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RULE NO. R161-26.13

NOTICE OF PROPOSED RULE **POSTING DATE: August 24, 2026**

The Director of Austin Watershed Protection proposes to adopt the following rule on or after September 25, 2026.

EFFECTIVE DATE OF PROPOSED RULE

A rule proposed in this notice may not become effective before the effective date established by a separate notice of rule adoption. A notice of rule adoption may not be posted before September 25, 2026, or after November 2, 2026 (the 70th day after the date of this notice).

If a proposed rule is not adopted on or before the 70th day, it is automatically withdrawn and cannot be adopted without first posting a new notice of proposed rule.

REQUEST FOR COMMENTS ON PROPOSED RULES

The City requests comments from the public with respect to the proposed rules included in this Notice. Comments must be submitted in writing to the contact person below no later than September 24, 2026. A summary of the written comments received will be included in the notice of rule adoption that must be posted for the rule to become effective.

Contact Person:

Nicole Corona, Program Coordinator
Austin Watershed Protection
nicole.corona@austintexas.gov
737-291-3084

TEXT OF PROPOSED RULE

The text of the proposed rule indicating changes from the current text is attached to this rule.

BRIEF EXPLANATION OF PROPOSED RULE

Rule R161-26.13 proposes revisions to the Environmental Criteria Manual to update the design requirements for water quality controls in the Barton Springs Zone.

An affordability impact statement regarding the proposed rule is available by contacting Nicole Corona, nicole.corona@austintexas.gov or 737-291-3084.

AUTHORITY FOR ADOPTION OF PROPOSED RULE

The authority and procedure for adoption of a rule to assist in the implementation, administration, or enforcement of a provision of the City Code is provided in City Code Chapter 1-2 (*Adoption of*

Rules). The authority to regulate design and construction of drainage facilities and improvements is established in City Code Section 25-7-64 (*Design and Construction of Drainage Facilities and Improvements*).

CERTIFICATION BY CITY ATTORNEY

By signing this Notice of Proposed Rule R161-26.13, the City Attorney certifies the City Attorney has reviewed the rule and finds that adoption of the rule is a valid exercise of the Director's administrative authority.

REVIEWED AND APPROVED:

Jorge L. Morales, P.E., CFM, Director
Austin Watershed Protection

Date: July 28, 2026

Deborah Thomas, City Attorney

Date: August 3, 2026

1.6.2 General Design Guidelines

The following section discusses general design parameters which most stormwater 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 forty-eight (48) hours or as specified. 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 impervious cover over twenty (20) percent within the drainage area to the control. This depth of runoff from the contributing drainage area to the control is and will be referred to as the Capture Volume (LDC 25-8-213(B)), also known as the "Water Quality Volume." The water quality volume must consist of runoff from all impervious surfaces such as roadways, parking areas and roof tops, and all developed pervious areas. 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 water quality volume. Off-site contributing drainage should be routed around the water quality basin except in cases where runoff from at least 10 acres of untreated, off-site area can be treated. In urban watersheds developments that treat off-site areas may be eligible for cost recovery and/or cost participation, per Section 1.9.2. The minimum water quality volume for a control that treats off-site runoff will be that required for the on-site area, and at least 0.15-inch for the contributing drainage area; larger volumes will, in general, increase the City's level of cost recovery and/or cost participation.

   If this is not done, off-site contributing areas must be included in the water quality volume or a hydrologic study must be presented which indicates insignificant mixing with the on-site water quality volume. A separate case from the above is a commercial subdivision. Since development on individual lots in commercial subdivisions will incorporate water quality controls, the water quality volume for roadways in commercial subdivisions may be based on only the likely contributing drainage area of the roadway after the lots are developed.

   That is, contributing drainage to roadways from the individual lots does not have to be included in the water quality volume for a commercial subdivision provided that the total drainage area contributing to the roadway pond does not exceed fifty (50) acres. Section 1.6.10 includes example calculations for determining water quality volumes.

   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.

   Runoff from the rooftop and interior surfaces of a parking garage should be routed to a water quality SCM. The calculation of water quality volume for parking garages must include the runoff from the rooftops but does not need to include the interior surfaces. Elevator sump water, as described in LDC Section 25-12, can be routed to water quality SCMs but does not need to be included in the water quality volume calculation.

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:

      a) The height of the diversion weir must be equal to or greater than the surface elevation of the water quality volume in the SCM.

      b) The diversion structure must be capable of passing the peak flow rate of the twenty-five (25) year storm into the stormwater control measure.

c) The maximum velocity entering the water quality basin shall not exceed two (2) feet per second.

d) 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.

e) 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.

f) As an alternative the design engineer can size the diversion structure for the flowrate of the twenty-five (25) year inflow hydrograph that will fill the pond; a hydraulic and hydrologic analysis must be provided that conforms with accepted procedures, as defined in the Drainage Criteria Manual.

Figures 1-48 through 1-50 in Appendix V 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:

- Partial sedimentation with sand filtration or biofiltration controls
- Full sedimentation with sand filtration or biofiltration controls
- ~~Retention Irrigation~~Sedimentation/Filtration/Infiltration controls that are not subject to compliance with the SOS ordinance.
- Rainwater Harvesting controls that are not subject to compliance with the Onsite Water Reuse Systems Ordinance of Chapter 15-13 of the City of Austin Code.
- Rain Gardens
- Porous Pavement

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:

a) The velocity of the flows entering the SCM for the developed 100 year peak flow must not exceed two feet per second.

b) 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.

c) 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 are also required for water quality basins located over the Edwards Aquifer Recharge Zone. If a liner is required and there are multiple controls in series, liners are only required for the first control in series. Impermeable liners may be concrete, geomembrane, or other approved liner, depending on the application. For water quality SCMs in the Edwards Aquifer Recharge Zone, clay liners are not acceptable and would not be considered an approved alternative liner design. 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. is applicable to any size basin or pond, while the criteria in item 2. may be applied to sedimentation basins, filtration basins and retention ponds that are less than 1,000 square feet in area. When required for sedimentation/filtration basins, the liner must underlie both the sedimentation basin and filtration

basin and any gabion wall areas.

1. The following criteria applies to all SCMs where a basin liner is required:

   There are a number of important engineering design and construction considerations for wet pond liners and other basin 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:

   a. **Liner subgrade** - A stable subgrade is very important in the construction of the pond or basin. 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 must be smooth and contain no particles greater than 0.375 inch diameter.

   b. **Liner characteristics** - A geomembrane liner is allowed. Alternative liner designs may also be considered.

      (1) A *geomembrane* 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 Watershed Protection 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. Standard Details Nos. 661-4A, 661-4B and 661-5 illustrate acceptable geomembrane liner end details for use on concrete walls, stacked stone walls, and earthen embankments.

      (2) Geomembrane liner placement over excavated rock requires installation of protective material to prevent damage to the liner. Examples of protective material include spray-on fiberglass, or placement of a geosynthetic fabric.

      (3) An **alternative liner design** may be approved by the Director of the Watershed Protection Department if it can be demonstrated by the responsible party that the liner is at least equivalent to or exceeds the above requirements.

   c. **Handling of liner penetrations -** Liner penetrations are one of the areas of the pond or basin 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 including but not limited to pipe inlet and outlet structures, headwalls, and areas where concrete access ramps, maintenance pads, 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 Drains** - Due to excessive leakage issues submerged inlets and storm drains to SCMs are to be avoided whenever possible. In situations where site conditions require a submerged inlet or storm drains 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 drains 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.

d. **Protecting the liner from erosion** - The integrity of the liner system can be severely compromised by any erosion that may occur at the surface or subgrade of the liner system. The design must provide appropriate mechanisms to prevent erosion of the liner system 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.

e. **Protecting the liner against damage and loss of moisture** – Damage to a liner system can also occur due to passage of equipment during construction or during future sediment removal and maintenance operations. To minimize the possibility of damage, all liner designs should include a protective soil layer over the liner with a minimum thickness of 24 inches (the 24-inch thickness can be reduced to a minimum of 12 inches 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. In addition, the sand and biofiltration media thickness can be counted towards meeting the protective soil layer requirement.

f. **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 or basin 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.

g. **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 to resist any uplift pressures. Alternative designs to relieve liner uplift pressure (French drain, etc.) will be considered and must be approved by the Watershed Protection Department.

h. **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 geomembrane liners, the QA/QC plan must include, but not be limited to,

the following items: geomembrane 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 placement (including, but not limited to panel identification, placement and installation schedule), seaming information (including, as applicable to geomembrane, seam layout, preparation, equipment, weather conditions, trial welds, general procedures, non-destructive testing and destructive testing), identification of defects and repair procedures, and geomembrane acceptance procedures.

i. **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 all geomembrane installation;
3. During geomembrane liner testing;
4. During construction of penetrations and any other construction that will affect the integrity of the liner (access ramps, pump pads, etc.).
5. During placement of protective soil layer.

Following completion of the liner construction, a 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.

j. **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, as specified in 1.6.6.C. 5, 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 Austin for review.

2. Sedimentation Basins, Filtration Basins and Retention Ponds less than 1,000 square feet in area.

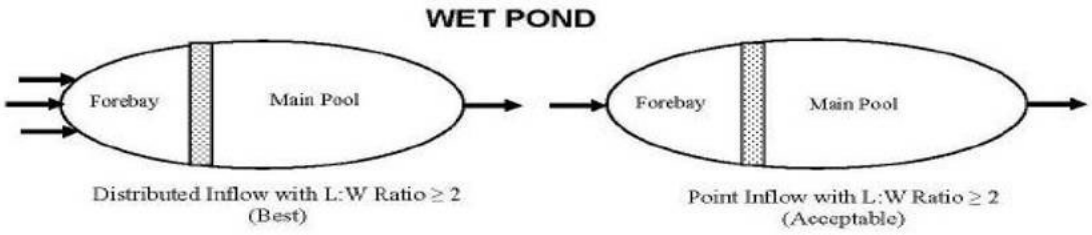
Concrete liners may be used for sedimentation basins, filtration basins and retention ponds less than one thousand (1,000) square feet in area. Concrete must be five (5) inch thick Class A or better as defined in the City of Austin Standard Specifications and must be reinforced by steel wire mesh. The steel wire mesh must be six (6) gauge wire or larger and six (6) inch by six (6) inch mesh or smaller. An Ordinary Surface Finish (as specified in Standard Specification ~~Item~~ No. 410S.~~25~~26.A) is required. When the underlying soil is clay or has an unconfined compressive strength of one-quarter (0.25) ton per square foot or less, the concrete must have a minimum six (6) inch compacted aggregate base consisting of coarse sand and river stone, crushed stone or equivalent with diameter of three-quarters (0.75) to one (1) inch. Where visible, the concrete must be inspected annually and all cracks must be sealed.

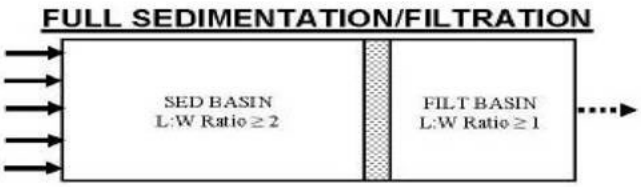
D. **Short-Circuiting and Dead Storage.** All water quality controls shall be designed to minimize short-

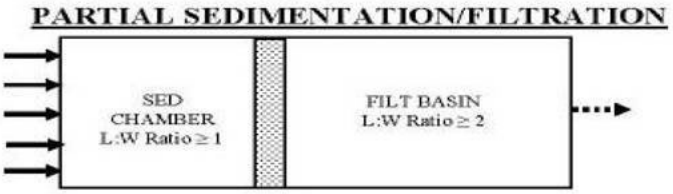
circuiting (flow reaching the outlet structure before utilizing the entire water quality volume and/or surface area) and dead storage (areas within the basin which are by-passed by the flow regime and are, therefore, ineffective in the treatment process). Irregular shapes shall be avoided, or shall use 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 V). 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).







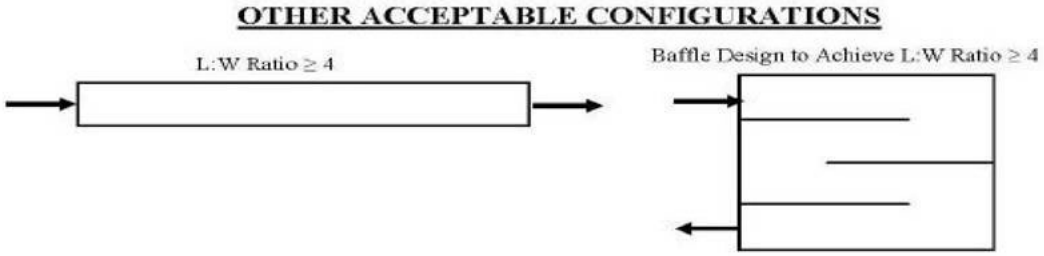


Figure 1.6.2.D Water Quality Control Configurations (adapted from Persson, Somes, Wong. Hydraulics Efficiency of Constructed Wetlands and Ponds, 1999)

E. **Subsurface Stormwater Control Measures (SCM).** Based upon field observations, subsurface SCMs can be difficult to inspect and maintain due to accessibility and constructability restraints. This section describes the minimum design and submittal requirements for subsurface SCMs.

1. The Engineer of Record shall prepare and submit a Subsurface Pond Maintenance Plan (SPMP) for the proposed development to be reviewed as part of the Site Development Permit. This document shall be signed and sealed by a Texas-Licensed Professional Engineer.

2. An SPMP must contain the following minimum components:

- **Access.** Adequate access including at least one temporary staging area for each subsurface pond must be provided for inspection and maintenance purposes. Minimum one access hatch per basin. Access hatch shall be designed and built for use in traffic bearing off-street and sidewalk applications and certified by a structural engineer. See Figure 1.6.2.E for minimum design standards for access points and sizing.

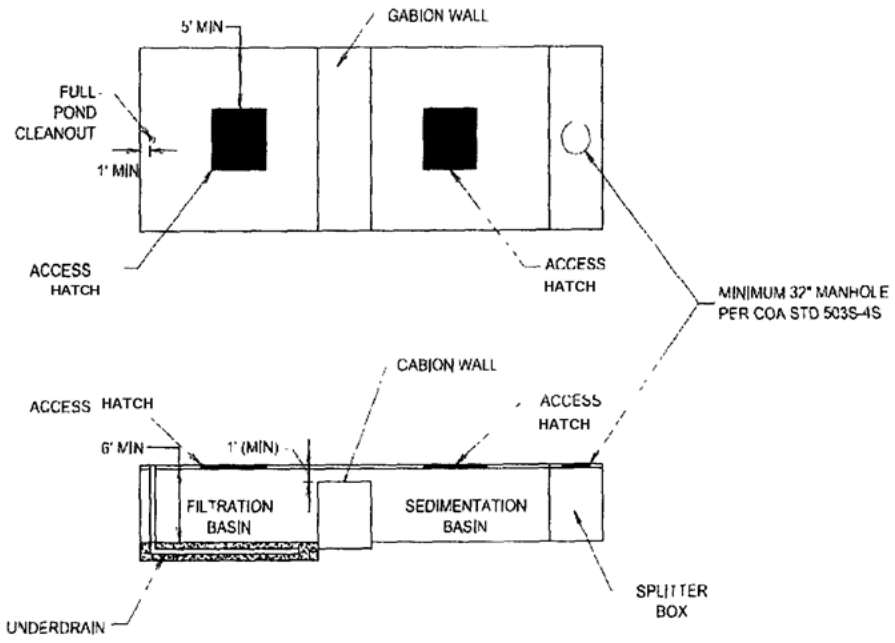


Figure 1.6.2.E Subsurface SCM Minimum Design Standards

- **Inspections.** Subsurface stormwater control measures (SCM), as defined by DCM 1.2.4.E, must be inspected at least once annually by the owner, preferably during, or immediately following, a significant rainfall event to evaluate SCM operation. A significant rainfall event for water quality SCMs will be rainfall equal to or greater than the designed capture depth

(water quality volume). Subsurface detention SCMs must be inspected after a rainfall event. Any structural damage or need for maintenance identified during an inspection should be addressed immediately.

- **Reporting.** At least once annually, a SCM drawdown report for each subsurface water quality SCM shall be completed in conjunction with a significant rainfall event as described in the previous section. The drawdown report shall verify the SCMs basins drawdown in the time frames as required by the ECM. At least one inspection shall be done annually by a 3rd party and an annual inspection report shall be submitted to the Watershed Protection Department (WPD) Pond Inspection and Dam Safety (PIDS) section for review. The annual 3rd party inspection report shall be sealed by a Texas-licensed Professional Engineer and include photographs of the SCM basins. For subsurface detention SCMs, an annual engineer's concurrence is required stating that the SCM is functioning as designed. The WPD PIDS section will be notified at least seven days prior to the annual 3rd party inspection to allow for the opportunity for observation.
- Major Maintenance Requirements.

    a. **Sediment Removal.** Remove sediment from the inlet structure and sedimentation basin 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.

    b. **Media Replacement.** Maintenance of the filter media is necessary when the drawdown time exceeds 96 hours, provided all other components of the subsurface SCM 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.

    c. **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.

    d. **Filter Underdrain.** Clean the underdrain piping network to remove any sediment buildup as needed to maintain design drawdown time.

    e. **Responsibility.** The responsibility of the inspection and maintenance of all subsurface SCMs shall be the responsibility of the owner of the facilities.

