Size	Quantity	Plant Size
1	Two-gallon	2	One gallon
2	4” pots	1	One gallon
4	Plugs	1	One gallon

All wetland plants which fulfill the minimum landscape requirements shall be propagated from, or harvested from, regionally adapted stock. These are plant species or genotypes which are native to a range of within 200 miles of the project site. Wetland plants grown outside the state of Texas are not acceptable. The designer is not limited to the species described. Additional species used for aesthetic reasons, etc. may be used. Plants not intended to meet minimum requirements do not need to be native or regionally adapted stock however under no circumstances may invasive plants be planted. Plants that are prohibited from wet ponds in the City of Austin include those in the following lists:

Texas Parks and Wildlife Department: Prohibited Exotic Species: **http://www.tpwd.state.tx.us/huntwild/wild/species/exotic/#plant** Texas Department of Agriculture: Noxious Plant List: **http://info.sos.state.tx.us/fids/04_0019_0300-1.html** TexasInvasives.org: Invasive Plants Database: **http://www.texasinvasives.org/invasives_database/index.php**

Cattails (Typha spp.) tend to invade almost all wetlands and aggressively colonize shallow water. Therefore, cattails shall not be specified on the planting plan.

A minimum of 90% of the vegetation shall be alive and viable for one year following installation.

Table 1-9D lists wetland plant categories and their respective ratios. Specific plants for use in wet ponds are listed in Tables 1-9E, 1-9F, and 1-9G.

Table 1-9D

Plant Category Ratios

Plant Category	Comments	% of Total
Pond Edge Zone	Plant rooted plants at or near the pond edge	40%
Marsh Zone	Plant rooted plants on the vegetated bench	40%
Deep Water Zone	Plant rooted plants on the deepest portion of the vegetated bench	20%
		100%

Wetland plants are adapted to specific water depths. These criteria identify pond planting zones based on the depth of the permanent pool. Install plants at water depths appropriate to the species. The water depths noted in the following tables show the range of depths in which these plants must be planted. The plants will often colonize deeper water than that in which they are planted. Taken together, the following zones comprise the vegetated bench.

(i) Pond Edge Zone - The pond edge zone is an area of saturated soil surrounding the perimeter of the pond. The zone extends from an elevation 3" above the permanent pool level to an elevation 3" below the permanent pool level. While a portion of this zone is above the elevation of the vegetated bench, plants listed in Table 1-9E that are installed in this area will count towards fulfilling the required minimum number of plants. Use at least four of the following species in this zone. Species noted as required must be included in this zone.

Table 1-9E

Pond Edge Zone Plants

Common Name	Latin Name	Height	Required	Comments
Big muhly	Muhlenbergia lindheimeri	3′		clump grass
Burhead	Echinodorus cordifolius (rostrata)	2′		foliage similar to Arrowhead
Burr marigold	Bidens laevis	3′		yellow flowers
Bushy bluestem	Andropogon glomeratus	3′		clump grass
Cardinal flower	Lobelia cardinalis	3′		red flowers
Caric-sedge	Carex Frankii (hystricina, cherokeensis)	2′		ornamental sedge
Crinum	Crinum americanum	3′		white flowers
Easterngama grass	Tripsacum dactyloides	4′		clump grass
Emory sedge	Carex Emoryii (microdanta)	2′		grass-like foliage
Flatsedge	Cyperus odoratus (ochraceus, alternifolius, pseudovegetus)	2′		planting depth
Horned rush	Rhynchospora corniculata (colorata)	18″		ornamental rush
Horsetail	Equisetum laevigatum (hyemale)	2′		deer-resistant
Inland sea oats	Chasmanthium latifolium	2′		grass, takes shade
Jamican saw grass	Cladium mariscus ssp. jamaicense	7′		dense evergreen, sharp leaf edges
Mallow	Hibiscus lasiocarpos (laevis), also Kosteletzkya virginica	3′		pink flowers
Mistflower	Conoclinum coelestinum (Eupatorium)	2′		colonizes, wildlife value
Nimblewill	Muhlenbergia Schreberia	1′		erosion control
Obedient plant	Physostegia angustifolia	4′		pink flowers
Palmetto	Sabal minor	6′		tropical evergreen
Pennywort	Hydrocotyl	1′		colonizes
Soft rush	Juncus effusus	4′		evergreen clump
Spikerush (short)	Eleocharis macrostachya (palustris, montevidensis)	1′	x	colonizes for shoreline erosion control
Thalia	Thalia dealbata	5′		ornamental
Umbrella sedge	Fuirena simplex	2′		ornamental sedge
Water clover	Marsilea macropoda (tenuifolia)	6″	x	clover-like fern

Water daisy	Spilanthes americana	6″		yellow flowers

(ii) Marsh Zone - The marsh zone is the shallow water area within the pond. The zone extends from an elevation 3″ below the permanent pool level to an elevation 12″ below the permanent pool level. Use at least four of the following species in the marsh zone. Species noted as required must be included in this zone.

Common Name	Latin Name	Height	Required	Comments
American water-willow	Justicia americana	3′	x	forms solid mass
Arrowhead	Sagittaria platyphylla (lancifolia, latifolia, graminae)	2′	x	wildlife value, white flowers
Canna lily (native)	Canna flaccida	2.5′		yellow flowers
Hard-stem bulrush	Schoenoplectus acutus*	6′		evergreen
Iris (native)	Iris (fulva, hexagona, virginica)	3′		colorful flowers
Lizard's Tail	Saururus cernuus	2′		colonizes, shade tolerant
Pickerelweed	Pontederia cordata	3′		flower spikes
Spikerush (tall)	Eleocharis (rostellata, quadrangulata, cellulosa)	2.5′	x	colonizing evergreen
Texas rush	Juncus texanus	3′		wildlife value
Three-square bulrush	Schoenoplectus americanus*	4′		triangular stems

* The genus which was formerly known as Scirpus is now known as Schoenoplectus c.

(iii) Deep Water Zone - The deep water zone extends from an elevation 12″ below the design pool level down to an elevation 24″ below the design pool level. This zone includes submergent plants (which grow underwater), floating-leaved aquatic plants, and tall emergent plants. The list includes a few plants that may be used only in very large ponds (2 acres or greater) due to their aggressive growth habit. Install submergent and floating-leaved aquatic plants throughout the pond to encourage colonization in a variety of locations, including the submerged earthen berm between the sediment forebay and the main pool. Install at least three species of the following:

Table 1-9G Deep Water Zone Plants				
Common Name	Latin Name	Height	Required	Comments
Common Poolmat	Zannichellia palustris			Submergent oxygenator
Coontail	Ceratophyllum demersum	6′		Submergent for nutrients
Eelgrass	Vallisneria Americana	4′		Submergent oxygenator

Fanwort	Cabomba caroliniana	6′		Submergent oxygenator
Giant bulrush	Schoenoplectus* (tabernaemontani, validus)	8′		Emergent 8′ ht. Evergreen; 2 acre min. pond size
Pondweed	Potamogeton pectinatus (nodosus, diversifolia, illinoensis)	4′	x	Floating-leaved aquatic, benefits wildlife
Water lily	Nymphaea (odorata, elegans, mexicana)	8′		Floating-leaved aquatic; 2 acre min. pond size
Water-naiad	Najas guadalupensis	4′	x	Common submergent
Water primrose	Ludwigia repens	4′		Float-leaved aquatic
Water star grass	Heteranthera dubia (Liebmannii)	5′		Submergent oxygenator

* The genus which was formerly known as Scirpus is now known as Schoenoplectus

2. Microbial Initiation - A substantial portion of the pollutant removal in wet ponds is due to biological processes. Bacteria in the pond substrate remove nutrients through a process of denitrification. These microbial processes require an organic food source, such as decaying plant litter. Because it is the supply of organic carbon that determines nutrient removal - more than uptake by living plants - denitrification can be expected to continue even during cold-weather plant dormancy. In mature ponds with abundant vegetation, aquatic plants supply the necessary litter layer and aerobic zone for microbial activity. However, since new ponds lack a sufficient source of organic matter, an appropriate amount of carbon (straw, hay, leaf clippings, soil, and other non-woody material) shall be installed during construction. After the pond liner is in place, yet prior to allowing the pond to be filled, spread the plant litter evenly on the sides of the pond (below the permanent pool level). Treat the entire shallow water bench in this manner, and all pond slopes (ranging from 3:1 to 10:1). The minimum required amount of plant litter is 45 pounds per 1,000 square feet of slope. When using coastal hay, this requirement can be expressed as 1.5 bales at 30 lb./bale. Ensure that the plant litter will not float by attaching the litter to the slopes (with staples or other appropriate methods). Cover a minimum of 40% of the slope surface area.

3. Integrated Pest Management - As with any landscape, there is a need for pest management in wet ponds. To the extent possible, these criteria are designed to minimize the potential for pests within a wet pond.

   (i) Algae - High nutrient loads in wet ponds may cause algae blooms to occur. Pungent odor is often associated with these algal blooms. However, treating with an algaecide is not recommended because blooms are usually short lived and are considered desirable for nutrient removal. The use of submergents and floating-leafed aquatics can reduce the extent of alga blooms by reducing nutrient loads and shading the water.

   (ii) Wildlife - Wildlife such as nutria and deer are occasionally a pest of wet ponds in the Austin area. Evaluation of the potential of such wildlife inhabiting or being attracted to the proposed pond site is required. When there is a potential for such activity, fencing or similar exclusionary method must be provided.

   (iii) Mosquito Control - Mosquitoes are problematic in urban areas. There is the potential for standing water in wet ponds to become ideal breeding localities. The wet pond should be stocked with the local native fish species Gambusia affinis to serve as a biological control for mosquitoes. Gambusia provide effective control for mosquitoes, eliminating the need for chemical control. Gambusia should be stocked at the initial density of 200 individuals per surface acre.

(iv) Domestic Waterfowl - Domestic waterfowl, including geese and swans can destroy vegetation and increase pollutant loading in wet pond systems. In addition, waterfowl can become nuisances to property owners near the pond. For these reasons, domestic waterfowl should not be introduced into these systems.

(v) Fish - Fish other than Gambusia affinis should not be introduced into a wet pond.

4. Water - After the pond liner is completed, the basin must fill up with water within a reasonable time period, preferably within one week. Safety concerns and pond liner integrity concerns must be properly addressed during pond construction.

Aeration and Recirculation Unit (optional) - Privately maintained wet ponds may include some type of aeration device (such as a fountain) which could enhance the dissolved oxygen concentration. Increased dissolved oxygen prevents the pond from becoming anaerobic, hence minimizing problems with odor from bacterial decomposition.

Make-up Water - A nearby source for make-up (supplemental) water is recommended as a way to maintain an adequate permanent pool level should the level drop to a severe drought. Potable and effluent water is not an acceptable make-up water source. Demonstrate that the quality of the make-up water is in compliance with all applicable regulations and will not harm the pond biology.

1.6.6 DESIGN GUIDELINES FOR EXTENDED DETENTION PONDS

A. Description

Extended detention basins capture and temporarily detain the water quality volume. They are intended to serve primarily as settling basins for the solids fraction, nutrients attached to solids, and as a means of limiting downstream erosion by managing stormwater. Extended detention basins are typically depressed basins that temporarily store stormwater runoff following a storm event and do not have a permanent water pool between storm events. Water is controlled by means of a hydraulic control structure to restrict outlet discharge.

The water quality benefits are the removal of sediment and buoyant materials. Furthermore, nutrients, heavy metals, toxic materials, and oxygen-demanding materials associated with the particles are also removed. The control of the maximum runoff rates serves to protect drainage channels below the device from erosion and to reduce downstream flooding. Refer to Figure 4-2 for a schematic of an extended detention basin.

B. Application

An extended detention basin cannot be used as a stand alone SCM to obtain compliance with the Bee Cave pollutant removal requirements and needs secondary treatment in the form of vegetative filter strips, an infiltration basin/trench or a bioretention basin, for example.

One of the main advantages of extended detention basins is their adaptability; they can be used on areas with thin soils, high evaporation rates, low-soil infiltration rates, in limited- space areas, and where groundwater is to be protected. Due to the simplicity of design, extended detention basins are relatively easy and inexpensive to construct and operate. Extended detention basins are generally best suited to drainage areas greater than three acres, since the outlet orifice becomes prone to clogging for small water quality volumes. Also extended detention basins can readily be combined with flood control detention facilities by providing additional storage above the water quality volume.

C. Design Guidelines

1. Contributing Drainage Area: Less than 128 acres recommended with a minimum of 3 acres.

2. Pre-treatment: A sediment forebay is designed to retain the bulk of the sediment entering the facility. This will simplify sediment removal and reduce overall basin maintenance. Refer to the design guidelines for sediment forebays in General Guidelines 1.6.5.C.2, where the forebay volume is equal to 25% of the water quality volume to retain the first flush runoff volume. To promote advanced treatment of the first flush volume, the forebay design relies on a berm and/or gabion within the basin to promote pollutant settling. Non-woven filter fabric with a 0.15 mm (U.S. Sieve Size 100) opening shall be placed on the gabion to enhance detention and facilitate maintenance. Rock rip rap shall be placed on the downstream side to prevent scouring in the event flow passes over the gabion.

3. Secondary Treatment: Extended detention ponds require secondary treatment either before or after the pond in the form a vegetative filter strip, an infiltration basin/trench, or a bioretention basin, for example. Reference the City of Bee Cave's pollutant removal spreadsheet to determine appropriate BMPs in series.

4. Basin Sizing: The BMP Volume is calculated by applying a factor of 1.05 to the Water Quality Volume (WQV). The WQV is increased by a factor of 5% to accommodate for the reduction in the available storage volume due to deposition of solids in the time between full-scale maintenance activities.

   BMP Volume = WQV * 1.05

   WQV = Required Water Quality Volume

   The full WQV shall drawdown within 48 hours. 50% of the WQV shall drawdown within 50% of the full drawdown time. Example: if a facility fully draws down in 42 hours, at least 50% of the WQV shall drawdown in 21 hours.

5. Basin Configuration: The extended detention basin is optimally designed to have a gradual expansion from the inlet toward the middle of the facility and a gradual contraction toward the basin outfall. The ratio of flow-path length to width from the inlet to the outlet should be at least 2:1 (L:W). The flow-path length is defined as the distance from the inlet to the outlet as measured at the surface. The width is defined as the mean width of the basin. Higher length-to-width ratios are recommended. Outlets should be placed to maximize the flow-path through the facility. The basin should maintain a longitudinal slope between 1.0 – 5.0% with a lateral slope between 1.0 – 1.5%. See Figure 4.2 for guidance.

6. Basin Depth: The water depth in the basin when full should be no greater than 8 feet.

7. Basin Outlet: The facility's drawdown time should be regulated by an orifice located downstream of the primary outflow opening. The outflow structure should be sized to allow for complete drawdown of the water quality volume within 48 hours. In addition, the outlet shall be configured to provide at least 12-hour detention for 0.5 inches of runoff from the total effective impervious cover. The minimum orifice diameter is 6-inches to reduce clogging. Non-woven filter fabric with a minimum opening of 0.15 mm (U.S. Sieve Size 100) shall be wrapped around the riser to enhance detention. The riser should be double-wrapped with filter fabric until the contributing drainage area is vegetated and stabilized. The outflow structure must have a trash rack or other acceptable means of preventing clogging at the entrance to the outflow pipes. Refer to Figure 4-4 for a detail of a typical riser pipe. An emergency overflow weir shall be designed to accommodate a 500-year storm event. The following equation can be used to determine the required orifice size:

$$A_O = \frac{0.001 BMP\_Vol.}{C\sqrt{2gH_{avg}}}$$

AO = maximum orifice area (square inches)

BMP Vol. = required basin volume as calculated above (cubic feet)

C = orifice coefficient (Typical. 0.62)

g = acceleration of gravity (32.2 ft/s2)

Havg = HT/2, average hydraulic head (ft)

HT = total hydraulic head determined from difference between the WQ elev. and the center of orifice

8. Basin Soils: To enhance infiltration and water storage within the basin, topsoil must be placed on the basin floor after excavated bottom is scarified to a depth of 2 to 3 inches to improve drainage. The topsoil must be 6 to 8 inches deep and a soil mixture of 30-40% sand or granite sand, 60-70% topsoil, and suggest 5-10% compost or peat to aid water retention and promote vegetation growth. Soil blend must have clay content less than 20 percent and be free of stones, stumps, roots or other similar objects larger than one (1) inch. If on-site soils do not meet these specifications, topsoil per the above specs must be added. Sandy loam is not an approved soil and caliche is not considered a soil.

9. Vegetation – To enhance appearance and function, trees and shrubs, and vegetation are recommended along with Bermuda grass coverage (strongly recommend sod); however the enhancements shall conform to the requirements the dam safety criteria as outlined in the DCM. Refer to biofiltration basin vegetation requirements for guidance. Muhly can be used to aid in spreading flow and concealing the riser pipe and mid-basin gabion. In addition, trees and shrubs can effectively screen other structural aspects and will aid in evapotranspiration and basin floor drying.

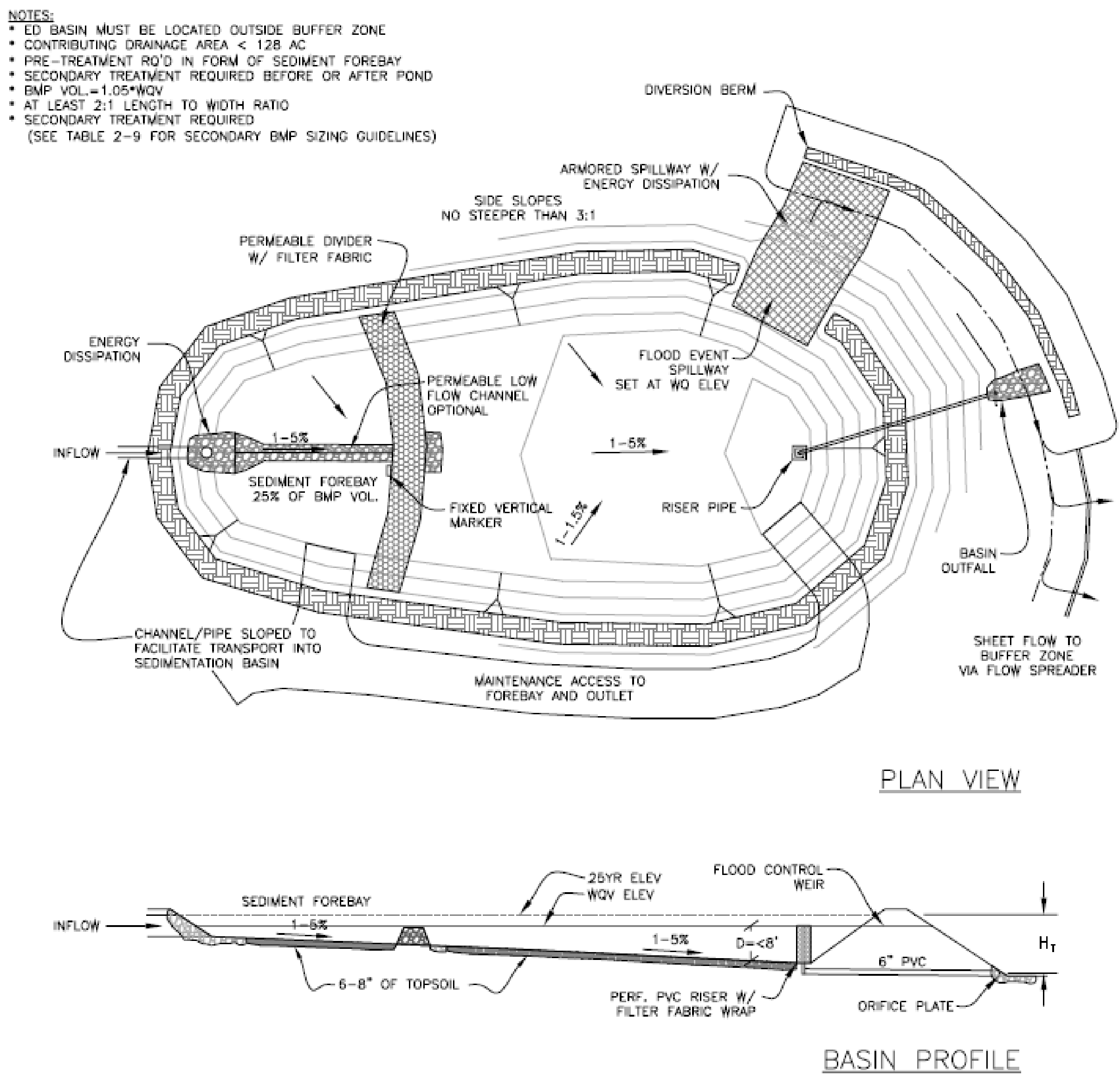


Figure 4-2 Extended Detention Basin Schematic

1.6.7 GREEN STORM WATER QUALITY INFRASTRUCTURE

A. Introduction

Section **1.6.7** includes the following subsections where design criteria and guidance are provided for each practice:

1. Retention/Irrigation Systems.
2. Vegetative Filter Strips.
3. Biofiltration.
4. Rainwater Harvesting.
5. Porous Pavement.

6. Non-Required Vegetation.
7. Rain Garden.

Maintenance requirements of the approved stormwater control measures are provided in **Section 1.6.3**.

B. Infiltration Rate Evaluation

An evaluation of infiltration rate is necessary to determine if infiltration is feasible and to establish design infiltration rates for several of the innovative water quality controls described in **Section 1.6.7**.

There are three basic steps for evaluating infiltration rate:

1. Desktop study (i.e., soil survey maps or existing geotechnical information).
2. Field sampling (i.e., soil depth verification and textural analysis).
3. In-situ testing (i.e., more rigorous in-situ infiltration or percolation testing).

The design infiltration rate shall be established by applying a minimum factor of safety of 2 to the estimated or measured infiltration rate. A higher factor of safety may be used at the discretion of the design engineer to take into variability associated with assessment methods, soil texture, soil uniformity, influent sediment loads, and compaction during construction.

Table 1.6.7-1 identifies the minimum required steps for establishing the infiltration rate for each applicable water quality control. Although not required, results from in-situ testing may be used to establish infiltration rate for any applicable control.

Table 1.6.7-1. Minimum Required Steps For Establishing Infiltration Rate.

	Desktop Study	Field Sampling	In-situ Testing
Retention/Irrigation System2	•	•	•
Vegetative Filter Strip	•	•	
Rainwater Harvesting1	•		
Porous Pavement	•		
Rain Garden - Full Infiltration2	•	•	•
Biofiltration/Rain Garden - Partial Infiltration	•	•	
Infiltration Trench	•	•	

Note 1: Infiltration evaluation is not required for rainwater harvesting when the system is designed for beneficial reuse only.

Note 2:Design infiltration rates which exceed 0.2 in/hr must be confirmed using field or laboratory testing.

1. Desktop Study

Desktop resources such as soil survey maps, published reports, or other available data is appropriate for screening to assess the feasibility and desirability of infiltration. The infiltration rate can be derived from the hydraulic conductivity listed in the U.S. Department of Agriculture National Resources Conservation

Service Soil Survey for the location and soil type reported for the site. Geotechnical data from previous site studies or nearby representative locations may also be used. If a range of hydraulic conductivity values is available, estimate the infiltration rate as the geometric mean. Porous Pavement for Pedestrian Use may be designed without additional field verification or sampling. Additional field sampling or testing is required for other infiltration-dependent controls.

2. Field Sampling

   The purpose of field sampling is to evaluate the depth and texture of soil at the location of the proposed water quality control. Field sampling activities must be conducted under the direction of a qualified professional. Soil depth and texture within the proposed footprint of the control must be evaluated via test pits, probes, borings, or similar means at a minimum frequency of one test location per 500 square feet. The probe or hole must extend to the minimum soil depth required for the proposed control. For example, the depth to an impermeable layer must be at least 2 feet below the bottom of a rain garden. If the bottom of the proposed rain garden is 1.5 feet below existing ground, the probe or hole must extend a minimum depth of 3.5 feet. Soil samples must be collected and evaluated at a depth below the expected bottom of the infiltration BMP (i.e., in the layer of underlying soil where infiltration will occur). Soil texture of representative samples may be classified in the field or by laboratory methods such as sieve and hydrometer analysis. Based on the soil texture determined in the field, a representative infiltration rate can be estimated from desktop resources (as described above). In the event that soil textures in the field differ from published references, additional testing and analysis must be conducted to establish a representative infiltration rate.

3. In-situ Testing

   More rigorous in-situ infiltration or percolation testing methods provide the most accurate estimate of infiltration rate. A variety of in-situ tests are available for measuring the infiltration capacity of the soil. Laboratory tests are not recommended because typical laboratory samples are less representative of field conditions.

   In-situ testing must be conducted under the direction of a qualified professional. Testing must be conducted within the proposed footprint at a minimum frequency of one test per 2,000 square feet. A higher testing frequency is recommended to more fully characterize the subsurface conditions. When more than one infiltration test is conducted for a single control, a representative infiltration rate may be calculated as the geometric mean of the test results. The infiltration test should be conducted as close as possible to the proposed bottom elevation for the water quality control (i.e., at the bottom of the growing medium layer). Based on observed field conditions, the designer may elect to modify the proposed bottom elevation of the control. Personnel conducting infiltration tests should be prepared to adjust test locations and depths depending on observed conditions.

   The City may require verification testing for infiltration facilities serving greater than one acre of contributing area and where the City believes there may be a risk of infiltration system failure. Site conditions that justify infiltration facility verification testing include but are not limited to: low infiltration capacity soils, history of infiltration failure in the project area, high groundwater levels, indications of soil compaction during construction, new information gained during construction with regards to infiltration facility design and performance (e.g., better soils data, groundwater data, etc.).

   The designer should keep in mind the difference between percolation tests and infiltration tests when determining the design infiltration rate. A measured infiltration rate can be determined from a single or double ring infiltrometer test; however, a percolation rate determined from the simple open pit percolation test is related to the infiltration rate but tends to overestimate infiltration rates due to both downward (vertical) and horizontal movement of water. Infiltration rates correspond only to the downward movement of water.

An acceptable testing protocol for percolation testing is provided below. Other testing methods that may be used but not discussed in detail in this section include:

(1) Single Ring Infiltrometer Test (ASTM D5126).

(2) Double Ring Infiltrometer Test (ASTM D3385).

(3) Guelph Permeameter.

(4) Constant Head Permeameter (Amoozemeter or USBR Procedure 7300-89).

(5) Other analysis methods at the discretion of the designer and approval of the Director.

4. Percolation Test Protocol

The percolation test is geared towards investigating smaller infiltration facilities (i.e., facilities with drainage areas 2 acres or less and maximum ponding depths 12 inches or less). The test can be conducted using simple tools and manual labor, and does not require extensive excavation.

(i) Test Preparation

(1) The test hole opening shall be between 8 and 12 inches in diameter or between 7 and 11 inches on each side if square.

(2) The bottom elevation of the test hole shall correspond to the bottom elevation of the proposed control (infiltration surface).

(3) Place approximately 2 inches of gravel in the bottom of the hole to protect the soil from scouring (optional).

(4) If horizontal infiltration is to be allowed, scarify the sides of the test hole.

(5) Pre-soak the hole by carefully filling it with water. If the hole has not drained completely within 24 hours, then an infiltration design is not recommended. Testing may commence after all of the water has percolated or after 15 hours has elapsed since initiating the pre-soak. However, to approximate saturated conditions, testing must commence no later than 26 hours after all pre-soak water has percolated through the test hole.

(6) Place a bar over the top of the hole or a nail near the top of the hole to serve as a datum from which depth measurements will be made.

(7) Measure the depth and diameter of the test hole.

(ii) Test Procedure

(1) Carefully fill the hole with water to a level greater than or equal to the maximum ponding depth of the rain garden. Measure this water elevation and the time it was taken.

(2) Measure the water surface elevation as it drops, and record the time of each measurement. Measurements shall be taken with a precision of 0.25 inches or better. The number of measurements, and thus time required to conduct the testing, will depend on the infiltration rate of the soil and the time available. As a general recommendation for finer grained soils typically found in Austin, plan to take at least 4 measurements over at least 2 hours. Refill the hole as necessary to extend the test to at least 2 hours. The test can be terminated when near steady-state conditions (i.e., when the rate of drop is approximately constant). Alternatively, terminate the test when the test hole is empty (this may require a much longer test period).

(3) Calculate the percolation rate using representative steady-state data points from the latter stages of test where the rate of drop is approximately constant. The percolation rate is the change in water elevation (in inches) by the corresponding time interval (in hours).

(4) Convert the steady-state percolation rate (p) to a representative infiltration rate (i) using the reduction factor (Rf) as follows:

$i = p/R_f$

The reduction factor (R_f) is given by:

$R_f = ((2d_1 - \Delta d)/D) + 1$

Where:

D_1 = water depth at start of representative time interval (in.) Δd = water level drop during representative time interval (in.) D = diameter of percolation hole (in.)

The reduction factor accounts for water losses through the sides of the percolation hole. It assumes that the percolation rate is affected by the depth of water in the hole and that the hole is located in uniform soil. If there are deviations from these assumptions, then other adjustment may be necessary.

C. Additional Resources

Note that while proven, many of the devices described in 1.6.7 are evolving in standard practice. The City should be contacted to determine if any acceptable variations to the controls described herein have been approved or are pending. When considering the use of innovative control the applicant is strongly encouraged to become familiarized with on-going stormwater research, monitoring and modeling concepts and studies, and recognized engineering practices. Some sources of additional information include:

(1) International Stormwater BMP database project **(http://www.bmpdatabase.org/)** including BMP Modeling Concepts and Simulation **(http://www.epa.gov/nrmrl/pubs/600r06033/600r06033.htm)**

(2) American Society of Civil Engineers and Water Environment Federation manuals of practice:
- Urban Runoff Quality Management (WEF Manual of Practice No. 23; ASCE Manual and Report on Engineering Practice No. 87).
- Design and Construction of Urban Stormwater Management Systems (ASCE Manual and Report on Engineering Practice No. 77; WEF Manual of Practice FD-20).

(3) University of Texas Center for Research in Water Resources **(http://www.crwr.utexas.edu/)**

(4) North Carolina State Stormwater Engineering Group **(http://www.bae.ncsu.edu/stormwater/)**

(5) University of Maryland Department of Civil and Environmental Engineering **(http://www.ence.umd.edu/~apdavis/LID-** Publications.htm)

(6) Low Impact Development Center **(http://www.lowimpactdevelopment.org/)**

(7) TexasLID.org **(http://texaslid.org/)**

2. Retention/Irrigation Systems.

(i) Introduction. A retention/irrigation water quality treatment system consists of two primary components:

(1) A partial sedimentation/filtration basin which captures and isolates the required volume of stormwater runoff; and

(2) A distribution and land application system which generally utilizes pumps, piping and spray irrigation components. The main characteristic of retention/irrigation systems is the ability to retain the entire water quality volume on site. The design should consider factors such as basin impermeability and the irrigation area's ability to infiltrate the water quality volume. When properly designed, this system is effective in removal of pollutants through settling in the retention basin and contact with vegetation, air and soils in the irrigation process, as well as in mitigating stream-bank erosion as required by **Section 1.6.8** of the Environmental Criteria Manual. The effectiveness of this BMP at meeting required pollutant removal efficiencies is based upon the following criteria being met.

(ii) Minimum Design Criteria for the Retention Basin. Refer to **Section 1.6.4** for water quality sizing and design standards related to partial sedimentation/filtration ponds.

(1) Retention Basin Volume. The basin must be of sufficient size to capture and hold the required capture volume. Retention basins are designed to capture and hold the water quality volume routed to them via diversion structures. All structural elements & piping below the Water Quality elevation shall be watertight.