The requirements discussed above should be considered minimum requirements for a SPMP. In developing a SPMP, during the design of the subsurface SCM, the engineer should consider the plan to be site-specific, and therefore add any additional requirements to ensure the subsurface SCM has adequate access and can be inspected. During the course of inspections and field observations, adjustments to the SPMP may be required.

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 SPMP. The restrictive covenant must be in a form approved by the City Law Department.

F. **Integrated Pest Management Guidelines.** Integrated Pest Management (IPM) plans are required for the following stormwater control measures (SCMs):

Wet pond - 1.6.6

~~Retention/Irrigation~~ Sedimentation/Filtration/Infiltration Systems - 1.6.7.A

Vegetative Filter Strips - 1.6.7.B

Biofiltration - 1.6.7.C

Rainwater Harvesting (if used in conjunction with vegetation) - 1.6.7.D

Non-Required Vegetation - 1.6.7.G

Rain Garden - 1.6.7.H

The management of these SCMs must adhere to the techniques and control options described in this section and documented in an approved IPM plan. The requirements of this section also apply to Vegetated "Green" Roofs (Appendix W), but do not address structural pest control concerns. Also, note that Green Roofs are not considered SCMs and are not eligible for water quality credit. 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.

Manage the treatment system in conformance with the following criteria:

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.).

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.

Mowing and/or Trimming - Mowing and/or trimming of herbaceous vegetation shall occur with certain restrictions.

1. 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.
2. 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.

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.

1. 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.

2. Biofiltration and Rain Garden SCMs - Mulching to control weeds by blocking light and air space is acceptable.

    a. 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.

    b. Gravel or crushed recycled glass equivalent in size to gravel may be used to cover the soil surface in biofiltration.

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

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 Watershed Protection Department - Environmental Resource Management Division.

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.

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.

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.

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).

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.

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, subdivision construction plan notes will establish the requirements for the implementation and on-going maintenance of the IPM plan.

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

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. Section 25-8-231 of the Land Development Code requires maintenance be performed on SCMs when necessary as defined by this section.

Stormwater control measures required for commercial and multi-family development shall be maintained by the property owner.

Stormwater control measures for single-family or duplex residential development shall be maintained by the City of Austin once the facilities have been accepted by the City, unless otherwise determined during the review process. For the City to accept an SCM, the facility must:

1. be constructed per the approved development plan;
2. meet all applicable requirements of Section 1.6.3 and the Drainage Criteria Manual, Section 1.2.4 E.;
3. complete a one-year warranty period, including the completion of all maintenance and rehabilitation activities identified by the Watershed Protection Department; and
4. obtain final warranty release approval from the Watershed Protection Department.

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 drain, area inlets, and detention, retention and stormwater control measures and their appurtenances) shall comply with the requirements of Section 1.2.4.E 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 Austin 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" 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 No. 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. Grouted rock walls on water quality SCMs in the Barton Springs Zone must have an approved geomembrane liner per Standard Detail No. 661-4B. The liner must be shown on a profile view of the basin in the site plan. Free standing dry stacked rock walls are not acceptable in any SCM.

8. As-Built Surveys - As-built surveys of all flood detention basins and water quality SCMs shall be submitted to the City upon completion of final grade. Surveys shall be conducted by a licensed surveyor or the engineer of record and include representative survey points with elevations taken at top of wall, bottom of wall, center of basin, inlets, outfalls, overflow structures, and side slopes. Additional survey points may be requested at the discretion of the City Inspector to ensure basin integrity. Water quality basins with a drainage area of less than two (2) acres as well as vegetated filter strips do not require submittal of as-built surveys unless deemed necessary by the City Inspector.

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:

   a) Accumulated paper, trash and debris shall be removed every six (6) months or as necessary to maintain proper operation.

   b) 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.

   c) Corrective maintenance shall occur:

      i. 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.

      ii. For detention ponds only, any time drawdown does not occur within twenty-four (24) hours.

   d) 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.

   e) 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.

   f) Integrated pest management shall be performed and shall adhere to Section 1.6.2.F, Integrated Pest Management Guidelines.

   g) 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.

   h) Sediment build-up shall be removed:

      i. When the accumulation exceeds six (6) inches in splitter boxes, wet wells and basins.

      ii. When sediment traps are full.

iii. When sediment, of any amount, causes standing water conditions or reduces basin storage by more than 10%.

i) When sediment is removed, the following requirements apply:

i. Irrigation shall be provided, as needed, until vegetation is established (well rooted). See Section 1.6.3.D, Irrigation Guidelines.

ii. The design depth of the filtration media shall be verified. See Section 1.6.3.B.5.

iii. Tilling of the filtration medium is not allowed.

j) For subsurface ponds maintenance plan requirements, refer to ECM Section 1.6.2(E).

2. Sedimentation and Filtration SCMs (Section 1.6.5).

a. Vegetation within the SCM shall not exceed eighteen (18) inches in height at any time, except as called for in the design.

b. Vegetation that is mowed or cut shall be removed from the SCM.

3. Detention Basins.

a. Vegetation within the basin shall not exceed eighteen (18) inches in height at any time.

4. Wet Ponds (See Section 1.6.6).

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:

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.

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.

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.

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.

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.

Every Three Years - The sediment build-up in the sediment forebay shall be checked. The sediment forebay shall be cleaned if more than one-third of the forebay volume is lost.

Every Six Years - The sediment build-up in the main pool shall be checked. Sediment shall be

removed from the main pool when twenty percent of the main pool volume is lost.

5. Retention-Irrigation and Sedimentation/Filtration/Infiltration Systems (Section 1.6.7.A).

   a. 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 COA.

   b. Irrigation Areas and Infiltration Areas. To the greatest extent practicable, irrigation and infiltration areas are to remain in their natural state. ~~However~~For irrigation areas, vegetation must be maintained ~~in the irrigation area~~ such that it does not impede the spray of water from the irrigation heads~~.~~, and ~~T~~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~~ infiltration areas.

   c. 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 all equipment and 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 Austin.

   d. Flow Spreader and Infiltration System. For systems which incorporate flow spreaders and not spray irrigation, testing and inspection must occur a minimum of three (3) times per year to show all components are operating as intended. One (1) of these three (3) inspections should be after rain events to ensure that the infiltration system and all of its components perform as designed. This includes pumps (if present) and all equipment and controls such as weather stations or rain sensors, delays, valves, alarm system, distribution lines, or other components as specified in the system design. Berms should be inspected at a minimum of one (1) time per year to ensure they are intact and free from erosion or excessive settling. City Inspectors may request confirmation that the berm elevations are in conformance with as-built conditions. Corrective actions shall be required to restore berm and overflow elevations to as-built conditions if a significant discrepancy is identified. Vegetative cover must be maintained, and woody vegetation should be controlled/removed to maintain structural integrity of the berms. Flow spreaders should be inspected for even flow distribution, sediment accumulation, and debris clogging. Flush out any pipes as necessary. All inspection and testing reports must be accessible to the City of Austin.

   e~~d~~. 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.B).

   a. Filter strips shall be managed so that a dense, healthy vegetative cover is preserved.

   b. 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.

   c. Bare spots and areas of erosion identified during inspections must be replanted and restored to meet specification.

   d. Accumulated sediment shall be removed.

   e. Any disturbance to the filter strip as a result of maintenance procedures or other reasons

shall be repaired, including re-establishment of the vegetation.

f. 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).

g. The level spreaders shall be repaired if damaged or not functioning correctly.

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

A. 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).

B. 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:

Biweekly during first growing season: Inspect vegetation until 95% vegetative cover is established.

Monthly: Check for accumulated sediments, remove as needed.

Quarterly: Remove debris and accumulated sediment; replace soil media in void areas caused by settlement; repair eroded areas; remulch by hand any void areas.

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.

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.

Spring: Remove previous mulch layer and apply new mulch layer by hand (option) once every two to three years.

C. Other items.

a. 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.D).

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:

Post Construction:

- The control and repair of erosion rills, from the irrigation system, should take place after each rainfall event until the vegetation is well established.
- Adjustments to the irrigation area should be considered as the vegetation matures and/or to minimize erosion problem areas.

Quarterly or after each rain event:

- Inspect water tanks periodically to ~~insure~~ ensure proper functioning. Screen inlet and outlet pipes to keep the system closed to mosquitoes. Cap and lock tanks for safety.
- Caps should have access ports for interior inspection and maintenance.
- 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.
- Irrigation systems should be cleaned and damage sprinkler heads replaced.

Other items:

a. The requirements ~~for retention/irrigation systems~~ in Section 1.6.3.C.5 apply when rainwater harvesting is designed to irrigate a vegetated area. ~~– see Section 1.6.3.C.4.~~

b. The requirements ~~for vegetative filter strips~~ in 1.6.3.C.6 apply when ~~a~~ rainwater harvesting is designed to discharge to a ~~vegetated area to be infiltrated – see Section 1.6.3.C.5.~~ vegetated filter strip.

9. Porous Pavement (Section 1.6.7.E).

General Maintenance

- Verify that the porous pavement receives no off-site runoff.
- 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:

- For porous concrete and porous asphalt use ASTM C1701.
- For open-jointed block pavement, permeable interlocking concrete pavement (PICP) or concrete grid pavement (CGP) use ASTM C1781.

Construction and Post construction:

- When installing porous concrete, floating and troweling are not used, as those may close

the surface pores.

- Do not seal or repave with non-porous materials.
- 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.
- 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.
- 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.
- Chemical migration control may require flushing, and/or the introduction of microbiological organisms to neutralize any impacts to the soil or water.

Monthly:

- Ensure that paving area is clean of debris, ensure that paving dewaters between storms, and ensure that the area is clean of sediments.

Semi-annually:

- 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.

Annually:

- 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.
- It is required that this frequency be increased for areas where overhanging vegetation, excessive dirt, and pollutants are frequent.
- 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.G).

    a. An approved Integrated Pest Management Plan 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.

    b. 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.8).

    c. Damage to vegetation must be corrected immediately, with replanting done if necessary.

D. Irrigation Guidelines.

Irrigation is necessary 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.

If an irrigation system is proposed, the design shall address both the SCM and plant health needs. In particular, overwatering is unacceptable as it will negatively impact the hydraulic performance and pollutant removal capabilities of SCM.

Treated wastewater effluent (also referred to as reclaimed water) contains nutrients at concentrations higher than stormwater runoff. Because these elevated nutrient concentrations would impair the nutrient removal function of SCM, no temporary or permanent irrigation of SCM may occur with reclaimed water or treated wastewater effluent.

The following minimum criteria will apply for permanent irrigation systems:

1. Soil water moisture sensors shall be installed and connected to the controller at appropriate depths and locations in the biofiltration basin.
2. No irrigation during periods when rainfall is occurring.
3. Irrigation shall not commence until the soil moisture content of the filtration media is ≤ 25% of the Available Water Capacity (AWC). For plants native or adapted to arid and semi-arid conditions, irrigation shall not commence until the soil moisture content is ≤ Wilting Point (WP), or 0% AWC.
4. Irrigation shall cease once the soil moisture content is ≤ 75% AWC; 50% for plants native or adapted to arid and semi-arid conditions.

1.6.7.4 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 "representative" estimated or measured infiltration rate. A higher factor of safety may be used at the discretion of the design engineer to take into account 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 for every control, 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~~Sedimentation/Filtration/Infiltration System[2,3]	•	•	•
Vegetative Filter Strip	•	•	

Rainwater Harvesting[1]	•	•	•
Porous Pavement	•	•	•
Rain Garden - Full Infiltration	•	•	•
Rain Garden - Partial Infiltration	•	•	

Note 1: Infiltration evaluation is not required for rainwater harvesting when the system is designed for beneficial reuse (i.e., when capacity for WQV is restored by pumping water to a separate tank).

Note 2: Irrigation area and infiltration field design infiltration rates cannot exceed 0.20 inches per hour, see Section 1.6.7.A.45.b.

Note 3: Sedimentation/Filtration/Infiltration Systems also require the submittal of an Infiltration Rate Evaluation Report (IRER), see Section 1.6.7.4.E.

A. 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.

B. 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~~water quality control (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.

C. 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. For infiltration fields designed as part of sedimentation/filtration/infiltration systems, all testing activities must be performed under the supervision of a licensed professional engineer with experience in geotechnical engineering, and the double ring infiltrometer test method (ASTM D3385) shall be used.

The minimum required testing frequency shall vary based on the size of the control. For water quality

controls with an infiltration footprint area of 0.25 acres or less, t~~T~~esting 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.~~ For water quality controls with an infiltration footprint area greater than 0.25 acres but less than 0.5 acres, testing must be conducted at a minimum frequency of one test per 4,000 square feet. For water quality controls with an infiltration footprint greater than 0.5 acres, testing must be conducted at a minimum frequency of five tests per acre. Testing locations should be evenly distributed across the infiltration area and should include at least one test for each soil type present on a site, if applicable. 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~~ representative infiltration rate. A ~~measured~~ representative infiltration rate can be determined directly 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. A reduction factor must be applied to a measured percolation rate to obtain the representative infiltration rate.

Calculation of the design infiltration rate should proceed only after determining the representative infiltration rate from in-situ testing. A minimum factor of safety of 2 must be applied to the representative infiltration rate to arrive at the design infiltration rate. Final design infiltration rates for infiltration fields that are part of sedimentation/filtration/infiltration systems cannot exceed 0.20 inches per hour, see Section 1.6.7.A.5.b.

Approved in-situ testing methods for determining infiltration rate include the percolation test and the double ring infiltrometer test. However, only the double ring infiltrometer test shall be used when the proposed control is Sedimentation/Filtration/Infiltration. Section 1.6.7.4.D outlines ~~A~~an acceptable ~~testing~~ protocol for percolation testing ~~is provided below~~. The protocol described in ASTM D3385 should be followed for all double ring infiltrometer tests. Other testing methods may be utilized only with approval of the Director. ~~Other testing methods that may be used but not discussed in detail in this section include:~~

~~• Single Ring Infiltrometer Test (ASTM D5126).~~

~~• Double Ring Infiltrometer Test (ASTM D3385).~~

~~• Guelph Permeameter.~~

~~• Constant Head Permeameter (Amoozemeter or USBR Procedure 7300-89).~~

~~• Other analysis methods at the discretion of the designer and approval of the Director.~~

D. Percolation Test Protocol

The percolation test is geared towards investigating smaller infiltration facilities and rain gardens (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.

1. Test Preparation

   - The test hole opening shall be between 8 and 12 inches in diameter or between 7 and 11 inches on each side if square.
   - The bottom elevation of the test hole shall correspond to the bottom elevation of the proposed control (infiltration surface).
   - Place approximately 2 inches of gravel in the bottom of the hole to protect the soil from scouring (optional).
   - If horizontal infiltration is to be allowed, scarify the sides of the test hole.
   - 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.
   - 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.
   - Measure the depth and diameter of the test hole.

2. Test Procedure

   - 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.
   - 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).
   - 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).
   - 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 adjustments may be necessary. The reduction factor is not the factor of safety. To calculate the design infiltration rate, the reduction factor must first be applied according to the above equations, then a minimum factor of safety of 2 must be applied to the calculated representative infiltration rate (i).

E. Infiltration Rate Evaluation Report (IRER)

For infiltration fields designed as part of sedimentation/filtration/infiltration systems, the infiltration rate evaluation activities must be performed under the supervision of a licensed professional engineer with experience in geotechnical engineering. The engineer or designated representative must be on site during all in-situ infiltration rate evaluation activities. Following completion of the evaluation and determination of the design infiltration rate, an infiltration rate evaluation report (IRER) must be prepared under the direction of and sealed by the engineer and submitted to the City. The report is intended to ensure adequacy of design and provide documentation of:

1. Desktop study of site soil characteristics and infiltration rates
2. Site soils reports, including soils investigations and field sampling
3. Map showing soil depth verification locations across the project site and compliance with testing frequency
4. In-situ testing methods and procedures for infiltration rate evaluation
5. Map showing in-situ test locations across the project site and compliance with testing frequency
6. Raw data from in-situ testing and calculation steps used to arrive at the final design infiltration rate

A. ~~Retention/Irrigation~~ Sedimentation/Filtration/Infiltration Systems.

1. Introduction. A ~~retention/irrigation~~ sedimentation/filtration/infiltration water quality treatment system consists of two (2) primary components: (1) a basin which ~~captures and isolates~~ captures, isolates, and filters the required volume of stormwater runoff; and (2) a distribution and land application system which generally utilizes ~~pumps, piping and spray irrigation~~ flow spreading components. It is preferred that basins are designed to drain via gravity flow because gravity flow systems require much less effort and expense to maintain than pumped systems. The main characteristic of ~~retention/irrigation~~ sedimentation/filtration/infiltration systems is the ability to retain the entire water quality volume on site and is generally the water quality technology used to meet the SOS non-degradation requirement~~,~~ in Section 25-8-514(A) of the Land Development Code. For additional guidance in complying with the technical requirements of the SOS non-degradation requirement, refer to Section 1.6.9. The design should consider factors such as basin impermeability and the ~~irrigation~~ infiltration area's ability to infiltrate the water quality volume. Clay liners are ~~not acceptable~~ prohibited for ~~retention~~ all storm water control measures (SCMs) in the Edwards Aquifer Recharge Zone. For technical requirements of liners, refer to Section 1.6.2. Additionally, refer to the Utilities Criteria Manual, Section 2, for high hazard backflow preventer requirements. When properly designed, this system is effective in removal of pollutants through settling in the ~~retention basin~~ sedimentation chamber, filtration through the sand or biofiltration media, and contact with vegetation, air, and soils in the ~~irrigation~~ infiltration 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~~ SCM at meeting required pollutant removal efficiencies is based upon the following criteria being met.