(2) One-Hundred Year Storm. A bypass capable of conveying the 100-year storm around the basin must be provided.

(3) Erosion Prevention. The inlets to the retention basin must be designed to prevent erosion of the soil. Rock rip-rap or other erosion prevention systems must be placed at the basin inlet to reduce velocities to less than three feet per second.

(iii) Minimum Design Criteria for Wet Well and Pumps.

(1) Pumps.

The retention basin must be emptied within 72-hours after a rain event ends. Emptying of the retention basin must not begin sooner than 12 hours after the end of the rainfall event. The flow rate of the pumps (gpm) shall be designed with either a 30 hour or 60-hour drawdown time (30 hrs for single zone irrigation systems and 60 hrs for multi-zone).

Pumps must be capable of delivering the required volume of water at the necessary rate and pressure to the irrigation system in the designated time period. Pumps and wet well must be sized to minimize the number of on and off-cycles of the pumps. The rate (Q_I) of inflow from the retention pond Intake Riser (see 1.6.7(A)(3)(c)) to the wet well must exceed the pump rate (Q_P) by a minimum factor of two (2) to account for potential clogging of the intake.

A dual pump system must be provided, with each pump capable of delivering 100 percent of the design capacity.

Plug valves must be located outside the wet well on the discharge side of each pump to isolate the pumps for maintenance and for throttling if necessary. Butterfly valves and gate valves must not be used.

Check valve(s) must be provided to prevent backflow from the irrigation system back into the pump well.

Pumps must be selected to operate within 20% of their best operating efficiency.

(2) Pump Operation.

The pumps must alternate on start up. The control logic must allow the system to operate normally with only one pump in service.

A manual control must be provided so both pumps can be turned on if necessary.

A high/low-pressure pump shut off system (to detect line clogging or breaking) shall be installed in the pump discharge piping. As an alternative, an amp draw (overloads) or other equivalent monitoring device may be used.

Float controls or submersible transducers must be provided to control operation of the pumps. Three control settings must be used: (1) one for starting the pump, (2) one for shutting off the pump at the normal low water level, and (3) one for back up shut off of the pump in case the first shut-off fails.

An alarm system shall be provided consisting of a red light located at a height of at least five feet above the ground level at the wet well and be equipped with an auto dialer system to notify the owner when the alarm is triggered. The alarm shall activate when:

- The water level is below the primary shutoff float and the pump has not turned off.
- The high/low-pressure pump shut off switch has been activated.
- Any other pump failures or system shut down indicated by control panel.

The alarm must be vandal proof and weather resistant. If the system is to be privately maintained, a sign must be placed at the wet well clearly displaying the name and phone number of a responsible party that may be contacted if the alarm is activated.

A green "pump run light" shall be provided which is activated any time a pump is running. The green light should be located directly adjacent to the red alarm light.

(3) Wet Well.
A separate wet well outside of the basin must be provided for the pumps. The wet well must be constructed of precast or cast in place concrete. Complete access to the pumps and other internal components of the wet well for maintenance must be provided through a lockable hatch cover. Public systems maintained by the City of Bee Cave shall be equipped with a safety netting fall protection system. An isolation plug valve to prevent flow from the retention basin to the wet well during maintenance activities must be provided.

Calculations must be provided with the design showing that the wet well will not float under saturated-soil conditions. The top elevation of the well must be higher than the water quality elevation. The wet well, lateral inflow pipe, and pump must be designed to completely evacuate the retention pond. A space of at least two feet must be available below the bottom of the pump intake. The two-foot minimum space below the bottom of the pump may be waived if the applicant demonstrates that adequate filtration of the water quality volume is provided.

The pump installation in the wet well and access to the wet well must be designed to allow the pumps to be removed using truck-mounted hydraulic hoist equipment or a portable "A-frame." A stainless-steel railing system must be provided to allow pump removal without entering the wet well.

(iv) Minimum Design Criteria for the Irrigation System or Infiltration Field.

(1) Irrigation Timing.
The retention basin must be emptied within 72-hours after a rain event ends.

Irrigation must be initiated no sooner than 12 hours after the rain event ceases.

The irrigation controller must be set to provide alternating, equivalent irrigation and rest periods until the basin is emptied.

The time of irrigation on any area must not exceed the rest time. Continuous application on any area must not exceed two hours.

An adjustable rain sensor must be provided which will normally be set to temporarily halt irrigation during rainfalls exceeding one half inch (1/2”). The rain sensor must be able to interrupt irrigation (stop pumps) in the event of subsequent rain events prior to emptying basin. The 12-hour pump delay may initiate after the rain sensor senses the rain event has terminated.

Division of the irrigation area into two or more sections such that irrigation occurs alternately in each section is an acceptable way to meet the requirement for a rest period.

(2) Irrigation Rate.
The design irrigation rate shall not exceed the infiltration rate of on-site soils underlying proposed irrigation areas (per in-situ testing requirements) with a safety factor of two (2). The application rate may not exceed the infiltration rate on any portion of the irrigation area.

(3) Irrigation Area or Infiltration Field.
Calculations must be provided which demonstrate that an adequate irrigation area or infiltration field will be provided based on the soil infiltration rate, water quality volume, and, for irrigation areas, the application rate and actual irrigation time. The irrigation area or infiltration field system must be included within the water quality easement.

(4) Irrigation Area Slope.
Irrigation must not occur on land with slopes greater than 10%.

(5) Piping and Valves.
All irrigation system distribution and lateral piping (i.e. from the pumps to the spray heads) must be Schedule 40 purple PVC. All pipes and electrical bundles passing beneath driveways or paved areas must be sleeved with PVC Class 200 pipe with solvent welded joints. Sleeve diameter must equal twice that of the pipe or electrical bundle with casing spacers in accordance with City of Austin Standard Detail 501S-1. Buried piping must be marked with detectable marking tape labeled "CAUTION: BURIED NON-POTABLE WATER LINE BELOW".

(6) Valves.
All valves must be designed specifically for sediment bearing water, and be of appropriate design for the intended purpose. All remote control, gate, and quick coupling valves must be located in ten-inch or larger plastic valve boxes with purple caps. All pipes and valves must be marked to indicate that they contain non-potable water. All piping must be buried to protect it from weather and vandalism. The depth and method of burial must be adequate to protect the pipe from vehicular traffic such as maintenance equipment. Velocities in all pipelines should be sufficient to prevent settling of solids. The irrigation design and layout must be integrated with the tree protection plan and presented as part of the Site Plan or Subdivision

(7) Construction Plan.
Systems must include a plug valve to allow flushing at the end of every line.

(8) Sprinklers.
All sprinkler heads must have full or partial circle rotor pop-up heads and must be capable of delivering the required rate of irrigation over the designated area in a uniform manner. Sprinkler heads should have purple caps to indicate non-potable water. Irrigation must not occur beyond the limits of the designated irrigation area and sprinkler heads should be located at least twice the calculated spray radius from any residential lot. Partial circle sprinkler heads must be used as necessary to prevent irrigation beyond the designated limits. Sprinkler heads must be capable of passing solids that may pass through the intake. Sprinkler heads must be flush mounted and encased within a 2 feet × 2 feet concrete housing capable of protecting the head from mowing and service equipment (see Appendix H, Figure 1-59F for an example).

(9) Vegetation.
The irrigation area must have native vegetation or be restored or re-established with native vegetation. These areas must not receive any fertilizers, pesticides, or herbicides. If landscaped areas are used for irrigation, fertilizers, pesticides, or herbicides must not be applied to those areas and this limitation must be outlined in the Integrated Pest Management (IPM) plan. For publicly maintained systems, fencing or signs must be installed to limit unauthorized use of the irrigation area. If signs are installed, they must include the phrase "Stormwater Irrigation Area - No Trespassing."

(10) Soil.
The irrigation area must contain a minimum of 12 inches of native or enhanced soil with the appropriate permeability rates. A site visit may be conducted by the city to confirm soil conditions, including when representative trenches have been opened or borings are being conducted. City staff must be given at least 72 hours' notice of when borings or trenches are to be backfilled.
If soil is enhanced, topsoil or amended topsoil shall meet the requirements of Standard Specification 601S, Salvaging and Placing Topsoil. The condition, type, structure, and quality of the soil shall be conducive to infiltration and to plant growth. If alternative methods of amending soil can be demonstrated to increase the infiltration capacity by at least a factor of three, these methods may be used with approval from the City Engineer.

(11) Geological Features.
The irrigation area must not contain any Critical Environmental Feature Buffer Zones.

(12) Irrigation Area Buffer.
A buffer area of un-irrigated vegetation must be provided downstream of the irrigation area to treat any runoff that may occur from the irrigation area during heavy rainfall or from excessive irrigation. This area must be a minimum of 50 feet in length (in the direction of flow) and be adjacent to all downstream edges of the irrigation area. As an option, a diversion system (e.g. a swale or berm) may be provided to route any runoff to the retention basin. This diversion system must be designed to carry the runoff from the two-year storm. Alternatively, the irrigation area may be located upstream from the development such that any runoff will be routed to the retention pond.

(v) Manuals and As-Built Plans.

(1) The applicant must provide two complete copies of an Operations Manual for the pumps and irrigation system, which must include:

- Pump curves, electrical schematics, pump and instrument technical information, components of the control panel, pump maintenance recommendations with required frequencies, irrigation controller operation instructions and a written warranty.

- As-built plans of the retention basin, wet well, pumps, piping and irrigation system. The plans must show the location, size, and type of all pipes, valves, wiring, wiring junctions, and sprinkler heads.

For retention-irrigation systems that are to be maintained by the City of Bee Cave, both sets of plans and manuals shall be submitted to the Planning and Development Department.

For systems that are to be maintained privately, one set of plans and one manual shall be included with the operating permit application and the second set of plans and one manual shall be retained on site at all times.

3. Vegetative Filter Strips

(i) Description
Vegetated filter strips are densely vegetated sections of land designed to accept runoff as overland sheet flow. Dense vegetative cover facilitates conventional pollutant removal through detention, filtration by vegetation, and infiltration. Vegetated filter strips can either utilize natural filter strips or be engineered to maximize water quality benefits.

Natural vegetated filter strips make use of existing natural buffers and offer a passive low-cost alternative. Natural vegetated filter strips require a slope of less than 10%, an allowable flow length of a minimum 30 feet and maximum 60 feet, and an average soil depth of 4 inches.

Engineered vegetative filter strips are specifically designed and constructed to maximize the water quality benefits of filter strips, particularly in areas where adequate buffers do not exist.

Engineered vegetative filter strips differ from natural vegetative filter strips in that they can be placed on slopes up to 20% when combined with an infiltration berm and require a flow length of a minimum 20 feet and maximum 40 feet, a minimum of 6-inches of topsoil, and a uniform and even surface.

(ii) Application
Filter strips cannot treat high velocity flows, and do not provide enough storage or infiltration to effectively reduce peak discharges to predevelopment levels for design storms. This lack of quantity control restricts their use as a stand-alone SCM to relatively small contributing drainage areas. Filter strips can be used in the following development circumstances:

Filter strips can treat perimeter lots, structures, or roadways of a development that will not drain via gravity to a structural SCM; however, overall site pollutant removal shall meet or exceed the City's pollutant removal criteria. The use of filter strips to treat perimeter areas is limited to a contributing drainage area of 3 acres and requires the conversion of concentrated flow to sheet flow before entering the strip;

Filter strips shall generally be used in conjunction with other structural SCMs such as an extended detention, sedimentation/filtration basin, or wet pond by either being placed in series before or after these structural BMPs; and

Filter strips utilized as a secondary or tertiary SCM downstream of a structural SCM are not limited by the contributing drainage area received by the structural SCM so long as the filter strip meets the design criteria outlined in this section (i.e. flow length, sheet flow, velocity, and slope).

(iii) Design Guidelines

(1) Natural Vegetative Filter Strips

Contributing Drainage Area: The use of a filter strip as a standalone SCM should be limited to a contributing drainage area of less than 3 acres. Larger contributing areas are allowed when a filter strip is used in series as a secondary or tertiary SCM with a water quality basin such as an extended detention pond, a sand filter, or a wet pond.

Slope Restrictions: No portion of the natural filter area shall exceed a slope of 10%.

Minimum Dimension in Direction of Flow: The flow length over the vegetative filter or filter width must be at least 30 feet and no greater than 60 feet to receive the full treatment credit.

Upper Boundary Requirements: The filter strip must run along the entire edge of the contributing area; no collection or routing is allowed except following a water quality basin with flow attenuation or discharge from a level spreader to the filter strip. The soil along the upper boundary must be reinforced with protective matting or an infiltration trench may be used. Refer to Figure 4.14 below.

Velocity Restrictions: Vegetative filter strips are susceptible to erosion and the formation of rills; therefore, they may require the use of a level spreader (in accordance with City of Austin Standard Detail No. 634S-1) or an infiltration trench to spread flows and dissipate erosive velocities.

The runoff from the contributing area entering the upper boundary of the filter strip shall be in sheet flow conditions. Sheet flow conditions must meet the following constraints during the peak flow of a 2-yr, 1-hr storm event utilizing the Rational Method (depth equals 1.72 inches per City of Austin Drainage Criteria Manual) under fully- developed conditions:

The velocity of flow across the filter strip must not exceed 1 ft/sec.

The average depth of flow across the filter strip must not exceed 0.2 feet for a vegetative filter strip used in combination with a water quality basin.

L = 5*Q2 year dev

L = minimum width of a flow spreader (ft) perpendicular to flow

Q1 year dev = Peak flow rate from the 2-yr, 1-hr storm event

The average depth of flow across the filter strip must not exceed 0.1 feet for a vegetative filter strip used as a standalone BMP.

L = 10*Q2 year dev

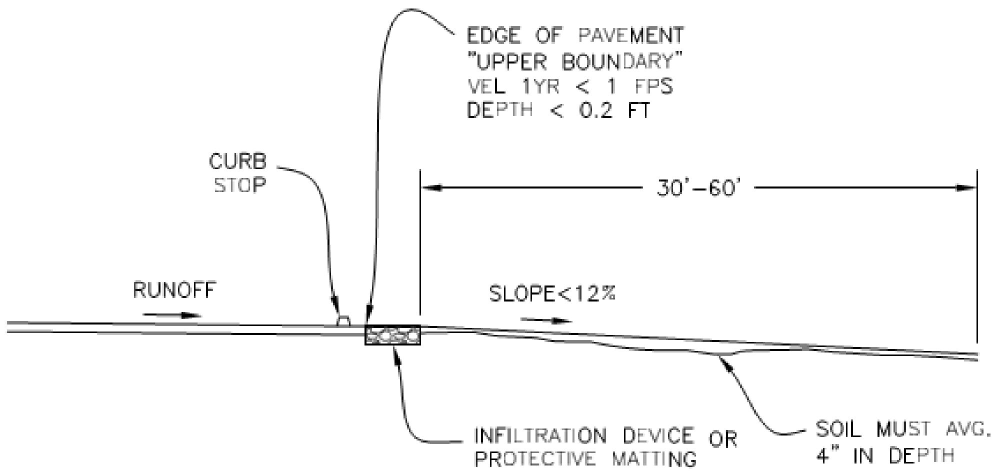
L = minimum width of a flow spreader (ft) perpendicular to flow

Q1 year dev = Peak flow rate from the 2-yr, 1-hr storm event

Surface and Vegetation Characteristics: The filter area must be free of gullies, rills and flow concentrations and have 95% vegetative cover. Suitable vegetation for VFS includes native grasses, forbs, shrubs and trees. In the case of natural wooded areas where 95% vegetative cover is not present, a minimum of four inches of leaf litter, mulch or other organic matter must be in place. In these areas, lower tree limbs should be removed, the canopy opened and the area seeded with appropriate native grasses and forbs in order to enhance ground cover.

Soil Requirements: The soil must average 4-inches in depth. Rock outcrop areas may be present but must be deducted from the total filter strip area and must not affect the function of the Vegetative Filter Strip.

Figure 4-14: Natural Vegetative Filter Strip



(2) Engineered Vegetative Filter Strips

Contributing Drainage Area: The use of a filter strip as a standalone BMP should be limited to a contributing drainage area of less than 3 acres. Larger contributing areas are allowed when a filter strip is used in series as a secondary or tertiary BMP with a water quality basin such as an extended detention pond, a sand filter, or a wet pond.

Slope Restrictions: No portion of the filter area shall exceed a slope of 20%.

Minimum Dimension in Direction of Flow: The flow length over the vegetative filter or filter width must be at least 20 feet and no greater than 40 feet to be credited towards the required area.

Upper Boundary Requirements: The filter strip must run along the entire edge of the contributing area; no collection or routing is allowed except following a water quality basin with flow attenuation or discharge from a level spreader to the filter strip. The soil along the upper boundary must be reinforced with protective matting or an infiltration trench may be used. Refer to Figure 4.15 below.

Velocity Restrictions: Vegetative filter strips are susceptible to erosion and the formation of rills; therefore, they may require the use of a level spreader (in accordance with City of Austin Standard Detail No. 634S-1) or an infiltration trench to spread flows and dissipate erosive velocities.

The runoff from the contributing area entering the upper boundary of the filter strip shall be in sheet flow conditions. Sheet flow conditions must meet the following constraints during the peak flow of a 2-yr, 1-hr storm event utilizing the Rational Method (depth equals 1.72 inches per City of Austin Drainage Criteria Manual) under fully- developed conditions:

The velocity of flow across the filter strip must not exceed 1 ft/sec.

The average depth of flow across the filter strip must not exceed 0.2 feet for a vegetative filter strip used in combination with a water quality basin.

L = 5*Q2 year dev

L = minimum width of a flow spreader (ft) perpendicular to flow

Q1 year dev = Peak flow rate from the 2-yr, 1-hr storm event

The average depth of flow across the filter strip must not exceed 0.1 feet for a vegetative filter strip used as a standalone BMP.

L = 10*Q2 year dev

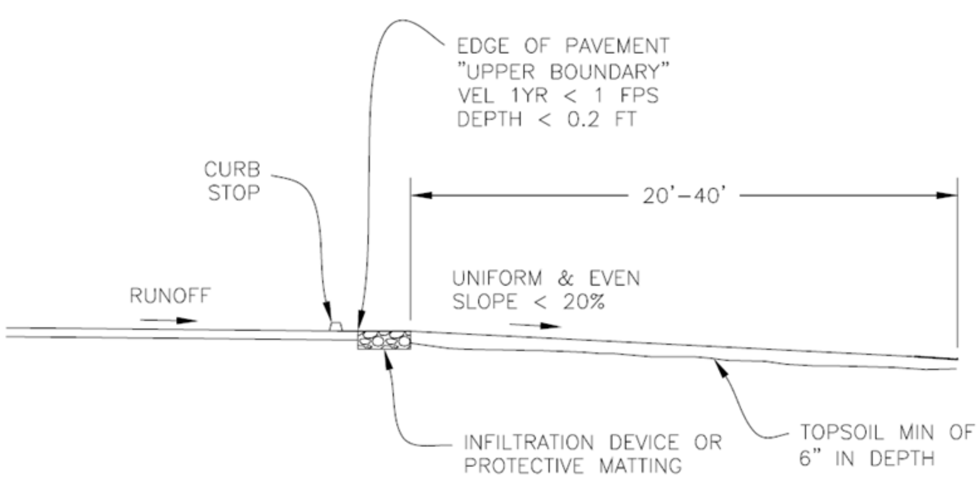
L = minimum width of a flow spreader (ft) perpendicular to flow

Q1 year dev = Peak flow rate from the 2-yr, 1-hr storm event

Surface and Vegetation Characteristics: The filter area, after final grading, should have a uniform and even slope and be capable of maintaining an even sheet flow across the entire filter surface. The filter area must be free of gullies, rills and flow concentrations. The strip must be sodded or if seed is used it must be native and accompanied by the appropriate soil retention blanket per City of Austin Specification No. 605S to ensure a minimum of 95% vegetative cover is established.

Soil Requirements: A minimum of 6-inches of topsoil is required. The topsoil must contain 10-20% compost, a clay content less than 20 percent and be free of stones, stumps, roots, or other similar objects larger than one (1) inch. If on-site soils do not meet these specifications, topsoil per the above specs must be added. Sandy loam is not an approved soil and caliche is not considered a soil.

Figure 4-15: Engineered Vegetative Filter Strip



(iv) Maintenance Requirements. See **Section 1.6.3**.

4. Biofiltration

(i) Introduction. Biofiltration devices are a type of stormwater control measure (SCM) that uses the chemical, biological, and physical properties of plants, microbes, and soils to remove pollutants from stormwater runoff.

A biofiltration system is an enhanced filtration device that typically utilizes more than one treatment mechanisms for removing pollutants from stormwater runoff. A sedimentation basin is required as a first step in the SCM, to provide pre- treatment of runoff in order to protect the biofiltration medium from becoming clogged prematurely by sediment loads. Then, flows are directed through a biofiltration medium which removes pollutants. A defining characteristic of the biofiltration SCM is a community of plants and microorganisms that is rooted in the filter medium and that can provide more treatment of runoff, directly and by uptake from the filter medium. As well as enhancing removal of pollutants, the plant community tends to sustain the permeability of the biofiltration medium for longer periods of time without maintenance. It is the existence of this biological community that differentiates a biofiltration SCM from a typical sand filter, which is otherwise comparable in design and performance.

There are several hydraulic features or components that combine to make the biofiltration system work effectively. There is commonly a splitter box or flow spreading structure at the flow entrance to ensure flows do not concentrate and potentially channelize the filter medium (see Section 1.6.2.B). There is a sedimentation chamber to capture coarse sediments, and in some cases (described below) a separator element. The biofiltration filtration chamber typically must have an underdrain piping system beneath it, with native or adapted vegetation rooted in the medium and selected for tolerance to ponding and dry soil conditions. Finally, there is an outlet structure from the SCM at the point of discharge.

For biofiltration ponds to work effectively, the stormwater velocity into the sedimentation chamber must not exceed two (2) feet per second (fps). This requirement tends to limit the size and amount of impervious cover that is practical for treatment using this kind of device. Biofiltration ponds are relatively low maintenance once native plantings are well established. These devices should be restricted from any use that may negatively affect the function of the biofiltration pond (e.g. pet use, application of herbicides and pesticides, excessive mowing, etc.). To ensure this, an approved and recorded Integrated Pest Management plan will be required for the drainage area up to and including the pond area. See **Section 1.6.3** for maintenance, and irrigation requirements.

(ii) Basin Surface Areas and Volumes.
The following equation gives the minimum surface area required for the filtration basin:

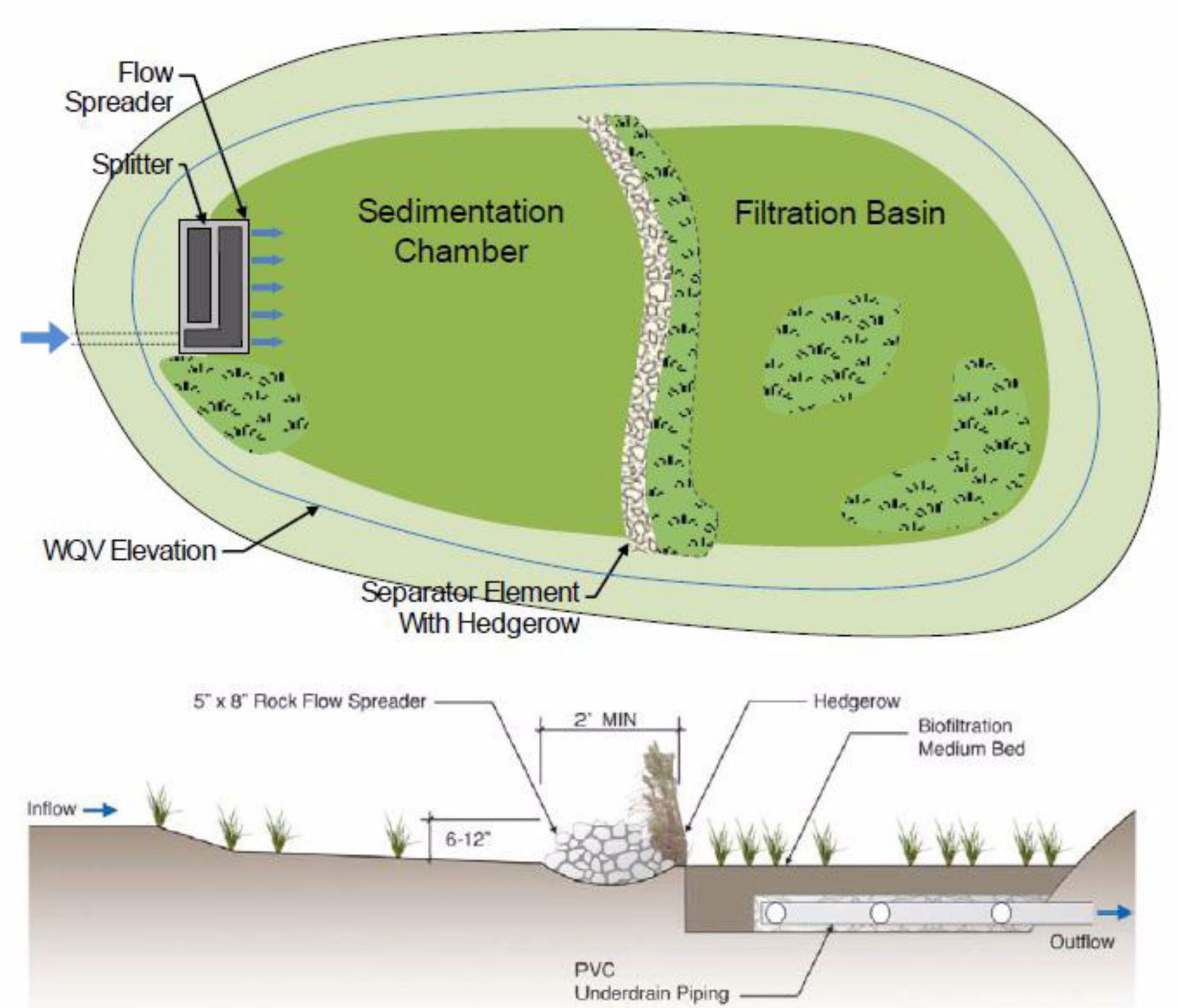
$A_f = WQV*L/(k*t*(H_{max}/2+ L))$ (Equation C-1) Where

- A_f = required surface area of the medium in square feet.
- WQV = the water quality volume in cubic feet as defined in **Section 1.6.2**.
- L = Depth of the filter medium (typ. 1.5 feet).
- k = Hydraulic Conductivity (3.5 ft/day for "full" sedimentation-filtration systems; 2 ft/day for "partial" systems).
- H_{max} = Maximum head over the filter medium (feet).
- t = Drawdown Time (two (2) days).

For design purposes, the hydraulic conductivity of the biofiltration medium can be assumed to be the same as that for sand filtration. Measured hydraulic conductivity of new biofiltration medium substantially exceeds 3.5 ft/day; however, a significant reduction in conductivity over time due to surface crusting and clogging of void spaces by lower-permeability silt and clay particles will occur. If surface crusting and clogging can be minimized (which should be the case for biofiltration systems due to the presence of vegetation) it is reasonable to assume that the hydraulic conductivity of biofiltration systems should be comparable to sand filters.

(1) Partial Sedimentation/Biofiltration Systems.
In this case, the sediment chamber is not large enough to store the whole water quality volume, so that volume must be stored partly over the sediment chamber and partly over the biofilter. The combined volume of the sediment chamber and filtration basin must therefore equal to the water quality volume, i.e., V s + V f = water quality volume where "V s " is the sediment chamber volume and "V f " is the filtration basin volume. The volume of the sediment chamber, "V s ", shall be no less than 20 percent of the water quality volume. For general details see Figure 1.6.7.C-2, Partial Sedimentation/Biofiltration Pond, and Section 1.6.5.B, Partial Sedimentation/Filtration.

Figure 1.6.7.C-2: Partial Sedimentation/Biofiltration Pond.



Based on the equation and assumptions given above, the minimum surface area required for the biofiltration basin is: Af = WQV/(4 + 1.33*H) (Equation C-3)

Where:

Af = required surface area of the medium in square feet,

WQV = water quality volume in cubic feet as defined in section 1.6.2.A, and H = maximum ponding depth above the filtration medium in feet.

(iii) Sedimentation Basin/Sediment Chamber Details. The system consists of an inlet structure, flow spreader, vegetative settling area, and separator element. It is recommended that the bottom of the sediment chamber be >2" higher than the top of the filtration basin in order to uniformly discharge flow at or above the biofiltration vegetation, and to prevent excessive drawdown times due to tailwater effects.

(1) Inlet Structure/Flow Spreader. The inflow of the water quality pond should pass through a splitter box structure or flow spreading device (see section 1.6.2.B). Either way, the water quality volume flowing into the BMP should be discharged uniformly and at low velocity into the basin/chamber in order to promote settling of entrained sediments, to avoid re-suspension of previously deposited sediments and, in extreme cases, to avoid flow concentration and subsequent channelizing of the basin/chamber substrate. Flow spreading should be designed to restore the flows entering the BMP (i.e., after the inlet structure) to sheetflow conditions with a maximum velocity of two (2) feet per second for the peak flow rate of the twenty-five (25) year storm with the assumption that the catchment area has reached its fully development condition. See Section 1.6.2.D. Plantings in the sedimentation basin may provide resistance to flow and further spread the flows, thereby reducing runoff velocities further to improve settling, biological uptake, and adsorption.
The basin/chamber should have a bottom slope of at least 1% for privately maintained ponds and 2% for publicly maintained ponds to ensure that the pond will drain adequately even after silt accumulation. Depending on the planned approach to maintenance and sediment removal, it may be desirable for the heavier suspended material to drop out near the inlet end of the basin.

(2) Separator Element. A Separator Element structure is required for the Partial Sedimentation Biofiltration pond and should be designed to discharge the flow evenly across the filtration basin. This is important to avoid channelizing and destruction of the filtration medium surface. A reinforced vegetated hedgerow is recommended that uses five (5) inch by eight (8) inch rock flow spreaders or low gabion structures, two (2) feet wide and six (6) inches to twelve (12) inches deep, with hedgerows located within the structure (see Figure 1.6.7.C-2). The outflow side should incorporate features to prevent gouging of the filtration medium.

(iv) Biofiltration Basin Details. The Biofiltration medium bed filtration system consists of the biofiltration medium bed, underdrain piping, and outlet structure.

(1) Biofiltration Medium. In order to provide acceptable drainage and plant growth characteristics, the biofiltration medium shall meet the following performance criteria: Percent Organic Matter (by weight) of 0.5—5.0% Texture Analysis (particle size distribution):

- Percent Sand 70—90%
- Percent Clay 3—10%
- Percent Silt plus Clay ≤27%

Suppliers of biofiltration media must have laboratory testing conducted at a minimum of six month intervals to verify percent organic matter and texture analysis. The medium must not contain any contaminated soils and be free of any household or hazardous waste. It must be free of stones, trash, and other undesirable material, and should not contain weeds or weed seeds. A saturated hydraulic conductivity of k≥2.0 in/hr can be presumed if the organic matter and texture analysis criteria are met.

The hydraulic conductivity needs to be high enough to provide adequate drainage, support healthy plant growth, and prevent nuisance conditions.

The criteria are intended to meet the NRCS definition of soils with "moderate" to "high" available water capacity. The criteria should ensure that the medium has sufficient water holding capacity to support vigorous plant growth, enhancing the ability for plants to survive during dry periods. It should also sustain a healthy microorganism population which, in concert with the plants, should enhance biological removal of pollutants in stormwater.

The percent organic matter criterion is needed to ensure healthy vegetation. Most native soils in the Austin area have less than 4% organic matter, and native plants in the area have adapted to surviving in these types of soils. A higher organic matter content is not desirable as nutrients may be exported from the medium, which is counter to the removal that is intended in this type of device. Immature compost, manure, compost derived from animal or human sources, and unstable forms of organic matter that may export nutrients should not be included in the biofiltration medium. Recommended sources of organic matter include that found naturally in native topsoil, humus, coconut coir fiber, and mature plant-derived composts with an established fungal component. The biofiltration medium must be certified by the project engineer or their designee (e.g. contractor, soil supplier, or appropriate qualified alternative individual) as meeting the above performance criteria (based on submittal of delivery tickets, test results, etc.) before acceptance by the City.

(v) Creating Biofiltration Mixture - See City of Austin Standard Specification 660S, Biofiltration Medium B.

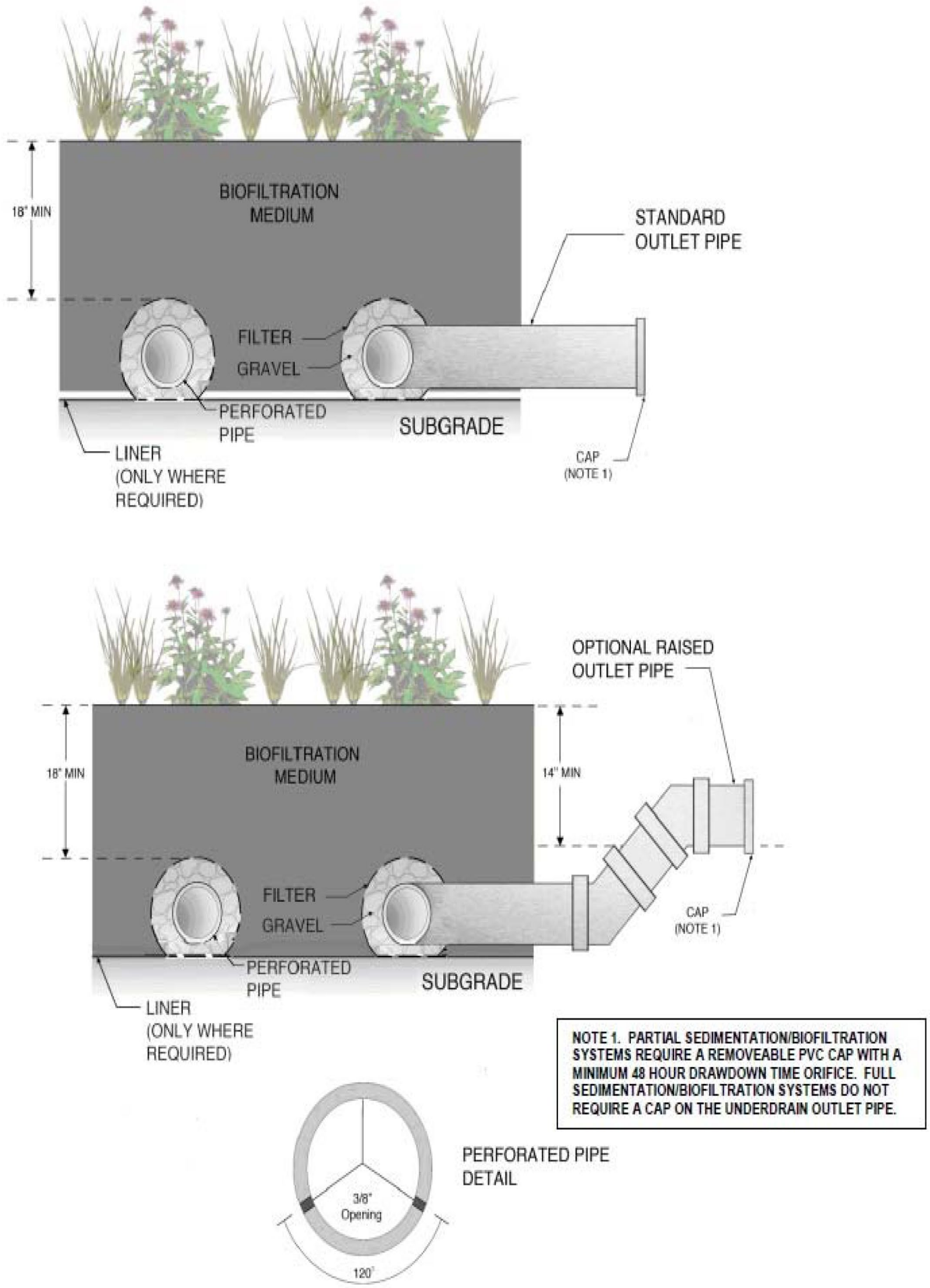
(1) Biofiltration Bed with Underdrain. The biofiltration medium bed for biofiltration basins must be built to the Biofiltration Bed configuration illustrated in Figure 1.6.7.C-3 (for details see City of Austin Standard Detail 661-3). The biofiltration medium layer is to be a minimum of eighteen (18) 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.
A filter can be of two (2) general forms. A fabric filter is a 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 geotextile filter fabric must comply with City of Austin Specification 620S, Table 2, High Flow Filter Fabric Requirements.

- The gradation of a granular filter design must comply with Section 1.4.6.D.6, Rock Riprap - Filter. 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 or four inches (102 mm) whichever is greater.

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.

Figure 1.6.7.C-3: Biofiltration medium bed with underdrain system.



Access must be provided for cleaning all underdrain piping. Cleanouts with a removable PVC cap are required within fifty (50) feet of every portion of lateral, at collector drain lines, and at every bend. In order to minimize damage to these cleanouts due to maintenance equipment, vandalism, and mowing, the top of the cleanout should be set flush with the top of the biofiltration medium bed or ground surface from which it emerges. It is recommended that cleanouts be located outside of the water quality volume ponding area and above the water quality volume elevation when feasible to reduce short circuiting caused by loss or damage to the cleanout caps. At least one lateral must be accessible for cleaning when the pond is full. The full pond cleanout must extend above the water quality elevation and/or be located outside of the water quality volume ponding area. In order to minimize vandalism or other types of damage the use of exposed piping shall be avoided or minimized.

Note: The top surface of the biofiltration medium bed must be horizontal.

(2) Outlet Structure. The outlet structure shall be designed in accordance with ECM section 1.6.4, Design Guidelines for Sedimentation/Filtration Systems, but may also include a raised outlet as shown in Figure 1.6.7.C-3 to create a saturated zone within the underdrain gravel area and part of the biofiltration medium. The advantages of a raised outlet are that the retained water is partially available to support plants in the filtration basin during extended dry periods and it reduces the total headloss across the system.
The surface discharge from the underdrain pipe shall be non-erosive. A splash pad or other dissipation system may be necessary. Unless site conditions make it impossible, the underdrain pipe should discharge to a gravel trench in order to diffuse the discharge flow and promote infiltration and recharge (see Figure 1.6.5.A.4, Sand Filtration Basin Details). The trench should be the width of the filtration basin and filled with gravel (See Figures 1-52 and 1-58 in Appendix H).

(vi) Landscape Design. Although an essential role of the landscaping is to make the pond attractive, the highest priority shall be to meet the pond's water quality and soil stabilization functional requirements. A diverse suite of plants should be selected based on their ability to survive under alternating conditions of inundation and extended dry periods, and in different areas within a facility (e.g., basin versus side slopes). High plant diversity will provide resiliency to the system and help prevent a situation where all vegetation is lost. Over time, the plant species that are best suited to the unique conditions of each basin will naturally self-select and spread.
The landscape elements for the sedimentation basin or chamber may be different than for the biofiltration basin, due primarily to different soil characteristics. Compared to most native soils in the Austin area, the biofiltration medium may drain more rapidly, and have less clay content. The selection of plants for the biofiltration medium depth will also be limited because the medium depth is typically about 1.5 feet, thus plants with large root systems are not appropriate. Trees shall not be used in the biofiltration chamber with underdrains. The soil characteristics and depth, and soil moisture availability including groundwater, in the sedimentation basin or chamber will probably vary widely from site-to-site, and this will have a significant effect on the plant selection.

City of Bee Cave maintained biofiltration systems may be designed with turf grass and/or ground cover plants only.

(1) Plant Selection, Quantities, and Spacing.
Vegetation shall be planted throughout the entire sedimentation and filtration basin areas as shown on a planting plan along with list of proposed plant species, container size, spacing, and quantity (Figure 1.6.7.C-4). The proposed vegetation must be diverse, appropriately distributed, and spaced according to the mature size of the particular plants. A landscape

architect or other qualified landscape professional should be involved in the design to ensure appropriate plant species selection and layout.

(1) Selection

Vegetation may comprise shrubs, perennials, bunchgrasses, succulents, groundcovers or turf, and this generally requires that there be a minimum of five (5) different species planted. Annuals are not permitted, and small trees, while allowed (see below) do not count towards the minimum species requirement. The designer can choose plants from the Grow Green Native and Adapted Landscape Plants guide (**www.austintexas.gov/department/grow-green/plant-guide**). Table 1.6.7.C-3 is a list of plants from this guide that the City of Austin does not recommend based on soil depth requirements, soil moisture requirements, and undesirable plant characteristics (e.g., short-lived, weak wood, suckering, maintenance concerns [messy fruit, thorny]).

Small trees can be incorporated:

- In the filtration basin, around the perimeter of the filtration basin, above the water quality volume, as long as the underdrain system is protected from penetration by the tree root system and the structure does not meet the definition of a dam or levee/floodwall as defined in the Drainage Criteria Manual section 8.3.3.
- In the sedimentation basin, in the floor and side slopes within the water quality volume, if soil conditions and depth are appropriate, and measures are taken to prevent root penetration into the adjacent filtration underdrain system.
- See Table 1.6.7.C-3 for a list of trees not recommended for biofiltration facilities.

Plants must be selected and arranged carefully so that they serve their intended functions. In addition to choosing plants for their aesthetic properties, select plants that:

- are adapted to the pond hydrology (i.e. both periodic flooding and drought);
- are adapted to the soil types within the pond, whether native site soils or biofiltration media;
- are suitable for their specific function (e.g. erosion control, filtration, etc.);
- are durable, resilient and resistant to pests and disease;
- are tolerant of the pollution in stormwater runoff;
- have a root system of the desired type, mass and depth;
- are resistant to weed invasion;
- require minimal maintenance;
- are not invasive; and
- are commercially available.

Rooted plants may be provided in bare- or live-root form, sod, or in containers (e.g., trays, pots, tubes). Root mass of bare- root plants must be equal in mass to the equivalent container sizes. For the purpose of fulfilling the required minimum plant quantity, it is assumed that the plants to be installed will be 1-gallon size. Other sizes are acceptable but overall the quantity must be equivalent to the required minimum one-gallon plants. See Table 1.6.7.C-1 for equivalency.

Table 1.6.7.C-1

Plant Size Equivalents

Potential Substitute		Equivalent To	
Quantity	Plant Size	Quantity	Plant Size
1	Five-gallon or larger	4	One-gallon
1	Two- or Three-gallon	2	One-gallon
4	4" pots or quarts	1	One-gallon
8	Plugs	1	One-gallon
2	Pieces of sod	1	One-gallon

(2) Quantities

A certain percentage of the basins should be planted with rooted plants to provide immediate cover, whereas the other parts can be seeded or covered with turf grass (see below). All species, including turf grass will count towards the diversity minimum. No one species should comprise more than 20% of the total area of the basin. Additional rooted plants beyond the minimum is encouraged. If it can be demonstrated that there is a compelling reason to deviate from these guidelines then an alternative design may be allowed with approval from City staff.

- Sedimentation Basin

  To determine the minimum required quantity of rooted plants, multiply the total surface area (in square feet) of the sedimentation basin by ten percent (0.1). This number represents the minimum number of plants to be placed in the sedimentation basin.

- Filtration Basin

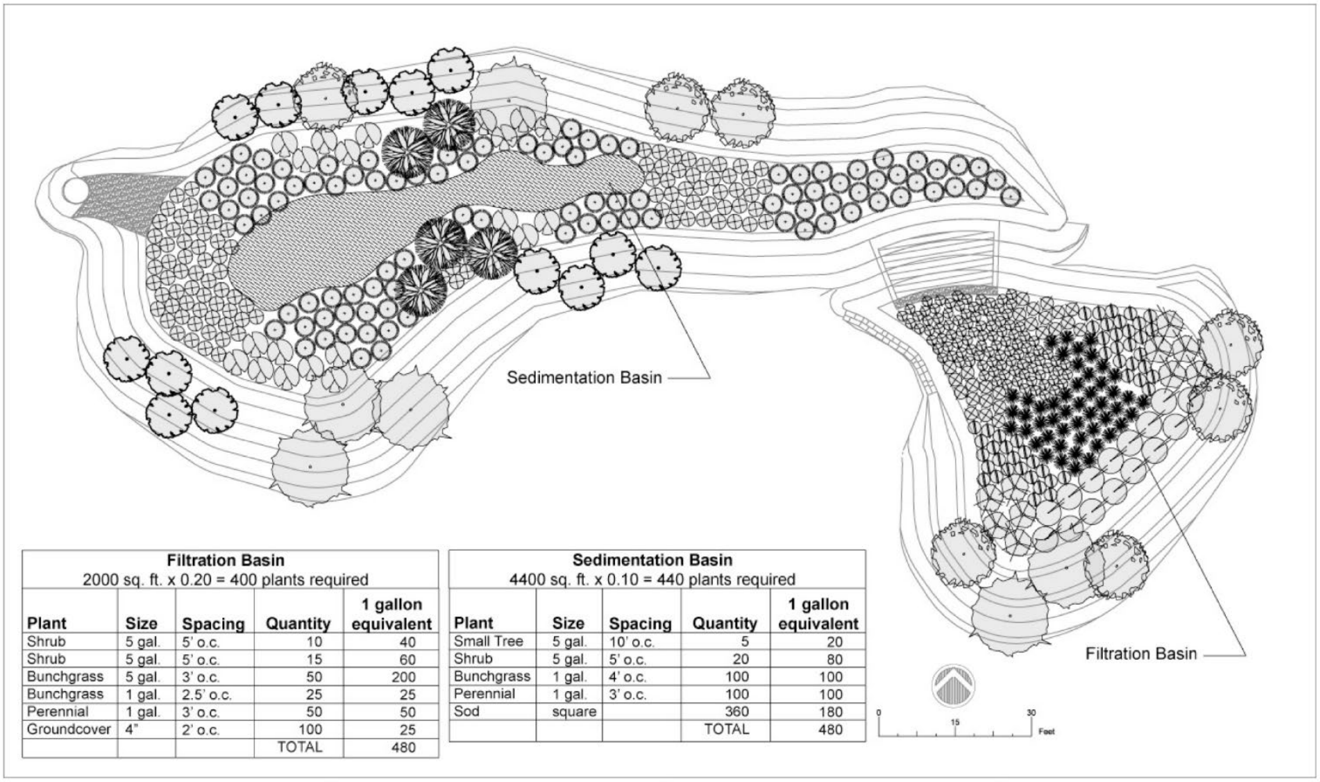
  To determine the minimum required quantity of rooted plants, except turf grass, multiply the total surface area (in square feet) of the filtration basin by twenty percent (0.2). This number represents the minimum number of rooted plants to be placed in the filtration basin.

(3) Spacing

The goal is to provide 95 percent vegetative coverage across the basins.

- Rooted plants should be spaced based on mature size to allow room for growth and avoid overcrowding conditions that will cause plant mortality or impenetrable barriers for maintenance personnel.
- Contiguous areas of sod should be planted end to end, allowing no bare soil.

Figure 1.6.7.C-4: Example of Biofiltration Landscape Layout and Calculations



Filtration Basin 2000 sq. ft. x 0.20 = 400 plants required				
Plant	Size	Spacing	Quantity	1 gallon equivalent
Shrub	5 gal.	5' o.c.	10	40
Shrub	5 gal.	5' o.c.	15	60
Bunchgrass	5 gal.	3' o.c.	50	200
Bunchgrass	1 gal.	2.5' o.c.	25	25
Perennial	1 gal.	3' o.c.	50	50
Groundcover	4"	2' o.c.	100	25
			TOTAL	480

Sedimentation Basin 4400 sq. ft. x 0.10 = 440 plants required				
Plant	Size	Spacing	Quantity	1 gallon equivalent
Small Tree	5 gal.	10' o.c.	5	20
Shrub	5 gal.	5' o.c.	20	80
Bunchgrass	1 gal.	4' o.c.	100	100
Perennial	1 gal.	3' o.c.	100	100
Sod	square		360	180
			TOTAL	480

(2) Plant Species Not Allowed or Recommended.
Various plant species are not allowed or not recommended in biofiltration facilities for various reasons. Plants listed in Table 1.6.7.C-2 are not permitted in biofiltration systems. These plants are not native and have shown the capacity to naturalize here or in other areas of the country. The intent is to avoid future problems with invasive plants. The following restrictions apply:

- Plant species listed as invasive by the City of Austin or the State of Texas are not allowed. Refer to:
- City of Austin Top 24 list **http://www.texasinvasives.org/plant_database/coa_results.php**
- TDA Noxious Weed List **http://texreg.sos.state.tx.us/fids/200701978-1.html**
- In addition, plants in the following table are not allowed due to their potential invasiveness.

Table 1.6.7.C-2

Vegetation That Is Not Permitted For Planting

Common Name	Botanical Name	Comments
Pampas grass	Cortaderia selloana	Potentially invasive
Scotch broom	Cytisus scoparius	Invasive shrub
Weeping love grass	Eragrostis curvula	Invasive grass
Cogon grass	Imperata cylindrica	Invasive grass
Japanese silver grass	Miscanthus sinensis	Invasive grass
Fountain grass	Pennisetum setaceum	Invasive grass
Common reed	Phragmites australis	Tall invasive grass

Table 1.6.7.C-3

Vegetation That Is Not Recommended

Plant Type	Common Name	Botanical Name	Comments
SMALL TREES/LARGE SHRUBS	Anacua	Ehretia anacua	Suckers; prefers well- drained soil; cold tender
	Cherry Laurel	Prunus caroliniana	Requires deep soils
	Crape Myrtle	Lagerstoemia indica	Requires deep soils
	Goldenball Lead Tree	Leucaena retusa	Requires consistently dry soil
	Mexican Olive	Cordia boissieri	Messy fruit
	Palms (non-native)	Various	Various
	Texas Persimmon	Diospyros texana	Messy fruit
	Pomegranate	Punica granatum	Messy fruit
	Retama	Parkinsonia aculeata	Suckers, short-lived
	Roughleaf Dogwood	Cornus drummondii	Suckers
	Flameleaf Sumac	Rhus lanceolata	Needs large space; suckers
	Viburnum	Viburnum rufidulum	Requires deep soils
	Wax Myrtle	Morella cerifera	Requires deep soils
	Xylosma	Xylosma congestum	Spiny; potentially invasive

SHRUBS	Japanese Aralia	Fatsia japonica	Requires shade and regular water
	Japanese Yew	Podocarpus macrophyllus	Requires shade and regular water
	Fragrant Mimosa	Mimosa borealis	Requires consistently dry soil
	Bush Germander	Teucrium fruticans	Requires consistently dry soil
	Globe Mallow	Sphaeralcea ambigua	Requires consistently dry soil
	Mock Orange	Philadelphus coronarius	Requires consistently dry soil
	Pineapple Guava	Eijoa sellowiana	Cold tender, messy fruit
	Rosemary	Rosmarinus offinialis & prostratus	May not tolerate poorly drained soil
	Texas Sage	Leucophyllum frutescens	Requires consistently dry soil
PERENNIALS	Blackfoot Daisy	Melampodium leucanthum	Requires consistently dry soil
	Bulbine	Bulbine frutescens	Cold tender
	Cast Iron Plant	Aspidistra elatior	Requires dry shade
	Frostweed	Verbesina virginica	Colonizes; limited commercial availability
	River Fern	Thelypteris kunthii	Requires shady, moist areas
	Gayfeather	Liatris mucronata	Requires consistently dry soil
	Hymenoxys	Tetraneuris scaposa	Requires consistently dry soil
	Shrimp Plant	Justicia brandegeana	Prone to spread to outside areas
GROUNDCOVERS	Monkey Grass	Ophiopogon japonicus	Requires shady, moist soil
	Purple Heart	Setcreasea pallida	Prone to root rot; cold tender
	Silver Ponyfoot	Dichondra argentea	Good drainage critical

(vii) References:

(1) Maryland Department of the Environment, Center for Watershed Protection, 2000, 2000 Maryland Stormwater Design Manual, Volumes I and II

(2) New Jersey Department of Environmental Protection, 2004, Stormwater Best Management Practices Manual , Division of Watershed Management Trenton, NJ.

(3) Prince George's County Department of Environmental Resources Programs and Planning Division, 2001, The Bioretention Manual , Maryland

(4) Low Impact Development (LID), Urban Design Tools, lid-stormwater.net

(5) USEPA, NPDES, Stormwater Best Management Practices, cfpub.epa.gov/npdes/stormwater/

5. Porous Pavement

(i) Description. Porous pavement describes a system comprising a limited capacity load-bearing, durable surface together with an underlying layered structure that temporarily stores water prior to infiltration and releases the temporarily stored water by infiltration into the underlying permeable subgrade. Porous pavement shall only be allowed for non-vehicular, pedestrian traffic. When proposing the use of a porous pavement system highly detailed specifications and details must be provided and an experienced contractor shall be selected, to minimize potential problems.

(ii) Credit. Permeable pavement may be granted a fifty percent (50%) impervious cover credit for the horizontal surface area of the permeable pavement if designed in strict accordance with this section.

The types of porous pavement systems that are acceptable for pedestrian traffic are as follows:

(1) Open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP): These systems consist of high strength concrete units that are separated by open or stone-filled joints that allow stormwater to infiltrate. The concrete units are laid on an open graded, single-sized granular base. See Figure 1.6.7.E-1 for a typical cross section (disregard vehicle in figure; credit for pedestrian pathways only).

(2) Porous concrete pavement: This system is monolithically poured concrete produced by binding aggregate particles with a mortar created with water and cement as specified by the manufacturer. Minimal sand content results in large voids and high pavement porosity, typically between 15 and 25%. This high porosity and the weaker cement bond result in less strength compared to conventional concrete. See Figure 1.6.7.E-3 for a typical cross section (credit for pedestrian pathways only).

(iii) Site Selection.

(1) Land Use - Porous pavement should be limited to pedestrian areas only. Permeable surfaces are currently not considered suitable for roads, drives, or parking areas.

(2) Off Site Flows - Run-on from drainage area(s) outside of the porous pavement area is not allowed.

(3) Hot Spots - Porous pavement systems depend upon infiltration into the underlying permeable subgrade. Due to the potential for groundwater contamination, porous pavement shall not be allowed under stormwater hot spots or in areas where land use or activities generate highly contaminated runoff or yield high sediment loads. Hot spot runoff frequently contains pollutant concentrations exceeding those typically observed in stormwater. Hot spots include, but are not limited to, commercial nurseries, auto salvage facilities, hazardous materials generators (where containers are exposed to rainfall), vehicle fueling and maintenance areas, and vehicle and equipment washing dry or steam cleaning facilities, food production/distribution loading dock and trash compactor areas (Note: Some of these land uses/activities may have additional discharge restrictions under City UDCs Section 20.04).

(4) Geotechnical Evaluation - A major factor for most design decisions is related to the existing soil conditions. It shall be necessary to obtain geotechnical/soils and subsurface information prior to the design of a porous pavement system. To demonstrate the feasibility of the design the following information must be submitted to the City Engineer with the site plan or subdivision construction permit application:

(5) Soil Conditions - The subgrade saturated hydraulic conductivity must be greater than or equal to 0.20 in/hr.

- For sites with a consistent soil type, a minimum of one soil permeability test must be taken per 5,000 square feet of **planned porous surface area. The determination of**

the infiltration rate must follow the criteria established in Section 1.6.7.4, Infiltration Rate Evaluation.

- Testing must be performed prior to the start of construction and prior to the placement of the base or gravel layer on the native soil to verify that design saturated hydraulic conductivity values are present. The Environmental inspector must be contacted 48 hours prior to these tests being performed so they can be present during the test and/or evaluate and approve the results.

(6) Water Table - The depth to water table is greater than or equal to twelve (12) inches.

(7) Bedrock -The depth to bedrock is greater than or equal to twelve (12) inches.
Setback Requirement - If a porous pavement system is proposed near a structure or a street. Then an additional geotechnical evaluation shall be undertaken to identify potential impacts and to establish minimum distances between the system and the structure.

(8) Impermeable Barrier - Porous pavement adjacent to buildings, roadways, and other structures may require the installation of an impermeable barrier to prevent possible damage to these structures due to infiltration. The requirement for impermeable barriers may be at the discretion of the design engineer. The Public Works Director or designated representative shall review any decisions on impermeable barrier(s) within City ROW and easements.

(9) Slopes - The use of porous pavement system shall be restricted to gentle slopes up to a 20 to 1 grade (5%). On steeper slopes the potential for water seepage out of the pavement surface limits effectiveness.

(iv) Design Guidelines. The designer must select the appropriate material properties, the appropriate pavement thickness, underlying layers, material types, and other characteristics needed to meet the anticipated traffic loads and hydrological requirements simultaneously.
The following criteria must be met when designing a porous pavement system:

(1) The gravel layer below porous pavement must have a minimum thickness greater than or equal to five (5) inches with an assumed effective porosity no greater than 0.30 to account for reduced volume due to sediment. The gravel layer must be an open graded (single size) aggregate, with little or no fines. Examples of standard open graded gravel materials that allow for storage and conveyance of storm water are those that meet C-33 ASTM Nos. 8, 9, 57, and 67.

(2) For open-jointed block pavement, PICP, or CGP:

- It is required that the joints be filled with a durable, angular, porous, open-graded, aggregate that promotes rapid infiltration, and meeting C-33 ASTM No. 8 or 9 aggregate requirements.
- In order to preserve the porosity and permeability of the pavement fine-graded sands or aggregates, such as concrete sand, soil and mortar sand, are not allowed.

(3) For porous concrete design and construction the design engineer must follow the recommendations provide by The American Concrete Institute (ACI) committee 522.

Figure 1.6.7-E.1 Typical Cross Section For Open-Jointed Block Pavement, Permeable Interlocking Concrete Pavement Or Concrete Grid Pavement.

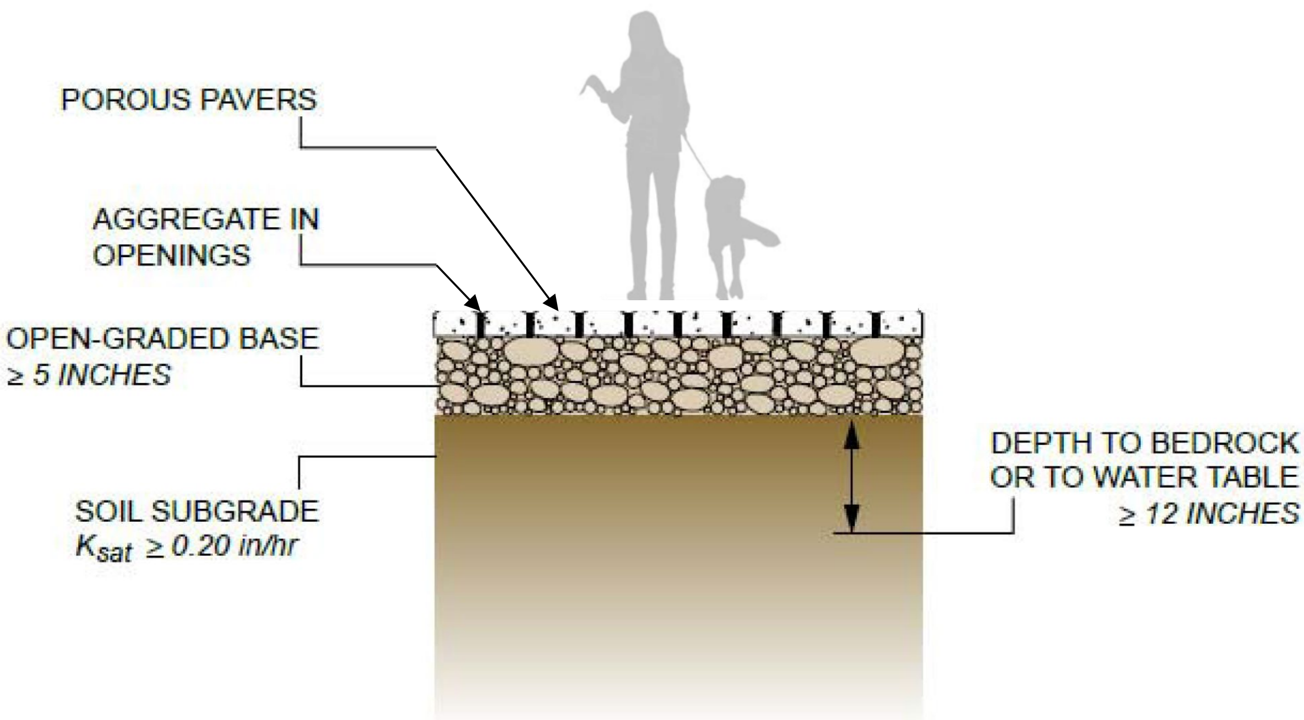
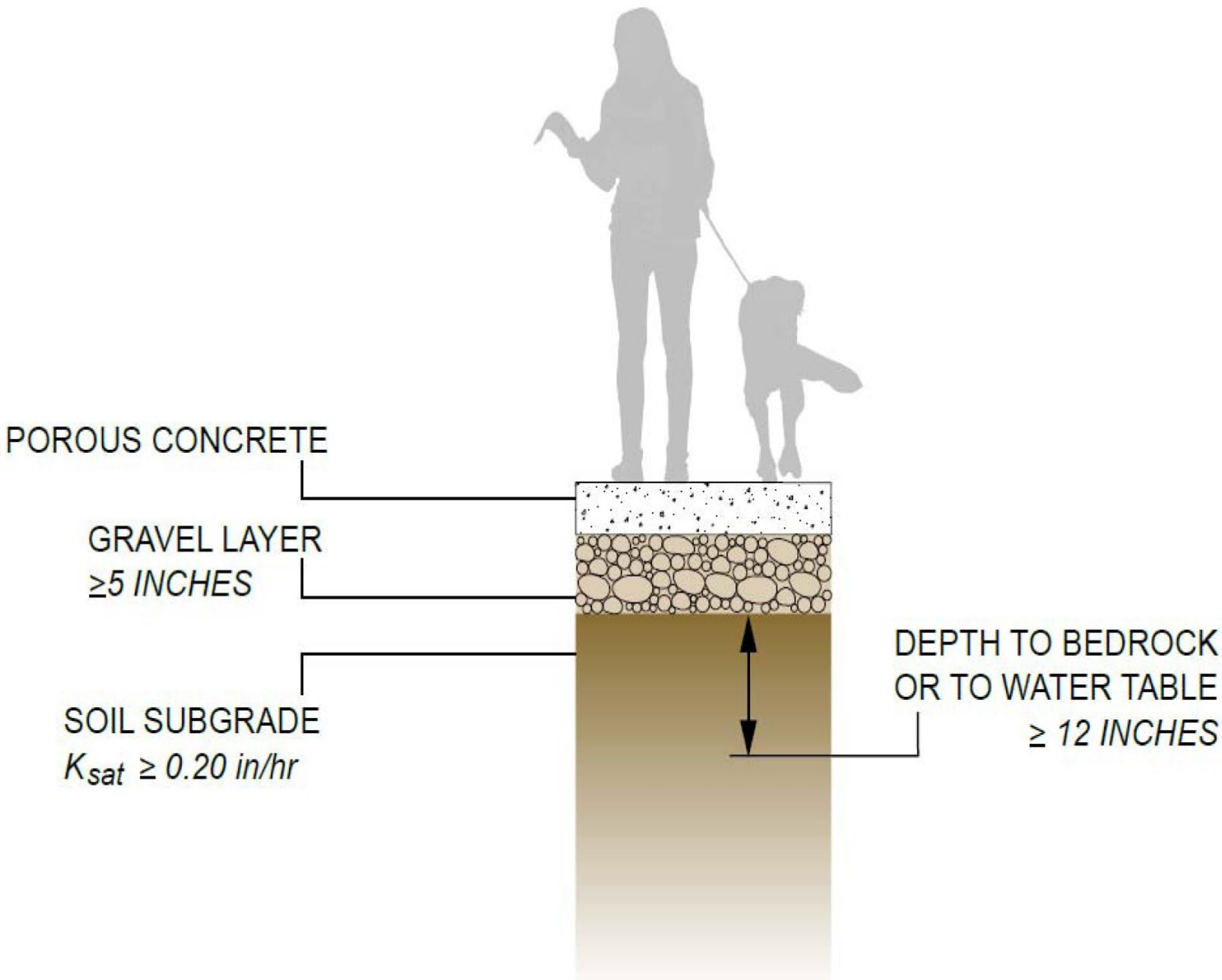


Figure 1.6.7.E-3 Typical Cross Section For Porous Concrete Pavement.