2. Minimum Design Criteria for the ~~Retention Basin~~ Sedimentation/Filtration System. Either sedimentation/sand filtration (Section 1.6.5) or biofiltration (Section 1.6.7.C) design guidelines may be implemented. Information on water quality volume, diversion structures, and lining requirements can be found in Section 1.6.2 (General Design Guidelines). In addition, applicable requirements of Section 1.6.3 (Maintenance and Construction Requirements) and Drainage Criteria Manual Section 1.2.4 (Drainage System) must be incorporated in the design.

a. ~~Retention~~ Basin Volume. Partial sedimentation design, with either sand filtration or biofiltration, is required. Refer to applicable design criteria in Section 1.6.5 and/or 1.6.7.C. The basin must be of sufficient size to capture and hold the required capture volume. ~~Retention~~ Sedimentation/filtration basins are designed to capture and hold the water quality volume routed to them via diversion structures. All structural elements ~~&~~ and piping below the w~~W~~ater q~~Q~~uality elevation including the storm sewer system piping, shall be watertight. Acceptable watertight piping includes gasketed RCP, PVC, and wastewater grade HDPE. For development in the Barton Springs Zone, refer to Section 1.6.9.3~~.~~ of this manual for the required capture volume.

b. One-Hundred Year Storm. A bypass capable of conveying the 100-year storm around the basin must be provided.

c. Lining. A liner ~~will be~~ is required for ~~a retention~~ any first-in-series control basin ~~if the basin is~~ located in the Edwards Aquifer recharge zone in accordance with Section 1. The liner must be designed in accordance with Section 1.6.2.C (Basin Liners). All ~~retention~~ basins are subject to Section 1.6.3.C~~.4~~ (Major Maintenance ~~and Construction~~ Requirements).

d. Erosion Prevention. The inlets to the ~~retention~~ sedimentation/filtration basin must be designed to prevent erosion of the soil, filtration medium, and liner. Rock rip-rap or other erosion prevention systems must be placed at the basin inlet to reduce velocities to less than ~~three~~ two feet per second.

3. Minimum Design Criteria for Gravity-Flow Systems. Gravity-flow systems are defined as systems which do not require mechanical/electrical equipment or pumps to convey stormwater from the sedimentation/filtration basin to the infiltration field. If site topography allows, a gravity-flow system is preferable to a pumped system. Gravity-flow systems must meet all criteria described in Section 1.6.7.A.5.a(1), but are exempt from criteria in 1.6.7.A.5.a(2-6) related to the required timing of stormwater application. Gravity-flow systems shall be designed to empty into the infiltration field within 48-72 hours via orifice control on the underdrain system outlet or another approved method. Calculations shall be submitted that demonstrate the outlet design complies with the drawdown time criteria.

4~~3~~. Minimum Design Criteria for Wet Well and Pumps.

a. Pumps.

(1) The ~~retention~~ sedimentation/filtration basin must be emptied within 72-hours after a rain event ends. Emptying of the ~~retention~~ basin must not begin sooner than 12 hours (lag time) after the end of the rainfall event. The flow rate of the pumps (gpm) shall be designed to empty the ~~retention~~ basin in 30 hours or 60 hours (30 hours for single zone and 60 hours for multi-zone ~~irrigation~~ infiltration systems).

(2) Pumps must be capable of delivering the required volume of water at the necessary rate and pressure to the ~~irrigation~~ flow spreader 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~~ filtration basin underdrain system ~~(see Section 1.6.7(A)(3)(c))~~ to the wet well must exceed the pump rate (Q_P).

(3) A dual pump system must be provided, with each pump capable of delivering 100 percent of the design capacity.

(a) Plug valves or ball 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.

(b) Check valve(s) must be provided to prevent backflow from the ~~irrigation~~ distribution system back into the pump well.

(c) Pumps must be selected to operate within 20% of their best operating

efficiency.

(d) Pumps shall be commercial or municipal grade effluent pumps with cast iron bodies and metal impellers. No moving portion of a pump shall be plastic.

(4) Pump Operation.

(a) The pumps must alternate on start up. The control logic must allow the system to operate normally with only one pump in service.

(b) A manual control must be provided so both pumps can be turned on independently if necessary.

(c) ~~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, a~~ An amp draw (overloads) or other equivalent monitoring device ~~may be used~~ is required.

(5) 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.

(6) 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. The alarm shall activate when:

(a) The water level is below the primary shutoff float and the pump has not turned off~~.~~;

(b) ~~The high/low-pressure pump shut off switch has been activated.~~ The amp draw (overload) monitoring device has been triggered; and

(c) 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.

(7) 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.

(8) Run time meters shall be provided for each pump to facilitate the monitoring of pump activity.

b. Wet Well.

(1) 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. Precast wet wells shall utilize water tight gaskets at all riser joints. Complete access to the pumps and other internal components of the wet well for maintenance must be provided through a lockable hatch cover. An isolation plug valve to prevent flow from the ~~retention~~ sedimentation/filtration basin to the wet well during maintenance activities must be provided.

(2) 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~~ sedimentation/filtration 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.~~

(3) 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 system must be provided to allow pump removal without entering the wet well. If rails are used they must be stainless steel.

(4) A space of at least one foot must be available below the bottom of the pump intake. The wet well must be sized to achieve pump manufacturer recommended submergence head or at least two feet, whichever is greater. ~~c. Intake Riser. Prior to entering the wet well, stormwater must pass through an appropriate intake riser with a screen to reduce the potential for clogging of distribution pipes and sprinklers by larger debris (e.g. cups, cans, sticks). The intake riser and screen should be designed similarly to Figure 1-54 in the Appendices of this manual. Alternative designs will be considered.~~

5~~4~~. Minimum Design Criteria for the ~~Irrigation System or~~ Infiltration Field.

a. ~~Irrigation~~ Timing of Stormwater Application.

(1) The ~~retention~~ sedimentation/filtration basin must be emptied within 72-hours after a rain event ends.

(2) ~~Irrigation~~ Application of stormwater to the infiltration field must be initiated no sooner than 12 hours after the rain event ceases.

(3) The ~~irrigation~~ controller must be set to provide alternating, equivalent ~~irrigation~~ stormwater application and rest periods until the basin is emptied.

(4) The time of ~~irrigation~~ stormwater application on any area must not exceed the rest time. Continuous application on any area must not exceed ~~two hours~~ thirty minutes.

(5) An adjustable rain sensor must be provided which will normally be set to temporarily halt ~~irrigation~~ stormwater application during rainfalls exceeding one half inch. The rain sensor must be able to interrupt ~~irrigation~~ operation (stop pumps) in the event of subsequent rain events prior to emptying basin. The 12 hour pump delay ~~may~~ must initiate after the rain sensor senses the rain event has terminated. A bypass switch shall be provided to facilitate manual operation if necessary for maintenance purposes.

(6) Division of the ~~irrigation~~ infiltration area into two or more sections such that ~~irrigation~~ infiltration occurs alternately in each section is an acceptable way to meet the requirement for a rest period. However, the number of sections should be minimized to a reasonable extent.

b. ~~Irrigation~~ Infiltration Rate. The infiltration rate at which the soil can accept the ~~irrigated~~ applied storm water must be determined in accordance with Section 1.6.7.4. ~~derived from the infiltration rate listed in the U.S. Department of Agriculture National Resources Conservation Service (NRCS) Soil Survey for the county, location, and soil type verified to be present at the irrigation site. If a range is given, the lower value of the range is to be used.~~ An Infiltration Rate Evaluation Report (IRER) must be submitted to provide a basis for the design infiltration rate. The design ~~irrigation~~ infiltration rate is not to exceed 0.20 inches per hour. ~~even if the lower value of the range exceeds that rate. City of Austin field experience has shown that infiltration rates above 0.20 inches per hour do not function as designed and generate significant nuisance ponding and runoff issues.~~ The average application rate may not exceed the infiltration rate on any portion of the ~~irrigation~~ infiltration area.

c. ~~Irrigation Area or~~ Infiltration Field Size. Calculations must be ~~provided~~ submitted which demonstrate that an adequate ~~irrigation area or~~ infiltration field size will be provided based on the soil infiltration rate, water quality volume, and, for ~~irrigation~~ infiltration areas, the application rate and duration ~~actual irrigation time~~. Refer to Section 1.6.9.3 for technical guidance. The ~~irrigation area or~~ infiltration field system must be included within the water quality easement.

d. ~~Irrigation~~ Infiltration Area Slope. ~~Irrigation~~ Application of stormwater must not occur on land with slopes greater than 10%. Any portion of the infiltration field which has a slope greater than 10% shall not be counted towards the total required infiltration area.

e. Piping and Valves.

(1) All ~~irrigation system~~ distribution system components and lateral piping (i.e. from the pumps to the ~~spray heads~~ flow spreader) 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. Buried piping must be marked with detectable marking tape labeled "CAUTION: BURIED NON-POTABLE WATER LINE BELOW".

(2) 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 not contained in above-ground flow spreaders 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 for distribution piping, flow spreaders, and berms must be integrated with the tree protection plan and presented as part of the ~~S~~site ~~P~~plan or ~~S~~subdivision ~~C~~construction ~~P~~plan.

(3) Systems must include a plug valve to allow flushing at the end of every line.

~~f. 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 V, Figure 1-59F for an example).~~

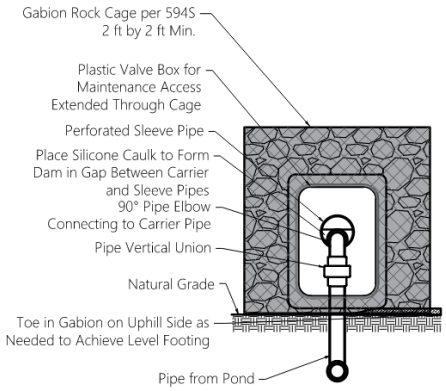
f. Flow Spreaders and Berms. To evenly apply captured stormwater runoff to the infiltration field and to maximize the total infiltration volume, the infiltration field design shall incorporate flow spreaders and berms. Sprinklers shall not be allowed as a method to distribute captured stormwater without special approval by the Director of Austin Watershed Protection.

(1) Flow Spreaders. The purpose of flow spreaders is to spread captured stormwater across the infiltration field as evenly as possible to maximize infiltration and minimize runoff from the field. Flow spreaders may be designed as either above-ground or below-ground (trench) systems. In both cases, flow spreaders shall be laid out parallel to site contour lines uphill of the associated infiltration area. Multiple flow spreader modules may be required to distribute stormwater across a given infiltration area and accommodate variable site terrain. Cumulatively, flow spreaders shall span the entire width of the area(s) proposed to provide infiltration. The flow diffusing elements (e.g,, perforated pipes) must be constructed at a constant elevation within the allowable tolerance. The maximum allowable slope tolerance along the length of any constant elevation flow diffusing element shall be 1%. Construction inspectors shall verify that constructed flow diffusing elements do not exceed the maximum slope tolerance.

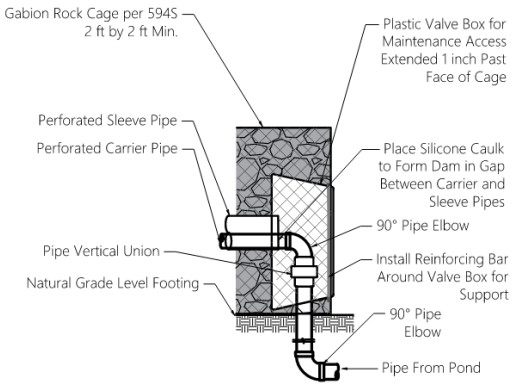
Alternative designs to distribute or spread captured stormwater other than those discussed in this section shall not be allowed unless reviewed and approved by the Director of Austin Watershed Protection. Once discharged from flow spreaders, stormwater is meant to flow

according to site topography and either infiltrate into site soils or be intercepted by constructed berms (see 1.6.7.A.5.f(2) below). Gravity-flow systems are likely more compatible with below-ground (trench) flow spreaders than above-ground flow spreaders. Similarly, above-ground flow spreaders are likely most compatible with pumped distribution as opposed to gravity flow.

For above-ground systems, the flow spreader shall consist of a rock gabion cage containing a pipe-in-a-pipe flow diffuser. The rock gabion cage shall have minimum dimensions of 2 feet by 2 feet in cross section, formed with PVC-coated 12 gage twisted woven wire mesh. Rock gabion construction shall generally comply with Standard Specification No. 594S. The gabion shall be placed at grade with a level footing. For a single, above-ground flow spreader module, the maximum allowable length shall be one hundred (100) linear feet. The inner "carrier" pipe shall be Schedule 40 PVC with a diameter typically between 2 and 4 inches. The outer "sleeve" pipe shall be Schedule 40 PVC with a diameter typically equal to twice the diameter of the carrier pipe. Both inner and outer pipes shall be perforated. The carrier pipe shall receive stormwater from the sedimentation/filtration basin and its perforations shall be designed to ensure approximately equal discharge from each perforation along the run of the pipe, considering head losses through the system. The engineer shall provide calculations demonstrating that the pipe perforation design meets this requirement. Typically, for a three-inch diameter carrier pipe, the inner pipe perforation hole diameters will be five-sixteenths (5/16) inches and the hole spacing will progressively decrease along the length of the pipe as available head decreases. The first three feet of carrier pipe shall be unperforated. The exact perforation hole sizing and spacing will depend on the choice of carrier pipe diameter and available head, among other factors. The outer sleeve pipe typically will have perforations one (1) inch in diameter evenly spaced eight (8) inches on center along the length of the flow spreader. The inner and outer pipes shall be laid out with a constant elevation, within the allowable tolerance referenced previously, along their lengths, and encased within the gabion rock cage. The gabion cage itself need not have a constant elevation but shall be laid out approximately parallel to site contour lines. The pipe embedment depth within the gabion cage can vary to allow for a constant pipe elevation. Access to carrier and sleeve pipes shall be provided at both ends of each gabion cage using plastic valve boxes extended through the cage or an approved alternative design. The access provided shall be adequate to facilitate the extraction of the carrier pipe for the purposes of system maintenance without disturbance of the sleeve pipe or gabion enclosure. A union shall be provided on the carrier pipe to allow it to be disconnected from the pipe entering from below.



Flow Sreader Pipe Entry Elevation / Section
Not To Scale



Flow Spreader Pipe Entry Section
Not To Scale

Figure 1.6.7.A-1: Above-Ground Flow Spreader Details

For below-ground systems, the flow spreader shall consist of a rock-filled trench containing a single perforated pipe flow diffuser. The trench dimensions shall be a minimum of 2 feet deep by 2 feet wide in cross section and the fill rock shall be one-half (0.5) to one and a half (1.5) inch diameter washed, rounded, river gravel. The trench must be lined with a high-flow geotextile filter fabric conforming with Standard Specification No. 620S Table 2. The perforated pipe shall be six (6) inch diameter Schedule 40 PVC and shall have three-eighths (3/8) inch diameter perforations evenly spaced eight (6) inches on center in two parallel rows 120 degrees apart along the length of the flow spreader (refer to Standard Specification No. 551S). The perforated pipe shall be installed at a constant level elevation, within the allowable tolerance, on the gravel bed providing three (3) inches between the bottom of the pipe and the bottom of the trench. Access must be provided for cleaning and maintenance of flow spreader perforated piping. Cleanouts with a removable PVC cap are required at the ends of each flow spreader run as well as every fifty (50) feet along the length of any given flow spreader. Cleanouts shall incorporate a "long sweep" wye junction or an approved equal to facilitate jet flushing of lines for removal of sediment/clogs and maintenance of flow capacity.

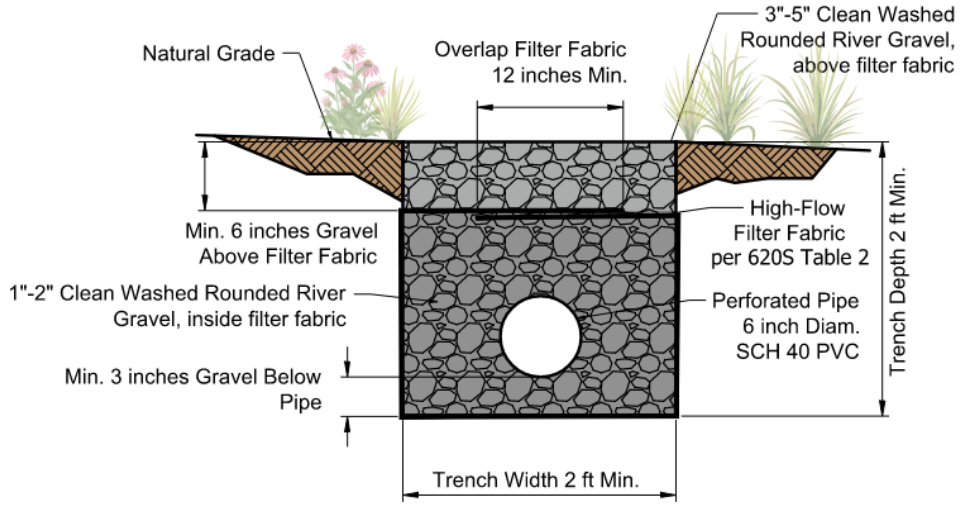


Figure 1.6.7.A-2: Above-Ground Flow Spreader Detail

(2) Berms. The purpose of earthen berms on the infiltration field is to intercept and detain any runoff which may be generated from the field in order to maximize infiltration and pollutant load reduction. An analysis done by Austin Watershed Protection showed that berms are necessary to ensure compliance with the pollutant load reduction requirements of Chapter 25-8, Subchapter A, Article 13 of the Land Development Code.