(v) Site Plan or Subdivision Construction Plan Requirements. The following information must be included in the Site or Subdivision Construction plan sheet(s):

(1) The standard sequence of construction must be modified to include the following special requirements:

- Pre-Construction - Contractor installation qualifications require that the contractor provide to the Environmental Inspector at the preliminary construction meeting a statement attesting to qualifications and demonstrating experience. Contractors must prove specialized competence by presenting a copy of current certification from an authoritative porous pavement industry association.

  Acceptable porous pavement industry associations are the following:

  - For open-jointed block pavement, permeable interlocking concrete pavement, or concrete grid pavement: Interlocking Concrete Pavement Institute, Brick Industry Association, National Concrete Masonry Association,
  - For porous asphalt: Texas or National Asphalt Pavement Associations,

   - For porous concrete pavement: Texas or National Ready Mixed Concrete Associations, or
   - American Society of Civil Engineers.

(2) Saturated hydraulic conductivity testing must take place twice:

- Prior to construction, and
- Prior to placement of the gravel bed.
- The gravel bed saturated hydraulic conductivity test results must be provided to the City Engineer documenting that the design saturated hydraulic conductivity has been met.

(vi) Construction. Proper construction of permeable pavement systems requires measures to preserve natural infiltration rates prior to placement of the pavement, as well as measures to protect the system from the time that pavement construction is complete to the end of site construction. The following recommendations apply to all permeable pavement systems:

(1) General.
Keep mud and sediment-laden runoff away from the pavement area.

Temporarily divert runoff or install sediment control measures as necessary to reduce the amount of sediment run-on to the pavement.

Cover surfaces with a heavy impermeable membrane when construction activities threaten to deposit sediment onto the pavement area.

Low ground pressure (LGP) track equipment should be used within the pavement area to limit over-compacting the subgrade. Wheel loads such as, passenger cars and pick-up trucks should not be allowed on the pavement area during construction.

(2) Subgrade Preparation. Since porous pavement is an infiltration practice it is imperative that the permeability of the underlying native soils be preserved. The following recommendations apply to all permeable pavement systems:
It is important to protect the subgrade from over compaction, accumulation of fines, excessive construction equipment traffic, and surface ponding. Any accumulation of debris, fines, or sediment that has occurred during subgrade preparation should be removed prior to starting the gravel bed installation.

Grading shall not take place during wet soil conditions to minimize sealing of the soil surface.

In situations where the subgrade has been over compacted or the permeability has been diminished scarification should take place to a depth sufficient to match the naturally occurring in-situ state. Typically scarification should be a minimum of four (4) to six (6) inches in depth.

(3) Gravel Bed Preparation. The gravel bed should consist of clean, crushed gravel, free of mud, clay, vegetation or other debris, conforming to ASTM C 33 for stone quality. Size gradation shall conform to ASTM C-33 No. 57 or No. 67 as described in City of Austin Standard Specification 510.2.(a), Pipe Bedding Stone.

Placement of the gravel bed can occur once:

- The design saturated hydraulic conductivity of the subgrade has been verified using the criteria stated in Section 1.6.7.4.
- A member of the City's engineering staff has approved the gravel bed preparation.

- Any accumulation of debris, fines, or sediment that has occurred during the placement of the gravel bed installation has been removed.

(4) Porous Pavement Installation. Contractor installation qualifications require that the contractor provide to the Planning and Development Department, at the preliminary construction meeting, a statement attesting to qualifications and demonstrating experience with the following porous pavement procedures and tests:

For all types of porous pavement systems:

- Contractors must prove specialized competence by presenting current certification from an authoritative industry association.
- Provide the addresses for a minimum of three (3) completed projects with similar geologic and climate conditions as the proposed site.

For porous concrete and porous asphalt systems provide additional information regarding the procedures that will be followed to meet the following:

- Measuring unit weight acceptance data.
- Conducting in-situ pavement tests including void content and unit weight.
- Preparing product samples.

If the installing contractor and pavement producer do not have sufficient experience with porous pavement systems, the installing contractor shall retain an experienced consultant to monitor production, handling, and placement operations at the contractor's expense.

(vii) Post Construction/Inspection. The porous pavement surface saturated hydraulic conductivity must be greater than or equal to 20 in/hr.
Use the following testing methods to verify the surface saturated hydraulic conductivity:

(1) For porous concrete and porous asphalt use ASTM C1701.
(2) For open-jointed block pavement, PICP, or CGP use ASTM C1781.

All inspection, infiltration testing, and maintenance activities shall be documented and made available to City of Bee Cave inspection staff upon request.

(viii) Maintenance. See Section 1.6.3.C.8 for requirements related to maintenance.

(ix) References.

(1) USEPA, NPDES, Stormwater Best Management Practices, cfpub.epa.gov/npdes/stormwater/
(2) Lower Colorado River Authority, Highland Lakes Watershed Ordinance, Water Quality Management Technical Manual, July 1, 2007, 4-57
(3) Urban Drainage and Flood Control District, Urban Storm Drainage Criteria Manual Volume 3, Best Management Practices, November 2010, pp. 6-15—6-17
(4) Texas Commission on Environmental Quality, RG-348 Complying with the Edwards Aquifer Rules Technical Guidance and Best Management Practices, July 2005, pp. 3-25—3-26
(5) Ferguson, Bruce K., 2005. Porous Pavements, CRC Press, pp. 2-4, 384
(6) Water Environment Federation (WEF) Manual of Practice No. 23/American Society of Civil Engineers (ASCE)/Environmental & Water Resources Institute (EWRI) Manuals and Reports on Engineering Practice No. 87, 2012, Design of Urban Stormwater Controls, 384

6. Full Infiltration Rain Garden.

(i) Description.

A rain garden is a vegetated, depressed landscape area designed to capture and infiltrate and/or filter stormwater runoff. The growing medium for the rain garden consists of native soil or biofiltration media. If the infiltration capacity of the subgrade soils is limited, the rain garden can be underlain by an underdrain system. Rain gardens will provide removal of pollutants in stormwater runoff similar to other treatment systems. However, because they are restricted to smaller drainage areas and shallower ponding depths, which necessitate a larger surface area, infiltration, evapotranspiration, and biological uptake mechanisms may be more significant for rain gardens than other treatment BMPs.

(ii) Site Selection.

Rain gardens can be used in new developments or as a retrofit within an existing site. Unlike conventional centralized stormwater management systems, multiple rain gardens may be dispersed across a development, and incorporated into the landscape, providing aesthetic as well as ecological benefits. Rain gardens allow for all or a portion of the water quality volume (WQV) to be treated within landscaped areas. Rain gardens are especially suited for small sites and are typically installed in locations such as parking lot islands, site perimeter areas, and other landscape areas.

Figure 1.6.7.A-8. Multiple rain gardens may be dispersed across a development, and incorporated into the landscape, providing aesthetic as well as ecological benefits.

The following site characteristics must be considered when designing a rain garden:

(1) Land Use - The use of rain gardens as a water quality control is limited to Commercial, Multi-Family, Civic Uses, Public Right of Way, and single family residential projects. The restrictions on use of rain gardens for single family residential are as follows:

- Rain Garden must be located in a dedicated common area or within a drainage easement that is accessible by standard maintenance equipment from the right of way.
- If utilized for a single-family residential application, a minimum of four (4) single family lots must be treated by the rain garden.
- No rain gardens are to be located in backyards or fenced in yards.

Full infiltration rain gardens are not allowed in areas where land use or activities generate highly contaminated runoff due to the potential for ground water contamination. These areas include commercial nurseries, auto recycle facilities, hazardous materials generators (if containers are exposed to rainfall), industrial process areas, gas stations, food production/distribution loading dock and trash compactor areas, vehicle fueling and maintenance areas, and vehicle and equipment washing and steam or dry cleaning facilities.

(2) Drainage Area - Rain gardens are restricted to a contributing drainage area not to exceed two acres and a ponding depth not to exceed 12 inches.

(3) Setbacks - Rain gardens must be designed to prevent adverse impacts to building foundations, basements, wellheads, and roadways from the infiltration of water.

(4) Slopes - Rain gardens should not be located on slopes exceeding 15 percent.

(5) Soil conditions - When siting a full infiltration rain garden, appropriate soil conditions must be present.

(iii) Full Infiltration Raingardens.
The depth to an impermeable layer must be at least equivalent to the depth of the media layer below the bottom of the rain garden. The underlying native soil must have a design infiltration rate that will draw down the full ponded depth in less than 48 hours. For example, for a 12-inch maximum ponding depth, the design infiltration rate must be at least 0.25 inches per hour. For a 6-inch maximum ponding depth, the design infiltration rate must be least 0.13 inches per hour. For a 3-inch maximum ponding depth, the minimum design infiltration rate is 0.06 inches per hour. The design infiltration rate is based on applying at least a factor of safety of two (2) to the measured steady state saturated infiltration rate (i.e., the design infiltration rate is equal to one-half of the measured infiltration rate). A higher factor of safety may be used at the discretion of the design engineer to take into variability associated with assessment methods, soil texture, soil uniformity, influent sediment loads, and compaction during construction. The infiltration rate of the soil subgrade below the growing medium of the rain garden must be determined using in-situ testing as described in **Section 1.6.7.B**. If a range of values are measured, then the geometric mean should be used.

Soil amendments may be approved by the City Engineer based on City of Austin Standard Specification 660S – Biofiltration Medium.

Groundwater and Soil Contamination - Full infiltration rain gardens are not allowed in locations where infiltration would cause or contribute to mobilization or movement of contamination in soil or groundwater or would interfere with operations to remediate groundwater contamination.

(iv) Maintenance Considerations.
Maintenance requirements are included in ECM **Section 1.6.3**. During design, the following should be considered to facilitate long-term maintenance:

Whenever possible, design the rain garden to be offline (whereby surface flow enters and exits (only when full) the system through the same opening), with runoff by-passing the system once ponding depth equals the water quality volume elevation. This configuration may reduce erosion from larger storm events and will also minimize mixing of the water quality volume.

While not required, consider providing pre-treatment to help reduce the extent and frequency of maintenance, especially if the contributing drainage area is expected to generate sediment, debris, or other pollutant that may cause decreased system functionality. Pre-treatment may include a sedimentation chamber, a vegetated or manufactured separator element (to functionally separate the rain garden into higher deposition and lower deposition zones), a vegetated filter strip, or an inlet designed at a minimal slope to encourage sediment deposition prior to flows entering the rain garden.

Select native vegetation, unless otherwise approved by the City, to reduce the need for long-term irrigation and maintenance. If rain gardens are over-irrigated and receive significant applications of fertilizers and herbicides, they can become sources of pollution rather than pollutant removal BMPs. Thus, it is essential that these rain garden systems be managed carefully and that an approved and recorded Integrated Pest Management plan be required for the drainage area up to and including the rain garden.

Whenever possible, vegetation should be planted throughout the entire rain garden to provide a fully stabilized surface. Containerized plants are typically grown in a looser growing medium conducive to drainage whereas grass sod is sometimes grown in more cohesive soils that may inhibit drainage. Avoid the use of wood chips because they tend to float and may clog the outlet or be washed downstream. Coarsely-shredded hardwood mulch such as that obtained from the primary run through an industrial tub grinder will be more resistant to movement and is recommended. Gravel or stone mulch is also resistant to movement but may cause sediment to build up and inhibit infiltration.

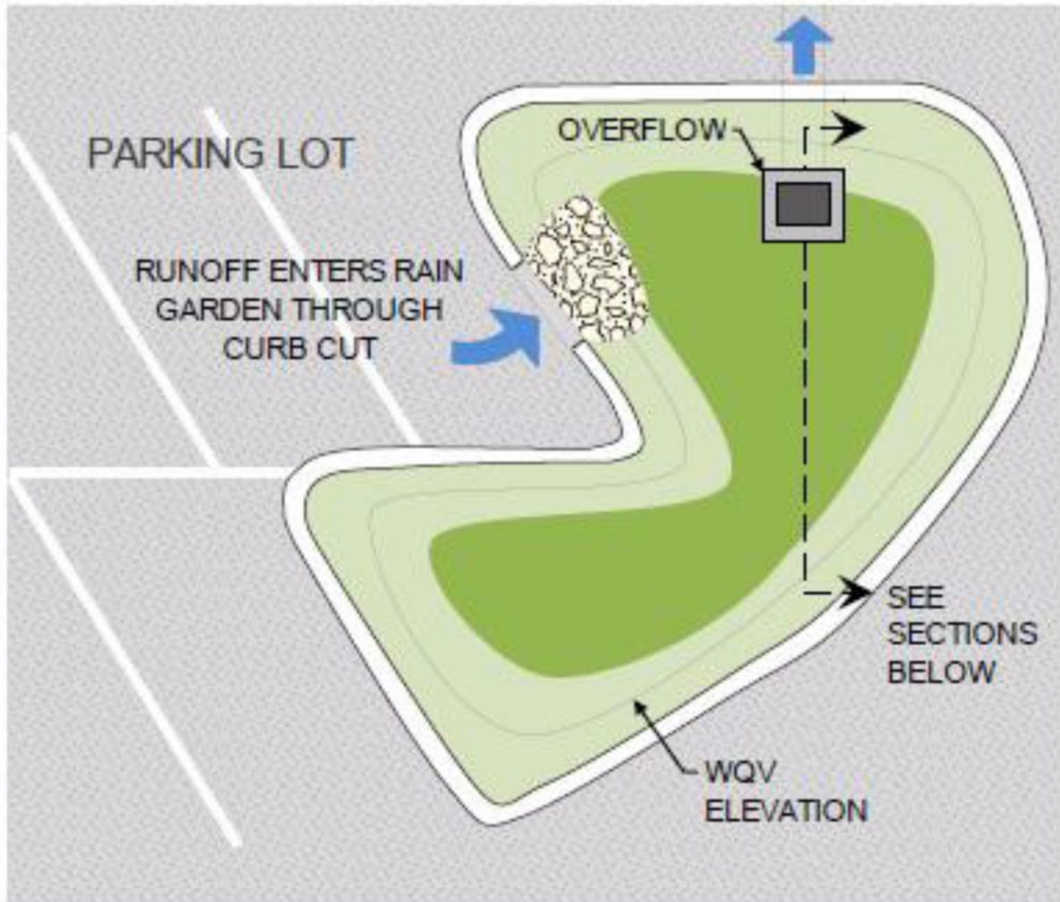
If pedestrian traffic is expected, provide stepping stone paths along a predefined route to discourage trampling of vegetation and compaction of soil. Planting spiny vegetation such as yucca, sotol, or agarita along the edge of the rain garden may effectively discourage pedestrian use.

Design the rain garden depression to be as shallow as possible to facilitate mowing and reduced erosion.

(v) Sizing.

Rain gardens may be sized to capture and treat the entire water quality volume. The storage volume provided is the combined volume of the ponded water in the basin and the effective porosity volume in the growing medium. Growing medium requirements are provided in Part 5 of this section. Raingardens should be designed with minimum 4:1 side slopes, should site conditions restrict the use of sloped embankments vertical walled raingardens may be approved on a case-by-case basis by the City Engineer.

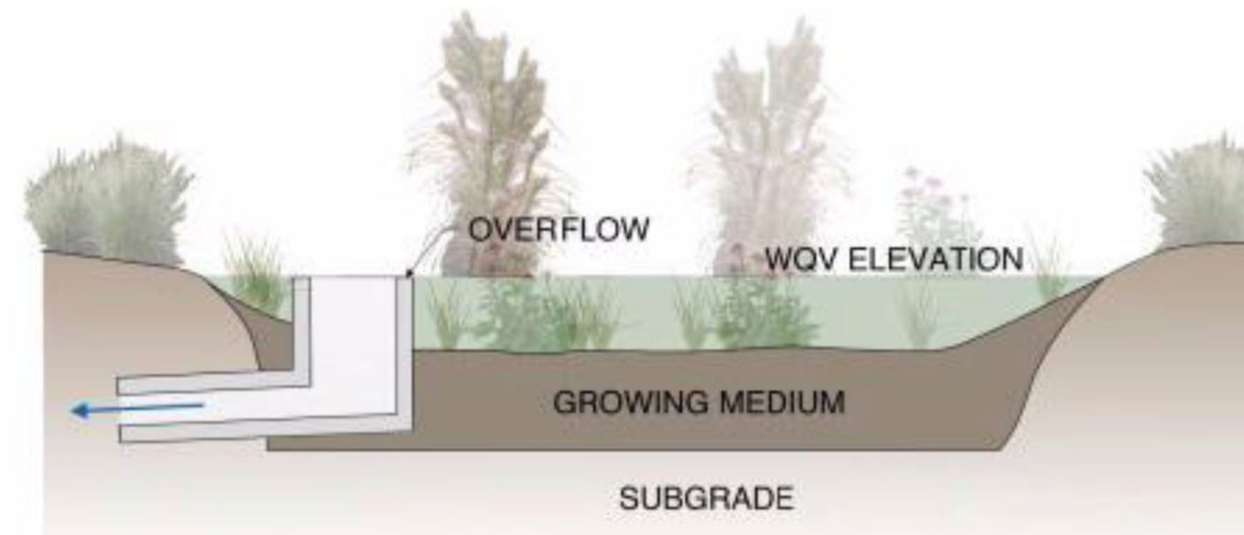
Figure 1.6.7.H-2. Rain Gardens Can Be Sized To Capture And Treat All Or A Portion Of The Required Water Quality Volume (WQV).



Sizing criteria for full infiltration rain gardens are provided below:

(1) Full Infiltration
Full infiltration rain gardens are sized to capture and fully infiltrate runoff. The infiltration area is the average surface area of the rain garden basin (i.e., the area at full ponding depth plus the area at zero ponding depth divided by two). If the side slopes of the basin are not permeable (e.g., masonry or concrete walls), then the infiltration area is the bottom permeable footprint. Equation H-1 below provides the infiltration area required for a full infiltration rain garden.

Figure 1.6.7.G-3. Full Infiltration Rain Gardens Use the Infiltration Capacity Of The Site Soils To Reduce Stormwater Runoff Volume And Associated Pollutants.



$A_i \geq WQV/(H + 0.24 * L)$ (Equation G-1) Where:

A_i = infiltration area (ft^2),

WQV = water quality volume (ft^3),

L = depth of the biofiltration growing medium (ft), and H = maximum head over the growing medium (ft).

The maximum allowable head over the growing medium for a full infiltration rain garden is 12 inches provided the design infiltration rate of the subgrade soil allows for draw down of the ponded depth in at most 48 hours (see soil condition requirements in Site Selection section above). Ponding depths in excess of 12 inches are not permitted

Note that maximum ponding depth and minimum design infiltration rate criteria are based on a maximum 48-hour drawdown time. Drawdown times less than 48 hours are permitted (and encouraged).

(vi) Growing Medium.
The rain garden growing medium should have sufficient water holding capacity to support vigorous plant growth, enhancing the ability for plants to survive during dry periods. It should also sustain a healthy microorganism population which, in concert with vegetation, should enhance biological removal of pollutants in stormwater.

Requirements for the growing medium depend on the type of rain garden design being considered. For full infiltration rain gardens, the growing medium should be native soil. In the event the designer is not certain about the native soil's ability to support vegetation, a 6-inch layer of topsoil may be added to the soil. This additional depth of soil must be accounted for in the depth and volume required for the pond. For partial infiltration rain gardens, only the biofiltration medium may be used. See Standard Specification 660S Biofiltration.

(vii) Underdrain System.

A full infiltration rain garden does not have an underdrain system and does not require a geotextile under the growing medium.

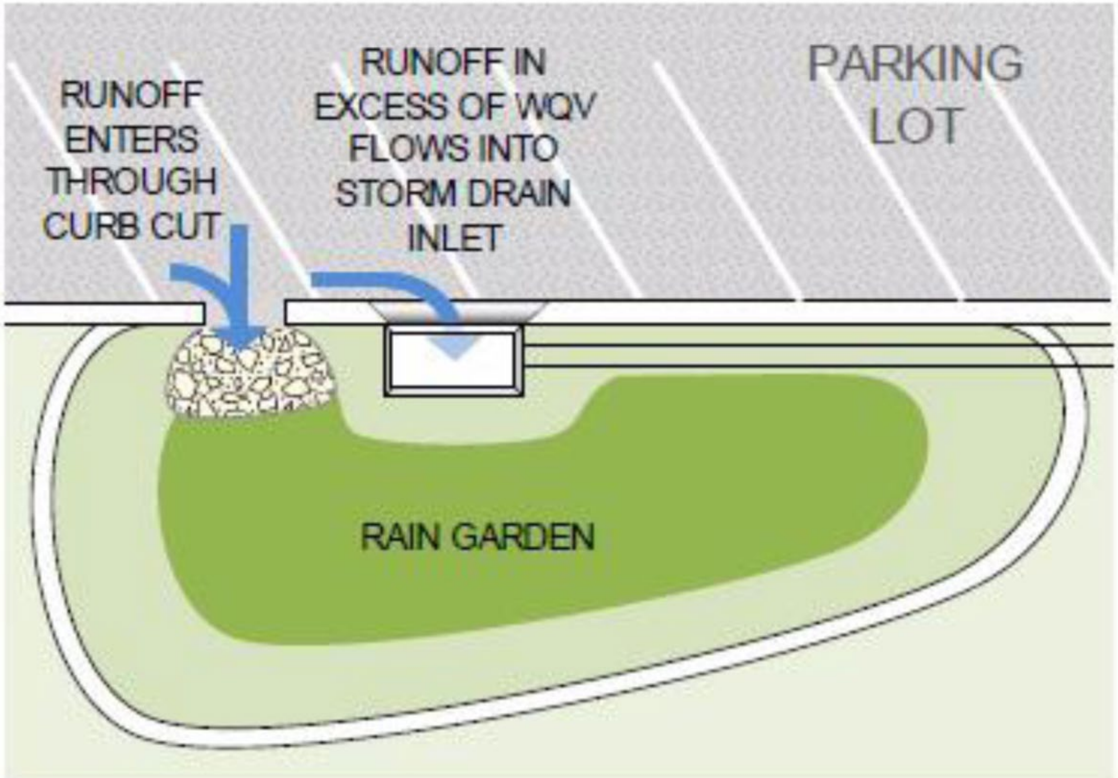
(viii) Flow Control.

(1) Inflow: How runoff enters (and for larger storms overflows or bypasses) the rain garden depends on the overall drainage configuration for the site. Runoff may enter via sheet flow from surrounding areas (for example, a parking lot with a ribbon curb), or runoff may enter as concentrated flow through a curb cut, a splitter box, or other inlet. When using a curb cut approach, ensure that inflow curb cuts have sufficient positive slope into the rain garden to prevent minor obstructions such as leaves in the curb line from obstructing flow into the system. Provide energy dissipation for rain gardens with concentrated points of inflow. The maximum velocity discharged to the rain garden should not exceed 2 feet per second.

(2) Internal Flow Management: Rain gardens located on a sloped area can be designed to pool to a specified water quality elevation and then overflow into downstream cells through a raised outlet structure or level spreader.

(3) Outflow: The preferred design to manage volume in excess of the WQV is to use an offline system configuration such that when the rain garden is full, additional runoff does not enter the system and instead flows past the inflow opening. Outflow of volume in excess of the WQV can also be managed through the use of standpipe risers, elevated catch basins, or down gradient curb cuts. When selecting the type and location of the outlet structure, incorporate enough detail in the design to prevent unintentional bypass of the rain garden before it is full. For example, when using an adjacent curb inlet to a storm drain for overflow, make sure to include sufficient grade control to establish preferential flow to the rain garden. The surface discharge from the rain garden shall be non-erosive with a maximum permissible flow velocity of 2 feet per second.

Figure 1.6.7.G-7. Example of the preferred offline system configuration for flow control.



(ix) Landscape Design.
Although an essential role of the vegetation is to make the rain garden attractive, the highest priority shall be to meet the water quality and soil stabilization functional requirements. Another important function of the vegetation is to help reduce clogging of the growing medium. Vegetation should be selected based on its ability to survive under alternating conditions of inundation and extended dry periods. High plant diversity is recommended and will provide resiliency to the system and help prevent a situation where all vegetation is lost. Over time, the plant species that are best suited to the unique conditions of each rain garden will naturally self-select and spread.

Vegetation quantity, size, spacing, and selection shall meet the requirements for filtration basins as provided in ECM Section 1.6.7C, Biofiltration, with the exception that rain gardens do not require a minimum of five different species (i.e., one species is acceptable), although higher diversity is recommended.

(x) Examples.
EXAMPLE CASE STUDY 1 - Full Infiltration Rain Garden (no underdrain system)

A 5-acre site has a total of 3 acres of impervious cover. Runoff from a 1-acre parking lot will be routed to a 0.08-acre parking lot island which will be designed as a full infiltration rain garden to capture and treat a fraction of the water quality volume. Based on the 1-acre parking lot and 0.08 acre parking lot island, the rain garden drainage area has a total impervious cover of 92.4%. The depressed parking lot island is 18 ft wide, 200 ft long, and 6 inches deep. The flat bottom of the parking lot island is 14 ft wide and 190 ft long. Infiltration tests indicate the infiltration rate of the subgrade is 0.25 in/hr. Determine the BMP Design Factor (BMPDF) and water quality credit for the rain garden (Figure 1.6.7-1 and Equation 1.6.7-1).

From Equation G-2,

$WQV_{BMP} = 12 * A_i * (H + 0.24 * L)/(0.87 * A)$

Based on the proposed geometry, the infiltration area, A_i, of the proposed rain garden is: (area @ full depth + area @ zero depth)/2 = (18' * 200' + 14' * 190')/2 = 3,130 ft^2

The growing medium is proposed to be topsoil amended with 15% expanded shale to a depth, L, of 1 ft.

Thus, the water quality capture depth provided by the rain garden is:

$WQV_{BMP} = 12 * 3130 ft^2 * [(0.5 ft + 0.24 * 1 ft)]/(0.87 * 43560 ft^2) = 0.73$ inches WQV_{ECM} for a 92.4% impervious cover area is 1.22 inches.

Next determine the BMPDF:

BMPDF is determined using Figure 1.6.7-1 and is a function of WQV_{BMP}/WQV_{ECM}

WQV_{BMP}/WQV_{ECM} = 0.73 in./1.22 in. = 0.60

Using Figure 1.6.7-1, BMPDF = 0.75

The water quality credit from Equation 1.6.7-1 can be calculated as follows:

WQC = IAF × BMPDF =1/3× 0.75 = 0.25

Therefore, the rain garden design would provide treatment for 25% of the required water quality volume for the entire site. The remainder of the required water quality volume must be treated using additional down gradient controls or through fee- in-lieu costs.

7. Infiltration Trench

(i) Pretreatment: Required, infiltration trenches must be the second BMP in series, located downstream of a water quality basin.

(ii) Soil Requirements: A subsoil infiltration rate between 0.3-5.0 in/hr is required (Minimum 10 hours drawdown, maximum 48 hours). There must be a three (3) foot separation between the trench invert and the high-water table and greater than one (1) foot of separation between bedrock and the BMP invert. At least one soil boring or test hole per 1,000 square feet required to observe soil properties and depth to water table and bedrock. The infiltration rate should be determined using one of the following:
Infiltrometer testing using a double ring infiltrometer (ASTM D 3385-94) or percolation test.

If the infiltration testing performed on-site indicates that underlying soils have an infiltration rate of less than 0.3 in/hr, then soil amendments will be required at the site. Refer to City of Austin Standard Specification 660S – Biofiltration Medium for appropriate design/planning criteria.

(iii) Trench Sizing: The required infiltration trench volume is determined from the type of upstream water quality basin, the calculated Water Quality Volume (WQV) and the hydraulic conductivity of soil. A porosity value "n" (n=Vv/Vi) of
0.35 should be used in the design of stone reservoirs for infiltration practices.

For All Primary (Upstream) BMPs

VIT = WQV *Xk

Xk – Primary BMP and Infiltration Rate Factor (see tables below)

k (in below tables) – hydraulic conductivity of soil

Table 1: Xk for Infiltration Trench Sizing

X_k - For Typical Primary BMPs (without downstream VFS)					
	Extended Detention	Batch Pond	Sand Filter/Sed-Fil	Biofiltration	Wet Pond
k (in/Hr)					
Less than 0.30	Not Permitted				
0.30-0.49	0.1404	0.1350	0.1370	0.1143	0.1270
0.50-0.69	0.0907	0.0878	0.0897	0.0765	0.0793
0.70-0.89	0.0672	0.0651	0.0667	0.0574	0.0593
0.90-1.09	0.0533	0.0518	0.0530	0.0460	0.0474
1.10-1.29	0.0442	0.0430	0.0440	0.0383	0.0394
1.30-1.49	0.0380	0.0368	0.0376	0.0328	0.0338
Greater than 1.5	0.0330	0.0321	0.0329	0.0287	0.0295

Table 2: Xk for Infiltration Trench Sizing – with downstream VFS

X_k - For Typical Primary BMPs (with downstream VFS as tertiary treatment)					
	Extended Detention	Batch Pond	Sand Filter/Sed-Fil	Biofiltration	Wet Pond
k (in/Hr)					
Less than 0.30	Not Permitted				
0.30-0.49	0.0723	0.0711	0.0690	0.0308	0.0689
0.50-0.69	0.0284	0.0267	0.0260	0.0203	0.0225
0.70-0.89	0.0205	0.0196	0.0197	0.0161	0.0172
0.90-1.09	0.0159	0.0157	0.0145	0.0112	0.0125
1.10-1.29	0.0140	0.0135	0.0138	0.0116	0.0121
1.30-1.49	0.0122	0.0118	0.0120	0.0101	0.0106
Greater than 1.5	0.0107	0.0104	0.0106	0.0090	0.0094

(iv) Trench Configuration: Ratio of required infiltration volume to infiltration surface area (VIT/Ai) should be no greater than 1.0 and preferably less. Infiltration surface area includes the invert and walls of the trench. The trench should be a minimum of 3’ deep and a maximum of 8’ deep. Infiltration trenches in parallel must be separated by a distance equal to twice the trench depth. Infiltration trench overflow must be located along a contour and will serve as an excellent flow spreading device.

(v) Trench Backfill: The backfill should consist of 1.5-3.0 inch washed bank run gravel aggregate with no fines. If the underlying soils have more than 40% silt and clay then a 6-inch sand layer is recommended as a bottom filter layer. Filter fabric is required on the bottom and sides of trench and below the top three inches of the trench to minimize soil movement into trench and facilitate maintenance. Non- woven 4 oz. geotextile fabric is required to separate gravel and sand from adjacent soil and layers.

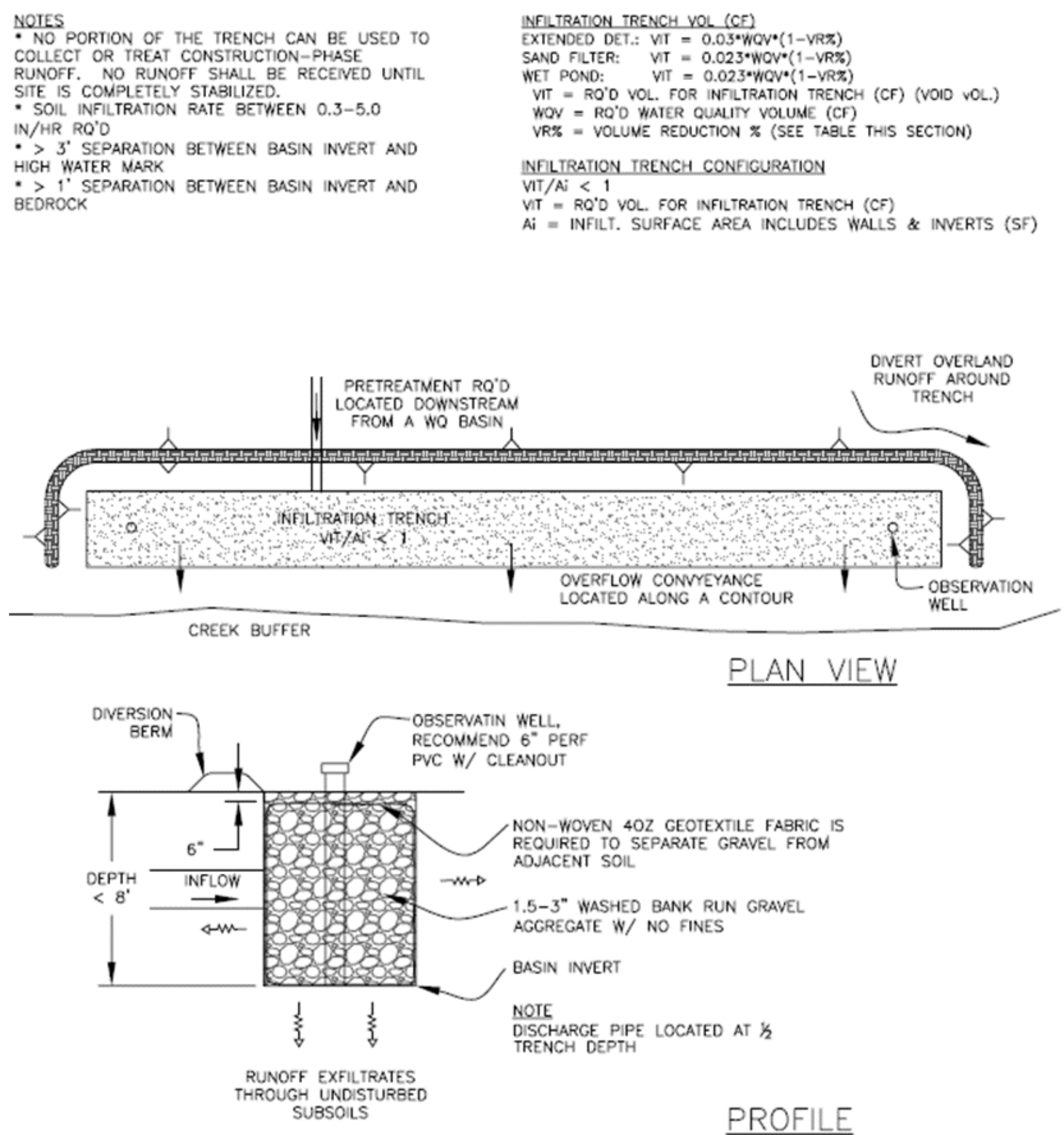
(vi) Overflow Conveyance: A conveyance system should be included in the design to ensure that excess flow from the trench is discharged at non-erosive velocities.

(vii) Discharge Pipe: The discharge pipe into the trench should be located at 1/2 the trench depth, i.e. if the trench is four feet deep, then the discharge pipe is placed two feet below the top of trench elevation.

(viii) Overland Runoff: Divert overland runoff from project site around trench through the use of an embankment, swale, or overflow berm.

(ix) Maintenance Requirements: Two observation wells are required, recommend 6” perforated PVC with cleanout. If trench exceeds 100 feet in length, then add one additional observation well for every 100 feet of trench length.

Figure 1.9.H.1 – Infiltration Trench Schematic



1.6.8 RULES TO IMPLEMENT ON-SITE CONTROL OF THE TWO-YEAR STORM

A. Introduction.

It has been recognized that the runoff from the two-year return frequency storm results in bank-full conditions in natural streams in undeveloped watersheds. Because of its frequency (approximately once every two years), this flow condition controls to a great extent the shape of natural channels through the erosion that occurs during these floods.

Development of a watershed and the associated impervious cover which results will increase not only the amount of runoff resulting from these storms but will increase the frequency at which the bank-full conditions occur. As a result, streams are subject to greatly increased erosion and transport of sediment. Problems which may result include streambank failures, loss of property, clogging and filling of downstream waterways and receiving waterbodies, increased maintenance needs and generally decreased water quality.

These guidelines shall be considered the minimum requirements for compliance with that section of the Code. Alternative methods of controlling the two-year storm runoff for the purpose of stream erosion control shall be submitted to the City of Bee Cave City Engineer for approval.

B. Compliance.

Peak runoff rates shall be calculated using the methodology described in the Drainage Criteria Manual. On- site control of the two-year storm is achieved when the developed-conditions peak runoff rate leaving the site for a given drainage area is less than or equal to the existing-conditions runoff rate. The flowrates can be considered equal if the developed rate is no more than one-half (0.5) cfs greater than the existing rate or if the developed rate is no more than one- half (0.5) percent greater than the existing rate and there are no existing erosion problems downstream of the site.

Off-site control of the two-year storm is permitted when the rate of erosion will not be increased between the point of discharge and the off-site facility. The use of an off-site control is permitted if the following two criteria are met:

1. The off-site facility controls the two-year peak flowrate. If the off-site facility is not specifically designed for the two-year storm, an analysis is required to verify that the facility will accomplish this, and
2. The conveyance facilities to the control are non-erodible. Storm sewers and concrete-lined channels are considered non- erodible. Grass-lined channels are considered non-erodible when the velocity in the channel does not exceed six (6) feet per second for a one-hundred (100) year storm considering fully-developed upstream conditions, or the peak flowrate is not increased anywhere along the conveyance facility between the site and the off-site control.

On-site controls shall be designed in accordance with the Drainage Criteria Manual. For purposes of compliance, the water quality volume captured in the water quality control can be used to satisfy, either totally or partially, the two-year detention requirement in this rule.

1.6.9 TECHNICAL NOTES

A. Control Measure Design

Table 1-9: Yearly Runoff as a Function of Impervious Cover.

Impervious Cover, IC (%)	Runoff-Rainfall Ratio, R v	Depression Storage, S d (in)	Annual Number of Runoff Events, θ	Annual Runoff, V (in/yr)
0	0.064	0.218	46	1.18
5	0.1	0.198	48.4	1.94
10	0.136	0.18	50.6	2.76
15	0.172	0.163	52.8	3.63
20	0.208	0.148	54.8	4.55
25	0.243	0.134	56.7	5.52
30	0.279	0.122	58.5	6.54
35	0.315	0.11	60.2	7.59
40	0.351	0.1	61.8	8.67
45	0.387	0.091	63.2	9.78
50	0.423	0.082	64.6	10.91
55	0.458	0.075	65.8	12.06
60	0.494	0.068	66.9	13.23
65	0.53	0.062	68	14.42
70	0.566	0.056	69	15.61
75	0.602	0.051	69.9	16.82
80	0.637	0.046	70.7	18.03
85	0.673	0.042	71.5	19.24
90	0.709	0.038	72.2	20.46
95	0.745	0.034	72.8	21.69
100	0.781	0.031	73.4	22.91
Austin Total	—	—	79.3	31.7

Pollutant, i		Pollutant Concentration, C Ex or C D	
		A Site Contains Development (IC ≥ 0%)	B Site Completely Undeveloped (IC = 0%)
COD	mg/L	= 38.9 + 66.6·IC	38.9
E. coli	CFU/100 mL	25000	8370
Pb	mg/L	= 0.00428·exp(2.42·IC)	0.00428
TN	mg/L	2.22	1.19
TOC	mg/L	13.03	13.03
TP	mg/L	0.396	0.124
TSS	mg/L	166	166
Zn	mg/L	= 0.0236·exp(2.18·IC)	0.0236

B. References.

1. Adams, B. J., & Papa, F. (2000). Urban Stormwater Management Planning with Analytical Probabilistic Models. New York: John Wiley & Sons, Inc.
2. Stormwater Quality Evaluation Section, Planning & Development Department. (2013). Impacts of Stormwater Control Measures on Water Quality in Austin, TX. (Report Number CM-13-02). Austin, Texas: City of Austin Planning & Development Department.
3. Technology Acceptance Reciprocity Partnership (TARP). (2003). Protocol for Stormwater Best Management Practice Demonstrations.
4. Water Quality Monitoring Section, Planning & Development Department. (2009). Stormwater Runoff Quality and Quantity from Small Watersheds in Austin, TX: Updated through 2008. (Report Number CM-09-03). Austin, Texas: City of Austin Planning & Development Department.
5. Water Quality Program, Washington State Department of Ecology. (2011). Technical Guidance Manual for Evaluating Emerging Stormwater Treatment Technologies: Technology Assessment Protocal - Ecology (TAPE). (Report Number 11- 10-061). Olympia, Washington: Washington State Department of Ecology.
6. Water Resource Evaluation Section, Planning & Development Department. (2014). BMP Bypass Pollutant Concentrations Based on Storm Runoff Concentrations. (Report Number SR-14-10). Austin, Texas: City of Austin Planning & Development Department.

C. Technical Basis for Sand Filtration Basin Surface Area Equations. The filtration rate through a sand filtration basin will be found using the following equation:

1. $q_f = Q/A_f$

   where

Q_f = average filtration rate (e.g. gpm/ft 2)

Q = average flowrate through sand bed (e.g. gpm)

A_f = surface area of sand bed (e.g. ft 2)

The average flow rate can be determined from the following equation:

2. $Q = WQV/t_f$

Where

WQV = volume of runoff to be filtered

T_f = time required for runoff volume to pass through filter media

The volume "WQV" is the Water Quality Volume and can be determined from the following equation:

3. $WQV = A_D H$

Where

A_D = drainage area contributing runoff to the basin H = runoff depth

Substituting equation (3) into equation (2) gives:

4. $Q = WQV/t_f$

The average flow rate can also be found using Darcy's Law:

5. $Q = kiA_f$

Where

k = coefficient of permeability for filtration media

i = hydraulic gradient

= (h+L)/L

h = average of water above surface of sand media between full and empty basin conditions

L = sand bed depth

Therefore,

6. $Q = kA_f (h+L)/L$

Substituting equation (6) into (1) gives:

7. $q_f = k(h+L)/L$

Substituting equations (4) and (7) into (1) and solving for "A_f" gives:

8. $A_f = WQV*L/k(h+L)t_f$

Discussion - For design purposes typical values are:

L = 18" sand = 1.5 feet

h = H/2 where H is the maximum ponding depth in the filtration basin (average head of water above sand bed - i.e., 6 ft. max. ponding depth)

T_f = 8 hour filtration basin draw-down time

The coefficient of permeability "k" will primarily be based on observed values for sand filtration basins in the Austin area. Actual "k" values (feet per day) have been observed to vary from approximately $0.5 < k < 2.7$ with an average value of about 1.5 feet per day. These values may appear to be conservative compared to "textbook" values but are considered realistic due to the clogging effects of accumulated sediment loads. Initial filtration runs may have higher "k" values but will typically drop to the above quoted rates after one (1) or two (2) significant storms.

For full sedimentation/filtration systems "k" is assumed to be 3.5 feet per day, or 0.146 feet per hour. This is about 30 percent higher than the upper limit of observed values but is justified because pretreatment (by full sedimentation) will reduce filter clogging and because coarse sand is specified. For partial sedimentation/filtration systems "k" is assumed to be 2 feet per day, or 0.083 feet per hour. This is 30 percent higher than the average observed "k" of 1.5 feet per day but is justified because the pretreatment in the settling chamber will reduce some clogging. Nonetheless, clogging will be greater than for the full sedimentation system and a lower permeability will result. Therefore, it is clear that a larger surface area will be required for partial sedimentation/filtration systems in order to achieve the same draw-down period.

Surface Areas for Sand Filtration Basins - Plugging in the values from the "Discussion" section into equation (8) for Full Sedimentation/Filtration Systems gives:

A f = [WQV(1.5)/0.146(H/2+1.5)(48)]

9. A f = WQV/(2.33H+7)

Doing likewise for Partial Sedimentation/Filtration Systems gives:

A f = [WQV(1.5)/0.083(H/2+1.5)(48)]

10. A f = WQV/(1.33H+4)

1.7 FLOODPLAIN MODIFICATION CRITERIA

1.7.1 INTRODUCTION

These guidelines set out standards for evaluating and processing proposed modifications of the 100-year floodplain with the following objectives:

- preserving the natural and traditional character of the land and waterway;
- encouraging sound engineering and ecological practices;
- preventing and reducing degradation of water quality;
- encouraging the stability and integrity of floodplains and waterways; and
- restoring floodplain health to support natural functions and processes.

The guidelines apply to development that results in any vertical or horizontal change in the cross section of the 100-year floodplain, both inside and outside of the Water Quality Buffer Zone. A vertical change in the cross section includes any change to the land elevation within the floodplain, such as cut, fill, or construction of a structure. A horizontal change in the cross section includes any change that widens or narrows the floodplain, such as channelization. Floodplain modification is defined as any change in the cross section, so compensatory cut and fill that does not change the surface water elevation is still considered a floodplain modification. However, development that consists solely of the addition or removal of vegetation is not considered a floodplain modification. Whenever a modification to a floodplain is proposed, a request for approval shall be submitted in conjunction with an application for a development permit. Such permit applications shall be reviewed in accordance with the provisions of these guidelines and all applicable ordinances. Note: These guidelines address the environmental aspects of floodplain modification.

Naturally functioning streams with connected floodplains dissipate stream energy, reduce soil erosion, reduce flood damage, capture and treat pollutants, and promote sustainable healthy ecosystems. Periodic flood flows that overtop the banks of stream areas are essential to the health of riparian corridors. The seasonal variability of flow and intermittent extreme events combine to shape the physical structure and biological diversity of floodprone areas. Healthy riparian zones filter pollutants from surface runoff and increase the baseflow of our waterways, thus improving water quality. Also, by providing shading and moderating water temperature, natural floodplains increase biodiversity and promote healthy riparian and aquatic habitats, improving water quality and the overall health of creeks.

1.7.2 CODE REQUIREMENTS

A. Water Quality Buffer Zone

The Water Quality Buffer Zone is a stream setback established by Article 7, Section 7.3.2.C.5 of the UDC. The geometry of the setback can vary with the size of the drainage area and the watershed.

Floodplain modifications are prohibited in the Water Quality Buffer Zone unless:

1. the floodplain modifications proposed are necessary to address an existing threat to public health and safety, as determined by the City Engineer; or
2. the floodplain modifications proposed are necessary for development allowed in the Water Quality Buffer Zone under Article 7, Section 7.3.2.C.5 of the UDC.

If the proposed modification does not qualify for one of the two exemptions listed above in accordance with Section 1.7.3 (Exemptions), then the applicant must seek a waiver from the City Engineer.

B. Outside of the Water Quality Buffer Zone

In some areas, the width of the 100-year floodplain can extend beyond the Water Quality Buffer Zone (see figure). Floodplain modification is permitted outside of the Water Quality Buffer Zone if:

1. the floodplain modifications proposed are necessary to address an existing threat to public health and safety, as determined by the City Engineer;
2. the floodplain modifications proposed are necessary for development allowed in the Water Quality Buffer Zone under Article 7, Section 7.3.2.C.5 of the UDC; or
3. the floodplain modifications proposed will restore the floodplain health to support natural functions and processes (see Sections 1.7.4).

C. Additional Requirements

Floodplain modifications must meet the following conditions:

1. the proposed modification is designed to accommodate existing and fully-vegetated conditions;
2. the proposed modification will encourage sound engineering and ecological practices, prevent and reduce degradation of water quality, and encourage the stability and integrity of floodplains and waterways; and

3. the applicant restores floodplain health to support natural functions and processes (see Sections 1.7.4).

1.7.3 EXEMPTIONS

A. Necessary to Address an Existing Threat to Public Health and Safety

Floodplain modification is permitted when necessary to address an existing threat to human life from flooding or erosion of existing occupied structures or public rights-of-way and private property, as determined by the City Engineer. This shall include the stabilization of eroding creek banks where existing structures are threatened or where there is a recognizable threat to public recreation and safety. The applicant shall perform an environmental assessment of alternatives to determine the least environmentally damaging feasible alternative. These projects shall improve floodplain and riparian zone function using stream restoration techniques that limit the use of hard armor except as needed at key erosive locations. The project shall retain the natural stable creek plan, profile, and dimension with natural function, to the greatest extent practicable, using the following techniques: graded slopes with soil retention blankets; vegetated mechanically stabilized earth; native riparian vegetation; natural materials such as native limestone (instead of gabions or concrete); toe wood; and constructed riffles that double as grade control where required for vertical channel stability. These projects do not need to comply with the restoration or mitigation ratios outlined in Sections 1.7.4 and 1.7.5. Any disturbed areas will need to comply with the vegetative stabilization requirements of Section 1.4.0 (Erosion and Sedimentation Control Criteria).

B. Development Allowed in the Water Quality Buffer Zone

Development permitted conditionally in the Water Quality Buffer Zone under section Article 7, Section 7.3.2.C.5 of the UDC includes:

1. Fences that do not obstruct flood flows
2. Open space uses such as parks
3. Hard-surfaced trails and trail crossings
4. Sustainable urban agriculture or community gardens
5. Athletic fields
6. Boat docks, piers, wharfs, or marinas
7. Utility lines and crossings
8. Detention basins and wet ponds
9. Green stormwater controls
10. Road crossings

Development within the Water Quality Buffer Zone shall be designed to protect the natural hydrologic function, long-term channel stability, and ecological function of the floodplain. These modifications do not need to comply with the restoration or mitigation ratios outlined in Sections **1.7.4** and **1.7.5**. Any disturbed areas will need to comply with the vegetative stabilization requirements of **Section 1.4.0** (Erosion and Sedimentation Control Criteria).

In-channel basins shall not adversely impact channel stability by creating additional erosion or sedimentation downstream of the structure. In alluvial channels, the basin shall not capture excess bed material load such that a "hungry water" effect results in additional erosion downstream. For channels with limited bed material load, the basins shall not extend the duration of erosive flows above the channel boundary material threshold and cause additional downstream erosion. Downstream impacts of in-channel impoundments shall be evaluated using a continuous simulation routing model that computes cumulative excess stream power or sediment transport.

1.7.4 RESTORATION

A. Requirements

Restoration of floodplain health as prescribed by this section is required for any proposed floodplain modification that does not qualify for one of the following exemptions:

1. the floodplain modifications proposed are necessary to protect the public health and safety;
2. the floodplain modifications proposed are necessary for development allowed in the Water Quality Buffer Zone under Article 7, Section 7.3.2.C.5 of the UDC.

Where possible, the required restoration shall always be located within the Water Quality Buffer Zone adjacent to the proposed area of modification. If the site does not have enough area within the adjacent Water Quality Buffer Zone to meet the restoration requirements or a Zone 2 functional assessment shows the Water Quality Buffer Zone is already in good condition or better, then the required restoration may be located in the floodplain outside of the Water Quality Buffer Zone. If the site does not have enough floodplain area outside of the Water Quality Buffer Zone to meet the restoration requirements or a Zone 1 functional assessment shows the floodplain is already in good condition or better, then mitigation shall be provided off-site (see **Section 1.7.5**).

The amount of area that is required to be restored shall be proportionate to the amount of area within the existing floodplain that is proposed to be modified, as shown in the table below. Depending on the condition of the area being modified, X square feet must be restored for every 1 square feet modified (for a ratio of X:1). There is a multiplier of two for modifications within the Water Quality Buffer Zone. In addition, any disturbed areas will need to comply with the vegetative stabilization requirements of **Section 1.4.0** (Erosion and Sedimentation Control Criteria).

Condition of the Area Proposed for Floodplain Modification (as determined by Functional Assessment)	Location of Proposed Modification	
	Outside Water Quality Buffer Zone	Water Quality Buffer Zone
Good or Excellent	4:1*	8:1*
Fair	3:1	6:1*
Poor	2:1	4:1*

*Not allowed by Code without a variance from the land use commission.

The applicant shall prepare and submit a Riparian Restoration Plan to be reviewed and approved by the Planning & Development Department as part of the Site Development Permit. A restoration plan must contain the following minimum components:

- Soil Amendments
- Native Species Seeding
- Tree Seedling Planting
- Exotic Invasive Species Control

- Ragweed Management
- Performance Criteria

During the course of inspections and field observations, adjustments to the Riparian Restoration Plan may be required. The plan may be amended with the submission of additional or amended parts of the plan and approval by the City of Bee Cave.

Riparian restoration will likely need additional time beyond the period of construction to successfully establish. Projects which have not completed the riparian restoration process before the final environmental inspection may enter into a Developer's Agreement for up to three years. The fiscal posting amount for the Developer's Agreement shall be based on contractor estimates of current cost for the materials and labor for installation and maintenance outlined in the approved Riparian Restoration Plan. The estimates must be dated within 12 months of the request for an agreement and must list suppliers who can provide the required items. A certified estimate must be submitted to the City of Bee Cave Environmental Inspector by a landscape architect or professional engineer for review and acceptance before a Developer's Agreement is written. The fiscal is returned only after a concurrence letter for restoration is received and the final inspection is passed.

A. Restoration Guidance

The overall goal of the restoration should be to elevate the function of the restored area from poor or fair condition to good. Restoration of floodplain function should focus on a passive approach that promotes managed succession and a minimal need for ongoing management. Strategies should include simple, straightforward techniques such as seeding, bare-root saplings, invasive removal, and soil amendments rather than a more formal design involving containerized plants and irrigation. Once completed, projects should demarcate restoration areas with signage or boulders to prevent future clearing or mowing.

B. Channel Design

Where modification of the channel is permitted (e.g., necessary to protect public health and safety, significant, demonstrable environmental benefit), design criteria, calculation of flood flows and limiting velocities shall be in accordance with the Drainage Criteria Manual. Innovative methods of design and construction which are intended to emulate natural watercourses, promote channel stability, preserve existing vegetation, preserve or improve in-stream aquatic habitat, and protect mature riparian landscapes are encouraged, subject to approval by the City of Bee Cave.

1.7.5 MITIGATION

A. Requirements

Where possible, the required restoration shall always be located within the Water Quality Buffer Zone adjacent to the proposed area of modification (see **Section 1.7.4**). If the site does not have enough area within the adjacent Water Quality Buffer Zone to meet the restoration requirements, then the required restoration may be located in the floodplain outside of the Water Quality Buffer Zone. If the site does not have enough floodplain area outside of the Water Quality Buffer Zone to meet the restoration requirements, then mitigation shall be provided off-site. Mitigation must be located within the same watershed classification and shall consist of:

1. paying into the Riparian Zone Mitigation Fund a non- refundable amount established by ordinance;
2. dedicating land to the City or another entity approved by the City Engineer in fee simple and which the City or other entity accepts; or

3. Placing restrictions on land to the benefit of the City or another entity approved by the City Engineer and which the City or other entity accepts.

If land is dedicated or restricted, it must be approved by the City and the applicant must file in the deed records a restrictive covenant, approved by the city attorney, that runs with the transferring tract and describes the restrictions on development and vegetation management. In addition, the applicant shall pay all costs of restricting the mitigation land or transferring the mitigation land to the City, including the costs of:

(i) an environmental site assessment without any recommendations for further clean-up, certified to the City not earlier than the 120th day before the closing date transferring land to the City;
(ii) a category 1(a) land title survey, certified to the City and the title company not earlier than the 120th day before the closing date transferring land to the City;
(iii) a title commitment with copies of all Schedule B and C documents, and an owner's title policy;
(iv) a fee simple deed, or, for a restriction, a restrictive covenant approved as to form by the city attorney;
(v) taxes prorated to the closing date;
(vi) recording fees; and
(vii) charges or fees collected by the title company.

The amount of area that is required as mitigation shall be proportionate to the amount of area within the existing floodplain that is proposed to be modified, as shown in the table below. Depending on the condition of the area being modified, X square feet of mitigation must be provided for every 1 square feet modified (for a ratio of X:1). The ratios for providing off-site mitigation are the same as the ratios established for restoration above.

Condition of the Area Proposed for Floodplain Modification (as determined by Functional Assessment)	Location of Proposed Modification	
	Outside Water Quality Buffer Zone	Water Quality Buffer Zone
Good or Excellent	4:1*	8:1*
Fair	3:1	6:1*
Poor	2:1	4:1*

*Not allowed by Code without a variance from the land use commission.

1.8 IMPERVIOUS COVER CALCULATION CRITERIA

1.8.1 CALCULATIONS

A. This section applies to the impervious cover requirements of Article 7 of the City of Bee Cave UDC. The impervious cover requirements of Article 7 of the City of Bee Cave Code do not restrict impervious cover on a single-family or duplex lot but apply to the subdivision as a whole. This section does not apply to impervious cover calculations for the purposes of complying with Article 7 of the City of Bee Cave Code.

B. Impervious cover is defined as the total area of any surface that prevents the infiltration of water into the ground, such as roads, parking areas, concrete, and buildings. Impervious cover calculations shall include all roads, driveways, parking areas, buildings, concrete, and other impermeable construction covering the natural land surface. Buildings or structures raised above the ground (e.g., pier and beam foundation) shall be considered impervious cover. Unpaved roads, driveways, and parking areas compacted by vehicle use shall be considered impervious cover.

For an uncovered wood deck that has drainage spaces between the deck boards and that is located over a pervious surface, 50 percent of the horizontal area of the deck shall be counted as impervious. A covered deck shall be considered impervious. Also, for a site used for the storage of scrap and metal salvage, including auto salvage, the entire designated scrapyard storage area shall be considered impervious cover.

Areas used on an ongoing or permanent, operational basis for the storage of dirt, rocks, or gravel shall be considered impervious cover. Spoils piles on a permitted construction site are not considered impervious cover. Pallets utilized for the storage of pavers, plastic bags of fertilizer or soil, or construction materials shall be considered impervious cover. For empty pallets or pallets used for the storage of potted plants, 50 percent of the horizontal area of pallet storage shall be counted as impervious cover. Potted plants stored on the ground shall not be considered impervious cover.

C. Impervious cover calculations exclude:

Existing roads adjacent to the development and not constructed as part of the development at an earlier phase;

Naturally occurring impervious features, such as rock outcrops;

Landscaped areas and areas remaining in their natural state;

Water quality controls and stormwater detention basins not lined with impermeable materials;

Stormwater drainage conveyance structures not lined with impermeable materials

D. For calculation purposes impervious cover for single-family or duplex lots shall be assumed as follows:

Lot Area	Impervious Cover
Greater than three (3) acres	10,000 square feet
Greater than one (1) acre - three (3) acres	7,000 square feet
Greater than 15,000 square feet - one (1) acre	5,000 square feet
Greater than 10,000 square feet - 15,000 square feet	4,000 square feet
10,000 square feet or less	3,500 square feet

1.8.2 CONSTRUCTION ON SLOPES

A. For driveways or roadways proposed to exceed 15 percent running slope, the alignment must be supported by topographic limitations present on-site and must be approved by the AHJ for Fire Protection and the City Engineer. Cuts and fills on roadways or driveways are to be restored as described herein.

B. No more than 15% of building or parking areas shall be constructed on slopes in excess of 25 percent

C. In all cases, slopes generated by cut and fill shall be stable, giving full consideration to soil characteristics and erosion potential. Techniques to be used are to be specified with the final plat. Slope exceeding a 3:1

ratio, other than cuts which are determined to be stable, must be stabilized by permanent structural means (e.g., dry stack wall, terraces, exposed aggregate concrete walls, etc.) and approved by the City Engineer.

D. Slope, contour, and grading plans shall utilize a 1-foot minimum contour delineation when showing proposed grading, erosion control, or determining slope categories.

1.9 CRITICAL ENVIRONMENTAL FEATURE IDENTIFICATION AND PROTECTION

Critical environmental feature identification and protection guidance shall be provided by the City of Austin Environmental Criteria Manual, latest edition, as applicable.

SECTION 2. APPENDICES

APPENDIX A: HAZARDOUS MATERIAL RATINGS

A. Determination of Degree of Health Hazard.

The health hazard rating of a material shall be determined by evaluating the potential for harm and the relative toxicity of the material or mixture of materials as a whole. Table A-1 applies to human effects data. In the absence of human exposure data, Table A-2 shall be used as a guideline. Where both acute and chronic exposure data are available, the data for the worst effect shall be used to develop the rating.

Table A-1

RELATIVE TOXICITY RATING FOR HAZARDOUS MATERIALS

(Human Exposure by Any Route)

*Includes substances which bear a significant relationship to the development of cancer in man, but excluding the common varieties of skin cancer.

** Allergens are rated according to their sensitizing potential rather than the severity of an allergic reaction upon re-exposure to a substance by a sensitized worker.

Table A-2

RELATIVE ACUTE TOXICITY CRITERIA

B. Determination of Degree of Fire Hazard.

The fire hazard rating of a product shall be determined by evaluating the potential for harm and the relative flammability of the material or mixture of materials as a whole, using the criteria which follows:

The fire hazard rating of a liquid shall be determined from the criteria contained in Table A-3 and based on data using the final product formulation. The test procedures as found in 29 CFR 1910.106 and 107 are mandatory liquids.

EXTREMELY FLAMMABLE: Rating 4

Materials which on account of their physical form or environmental conditions can form explosive mixtures with air and which are readily dispersed in air, such as dusts of combustible solids and mists or flammable or combustible liquid droplets.

HIGHLY FLAMMABLE: Rating 3

Liquids and solids that can be ignited under almost all ambient temperature conditions. This rating shall include:

Solid materials in the form of coarse dusts which may burn rapidly but which generally do not form explosive atmospheres with air.

Solid materials in a fibrous or shredded form which may burn rapidly and create flash fire hazards, such as cotton, sisal and hemp.

Materials which burn with extreme rapidity, usually by reason of self-contained oxygen (e.g., dry nitrocellulose and many organic peroxides).

Materials which ignite spontaneously when exposed to air or to other substances.

MODERATELY COMBUSTIBLE: Rating 2

Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Materials with this rating would not under normal conditions form hazardous atmospheres with air, but under high ambient temperatures or under moderate heating may release vapor in sufficient quantities to produce hazardous atmospheres with air. This rating shall include solids and semisolids which readily give off flammable vapors.

SLIGHTLY COMBUSTIBLE: Rating 1

Materials that must be preheated before ignition can occur.

Materials with this rating require considerable preheating, under all ambient temperature conditions, before ignition and combustion can occur. This rating shall include: Materials which will burn in air when exposed to a temperature of 1,500 F (815 C) for a period of five (5) minutes or less.

NONCOMBUSTIBLE: Rating 0

This group should include any material which will not burn in air when exposed to a temperature of 1,500 F (815 C) for a period of five (5) minutes.
The relative ratings are taken from the NFPA 704M booklet, with changes in flash point to reflect current IOTA regulations.