Berms shall be laid out parallel to site contour lines, shall have a flat top width of 1 ft, and shall have maximum 3:1 (H:V) side slopes. Berms shall be earthen and constructed from salvaged on-site soils whenever possible. Construction methods shall generally comply with Standard Specification No. 132S. Berms shall include adequate topsoil to facilitate successful growth of native vegetation as described in 1.6.7.A.5.g. A twenty-five (25) foot buffer must be provided between the last, most downhill berm and the property line or edge of the water quality easement in the direction of flow.

All berms shall have designated overflow locations along the berm at a minimum frequency of one overflow per twenty-five (25) linear feet of berm. A higher frequency of overflows is recommended for infiltration fields with slopes steeper than 7.5%. Berm overflow locations shall each be at least 4 feet wide and shall be designed as broad-crested weirs to facilitate the continued spreading of flow across the infiltration field. The downhill slope of each overflow must be protected from erosion using appropriately-sized vegetated rock riprap in general compliance with Standard Specification No. 591S, or another method approved by Austin Watershed Protection. Outside of the overflow locations, berms must be constructed with a freeboard height equal to 3 inches or the head required to pass the peak application rate across the overflows, whichever is greater.

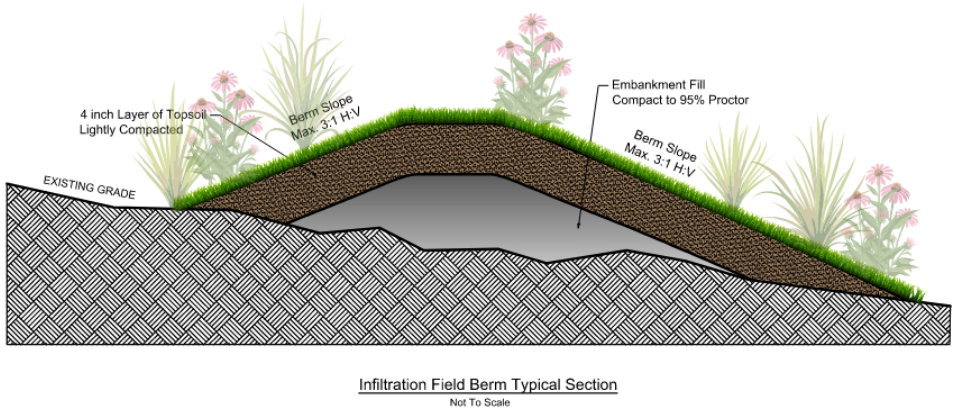


Figure 1.6.7.A-3: Berm Typical Section

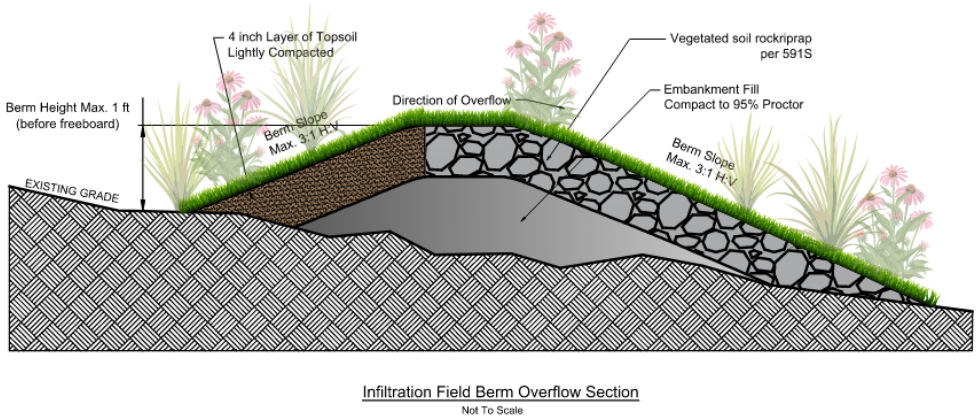


Figure 1.6.7.A-4: Berm Overflow Section

Berm layout, height, and spacing may be chosen by designers and may vary across the site. However, in all cases, designers shall submit calculations which show that the overall berm layout captures at least a combined volume equivalent to 0.1 ft over the infiltration field area. Equation 1 below describes this relationship:

$$V_{berm,total} = \sum_{i=1}^{n} V_{berm,i} \geq 0.1 \cdot A$$

(Equation 1)

Where:

$V_{berm,i}$ is the volume ponded behind the i^{th} berm (in cubic feet)

n is the total number of berms

A is the total infiltration field area (in square feet)

Constructed berm height shall be no less than six (6) inches. The maximum allowable ponding depth behind berms shall be twelve (12) inches. Berm layout should be chosen to optimize even spacing, minimize disturbance to natural areas and existing trees, and to preserve the natural and traditional character of the site to the extent possible.

In general, the optimal berm height for a given site will be a function of the infiltration field slope and the soil infiltration rate. It is suggested that for sites with very flat slopes and very slow infiltration rates, the berm height should be minimized in order to avoid the creation of nuisance conditions. Sites which have steeper slopes will likely require taller berms in order to meet the volume criteria described in Equation 1.

In general, the total number of berms required on the infiltration field is a function of the field length in the downslope direction (L), the average field slope (S), and the chosen berm height (H). Some equations to assist designers are provided below, however designers are not required to utilize them and may choose to submit alternative calculations for review. An estimate of the volume ponded behind a single berm is given by Equation 2 below:

$$V_{berm} = \frac{H^2 W}{2S} + \frac{HWB}{2}$$

(Equation 2)

Where:

V_{berm} is volume (cubic ft)

W is the berm width (ft)

H is the berm ponding height (ft)

B defines the uphill berm side slope as B:1 (horizontal:vertical)

S is the infiltration field slope (ft/ft)

An estimate of the total number of berms required on the infiltration field is given by Equation 3 below:

$$n = \frac{LS}{5H^2}$$

(Equation 3)

Where:

n is the total number of berms

L is the infiltration field length in the downhill direction (ft)

S is the infiltration field slope (ft/ft)

H is the berm ponding height (ft)

An estimate of the spacing between berms in the downhill direction, assuming even spacing and providing for a terminal buffer, is given by Equation 4 below:

$$d = \frac{L}{n+1}$$

(Equation 4)

Where:

d is berm spacing (ft)

L is the infiltration field length in the downhill direction (ft)

n is the total number of berms

Between berms, additional measures such as gravel contour breaks or vegetated hedgerows shall be placed to prevent overland flow from becoming concentrated (see figure 1.6.7.B-3 for examples). For sites with field slopes of less than 2.5%, measures shall be placed at least every 50 ft. For sites with steeper slopes or uneven terrain, measures shall be placed every 25 ft. In all cases, at least one measure shall be built in tandem with each constructed berm. Alternatively, designers may elect to add more berms than required by Equation 1 or other design elements to encourage the continued distribution of flow across the width of the infiltration field. However, concrete ribbon curb-style level spreaders shall not be allowed.

g. Vegetation. The ~~irrigation~~ infiltration area must have native vegetation or be restored ~~or re-established~~ with native vegetation, unless otherwise approved by the Director. A landscape architect or other qualified landscape professional should be involved in the design to ensure appropriate plant species selection and layout. Any clearing of existing native vegetation shall be limited to the footprints of proposed berms and flow spreading elements. These areas ~~must~~ shall not receive any fertilizers, pesticides, or herbicides. If landscaped areas are used for ~~irrigation~~ infiltration, fertilizers, pesticides, or herbicides ~~must~~ shall 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~~ infiltration area. If signs are installed, they must include the phrase "Stormwater ~~Irrigation~~ Infiltration Area - No Trespassing."

h. Soil. The ~~irrigation~~ infiltration area must contain a minimum of 12 inches of native or enhanced soil with the appropriate permeability rates. A soils report must be provided and must include at a minimum a soils map verifying soil types in the ~~irrigation~~ infiltration area, permeability rates, soil depths, percent of coarse fragments gravel size (2.0 mm diameter) and larger, found on the soil surface and in the subsurface soils, depth of roots, locations of borings or trenches, photographs of exposed soils, location and type of soil enhancement performed, soils testing results, etc. The soils report may be combined with the Infiltration Rate Evaluation Report (IRER)- see Section 1.6.7.4. A site visit may be conducted by the ~~c~~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 No. 601S, Salvaging and Placing Topsoil. The condition, type, structure, and quality of the soil shall be conducive to infiltration and to plant growth. The design infiltration rate for the infiltration field shall not be based on the permeability rate of enhanced, amended, or imported soil. The design infiltration rate must be established in accordance with Section 1.6.7.4. ~~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 Director of~~

~~WPD.~~ Care shall be taken during construction to minimize compaction of infiltration field soils.

i. Geological Features. The ~~irrigation~~ infiltration area must not contain any ~~Critical Environmental Feature Buffer Zones.~~ portion of a point recharge geologic Critical Environment Feature or its buffer to limit the transmission of pollutants in surface water, caves, sinkholes, faults, joints, and other related natural features as described in the Environmental Criteria Manual.

~~j. 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.~~

6~~5~~. Manuals and As-Built Plans.

a. The applicant must provide two complete printed copies and one complete digital copy in PDF format of an Operations Manual for the pumps and ~~irrigation~~ stormwater application system, which must include:

(1) Pump curves, electrical schematics, pump and instrument technical information, components of the control panel, pump maintenance recommendations with required frequencies, ~~irrigation~~ flow controller operation instructions and a written warranty.

(2) As-built plans of the ~~retention~~ sedimentation/filtration basin, wet well, pumps, piping ~~and irrigation system~~, flow spreaders, and berms. The plans must show the location, size, and type of all pipes, valves, wiring, wiring junctions, ~~and sprinkler heads~~ as well as plan, profile, cross sections, and details for flow spreaders and berms.

For ~~retention-irrigation~~ systems that are to be maintained by the City of Austin, both sets of plans and manuals shall be submitted to the ~~Field Operations Division of the~~ Watershed Protection ~~and Development Review~~ 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, or at the location defined by the telephone number on the alarm sign.

1.6.7 D. Rainwater Harvesting

1. Introduction. Rooftops can generate large volumes of runoff which, when discharged to paved surfaces and landscaped areas, can generate large pollutant loads. Rainwater Harvesting (RWH) systems can capture this runoff before it is discharged, thus preventing pollution while also putting the captured water to beneficial use, such as landscape irrigation, toilet flushing, or cooling water. In acknowledgement of the pollutant load removal provided by RWH, commercial developments that comply with and implement RWH as required by Chapter 15-13 shall be allowed a stormwater quality "credit" which would allow developers to reduce the size of their water quality ponds by a specified amount in the drainage area where the RWH system is located. The amount of runoff captured over the long-term, and thus the allowed stormwater credit will depend on the volume of the cistern and rate at which the cistern empties.

There are two types of RWH systems for the purposes of determining water quality credit. Type I systems generally are designed for stormwater control with ancillary potable water offset benefit. Type II systems are designed primarily for potable water offset with ancillary stormwater control. Both systems will be permitted for commercial developments and multifamily residential developments.

For the purposes of calculating water quality credit, the RWH system types are defined as follows:

A. **Type I -** a RWH system in which the collection cistern has a maximum drawdown time of 120 hours. These can be either gravity drained (Type IA) or pumped (Type IB) to an infiltration area. These systems are prohibited from having a potable water supply connection. Type IB systems are not allowed in the Barton Springs Zone.

B. **Type II -** a RWH system in which the collection cistern empties as stored water is used to meet onsite demand. Type II systems are designed and permitted in accordance with Chapter 15-13 of the Code of Ordinances (Onsite Water Reuse) and will have potable back up water to supply demands when there is no rainwater available. For the purpose of calculating the stormwater credit, Type II RWH systems are further defined as follows:

- **Type IIA -** a Type II system with a 1-inch capture depth and is located outside the Barton Springs Zone. This type allows a streamlined water quality crediting approach.
- **Type IIB -** a Type II system with a custom-sized collection cistern and/or is located inside the Barton Springs Zone. This type requires site-specific engineering analysis to obtain water quality credit.

Type I and Type II systems can also control the peak flow rate for the 2-year storm. See Section 1.6.8 if specifically designed for this purpose. Type I RWH systems can provide equivalent treatment to a standard sedimentation/filtration system and may be used within the Barton Springs Zone if the design achieves the non-degradation load requirements detailed in Section 1.6.9. Type I and Type II RWH systems will only be permitted for commercial developments. All systems with pumps (whether Type I or Type II systems) are subject to cross-connection testing in accordance with Chapters 15-1 (Cross Connection Regulations) and 25-12 (Technical Codes).

2. Water Quality Credit.

The water quality credit will typically be applied as either a reduction in the water quality volume for a structural control or a reduction in the payment in-lieu. The basic water quality credit equation is calculated using Equation 1.6.7-1.

A. Water Quality Credit for Type I rainwater harvesting systems.

For Type I RWH systems, the BMP Design Factor (BMPDF) variable is a function of the following factors:

- WQV_{rwh} is the water quality capture depth provided by the rainwater harvesting system in inches,
- WQV_{ecm} is the ECM required water quality capture depth in inches, and
- DDT_{rwh} is the rainwater harvesting system drawdown time in hours (a maximum of 120 hrs.).

The BMPDF for Type I systems shall be determined using Figure 1.6.7.D-1 below:

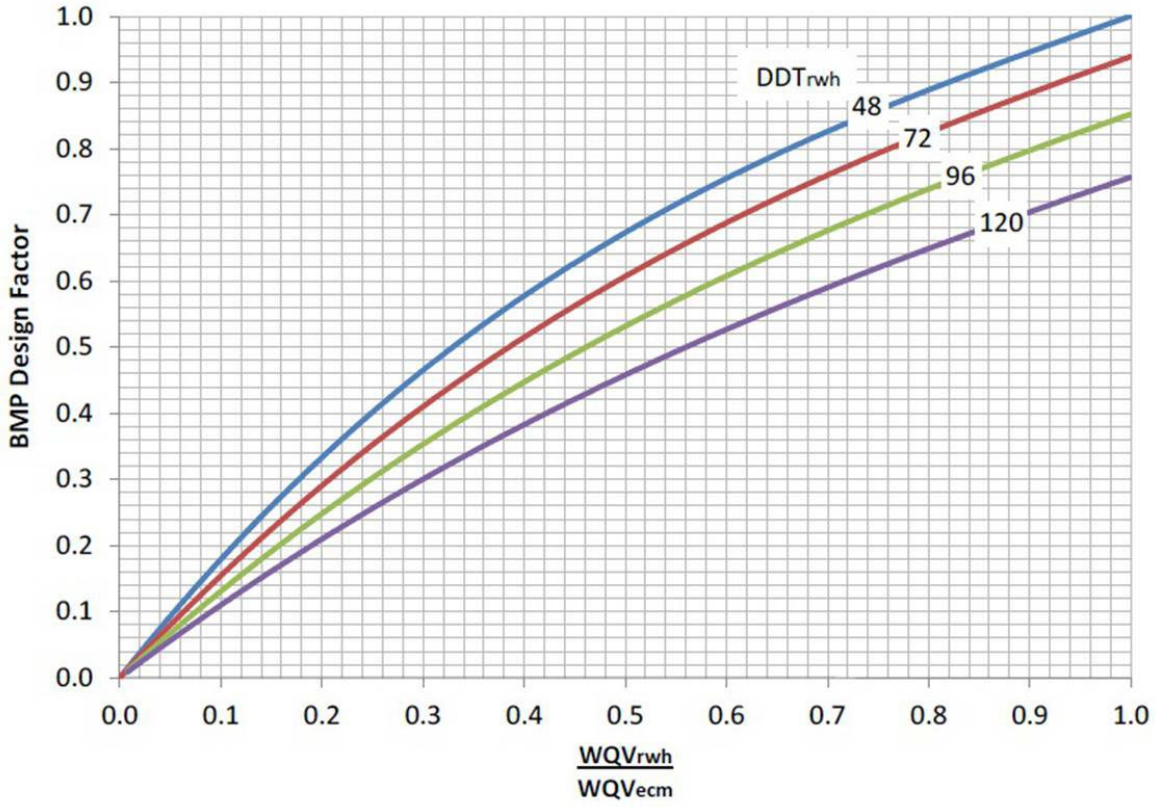


Figure 1.6.7.D-1. BMP Design Factor for Type I Rainwater Harvesting Systems.