Table A-3

RELATIVE FLAMMABILITY CRITERIA

C. Determination of Degree of Reactivity
The reactivity hazard rating of a material shall be determined by evaluating the potential for harm and the relative reactivity of the material or mixture of materials as a whole, using the criteria which follow.

Materials in this category may be self-reactive by polymerization, decomposition or condensation and/or reactive with other materials commonly encountered in the work place. The reactivity in this category often involves the rapid release of energy in the form of heat and pressure and/or the release of highly hazardous products. The assessment of relative reactivity requires specific knowledge of what materials may be encountered in the work place.

EXTREMELY REACTIVE: Rating 4

Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. This rating should include materials which are sensitive to mechanical or localized thermal shock at normal temperatures and pressures.

HIGHLY REACTIVE: Rating 3

Materials which in themselves are capable of detonation or of explosive decomposition or explosive reaction, but which require a strong initiating source or which must be heated under confinement before initiation. This rating should include materials which are sensitive to thermal or mechanical shock at elevated temperatures and pressures or which react explosively with water without requiring heat or confinement.

MODERATELY REACTIVE: Rating 2

Materials which in themselves are normally unstable and readily undergo rapid chemical change but do not detonate. This rating should include materials which can undergo chemical change with rapid release of energy at normal temperatures and pressure. It should also include those materials which may react violently with water or which may form potentially explosive mixtures with water.

SLIGHTLY REACTIVE: Rating 1

Materials which in themselves are normally stable but which can become unstable at elevated temperatures and pressures or which may react violently with water with some release of energy but not violently.

NONREACTIVE: Rating 0

Materials which in themselves are normally stable, even under fire exposure conditions and which are not reactive with water.

APPENDIX B: CONTINGENCY PLANS

The permit applicant shall develop a Contingency Plan for the facility which describes the planned response procedures facility personnel will take in the event of any unauthorized discharge of hazardous materials. One or more revised copies of this plan shall be kept readily accessible at the facility and one copy (to be revised as necessary) will be submitted with the permit application. The Contingency Plan shall include the following elements:

- **A.** Name, business address and emergency telephone numbers for the designated primary and alternate emergency response persons for the facility. Telephone numbers for during work hours and after work hours shall be included.
- **B.** A list of emergency assistance telephone numbers to be called in the event of a spill or leak.
- **C.** A hazardous materials spill or leak containment and cleanup plan describing the immediate actions facility personnel would take to contain the material, mitigate their effects on human health or the environment, and clean up the affected area of the spill or leak.
- **D.** The name, business address and telephone number of at least one (1) contractor capable of handling and disposing of the spilled material and the contaminated soil.
- **E.** A simplified version of the emergency procedures shall be provided to each employee who may be at the facility when a leak detector or monitor would activate, and shall also be posted in a conspicuous location at the facility.
- **F.** The Contingency Plan should be periodically reviewed and amended.

APPENDIX C: UNDERGROUND STORAGE TANK TESTER REGISTRATION STATEMENT OF OPERATING PROCEDURES AND QUALIFICATIONS

In order to register with the Department of Environmental Protection, please submit your SOPQ form in a typewritten report using the format given in the outline shown below. Be sure to address the following issues to the best of your ability. Keep in mind you must meet the minimum requirements specified in "Safety Requirements and Required Documentation for Underground Storage Tank Testing" available at the Department of Environmental Protection.

G. Describe the safety equipment and precautions you routinely employ at the test site. Include information about restricting entry to the test items, signs, fire extinguishers, spill sorbents, intrinsically safe equipment and such.

H. Describe the applicable aspects of your tank test method and equipment.
   1. Give the stated accuracy of your test method, in GPH.
   2. Briefly describe your liquid level measurement method.
   3. Describe how long you mix or allow the tank to stratify after a delivery before you begin your test.
   4. Briefly describe the steps taken and the length of time between data readings for a typical tank test.
   5. Describe how you determine when a test is completed.
   6. Describe the location and number of temperature sensors employed.
   7. Describe how the coefficient of expansion for the liquid is determined.
   8. Describe how the water level outside the tank is determined. Describe a typical observation well (materials of construction, diameter, screening/slotting dimensions, depth, etc.

I. Describe how your tank test method eliminates, controls, measures or otherwise takes into account the following:
   1. Changes in coefficient of expansion of the test liquid in the system due to temperature difference.
   2. Tank end deflection and/or tank bulging.
   3. Vapor pockets trapped in the tank.
   4. The effect of groundwater outside the tank.
   5. Evaporation.
   6. Changes in barometric pressure during the test.
   7. Ground vibrations.
   8. Any other variables that you feel are pertinent.

J. Describe the following aspects of your line test method for both suction and remote pumped systems.
   1. Give the stated accuracy of your test method, in GPH and/or psi.
   2. Describe the parameters you use to determine system integrity - pressure drop, liquid level drop, etc.
   3. Briefly describe your level measurement method, if applicable.
   4. Briefly describe the steps taken and the length of time between data readings for a typical line test.
   5. Describe how you determine when a test is complete.

K. Describe the applicable training and work experience of each person who will be performing these tests.
   1. Briefly describe and give the number of years of experience with underground storage tanks systems - as an operator, installer, repair person, etc.
   2. Briefly describe and give the number of years of experience with underground storage tank testing.
   3. Describe any tank test training. Differentiate between on-the-job and classroom training.
   4. Include copes of any current certifications for each tester.

L. Include a copy of your test report and any other information you feel is appropriate, such as copies of any letters of acceptance or certifications by other government agencies, amounts of liability insurance carried, employee bonds, etc.

APPENDIX D: CITY OF BEE CAVE PREFERRED PLANT LIST

Other native or well adapted plant may be used if drawings are sealed by a registered Texas Landscape Architect and approved by the Director of Planning and Development Review. The invasive potential of non-native plants should be considered when developing landscape plans.

EVERGREEN TREES	HEIGHT	FEATURES (N = Native)
Arizona Cypress Cupressus arizonica	30'-75'	good heat and drought tolerance, aromatic foliage
Cherry Laurel Prunus caroliniana	25'-30'	N , screening plant, wildlife food
Deodar Cedar Cedrus deodara	40'-50'	fine texture, needs drainage
Live Oak Quercus virginiana	50'-60'	N , oak wilt susceptible
Mountain Laurel Sophora secundiflora	15'-25'	N , fragrant purple spring blossoms, small tree, large shrub
Texas Madrone Arbutus texana	2'-30'	N , distinctive, attractive bark, difficult to propagate and transplant
Yaupon Holly Ilex vomitoria	15'-20'	N , red berries in winter, small tree, large shrub
DECIDUOUS TREES	HEIGHT	FEATURES (N = Native)
American Elm Ulmus americana	60'-80'	N , vase-shaped canopy, susceptible to Dutch Elm disease
American Smoketree Cotinus obovatus	15'-25'	N , spring floral "clouds", fall color
Arizona Walnut Juglans major	40'-50'	N , nuts attract wildlife
Bald Cypress Taxodium distichum	60'-70'	N , fine texture, rust fall color
Bigtooth Maple Acer grandidentatum	30'-40'	N , outstanding fall foliage, requires drainage
Blackjack Oak Quercus marilandica	50'-60'	N , short-lived, bell-shaped leaves
Bradford Pear Pyrus calleryana "Bradford"	30'-40'	showy white spring flowers

Bur Oak Quercus macrocarpa	60’-100’	N , large fringed acorn, majestic, adaptable tree
Cedar Elm Ulmus crassifolia	50’-60’	N , fall color, small leaves
Chinquapin Oak Quercus Muhlenbergii	40’-60’	N , tall, slender form, dark glossy lush foliage
Crape Myrtle* Lagerstroemia indica	25’-30’	summer flowers, many varieties
Desert Willow Chilopsis linearis	15’-25’	N , orchid-like blooms, not a true willow
Drake Elm Ulmus parvifolia 'Drake'	20’-30’	nearly evergreen, drought tolerant
Durand Oak Quercus sinuata	50’-70’	N , large oak, prefers moist sites
Eastern Walnut Juglans nigra	70’-80’	N , large tree, valued for nuts
Escarpment Cherry Prunus serotina	20’-30’	N , fall color, fruit for wildlife and jellies
Eve's Necklace Sophora affinis	20’-30’	N , same genus as Mt. Laurel, pink blooms in late spring
Flameleaf Sumac Rhus copallina and R. glabra	15’-20’	N , brilliant fall color, may colonize
Fragrant Ash Fraxinus cuspidata	10’-12’	N , fragrant white flowers in late spring
Honey Mesquite Prosopis glandulosa	25’-30’	N , drought tolerant, wood valued for smoking meat
Kidneywood Eysenhardtia texana	10’-15’	N , fragrant fall flowers, small tree, large shrub
Lacey Oak Quercus glaucoides and Q. laceyi	20’-40’	N , small tree, peach colored foliage in spring and fall
Little Walnut Juglans microcarpa	20’-30’	N , small tree, strongly scented, good for attracting wildlife
Mexican Buckeye Ungnadia speciosa	10’-15’	N , pink spring flowers, small tree, large shrub
Mexican Plum Prunus mexicana	15’-25’	N , white spring blossoms, wildlife food
Orchid Tree Bauhinia spp.	6’-12’	N , showy white blossoms, small understory or patio tree

Pecan Carya illinoinensis	60'-80'	N , shade tree, nut producing
Possumhaw Ilex decidua	15'-20'	N , red winter berries, large shrub, small tree
Post Oak Quercus stellata	50'-75'	N , large oak, roots sensitive to disturbance
Red Buckeye Aesculus pavia	10'-20'	N , good understory tree, requires deep well-drained soils
Rusty Blackhaw Viburnum rufidulum	10'-15'	N , good understory tree, glossy leaves, fall color
Shin Oak Quercus sinuata brevifolia	30'-35'	N , small tree, attractive bark, grows in thickets
Shumard Oak Quercus shumardii	50'-75'	N , fast growing, good fall red foliage coloration, tolerant of limestone soils
Texas Ash Fraxinus texensis	40'-50'	N , fast growing, shade tree exceptional fall foliage coloration
Texas Persimmon Diospyros texana	15'-25'	N , wildlife food, multi-trunk
Texas Redbud Cercis canadensis var. 'Texensis'	20'-25'	N , early pink blossoms, drought tolerant
Texas Red Oak Quercus texana	30'-40'	N , white patches on bark, fall color
Western Soapberry Sapindus Drummondii	30'-40'	N , showy winter fruit, yellow fall color
*Susceptible to severe freeze		

EVERGREEN SHRUBS	SUN	SHADE	FEATURES (N = Native)
Agarita Berberis trifoliolata	o		N , prickly leaves, bright red berries
Barbados Cherry* Malpighia glabra	o	o	N , pale pink flowers, berries attract wildlife
Burford Holly Ilex cornuta 'Burfordii'	o	o	glossy dark green foliage, red fruit

Dwarf Burford Holly Ilex cornuta 'Burfordii nana'	o	o	glossy leaves, berries not prominent
Dwarf Chinese Holly Ilex cornuta 'Rotunda nana'	o	o	spiney foliage, no berries
Dwarf Yaupon Holly Ilex vomitoria 'Nana'	o	o	low mound-like shrub, no berries
Evergreen Sumac Rhus virens	o	o	N , glossy leaves, red fall color when mature
Indian Hawthorn* Raphiolepis indica	o		pink flowers, copper colored new foliage
Mountain Laurel Sophora secundiflora	o	o	N , showy fragrant purple flower, large shrub
Oleander* Nerium oleander	o		summer flowers, large shrub
Red Yucca Hesperaloe parviflora	o		N , coral flower spike, not a true yucca
Rock Cotoneaster Cotoneaster horizontalis	o		red fall fruit, small leaves
Rosemary* Rosmarinus officinalis	o		aromatic leaves, 'Prostratus' cultivar
Sacahuista, Bear Grass Nolina texana	o	o	N , grass-like mounding clumps
Shore Juniper Juniperus conferta	o		spreading, ground cover, blue-green
Silverleaf Cotoneaster Cotoneaster glaucophyllus	o		silver leaves, red fall fruit
Texas Sage Leucophyllum frutescens	o		N , lavender flowers, gray or green foliage
Texas Sotol Dasylirion texanum	o		N , long blade-like leaf with spines
Wax Myrtle Myrica cerifera	o	o	N , very adaptable, aromatic leaves, berries used for Bayberry fragrance
* susceptible to severe freeze			
SEMI-EVERGREEN SHRUBS**	SUN	SHADE	FEATURES (N = Native)
Cast Iron Plant* Aspidistra elatior	o		broad strap shaped leaves to 2’ height

Glossy Abelia Abelia grandiflora		o	small pink flowers, glossy leaves
Muhly Grass Muhlenbergia lindheimeri	o		N , looks like small pampas grass
Pineapple Guava* Feijoa sellowiana	o		exotic fragrant flowers
Pomegranate* Punica granatum	o	o	orange flowers, yellow fall color
Primrose Jasmine* Jasminum mesnyi	o		yellow flowers, mounding form
* susceptible to severe freeze			
**influenced by severity or duration of winter			
DECIDUOUS SHRUBS	SUN	SHADE	FEATURES (N = Native)
Althaea Hibiscus syriacus	o		showy summer flowers
American Beautyberry Callicarpa americana	o	o	N , purple fruit in autumn, wildlife food
Aromatic Sumac Rhus aromatica	o	o	N , red berries in late spring, brilliant fall foliage
Arrowwood Viburnum dentatum	o	o	N , spring flowers, fall color
Black Dalea Dalea frutescens	o		N , purple summer flowers, fine foliage
Butterfly Bush Buddleia Davidii	o		N , lavender/lilac flowers, small fuzzy leaves
Flame Acanthus Anisacanthus Wrightii	o	o	N , orange flowers attracts hummingbirds
Possumhaw Holly Ilex decidua	o	o	N , red winter berries large shrub
Texas Lantana* Lantana horrida	o		N , good summer color, many varieties
Trailing Lantana* Lantana montevidensis	o	o	N , lilac colored flowers summer through fall
*susceptible to severe freeze			
EVERGREEN VINES & GROUNDCOVERS	SUN	SHADE	FEATURES (N = Native)

Asian Jasmine* Trachelospermum asiaticum	o	o	low vigorous groundcover
Carolina Jessamine Gelsemium sempervirens	o	o	N , fragrant yellow flowers in spring
Coral Honeysuckle Lonicera sempervirens	o	o	N , coral flowers, red fruit, attracts wildlife
Cross Vine Bignonia capreolata	o	o	N , yellow/red flowers, clinging vine
Damianita Chrysactinia mexicana	o		N , yellow flowers, low growing to 12" height
Fig Vine* Ficus pumila	o	o	clinging vine, fine texture
Lady Banksia Rose Rosa banksiae	o		yellow spring flowers, large cascading form
Liriope Liriope muscari		o	purple spike flowers, clump-like foliage
Monkey Grass Ophiopogon japonicus		o	tufted grass-like groundcover
Oregano Origanum vulgare	o	o	perennial, spreading herb
Santolina Santolina chamaecyparissus	o		fine textured, aromatic foliage
Stonecrop Sedum spp.	o	o	low, fast growing groundcover
*susceptible to severe freeze			
DECIDUOUS VINES & GROUNDCOVERS	SUN	SHADE	FEATURES (N = Native)
Boston Ivy Parthenocissus tricuspidata 'Veitchii'	o	o	N , red fall color, clinging vine
Bush Morning Glory Ipomoea leptophylla	o	o	N , forms 1½' - 3' mounds of foliage, avender to purple flowers
Cypress Vine Ipomoea quamoclit	o		red tube-like flowers, twining vine, annual
Gregg Dalea* Dalea greggii	o	o	N , purple flowers in fall, groundcover
Mustang Grape Vitis mustangensis	o	o	N , native grape, climbs by tendrils

Old Man's Beard Clematis Drummondii	o	o	twining vine, feathery seeds
Passion Vine* Passiflora incarnata	o	o	N , lavender flowers, edible fruit: Maypop
Sweet Autumn Clematis Clematis paniculata	o		fragrant fall flowers, twining vine
Trumpet Vine Campsis radicans	o	o	N , orange-scarlet flowers, invasive
Virginia Creeper Parthenocissus quinquefolia	o	o	N , red fall color, clinging vine
*susceptible to severe freeze			
FLOWERING PERNNIALS	SUN	SHADE	FEATURES (N = Native)
Artemisia Artemisia ludoviciana	o		N , aromatic foliage, white fuzzy leaves
Black-eyed Susan Rudbeckia hirta	o	o	N , yellow dark-centered daisy, flowers May to September
Blackfoot Daisy Melampodium leucanthum	o		N , short white daisy, flowers all summer, short-lived
Butterfly Weed Asclepias tuberosa	o	o	N , orange/yellow flowers, attracts butterflies
Canna Lily Canna X generalis	o		banana-like foliage blooms in summer
Cedar Sage Salvia roemeriana		o	N , red flowers, naturalizes
Cherry Sage Salvia greggii	o	o	N , red, pink or white flowers
Cigar Plant Cuphea micropetala	o		orange-yellow fall flowers
Coreopsis Coreopsis lanceolata	o		N , yellow spring and fall flowers, clumping
Daylily Hemerocallis fulva	o		orange/yellow funnel-shaped flower
Fall Aster Aster spp.	o	o	N , blue/purple autumn flowers
Firebush* Hamelia patens	o		red-orange flowers, red fall color

Gayfeather Liatris spp.	o		N, purple flower spikes in autumn
Heartleaf Hibiscus Hibiscus cardiophyllus	o	o	N , red flowers all summer
Hinckley's Columbine Aquilegia Hinckleyana		o	bright yellow flowers in spring
Hymenoxys Hymenoxys scaposa	o		N , small yellow daisy, bitter smelling leaves
Lamb's Ears Stachys byzantina	o		unique foliage, low growing
Maximillian Sunflower Helianthus maximiliana	o		N , yellow flower, late summer to fall
Mealy Blue Sage Salvia farinacea	o		N , blue flower spikes spring and summer
Mexican Bush Sage Salvia leucantha	o		tall purple flower spikes
Mexican Heather* Cuphea hyssopifolia	o		tiny purple, pink or white flowers
Mexican Marigold Mint Tagetes lucida	o	o	yellow fall flowers, anise flavored foliage
Mexican Oregano Poliomintha longiflora	o		lavender/pink flowers, aromatic
Oxeye Daisy Chrysanthemum leucanthemum	o		white early summer flower, yellow center
Peruvian Verbena* Verbena peruviana	o		pink, purple, red or white flowers,
Pink Skullcap Scutellaria suffrutescens	o	o	pink flowers in summer, low growing
Plumbago* Plumbago auriculata	o	o	low growing, blue flowers
Purple Coneflower Echinacea purpurea	o	o	N , purple daisy-like flowers
Rose Mallow Pavonia lasiopetala	o	o	N , pink hibiscus-like flowers
Scarlet Sage Salvia coccinea	o	o	N , red, pink or white flowers, spring to fall

Spiderwort Tradescantia x Andersoniana		o	N , purple-blue flowers, informal ground cover
Turk's Cap Malvaviscus arboreus colonizing 'Drummondii'	o	o	N , red flowers and fruit, colonizing
Yarrow Achillea millefolium	o	o	off-white flowers, pink variety available
White Mistflower Eupatorium Wrightii	o	o	N , white autumn flowers, attracts butterflies
Wild Petunia M Ruellia nudiflora		o	N , purple flowers from March to December
Zexmenia Wedelia hispida	o	o	N , orange/yellow flowers, May to November
*susceptible to severe freeze			
TURF & LOW GRASSES	SUN	SHADE	FEATURES (N = Native)
Bermuda Cynodon dactylon	o		seed or hybrid sod
Blue Grama Bouteloua gracilis	o		N , seed, fine-leaf tufted grass, good meadow grass, not for mowed lawns
Buffalograss Buchloe dactyloides	o		N , many seed varieties, sod available in '609' and Prairie hybrids
Little Bluestem Schizachyrium scoparium	o		N , seed, blue-green, fine texture, not for mowed lawns
Side Oats Gramma Bouteloua curtipendula	o	o	N , seed, not for mowed lawns

APPENDIX E: STANDARD NOTES

APPENDIX E-1: EROSION CONTROL NOTES

1. The contractor shall install erosion/sedimentation controls, tree/natural area protective fencing, and conduct "Pre- Construction" tree fertilization (if applicable) prior to any site preparation work (clearing, grubbing or excavation).
2. The placement of erosion/sedimentation controls shall be in accordance with the Environmental Criteria Manual and the approved Erosion and Sedimentation Control Plan. The Bee Cave ESC Plan shall be consulted and used as the basis for a TPDES required SWPPP. If a SWPPP is required, it shall be available for review by the City of Bee Cave Engineering Staff at all times during construction, including at the Pre-Construction meeting. The checklist below contains the basic elements that shall be reviewed for permit approval by Bee Cave EV Plan Reviewers as well as Bee Cave EV Inspectors.

   Plan sheets submitted to the City of Bee Cave MUST show the following:
   - Direction of flow during grading operations.
   - Location, description, and calculations for off-site flow diversion structures.
   - Areas that will not be disturbed; natural features to be preserved.
   - Delineation of contributing drainage area to each proposed BMP (e.g., silt fence, sediment basin, etc.).
   - Location and type of E&S BMPs for each phase of disturbance.
   - Calculations for SCMs as required.
   - Location and description of temporary stabilization measures.
   - Location of on-site spoils, description of handling and disposal of borrow materials, and description of on-site permanent spoils disposal areas, including size, depth of fill and revegetation procedures.
   - Describe sequence of construction as it pertains to ESC including the following elements:
     1. Installation sequence of controls (e.g. perimeter controls, then sediment basins, then temporary stabilization, then permanent, etc.)
     2. Project phasing if required (LOC greater than 25 acres)
     3. Sequence of grading operations and notation of temporary stabilization measures to be used
     4. Schedule for converting temporary basins to permanent WQ controls
     5. Schedule for removal of temporary controls
     6. Anticipated maintenance schedule for temporary controls
        - Note the location of each BMP on your site map(s).
        - For any structural BMPs, you should provide design specifications and details and refer to them.
        - For more information, see City of Bee Cave Environmental Criteria Manual 1.4.3.

3. The Placement of tree/natural area protective fencing shall be in accordance with the City of Bee Cave standard notes for Tree and Natural Area Protection and the approved Grading/Tree and Natural Area Plan.

4. A pre-construction conference shall be held on-site with the contractor, design Engineer/permit applicant and Bee Cave Engineering Staff after installation of the erosion/sedimentation controls, tree/natural area protection measures and "Pre-Construction" tree fertilization (if applicable) prior to beginning any site preparation work. The owner or owner's representative shall notify the Planning & Development Department, 512-767-6675, at least three days prior to the meeting date. Bee Cave approved ESC Plan and TPDES SWPPP (if required) should be reviewed by the engineering staff at this time.

5. Any major variation in materials or locations of controls or fences from those shown on the approved plans will require a revision and must be approved by the reviewing Engineer. Major revisions must be approved by authorized Bee Cave staff. Minor changes to be made as field revisions to the Erosion and Sedimentation Control Plan may be required by the engineering staff during the course of construction to correct control inadequacies.

6. The contractor is required to provide a certified inspector that is either a licensed engineer (or person directly supervised by the licensed engineer) or Certified Professional in Erosion and Sediment Control (CPESC or CPESC - IT), Certified Erosion, Sediment and Stormwater - Inspector (CESSWI or CESSWI - IT) or Certified Inspector of Sedimentation and Erosion Controls (CISEC or CISEC - IT) certification to inspect the controls and fences at weekly or bi-weekly intervals and after one-half (½) inch or greater rainfall events to insure that they are functioning properly. The person(s) responsible for maintenance of controls and fences shall immediately make any necessary repairs to damaged areas. Silt accumulation at controls must be removed when the depth reaches six (6) inches or one-third (⅓) of the installed height of the control whichever is less.

7. Prior to final acceptance by the City, haul roads and waterway crossings constructed for temporary contractor access must be removed, accumulated sediment removed from the waterway and the area restored to the original grade and revegetated. All land clearing debris shall be disposed of in approved spoil disposal sites.

8. All work must stop if a void in the rock substrate is discovered which is; one square foot in total area; blows air from within the substrate and/or consistently receives water during any rain event. At this time it is the responsibility of the Project Manager to immediately contact a City of Bee Cave for further investigation. In addition, if the project site is located within the Edwards Aquifer, the Project Manager must notify the Travis County Balcones Canyonlands Conservation Preserve (BCCP) by email at **bccp@traviscountytx.gov.** Construction activities within 50 feet of the void must stop.

9. Temporary and Permanent Erosion Control: All disturbed areas shall be restored as noted below:

   (i) All disturbed areas to be revegetated are required to place a minimum of six (6) inches of topsoil [see City of Austin Standard Specification Item No. 601S.3(A)]. Do not add topsoil within the critical root zone of existing trees.

   - Topsoil salvaged from the existing site is encouraged for use, but it should meet the standards set forth in 601S.

   An owner/engineer may propose use of onsite salvaged topsoil which does not meet the criteria of City of Austin Standard Specification 601S by providing a soil analysis and a written statement from a qualified professional in soils, landscape architecture, or agronomy indicating the onsite topsoil will provide an equivalent growth media and specifying what, if any, soil amendments are required.

- Soil amendments shall be worked into the existing onsite topsoil with a disc or tiller to create a well-blended material.

The vegetative stabilization of areas disturbed by construction shall be as follows:

TEMPORARY VEGETATIVE STABILIZATION:

A. From September 15 to March 1, seeding shall be with or include a cool season cover crop: (Western Wheatgrass (Pascopyrum smithii) at 5.6 pounds per acre, Oats (Avena sativa) at 4.0 pounds per acre, Cereal Rye Grain (Secale cereale) at 45 pounds per acre. Contractor must ensure that any seed application requiring a cool season cover crop does not utilize annual ryegrass (Lolium multiflorum) or perennial ryegrass (Lolium perenne). Cool season cover crops are not permanent erosion control.

B. From March 2 to September 14, seeding shall be with hulled Bermuda at a rate of 45 pounds per acre or a native plant seed mix conforming to Item 604S or 609S.

1. Fertilizer shall be applied only if warranted by a soil test and shall conform to Item No. 606S, Fertilizer. Fertilization should not occur when rainfall is expected or during slow plant growth or dormancy. Chemical fertilizer may not be applied in the Water Quality Buffer Zone.
2. Hydromulch shall comply with Table 1, below.
3. Temporary erosion control shall be acceptable when the grass has grown at least 1½ inches high with a minimum of 95% total coverage so that all areas of a site that rely on vegetation for temporary stabilization are uniformly vegetated, and provided there are no bare spots larger than 10 square feet.
4. When required, native plant seeding shall comply with requirements of the City of Bee Cave UDC and Environmental Criteria Manual, and City of Austin Standard Specification 604S or 609S.

Table 1: Hydromulching for Temporary Vegetative Stabilization

Material	Description	Longevity	Typical Applications	Application Rates
100% or any blend of wood, cellulose, straw, and/or cotton plant material (except no mulch shall exceed 30% paper)	70% or greater Wood/Straw 30% or less Paper or Natural Fibers	0—3 months	Moderate slopes; from flat to 3:1	1,500 to 2,000 lbs per acre

PERMANENT VEGETATIVE STABILIZATION:

A. From September 15 to March 1, seeding is considered to be temporary stabilization only. If cool season cover crops exist where permanent vegetative stabilization is desired, the grasses shall be mowed to a height of less than one-half (½) inch and the area shall be re-seeded in accordance with Table 2 below. Alternatively, the cool season cover crop can be mixed with Bermudagrass or native seed and installed together, understanding that germination of warm-season seed typically requires soil temperatures of 60 to 70 degrees.

B. From March 2 to September 14, seeding shall be with hulled Bermuda at a rate of 45 pounds per acre with a purity of 95% and a minimum pure live seed (PLS) of 0.83. Bermuda grass is a warm season grass and is considered permanent erosion control. Permanent vegetative stabilization can also be accomplished with a native plant seed mix conforming to Item 604S or 609S.

1. Fertilizer use shall follow the recommendation of a soil test. See Item 606S, Fertilizer. Applications of fertilizer (and pesticide) on City-owned and managed property requires the yearly submittal of a Pesticide and Fertilizer Application Record, along with a current copy of the applicator's license. For current copy of the record template contact the City of Bee Cave Engineering Staff.
2. Hydromulch shall comply with Table 2, below.
3. Water the seeded areas immediately after installation to achieve germination and a healthy stand of plants that can ultimately survive without supplemental water. Apply the water uniformly to the planted areas without causing displacement or erosion of the materials or soil. Maintain the seedbed in a moist condition favorable for plant growth. All watering shall comply with City Code, at rates and frequencies determined by a licensed irrigator or other qualified professional, and as allowed by the WTCPUA/WCID No. 17 and current water restrictions and water conservation initiatives.
4. Permanent erosion control shall be acceptable when the grass has grown at least 1½ inches high with a minimum of 95 percent for the non-native mix, and 95 percent coverage for the native mix so that all areas of a site that rely on vegetation for stability must be uniformly vegetated, and provided there are no bare spots larger than 10 square feet.
5. When required, native plant seeding shall comply with requirements of the City of Bee Cave UDC, Environmental Criteria Manual, and City of Austin Items 604S and 609S.

Table 2: Hydromulching for Permanent Vegetative Stabilization

Material	Description	Longevity	Typical Applications	Application Rates
Bonded Fiber Matrix (BFM)	80% Organic defibrated fibers			
10% Tackifier	6 months	On slopes up to 2:1 and erosive soil conditions	2,500 to 4,000 lbs per acre (see manufacturers recommendations)	
Fiber Reinforced Matrix (FRM)	65% Organic defibrated fibers 25% Reinforcing Fibers or less 10% Tackifier	Up to 12 months	On slopes up to 1:1 and erosive soil conditions	3,000 to 4,500 lbs per acre (see manufacturers recommendations)

Developer Information:

Owner ____________________

Phone # ____________________

Address ____________________

Owner's representative responsible for plan alterations: ____________________

Phone #____________________

Person or firm responsible for erosion/sedimentation control maintenance: ___________________

Phone # ____________________

Person or firm responsible for tree/natural area protection Maintenance: ____________________

Phone # ____________________

The contractor shall not dispose of surplus excavated material from the site without notifying the Planning & Development Department at 512-767-6675 at least 48 hours prior with the location and a copy of the permit issued to receive the material.

APPENDIX E-2: CITY OF BEE CAVE STANDARD NOTES FOR TREE AND NATURAL AREA PROTECTION

A. All trees and natural areas shown on plan to be preserved shall be protected during construction with temporary fencing.
B. Protective fences shall be erected according to City of Bee Cave Standards for Tree Protection.
C. Protective fences shall be installed prior to the start of any site preparation work (clearing, grubbing or grading), and shall be maintained throughout all phases of the construction project.
D. Erosion and sedimentation control barriers shall be installed or maintained in a manner which does not result in soil build- up within tree drip lines.
E. Protective fences shall surround the trees or group of trees, and will be located at the outermost limit of branches (drip line), for natural areas, protective fences shall follow the Limit of Construction line, in order to prevent the following:
   1. A.Soil compaction in the root zone area resulting from vehicular traffic or storage of equipment or materials;
   2. Root zone disturbances due to grade changes (greater than 6 inches cut or fill), or trenching not reviewed and authorized by the City;
   3. Wounds to exposed roots, trunk or limbs by mechanical equipment;
   4. Other activities detrimental to trees such as chemical storage, cement truck cleaning, and fires.
F. Exceptions to installing fences at tree drip lines may be permitted in the following cases:
   1. Where there is to be an approved grade change, impermeable paving surface, tree well, or other such site development, erect the fence approximately 2 to 4 feet beyond the area disturbed;
   2. Where permeable paving is to be installed within a tree's drip line, erect the fence at the outer limits of the permeable paving area (prior to site grading so that this area is graded separately prior to paving installation to minimized root damage);
   3. Where trees are close to proposed buildings, erect the fence to allow 6 to 10 feet of work space between the fence and the building;
   4. Where there are severe space constraints due to tract size, or other special requirements, contact the City at 512-767-6675 to discuss alternatives.

   Special Note: For the protection of natural areas, no exceptions to installing fences at the Limit of Construction line will be permitted.

G. Where any of the above exceptions result in a fence being closer than 4 feet to a tree trunk, protect the trunk with strapped- on planking to a height of 8 ft (or to the limits of lower branching) in addition to the reduced fencing provided.
H. Trees approved for removal shall be removed in a manner which does not impact trees to be preserved.
I. Any roots exposed by construction activity shall be pruned flush with the soil. Backfill root areas with good quality top soil as soon as possible. If exposed root areas are not backfilled within 2 days, cover them with organic material in a manner which reduces soil temperature and minimizes water loss due to evaporation.
J. Any trenching required for the installation of landscape irrigation shall be placed as far from existing tree trunks as possible.

K. No landscape topsoil dressing greater than 4 inches shall be permitted within the drip line of trees. No soil is permitted on the root flare of any tree.
L. Pruning to provide clearance for structures, vehicular traffic and equipment shall take place before damage occurs (ripping of branches, etc.).
M. All finished pruning shall be done according to recognized, approved standards of the industry (Reference the National Arborist Association Pruning Standards for Shade Trees available on request from the City Arborist).
N. Deviations from the above notes may be considered ordinance violations if there is substantial non-compliance or if a tree sustains damage as a result.

APPENDIX E-3: STANDARD SEQUENCE OF CONSTRUCTION

The following sequence of construction shall be used for all development. The applicant is encouraged to provide any additional details appropriate for the particular development.

A. Temporary erosion and sedimentation controls are to be installed as indicated on the approved site plan or subdivision construction plan and in accordance with the Erosion Sedimentation Control Plan (ESC) and Stormwater Pollution Prevention Plan (SWPPP) that is required to be posted on the site. Install tree protection, initiate tree mitigation measures and conduct "Pre - Construction" tree fertilization (if applicable).
B. The Environmental Project Manager or Site Supervisor must contact the Planning & Development Department at 512-767-6675, 72 hours prior to the scheduled date of the required on-site preconstruction meeting.
C. The Environmental Project Manager, and/or Site Supervisor, and/or Designated Responsible Party, and the General Contractor will follow the Erosion Sedimentation Control Plan (ESC) and Storm Water Pollution Prevention Plan (SWPPP) posted on the site. Temporary erosion and sedimentation controls will be revised, if needed, to comply with City Inspectors' directives, and revised construction schedule relative to the water quality plan requirements and the erosion plan.
D. Rough grade the pond(s) at 100% proposed capacity. Either the permanent outlet structure or a temporary outlet must be constructed prior to development of embankment or excavation that leads to ponding conditions. The outlet system must consist of a sump pit outlet and an emergency spillway meeting the requirements of the Drainage Criteria Manual and/or the Environmental Criteria Manual, as required. The outlet system shall be protected from erosion and shall be maintained throughout the course of construction until installation of the permanent water quality pond(s).
E. Temporary erosion and sedimentation controls will be inspected and maintained in accordance with the Erosion Sedimentation Control Plan (ESC) and Storm Water Pollution Prevention Plan (SWPPP) posted on the site.
F. Begin site clearing/construction (or demolition) activities.
G. Permanent water quality ponds or controls will be cleaned out and filter media will be installed prior to/concurrently with revegetation of site.
H. Complete construction and start revegetation of the site and installation of landscaping.
I. Upon completion of the site construction and revegetation of a project site, the design engineer shall submit an engineer's letter of concurrence bearing the engineer's seal, signature, and date to the City Engineer indicating that construction, including revegetation, is complete and in substantial compliance with the approved plans. After receiving this letter, a final inspection will be scheduled by the appropriate City engineering staff.
J. Upon completion of landscape installation of a project site, the Landscape Architect shall submit a letter of concurrence to the City Engineer indicating that the required landscaping is complete and in substantial conformity with the approved plans. After receiving this letter, a final inspection will be scheduled by the appropriate City engineering staff.
K. After a final inspection has been conducted by the City Engineer and with approval from the City Engineer, remove the temporary erosion and sedimentation controls and complete any necessary final revegetation

resulting from removal of the controls. Conduct any maintenance and rehabilitation of the water quality ponds or controls.

APPENDIX F: WATER QUALITY CONTROL CALCULATIONS

F-1 Partial Sedimentation/Filtration pond, Biofiltration pond, and Vegetative Filter Strips Calculations for Preliminary Plans and Final Plats

F-2 Partial Sedimentation/Filtration Pond Calculations for Development Permits

F-3 Wet Pond Calculations for Development Permits

F-4 Retention/Irrigation System Calculations for Development Permits

F-5 Biofiltration Pond Calculations for Development Permits

F-6 Non-Required Vegetation Calculations for Development Permits

F-7 Rain Garden Calculations for Development Permits

APPENDIX F-1: PARTIAL S EDIMENTATION/FILTRATION POND, BIOFILTRATION POND, AND VEGETATIVE FILTER STRIP CALCULATIONS FOR PRELIMINARY PLANS AND FINAL PLATS

FULL AND PARTIAL SEDIMENTATION/FILTRATION POND, BIOFILTRATION POND, AND VEGETATIVE FILTER STRIP CALCULATIONS FOR PRELIMINARY PLANS AND FINAL PLATS

DRAINAGE AREA DATA:	Required	
Drainage Area to Control	____________	ac.
Drainage Area Impervious Cover	____________	%
Capture Depth(CD)	____________	in.
WATER QUALITY CONTROL CALCULATIONS:		
25-year Peak Flow Rate to Control (Q25)	____________	cfs.
100 year Peak Flow Rate to Control (Q100)	____________	cfs.
FOR FULL SEDIMENTATION/FILTRATION POND:		
Water Quality Volume *(CD * Drainage Area)*	____________	cf.
Sedimentation Pond Area *(WQV/10)*	____________	sf.
Sedimentation Pond Volume *(≥WQV)*	____________	cf.
Filtration Pond Area *(WQV/(7 + 2.33*H))*	____________	sf.
Filtration Pond Area *(≥20% WQV)*	____________	cf.
FOR PARTIAL SEDIMENTATION/FILTRATION POND:		
Water Quality Volume *(CD * Drainage Area)*	____________	cf.
Sedimentation Pond Area	____________	sf.
Sedimentation Pond Volume*(≥20% WQV)*	____________	cf.
Filtration Pond Area *(WQV/ (4 + 1.33*H))*	____________	sf.
Filtration Pond Volume	____________	cf.
FOR PARTIAL OR FULL BIOFILTRATION POND:		
Water Quality Volume (*CD * Drainage Area*)	____________	cf.
Sedimentation Pond Area	____________	sf.
Sedimentation Pond Volume	____________	cf.
Filtration Pond Area	____________	sf.
Filtration Pond Area	____________	cf.
FOR VEGETATIVE FILTER STRIPS:		
Size of Vegetative Filter Strip (*see ECM 1.6.7*)	____________	sf.

APPENDIX F-2: PARTIAL SEDIMENTATION/FILTRATION POND CALCULATIONS FOR DEVELOPMENT PERMITS

PARTIAL SEDIMENTATION/FILTRATION POND CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE AREA DATA:

Drainage Area to Control (DA)		ac
Drainage Area Impervious Cover		%
Capture Depth (CD)		in.

WATER QUALITY CONTROL CALCULATIONS:	Required		Provided	
The Water Quality Control is to be **PARTIAL SEDIMENTATION FILTRATION**				
25-year Peak Flow Rate to Control (Q25)		cfs.		
100-year Peak Flow Rate to Control (Q100)		cfs		
Water Quality Volume (WQV = CD*DA*3630)		cf		cf
Maximum Ponding Depth above Sand Bed (H)				ft
Sedimentation Pond Area				sf
Sedimentation Pond Volume (minimum 20% of WQV)		cf		cf
Filtration Pond Area (WQV/(4 + 1.33 * H))		sf		sf
Filtration Pond Volume				cf
Water Quality Elevation		ft msl		
Elevation of Splitter/Overflow Weir	minimum WQ elevation	ft msl		ft msl
Height of Gabion Wall	WQ elevation - 0.5ft.	ft msl		ft msl
Length of Splitter Weir				ft
Required Head to Pass Q100	maximum 1.0 ft.	ft		ft
Pond Freeboard Provided to Pass Q100	minimum 0.25 ft.	ft.		ft
48 Hour Drawdown Time Orifice Opening diameter (inches)				in

Sedimentation Pond:

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

Filtration Pond.

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

*in one foot or less increments

APPENDIX F-3: WETPOND CALCULATIONS FOR DEVELOPMENT PERMITS

WETPOND CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE AREA DATA:

Drainage Area to Control (DA)	________ ac.	
Drainage Area Impervious Cover	________ %	
Over Recharge Zone (Yes or No)	________	
Annual Runoff Coefficient (Rf) Table 1-9	________	
Liner Type (Clay or Geomembrane)	________ liner	
Depth of Clay Liner	minimum 12 in.	________ in

WATER QUALITY CONTROL CALCULATIONS:	Required	Provided
The Water Quality Control is to be WET POND		
Permanent Pool Volume (PPV = 0.162 *Rf * DA)	________ cf	________ cf
Permanent Pool Area (PPA)		________ sf
Permanent Pool Elevation (PPE)		________ ft msl
Forebay Volume (15 to 25% of PPV)	________ cf	________ cf
Elevation of Forebay Separation Wall (PPE – 2.0 ft.)		________ ft msl
Main Pool Volume	________ cf	________ cf

BIOLOGICAL ELEMENTS CALCULATIONS:

Area of Vegetative Bench (minimum 5% of PPA)		________ sf
Wetland Planting Quantity (PPA * 0 03)		________ plants
Gambusia Affinis (200 * (PPA / 43560))		________ individuals

EXTENDED DETENTION CALCULATIONS:

Extended Detention Peak Flow 1-year, 3-hour Storm	________ cfs	
Extended Detention Volume	________ cf	________ cf
Elevation of soffit of PVC Pipe (1/2 PPE depth from bottom of Main Pool)		________ ft msl
Diameter of PVC Pipe	minimum 6 in.	________ in.
Extended Detention Drawdown Time (hours)	minimum 72 hrs	________ hrs

Forebay Pond

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

Main Pool Pond

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

APPENDIX F-4: RETENTION/IRRIGATION POND CALCULATIONS FOR DEVELOPMENT PERMITS

RETENTION/IRRIGATION POND CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE AREA DATA:

Drainage Area to Control (DA)	______	ac.
Drainage Area Impervious Cover	______	%
Capture Depth (CD)	______	in

WATER QUALITY CONTROL CALCULATIONS	Required		Provided	
The Water Quality Control is to be **Retention Irrigation**				
25-year Peak Flow Rate to Control (Q25)	______	cfs.		
100-year Peak Flow Rate to Control (Q100)	______	cfs		
Water Quality Volume (WQV = CD*DA*3630)	______	cf	______	cf
Retention Pond Volume	minimum WQV	cf	______	cf
Water Quality Elevation	______	ft. msl		
Elevation of Splitter/Overflow Weir	minimum WQ elevation	ft msl	______	ft msl
Length of Splitter Weir			______	ft
Required Head to Pass Q100	maximum 1.0 ft	ft.	______	ft.
Pond Freeboard Provided to Pass Q100	minimum 0 25 ft.	ft.	______	ft.

IRRIGATION AREA CALCULATIONS.

Soil Permeability	minimum 0 03	in./hr	______	in./hr.
Pond Drawdown Time	maximum 72	hrs	______	hrs.
Irrigation Rate			______	in./hr.
Irrigation Area			______	ac

Retention Pond:

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

*in one foot or less increments

APPENDIX F-5: PARTIAL BIOFILTRATION POND CALCULATIONS FOR DEVELOPMENT PERMITS

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:

	Required	Provided
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

APPENDIX F-6: NON-REQUIRED VEGETATION CALCULATIONS FOR DEVELOPMENT PERMITS

NON-REQUIRED VEGETATION CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE AREA AND WATER QUALITY VOLUME DATA:

Drainage Area (DA)	______ ac.	
Total Site Percent Impervious Cover (IC)	______ %	______ ac
Capture Depth (CD)	______ in.	
Total Site Required Water Quality Volume (WQV = CD*DA*3630)	______ cf.	

NON-REQUIRED VEGETATION CALCULATIONS:	Required	Provided
Total 25-year Growth Root System of Non-Required Vegetation		______ ac
Impervious Cover of Area Treated by Non-required Vegetation (Treated IC)		______ ac.
IAF = Treated IC / IC	maximum 1.0	______

WATER QUALITY CREDIT:

Impervious Area Factor (IAF)	maximum 1.0	______
BMP Design Factor (BMPDF)	maximum 1.0	______
Water Quality Credit (WQC = IAF * BMPDF)	maximum 1.0	______

Water Quality Volume Reduction (WQV * WQC)		______ cf.

APPENDIX F-7: RAIN GARDEN CALCULATIONS FOR DEVELOPMENT PERMITS

RAIN GARDEN CALCULATIONS FOR DEVELOPMENT PERMITS

DRAINAGE AREA DATA:

Drainage Area to Control (DA - Maximum 2.0 Ac.)	______ Ac.	
Drainage Area Percent Impervious Cover	______ %	
Capture Depth (CD)	______ in.	

WATER QUALITY CONTROL CALCULATIONS:	**Required**	**Provided**
Water Quality Volume	______ cf.	______ cf.
100 Year Peak Flow Rate to Control (Q100)	______ cfs.	
Filtration Pond Area (Af)	______ sf.	______ sf.
Depth of Ponding (D)	Maximum 1.0 ft.	______ ft.
Depth of Filtration Media (L)	Minimum 1.5 ft.	______ ft.
Effective Porosity Water Quality Volume (WQV_{ep} = 0.24 * Af * L)		______ cf.
Ponded Water Quality Volume (WQV_{ponded} = WQV - WQV_{ep})		______ cf.
	Total WQV	______ cf.
Water Quality Elevation (WQE)		______ ft. MSL
Elevation of Splitter/Overflow Weir (Minimum WQE)		______ ft. MSL
Length of Splitter Weir		______ ft.
Required Head to Pass Q100	Maximum 0.5 ft.	______ ft.
Pond Freeboard Provided to Pass Q100	Minimum 0.25 ft.	______ ft.

FOR FILTRATION RAIN GARDENS:

Rain Garden Pond Drawdown Time	Minimum 48 hr.	______ hr.
Underdrain Orifice Size (Diameter)		______ in.
Underdrain Orifice Size (Area)		______ sq. in.

FOR INFILTRATION RAIN GARDENS:

Infiltration Rate (in/hr)	______ in/hr.
Rain Garden Pond Drawdown Time	______ hr.

APPENDIX G-1: COST ESTIMATES FOR EROSION/SEDIMENTATION CONTROL FISCAL SURETY (LDC 25-7- 65)

Silt Fence $3.00 per linear ft.

Rock Berm $14.00 per linear ft.

Reinforced Rock Berm $16.00 per linear ft.

Triangular Filter Dike $3.50 ft.

Mulch Berm $4.00 ft.

Mulch Sock (12 inch) $4.00 ft.

Mulch Sock (18 inch) $6.00 ft.

Hay Bale Dike. $3.50 ft.

Stabilized Construction Entrance $1000 each

Diversion/Interceptor/Perimeter Dike. $3.00 per linear ft.

Interceptor/Perimeter Swale (flat slope) $4.00 per linear ft.

Interceptor/Perimeter Swale (rock lined) $6.00 per linear ft.

Hydromulch seeding < 5,000 sq. yds. (w/topsoil & watering for temporary and permanent revegetation) $3.00 per sq yd

Hydromulch seeding > 5,000 sq. yds. (w/topsoil & watering for temporary and permanent revegetation) $2.00 per sq yd

Standard 604S Seeding for Erosion Control $5.00 per sq yd

Standard 609S Native Grasslands for Erosion Control $7.00 per sq yd

Revegetation matting-slopes (wood fiber) $1.50 per sq yd

Revegetation matting-channels (synthetic) $7.00 per sq yd

Standard 602 S Sodding for Erosion Control $5.00 per sq yd

On-site/off-site clean-up and remedy of erosion damage that results from development (only required for sites with LOC greater than 1 acre)

Phase 1: number of acres disturbed within LOC:________× $3000 = $________

Phase 2: number of acres disturbed within LOC: ________× $3000= $________

Phase 3: number of acres disturbed within LOC: ________× $3000= $________

Total fiscal for clean-up = Phase 1+ Phase 2+Phase 3 = $ ________

APPENDIX H: FIGURES AND DIAGRAMS

FIGURES FROM APPENDIX H – FIGURES AND DIAGRAMS IN THE CITY OF AUSTIN ENVIRONMENTAL CRITERIA MANUAL shall hereby be referenced.

REFERENCES

1. Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.
2. http://water.epa.gov/scitech/monitoring/rsl/bioassessment/index.cfm
3.
4. Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC. EPA 843-K-12-006.
5. http://water.epa.gov/lawsregs/guidance/wetlands/upload/A_Function-Based_Framework-2.pdf
6.
7. Pfankuch, D. J. 1975. Stream reach inventory and channel stability evaluation. U.S. Department of Agriculture Forest Service. Region 1. Missoula, Montana.
8.
9. Richter, F.A. and A. Duncan. 2012. Riparian Functional Assessment: Choosing Metrics that Quantify Restoration Success in Austin, Texas. City of Austin, Planning & Development Department, Environmental Resource Management. SR-12-12.
10. Source: Rule No. 14-06, 3-5-2014 ; Rule No. R161-15.13, 1-4-2016

DEFINITIONS

APPENDIX TERMS BEGINNING WITH "A"

1. **ABANDONED**

   When referring to an underground storage tank installation, means out of service and not safeguarded in compliance with the City Code. However, an underground storage tank installation shall not be deemed to be abandoned within the meaning of the City Code if it was closed previously in accordance with this ordinance or any other applicable state, federal or local laws or regulations.

2. **ACCEPTABLE OUTLET**

   That point where stormwater runoff can be released into a watercourse or drainageway of adequate capacity without causing scour or erosion.

3. **AGGREGATE**

   A broad category of coarse inert particulate material used in construction, including sand, gravel, crushed stone, or glass.

4. **ALLUVIAL FAN**

   A sloping, fan-shaped mass of sediment deposited by a stream where it emerges from an upland onto a plain.

5. ALLUVIUM

A general term for all detrimental material deposited or in transit by streams, including gravel, sand, silt, clay and all variations and mixtures of these. Unless otherwise noted, alluvium is unconsolidated.

6. ALTERATIONS

Cutting, filling, widening, bypassing, channelizing, stabilizing or clearing vegetation in a floodplain.

7. ANGLE OF REPOSE

The angle between the horizontal and the maximum slope that a soil assumes through natural processes.

8. ANNUAL

A plant that lives and grows for only one (1) year or season, during which the life cycle is completed.

9. ANTISEEP COLLAR

An impermeable diaphragm, usually of sheet metal or concrete, constructed at intervals within the zone of saturation along the conduit of a principal spillway to increase the seepage length along the conduit and thereby prevent piping or seepage along the conduit.

10. ANTIVORTEX DEVICE

A device, usually a vertical or a horizontal plate, carefully designed and placed at the entrance of a pipe to prevent the formation of a vortex in the water at the pipe entrance.

11. APRON

A floor or lining to protect a surface from erosion; for example, for the pavement below chutes, spillways or at the toes of dams.

12. ASPECT

The direction a slope faces is a physiographic feature on steep slopes which influences plant growth and adaptation.

13. ASPHALT

a. Cutback - Asphalt thinned with lighter hydrocarbons, such as kerosene or naptha.
b. Emulsion - An emulsion of water and asphalt.
c. Liquid - (In this application) asphalt which has a sufficiently low viscosity to be sprayed without thinning.

14. ATTERBERG LIMITS

Soil properties measured for soil materials the Number 40 sieve.

a. Liquid Limit - The water content corresponding to the arbitrary limit between the liquid and plastic states of consistency of a soil.
b. Plastic Limit - The water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of a soil.
c. Plasticity Index - The numerical difference between the liquid limit and the plastic limit.

APPENDIX TERMS BEGINNING WITH "B"

15. BARREL

The usually mildly sloping closed conduit used to convey water under or through a dam; part of a principal spillway.

16. BASE FLOW

The stream discharge from ground water accretion.

17. BEDLOAD

The sediment that moves by sliding, rolling or bounding on or very near the stream bed; sediment moved mainly by tractive or gravitational forces or both, but at velocities less than the surrounding flow.

18. BERM

A shelf that breaks the continuity of a slope.

19. BLIND DRAIN

A type of drain consisting of an excavated trench refilled with previous material, such as coarse sand, gravel or crushed stone, through whose voids water percolates and flows to an outlet. Often referred to as a French drain because of its initial development and widespread use in France.

20. BUFFER AREA

A landscape area on a lot, situated between all street views and all vehicles, structures and areas to be buffered from those views.

21. BUFFERING

The use of landscaping (other than mere grass on flat terrain) or the use of landscaping along with berms, walls or decorative fences that at least partially and periodically obstruct the view from the street, in a continuous manner, of vehicular use areas, parking lots and their parked cars and detention ponds.

APPENDIX TERMS BEGINNING WITH “C”

22. CALIPER

The diameter of an installed tree measured six (6) inches above ground level for small trees (four (4) inches diameter or less) at time of planting; measured at 12 inches above ground level for large trees (greater than four (4) inches diameter). (See Figure 3-1 in Appendix H of this manual) The caliper of installed multi-stemmed trees is determined by adding the full diameter of the largest stem to half the diameter of each additional stem.

23. CANOPY COVER

That geographic area covered by the vertical projection of the drip line or outer branches of a tree or group of trees in a woodland tract, which may be measured directly from aerial photography and/or measured for all trees at least 30 feet in height.

24. CATCHMENT AREA

The area, defined by topographic relief, which drains to a point recharge or critical environmental feature.

25. CAVE

A natural underground cavity, recess, chamber or series of chambers generally produced by the solution of limestone by subterranean water.

26. CHANNEL

An existing natural water course or a manmade water course designed to meet specifications contained in the City of Austin Drainage Criteria Manual.

27. CHANNEL

A natural stream that conveys water; a ditch and channel excavated for the flow of water.

28. CHANNEL IMPROVEMENT

The improvement of the flow characteristics of a channel by clearing, excavation, realignment, lining or other means in order to increase its water carrying capacity.

29. CHANNEL STABILIZATION

Erosion prevention and stabilization of distribution in a channel using jetties, drops, revetments, structural linings, vegetation and other measures.

30. CHECK DAM

A small dam constructed in a gully or other small watercourse to decrease the stream flow velocity (by reducing the channel gradient), minimize channel scour and promote deposition of sediment.

31. CHUTE

A high velocity, open channel for conveying water to a lower level without erosion.

32. CLAY (SOILS)

a. A mineral soil separate consisting of particles less than 0.002 millimeter in equivalent diameter.

b. A soil texture class.

c. (Engineering) A fine grained soil (more than 50 percent passing the Number 200 sieve) that has a high plasticity index in relation to the liquid limit (Unified Soil Classification System).

33. COMPACTION

To unite firmly. With respect to construction work with soils, engineering compaction is any process by which the soil grains are rearranged to decrease void space and bring them into closer contact with one another, thereby increasing the weight of solid material per unit of volume, increasing the shear and bearing strength and reducing permeability.

34. COMPOST

A mixture of vegetable refuse, manure or other organic matter which has gone through a decaying process. CONDUIT - Any channel intended for the conveyance of water, whether open or closed.

35. CONSTRUCTION LIMIT LINE (Limit of Construction, Construction Limit, Limit Line)

See Limits of Construction

36. CONTOUR

a. An imaginary line on the surface of the earth connecting points of the elevation.

b. A line drawn on a map connecting points of the same elevation.

37. CREST

a. The top of a dam, dike, spillway or weir, frequently restricted to the overflow portion.

b. The summit of a wave or peak of a flood.

38. CRITICAL AREA OR SITE

Sediment producing, highly erodible or severely eroded areas.

39. CRITICAL DEPTH (HYDRAULICS)

That slope which will sustain a given discharge at uniform critical depth in a given channel.

40. CRITICAL ENVIRONMENTAL FEATURES

Features which have been determined to be of critical importance to the protection of one (1) or more environmental resources. They include such features as bluffs, springs, canyon rimrocks, caves, sinkholes and wetlands.

41. CRITICAL ROOT ZONE

The area of undisturbed natural soil around a tree defined by a concentric circle with a diameter in feet equal to twice the number of inches of trunk diameter (see Section 3.3.2 D 2).

42. **WATER QUALITY BUFFER ZONE**

Zones along creeks and tributaries as defined in Article 7, Section 7.3.2.C.5 of the UDC. If a proposed development has been exempted or waived from this provision, Water Quality Buffer Zones shall be those established under the applicable special watershed ordinance, if any.

43. **CROWN**

Branch structure of a tree. CROWN (OF SLOPE) - Top of slope, apex.

44. **CRUSHED STONE**

Aggregate consisting of angular particles produced by mechanically crushing rock.

45. **CULM**

The stem of grasses, sedges and rushes, which is jointed and usually hollow in grasses and usually solid in sedges and rushes.

46. **CULTIPACKER**

A corrugated roller used to crush sods and eliminate coarse pores in soil by firming the seed bed.

47. **CULTIPACKER SEEDER**

In addition to being a cultipacker, this is a farm tool equipped with a seed box which drops the seed between cultipacker rollers to place the seed on firm soil where they will be pressed into the soil by the second corrugated roller.

48. **CUT**

Portion of land surface or area from which earth has been removed or will be removed by excavation; the depth below original ground surface to excavated surface.

49. **CUT-AND-FILL**

Process of earth moving by excavating part of an area and using the excavated material for adjacent embankments or fill areas.

50. **CUTOFF**

A wall or other structure, such as a trench, filled with relatively impervious material intended to reduce seepage of water through porous strata.

51. **CYCLONE (SEEDER)**

A hand-turned or tractor-drawn seeder that broadcasts seed onto the seed bed by a rotary motion that slings the seed outward from the seeder.

APPENDIX TERMS BEGINNING WITH “D”

52. **DAM**

A barrier to confine or raise water for storage or diversion, to create a hydraulic head, to prevent gully erosion or for retention of soil, sediment or other debris.

53. **DEBRIS**

Broken remains of plants, objects and rocks that form trash or remains. DECIDUOUS - Plants that shed their leaves annually, as opposed to evergreen.

54. **DEPOSITION**

The accumulation of material dropped because of a slackening movement of the transporting agent, water or wind.

55. DESICCATION

Drying out as of root systems of plants before they are planted.

56. DESILTING AREA

An area of grass, shrubs or other vegetation used for inducing deposition of silt and other debris from flowing water, located above a pond, field or other area needing protection from sediment accumulation (see filter strip).

57. DETENTION DAM

A dam constructed for the purpose of temporary storage of stream flow or surface runoff which releases the stored water at controlled rates.

58. DIAMETER

The diameter of an existing tree at 4½ feet above natural grade (diameter breast height - dbh) as determined by measuring the trunk circumference and dividing by pi (3.14) (see Figure 3-1 in Appendix H of this manual)

59. DIKE (ENGINEERING)

An embankment to confine or control water; for example, one built along the banks of a river to prevent overflow of lowlands; a levee.

60. DISTURBED AREA

An area in which the natural vegetation or soil cover has been removed or altered, which is therefore susceptible to erosion.

61. DIVERSION

A channel with a supporting ridge on the lower side constructed across the slope to divert water from areas where it is in excess, to sites where it can be used or disposed of safely. Diversions differ from terraces in that they are individually designed.

62. DOUBLE-WALLED

Constructed with more than one (1) containment layer with space between the layers sufficient to all monitoring of any leakage into or from the enclosed space. Laminated, coated or clad materials shall not be considered as double-walled construction.

63. DRAIN (NOUN)

a. A buried pipe or other conduit (subsurface drain).

b. A ditch or channel (open drain) for carrying off surplus surface water or ground water.

64. DRAIN (VERB)

a. To provide channels, such as open ditches or closed drains, so that excess water can be removed by surface flow or internal flow.

b. To lose water (from the soil) by percolation.

65. DRAINAGE

a. The removal of excess surface water or ground water from land by means of surface or subsurface drains.

b. Soil characteristics that affect natural drainage.

66. DRAINAGE AREA (WATERSHED)

All land and water from which runoff may run to a common (design) point. DRIP IRRIGATION - The process of slowly applying small amounts of water on or beneath the root system of plants. DRIPLINE - A vertical line extending downward from the outermost extremities of a tree's branches.

67. DROP INLET SPILLWAY

An overfall structure in which the water drops through a vertical riser connected to a discharge conduit.

68. DROP SPILLWAY

An overfall structure in which the water drops over a vertical wall onto an apron at a lower elevation.

69. DROP STRUCTURE

A structure for dropping water to a lower level and dissipating its surplus energy; a fall. The drop may be vertical or inclined.

70. DROUGHTY (SOIL OR SLOPE)

Lacking medium to high moisture during part of the poor growing season during a typical year.

APPENDIX TERMS BEGINNING WITH "E"

71. EDWARDS AQUIFER

The water bearing substrata also known as the Edwards and Associated Limestones Aquifer. It includes the stratigraphic rock units known as the Edwards Formation and Georgetown Formation.

72. EFFECTIVE SOIL See Topsoil.

73. EMERGENCY SPILLWAY

A dam spillway designed and constructed to discharge flow in excess of the principal spillway design discharge.

74. ENERGY DISSIPATER

A designed device, such as an apron of riprap or a concrete structure, placed at the end of a water-transmitting apparatus, such as a pipe, paved ditch or paved chute, for the purpose of reducing the velocity, energy and turbulence of the discharged water.

75. ENTRANCE HEAD

The height of water required to cause flow into a conduit or other structure, including both entrance loss and velocity head.

76. EROSION

a. The wearing away of land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.

b. Detachment and movement of soil or rock fragments by water, wind, ice or gravity. The following terms are used to describe different types of water erosion:

77. Erosion, Accelerated

Erosion much more rapid than normal, natural or geologic erosion, primarily as a result of the influence of the activities of man or in some cases of other animals or natural catastrophes that expose base surfaces; for example, fires.

78. Erosion, Gully

The erosion process whereby water accumulates in narrow channels and over short periods removes the soil from this narrow area to considerable depths, ranging from one (1) or two (2) feet to as much as 75 to 100 feet (see gully).

79. Erosion, Rill

An erosion process in which numerous small channels only several inches deep are formed (see rill).

80. Erosion, Sheet

The removal of a fairly uniform layer of soil from the land surface by runoff water.

81. Erosion, Splash

The spattering of small soil particles caused by the impact of raindrops on wet soils. The loosened and spattered particles may or may not be subsequently removed by surfaces runoff.

82. ESTHETIC (AESTHETIC)

Pleasing to look at.

83. EVERGREEN

Plants which have leaves or needles year long, as opposed to those that lose their leaves during part of the year.

84. EXCELSIOR BLANKET

An erosion retardant material made from excelsior strands held together with net-like strands of plastic or other material.

85. EXISTING TREE

A tree which exists on a site or easement prior to any development or disturbance.

86. EXISTING UNDERGROUND STORAGE TANK INSTALLATION

Any underground storage tank system in existence as of or being constructed on the effective date of the City Code or any underground storage tank installation for which a building permit was applied for prior to that date.