The derivation of the drawdown time will vary with the type of system, as described below for specific design options. In all cases the drawdown is calculated as:

$DDT = WQV/Q_{rwh}$

Where:

B. Water Quality Credit for Type II rainwater harvesting systems.

For Type II RWH systems, the approach for determining BMPDF is based on the Net Annual Reuse Demand Intensity (NARDI). The NARDI is a ratio of the net annual demand to the available rainwater storage capacity and is calculated as:

$NARDI = (D_{npr} - S_{acc}) / V_{rwh}$

Where:

- D_{npr} is the annual non-potable reuse demand in gallons,
- S_{acc} is the annual air conditioning condensate supply in gallons, and
- V_{rwh} is the volume of the rainwater harvesting system tank in gallons.

Values for D_{npr} and S_{acc} shall be determined using Austin Water's Water Balance Calculator, which is available at Austin Water's Onsite Water Reuse web page (https://www.austintexas.gov/department/onsite-water-reuse-systems). The BMPDF for Type IIA systems can be determined using Figure 1.6.7.D-2 or the equation below:

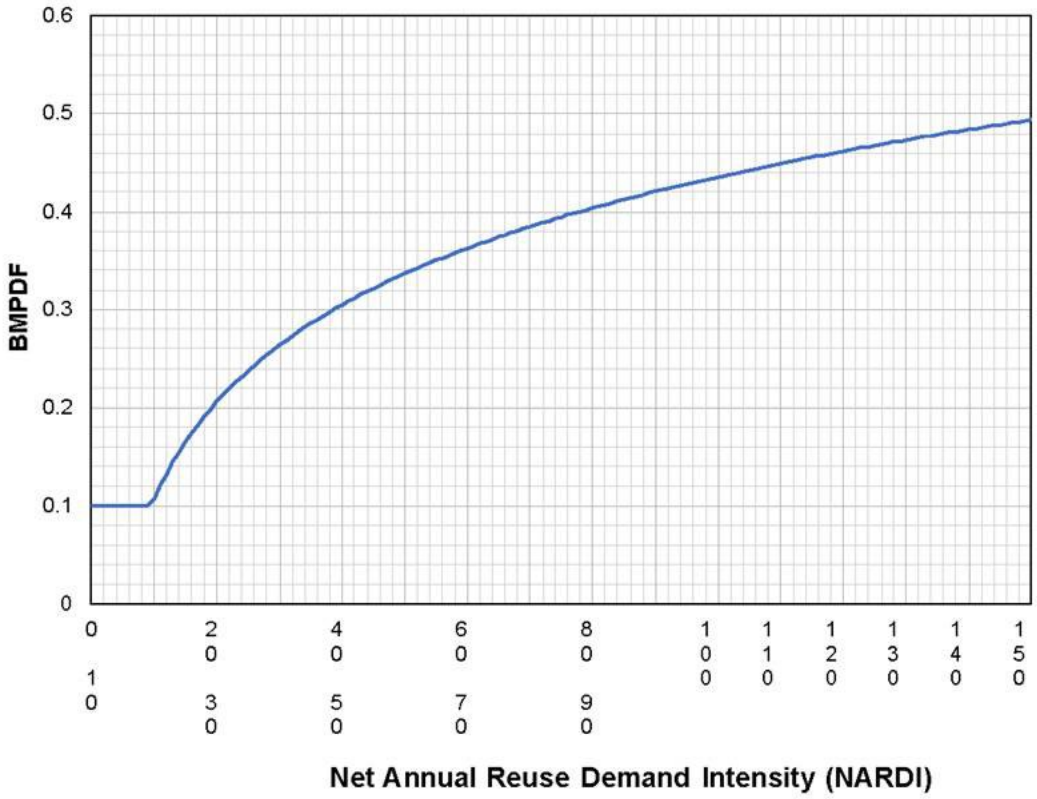


Figure 1.6.7.D-2. BMP Design Factor for Type IIA Rainwater Harvesting Systems.

For Type IIA systems, the BMPDF is calculated as:

BMPDF = max(0.1, min(0.5, 0.1429 ln(NARDI) - 0.2221))

The equation above yields a BMPDF ranging between a minimum value of 0.1 and a maximum value of 0.5. The BMPDF is based on a Type IIA RWH. Systems designed to meet the minimum requirements of LDC Section 25-9-414 are considered Type IIA.

For Type IIB RWH systems, applicants must provide a site-specific engineering analysis. The site-specific engineering analysis shall demonstrate that average annual pollutant loads from the proposed developed site with the proposed Type IIB system do not exceed the average annual pollutant loads produced by the site under baseline conditions (as defined below). Applicants are encouraged to contact the Watershed Protection Department and Austin Water Onsite Water Reuse staff prior to submitting plans proposing Type IIB systems. The site-specific engineering analysis shall meet the following requirements:

• SWMM software - The analysis shall be based on long-term continuous simulation calculations using the Environmental Protection Agency's Storm Water Management Model (SWMM) Version 5.2 or later and should follow COA's SWMM Guidance Manual which is available from the Watershed Protection Department. SWMM is a Windows-based desktop program. It is open-source public software and is free for use worldwide.

• Rainfall record - SWMM calculations shall incorporate a long-term continuous 13-year, 15-minute rainfall record (2006-2018) from the Lady Bird Lake gauge. The rainfall record is available from Austin Watershed Protection ~~Department~~.

• Pollutant concentrations - Pollutant concentrations in runoff, SCM effluent, and SCM bypass shall be based on those listed in ECM Section 1.6.9. The pollutant loading analysis shall be based on total suspended solids, total

phosphorus, and zinc. Pollutant concentrations in AC condensate shall be assumed to be zero. Pollutant concentrations in RWH system bypass shall be equal to those entering RWH systems.

• Baseline conditions scenario (see Figure 1.6.7.D-3) - SWMM shall be used to calculate average annual pollutant loads for the site for baseline conditions. For sites outside the Barton Springs Zone, the baseline scenario shall calculate annual pollutant load for the developed site including a sedimentation-filtration system sized with the standard half-inch plus WQV. For sites inside the Barton Springs Zone, the baseline scenario shall calculate pollutant loads for the existing site conditions in accordance with the Save Our Springs Ordinance.

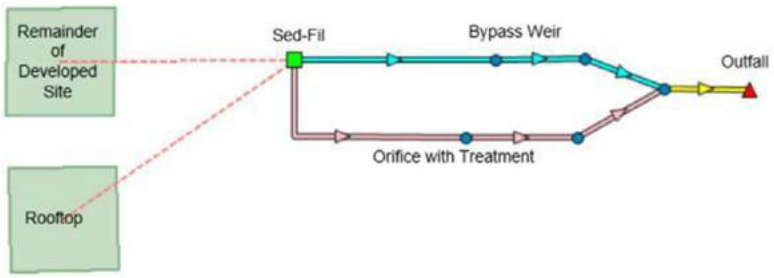
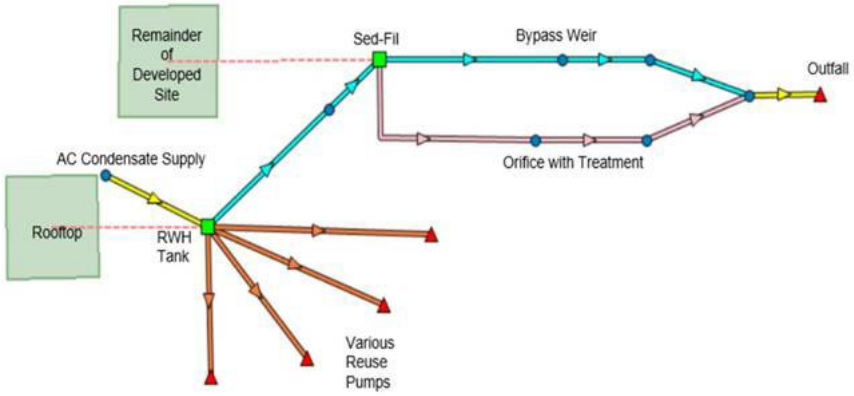


Figure 1.6.7.D-3. Model Network for Sedimentation-Filtration Baseline Scenarios.

• Proposed conditions scenario (see Figure 1.6.7.D-4) - SWMM shall be used to calculate average annual pollutant loads for the site under proposed developed conditions. Proposed conditions shall include the Ordinance-mandated RWH system with the proposed RWH cistern. Overflow from the RWH system and runoff from the remainder of the developed site shall be routed to one or more stormwater control measure(s). The RWH system and other proposed SCMs shall be designed and sized to demonstrate that average annual pollutant loads for the site do not exceed the average annual pollutant loads for baseline conditions. The analysis shall account for reuse demands on a daily basis at rates and frequencies to match proposed conditions. For example, reuse rates for indoor commercial uses shall be applied five days per week if weekend demands are expected to be significantly less than weekday demands. Similarly, reuse rates for landscape irrigation shall be applied one or two days per week to match the expected irrigation frequency.

Figure 1.6.7.D-4. Model Network for Beneficial Reuse Scenarios.



3. Design Options.

   A typical configuration for a Type I RWH system is shown in Figure 1.6.7.D-5. To receive water quality credit, rainwater harvesting systems must be designed so that captured runoff is held for at least 12

hours after rainfall has ceased, then either gravity-drained to a vegetated area sized large enough to infiltrate all the water (Design Guidance for Type IA) or pumped to a vegetated area (Design Guidance for Type IB). ~~The latter design is similar to a retention/irrigation system and Section 1.6.7(A) should be referenced for guidance.~~ The vegetated area can also serve as a vegetated filter strip for flows that by-pass the rainwater harvesting system. Type IB systems are not allowed in the Barton Springs Zone.

Because the required drawdown time is no more than five (5) days, these systems generally cannot be used to meet water conservation-oriented landscape irrigation needs (e.g., 5-day watering schedule). However, the portion of the system capacity that is recovered during the 5-day (maximum) drawdown period may be eligible for water quality credit. For example, water in the system may be pumped to a separate tank for subsequent beneficial reuse such as landscape irrigation during dry conditions.

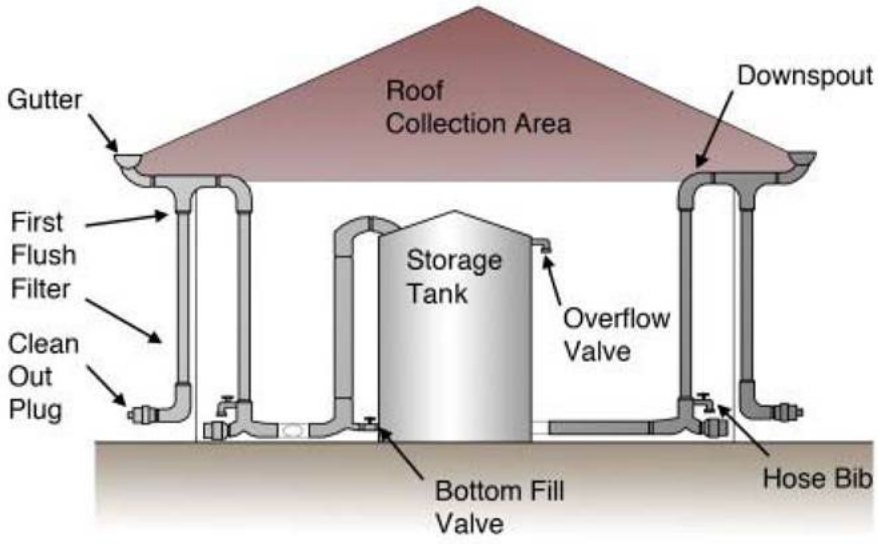


Figure 1.6.7.D-5. Typical configuration for a rainwater harvesting system.

Alternatively, and with approval from the Director, the system may be designed to empty or partially empty prior to the next forecasted rain event using an advanced real-time controller.

The water quality volume must be provided by the system designer, with the drawdown time set to a maximum of 120 hours. The designer must demonstrate that the vegetated area is sufficiently large to infiltrate the entire water quality volume within 120 hours (see Figure 1.6.7.D-3 below).

The average "treatment" rate of the rainwater harvesting system is:

$Q_{avg} = WQV/DDT$

Where:

It is reasonable to assume saturated conditions, and the infiltration rate of the vegetated area can be calculated as:

$Q_{veg} = k * i * A$

Where:

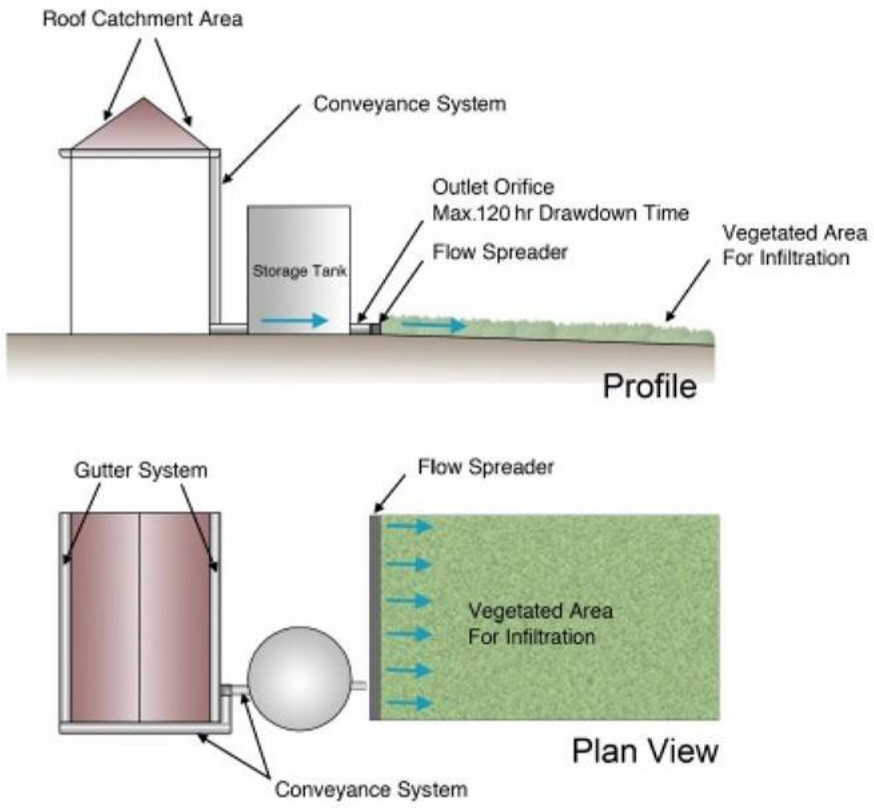


Figure 1.6.7.D-6. Type IA RWH System with captured runoff discharged to a vegetated area for infiltration.

As minimal ponding of water over the vegetated area is expected, the hydraulic gradient can be assumed equal to 1, thus:

$Q_{veg} = k * A$

To be conservative, design the vegetated area for the maximum flowrate discharged from the rainwater harvesting system. A reasonable assumption is to assume a value twice Q_{avg}, and to also assume a lag time (LT) between the time runoff ends and when the rainwater harvesting system begins discharging:

$Q_p = (2 * WQV)/(DDT - LT)$

Setting the peak flow rate discharged from the rainwater harvesting system equal to the vegetated area infiltration rate, and solving for A:

$A = (2 * WQV)/(k * (DDT - LT)$

Where:

A design infiltration rate (i.e., hydraulic conductivity) for the site must be established through desktop study and field sampling as described in Section 1.6.7.4. The lag time LT should be set to a minimum of 12 hours.

To be eligible for water quality credit the vegetated area also must meet the following criteria:

- The length (dimension in direction of flow) of the vegetative area should be at least 15 feet.
- The average slope of the vegetative area must be between 1% and 10%, with no portion exceeding 15%.
- The hydraulic loading rate should not exceed 0.05 cfs per feet width for the maximum flowrate applied to the vegetated area (see below for procedure to calculate peak flowrate). Higher hydraulic loading rates are allowed

but will reduce water quality credit. In this case, a maximum allowable rate of 0.15 cfs per feet width is allowed.

- The soil depth should be a minimum of twelve (12) inches.

- The vegetated area should have dense vegetative cover (minimum 95% coverage as measured at the base of the vegetation). The use of native grasses is strongly recommended due to their resource efficiency and their ability to enhance soil infiltration. In the case of natural wooded areas where 95% vegetative cover is not present, a minimum of four inches of leaf litter or mulch must be in place.

- An irrigation plan is required. Type IA RWH systems are prohibited from having a potable water supply connection.

Design Guidance for Type IB RWH System - Captured Runoff Pumped to Vegetated Irrigation Area

A typical design configuration in which captured runoff is pumped to irrigate a vegetated area is shown in Figure 1.6.7.D-7 below. The water quality volume must be provided by the system designer, with the drawdown time set to a maximum of 120 hours. ~~The system should be designed according to the retention/irrigation criteria in Section 1.6.7.A.~~

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 V, Figure 1-59F, for an example). Alternative sprinkler head designs shall be allowed if approved by Austin Watershed Protection.

Rainwater systems are considered auxiliary water sources by the Austin Water Utility. When a rainwater harvesting system meets the definition of Auxiliary Water per the City of Austin - Utility Criteria Manual (UCM) then the design of this system must comply with the backflow protection requirements established in Section 2.3.4 of the UCM, Backflow Prevention Rules and Regulations Pertaining to Sites With Both City Potable Water and Auxiliary Water.