87. EXPOSURE (SLOPE)

a. North - Slopes facing in any compass direction clockwise between N45W and S45E.

b. South - Those slopes which face in any compass direction clockwise between S45E and N45W.

APPENDIX TERMS BEGINNING WITH "F"

88. FACILITY

A building or buildings, appurtenant structures and surrounding land area used by a person at a single location or site.

89. FAULTS AND FRACTURES

Significant fissures or cracks in rock which may permit infiltration of surface water to underground cavities and channels.

90. FILTER STRIP

A strip of permanent vegetation above ponds, diversions and other structures to retard flow of runoff water, causing deposition of transported material, thereby reducing sediment flow.

91. FINES (SOIL)

Generally refers to the silt and clay size particles in soil.

92. FLOODPLAIN

The land area adjacent to a waterway necessary to contain a 100 year flood under fully developed conditions in accordance with the Drainage Criteria Manual, as well as all land contained within a Water Quality Buffer Zone, where Section 25-8-92 of the Land Development Code applies.

93. FORBS

Vascular plants other than trees, shrubs, woody vines or grasses.

94. FREEBOARD (HYDRAULICS)

The vertical distance between the maximum water surface elevation anticipated in design and the top of retaining banks or structures. Freeboard is provided to prevent overtopping due to unforeseen conditions.

95. FRONT WALL (BUILDING)

A building wall facing and parallel to a street or a building wall facing a street at an angle less than 45 degrees.

APPENDIX TERMS BEGINNING WITH “G”

96. GABION

A flexible, woven wire basket composed of two (2) to six (6) rectangular cells filled with small stones. Gabions may be assembled into many types of structures, such as revetments, retaining walls, channel liners, drop structures and groins.

97. GABION MATTRESS

A thin gabion, usually six (6) or nine (9) inches thick, used to line channels for erosion control.

98. GRADE

a. The slope of a road, channel or natural ground.

b. The finished surface of a canal bed, roadbed, top of embankment or bottom of excavation; any surface prepared for the support of construction, like paving or laying a conduit.

c. To finish the surface of a canal bed, road bed, top of embankment or bottom of excavation.

99. GRADE STABILIZATION STRUCTURE

A structure for the purpose of stabilizing the grade of a gully or other watercourse, thereby preventing further head cutting or lowering of the channel grade.

100. GRASSED WATERWAY

A natural or constructed waterway, usually broad and shallow, covered with erosion-resistant grasses, to convey surface water down the slope.

101. GRAVEL

a. Aggregate consisting of mixed sizes of ¼ inch to three (3) inch particles, which normally occur in or near old stream beds and have been worn smooth by the action of the water.

b. A soil having particle sizes, according to the Unified Soil Classification System, ranging from the Number 4 sieve size (approximately ¼ inch) to three (3) inches. Particles may be natural gravel or angular in shape, as produced by mechanical crushing.

102. GRAVEL ENVELOPE

Selected aggregate placed around the screened or perforated pipe section of well casing or a subsurface drain to facilitate the entry of water into the well or drain.

103. GRAVEL FILTER

Washed and graded sand and gravel aggregate, placed around a drain or well screen to prevent the movement of fine materials from the surrounding material into the drain or well.

104. GROUND COVER

Plants which are low-growing and provide a thick growth which protects the soil, as well as providing some beautification of the area occupied.

105. GULLY

A channel or miniature valley cut by concentrated runoff through which water commonly flows only during and immediately after heavy rains. The distinction between gully and rill is one of depth. A gully is sufficiently deep enough not to be obliterated by normal tillage operations, whereas a rill is of less depth and would be smoothed by ordinary farm tillage.

APPENDIX TERMS BEGINNING WITH “H”

106. HAZARDOUS MATERIAL

Any material which is subject to regulation pursuant to Chapter 9-10 of the Austin City Code.

107.HEAD (HYDRAULICS)

a. The height of water above any plane or reference.

b. The energy, either kinetic or potential, possessed by each weight of a liquid expressed as the vertical height through which a unit weight would have to fall to release the average energy possessed. Used in various compound terms such as pressure head, velocity head and head loss.

108.HERBACEOUS PERENNIAL (PLANTS)

A plant whose stems die back to the ground each year.

109.HERBICIDE

Chemical formulations used to control weeds or brush.

110.HULLED (SEED)

Seed without hulls such as Sericea lespedeza. Seed are usually processed after threshing to take off outer hull to facilitate scarification and quicken germination.

111.HYDRAULIC GRADE LINE

In a closed conduit, a line joining the elevations to which water could stand in risers or vertical pipes connected to the conduit at their lower end and open at their upper end. In open channel flow, the hydraulic grade lien is the free water surface.

112.HYDRAULIC GRADIENT

The slope of the hydraulic grade line. The slope of the free surface of water flowing in an open channel.

113.HYDRAULIC JUMP

The sudden turbulent rise in water level from a flow stage below critical depth to flow stage above critical depth, during which the velocity passes from super critical to subcritical.

114.HYDRAULIC RADIUS

The cross-sectional area of a channel divided by its wetted perimeter. The "r" in Manning's Formula.

115.HYDROGRAPH

A graph showing variation in stage (depth) or discharge of a stream of water over a period of time.

116.HYDROSEEDER

A machine designed to apply seed, fertilizer, lime and short fiber wood or paper mulch to the soil surface.

HYDROSEEDING Seeding with a hydroseeder.

APPENDIX TERMS BEGINNING WITH "I"

117.INLET (HYDRAULICS)

a. A surface connection to a closed drain.

b. A structure at the entrance end of a conduit.

c. The upstream end of any structure through which water may flow.

118.IN-CHANNEL DETENTION

Detention accomplished by channel storage or onstream storage, as opposed to offstream or upland detention (see the Drainage Criteria Manual).

119.INSTALLED TREE

A tree which is planted on a site after development occurs.

120.INTERCEPTOR DRAIN

A surface or subsurface drain or a combination of designed and installed to intercept flowing water.

121.IRRIGATION

Providing water to plants in an amount and frequency adequate to sustain growth of the plants on a permanent basis.

122.ISOBUTYLIDENE UREA

A slowly soluble synthetic organic compound containing 31 percent nitrogen.

123.ISOLATED BUILDING

A detached building in front of and physically separate from the main building or buildings on a site and smaller in square footage than the anchor building.

APPENDIX TERMS BEGINNING WITH “J”

124.JUTE

A coarsely woven material of jute yarn which can be used to control soil erosion in waterways and on steep slopes.

APPENDIX TERMS BEGINNING WITH “K”

125.KARST FEATURE

For the purpose of these guidelines a karst feature is defined as a cave, fault, fracture, joint, sinkhole or other associated features formed in limestone, dolomite or associated geologic strata.

APPENDIX TERMS BEGINNING WITH “L”

126.LANDSCAPE AREA

Any area within the boundaries of a given lot which is devoted to and consists of living plant material and other landscape material, including but not limited to grass, trees, shrubs, flowers, vines, groundcover, native plant materials, existing native vegetation areas, planters, brick, stone, natural forms, water forms and other landscape features, but not including the use of smooth concrete, asphalt or aggregate. Provided, however that the use of nonliving landscape materials shall not predominate over the use of organic living plant material within any single landscape area.

127.LANDSCAPE ISLAND

A landscape area completely surrounded by a parking area and/or a vehicular use area.

128.LANDSCAPE MEDIAN

A linear landscape area between two (2) rows of parking, between two (2) drives or between a row of parking and a drive.

129.LANDSCAPE PENINSULA

A landscape area surrounded on two (2) or three (3) sides by a parking area and/or a vehicular use area.

130.LARGE SHRUB

A woody plant of smaller proportions than a tree which usually produces several branches from the base and will reach a mature height of over four (4) feet.

131.LARGE TREE

A tree species listed in Appendix F as having a mature height of more than 30 feet. LAYERING - A shoot or twig attached to the living stock for the purpose of propagation.

132.LIME

Basic calcareous materials used to raise pH of acid soils for benefit of plants being grown. May be either ground limestone or hydrated lime.

133. **LIMITS OF CONSTRUCTION**

The outer limits of the area which will be disturbed by a proposed development activity including the area of all proposed cuts, fills, regrading, structures, ancillary facilities, temporary utilities, temporary or permanent spoil storage areas, access roads, storage areas, staging areas and any other activities or facilities which may cause temporary or permanent loss or damage of vegetation or disruption of the soil surface.

134. **LINEAMENT**

A linear figure that is perceived from an aerial photograph of a site, is continuous with definable end points and lateral boundaries, has a relatively high length/width ratio and hence a discernible azimuth and is shown or presumed to be correlated with natural structural geological features.

135. **LINEAR DEVELOPMENT**

Development which is typically not confined to one site and is linear in nature such as a utility or waterway alteration project.

APPENDIX TERMS BEGINNING WITH “M”

136. **MANNING'S FORMULA (HYDRAULICS)**

A formula used to predict the velocity of water flow in an open channel or a pipeline:

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

Wherein V is the mean velocity of flow in feet per second; R is the hydraulic radius; S is the slope of the energy gradient or for assumed uniform flow the slope of the channel, in feet per foot; and n is the roughness coefficient or retardance factor of the channel lining.

137. **MEDIUM SHRUB**

A woody plant of smaller proportions than a tree which usually produces several branches from the base and will have a maximum mature height of between four (4) and six (6) feet.

138. **MULCH**

Covering on surface of soil to protect and enhance certain characteristics, such as water retention qualities.

139. **MULCH (ORGANIC)**

Organic mulches are those that are made up of decomposing plant parts such as shells, hulls, bark, leaves, hardwoods and softwoods. Organic mulch provides root protection, keeps the soil and roots cooler, and adds organic matter as it decomposes.

140. **MULCH ANCHORING TOOL**

A tool that looks like a dull disk designed to press straw and similar mulches into the soil to prevent loss due to wind, water or gravity.

APPENDIX TERMS BEGINNING WITH “N”

141. **NATIVE PLANTS**

Plants native to the Austin area or adjacent areas of the Edwards Plateau, which are compatible with environmental conditions of a site or portions of a site. The standard reference for this criterion shall be the Manual of Vascular Plants of Texas by Correll and Johnston, published by the University of Texas at Dallas (1970).

142.NATURAL AREA

Area of a site existing in a natural state.

143.NATURAL FORMS

Features in a natural landscape other than plants, such as ponds, streams, rock outcroppings, cliffs, etc.

144.NATURAL GROUND

Ground surface which has not been disturbed by man.

145.NATURAL GROUND COVER

Any organic material either existing prior to construction or installed after construction.

146.NATURAL STATE

Substantially the same conditions of the land which existed prior to any development, including, but not limited to, the same type, quality, quantity and distribution of soils, ground cover, vegetation and topographic features.

147.NETTING (MULCH)

Plastic, paper or cotton material used to hold mulch material on the soil surface.

148.NEW UNDERGROUND STORAGE TANK INSTALLATION

Any underground storage tank installation for which a building permit was applied for after the effective date of this article or any existing underground storage tank installation which is substantially modified or added to after that date.

149.NITROGEN-FIXING (BACTERIA)

Bacteria having the ability to fix atmospheric nitrogen, making it available for use by plants. Inoculation of legume seeds is one way to insure a source of these bacteria for specified legumes.

150.NORMAL DEPTH

Depth of flow in an open conduit during uniform flow for the given conditions (see uniform flow).

151.NOXIOUS WEEDS Harmful; undesirable; hard to control.

a. Restricted - may be sold in the trade, but are limited to very small amounts as undesirable contaminants.

APPENDIX TERMS BEGINNING WITH "O"

152.OUTFALL

The point where water flows from a conduit, stream or drain.

153.OUTLET

The point at which water discharges from such things as a stream, river, lake, tidal basin, pipe, channel or drainage area.

154.OUTLET CHANNEL

A waterway constructed or altered primarily to carry water from manmade structures, such as terraces, subsurface drains, diversions and impoundments.

155.OVATE

Egg-shaped in outline.

156.OVERBANK

The area outside the immediate natural stream channel or outside the pilot channel of a new channel which contains the 100 year floodplain.

157.OVERFALL

Abrupt change in stream channel elevation; the part of a dam or weir notch over which the water flows.

158.OVOID

A three (3) dimensional solid, ovate in outline.

APPENDIX TERMS BEGINNING WITH "P"

159.PADS

Individual pieces of sod cut to supplier's standard width and length.

160.PAPER FIBER

A short fiber mulch material usually applied by hydroseeder along with fertilizer and seed.

161.PARENT MATERIAL

The unconsolidated rock material from which the soil profile develops.

162.PARKING BAY

A parking area serviced by one (1) drive and including back-up space. This may include a single bay with one (1) row of parking or a double bay with two (2) rows of parking sharing a common drive.

163.PARKING STRUCTURE

Any parking area which is totally or partially enclosed overhead or in which the parking surface is not at finish grade.

164.PERMANENT SEEDING

Results in establishing perennial vegetation which may remain on the area for many years.

165.PERMANENT STORAGE OR PERMANENTLY STORING

Shall mean storage for a period of over thirty (30) days.

166.PERMEABLE PAVING

A paving surface which permits adequate gas exchange and water penetration to sustain a tree root system beneath it.

167.PERMISSIBLE VELOCITY (HYDRAULICS)

The highest average velocity at which water may be carried safely in a channel or other conduit. The highest velocity that can exist through a substantial length of a conduit and not cause scour of the channel. Safe, noneroding or allowable velocity.

168.PERMIT

Any Hazardous Material Underground Storage Tank Registration Permit issued pursuant to the City Code.

169.PERMITTEE

Any person to which a permit is issued pursuant to the City Code and any authorized representative, agent or designee of such person.

170.PERSON

Any individual, firm, trust, partnership, corporation, joint venture, association or other legal entity; any group of the foregoing, organized or united for a business purpose; or any governmental entity.

171.pH

A number denoting the common logarithm of the reciprocal of the hydrogen ion concentration. A pH of seven (7.0) denotes neutrality, higher values indicate alkalinity and lower values indicate acidity.

172.PHREATIC LINE

The upper surface of the zone of saturation in an embankment is the phreatic (zero pressure) surface; in cross section, this is called the phreatic line.

173.PIPES OR PIPING

Any pipeline system which is used for the transfer of hazardous materials in connection with an underground storage tank within the confines of a facility.

174.PIPING

Removal of soil material through subsurface flow channels or "pipes" developed by seepage water.

175.PLANT MATERIALS

Living plants which are part of an installed landscape.

176.PLASTICITY INDEX

See Atterberg limits. PLASTIC LIMIT - See Atterberg limits.

177.PLUGS

Pieces of turf or sod, usually cut with a round tube, which can be used to propagate the turf or sod by vegetative means.

178.POINT RECHARGE FEATURE

Any cave, sinkhole, fault, joint or other specific natural feature situated over the Edwards Aquifer Recharge Zone which may be demonstrated to transmit, or has the potential to transmit, a significant amount of surface water into the subsurface strata.

179.PRECISION TEST

Any test performed on an underground storage tank system which is capable of measuring a quantitative leak rate and which controls, eliminates, measures or otherwise takes into account changes in the coefficient of expansion of the liquid due to temperature changes, containment system deformations due to pressure changes, evaporative losses and other relevant variables during the course of the test, as discussed in NFPA 329, "Recommended Practice for Handling Underground Leakage of Flammable and Combustible Liquids," as amended and published by the National Fire Protection Association.

180.PREDOMINATE

verb (used without object)

1.to be the stronger or leading element or force.

2.to have numerical superiority or advantage.

3.to surpass others in authority or influence; be preeminent.

4.to have or exert controlling power (often followed by over,

5.to appear more noticeable or imposing than something else.

181.PRESS WHEEL

A wheel which usually follows a seeding and presses seed into or on the surface of the seed bed.

182.PRIMARY CONTAINMENT

The first level of containment or the inside portion of an underground storage tank system, which comes into immediate contact on its inner surface with hazardous material being contained, including the piping.

183.PROCUMBENT

Lying down prone; trailing as a vine, usually not rooting at the nodes.

184.PRODUCT TIGHT

Impervious to the hazardous material which is contained so as to prevent the release of the hazardous material from the primary containment. To be product tight, the tank shall be made of a material that is highly resistant to physical or chemical deterioration by the environment and the hazardous material being contained or shall be equipped with an inner liner which protects the construction material of the tank from the environment and the contained material.

185.PROTECTED RIPARIAN AREAS

Those ecological features within a floodplain associated with a waterway segment, which contribute to the natural and traditional character of the waterway, as follows:

1. Floodplain woodlands. Any wooded area in a floodplain with all of the following characteristics:

- Has a minimum extent of canopy cover of ½ acre;
- Voids in the canopy cover comprise less than 30 percent of the total woodland area;
- At least 50 percent of all trees which have diameters of eight (8) inches or greater measured at 4½ feet above the ground are comprised of three (3) or more of the following species:

pecan	Carya illinoiensis
American elm	Ulmus americana
Arizona walnut	Juglans major
bald cypress	Taxodium distichum
black walnut	Juglans nigra
bur oak	Quercus macrocarpa
cedar elm	Ulmus crassifolia
little walnut	Juglans microcarpa
green ash	Fraxinus pennsylvanica
Texas sugarberry	Celtis laevigata
American sycamore	Platanus occidentalis
Eastern cottonwood	Populus deltoides
Black willow	Salix nigra

2.Wetlands (other than springs). As defined in Section 25-8-1 of the Land Development Code.

3.Permanent natural pools in perennial or intermittent waterways.

186.<u>PROTECTED TREE</u>

A tree having a trunk circumference of 60 inches or more, measured at 4½ feet above natural grade level.

APPENDIX TERMS BEGINNING WITH “Q”

187.QUALIFIED PERSON

Experienced as defined in A.P.I. (American Petroleum Institute) Bulletin 1631, 1987 edition.

APPENDIX TERMS BEGINNING WITH “R”

188.RELEASE

Any spilling, leaking, emitting, discharging, escaping, leaching or disposing into ground water, surface water or soils.

189.RESIDUES (PLANT)

Dead parts of plants which may be left on the soil surface following harvest, grazing or cutting.

190.RESTORATION

(See Revegetation)

191.RETENTION

The amount of precipitation on a drainage area that does not escape as runoff. It is the difference between total precipitation and total runoff.

192.REVEGETATION

The installation of native trees, shrubs, grasses and wildflowers in an area after its disturbance, along with subsequent maintenance, intended to restore the area to a natural state.

193.REVETMENT

Facing of stone or other materials, either permanent or temporary, placed along the edge of a stream or shoreline to stabilize the bank and to protect it from the erosive action of water.

194.RHIZOME

Any prostate, more or less elongated stem growing partly or completely beneath the surface of the ground; usually rooting at the nodes and becoming upcurved at the apex.

195.RIGHT OF WAY

Right of passage, as over another's property. A route that is lawful to use. A strip of land acquired for transport or utility construction.

196.RILL

A small channel cut by concentrated runoff, but through which water commonly flows only during and immediately after rains. A rill is usually only a few inches deep (but no more than one (1) foot) and hence, no obstacle to tillage operations.

197.RIPPING

Pulling a chisel or subsoiling implement through the soil to reduce compaction and promote infiltration of water into the soil. Does not invert the soil.

198.RIPRAP

Broken rock, cobbles or boulders placed on earth surfaces, such as the face of a dam or the bank of a stream, for protection against the action of water (waves); also applies to brush or pole mattresses or brush and stone or similar materials used for soil erosion control.

199.ROUGHNESS COEFFICIENT (HYDRAULICS)

A factor in velocity and discharge formulas representing the effect of channel roughness on energy losses in flowing water. Manning's "n" is a commonly used roughness coefficient.

200.RUNOFF (HYDRAULICS)

That portion of the precipitation on a drainage area that is discharged from the area in stream channels. Types include surface runoff, ground water runoff or seepage.

APPENDIX TERMS BEGINNING WITH “S”

201.SAND

a. (Agronomy) A soil particle between 0.05 and 2.0 millimeters in diameter.
b. A soil textural class.
c. (Engineering) According to the Unified Soil Classification System, a soil particle larger than the Number 200 sieve (0.074 millimeters) and passing the Number 4 sieve (approximately ¼ inch).

202.SCREENED

Shielded, concealed and effectively hidden from the view of a person standing at ground level on an abutting site or outside the area or feature so screened, by a fence, wall, hedge, berm or similar architectural or landscape feature which is, or will grow to, at least six (6) feet in height.

203.SECONDARY CONTAINMENT

The level of containment external to, and separate from, the primary containment, consisting of an impervious layer of materials which are installed so that any release of hazardous materials from the primary containment of an underground storage tank installation will be prevented from contacting the environment outside said impervious layer.

204. SEDIMENT

Solid material, both mineral and organic, that is in suspension, is being transported or has been moved from its site of origin by air, water, gravity or ice and has come to rest on the earth's surface either above or below sea level.

205. SEDIMENTATION

Deposition of detached soil particles.

206. SEDIMENT DISCHARGE (SEDIMENT LOAD)

The quantity of sediment, measured in dry weight or by volume, transported through a stream cross section in a given time. Sediment discharge consists of both suspended load and bedload.

207. SEEPAGE

a. Water escaping through or emerging from the ground.

b. The process by which water percolates through the soil.

208. SEEPAGE LENGTH

In sediment basins or ponds, the length along the pipe and around the antiseep collars that is within the seepage zone through an embankment (see phreatic line).

209. SHEET FLOW

Water, usually storm runoff, flowing in a thin layer over the ground surfaces.

210. SIDE SLOPES (ENGINEERING)

The slope of the sides of a canal, dam or embankment. It is customary to name the horizontal distance first, as 1.5:1 meaning a horizontal distance of 1.5 feet to one (1) foot vertical.

211. SIDE WALL (Building)

A building wall perpendicular to a street; a building wall facing a street at an angle of more than 45 degrees.

212. SIGNIFICANT TREE

A tree determined to be significant by the Planning & Development Department using the tree evaluation method described in Section 3.5.1.

213. SILT

a. (Agronomy) A soil separate consisting of particles between 0.05 and 0.002 millimeter in equivalent diameter.

b. A soil textural class.

c. (Engineering) According to the Unified Soil Classification System, a fine grained soil (more than 50 percent passing the Number 200 sieve) that has a low plasticity index in relation to the liquid limit.

214. SINGLE-WALLED

Constructed with walls made of but one (1) thickness of material. Laminated, coated or clad materials shall be considered as single-walled construction.

215. SINKHOLE

A circular or oblong depression formed in soluble rock by the action of subterranean water which is a potential point of significant recharge.

216. SITE SPECIFIC DEVELOPMENT

Development which is typically confined to one (1) lot and is not linear in nature. SLURRY - A thickened, aqueous mixture of such things as seed, fertilizer, short fiber mulch or soil.

217. SMALL GRAIN MULCH MATERIAL

Straw material from oats, barley, wheat or rye.

218. SMALL SHRUB

A woody plant of smaller proportions than a tree which usually produces several branches from the base and will have a maximum mature height of between two (2) and four (4) feet.

219. SMALL TREE

A tree species listed in Appendix F as having a mature height of 30 feet or less. SOD - A piece of earth containing grass plants with their matted roots; turf.

220. SODDED WATERWAY

A grassed waterway vegetated by sodding with adapted species of grasses.

221. SOIL

a. (Agronomy) The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants.
b. (Engineering) Earth and rock particles resulting from the physical and chemical disintegration of rocks and may or may not contain organic matter. It includes fine material (silts and clays), sand and gravel.

222. SOIL TEST

Chemical analysis of soil to determine needs for fertilizers or amendments for species of plants being grown.

223. SPECIFIC ENERGY

The energy of a stream referred to its bed, namely, depth plus velocity head of mean velocity.

224. SPILLWAY

An open or closed channel or both, used to convey excess water from reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of excess water.

225. SPREADER (HYDRAULICS)

A device for distributing water uniformly in or from a channel.

226. STABILIZATION

Providing adequate measures, vegetative and/or structural, that will prevent erosion from occurring.

227. STABILIZED AREA

An area sufficiently covered by erosion resistant material, such as a good cover of grass or paving by asphalt, concrete or stone, in order that erosion of the underlying soil does not occur.

228. STABILIZED GRADE

The slope of a channel at which neither erosion nor deposition occurs.

229. STABLE (STREAM OR CHANNEL)

The condition of a stream, channel or other water course in which no erosion or deposition occurs; adequately protected from erosion.

230. STAGE (HYDRAULICS)

The variable water surface or the water surface elevation above any chosen datum.

231. STATIC HEAD

Head resulting from elevation difference; for example, the difference in elevation in headwater and tailwater in a hydroelectric plant.

232. STILLING BASIN

An open structure or excavation at the foot of an overfall, conduit, chute, drop or spillway to reduce the energy of the descending stream of water.

233. STOLON

A trailing or reclining above ground stem capable of rooting and/or sending up new shoots from the nodes.

234.STORAGE TANK

Any tank, sump, vault or other containment vessel which has a primary storage capacity of 60 gallons or more.

235.STREET VIEW

The view into a site from any point on an adjacent street or roadway.

236.STREET YARD

The street yard is the area of a lot which lies between the street right of way line and the actual front wall line of the building, as such building wall line extends from the outward corners of the building parallel to the street, until such imaginary extensions of such front building wall line intersects the side property lines.

237.STRUCTURAL

Relating to something constructed or built by man.

238.STRUCTURE (SOIL)

The combination or arrangement of primary soil particles into secondary particles, units or pads.

239.SUBCRITICAL FLOW

Flow at velocities less than critical velocity.

240.SUBGRADE

The soil prepared and compacted to support a structure or a pavement system. SUBSOIL - Roughly, that part of the soil below plow depth.

241.SUMP

A pit or well in which liquids collect.

242.SUMPAGE

Water that enters a primary or secondary containment system other than by direct precipitation or runoff.

APPENDIX TERMS BEGINNING WITH “T”

243.TAILWATER (HYDRAULICS)

Water in a river or channel immediately downstream from a structure.

244.TANK INSTALLATION

Any one (1) or combination of storage tank systems.

245.TANK SYSTEM

A storage tank and all piping and appurtenances in connection with it which is used for the storage, transfer or containment of hazardous materials at a facility.

246.TEMPORARY SEEDING

A seeding which is made to provide temporary cover from the soil while waiting for further construction or other activity to take place.

247.TERRACE

An embankment or combination of an embankment and channel constructed across a slope at a suitable spacing to control erosion by diverting or storing surface runoff instead of permitting it to flow uninterrupted down the slope. Normally used only on cropland.

248.TEXTURE (SOIL)

The relative proportions of various soil separates in a soil material. THATCH - A tightly intermingled layer of living and dead stems, leaves and roots of grasses.

249. THREAT TO HUMAN LIFE

For purposes of these guidelines, a threat to human life exists when either or both of the following conditions exist:

a. Occupied Structures. The water surface elevation of the 100 year flood is greater than the lowest habitable finished floor elevation and/or the water velocity at the perimeter of the structure exceeds three (3) feet per second.

b. Roadway Crossings (rights of way). The water surface of the 100 year flood results in residential roadway flooding exceeding 12 inches above the roadway crown or exceeding six (6) inches above the crown for roadways larger than residential.

250. TIME OF CONCENTRATION

Time required for water to flow from the most remote point of a watershed in a hydraulic sense to the outlet.

251. TOE (OF SLOPE)

Where the slope stops or levels out. The bottom of the slope.

252. TOE WALL

The downstream wall of a structure, usually to prevent flowing water from eroding under the structure

253. TOPSOIL

The topsoil shall be composed of 4 parts of soil mixed with 1 part compost, by volume. The compost shall meet the definition of compost as defined by TxDOT Specification Item 161. The soil shall be locally available native soil that meets the following specifications:

- Shall be free of trash, weeds, deleterious materials, rocks, and debris.
- 100% shall pass through a 1.5-inch (38-mm) screen.
- Soil to be a loamy material that meets the requirements of the table below in accordance with the USDA textural triangle. Soil known locally as "red death" is not allowable soil. Textural composition shall meet the following criteria:

Textural Class	Minimum	Maximum
Clay	5%	50%
Silt	10%	50%
Sand	15%	67%

254. TRAP EFFICIENCY

The capability of a reservoir to trap sediment. The ratio of sediment trapped to the sediment delivered, usually expressed in percent.

255. TRASH RACK

Grill, grate or other device at the intake of a channel, pipe, drain or spillway for the purpose of preventing oversize debris from entering the structure.

256. TREE CLUSTERS

A group of three (3) or more trees with trunk diameters ranging from two (2) to six (6) inches which can be enclosed in a circle with a radius of ten (10) feet (see Figure 3-4 in Appendix H of this manual).

257. TREE REMOVAL

The uprooting or severing of the main trunk of a tree or any act which causes or may reasonably be expected to cause a tree to die, including, but not limited to, damage inflicted upon the root system by machinery, storage of materials or soil compaction; substantially changing the natural grade above the root system or around the trunk; excessive pruning or paving with concrete, asphalt or other impervious materials in a manner which may reasonably be expected to kill a tree.

258.TUFTS

Having a cluster of hairs or other slender outgrowths; stems in a very close cluster.

APPENDIX TERMS BEGINNING WITH "U"

259.UNDERGROUND STORAGE TANK

That portion of a storage tank system which has its available primary containment volume beneath the final cover and is surrounded by a backfill material.

260.UNHULLED (SEED)

Seed still encased with a hull. Example: Sericea lespedza before it is rendered hulless by mechanically removing the hull.

261.UNIFIED SOIL CLASSIFICATION SYSTEM (ENGINEERING)

A classification system based on the identification of soils according to their particle size, gradation, plasticity index and liquid limit.

262.UNIFORM FLOW

A state of steady flow when the mean velocity and cross-sectional area are equal at all sections of a reach.

263.UNIVERSAL SOIL LOSS EQUATION

An equation used for the design of water erosion control system: A = RKLSCP, wherein "A" is average annual soil loss in tons per acre per year; "R" is rainfall factor; "K" is soil erodibility factor; "L" is length of slope; "S" is percent of slope; "C" is cropping and management factor; and "P" is conservation practice factor.

264.UPLIFT (HYDRAULICS)

The upward force of water on the base or underside of a structure.

265.UREAFORM-URAMITE/UREAFORMALDEHYDE

A slowly soluble synthetic organic fertilizer containing 38 percent nitrogen, which contains about 30 percent readily available nitrogen.

APPENDIX TERMS BEGINNING WITH "V"

266.VARIETY

A variant within a species which reproduces true by seed or vegetative propagation as applicable.

267.VEHICULAR USE AREAS

Areas of a site used for the movement or other operation of vehicles, such as drives, loading docks, fire lanes, etc.

268.VELOCITY HEAD (HYDRAULICS)

Head due to the velocity of a moving fluid, equal to the square of the mean velocity divided by twice the acceleration due to gravity (32.16 feet per second).

APPENDIX TERMS BEGINNING WITH "W"

269.WATER SURFACE PROFILE (HYDRAULICS)

The longitudinal profile assumed by the surface of a stream flowing in an open channel; the hydraulic grade line.

270.WEEP-HOLES (ENGINEERING)

Openings left in retaining walls, aprons, linings or foundations to permit drainage and reduce pressure.

271.WETTED PERIMETER (HYDRAULICS)

The length of the line of intersection of the plan of the hydraulic cross section with the wetted surface of the channel.

272.WING-WALL

Side wall extensions of a structure used to prevent sloughing of banks or channels and to direct and confine overfall.

273.WINTERKILL

Killed by low temperatures during winter months.

274.WOOD FIBER

A short fiber mulch material, usually applied with a hydroseeder in an aqueous mixture.

APPENDIX TERMS BEGINNING WITH “X”,” Y”, AND ”Z”

275.XERISCAPE

A method of landscaping using certain principles of design and installation which conserve water and energy.

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