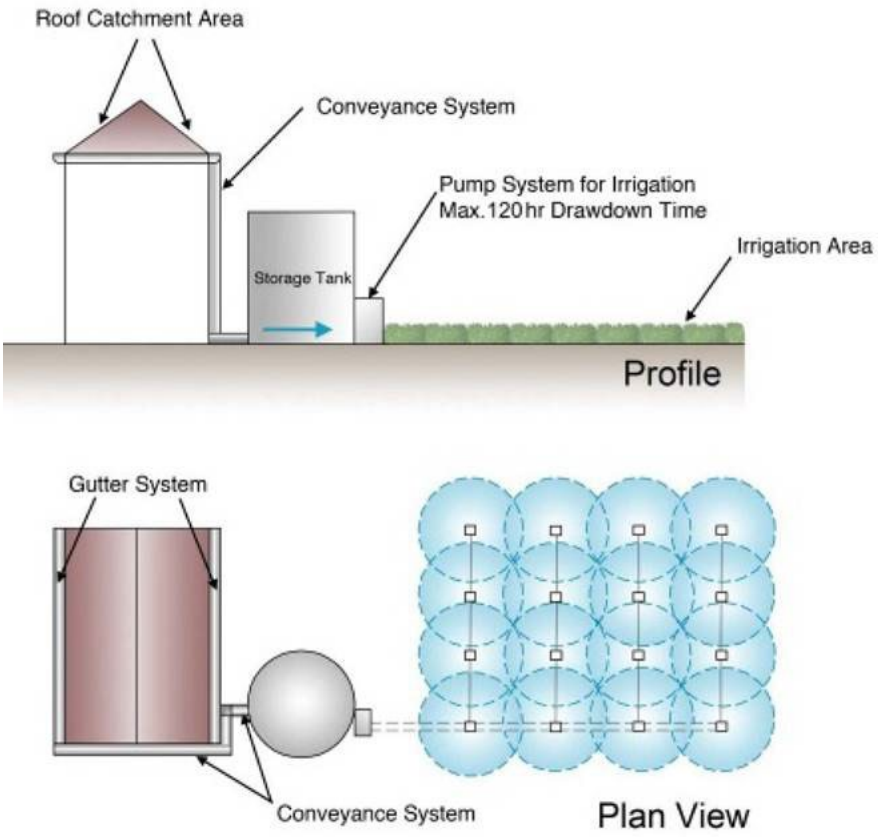


Figure 1.6.7.D-7. Type IB RWH system with captured runoff used to irrigate a vegetated area.

Design Guidance for Type II Rainwater Harvesting Systems

Type II RWH systems (both A and B) must be designed in accordance with requirements set forth in Chapter 15-13 - Regulation of Onsite Water Reuse Systems of the City of Austin Code of Ordinances. Some developments may be required to install Type II systems per LDC Section 25-9-412 (Onsite Water Reuse System Requirement). In addition, Type II RWH systems are subject to in Chapters 15-1 (Cross Connection Regulations) and 25-12 (Technical Codes).

4. Example.

A 5 acre commercial development with 50% impervious cover (2.5 impervious acres) is proposing a rainwater harvesting system that would capture runoff from 1 acre of rooftop and drain it by gravity to a vegetated area (Option A). The development is located outside of the Barton Springs Zone. The system would have a water quality volume of 25,000 gallons, which would be emptied in 96 hours by discharging to a vegetated area that is 260' wide by 90' long. The design hydraulic conductivity for the site was established to be 0.06 in/hour, or 0.005 ft/hour. Evaluate this design and determine the water quality credit it may be eligible for.

The water quality credit will typically be applied as either a reduction in the water quality volume of a structural control or a reduction in the payment instead of structural controls.

As the alternative control is for 1 acres of impervious cover, and the site has a total of 2.5 impervious acres, the IAF value is 0.40 (=1/2.5).

- The BMPDF factor is a function of two components, the rainwater harvesting system and the

vegetated area. The BMPDF value for the rainwater harvesting system is based on the water quality volume and drawdown time, subject to the requirement that the vegetated area must be large enough to infiltrate the captured volume.

To determine the BMPDF value, first convert the water quality volume from gallons to inches:

WQV_{rwh} = (25,000 gallons * 1 ft^3 /7.481gal) = 3,342 ft^3 = 0.92-inch

The BMPDF value is a function of the following factors:

WQV_{rwh} /WQV_{ecm} and

DDT_{rwh}

The rainwater harvesting system will be capturing runoff from a rooftop that is 100% impervious cover. The water quality capture depth for 100% impervious cover is 1.30-inch for projects located outside of the Barton Springs Zone. Therefore, the factors to determine BMPDF are:

WQV_{rwh} /WQV_{ecm} = 0.92/1.3 = 0.71, and

DDT_{rwh} = 96 hours.

Inserting these values into Figure 1.6.7.D-1, gives:

BMPDF = 0.68.

Before this credit can be applied first determine if the vegetated area is sufficient to infiltrate the water quality volume in 96 hours.

Is it large enough?

Minimum size A = (2 * WQV)/(k * (DDT - LT)) = (2 * 3,342)/(0.005 * (96-12) = 15,914 ft^2 .

Size provided = 260' * 90' = 23,400 ft^2 - this is large enough.

Is the length of the vegetated area at least 15 feet?

Yes as the proposed length is 90 feet.

Does it meet the 0.05 cfs/ft. width hydraulic loading rate for the discharge from the rainwater harvesting system?

To estimate peak flowrate and hydraulic loading rate:

Q_p = (2 * WQV)/(DDT - LT) = (2 * 3,342)/(96 - 12) = 80 cfh = 0.022 cfs

HLR = Q/W = 0.022/260 = 0.00008 cfs/ft width - Okay as < 0.05

All other slope, soil depth, vegetative cover, etc. criteria is also met, thus the vegetated area is acceptable and:

The total water quality credit for the proposed system is:

WQC = IAF * BMPDF = 0.4 * 0.68 = 0.272

5. **References:**

1. The Texas Manual on Rainwater Harvesting, 3rd edition 2005.
2. City of Tucson Water Harvesting Guidance Manual, October 2005.
3. City of Austin Energy, Green Building Program, 1995.

1.6.9 Guidance for Compliance with Technical Requirements of Chapter 25-8, Subchapter A, Article 13 (Save Our Springs Initiative)

1.6.9.1 Introduction

This section is designed to provide guidance for development in the Barton Springs Zone subject to Section 25-8-514 of the Land Development Code. All development subject to these regulations shall demonstrate that average annual stormwater discharge pollutant loads do not exceed the average annual pollutant loads produced by the site on the effective date of the project application (existing conditions loads) in accordance with the procedures established in these rules. If water quality controls cannot be designed which achieve the required pollutant load reduction to existing levels, impervious cover on the site shall be reduced to the extent necessary to comply with the pollutant load requirement. As indicated below, a combination of structural and non-structural stormwater treatment methods and source control techniques shall be used to comply with the ordinance requirements.

Runoff resulting from areas which store or receive irrigation of wastewater shall meet the pollution reduction requirements of the SOS Ordinance.

These rules are divided into two sections: (1) Pollution Prevention Measures and (2) Control Measure Design. Section 1.6.9.2 describes the minimum requirements for pollution prevention techniques. Section 1.6.9.3 describes the methodology for the calculation of existing and developed pollutant loads, and the minimum requirements for the design of water quality controls to prevent the increase in these loads above existing levels.

Source: Rule No. R161-14.27, 12-30-2014.

1.6.9.2 Pollution Prevention Measures

A. **General.** Pollution prevention measures shall be used to the greatest extent possible to reduce the number of potential sources of pollutants on sites. For commercial and multi-family sites, the applicant shall identify such potential sources of pollutants such as: liquid or solid waste storage locations, storage locations for chemicals including, but not limited to, pesticides, herbicides, fuels, petroleum products, hazardous wastes; vehicle fueling or washing areas; storage of raw materials, by-products or products of manufacturing processes; and mechanical equipment repair facilities.

Such areas shall be identified on the site plan and in the engineer's report. In addition, the report shall identify the proposed methods for the prevention of the discharge of pollutants from the potential sources. Preference shall be given to measures that prevent the exposure of these areas to stormwater runoff such as through covering or enclosing the areas within a building. Drains from such covered or enclosed areas shall not be routed to the storm drain system.

In addition, all storm drain inlets located on commercial and multi-family sites shall be stenciled by the owner with a sign which indicates that the inlet drains to local creeks or waterways and that no wastes should be dumped. The design of the stencil must be approved by the Director of the WPD~~R~~ prior to its use on the site.

B. **Cadmium.** In addition to the control measure design requirements for zinc in Section 1.6.9.3, this section describes the minimum requirements for pollution prevention and source control measures that are required for cadmium.

1. For commercial and industrial developments, the owner is required to identify any proposed storage, sale, use, or process involving cadmium on the site, and develop a source control plan for cadmium. This source control plan must be included in a restrictive covenant referenced on the site plan, filed with the appropriate

county and implemented on the site.

2. In addition to the items listed above, all proposed residential developments (single family/duplex and multi-family) will incorporate a Public Education Program as described in Section 1.6.9.2.F. of these Rules.

C. **Volatile Organic Compounds.** Volatile Organic Compounds (VOCs) are those compounds defined as VOCs in the NPDES Priority Pollutant listing. No calculations are required to show that VOC loads have been reduced to background or baseline levels. Development subject to this ordinance shall comply with the following source control and treatment methods:

1. Source controls will be required for developments that propose to store, use, or dispense VOCs for commercial purposes. A source control plan must be developed for these types of developments and must be included in a restrictive covenant referenced on the site plan, filed with the appropriate county and implemented on the site. The source control plan shall include: storage of materials in areas protected from rainfall and runoff, use of spill catchment devices (e.g. oil/water separators), demonstration of a spill response, containment, and clean-up plan, enclosure or covering of loading/ unloading areas.

2. In addition to the items listed above, all proposed residential developments (single family/duplex and multi-family) will incorporate a Public Education Program as described in Section 1.6.9.2.F. of these rules.

D. **Pesticides and Herbicides.** Pesticides are defined as insecticides, herbicides, rodenticides, nematocides, miticides, algicides, fungicides, and molluscides. This section describes the minimum requirements for pollution prevention and source control measures that are required for pesticides.

1. The developer shall prepare and submit an Integrated Pest Management (IPM) plan for the proposed development.

2. An IPM plan should contain the following components:

    - Lists of any pests (insects, mammals, plant disease, weeds, etc.) anticipated to require control.
    - For each pest, a hierarchy of treatments must be developed beginning with cultural, mechanical, biological and other non-toxic controls, and ending with chemical control. This hierarchy will determine the general sequence of control efforts to made once it has been determined that a pest population has reached a level which requires control. In addition to the control hierarchy, for each pest, there must be a description of the monitoring plan, damage level, or other method to be used to determine when treatments are necessary.
    - A list of all control products included in the hierarchies, identified by active ingredient and toxicity class, if necessary.
    - A description of the project for which the plan has been developed (commercial, residential, etc.), including approximate acreage of each landscape type(s) (i.e., turf, ornamental, etc.).
    - A drawing which identifies any creek or channel draining one acre or more, spring, pond, storm sewer inlet, sinkhole, cave, or fault within 150 feet of the area to be maintained.

      One hundred foot pesticide and fertilizer setbacks from these features are required, and must be indicated on the drawing. Notwithstanding, pesticides and herbicides should not be applied within the setback established for a Critical Environmental Feature.

      An IPM plan is a dynamic document. The applicant may wish to tailor the plan, eliminating any measures which have proven ineffective or adding additional measures to be tried. Also, pest problems may arise that are not anticipated at the time of the IPM plan submittal. The plan may therefore be amended with the submission and approval by WPD~~R~~ staff of additional or amended pest control hierarchies, or additions to other parts of the plan.

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 IPM plan. This shall include

information to be provided to tenants in multi-family developments.

4. For residential subdivision development, the developer must include plat notes approved by the WPD~~R~~ regarding the use of pesticides through an IPM plan.

5. In addition to the items listed above, all proposed residential developments (single family/duplex and multi-family) will incorporate a Public Education Program as described in Section 1.6.9.2.F. of these rules.

E. **Turf and Landscaping Regulations.** To minimize the potential for water quality impacts from chemical maintenance, the maximum portion of any commercial, multi-family, or single family/duplex lot that may be established as turf or landscaped is 15 percent. However, no lot shall be restricted to less than 2,000 square feet of turf or landscaped area. For the purposes of this rule, undisturbed natural areas or areas restored to natural conditions shall not be considered landscaping or turf. All natural areas or areas restored to natural conditions shall be shown on each site plan. For commercial and multi-family projects, these restrictions must be included in a restrictive covenant referenced on the site plan, included as a note on the final plat, filed with the appropriate county and implemented on the site. For single family/duplex development, these restrictions must be included as a note on the final plat.

The applicant may submit a request to allow additional turf or landscaped area on a site to the Director of the WPD~~R~~ for review. No later than 30 calendar days after receipt of the request for additional turf or landscaping, the Director of the WPD~~R~~ shall review the request and either: (1) approve the request in accordance with this section, (2) request additional information, or (3) deny the request. No later than 30 calendar days after receipt of all requested additional information, the Director shall approve or deny the request.

If the Director denies the request a letter will be provided to the applicant indicating the reasons therefor. The Director of the WPD~~R~~ shall approve the request for additional turf or landscaping only if: (1) more than 15 percent turf or landscaped area is necessary to comply with City Code regulations or other applicable regulations, or (2) more than 15 percent turf or landscaped area is necessary for the proposed land use AND the applicant demonstrates all of the following to the Director's satisfaction:

- Use of turf and landscaping is minimized;
- Use of types of turf and landscaping which require less chemical maintenance is maximized;
- The IPM plan for the project is designed specifically for the particular land use; and
- The pollution management plan meets the standards established in Section 25-8-514 of the LDC (the SOS Ordinance).

If the Director denies the request, a letter will be provided to the applicant indicating the reason therefor.

F. **Public Education Program.** For all residential developments (single family/duplex and multi-family), a plan must be developed by the applicant to provide public education to all prospective home buyers and tenants on methods to reduce non-point source pollution and protect the Barton Springs Zone of the Edwards Aquifer. The plan must include information on the following:

- Proper disposal and methods of recycling of nickel/cadmium batteries.
- Proper disposal and methods of recycling of motor oil.
- Proper vehicle maintenance techniques.
- Information detailing the restriction on the use of pesticides and describing an acceptable IPM plan for home use. It must be emphasized that it is a violation of federal law to use a pesticide in a manner inconsistent with its labeling, including dosage levels and target pests.
- Notification of restrictive covenants or plat notes.

All public education plans must be reviewed and approved by the WPD~~R~~ prior to final plat approval for

single family/duplex subdivisions or prior to site plan approval for multi-family developments. At the option of the Director, WPDR-generated public education material will be available for purchase and distribution to single family/duplex development or may be distributed through means other than the site developer.

Source: Rule No. R161-24.11, 9-6-2024.

1.6.9.3 Control Measure Design

For each site within the Barton Springs Zone, the average annual stormwater pollutant load for the specified pollutants (Section 1.6.9.3.B.1) discharged from a site shall not exceed the existing pollutant load. This is the non-degradation requirement. A series of steps for calculating whether a site's proposed conditions meet non-degradation requirements in the Barton Springs Zone is provided below:

- Calculating existing condition loads (Section 1.6.9.3.B);
- Calculating developed conditions uncontrolled runoff volume and pollutant concentrations (Section 1.6.9.3.C);
- Identifying the stormwater control measures that are currently approved for use within the Barton Springs Zone (Section 1.6.9.3.D);
- Calculating the effluent pollutant concentration of controls operating in series (Section 1.6.9.3.E);
- Calculating proposed developed condition loads (Section 1.6.9.3.E);
- Determining whether the proposed developed condition load complies with non-degradation requirements (Section 1.6.9.3.F); and
- Evaluating alternative stormwater control measures, if applicable (Section 1.6.9.3.G).

For stormwater control measures that do not discharge directly to the surface drainage system (i.e. infiltration measures), the proposed treatment methodology shall be designed to meet the pollutant loading reduction requirements for runoff prior to the treated runoff's re-emergence to the surface or entering the local groundwater system.

To the maximum extent feasible, areas of the site which are to remain undisturbed and undeveloped should not contribute runoff to a proposed developed area and are excluded from the calculations. Such undeveloped areas must remain in their natural condition and must be protected by a plat note or restrictive covenant referenced on the site plan and filed with the appropriate County to prevent the application of fertilizers or pesticides and to limit the disturbance of the natural areas. The removal of diseased or damaged trees or other plants which pose a hazard to health and safety or which pose a threat to the health of other plants in the area may be allowed, upon review and approval of the Watershed Protection Department (WPD).

A. Definitions.

1. Existing conditions. Existing conditions is a reference condition against which to compare developed conditions for the purposes of calculating pollutant loads in this section. (ECM Section 1.6.9.3.B). When calculating existing conditions load, use base impervious cover. (ECM 1.9.2.B). Existing conditions does not include development constructed in violation of City Code.

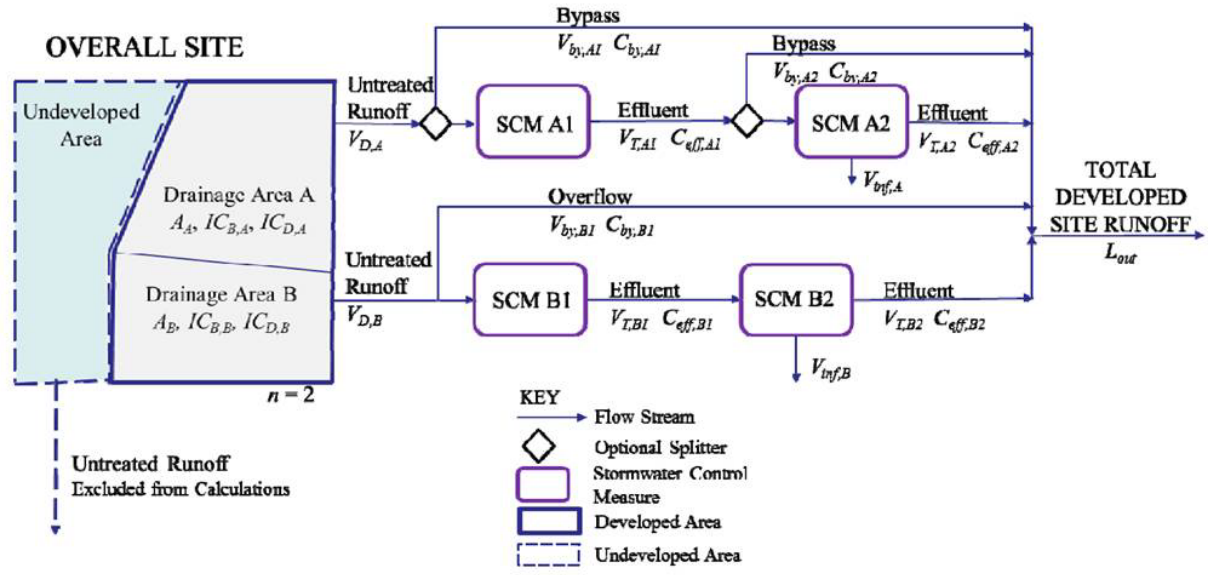
2. Developed conditions. Developed conditions represents the site characteristics under the proposed future development or redevelopment for the purposes of calculating pollutant loads in this section.

3. Stormwater Control Measure. All stormwater runoff treatment systems in this section are referred to as stormwater control measures (in short, SCMs or controls). SCMs are also commonly known as best management practices (BMPs).

4. Calculation Variables and Conceptual Layout. The pollutant load calculations in Section 1.6.9.3.B are based on a mass balance on the developed site runoff streams. Figure 3.A.1 shows an example conceptual layout of a site with multiple drainage areas and treatment trains. The applicant may customize the layout for their site by varying: the number of drainage areas, the presence, absence, type, and size of each SCM, and the flow volumes directed to each SCM. Each SCM and treatment train shall comply with requirements listed in Sections 1.6.7, 1.6.9, and other applicable Sections.

The goal of the ordinance is to treat all of the developed land. In the event that it is not physically possible to route all developed area runoff to an SCM, the runoff from the remaining developed drainage areas shall be treated to a greater extent such that the entire developed site load meets non-degradation requirements.

Figure 1.6.9.3.A.1: Example site showing two developed drainage areas, two SCM treatment trains, and associated calculation variables.



The following list summarizes the variables that will be introduced in the calculation procedure in Sections 1.6.9.3.B through 1.6.9.3.F:

A_{field} = ~~Irrigation~~ Infiltration field size (Acres)

A_n = Area of each drainage area (Acres)

b = Interevent time (hours)

C_{Ex} = Pollutant concentration for existing conditions (mg/L or CFU/100 mL)

$C_{by,1}$ = Pollutant concentration in flow that bypasses or overflows the first SCM in series (mg/L or CFU/100 mL)

$C_{by,2}$ = Pollutant concentration in flow that bypasses the second SCM in series

C_D = Pollutant concentration for developed conditions (mg/L or CFU/100 mL)

C_{eff} = Treated surface effluent concentration for each pollutant (mg/L or CFU/100 mL)

C_i = The concentration associated with the i^{th} flow stream (mg/L or CFU/100 mL)

$C_{inf,2}$ = Infiltrated concentration for each pollutant for the second SCM in series (mg/L or CFU/100mL)

CF = Conversion factor

For pollutant in mg/L CF = 0.2267 [lb-L/(mg-Ac-in)]

For pollutant in CFU/100 mL CF = 1.0279 [100 mL/(Ac-in)]

DDT = Drawdown time, or time for control to empty its full water quality volume, including any lag time (hours)

I = Field-verified infiltration rate (in/hr)

IC_B = Base impervious cover (percentage, 0 to 100)

IC_D = Developed impervious cover (percentage, 0 to 100)

LEF_p = Load equivalency factor for pollutant p (unitless)

L_{Ex} = Existing pollutant load (lb/yr or 10^6 CFU/yr)

L_n = The load of each pollutant in the runoff for a single drainage area n (lb/yr or 10^6 CFU/yr)

L_{out} = The annual pollutant load off the site (lb/yr or 10^6 CFU/yr)

m = Peak discharge multiplication factor (unitless)

n = Drainage area ID number

n_z = Number of application zones where ~~irrigation~~ infiltration is alternated

n_{max} = Total number of distinct drainage areas on the site

p = Pollutant ID

RCE = Runoff Capture Efficiency, or percent of total drainage area runoff that is captured on an average annual basis (%)

RCE_{inf} = Runoff capture efficiency for infiltrated (or reused) volume on an annual average basis (%)

R_v = Runoff-rainfall ratio (unitless)

S_d = Depression storage (inches)

t = Mean annual rainfall event duration (hours)

t_D = Drain time for full control to empty, excluding any lag time (hours)

LT = Lag time between end of rain event and beginning of drain time (hours)

v = Mean annual rainfall event volume (inches)

$V_{by,1}$ = Annual bypassed/untreated runoff volume (in/yr)

$V_{by,2}$ = Annual runoff volume treated by SCM 1 but bypassing SCM 2 (in/yr)

V_D = Developed annual runoff volume (in/yr)

V_{Ex} = Existing annual runoff volume (in/yr)

V_i = The volume associated with the i^{th} flow stream (in/yr)

V_{inf} = Annual average volume that is infiltrated (or reused) (in/yr)

$V_{T,1}$ = Annual average runoff volume treated by the first SCM in series (in/yr)

$V_{T,2}$ = Annual average runoff volume treated by SCM 2 but not infiltrated (or reused) (in/yr)

WQV = Water quality volume, or storage volume in SCM 1, normalized to the drainage area (inches)

WQV_{inf} =Infiltrated (or reused) water quality volume normalized to the drainage area (inches)

B. Calculating Pollutant Load for Existing Conditions.

1. Pollutants. Existing and developed pollutant loads shall be calculated for the following pollutant species:

Chemical Oxygen Demand (COD)

Escherichia coli (EC)

Total Lead (Pb)

Total Nitrogen (TN)

Total Phosphorus (TP)

Total Suspended Solids (TSS)

Total Zinc (Zn)

Although cadmium (Cd) is also a pollutant of concern, cadmium levels are typically lower than City of Austin monitoring detection limits. Therefore there is insufficient monitoring data to publish cadmium runoff concentrations. Zinc is more easily detected, therefore zinc (Zn) concentrations are calculated to determine compliance. See Section 1.6.9.2.B for additional cadmium requirements.

2. Drainage Areas. Each site shall be subdivided into one or more drainage areas. Pollutant load calculations shall be provided for each drainage area that contains any development, including both impervious and pervious cover, regardless of whether it drains to proposed stormwater control measures or does not drain to any stormwater control measure. The following variables shall correspond to each drainage area:

A_n = Area of drainage area (Acres)

n = Drainage area ID number

Flows from off-site as well as undeveloped areas should be diverted around proposed developed drainage areas. Such diversions may be constructed as open waterways or closed conduits. If swales or berms are used, they must be revegetated and located such that they do not receive on-site flow from developed areas. If flows from off-site and undeveloped areas are not diverted, the total contributing area must be considered when calculating the existing load, developed load, and volume to be captured and treated. However, undeveloped and offsite areas shall not be used to decrease average impervious cover percentage of the drainage area. Where a drainage area must include off-site drainage, the water quality volume associated with the drainage area shall be no less than the required water quality volume for the developed area alone.

3. Base Impervious Cover. Each drainage area has an associated base impervious cover, which is defined in Section 1.9.2. Note that base impervious cover may be 0%, such as if the site is undeveloped or if the entire site is redeveloped, or it may be greater than 0%.

IC_B = Base impervious cover (percentage, 0 to 100)

4. Existing Runoff. Each drainage area has an associated existing yearly runoff, which can be interpolated from Table 1-9, below. The table was developed from monitoring data collected and analyzed by the City of Austin. From the data, correlations were developed which relate a site's impervious cover to its runoff-rainfall ratio, R_v, and depression storage, S_d (Glick et al. 2009). Through an additional procedure (Adams & Papa, 2000) these variables were further correlated to annual runoff volume, V, as a function of impervious cover.

V_{Ex} = Existing annual runoff volume, a function of IC_B (in/yr)

Table 1-9: Yearly Runoff as a Function of Impervious Cover.

Impervious Cover,	Runoff-Rainfall	Depression	Annual Number of	Annual Runoff, V

IC (%)	Ratio, R_v	Storage, S_d (in)	Runoff Events, θ	(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

Source: COA WPD, CM-09-03.

5. Pollutant Concentration. Each drainage area has an associated existing pollutant concentration. The standard concentrations for the 8 pollutants, based on local monitoring data collected and analyzed by the City of Austin, are shown in Table 1-10, below. When determining pollutant concentrations, the applicant shall use column A for all cases where any development exists, including where the development is pervious (i.e. landscaped areas), and column B only where the site has no existing development.

C_{Ex} = Pollutant concentration for existing conditions (mg/L or CFU/100 mL)

Table 1-10: Pollutant Concentrations in Surface Runoff

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

Source: COA WPD, CM-09-03.

6. Pollutant Load. To calculate the existing pollutant load, evaluate Equation 1 for each of the eight pollutant species for each drainage area.

$L_{Ex} = C_{Ex} \cdot V_{Ex} \cdot A_n \cdot CF$ **(Equation 1)**

Where:

L_{Ex} = Existing pollutant load (lb/yr or 10^6 CFU/yr)

C_{Ex} = Pollutant concentration for existing conditions (mg/L or CFU/100 mL), see Section 1.6.9.3.B.5

V_{Ex} = Existing annual runoff volume (in/yr), See Section 1.6.9.3.B.4

A_n = Area of drainage area (Acres), see Section 1.6.9.3.B.2

CF = Conversion factor

CF (pollutant in mg/L) = 0.2267 (lb-L/mg-Ac-in)

CF (pollutant in CFU/100 mL) = 1.0279 (100 mL/Ac-in)

C. Calculating the Developed Conditions Runoff Volume and Pollutant Concentrations.

1. Impervious Cover. Calculation of developed condition pollutant loads must use the same drainage area used to determine the existing conditions loads. Within each drainage area, the total developed impervious cover will be determined as a percent of the gross drainage area. Total developed impervious cover includes all base impervious cover, new impervious cover, and redeveloped impervious cover as defined in Section 1.9.2.B. All developed areas, including areas of impervious cover, lawns, landscaping, gardens, and other maintained pervious areas, shall be included in the developed impervious cover percentage calculation and should be routed to a control. Existing or restored natural areas which are restricted from development, and pesticide, herbicide, or fertilizer application through a plat note or restrictive covenant shall be excluded from the drainage area and associated impervious cover calculations; refer to Section 1.6.9.3.B.2.

IC_D = Developed impervious cover (percentage, 0 to 100)

2. Runoff. Each developed drainage area has an associated annual average runoff volume that is a function of the developed impervious cover. This value can be interpolated from Table 1-9, above.

V_D = Developed annual runoff volume (in/yr), a function of IC_D

3. Pollutant Concentration. The runoff from each developed drainage area, prior to treatment by any control, has an associated pollutant concentration for developed conditions. This concentration can be found in Column A of Table 1-10, above.

C_D = Pollutant concentration for developed conditions (mg/L or CFU/100 mL)

D. Determining Treatment Volumes.

1. Approved Stormwater Control Measures (SCMs). For each drainage area, the stormwater control measures shall be designed as two SCMs in series. The first shall be a volume retention and filtration-type control that does not allow infiltration. The second shall be a volume reduction-type control; volume reduction, such as by infiltration, is generally the only practical way to achieve non-degradation criteria. Approved SCMs that can be used to treat the runoff from each drainage area are the following:

- First control in series (SCM 1):
    - Sedimentation/filtration (see Section 1.6.7.~~C~~A)
    - ~~Retention basin (see Section 1.6.7.A)~~
    - Rainwater cistern (see Section 1.6.7.D)
    - Biofiltration (see Section 1.6.7.~~H~~C)
    - Alternative, approved SCM (see Section 1.6.9.3.G)
- Second control in series (SCM 2):
    - Infiltration field (see Sections 1.6.7.A and 1.6.7.D)
    - Beneficial reuse (typically following a rainwater cistern)
    - Alternative, approved SCM (see Section 1.6.9.3.G)

SCM 1 shall be designed such that the full capture volume is released over a minimum 48 hour period. This allows better treatment of VOCs, pesticides, herbicides, and other toxic pollutants. Where basins are required to have liners, such liners shall be designed in accordance with the criteria in Section 1.6.2.C of the Environmental Criteria Manual.

Beneficial reuse includes other volume reduction techniques that result in less runoff discharged offsite. Examples include plumbing for non-potable uses such as toilet flushing or irrigation of a landscaped area. If selecting this option, the applicant shall provide calculations that quantify the volume reduction on an average annual basis.

Water shall be applied to infiltration fields ~~through either irrigation~~ using flow spreaders, either designed per Section 1.6.7.A, or ~~level-spreading, designed~~ for rainwater harvesting systems per Section 1.6.7.D. Water from SCM 1 can be conveyed to the infiltration field through pumping or, in cases where site topography allows, gravity drainage. Infiltration fields shall be located to avoid impacts to existing springs and other Critical Environmental Features, including impacts resulting from the discharge of inadequately treated runoff at such locations.

Infiltration fields shall be designed and sized such that there is no runoff of the applied water from the infiltration field. Application of water from SCM 1 onto the infiltration field shall not commence until a minimum of 12 hours after rainfall ends. This is known as the lag time, t_L. However, systems that satisfy all of the following do not require the 12 hour lag time:

(1) Use a sedimentation/filtration basin for SCM 1.

(2) Gravity-drain to the infiltration field.

(3) Include measures to ensure infiltration of the ~~entire~~ water quality volume, ~~such as berms a maximum of six inches high and that contain two inches of freeboard.~~ such as flow spreaders and berms as described in Section 1.6.7.A.

Where higher treatment levels are proposed in one drainage area to compensate for lower treatment levels in another drainage area on the same site, the applicant shall provide information which shows the following:

- The discharge from the area with lower treatment is within the same named watershed as the discharge which provides higher load removal and that the confluence of the discharges occurs within ½ mile of the site;
- No significant recharge features are present in the receiving waterway below the area with lower pollutant load removal and prior to the confluence with the waterway which drains the area with better treated runoff.

Development within the Barton Springs Zone must meet the guidelines in other areas of the ECM

such as Section 1.6.7, plus the guidelines listed in Section 1.6.9. Where design guidelines within the ECM conflict, the guidelines in Section 1.6.9 shall take precedence for development.

2. Treatment Volume for First SCM in Series. The runoff capture efficiency (RCE) is the annual average percent of runoff that is captured by a control, considering all storm events. To determine the RCE for SCM 1, the applicant shall either use the equations presented below, perform an independent engineering analysis, or use the City of Austin's Stormwater Load Analysis Tool (SLAT), which is available at the Watershed Protection Department's stormwater management web page (www.austintexas.gov/department/stormwater-management).

   Equation 2.A is an expression for runoff capture efficiency that was derived using a probabilistic methodology (Adams & Papa, 2000). In this expression, the runoff capture efficiency is a function of the SCM water quality volume, the SCM drain time, rainfall/runoff variables listed in Table 1-9, and rainfall statistics from a period of record. These rainfall statistics are mean annual rainfall event volume v, mean annual event duration t, and interevent time b and are further defined below.

$$RCE = 1 - \frac{DDT}{DDT + \frac{t.WQV}{v.R_v}} * \frac{\left(\frac{DDT}{b \cdot WQV}\right) + \left(\frac{1}{v \cdot R_v}\right) \exp\left[-\left(\frac{DDT}{b \cdot WQV} + \frac{1}{v \cdot R_v}\right) WQV\right]}{\frac{DDT}{b \cdot WQV} + \frac{1}{v.R_v}} \exp$$

(Equation 2.A)

Where:

RCE = Runoff capture efficiency, or percent of drainage area runoff that is captured, on an average annual basis (%)

v = Mean annual rainfall event volume = 0.40 inches

t = Mean annual rainfall event duration = 5.77 hours

b = Interevent time = 103.63 hours

DDT = t_D + LT = drain time plus any lag time (hours)

R_v = Runoff-rainfall ratio (unitless) (See Table 1-9)

S_d = Depression storage (inches) (See Table 1-9)

WQV = Water quality volume, or storage volume in SCM available to capture runoff normalized to the drainage area (inches)

Typically, the water quality volume is first assumed or iteratively calculated (see Section 1.6.9.3.F).

To calculate the runoff volume treated by SCM 1 on an annual basis, evaluate Equation 3.A:

3. Treatment Volume for SCM 2. Unless proposing a non-volume reduction-based alternative, SCM 2 reduces runoff volume by infiltrating ~~or irrigating~~ into the soil, or reusing water that later joins the sanitary sewer system. ~~Pollutants associated with the infiltrated volume are assumed to pass through sufficient soil to achieve undeveloped concentrations.~~

   The infiltrated (or reused) water quality volume, WQV_{inf}, is the maximum volume of water that is infiltrated (or reused) over the drawdown period of SCM 1, normalized to the drainage area. The designer typically selects WQV_{inf}.

Often, WQV_{inf} is equal to the water quality volume of the first control, WQV, and in this case the average annual volume infiltrated (or reused), V_{inf}, is equal to the average annual treated volume of SCM 1, $V_{T,1}$ (see Section 1.6.9.3.D.2). However, WQV_{inf} can be less than WQV depending on design criteria, for example, a limited infiltration field area or a slow rate of beneficial reuse. If WQV_{inf} is anticipated to be less than WQV, a continuous simulation model such as EPA SWMM must be used to calculate WQV_{inf} and V_{inf}.

The average annual volume infiltrated (or reused), V_{inf}, can be calculated using the same method as $V_{T,1}$ but replacing WQV with WQV_{inf} as shown in Equations 2.B and 3.B:

$$RCE_{inf} = 1 - \frac{DDT}{DDT + \frac{t.WQV_{inf}}{v.R_v}} * \frac{\left(\frac{DDT}{b \cdot WQV_{inf}}\right) + \left(\frac{1}{v \cdot R_v}\right) \exp\left[\left(\frac{DDT}{b \cdot WQV} + \frac{1}{v \cdot R_v}\right) WQV_{inf}\right]}{\frac{DDT}{b \cdot WQV_{inf}} + \frac{1}{v.R_v}} \exp\left(\frac{-S_d}{v}\right)$$

(Equation 2.B)

Where:

RCE_{inf} = Runoff capture efficiency for infiltrated (or reused) volume on an average annual basis (%)

v = mean annual rainfall event volume (See Section 1.6.9.3.D.2)

t = mean annual rainfall event duration (See Section 1.6.9.3.D.2)

b = interevent time (See Section 1.6.9.3.D.2)

DDT = drawdown time (total time for full control to empty, including any lag time) (See Section 1.6.9.3.D.2)

R_v = Runoff-rainfall ratio (unitless) (See Table 1-9)

S_d = depression storage (inches) (See Table 1-9)

WQV_{inf} = Infiltrated (or reused) water quality volume normalized to the drainage area (inches)

Equation 3.A is then re-evaluated using RCE_{inf} instead of RCE and becomes Equation 3.B:

$V_{inf} = RCE_{inf} \cdot V_D$ **(Equation 3.B)**

Where:

V_{inf} = Annual average runoff volume that is infiltrated (or reused) (in/yr)

RCE_{inf} = Runoff capture efficiency for infiltrated (or reused) volume on an annual average basis (%)

V_D = Developed annual runoff volume (in/yr), see Section 1.6.9.3.C.2

~~If~~ When using an infiltration ~~(or irrigation)~~ field, the infiltrated water quality volume is related to field area by Equation 4. Equation 4 is based on the expressions in Section 1.6.7.D but has been modified to fit the variable definitions of Section 1.6.9. ~~The expression assumes minimal ponding over the infiltration area, and thus,~~ tThe infiltrated water quality volume is a function of the soil properties, field area, and application rate. To be conservative, for both gravity-draining systems and ~~irrigated~~ pumped systems, the maximum flow rate is assumed to size the infiltration area.

The maximum flow rate is defined as twice the average application rate of WQV_{inf}/DDT. ~~If instantaneous application rates exceed the average, the field~~ All infiltration fields shall include design measures, such as low berms, to ensure that there is no excess runoff (see Section ~~1.6.9.3.D.1~~1.6.7.A).

$$A_{field} = 2\,x\,\frac{WQV_{inf}}{(DDT - LT)\,\cdot I}A_n$$ **(Equation 4)**

Where:

A_{field} = ~~Irrigation~~ Infiltration field size (Acres)

WQV_{inf} = Infiltrated (or reused) water quality volume normalized to the drainage area (inches)

DDT = Drawdown time, or time for first control to empty its full water quality volume, including any lag time (hours)

LT = lag time between end of rain event and beginning of drain time (hours)

I = Field-verified design infiltration rate (in/hr) (See ECM Section 1.6.7.4)

A_n = Area of each drainage area (acres) (See Section 1.6.9.3.C)

If SCM 2 does not infiltrate 100% of the volume, i.e. it has overflow on an average annual basis or is a non-infiltration-based alternative SCM, then the effluent load of the non-infiltrated component is included in the load calculations. The non-infiltrated volume, $V_{T,2}$, shall be determined with Equation 5, which assumes that no bypass from SCM 1 is routed to SCM 2. If this assumption is not met, the volume shall be calculated independently such as with a continuous simulation model (i.e., EPA SWMM).

$V_{T,2} = V_{T,1} - V_{inf}$ **(Equation 5)**

Where:

$V_{T,2}$ = Annual average runoff volume treated by SCM 2 but not infiltrated or reused (in/yr)

$V_{T,1}$ = Average annual runoff volume treated by the first SCM in series (in/yr) (See Section 1.6.9.3.D.2)

V_{inf} = Annual average volume that is infiltrated (or reused) (in/yr) (See Equation 3.b)

4. Bypass Volume. A portion of the runoff volume may bypass or overflow both the first and second SCM, thus remaining untreated. To calculate the annual average bypass volume which is not treated by any SCM, use a continuous simulation model (i.e., EPA SWMM) or SLAT. For a typical configuration where two SCMs in series treat the same drainage area, Equation 6 can be used to find this bypass volume:

$V_{by,1} = V_D - V_{T,1}$ **(Equation 6)**

Where:

$V_{by,1}$ = Annual bypassed/untreated runoff volume (in/yr)

V_D = Developed annual runoff volume (in/yr), see Section 1.6.9.3.C.2

$V_{T,1}$ = Annual average runoff volume treated by the first SCM in series (in/yr), see Equation 3.A

The treatment train design may divert a portion of the SCM 1 effluent offsite, bypassing SCM 2. To determine the annual average runoff volume that is treated only by SCM 1 before running

offsite ~~$V_{by,2}$~~, evaluate Equation 7, which assumes that two SCMs in series treat the same drainage area:

$V_{by,2} = V_{T,1} - V_{T,2} - V_{inf}$ **(Equation 7)**

Where:

$V_{by,2}$ = Annual runoff volume treated by SCM-1 but bypassing SCM 2(in/yr)

$V_{T,1}$ = Annual average volume treated by the first SCM in series (in/yr), see Equation 2

$V_{T,2}$ = Annual average runoff volume treated but not infiltrated (or reused) by SCM 2 (in/yr), see Section 1.6.9.3.D.3

V_{inf} = Annual average volume that is infiltrated (or reused) (in/yr), see Section 1.6.9.3.D.3

E. Calculate the Pollutant Load for the Developed Site with Controls.

1. Treated Effluent Pollutant Concentrations. Each volume component calculated in Section 1.6.9.3.D has an associated pollutant concentration. To find the pollutant concentrations associated with treated effluent, use Table 1-11 below. If using an alternative SCM, apply the effluent concentrations proven with approved testing protocols per Section 1.6.9.3.G.

For SCMs in series, pollutant concentrations are assumed not to increase as they travel through the treatment train. Therefore, for each individual pollutant, the effluent concentration after the final SCM in series shall be the minimum effluent concentration of any of the SCMs that are in that series.

C_{eff-1} = Treated effluent concentration for each pollutant (mg/L or CFU/100 mL)

Table 1-11: Effluent Concentrations for Approved SCMs

Pollutant	Unit	C_{eff}					
		Infiltration Field[1]	Retention Basin[2] and Rain Gardens without Underdrain	Rainwater Harvesting[2]	Sedimentation /Filtration	Biofiltration[3]	Approved Alternative SCM
COD	mg/L	38.9	43.79	43.79	22.4	22.4	Applicant Provided
EC	CFU/100 mL	8370	11065	11065	4895	4895	Applicant Provided
Pb	mg/L	0.00428	0.00831	0.00831	0.00574	0.00574	Applicant Provided
TN	mg/L	1.19	1.42	1.42	1.07	1.07	Applicant Provided
TOC	mg/L	13.03	11.45	11.45	7.33	7.33	Applicant Provided
TP	mg/L	0.124	0.224	0.224	0.099	0.099	Applicant Provided
TSS	mg/L	166	134	134	20.62	20.62	Applicant Provided

Zn	mg/L	0.0236	0.0453	0.0453	0.0230	0.0230	Applicant Provided

Source: COA WPD, CM-13-02.

Table 1-11 Notes:

1. The infiltrated fraction is assumed to achieve background, or undeveloped, loads.
2. These SCMs, given sufficient settling time, are assumed comparable to sedimentation basins.
3. These SCMs are assumed comparable to sedimentation/filtration basins.

2. Bypass Pollutant Concentrations. Runoff that bypasses SCM 1 remains untreated. However, due to the first flush phenomena, the pollutant concentration in the bypass may be less than the event mean concentration. In this calculation methodology, the bypass concentration is a function of SCM 1's water quality volume in inches. Different bypass concentrations are assigned depending on whether SCM 1 is off-line and isolates the water quality volume (typically a splitter is used) or on-line. Table 1-12 summarizes the bypass concentrations for the flows identified in Figure 1.6.9.3.A.1 and defined below:

$C_{by,1}$ = Pollutant concentration in flow that bypasses or overflows SCM 1 (mg/L or CFU/100 mL)

$C_{by,2}$ = Pollutant concentration in flow that bypasses SCM 2 (mg/L or CFU/100 mL)

Table 1-12: Bypass Concentrations

Pollutant	Units	SCM 1 Bypass Concentration, $C_{by,1}$		SCM 2 Bypass Concentration, $C_{by,2}$
		Off-line	On-line	
COD	mg/L	= min{$C_{D,COD}$, exp[4.493-0.510(WQV)]	= min{$C_{D,COD}$, exp[4.916-0.545(WQV)] }	= C_{eff-1},Table 1-11
EC	CFU/100mL	= min{$C_{D,EC}$, exp[10.18-0.465(WQV)]	= min{$C_{D,EC}$, exp[10.79-0.624(WQV)]	= C_{eff-1},Table 1-11
Pb	mg/L	= min{$C_{D,Pb}$, 0.001·exp[2.882-0.489(WQV)]	= min{$C_{D,Pb}$, 0.001·exp[3.522-0.529(WQV)]	= C_{eff-1},Table 1-11
TN	mg/L	= min{$C_{D,TN}$, exp[0.957-0.267(WQV)]	= min{$C_{D,TN}$, exp[1.322-0.236(WQV)]	= C_{eff-1},Table 1-11
TOC	mg/L	= min{$C_{D,TOC}$, exp[2.724-0.189(WQV)]	= min{$C_{D,TOC}$, C_{by} = exp[3.112-0.282(WQV)]	= C_{eff-1},Table 1-11
TP	mg/L	= min{$C_{D,TP}$, exp[-0.613-0.469(WQV)]	= min{$C_{D,TP}$, exp[-0.223-0.400(WQV)]	= C_{eff-1},Table 1-11
TSS	mg/L	= min{$C_{D,TSS}$, exp[5.290-0.934(WQV)]	= min{$C_{D,TSS}$, exp[5.862-0.765 (WQV)]	= C_{eff-1},Table 1-11
Zn	mg/L	= min{$C_{D,Zn}$, 0.001·exp[4.610-0.442(WQV)]	= min{$C_{D,Zn}$, 0.001·exp[5.200-0.531(WQV)]	= C_{eff-1},Table 1-11

Source: COA WPD, SR-14-10.

Note that the bypass concentration shall not exceed the event mean concentration for the developed drainage area. In the table, $\min\{C_D, C_{by}\}$ means to use the minimum of the two terms.

3. Treated Pollutant Load. Pollutant loads are found by multiplying the volume of each flow component by its associated concentration and then summing for every flow component that contributes to offsite runoff. For each drainage area n, find the pollutant load by evaluating the general expression in Equation 8.A:

   $L_n = A_n \cdot CF \cdot \Sigma(Ci \cdot Vi)$ **(Equation 8.A)**

   Where:

   L_n = The load of each pollutant in the runoff for a single drainage area (lb/yr or 10^6 CFU/yr)

   A_n = Area of drainage area (Acres), see Section 1.6.9.3.B.2

   CF = Conversion factor, see Section 1.6.9.3.B.6

   Ci = The concentration associated with the i^{th} flow stream (mg/L or CFU/100 mL)

   Vi = The volume associated with the i^{th} flow stream (in/yr)

   Written more explicitly, Equation 8.A becomes Equation 8.B. Note that the infiltrated volume is omitted from the calculation, as only the load in surface runoff is considered.

   $L_n = A_n \cdot CF \cdot \Sigma(C_{eff\text{-}1} \cdot V_{by,2} + C_{eff\text{-}2} \cdot V_{T,2} + C_{by,1} \cdot V_{by,1})$ **(Equation 8.B)**

   Where:

   L_n = The load of each pollutant in the runoff for a single drainage area (lb/yr or 10^6 CFU/yr)

   A_n = Area of drainage area (Acres), see Section 1.6.9.3.B.2

   CF = Conversion factor, see Section 1.6.9.3.B.6

   $C_{eff\text{-}1}$ = Treated surface effluent concentration for each pollutant from first SCM in series (mg/L or CFU/100 mL), see Section 1.6.9.3.E.1

   $V_{by,2}$ = Annual runoff volume treated by SCM 1 but bypassing SCM 2 (in/yr), see Section 1.6.9.3.D.4

   $C_{eff\text{-}2}$ = Treated surface effluent concentration for each pollutant from second SCM in series (mg/L or CFU/100mL), see Section 1.6.9.3.E.1

   $V_{T,2}$ = Annual average runoff volume treated but not infiltrated (or reused) (in/yr), see Section 1.6.9.3.D.3

   $C_{by,1}$ = Pollutant concentration in flow that bypasses or overflows the first SCM in series (mg/L or CFU/100 mL), see Section 1.6.9.3.E.2

   $V_{by,1}$ = Annual bypassed/untreated runoff volume (in/yr), see Section 1.6.9.3.D.4

4. Total Developed Pollutant Load. Find the total developed pollutant load for the entire site by summing the pollutant loads from each developed drainage area n, as in Equation 9:

   $L_{out} = \Sigma L_n$ for n=1 to n_{max} (Equation 9)

   Where:

   L_{out} = The annual pollutant load off the entire site (lb/yr or 10^6 CFU/yr)

   n_{max} = Total number of distinct drainage areas on the site

F. Compare the Proposed Developed Load to the Existing Load. Compare the developed pollutant load to the existing pollutant load for each of the pollutants. If the developed load is less than the existing pollutant load for all pollutants, then the site is compliant.

A quick way to demonstrate compliance is with the load equivalency factor (LEF), shown in Equation 10. The LEF normalizes the proposed load to the existing load.

$LEF_p = L_{out,p} / L_{Ex,p}$ (Equation 10)

Where:

LEF_p = Load equivalency factor for pollutant p (unitless)

If the LEF is less than or equal to one for every pollutant, then the proposed design is compliant. No further calculations are necessary to satisfy the requirements of Section 1.6.9.

If the LEF is greater than one for any pollutant i, then the proposed design is not compliant and the applicant shall modify their design. Options for design modifications include but are not limited to:

- Increase the water quality volume of the SCM(s).
- Increase the area of the infiltration field(s).
- Reduce the developed impervious cover.

The applicant should iterate through the calculation procedure with the modified design until compliance is demonstrated.

G. Evaluation of Alternative Stormwater Control Measures. All stormwater control measures not explicitly listed in Section 1.6.9.3.D, as well as those listed but that modify the standard designs in the Environmental Criteria Manual and/or that propose effluent concentrations that vary from Table 1-11, are considered alternative designs. Designs for alternative stormwater control measures must be reviewed and approved by the Director of the WPD, and the design criteria must be substantiated in the scientific and engineering literature.

The applicant shall submit an engineering report from a third party testing source to verify the effluent concentrations from the proposed alternative SCM. Appropriate third party testing sources include Accreditation Board for Engineering and Technology (ABET) approved universities, peer-reviewed, published journal articles, tests performed according to Technology Assessment Protocol-Ecology (TAPE) (Washington State Department of Ecology, 2011) or Technology Acceptance Reciprocity Partnership (TARP, 2003) protocols. Testing data provided only from the manufacturer, without certified third party testing, is unacceptable. Additional criteria used to determine the acceptability of the alternative design include: similarity of studied site to conditions in the Austin, Texas area including items such as rainfall patterns, soil characteristics, and type of development; applicability of study to the proposed site; and conformance of proposed design with that studied.

The applicant is encouraged to discuss proposed designs with the WPD staff at an early stage to ascertain the acceptability of all alternative or innovative design concepts. The final acceptability of data shall be determined by the Director of the WPD. If approved, the applicant may use the data in pollutant load removal calculations to determine compliance with the appropriate Land Development Code requirements.

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